Pavement Management Guide

October 18, 2021

Prepared by the Pavement and Geotechnical Division of the Office of Materials Technology

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

Foreword

The Pavement Management Guide was written to document the procedures followed by the pavement management engineers and technicians of the Maryland Department of Transportation State Highway Administration (MDOT SHA) Pavement Management (PM) Section for pavement data processing and analysis to support MDOT SHA's System Preservation efforts.

All the position titles described throughout this guide are referenced to MDOT SHA positions and roles. As such, a current organizational chart for the PM Section was also included in the MDOT-SHA Organization of this guide to assist the readers with understanding the organizational structure within the PM Section.

A vast majority of the MDOT SHA's pavement management functions are performed by engineers and technician staff in the PM Section of the Pavement and Geotechnical Division (PAGD) of the Office of Materials Technology (OMT). The Team Leaders and Assistant Division Chief are responsible for the quality and timeliness of all the pavement management functions for the Division. Other data collection divisions within OMT also support the pavement management functions of the Pavement Management Section.

MDOT SHA has adopted a policy of continuous improvement when managing data quality. Infrastructure condition measurements are used to support data-driven decision making which maximizes the return on public investment. As technology advancements are implemented, both current data and historic data are managed to provide both accuracy and consistency by storing and re-processing historic raw data within current protocols, to the extent feasible considering prior technology limitations. Data analysis procedures are continuously updated as and when more data becomes available, thereby facilitating improved decision making. This document is actively managed to reflect the latest pavement data collection, pavement data quality management and pavement data analysis procedures that are followed by MDOT SHA.

Any questions or comments concerning this guide should be directed to:

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1 OVERVIEW

1.01 INTRODUCTION

This Maryland Department of Transportation State Highway Administration (MDOT-SHA) Pavement Management (PM) Guide provides a comprehensive set of standard operating procedures (SOPs) designed to assist in conducting different processes involved in the collection, processing, analysis and reporting of PM data. These data directly support MDOT-SHA's pavement asset management program, including all data development, analysis, and any state or federal reporting efforts, including the Highway Performance Monitoring System (HPMS) deliverables, among other applications.

The set of SOPs contained in this guide includes procedures related to the production and submittal of data to the FHWA HPMS as well as other procedures related to the production of pavement management data to support the strategies and goals defined by the MDOT-SHA. This guide is a living document. The contents will be updated and new procedures will be added as they become available.

Each SOP document includes the following five elements: (i) general aspects of the SOP; (ii) frequency of the SOP; (iii) purpose of the SOP; (iv) resources required to perform the SOP; and (v) procedural steps to perform the SOP. The latter SOP element includes the Quality Control (QC) and Quality Assurance (QA) processes performed to check that the data collected and processed at each step have acceptable quality. The definition of QC and QA used in this document follow the definitions used internally by MDOT-SHA staff: QC refers to the quality checks performed by the personnel involved in conducting the process whereas QA refers to the independent quality checks performed by personnel not involved in conducting the process.

The materials contained in the Guide are meant to be useful for both the training of new employees and as a reference to be utilized as needed throughout the course of work. This is a resource document. It is not intended to override or replace the necessary use of good judgment, common sense, and research of current best practices. The audience for whom the Guide was written should have a basic background and general understanding of pavement management, as well as knowledge of the technical skills required for the position and function of the specific SOP.

The following two sections of this Overview chapter provide general information on the Maryland Department of Transportation (MDOT) divisions related to the SOPs included in this Guide, as well as the organization of the document and a description of the relationship among SOPs. The remaining chapters of the document contain the set of PM SOPs grouped by the PM process stage they belong to.

1.02 MDOT-SHA ORGANIZATION

The MDOT divisions relevant to the SOPs contained in this Guide are shown in Figure 1. The MDOT-SHA and the Maryland Transit Authority (MDTA) are sub-divisions of the MDOT Secretary. The MDTA is responsible for the administration of toll facilities, among other responsibilities. The MDOT-SHA is responsible for the administration of the majority of high volume public highways in Maryland outside Baltimore City. The MDOT-SHA is also responsible for the collection, processing, analysis and reporting of pavement management data on sections administered by other offices, such as the MDTA's toll roads.

The SOPs in this guide relate to both planning and operations work done by respective offices and divisions. The planning efforts which relate to highway inventory management and HPMS reporting are conducted by the Innovative Performance Planning Division (IPP), the Data Services Division (DSD), and the Data Governance Division (DGD). The IPP group is responsible for the submittal of the MDOT data Quality Management Plan to meet requirements from item §490.319(c) of the FHWA's third final rule[06/12/2019] for national performance management measure regulations. The DSD is responsible for the highway inventory management and the annual submittal of the HPMS data to the FHWA. The DGD is responsible for hosting and managing several of the databases referenced in the SOPs of this document. The Highway Development group is responsible for the development of major projects. Within the Operations branch of MDOT-SHA, the Office of Materials Technology (OMT) is responsible for the field data collection efforts, pavement management, and pavement design. The other offices within the Operations branch provide more tangible components of asset management, including project development, construction and maintenance.

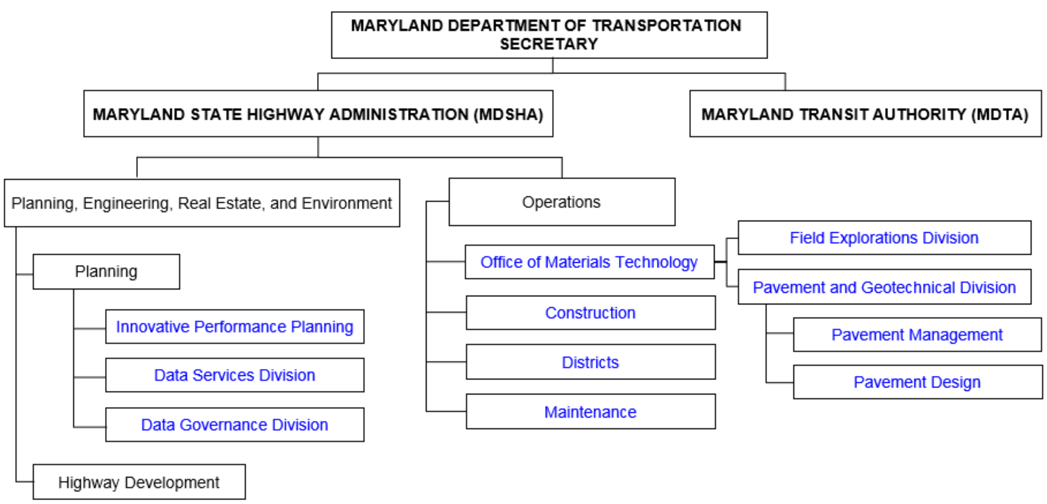


Figure 1: MDOT-SHA Organization Chart

As noted in the organizational breakdown above, the PM section of MDOT-SHA is a sub-group of the Pavement and Geotechnical Division (PAGD), located at the OMT. The PM section of the PAGD, along with the Field Explorations Division (FED), handle many pavement data collection activities, all pavement data processing and analysis responsibilities, and several reporting functions which support MDOT-SHA business plan goals and performance measures.

The Field Explorations Division (FED) is responsible for all pavement field data collection activities. Along with daily data collection, the FED handles equipment calibration, validation, verification, maintenance, and QC/QA of the collected data. The procedures contained in this version of the Guide pertain to data collection activities relating to the Automatic Road Analyzer (ARAN) and skid trailers.

The PM section of the PAGD consists of several teams with defined roles in the pavement management process. Figure 2, shown below, summarizes the various teams and their place in the PM section of the PAGD.

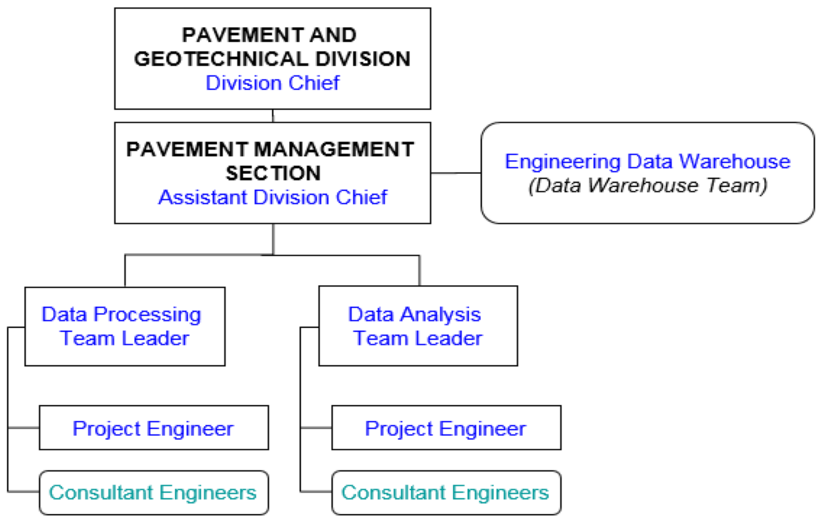


Figure 2: Pavement Management Section Organization

The following list provides a brief description of the roles and responsibilities of the different PM teams, focusing on the processes included in the SOPs of this version of the Guide:

- The Data Processing Team (DPT) is responsible for the processing, updating, managing, developing, and QC/QA of construction data and of the condition data collected in the field by the FED.
- The Data Warehouse Team (DWT) is mainly responsible for the management of PM databases and the integration of data with databases administered by others. It provides support to other PM teams to facilitate the production and processing, quality control, analysis, and reporting of data.
- The Data Analysis Team (DAT) is mainly responsible for the analysis of pavement management data. This includes the projection of the pavement network condition, the optimization of maintenance and rehabilitation strategies, as well as the reporting of pavement management data, including State-wide public reports and state reporting and subsequent federal reporting by planning divisions. The DAT also provides protocol development, outlier review, and any re-processing of historic data as new protocols emerge.

1.03 MDOT-SHA PM GUIDE ORGANIZATION

The Guide has several sections of interest, representing the many different stages of PM. These include the following:

- The section on Planning provides guidance on the annual planning and updating of inventory information for the list of sections to collect pavement surface condition data with the ARAN survey vans (ARAN Collection List) and skid trailers (Skid Collection List).
- The section on Field Data Collection provides guidance on field testing requirements, equipment calibrations, validation, verification, and maintenance, related to the collection of pavement surface condition data with the ARAN survey vans and skid trailers.
- The section on Construction Data provides guidance on the collection, importing and processing of construction data from various data sources necessary to support PM activities.
- The section on Data Processing provides guidance on the processing and management of the different data elements collected in the field by the ARAN survey vans and skid trailers.
- The section on Data Migration provides guidance on the updating of performance data tables and migration to various data formats.
- The section on HPMS Data Reporting provides guidance on the updating, formatting, and reporting of data to the FHWA's HPMS.
- The section on Trend Analysis provides guidance on the annual updating of pavement condition metric performance models to be used in the optimization of targeted projects, among other applications.
- The section on Optimization provides guidance for the entry of required inputs and generation of the yearly targeted projects list.
- Several Appendices are provided for reference.

Figure 3 and Figure 4 provide a summary of the processes, databases, elements, and procedures which make up the pavement management SOPs described in this document. Figure 3 is an overall summary of database production, beginning with the inventory list received from the DSD and ending with the generation of the optimized targeted projects list. The white trapezoids denote databases; the arrows between the databases indicate the flow of data throughout the PM process; and the colored boxes group the databases together by the stage in which they are produced or utilized (e.g., Planning stage).

Figure 4 is provided to visualize the order and stage of each of the SOPs included in this version of the Guide, as well as the relationship between the different SOPs. Each white circle indicates a stage of pavement management. The rectangles which branch off from the stages are individual SOPs developed for the completion of the particular stage. The dotted lines which surround various stages denote the frequency with which they are performed.

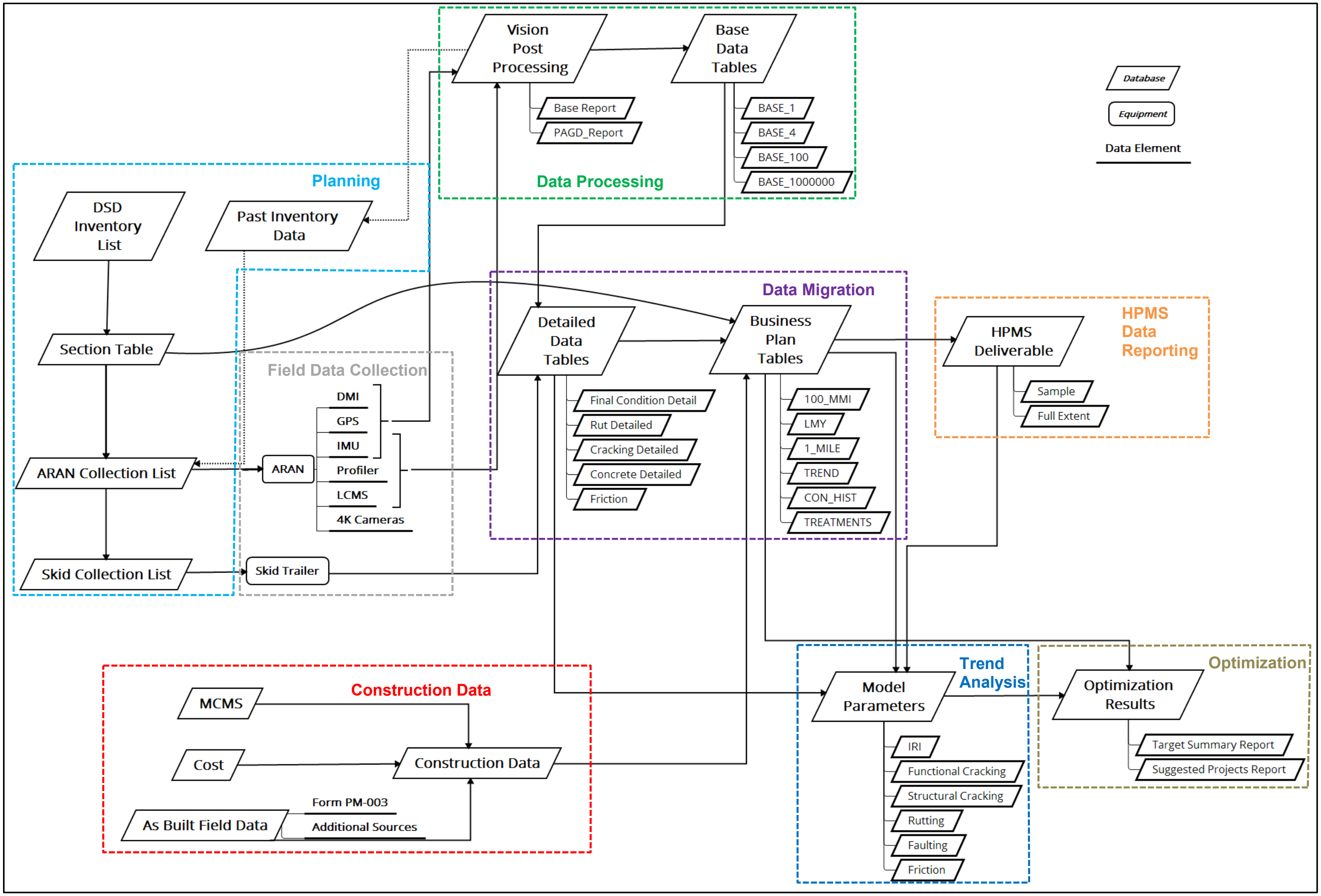


Figure 3: MDOT-SHA PM Information Flowchart

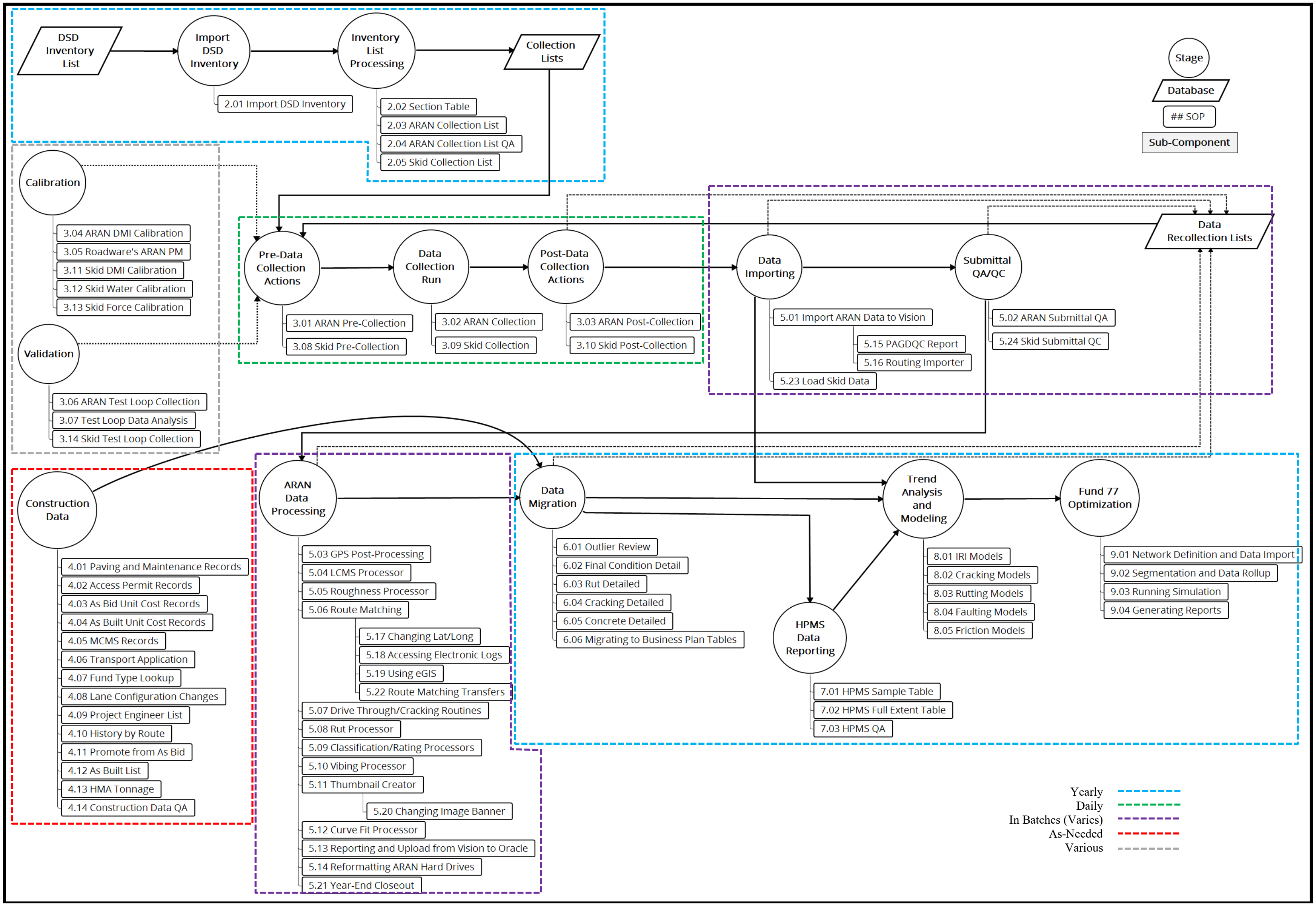


Figure 4: MDOT-SHA PM Guide SOPs Flowchart

2 PLANNING

Click to go to Update of HMIS Tables
Click to go to Production of Annual Section Table
Click to go to Production of ARAN Collection List
Click to go to ARAN Collection List QA
Click to go to Production of Skid Collection List

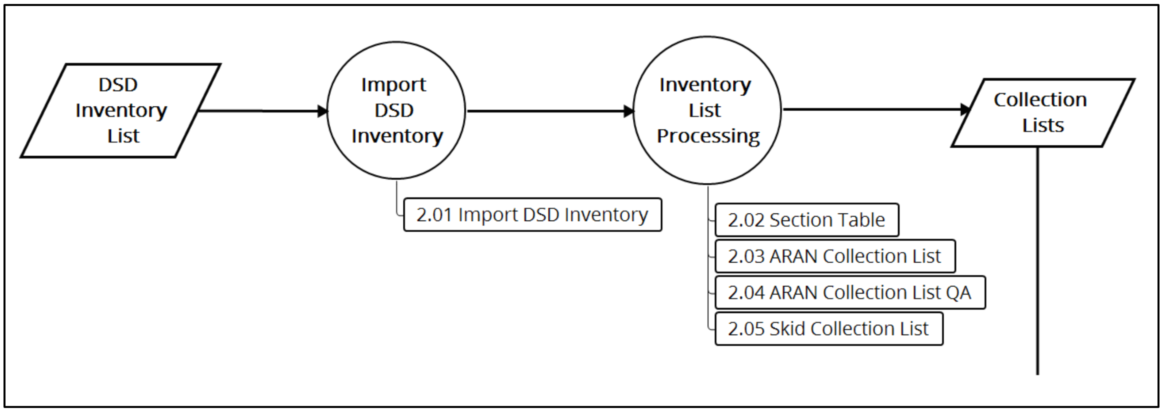


Figure 5: Planning Flowchart

This section describes the set of standard operating procedures (SOP) used by staff from the Data Warehouse Team (DWT) of the Maryland Department of Transportation State Highway Administration's (MDOT-SHA) Office of Materials Technology (OMT) to produce the annual lists of highway segments in the network to be collected by the Field Explorations Division team. The SOPs included in this version of the guide focus on the production of the Automatic Road Analyzer (ARAN) Collection List and the Skid Collection List. The ARAN Collection List consists of the routes on which data are to be collected using the ARAN survey vans for the upcoming year. The Skid Collection List consists of the routes on which data are to be collected using the skid trailers for the upcoming year.

The first step in the planning process is to update the Highway Management Information System (HMIS) tables using the annual inventory data provided by the Data Services Division (DSD). The next stage in the process consists of processing the DSD inventory data to create the ARAN Collection List. This stage includes three SOPs: the production of the Section Table, the production of the Collection List, and, lastly, the QA checks of the annual ARAN Collection List. Following the finalizing of the ARAN Collection List, a procedure is followed to create the Skid Collection List. These tasks are to be completed before the commencement of the data collection season.

2.01 UPDATE OF HMIS TABLES

2.01.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Warehouse Team (DWT) to update the HMIS_UNIVERSE and HMIS_MASTER tables based on the Data Services Division's (DSD) latest inventory data. This section also includes the quality control (QC) processes to check that the updated Highway Management Information System (HMIS) tables are correctly processed and stored. The procedure documented in this section is the first step of the Pavement Management (PM) planning stage.

2.01.02 *Frequency*

The two HMIS tables in question are updated once a year, after the DSD releases its annual inventory list tables, which generally happens around June.

2.01.03 *Purpose*

The purpose of this SOP is to populate the HMIS_UNIVERSE and HMIS_MASTER tables with data from the DSD's annual inventory list. The two tables serve as the basis for the Pavement and Geotechnical Division (PAGD) annual inventory update and creation of the collection lists for the upcoming data collection season.

2.01.04 *Resource Requirements*

The updating of HMIS tables involves two people: (1) a DWT member knowledgeable in database management, the two HMIS tables, and the DSD's ARCHIVE tables and, (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the updating of the tables and perform the QC checks. These time estimates assume that no issues are detected during the QC checks. The actual level of effort required will increase if the number of issues to address during QC increases.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Database Management	1	2.0
DWT Team Leader (TL)	Supervisor	1	AR[06/12/2019]

2.01.05 *Procedure*

The procedure to update the two HMIS tables using the Pavement Data Warehouse (PDW) program and perform QC is comprised of the following two tasks:

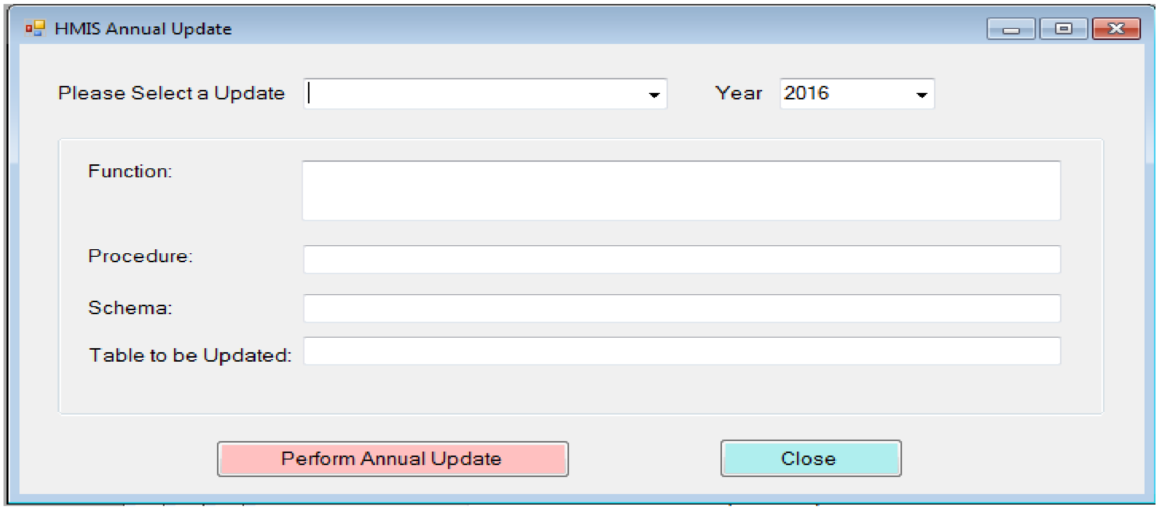
(1) updating of HMIS Tables, and
(2) performing QC of the updated tables.

1- Updating of HMIS Tables – *performed by DWT member*

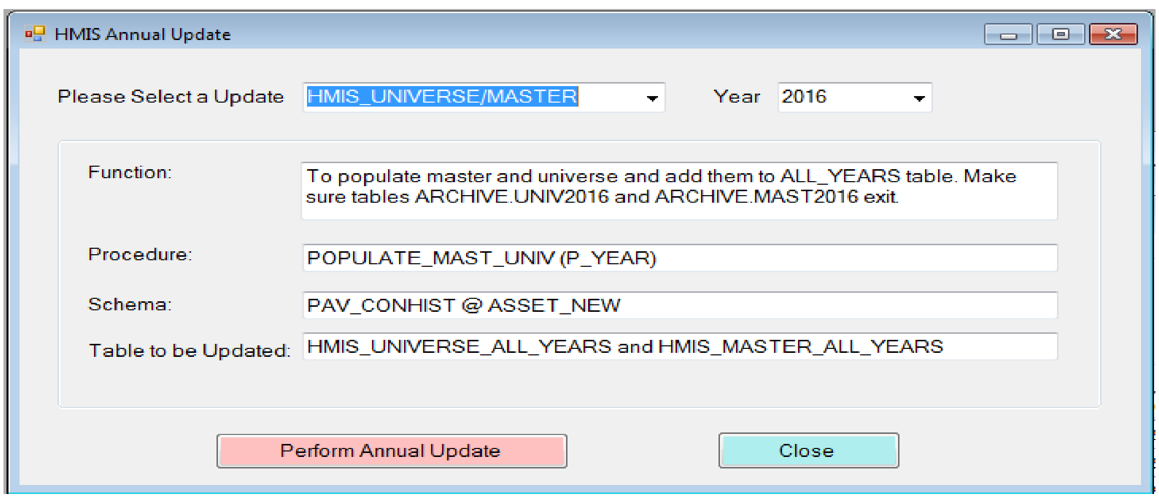
Summary: This task uses the PDW program to update the HMIS_UNIVERSE and HMIS_MASTER tables.

Step 1. Start PDW program and click on "Analysis", then "HMIS_Annual_Update." The "HMIS Annual Update" input box will appear on the screen (see below image).

The "Year" field in the input box is defaulted to the current year minus one (each year the DSD releases inventory data corresponding to the previous year).



Step 2. From the drop-down menu list in the "Please Select a Update" field, select "HMIS_UNIVERSE/MASTER." The detailed information required for updating the HMIS tables will then appear on the input box. This information includes the "Procedure" name, the appropriate "Schema," and the "Tables to be Updated" (see below image).



Step 3. Using Oracle SQL Developer, check whether ARCHIVE.UNIV[YEAR] and ARCHIVE.MASTER[YEAR][06/12/2019] exist or not.

i. If they do exist, proceed to Step 4.

ii. If they do not exist, stop and wait until the DSD is done creating its latest inventory data before updating the HMIS tables.

Step 4. Click the "Perform Annual Update" button of the input box. The procedure POPULATE_MAST_UNIV will be run automatically in the background.

i. If no errors occur during the importing of the DSD data, a message will appear on the screen indicating the completion of the procedure once it is done. If so, proceed to Step 6.

ii. If errors occur during the importing of the DSD data, a message will appear on the screen indicating that the procedure cannot be completed. If so, proceed to Step 5.

Step 5. If errors occur during the importing of the DSD data in Step 4, then debug the POPULATE_MAST_UNIV procedure using the Oracle SQL Developer to find the location(s) in the code producing the error. Once issue(s) producing errors have been identified, modify the POPULATE_MAST_UNIV code accordingly, until the procedure can be run without errors.

2- Performing QC of Updated Tables – *performed by DWT member*

Summary: This task performs QC checks of the updated tables to correct any errors that may have occurred during the update.

Step 6. Once the HMIS tables are created, perform the following QC checks to confirm that the DSD inventory data for the latest year have been correctly populated into the HMIS_UNIVERSE_ALL_YEARS and HMIS_MASTER_ALL_YEARS tables.

i. Completeness check – Using Oracle SQL Developer, check that the number of records for the updated HMIS_UNIVERSE_ALL_YEARS and HMIS_MASTER_ALL_YEARS tables are similar to the number of records in the same tables for the previous year.

ii. Validity check – Using Oracle SQL Developer, check that:

1. Values inputted in the updated HMIS tables are within the expected range for the field. For example, lane width values should consist of positive values not greater than 20 feet.
2. Amount of missing values is not excessive.

Step 7. If the updated HMIS tables pass the QC checks, then the tables are acceptable. Otherwise, perform a detailed inspection of the POPULATE_MAST_UNIV procedure using Oracle SQL Developer to identify and to resolve the issue(s) preventing successful completion of the QC checks in the previous step. Issues to look for include changes in the field names of the inventory list (with respect to the previous year's list) and missing data elements. Once the cause(s) of the issue(s) has/have been identified, modify POPULATE_MAST_UNIV procedure accordingly and regenerate the HMIS tables. Repeat Step 6 and Step 7 until the HMIS tables generated pass all QC checks.

Step 8. Notify other members of the team that the HMIS_UNIVERSE_ALL_YEARS and the HMIS_MASTER_ALL_YEARS tables have been correctly updated.

2.02 PRODUCTION OF ANNUAL SECTION TABLE

2.02.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Warehouse Team (DWT) to produce and to quality control (QC) the annual Section Table. This table contains roadway inventory data for the entire Maryland Department of Transportation State Highway Administration (MDOT-SHA) highway network, which are extracted from the Data Services Division (DSD) inventory data tables in the format and structure required to meet the Pavement and Geotechnical Division (PAGD) needs.

2.02.02 *Frequency*

The Section Table is generated once per year, after the HMIS_UNIVERSE and HMIS_MASTER tables are updated with the annual DSD inventory data (see Update of HMIS Tables).

2.02.03 *Purpose*

The purpose of this SOP is to generate the Section Table using the annual DSD inventory data, as contained in the HMIS UNIVERSE and MASTER tables. The Section Table serves as the primary information source for producing the Automatic Road Analyzer (ARAN) Collection List, which contains the complete set of sections to be surveyed in the current year.

2.02.04 *Resource Requirements*

The production and QC of the Section Table involves two people: (1) a DWT member knowledgeable in database management and, (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the production of the Section Table and perform the QC checks. These time estimates assume that no issues are detected during the QC checks. The actual level of effort required will increase if the number of issues to address during QC increases.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Database Management	1	40.0
DWT Team Leader (TL)	Supervisor	1	AR[06/12/2019]

2.02.05 *Procedure*

The procedure to produce and QC the Section Table is comprised of the following two tasks:

(1) producing the Section Table, and
(2) performing QC of the Section Table.

1- Producing the Section Table – *performed by DWT member*

Summary: This task uses Oracle SQL Developer to produce the Section Table from the updated HMIS Tables.

Step 1. Using the Oracle SQL Developer, verify that the HMIS_UNIVERSE AND HMIS_MASTER tables have been correctly updated with the annual DSD inventory data for the current year. If not, update the tables following the procedure described in Update of HMIS Tables.

Step 2. Run SECTION_TABLE_PROP_PKG package to produce the initial version of the Section Table.

2- Performing QC of the Section Table – *performed by DWT member*

Summary: This task performs QC checks of the created Section Table to correct any errors that may have occurred during the production by comparing mileage of the network and mileage of specific sections to the previous year.

Step 3. Total mileage check: using the Oracle SQL Developer, compare the total mileage of the initial Section Table version to the total mileage of the same table for the previous year.

i. If the difference in total mileage is not greater than 100 miles, then the Section Table generated for the current year is acceptable and no further checks are required – proceed to Step 5. The 100 miles allowance is intended to account for the addition of highway sections from one year to the next, minor processing errors, and other factors. This value represents less than 1% of the total highway network managed by the MDOT-SHA.

ii. Otherwise, proceed to Step 4.

Step 4. Individual route mileage check – using the Oracle SQL Developer, compare the mileage for the individual routes in the initial version of the Section Table to the mileage for the same individual routes in the Section Table for the previous year. The difference in mileage for each individual route should not exceed 10%. Otherwise, inspect the SECTION_TABLE_PROP_PKG package to identify issue(s) that may explain the large differences in mileage for the individual routes. Possible issues to look for when inspecting the code include the presence of duplicate records and incorrect mainline codes. The mainline code is used to classify the road mileage of the inventoried road into mainline, interchange ramps, service roads, couplet, and others. The two possible outcomes from the inspection are:

i. If no issues are detected in the code that explain the large difference in mileage for a specific route, look for additional information that may explain the difference. A possible source of information for this is the “Change Log” published by the DSD as part of their inventory lists. This log contains the differences in DSD’s inventory data with respect to the previous year’s list.

ii. If issues are detected in the code, modify the code as appropriate until the difference in total mileage between the Section Table produced for the current year and the one for the previous year is less than 100 miles.

Step 5. Once the QC checks have been passed, name the final version of the resulting table as SECTION_TABLE and store it in the PAV_CONHIST user within the ASSET_NEW database.

2.03 PRODUCTION OF ARAN COLLECTION LIST

2.03.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Warehouse Team (DWT) to produce and to quality control (QC) the Automatic Road Analyzer (ARAN) Collection List. This list contains the routes on which data are to be collected using ARAN survey vans, as part of the annual field data collection season. The ARAN Collection List is produced from the current year's Section Table (see Production of Annual Section Table).

2.03.02 *Frequency*

The ARAN Collection List is produced annually, after the final version of the Section Table for the current year has been generated.

2.03.03 *Purpose*

The purpose of this standard operating procedure (SOP) is to produce the ARAN Collection List from the current year's Section Table generated using the Production of Annual Section Table. The list is used by the Field Explorations Division (FED) to plan their annual ARAN data collection.

2.03.04 *Resource Requirements*

The production and QC of the ARAN Collection List involves two people: (1) a DWT member knowledgeable in database management and, (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the production of the ARAN Collection List and perform the QC checks. These time estimates assume that no issues are detected during the QC checks. The actual level of effort required will increase if the number of issues to address during QC increases.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Database Management	1	40.0
DWT Team Leader (TL)	Supervisor	1	AR[06/12/2019]

2.03.05 *Procedure*

The procedure to produce and QC the ARAN Collection List is comprised of the following three tasks:

(1) producing the Initial ARAN Collection List,
(2) performing QC of the Initial ARAN Collection List, and
(1) replacing Initial Section Table GPS Data with ARAN GPS Data.

1- Producing the Initial ARAN Collection List – *performed by DWT member*

Summary: This task uses Oracle SQL Developer to produce the Initial ARAN Collection List from the Section Table.

Step 1. Using the Oracle SQL Developer, check that the Section Table for the current year exists in the PAV_CONHIST user in the ASSET_NEW database. If it does not, follow the procedure described in Production of Annual Section Table to produce the Section Table before starting the generation of the ARAN Collection List.

Step 2. Run the ARAN_COLLECTION_LIST_PKG package to produce an initial version of the ARAN Collection List. The procedures contained in this package define the location of the starting and ending mile-points for each network route by aggregating the sections within each route in the Section Table.

2- Performing QC of the Initial ARAN Collection List – *performed by DWT member*

Summary: This task performs QC checks of the created Initial ARAN Collection List to correct any errors that may have occurred during the production by comparing mileage of the network to the previous year.

Step 3. Once the initial version of the ARAN Collection List has been created, use the Oracle SQL Developer to compare the resulting total mileage to the mileage from the previous year's ARAN Collection List.

i. If the difference in mileage is less than 100 miles, then the initial version of the ARAN Collection List is acceptable – proceed to Step 5.

ii. Otherwise, proceed to Step 4.

Step 4. If the difference in total mileage between the current and last year's ARAN Collection List is greater than 100 miles, inspect the ARAN_COLLECTION_LIST_PKG package to identify the issues that are causing the difference in mileage. Once the issues have been identified, modify the package as appropriate and generate another version of the ARAN Collection List. Apply the QC check described in the previous step to the new version of the list. Repeat this process until the resulting ARAN Collection List passes the QC check in Step 3.

3- Replacing Initial Section Table GPS Data with ARAN GPS Data – *performed by DWT member*

Summary: This task replaces initial Section Table GPS data with GPS data from the ARAN survey vehicles and results in the submittal of the final version of the ARAN Collection List.

Step 5. The inventory data for each highway section in the initial version of the ARAN Collection List are extracted from the Section Table, which, in turn, contains the inventory data released by the Data Services Division (DSD). The GPS data contained in the initial version of the list are replaced with GPS coordinates measured by the Maryland Department of Transportation State Highway Administration (MDOT-SHA) ARAN survey vehicles and reviewed by the Data Processing Team (DPT) staff during the previous year's data collection season[06/12/2019]. This step is performed by running the UGS_VISION_MATCHED_EXPORT_PKG package from the Oracle SQL Developer. Manual entry of GPS coordinates may also be required in this step for locations where the GPS data have been obtained through ad-hoc communications with the DPT staff based on the results of their ARAN data processing procedures.

Step 6. Submit the final version of the ARAN Collection List with updated GPS data to the personnel involved in the quality assurance (QA) of the ARAN Collection List.

2.04 ARAN COLLECTION LIST QA

2.04.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Processing Team (DPT) and the Data Warehouse Team (DWT) to perform quality assurance (QA) of the Automatic Road Analyzer (ARAN) Collection List before the list is submitted to the Field Explorations Division (FED). The QA is applied to a version of the ARAN Collection List that incorporates Global Positioning System (GPS) data from the previous year's ARAN data collection.

2.04.02 *Frequency*

The QA of the ARAN Collection List is performed annually, once a version of the ARAN Collection List with revised GPS data has been produced.

2.04.03 *Purpose*

The purpose of this SOP is to perform QA of the ARAN Collection List to confirm, prior to actual data collection, that the (1) routes on the list are feasible for data collection and (2) location and inventory information on the list is accurate and complete.

2.04.04 *Resource Requirements*

The QA of the ARAN Collection List involves three people: (1) a DPT member knowledgeable in inventory data collection for the Maryland Department of Transportation State Highway Administration (MDOT-SHA) highway network, (2) a DWT member knowledgeable in database management and, (3) a supervisor who, as required, provides guidance and decision-making. The inventory data expert's (IDE) primary role is to identify possible errors in inventory data and to ensure that routes on the list are feasible for data collection. The database management expert's (DBME) primary role is to produce updated versions of the ARAN Collection List based on the IDE's review. The estimated effort levels in the table below represent the total time, in man-hours, to complete the QA of the ARAN Collection List. These time estimates assume that no issues are detected during the QA checks. The actual level of effort required will increase if the number of issues to address during QA increases.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Inventory Data Expert	1	4.0
DWT Staff	Database Management	1	8.0
DWT Team Leader (TL)	Supervisor	1	AR 06/12/2019

2.04.05 *Procedure*

The procedure to perform QA of the ARAN Collection List is comprised of two tasks:

(1) checking feasibility and accuracy of data collection routes, and
(2) checking inclusion of revised GPS data.

1- Checking Feasibility and Accuracy of Data Collection Routes – *performed by IDE from the DPT and DBME from the DWT*

Summary: This task is performed to confirm that the routes defined by the ARAN Collection List are feasible for data collection and only homogeneous inventory data features are contained within the section limits. Another important element of this first check is confirming that the routes on the list can accommodate multiple collection runs when required[06/12/2019].

Step 1. IDE: open initial version of ARAN Collection List. The list is received by IDE via email as a spreadsheet in MS Excel file format, and it is named "ARAN_Collection_[FISCAL_YEAR]_[DATE]"[06/12/2019].

Step 2. IDE: using initial version of ARAN Collection List spreadsheet, search for systematic errors concerning the feasibility and accuracy of the data collection routes, especially at locations where systematic errors are often identified. If systematic errors are identified, report these errors to DBME for remedial action.

Step 3. DBME: modify ARAN_COLLECTION_LIST_PKG package to account for the systematic errors detected by the IDE (if any). Re-run the package and inspect the output list until the systematic errors detected by the IDE are no longer present. Re-submit updated version of the ARAN Collection List to the IDE.

Step 4. Repeat Step 1 to Step 3 until the IDE does not identify further inventory errors on the ARAN Collection List produced by the DBME.

2- Checking Inclusion of Revised GPS Data – *performed by IDE from the DPT and DBME from the DWT*

Summary: This task is performed to confirm that the updates made to the GPS data during last year's processing of ARAN collected data (conducted following Production of ARAN Collection List) are incorporated into the present year's ARAN Collection List.

Step 5. IDE: locate lists of revised GPS data that resulted from corrections performed to the ARAN Collection List coordinates during last year's data processing.

Step 6. IDE: randomly select a location with revised GPS data and confirm that GPS coordinates in the initial version of the ARAN Collection List for the selected location match the coordinates on the revised GPS list. Typically, the IDE checks approximately 10 locations with revised GPS data. If the coordinates do not match, report discrepancy to DBME for remedial action.

Step 7. DBME: inspect UGS_VISION_MATCHED_EXPORT_PKG package and modify accordingly to incorporate revised GPS coordinates, which were not included in the initial version of the ARAN Collection List, as reported by the IDE. Re-run the package and inspect the GPS coordinates in the output list until the reported discrepancies identified by the IDE are no longer present. Re-submit updated version of the ARAN Collection List to the IDE.

Step 8. Repeat Step 5 to Step 7 until the IDE is able to confirm that the revised GPS data have been incorporated into the ARAN Collection List.

Step 9. Once the checks have been completed and the modifications required by the IDE have been addressed, submit final version of ARAN Collection List to the FED.

2.05 PRODUCTION OF SKID COLLECTION LIST

2.05.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Warehouse Team (DWT) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to produce and to quality control (QC) the "Skid Collection List." This list contains the routes on which skid data are to be collected using the two MDOT-SHA owned skid trailers[06/12/2019], as part of the field data collection program. Skid collection is performed on a two-year cycle, and therefore the list of routes is similar on alternating data collection years. The "Skid Collection List" is produced from the current year's "ARAN Collection List" (see Production of Skid Collection List).

2.05.02 *Frequency*

The "Skid Collection List" is produced annually by the MDOT-SHA DWT staff, after the final version of the ARAN Collection List for the current year has been generated.

2.05.03 *Purpose*

The purpose of this SOP is to produce the "Skid Collection List" from the current year's "ARAN Collection List" generated using Production of Skid Collection List. The list is used by the Field Explorations Division (FED) of the MDOT-SHA to plan their annual skid data collection program.

2.05.04 *Resource Requirements*

The production and QC of the "Skid Collection List" involves the following two MDOT-SHA staff members: (1) a DWT staff member knowledgeable in database management and, (2) a DWT supervisor – typically the DWT Team Leader (TL) – who, as required, provides guidance and decision-making. The estimated effort levels shown in the table below represent the total time, in man-hours, to complete the production of the "Skid Collection List" and to perform the QC checks. These time estimates assume that no issues are detected during the QC checks. The actual level of effort required will increase if issues are identified during the QC checks.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff Member	Database Management	1	4.0
DWT TL	Supervisor	1	As Required[06/12/2019]

2.05.05 *Procedure*

The procedure used to produce and to QC the "Skid Collection List" is comprised of the following two tasks:

(1) production of the "Skid Collection List," and
(2) QC of the "Skid Collection List."

1- Production of the "Skid Collection List" – *performed by DWT staff member*

Summary: This task uses Oracle SQL Developer to produce the "Skid Collection List" from the "ARAN Collection List."

Step 1. Using Oracle SQL Developer, check that the "ARAN Collection List" for the current year exists. If it does not, follow the procedure described in Production of ARAN Collection List to produce the "ARAN Collection List" before starting the generation of the "Skid Collection List."

Step 2. Using Oracle SQL Developer, run the statement provided in Skid Collection List SQL Statement to produce the "Skid Collection List."

2- QC of the "Skid Collection List" – *performed by DWT member*

Summary: Under this task, QC checks of the "Skid Collection List" are performed to correct errors that may have occurred during the production. These checks are done by comparing the network mileage included in the current year's list to the network mileage from two years ago. Since skid data collection is performed on a two-year cycle, the list of routes and hence network mileage is similar on alternating data collection years; i.e., every other year. For example, the mileage included in the "Skid Collection List" created in 2018 should be compared to the mileage included in the "Skid Collection List" created in 2016.

Step 3. Once the "Skid Collection List" has been created, use Oracle SQL Developer to compare the resulting total network mileage to the total network mileage from the "Skid Collection List" from two years ago.

i. If the difference in total mileage is less than 100 miles, then the "Skid Collection List" is acceptable, and the process is complete.

ii. Otherwise, proceed to Step 4.

Step 4. If the difference in total mileage is greater than 100 miles,

i. Inspect the SQL statement to identify the issues that are causing the difference in mileage.

ii. Once the issues have been identified, modify the statement as appropriate and generate another version of the Skid Collection List.

iii. Apply the QC check described in the previous step to the new version of the list.

iv. Repeat this process until the resulting Skid Collection List passes the QC check in Step 3.

3 FIELD DATA COLLECTION

Click to go to ARAN Pre-Data Collection Actions
Click to go to ARAN Data Collection
Click to go to ARAN Post-Data Collection Actions
Click to go to ARAN DMI Calibration
Click to go to ARAN Preventive Maintenance
Click to go to ARAN Test Loop Data Collection
Click to go to Test Loop Data Analysis
Click to go to Skid Pre-Data Collection Actions
Click to go to Skid Data Collection
Click to go to Skid Post-Data Collection Actions
Click to go to Skid DMI Calibration
Click to go to Skid Water Calibration
Click to go to Skid Force Calibration
Click to go to Skid Test Loop Data Collection

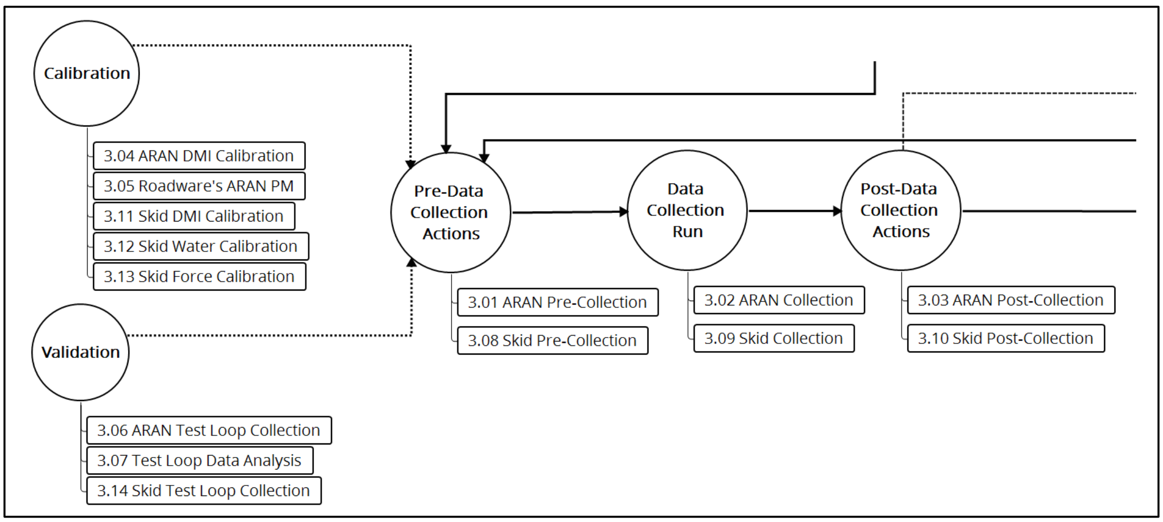


Figure 6: Field Data Collection Flowchart

This section describes the set of standard operating procedures (SOP) conducted by staff from the Field Explorations Division (FED) of the Maryland Department of Transportation State Highway Administration's (MDOT-SHA) Office of Materials Technology (OMT) to perform field data collection activities and quality control (QC) and quality assurance (QA) of pavement data. The SOPs contained in this version of the guide focus on the calibration, validation and daily data collection activities for the Automatic Road Analyzer (ARAN) survey vans and skid trailers.

The daily data collection activities are divided into six SOPs: ARAN Pre-Data Collection Activities, ARAN Data Collection, ARAN Post-Data Collection Activities, Skid Pre-Collection Activities, Skid Data Collection, and Skid Post-Data Collection Activities. These SOPs describe the tasks required from the beginning of the data collection day to the final shut down of the survey van, and include all quality checks conducted throughout the different daily activities.

This section contains four SOPs related to the calibration and the validation of measurements of the ARAN survey vans. The first is a procedure for calibrating the ARAN's Distance Measuring Instrument (DMI) once a month and involves the adjustment of the DMI measurements to bring their accuracy and precision to the target standard. The second SOP is a procedure for the activities related to the annual preventive maintenance activities on the ARAN vans. This is typically performed before the start of the data collection season in which all sub-components of the vehicles are checked and corrective actions are taken, if necessary. The third SOP involves the collection of test data with the ARAN survey van along a predetermined "test loop." This is typically performed once every three weeks during the collection season to check that the quality of measurements is within acceptable standards. The fourth SOP outlines the checks performed on data collected on the test loop to validate the measuring equipment before and throughout the data collection season.

In addition, this section contains four SOPs related to the calibration and the validation of measurements of the skid trailers. The first is a procedure for calibrating the skid trailer's Distance Measuring Instrument (DMI) once a month and involves the adjustment of the DMI measurements to bring their accuracy and precision to the target standard. The second and third SOPs are procedures for the calibration of water output and force measurements. The fourth SOP involves the collection of test data with the skid trailer along a predetermined "test loop." This is typically performed once every three weeks during the collection season to check that the quality of measurements is within acceptable standards.

3.01 ARAN PRE-DATA COLLECTION ACTIONS

3.01.01 *General*

This section describes the standard operating procedure (SOP) followed by the Automatic Road Analyzer (ARAN) crew members of the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Field Explorations Division (FED) to perform preliminary routing, safety, and diagnostic checks prior to daily data collection using an ARAN 9000 survey van with ARAN Collection System (ACS) software Version 2.3[06/12/2019] (hereafter referred to in this SOP as ARAN). This SOP is one of three to be utilized for daily data collection with the referenced ARAN. It is succeeded by ARAN Data Collection and then ARAN Post-Data Collection Actions. The pre-data collection actions covered in this SOP start from the daily route planning before data collection to the commencement of the first data collection run of the day. This procedure utilizes the ARAN Collection List (see Production of ARAN Collection List) for the current year.

3.01.02 *Frequency*

This SOP is to be performed each day of ARAN data collection, prior to the first data collection run of the day. The annual ARAN data collection season typically lasts from March to Mid-December.

3.01.03 *Purpose*

The purpose of this SOP is to develop an efficient routing plan for the data collection and to check the ARAN van is safe to operate and functioning properly for data collection by:

- reducing the effect of environmental factors on the quality of collected data,
- conducting vehicle-related safety checks, and
- validating the functionality of the ARAN sub-components.

3.01.04 *Resource Requirements*

The actions detailed in this SOP are to be performed by the crew of the ARAN van, which is composed of a driver and an operator. The estimated effort levels in the table below represent the total time, in man-hours, required for completion of the daily planning, safety checks, and diagnostics of sub-components. These time estimates assume adequate weather conditions and that the diagnostic checks do not produce results that require additional troubleshooting.

Position	Function	Resources	Effort Level (man-hrs)
ARAN Testing Crew	Driver	1	1.5
ARAN Testing Crew	Operator	1	1.5
FED TL or Coordinator	Supervisor	1	AR[06/12/2019]

3.01.05 *Procedure*

The procedure to be followed by the ARAN crew members before starting their data collection runs for the day is comprised of three tasks:

(1) daily planning of data collection routes,
(2) vehicle and safety checks, and
(3) daily diagnostic checks of the ARAN sub-components.

1- Route Planning – *performed by driver and operator, with input from Supervisor*

Summary: This task creates a routing outline plan for the daily data collection and assesses conditions to determine whether data collection should proceed or be suspended.

Step 1. Develop an initial routing plan outline for the day using the selected sections from the ARAN Collection List (see Production of ARAN Collection List) to be collected within the county and a map of the county[06/12/2019].

i. The route is selected based on several logistic and practical factors such as proximity to office, proximity to ARAN van storage location[06/12/2019], proximity to gas stations, and others, with the objective of maximizing the collected mileage for the day.

ii. The starting location for the day (first test run) is selected to minimize the impact of sunlight interference with the ARAN's forward facing camera[06/12/2019].

Step 2. Assess weather conditions for the day in order to decide whether to perform or to cancel data collection. Typical weather factors affecting this decision are:

i. Fog, rain, snow, or ice – ARAN data collection must be cancelled if there is fog, rain, snow, or ice regardless of intensity[06/12/2019].

ii. Surface wetness or ice – If it is not raining or snowing, but the pavement surface is determined to be wet or icy after a visual inspection, data collection is delayed until the surface is dry[06/12/2019].

iii. Excessive winds – If winds are determined to be strong enough to affect measurements[06/12/2019], data collection is delayed until conditions subside.

If weather considerations do not result in the cancelation or delay of data collection, proceed to Step 3.

2- Vehicle and Safety Checks – *performed by driver and operator*

Summary: This task performs vehicle-related safety assessments to check that the ARAN is in proper working order and safe to operate.

Step 3. Driver: Turn on ARAN van ignition.

Step 4. Driver: Ensure mirrors (left, right, and rear view) and seat position are properly set for safe driving.

Step 5. Operator: Clean windshield. Remove dirt or visual obstructions using windshield cleaner so that right-of-way (ROW) images are clear.

Step 6. Operator: Check tire pressure of all tires, including inner tires from rear axis. If pressure does not read 65 psi, adjust air (release or fill) until 65 psi is achieved on all tires[06/12/2019].

Step 7. Operator: Clean inertial profilers, Laser Crack Measurement Systems' (LCMS), and grade sensors' lenses using a dry, soft rag[06/12/2019].

Step 8. Driver: Check that all ARAN van lights are functioning properly. This includes beacons, hazards, turning signals, and brake lights. If any lights or beacons are not functioning, communicate issue to Supervisor for further remedial action and suspend data collection until the issue has been resolved.

Step 9. Driver: Test that back-up alarm is functioning properly by placing vehicle in reverse and moving slightly. If the backup alarm is not functioning, communicate issue to Supervisor for further remedial action and suspend data collection until the issue has been resolved.

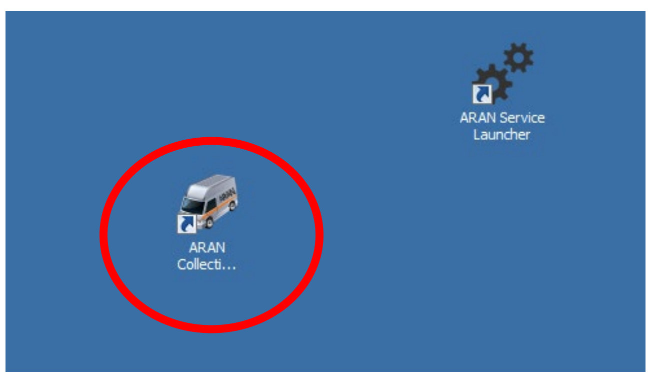
3- Diagnostic Sub-Component Checks – *performed by driver and operator*

Summary: This task runs diagnostics on the various ARAN sub-components to check that they are functioning properly for data collection.

Step 10. Operator: Turn on power inverters using control panel on the center console and check that the inverter reading in the back of the van reads 120 +/- 3 V. If inverter reading is within tolerance, proceed to Step 11. Otherwise, turn inverter off and back on again and check new inverter's reading. If reading is still incorrect, battery level may not be adequate for data collection and further troubleshooting is required. If this occurs, communicate issue to Supervisor and suspend data collection until the issue has been solved. Please refer to the ARAN 9000 Operation Guide for further information regarding this step.

Step 11. Operator: Power up main computer by turning the system start switch (either front control or on the AC power box) to the third position clockwise and release. Start switch will return to the second position on its own. Wait until all computers have started Windows operating system and login using proper sign-in credentials.

Step 12. Operator: Open the ACS software by double clicking on the icon "ARAN Collection System" (see image below with icon circled in red) on the ROW desktop[06/12/2019].

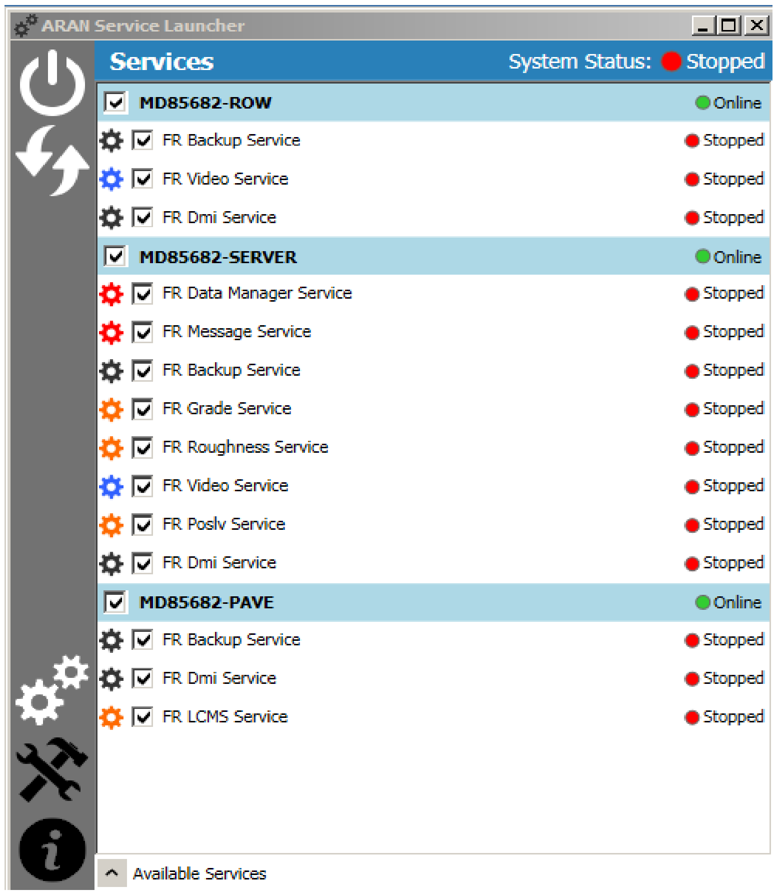


Step 13. Operator: Once the ACS software is open, check that the different ARAN sub-systems are correctly connected by observing the icon lights on the right column of the window (see image below). If the sub-systems are correctly connected, all of the icon lights should turn green after a few seconds.

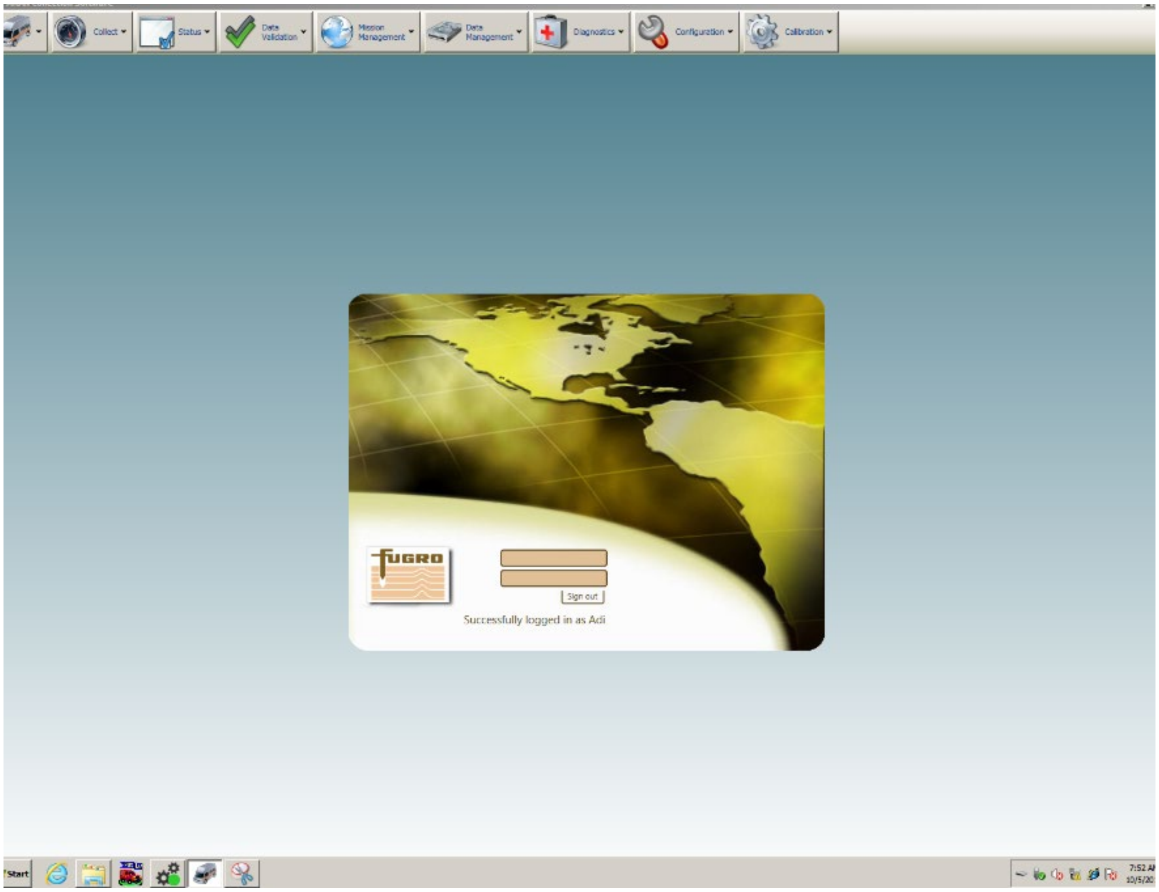
i. If all icons turn green, proceed to Step 14.

ii. If one or more icon lights remain red (as shown in the image below), identify which sub-system is not properly connected and attempt to troubleshoot issue.

For example, operator should reconnect the cables connecting the sub-system equipment to the computer, as a first step. If Operator is not able to solve the issue, he/she should contact Roadware's Technical Service for assistance. If still not able to correct issue, communicate issue to the Supervisor and suspend daily data collection until all sub-systems are properly connected.

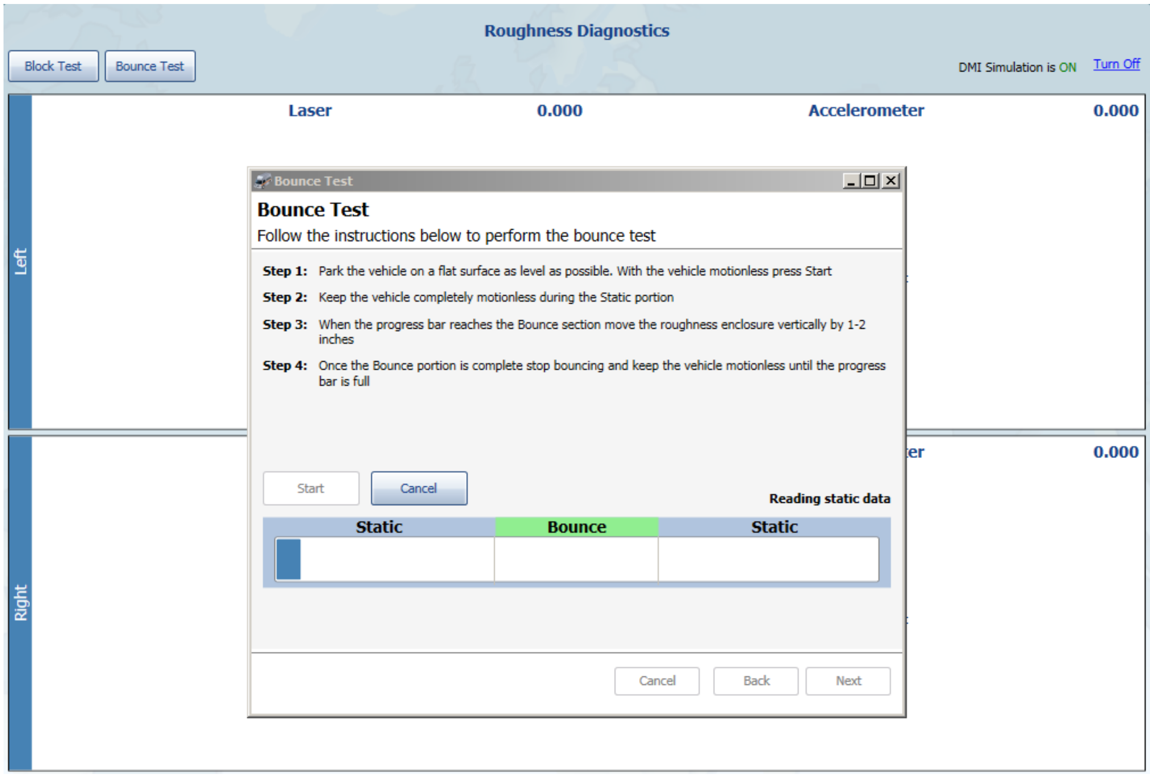


Step 14. Operator: Click on the large "Power" button in the upper-left corner of the window (see above image). ACS main screen appears (see below image).



Step 15. Operator: Login using proper sign-in credentials.

Step 16. Operator: **Perform Bounce Test**. Make sure the vehicle is on a level, smooth surface (garage floor at MDOT-SHA OMT is acceptable). Click on the "Diagnostics" drop down menu from the main ACS ribbon at the top of the screen. Select "Roughness", then "Bounce Test." The test screen will appear (see below image)[06/12/2019].



Step 17. Operator: When ready, hit start. The progress bar on the "Bounce Test" window will begin to fill up from left to right.

Step 18. Operator: When progress bar reaches the beginning of the "Bounce" section, instruct the driver to "start bouncing."

Step 19. Driver: Apply pressure to the front of the vehicle, causing it to bounce[06/12/2019].

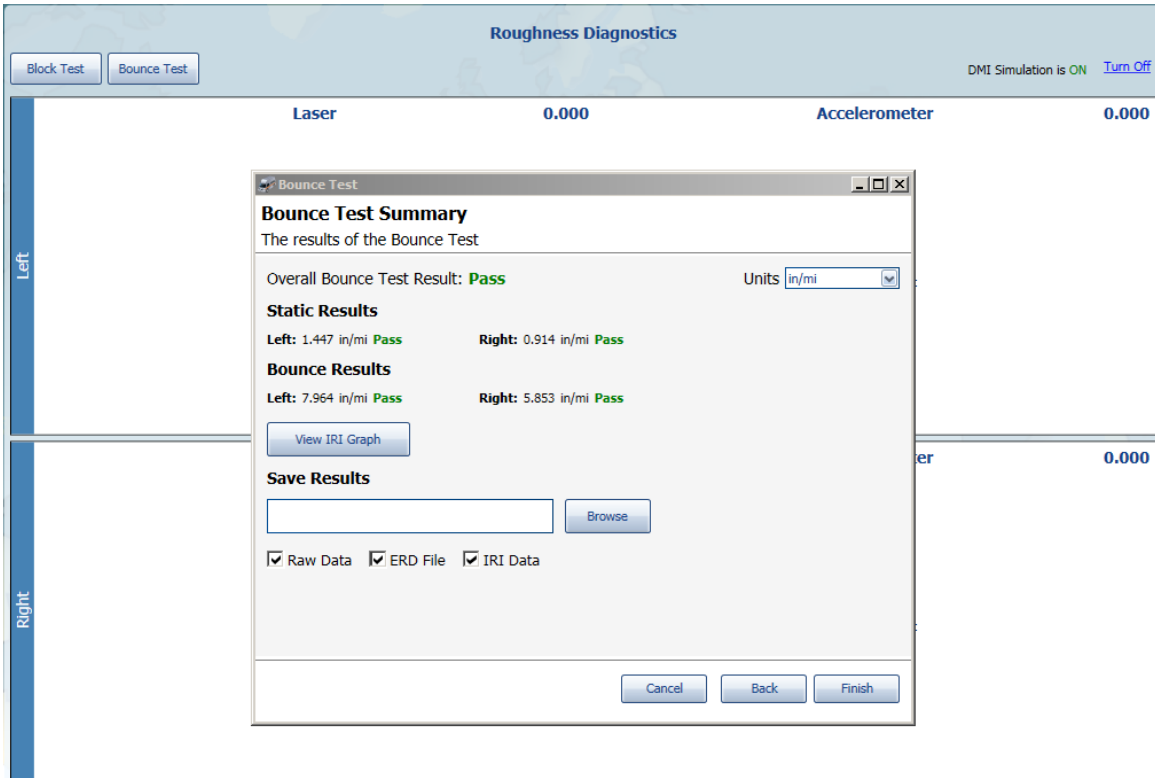
Step 20. Operator: When the progress bar reaches the end of the "Bounce" section, instruct the driver to "stop bouncing."

Step 21. Driver: Step back from the vehicle and allow the test to complete with the vehicle stationary.

Step 22. Operator: Wait until the screen indicates that the test is complete. Click "Next." Results screen will appear (see below image). There are four component results (left-static, right-static, left-bounce, right-bounce) that will either show as **PASS** or **FAIL**, then an overall **PASS** or **FAIL** rating will also be displayed.

i. If the overall result is **PASS**, click Finish and proceed to Step 23.

ii. If the overall result is **FAIL**, click "Cancel" and return to Step 16. Repeat test up to 5 times until a passing result is achieved. If a passing result is still not achieved, communicate issue to the Supervisor and suspend daily data collection until issue is resolved.



Step 23. Driver: Drive the van from the bounce test location to an appropriate and safe location – such as the parking lot of the OMT building – to perform the dynamic diagnostic checks.

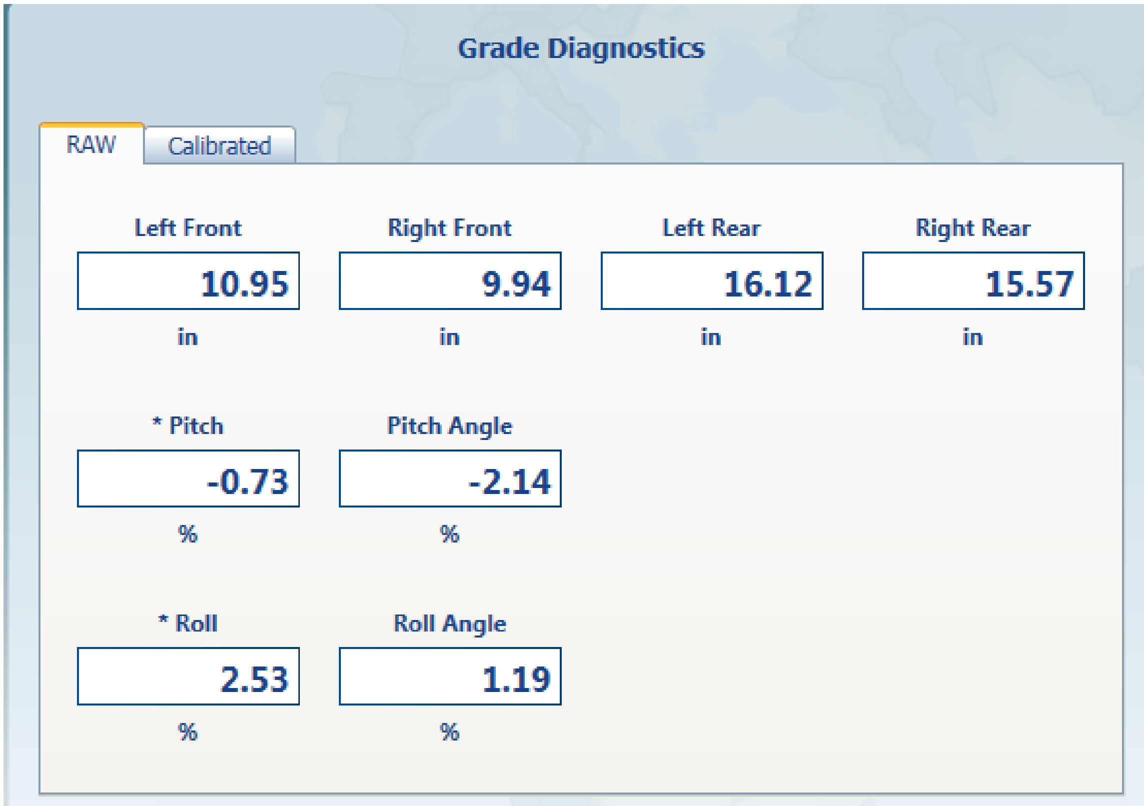
Step 24. Operator: **Perform Grade Diagnostic Check**. Click on the “Diagnostics” drop down menu from the main ACS ribbon at the top of the screen. Select “Grade.” Grade diagnostic window will appear.

Step 25. Driver: Begin driving around the test area.

Step 26. Operator: Click “Start.” Check diagnostic window.

i. All 4 grade sensors should be showing readings. Readings should change as ARAN van moves and should be within reasonable values according to the pavement surface being driven.

ii. Pitch and roll sensors should also be showing readings. Readings should change as ARAN van moves and should be within reasonable values according to the pavement surface being driven.



Operator: Select "Stop" at bottom of screen after checks are confirmed (should take approximately 1 minute).

i. If checks in Step 26 are acceptable, proceed to Step 27.

ii. If checks in Step 26 were not acceptable, stop vehicle. Reconnect the cables connecting the sub-system equipment to the computer and restart test by returning to Step 24. If Operator is not able to resolve the issue, contact Roadware's Technical Service for assistance. If still not able to resolve the issue, communicate issue to the Supervisor and suspend daily data collection until sub-system is functioning properly.

Step 27. Operator: **Perform DMI Diagnostic Check**. Return to the "Diagnostics" drop down menu from the main ACS ribbon at the top of the screen. Select "DMI." DMI diagnostic window will appear (see below image).

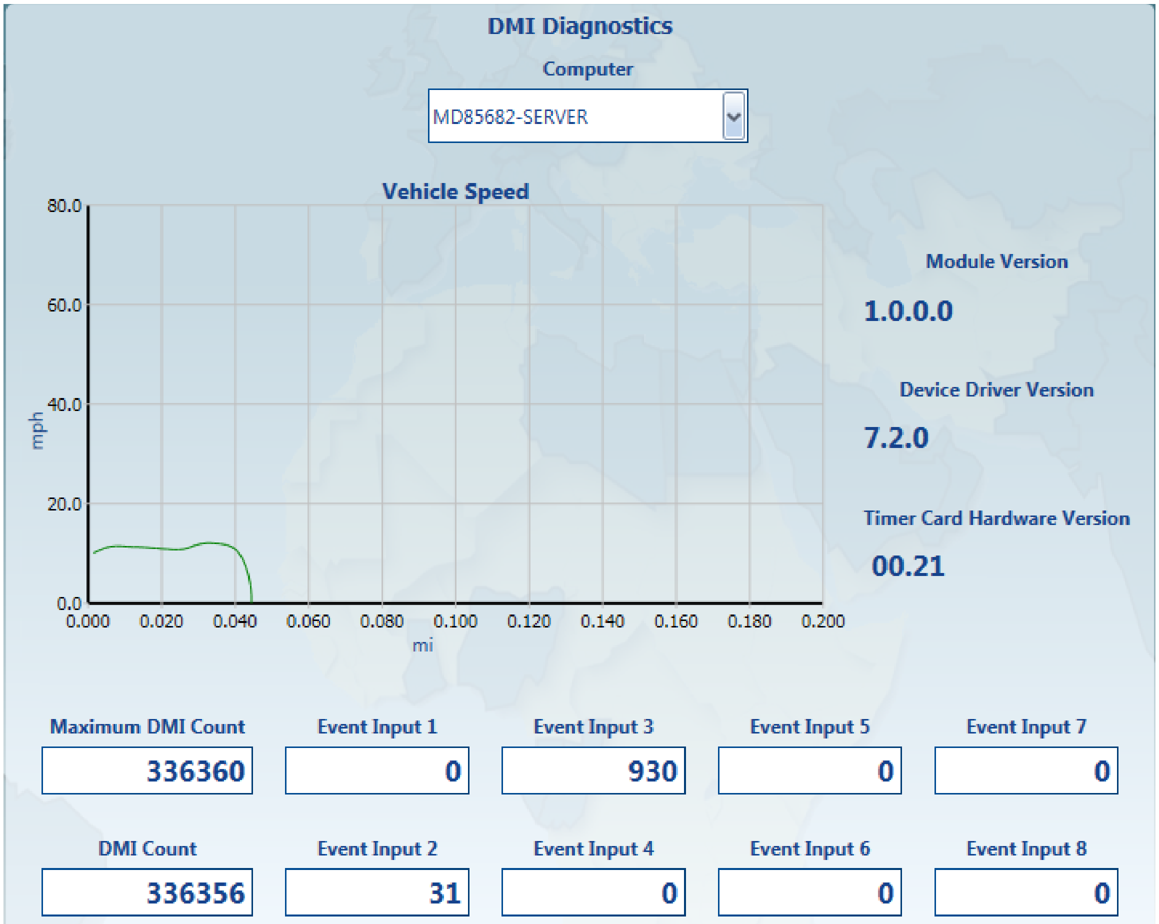
Step 28. Driver: Continue driving around the same test area.

Step 29. Operator: Click "Start." Check diagnostic window.

i. DMI Count should increase as vehicle moves.

ii. Graph should update in real time.

iii. Graph should have a positive slope when increasing speed and return to x-axis when vehicle stops.



Operator: Select "Stop" at bottom of screen after checks are confirmed (should take approximately 1 minute).

i. If checks in Step 29 are acceptable, proceed to Step 30.

ii. If checks in Step 29 are not acceptable, stop vehicle. Check DMI connection on wheel. Reconnect cables connecting the sub-system equipment to the computer and restart test by returning to Step 27. If Operator is not able to solve the issue, contact Roadware's Technical Service for assistance. If still not able to resolve issue, communicate issue to the Supervisor and suspend daily data collection until sub-system is functioning properly.

Step 30. Operator: **Perform LCMS Diagnostic Check**. Return to the "Diagnostics" drop down menu from the main ACS ribbon at the top of the screen. Select "LCMS." LCMS diagnostic window will appear.

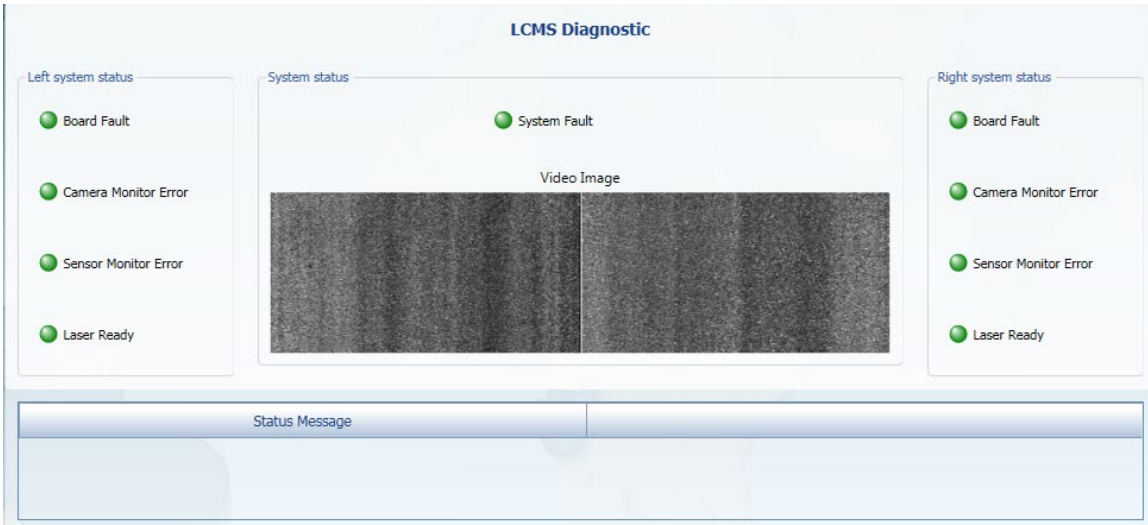
Step 31. Driver: Continue driving around the same test area.

Step 32. Operator: Click "Start." Check diagnostic window.

i. All icon lights should be green.

ii. Two images in the center of the window should be updating as the ARAN van moves.

iii. Images should be representative of the pavement that is being driven over.



Operator: Select "Stop" at bottom of screen after checks are confirmed (should take approximately 1 minute).

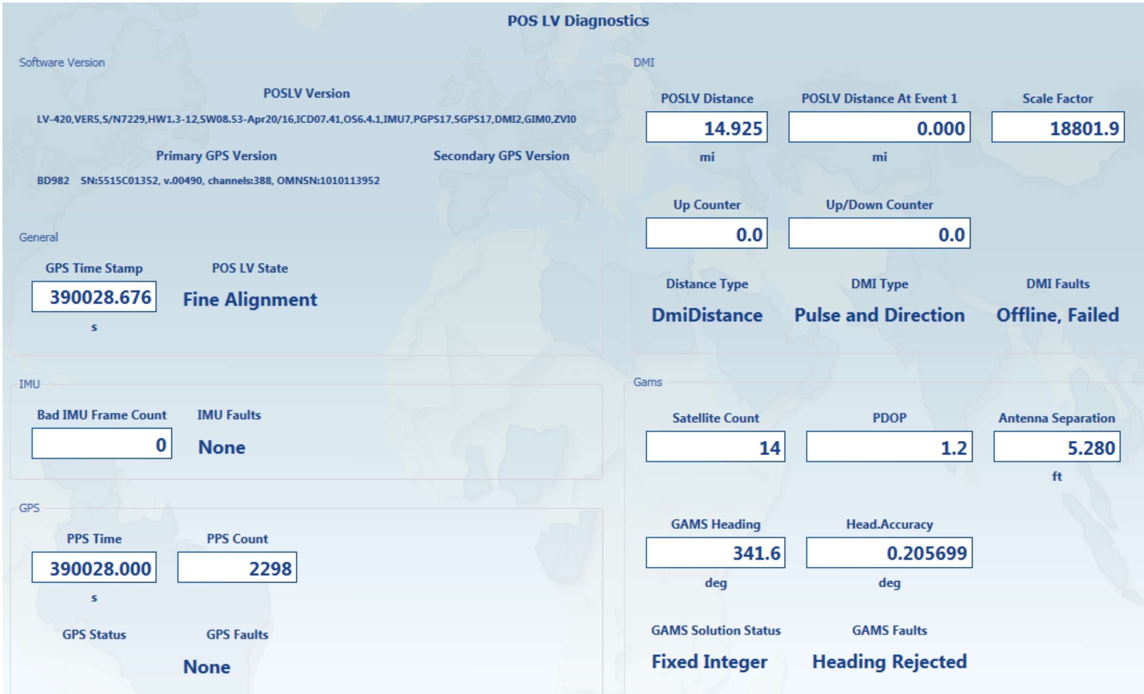
i. If checks in Step 32 are not acceptable, stop vehicle. Reconnect the cables connecting sub-system equipment to the computer and restart test by returning to Step 30. If Operator is not able to solve the issue, contact Roadware's Technical Service for assistance. If still not able to resolve issue, communicate issue to the Supervisor and suspend daily data collection until sub-system is functioning properly.

Step 33. Operator: **Perform PS LV Diagnostic Check**. Return to the "Diagnostics" drop down menu from the main ACS ribbon at the top of the screen. Select "POS LV." POS LV diagnostic window will appear.

Step 34. Driver: Continue driving around the same test area. Ensure no buildings or trees are obstructing the GPS receiver.

Step 35. Operator: Click "Start." Check diagnostic window.

i. Two GPS readings should be reasonable and updating as the vehicle moves. It may take a few moments for the GPS readings to display.



Operator: Select “Stop” at bottom of screen after checks are confirmed (should take approximately 1 minute).

i. If checks in Step 35 are acceptable, proceed to Step 36.

ii. If checks in Step 35 are not acceptable, stop vehicle. Reconnect the cables connecting sub-system equipment to the computer and restart test by returning to Step 33. If Operator is not able to solve the issue, contact Roadware’s Technical Service for assistance. If still not able to resolve issue, communicate issue to the Supervisor and suspend daily data collection until sub-system is functioning properly.

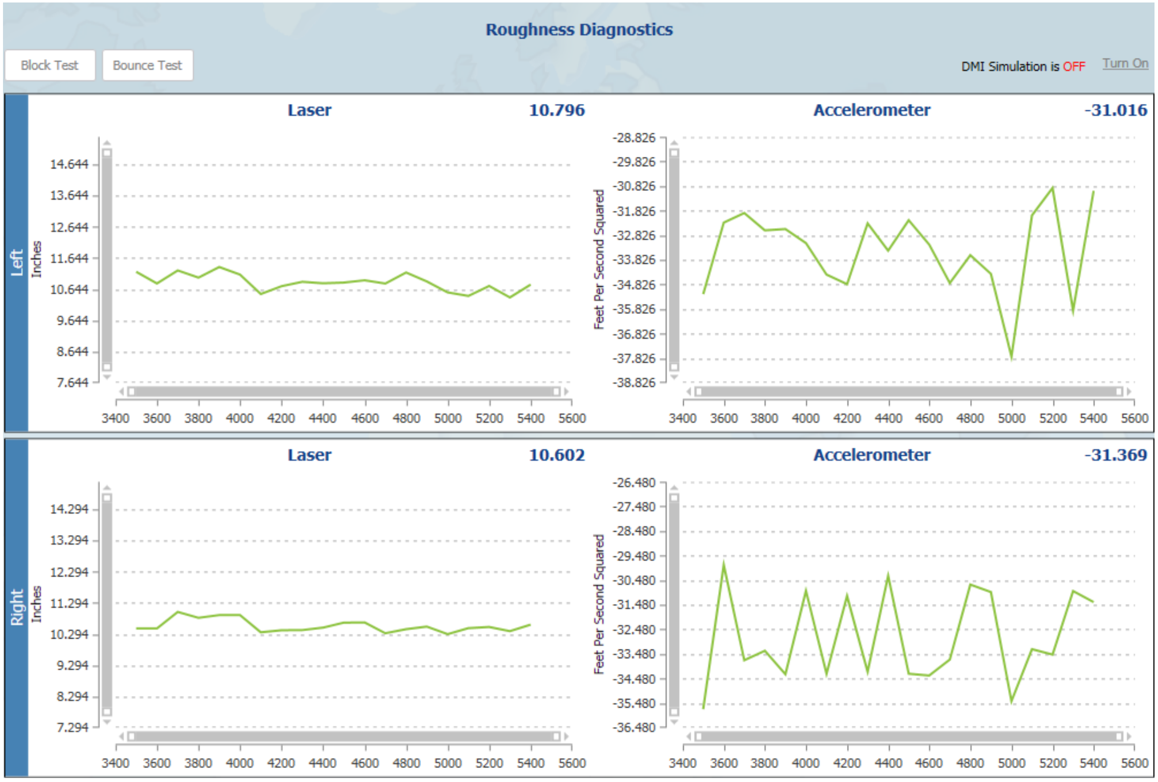
Step 36. Operator: **Perform Roughness Diagnostic Check**. Return to the “Diagnostics” drop down menu from the main ACS ribbon at the top of the screen. Select “Roughness.” Roughness diagnostic window will appear.

Step 37. Driver: Continue driving around the same test area.

Step 38. Operator: Click “Start.” Check diagnostic window.

i. Four plots in total (2 laser, 2 accelerometer) should be updating as the ARAN van moves.

ii. Laser readings should appear reasonable based on smoothness of test pavement.



Operator: Select “Stop” at bottom of screen after checks are confirmed (should take approximately 1 minute).

i. If checks in Step 38 are acceptable, proceed to Step 39.

ii. If checks in Step 38 are not acceptable, stop vehicle. Reconnect the cables connecting sub-system equipment to the computer and restart test by returning to Step 36. If Operator is not able to solve the issue, contact Roadware’s Technical Service for assistance. If still not able to resolve issue, communicate issue to the Supervisor and suspend daily data collection until sub-system is functioning properly.

Step 39. Operator: **Perform Video Diagnostic Check**. Return to the “Diagnostics” drop down menu from the main ACS ribbon at the top of the screen. Select “Video.” Video diagnostic window will appear.

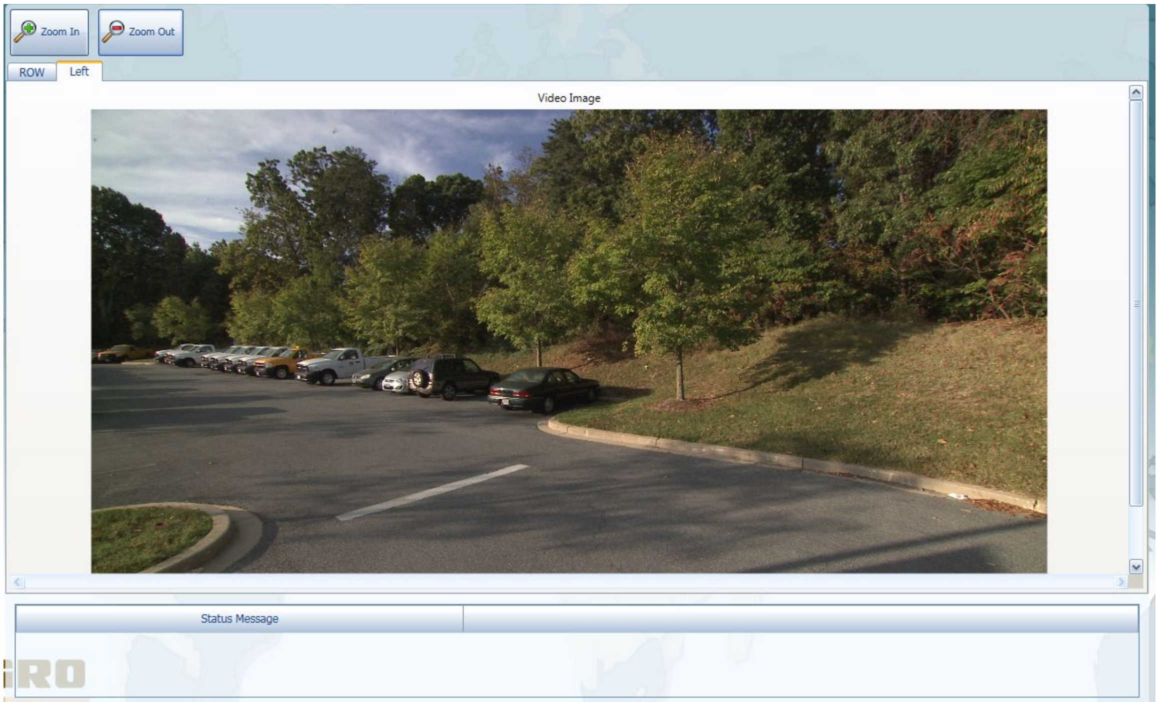
Step 40. Driver: Continue driving around the same test area.

Step 41. Operator: Click “Start.” Check diagnostic window. There is a tab for each video stream.

i. Each image should be clear.

ii. Sunlight “wash-out” should be minimal.

iii. Image should change as ARAN van moves.

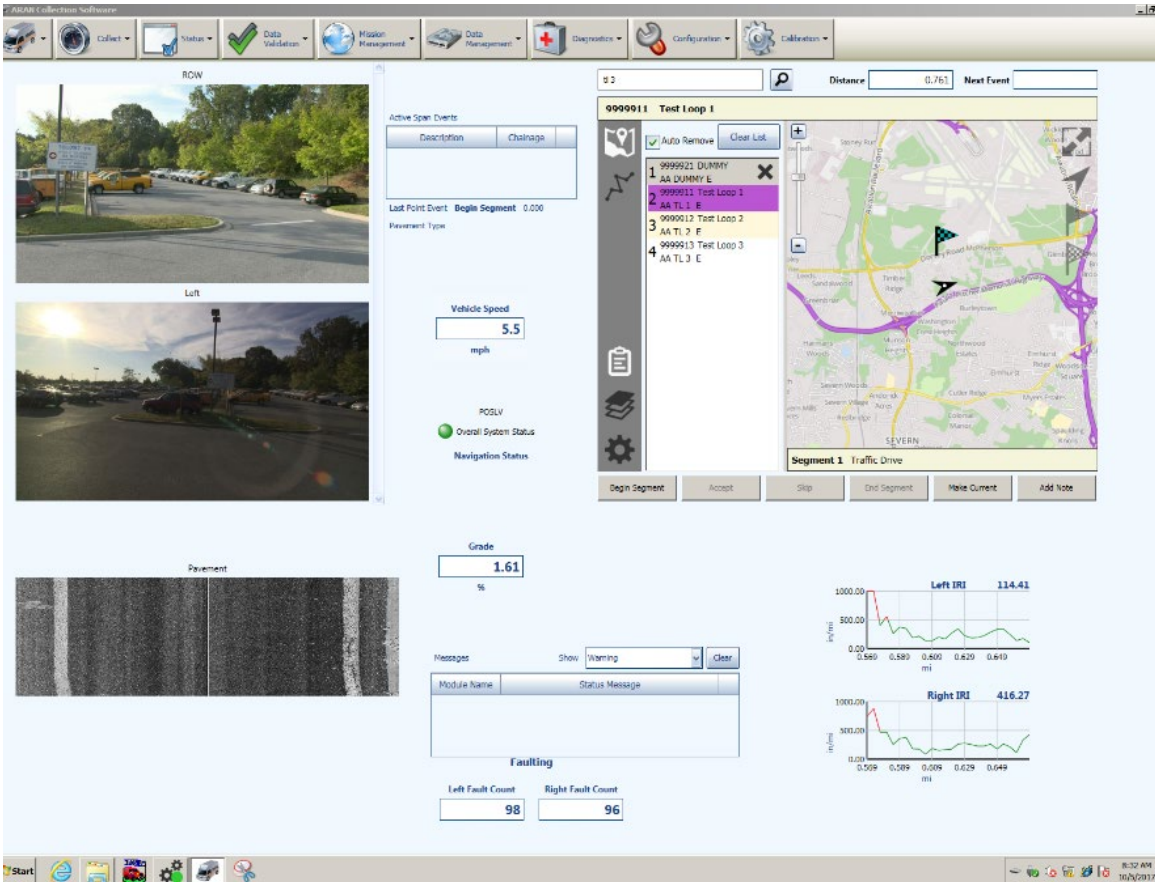


Operator: Select "Stop" at bottom of screen after checks are confirmed (should take approximately 1 minute).

i. If checks in Step 41 are acceptable, proceed to Step 42.

ii. If checks in Step 41 are not acceptable, stop vehicle. Reconnect the cables connecting sub-system equipment to the computer and restart test by returning to Step 39. If Operator is not able to solve the issue, contact Roadware's Technical Service for assistance. If still not able to resolve issue, communicate issue to the Supervisor and suspend daily data collection until sub-system is functioning properly.

Step 42. Operator: **Perform dummy test run**. Select the "Collect" drop down menu from the main ACS ribbon at the top of the screen. Click on "Summary." Data collection window will appear (see below image).



Step 43. Operator: In the search bar above the map window, type in “DUMMY.” Click the magnifying glass to begin the search.

Step 44. Operator: A list of search results will appear. The section for the dummy test run will read “9999921 DUMMY, AA DUMMY E.” Click “Add to List.”

Step 45. Operator: In the queue list of selected sections, click on “DUMMY”. Click “Make Current” at the bottom of the map window.

Step 46. Operator: Confirm the beginning and end of the selected section by the flag icons in the map window.

Step 47. Operator: Follow ARAN Data Collection, beginning with Step 14, for completing the dummy data collection run.

Step 48. Operator: If the dummy data collection run does not result in issues, diagnostics are completed[06/12/2019]. If issues are discovered during dummy test run, troubleshooting of specific sub-component is necessary before beginning data collection.

3.02 ARAN DATA COLLECTION

3.02.01 *General*

This section describes the standard operating procedure (SOP) followed by the Automatic Road Analyzer (ARAN) crew members of the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Field Explorations Division (FED) to perform data collection using an ARAN 9000 survey van with ARAN Collection System (ACS) software Version 2.3[06/12/2019] (hereafter referred to in this SOP as ARAN). This SOP is one of three to be utilized for daily data collection with the referenced ARAN. It is preceded by ARAN Pre-Data Collection Actions and succeeded by ARAN Post-Data Collection Actions. The data collection activities covered in this SOP start from the end of the daily diagnostic checks and dummy data collection run (see ARAN Pre-Data Collection Actions) to the commencement of the daily data export (see ARAN Post-Data Collection Actions). This SOP describes the process of completing a full day of data collection. This procedure utilizes the ARAN Collection List (see Production of ARAN Collection List) for the current year. The ACS software should already be initialized from ARAN Pre-Data Collection Actions.

3.02.02 *Frequency*

This SOP is to be performed daily for each day of ARAN data collection. The annual ARAN data collection season typically lasts from March to Mid-December.

3.02.03 *Purpose*

The purpose of this SOP is to successfully daily data collection using the ARAN van and to perform quality control (QC) checks of the data while is being collected.

3.02.04 *Resource Requirements*

The actions detailed in this SOP are to be performed by the crew of the ARAN van, which is composed of a driver and an operator. The estimated effort levels in the table below represent the total time, in man-hours, required for completion data collection. These time estimates assume adequate weather conditions and a typical data collection schedule. Actual time to complete individual runs in the field will vary between routes.

Position	Function	Resources	Effort Level (man-hrs)
ARAN Testing Crew	Driver	1	7.0
ARAN Testing Crew	Operator	1	7.0

3.02.05 *Procedure*

The procedure to be followed by the ARAN crew members for each unique data collection run is comprised of two tasks:

(1) route selection and
(2) data collection.

1- Route Selection – *performed by operator*

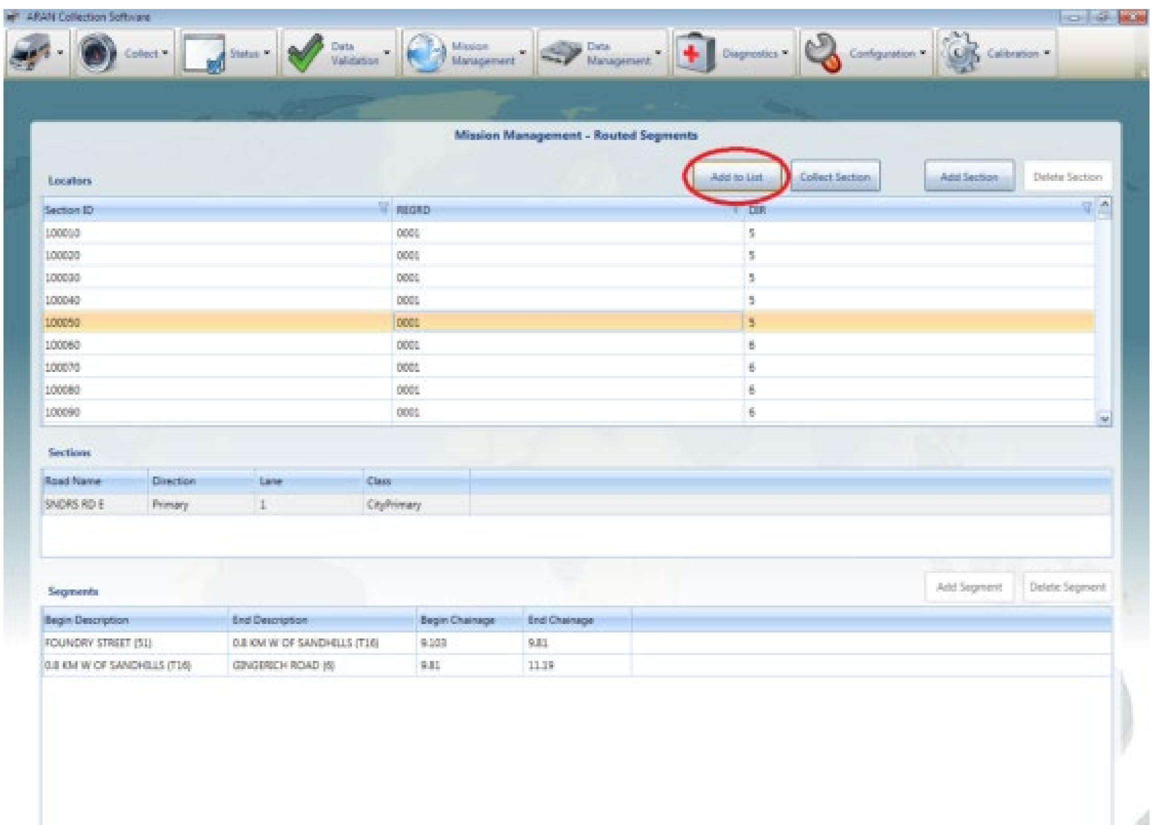
Summary: This task uses the ACS software to add sections to the data collection queue.

Step 1. Operator: There are two options for selecting daily routes for data collection based on the routing plan completed in ARAN Pre-Data Collection Actions in the ACS:

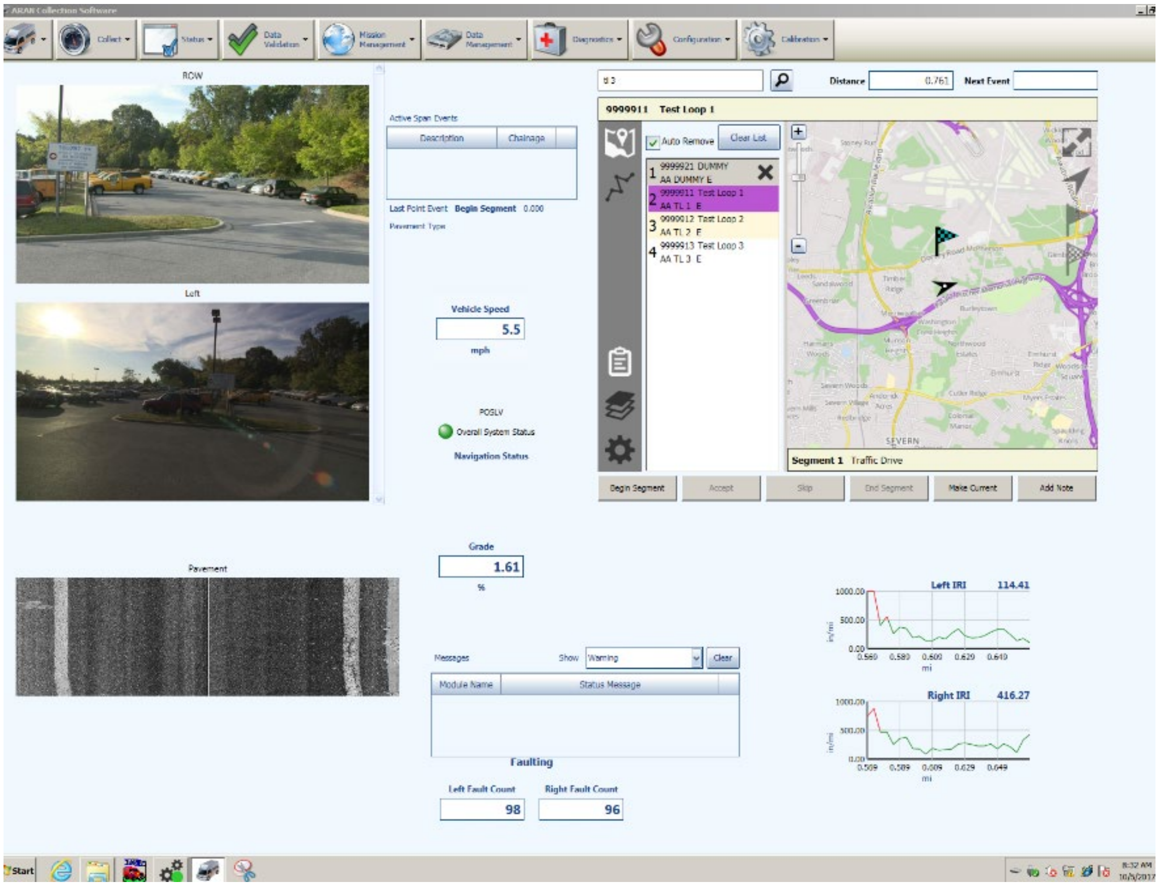
i. Browsing the populated list under "Mission Management." If this is the preferred method, select the "Mission Management" drop down menu from the main ACS ribbon at the top of the screen. Click on "Routed Segments." The list of sections that have already been imported into the system will appear. Proceed to Step 2.

ii. Searching for a specific route in the "Collect" window. If this is the preferred method, skip to Step 3.

Step 2. Operator: Find the section for which data are to be collected and select it so that the row is highlighted (see below image). Click "Add to List." Multiple sections may be added to queue list, if desired[06/12/2019].



Step 3. Operator: Select the "Collect" drop down menu from the main ACS ribbon at the top of the screen. Click on "Summary." Data collection window appears (see below image). If section(s) was (were) selected using the "Mission Management" window, skip to Step 5.



Step 4. Operator: In the search bar above the map window (see above image), type in the section identifier of the route to be collected. A list of search results will appear. Select the appropriate section and click “Add to List.” Multiple sections may be added to queue list, if desired[06/12/2019].

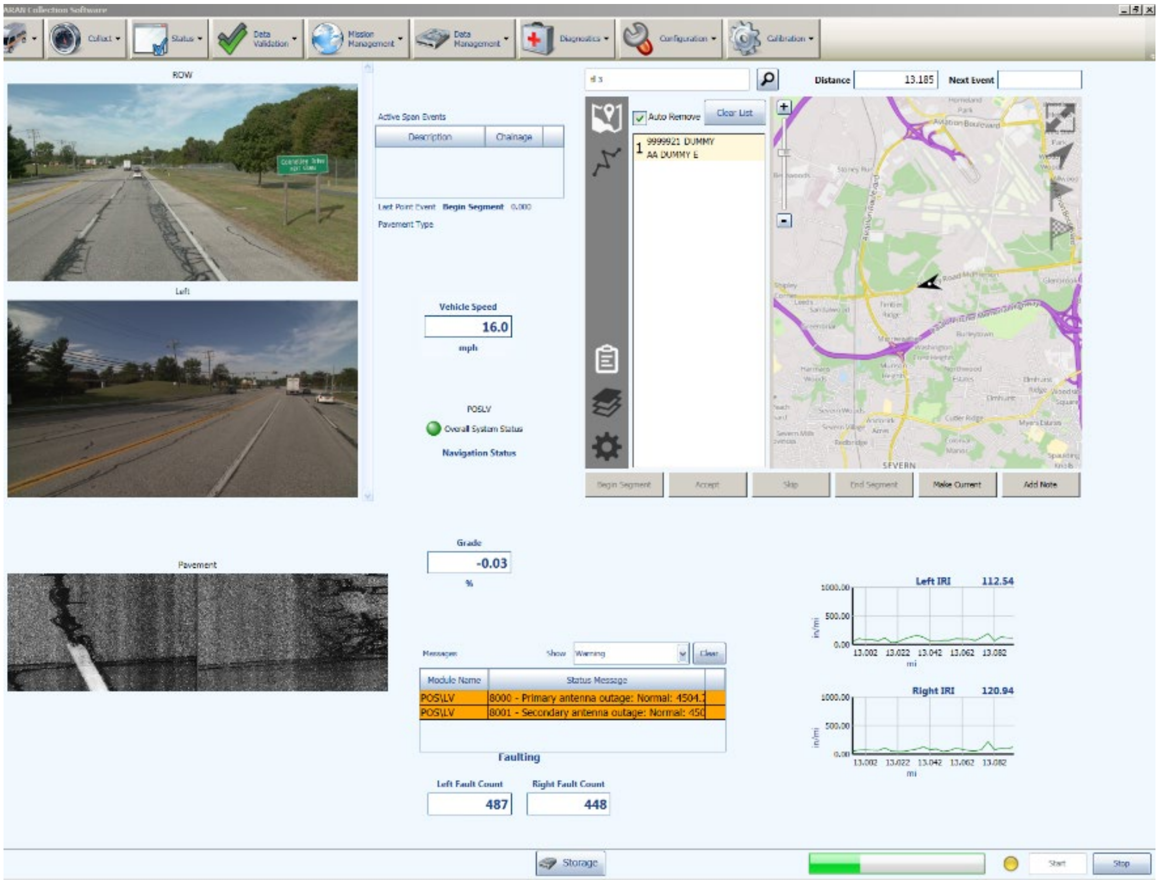
Step 5. Operator: In the queue list of selected sections, click on the section that is to be collected next. Click “Make Current” at the bottom of the map window (see above image). Confirm the beginning and end of the selected section by the flag icons in the map window. Otherwise, the incorrect section may be selected and the route selection will have to be repeated by returning to Step 1.

2- Data Collection – *performed by driver and operator*

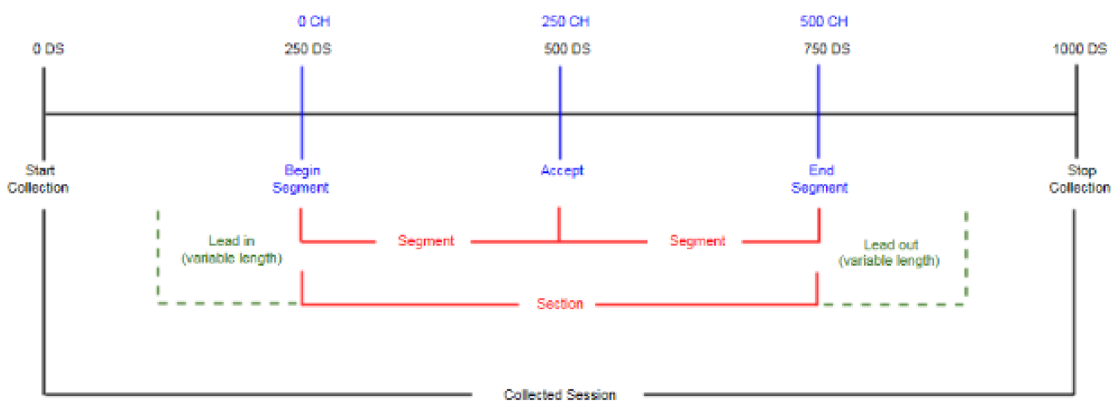
Summary: This task uses the ACS software to complete a data collection run.

Step 6. Driver: Navigate vehicle to selected first route and approach beginning of test section. Throughout collection run, adhere to local traffic laws. Attempt to maintain a steady path in the driving lane[06/12/2019].

Step 7. Operator: Click “Start” at the bottom of the screen prior to reaching the beginning of the test section. System will begin to initialize[06/12/2019]. A green progress bar will begin filling up at the bottom of the screen (see below image). System is initialized and lead-in is complete when bar is completely green.



Step 8. Operator: When van reaches beginning of section, click "Begin Segment." The image below depicts a flowchart for the data collection process.



Step 9. Operator: **Perform Manual/Visual QC** of data being collected through information displayed in monitor windows during data collection. Visual checks include the following[06/12/2019]:

i. Forward cameras – Right-of-way (ROW) camera window and Left camera window. Confirm that the images are crisp, clear and void of obstructions, that there is minimal sunlight interference, and that the images are updating as the vehicle moves down the road.

ii. LCMS pavement images – Confirm that both sets of pavement images are updating as the vehicle moves down the road, and that identifiers on the pavement (such as paint stripes or large cracks) are visible in the image window.

iii. International Roughness Index (IRI) values – Confirm that left and right IRI plots show reasonable numbers based on operator's experience and condition of the pavement being collected.

iv. Grade – Confirm % grade change window shows a reasonable value and it is updating as the vehicle moves down the road.

v. GPS – Confirm Position and Orientation System for Land Vehicles (POS LV) status is green.

vi. Fault Count – Confirm fault count windows shows reasonable values and are updating as the vehicle moves down the road.

vii. Additional Notes – Notes regarding special events during data collection should be added where necessary by typing the appropriate event abbreviation into the dialogue box on the data collection screen. Common events and their abbreviations for data entry are shown in below table.

Description	**Event Abbreviation**
Lane Exception	L
Milled Surface	M
Construction Zone	C
Rumble Strips in Lane	R
Wet Surface	W
Road Closed Ahead	X
Roundabout	O
Traffic Signal Red	T
New Pavement	N
Debris	D

If no issues arise from the checks in this step, proceed to Step 10. If issues do arise, stop the data collection run and attempt to fix problem. For example, operator should reconnect the cables connecting malfunctioning sub-system equipment to the computer, as a first step. If Operator is not able to resolve the issue, contact Roadware's Technical Service for assistance. If still not able to resolve the issue, communicate issue to the Supervisor and suspend daily data collection until all sub-systems are functioning properly. When issue has been corrected, return to Step 5.

Step 10. Operator: **Observe Automated QC Checks**. Error messages will appear in a window towards the bottom of the data collection screen. Messages highlighted in ORANGE are warnings but do not require the data collection run to be stopped (such as one GPS receiver going out for a moment). Messages highlighted in RED are alerts that require the data collection run to be stopped and the specific error corrected.

i. If no issues arise from the checks in this step, proceed to Step 11.

ii. If issues do arise, stop the data collection run and attempt to fix problem. For example, operator should reconnect the cables connecting malfunctioning sub-system equipment to the computer, as a first step. If Operator is not able to resolve the issue, contact Roadware's Technical Service for assistance. If still not able to resolve the issue, communicate issue to the Supervisor and suspend daily data collection until all sub-systems are functioning properly. When issue has been corrected, return to Step 1.

Step 11. Operator: If multiple segments exist along the section, click "Accept" to mark the end of a segment. This will end that segment and begin the next segment automatically. When van reaches the end of the entire section, click "End Segment."

Step 12. Operator: Click "Stop" at the bottom of the screen once the data collection route is complete. Green status bar will appear and lead-out process will begin. Lead-out is complete when bar is completely green.

Step 13. Operator: In the queue list of selected sections, click on the section that is to be collected next. Click "Make Current" at the bottom of the map window (see above image). Confirm the beginning and end of the selected section by the flag icons in the map window. Otherwise, an incorrect section may be selected and the route selection will have to be repeated by returning to Step 1.

Step 14. Driver: Navigate vehicle to next selected route and approach beginning of test section. Return to Step 7 and repeat for all data collection runs for the day[06/12/2019].

3.03 ARAN POST-DATA COLLECTION ACTIONS

3.03.01 *General*

This section describes the standard operating procedure (SOP) followed by the Automatic Road Analyzer (ARAN) crew members of the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Field Explorations Division (FED) to perform data management and validation activities after daily data collection using an ARAN 9000 survey van with ARAN Collection System (ACS) software Version 2.3[06/12/2019] (hereafter referred to in this SOP as ARAN). This SOP is one of three to be utilized for daily data collection with the referenced ARAN. It is preceded by ARAN Pre-Data Collection Actions and then ARAN Data Collection. The post-data collection actions covered in this SOP start from the completion of the last data collection run of the day (see ARAN Data Collection) to system shut down.

3.03.02 *Frequency*

This SOP is to be performed each day of ARAN data collection[06/12/2019], following the last data collection run of the day.

3.03.03 *Purpose*

The purpose of this SOP is to perform post-data collection quality control (QC) checks of the ARAN data collected each day (see ARAN Data Collection) and to safely store those data by:

- properly exporting the data,
- checking quality of imaging and roughness data through the review of different runs, and
- documenting the events of the day through a daily report, referred to as the end of day daily report.

3.03.04 *Resource Requirements*

The actions detailed in this SOP are to be performed by the crew of the ARAN van, which is composed of a driver and an operator. The estimated effort levels in the table below represent the total time, in man-hours, required for completion of all post-data collection activities. These time estimates assume no issues are encountered with exporting and QC of data.

Position	Function	Resources	Effort Level (man-hrs)
ARAN Testing Crew	Driver	1	0.5-1.0
ARAN Testing Crew	Operator	1	0.5-1.0
FED TL or Coordinator	Supervisor	1	AR[06/12/2019]

3.03.05 *Procedure*

The procedure to be followed by the ARAN crew members following completion of data collection runs for the day is comprised of five components:

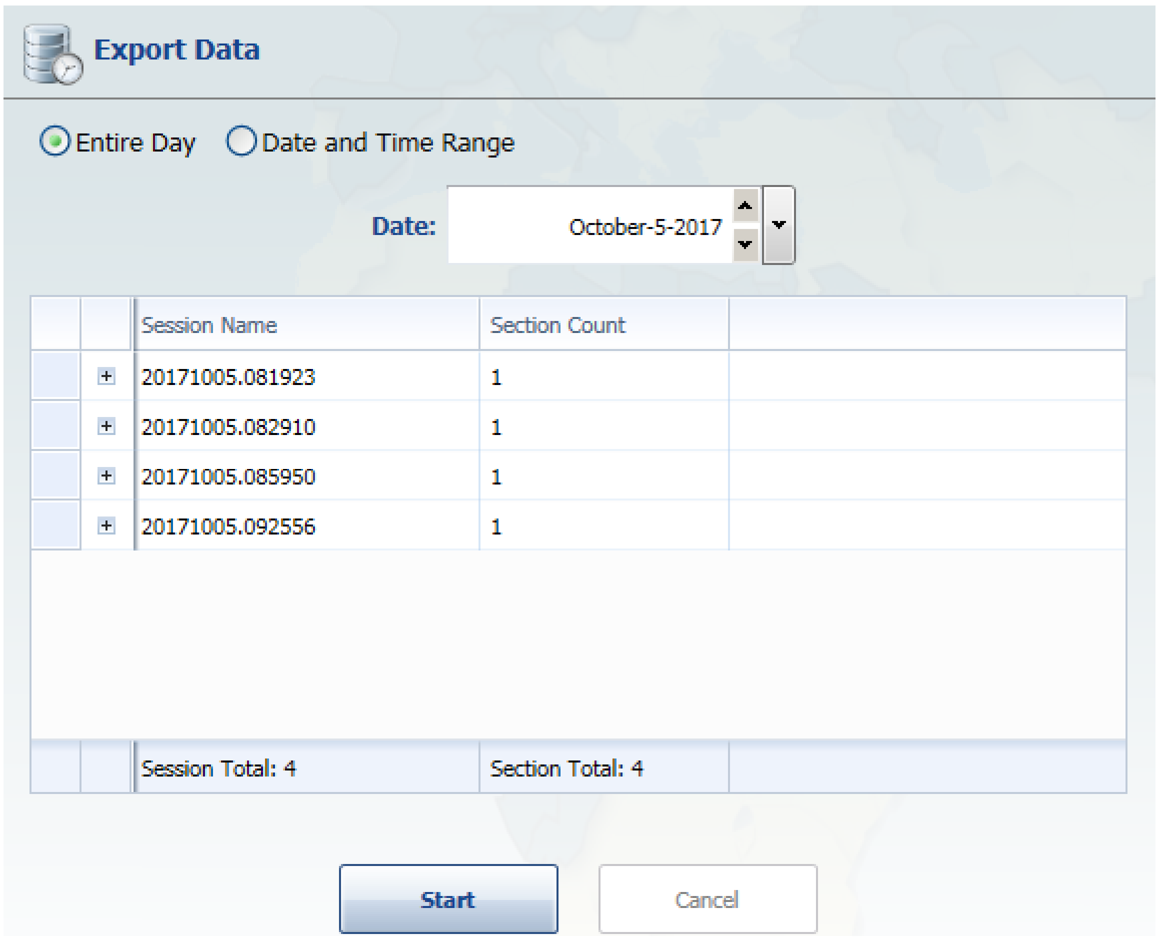
(1) data export,
(2) run review,
(3) end of day daily report,
(4) pavement image QC, and
(5) computer shut down and hard drive removal[06/12/2019].

1- Data Export – *performed by Operator*

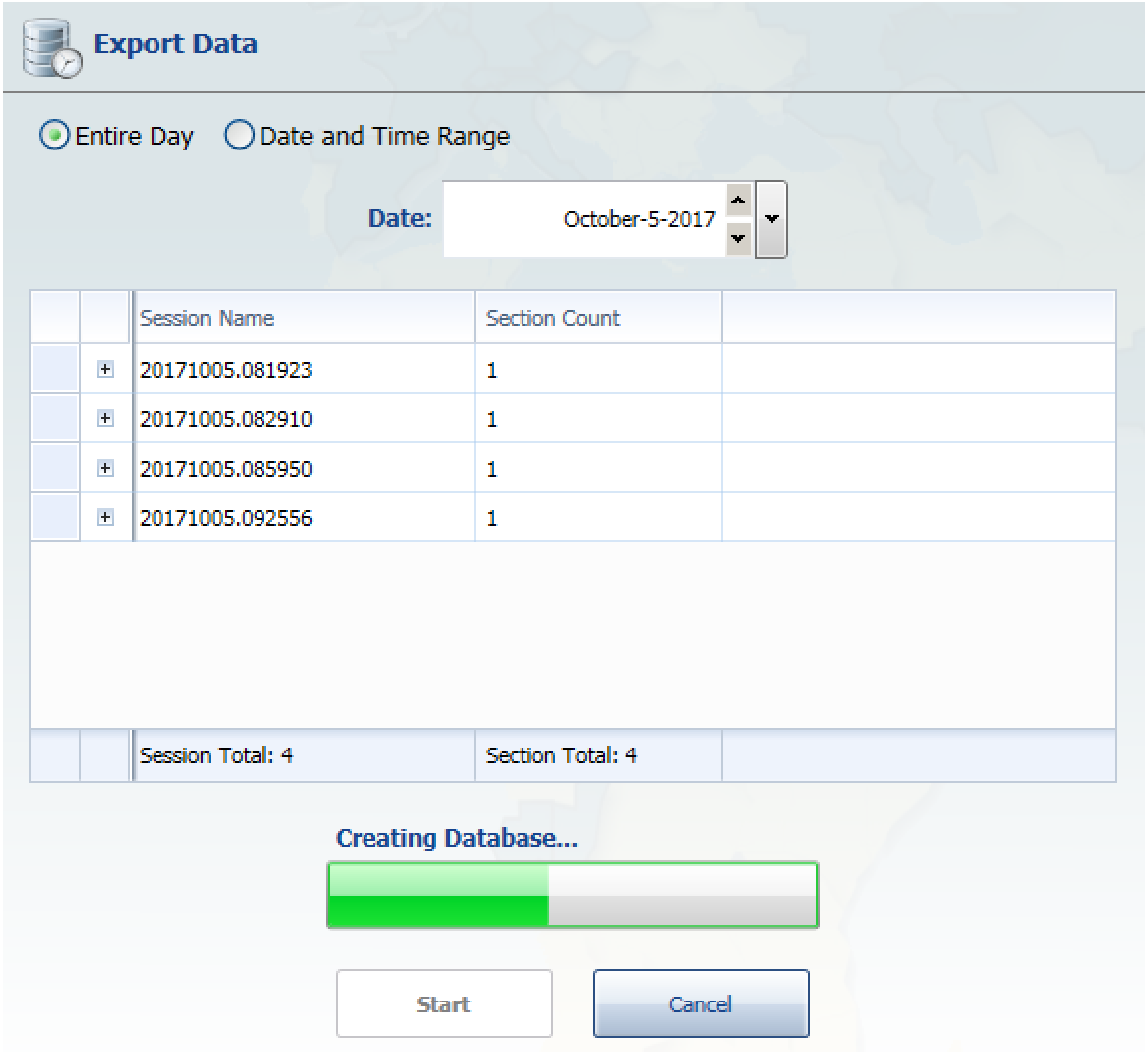
Summary: This task uses the ACS software to export the collected data at the end of the day.

Step 1. Select the “Data Management” drop down menu from the main ACS ribbon at the top of the screen. Select “Export.”

Step 2. Select today’s date from window. Ensure “Entire Day” bubble is filled in at top of window. All runs for the day should appear in the dialogue box (see below image).



Step 3. Select “Start” (see above image). Progress bar appears as data exports (see below image).

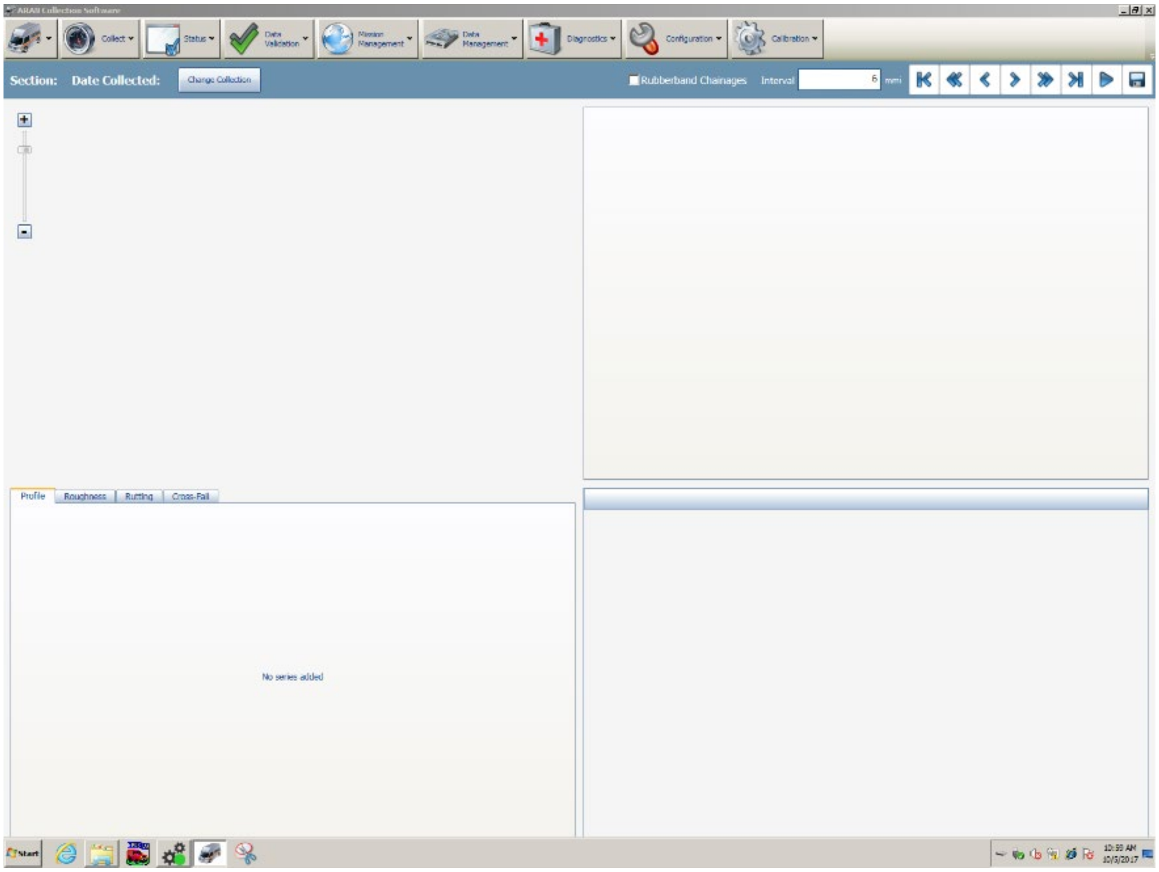


Step 4. Small notification window will appear that says "Export Completed." Click "OK."

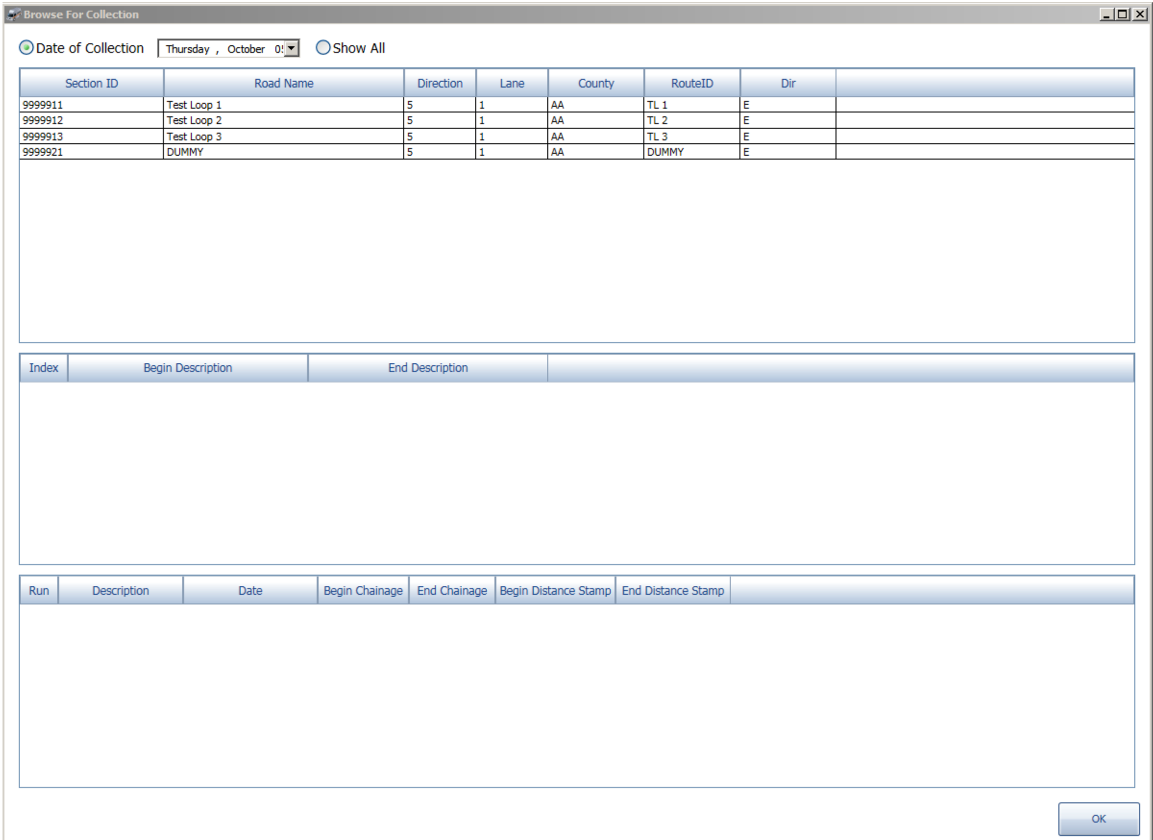
2- Run Review and ROW Imaging QC – *performed by Operator*

Summary: This task uses the ACS software to review a sample of the collected data and QC the collected images.

Step 5. Select the "Data Validation" drop down menu from the main ACS ribbon at the top of the screen. Select "Review." Review window appears (see below image).



Step 6. Select "Change Collection" at top left of window (see above image). Window appears with a list of runs completed for the date selected (see below image). Randomly select a specific run to be reviewed by highlighting the row of the corresponding section[06/12/2019].



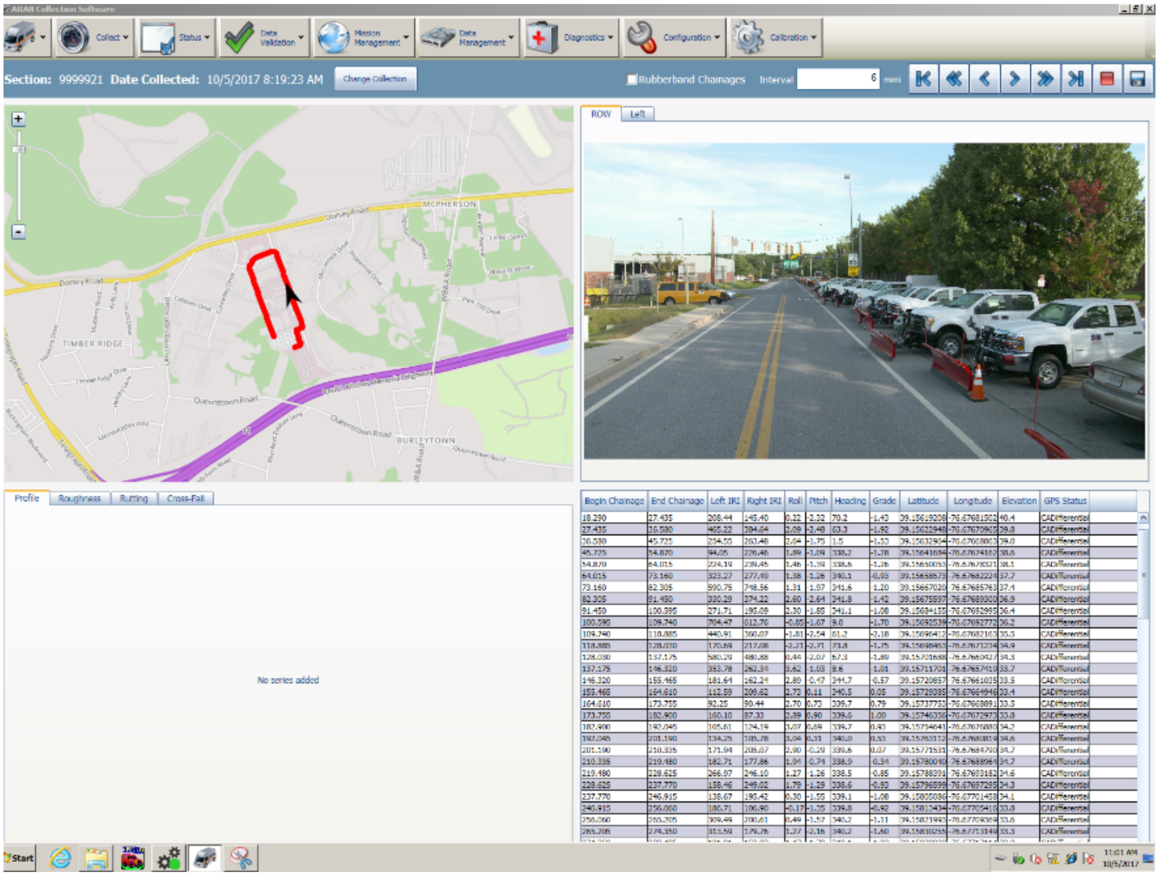
Step 7. Click "OK" (see above image).

Step 8. Click "Play." Software will simulate the data collection of the selected section (see below image). Operator should observe the following[06/12/2019]:

i. Route map – Confirm by visual check that map in the upper left corner is showing the correct "trace" of the data collection run, which indicates the GPS was working properly.

ii. Attribute Table – Confirm by visual check that the table in the bottom right corner is populated without gaps[06/12/2019] and that the values for the corresponding attributes are reasonable[06/12/2019].

iii. Cameras – Confirm via visual check that the camera images in the upper right corner are updating and that they are of acceptable quality. Toggle between the two cameras to perform visual check on both.

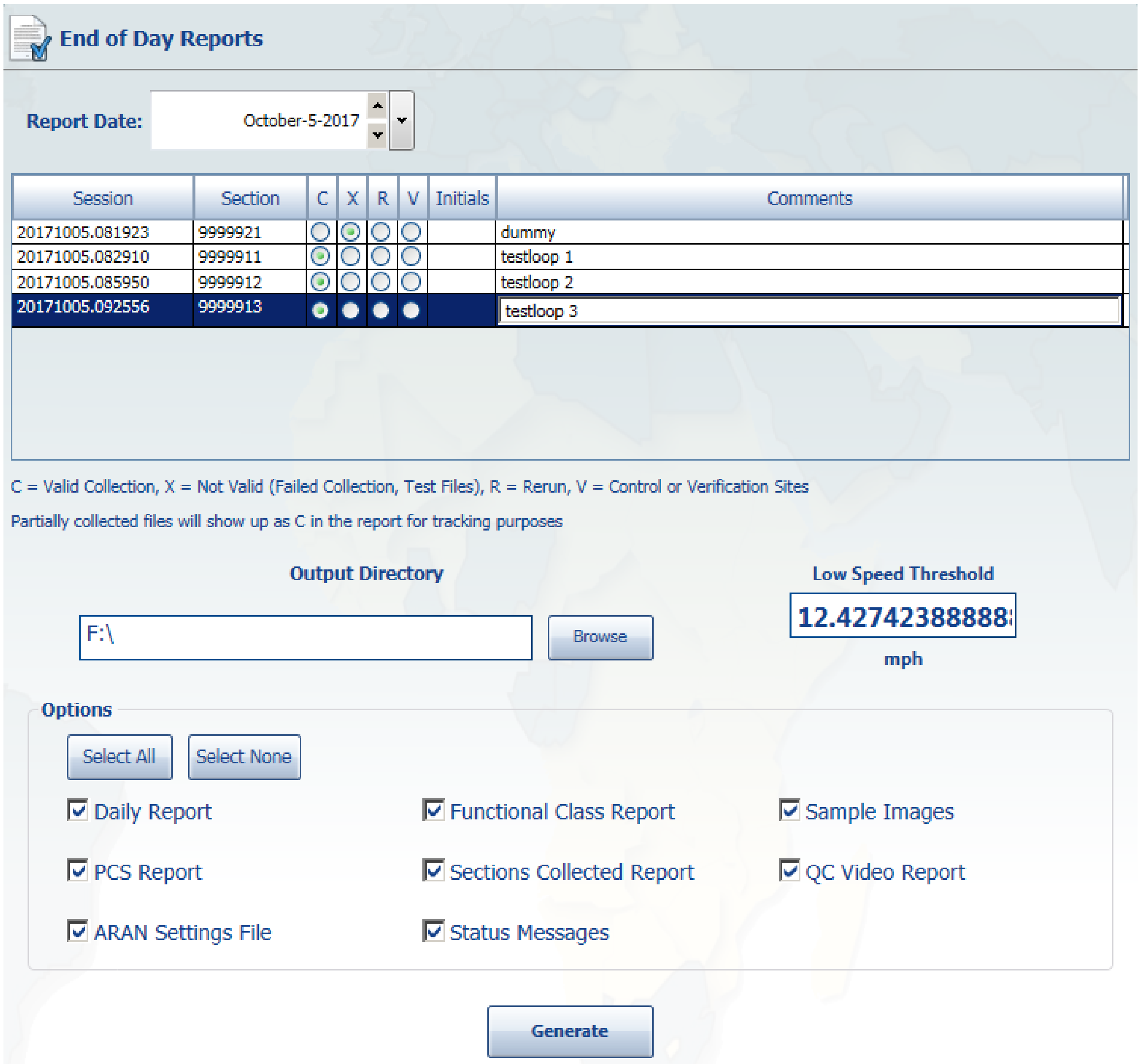


Exit the review if the data collection run is complete and the checks have been found to be satisfactory. If issues are noted during the visual checks in Step 8, return to Step 5 and repeat the steps again, but select a different run. If the same issues are identified over multiple runs, communicate issue with Supervisor who will help decide if further action is required, such as recollection of data.

3- End of Day Daily Report – *performed by Operator*

Summary: This task uses the ACS software to produce a daily report.

Step 9. Select the “Data Validation” drop down menu from the main ACS ribbon at the top of the screen. Select “End of Day Daily Report.” “Daily Report” window appears (see below image).



Step 10. Check appropriate bubbles next to section identifiers (see above image). Designations are as follows:

i. C = Regular collection

ii. X = Eliminated data or dummy file

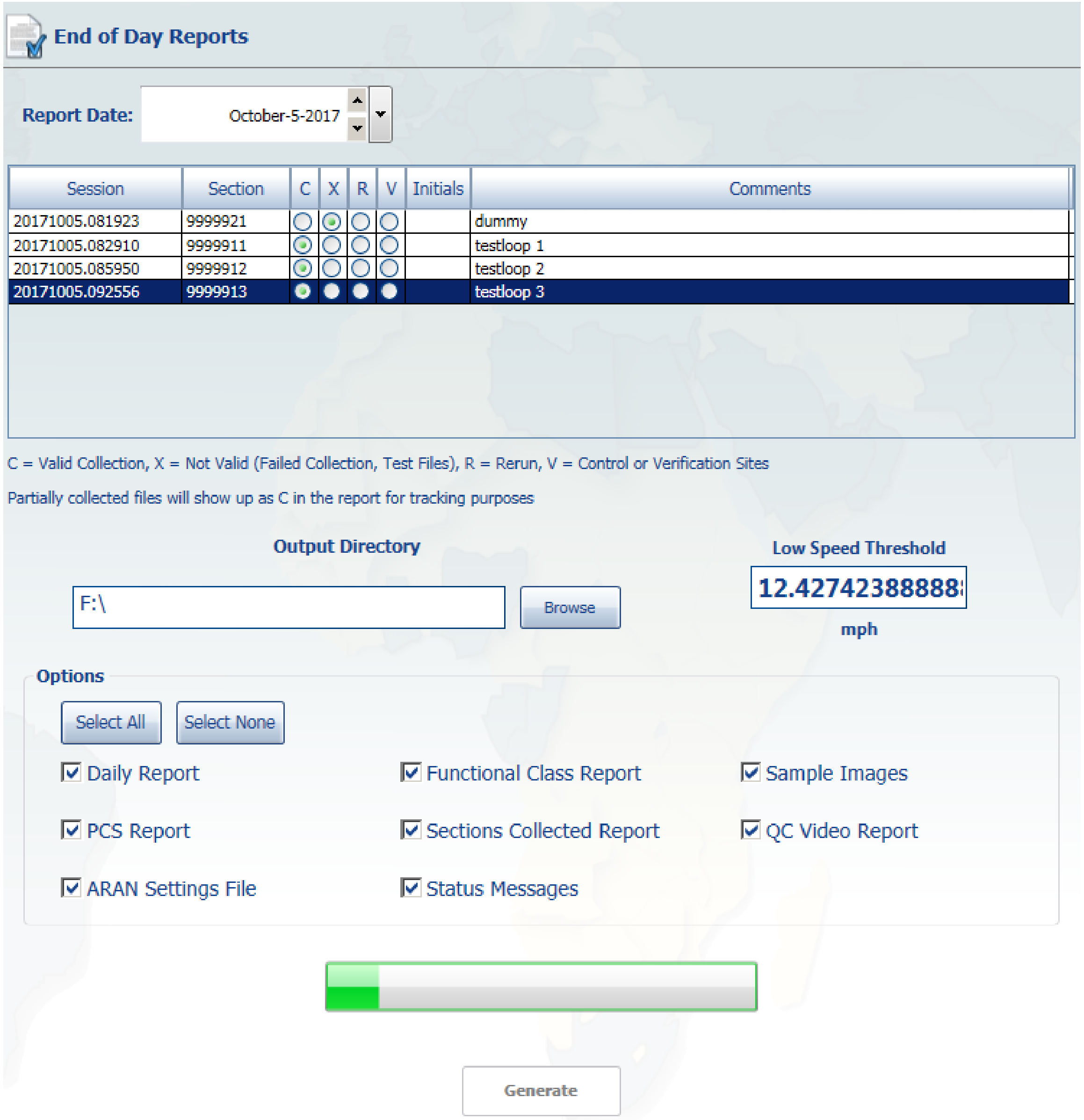
iii. R = Recollected data

iv. V = Validation data (test loop)

Step 11. Add road names under the “Comments” column for each section.

Step 12. Select “Output Directory” (F Drive).

Step 13. Confirm all report types have been checked. Click “Generate.” Progress bar will appear as report is generated (see below image).

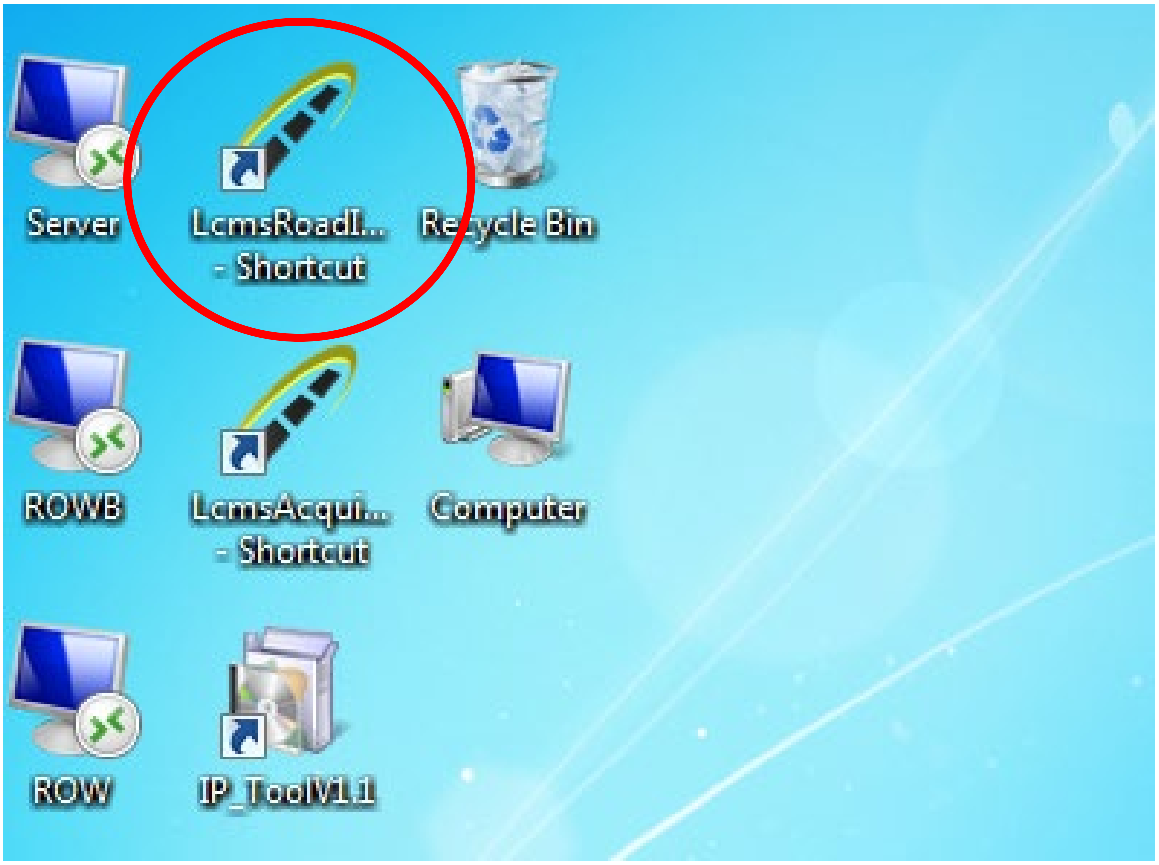


4- Pavement Image QC – *performed by Operator*

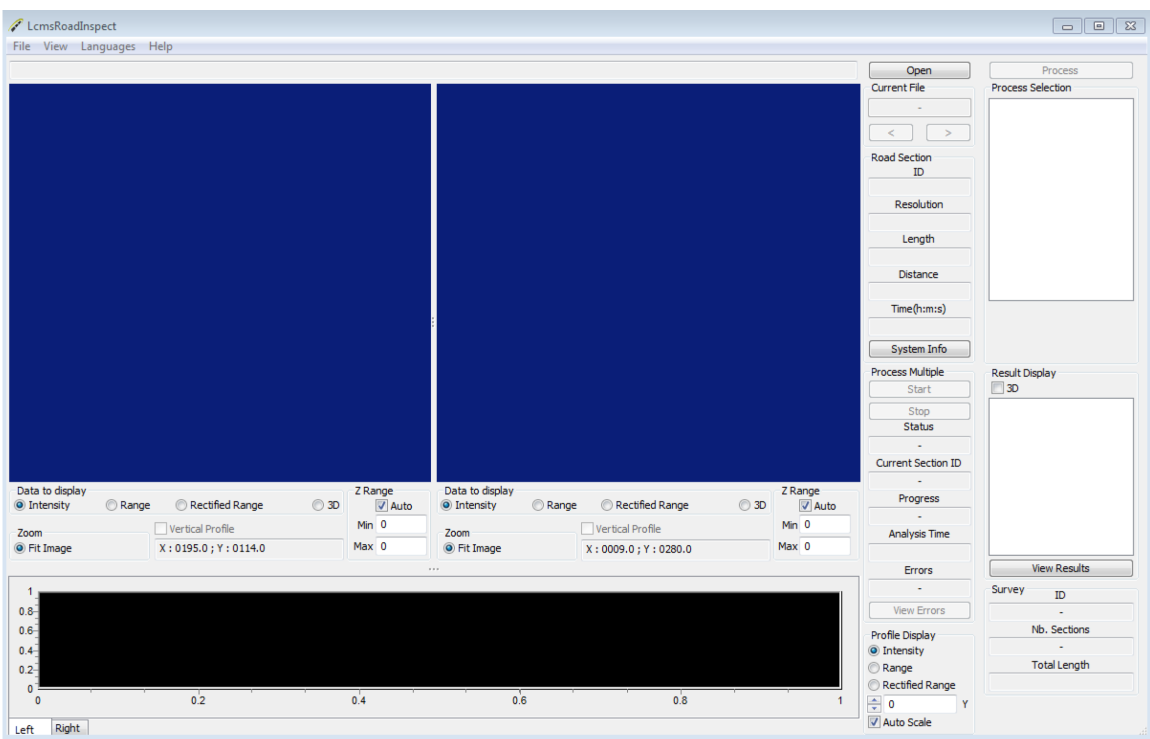
Summary: This task uses the LCMS Road Inspect software to review and QC collected LCMS pavement images.

Step 14. On the ROW computer desktop, double click on the "PAVE" computer icon. Monitor will switch to the PAVE computer desktop.

Step 15. Double-click on the "LCMS Road Inspect" icon (see below image).



Step 16. Click “Open” in upper right hand corner (see below image).



Step 17. Select F Drive.

Step 18. Select “FIS Pavement” icon.

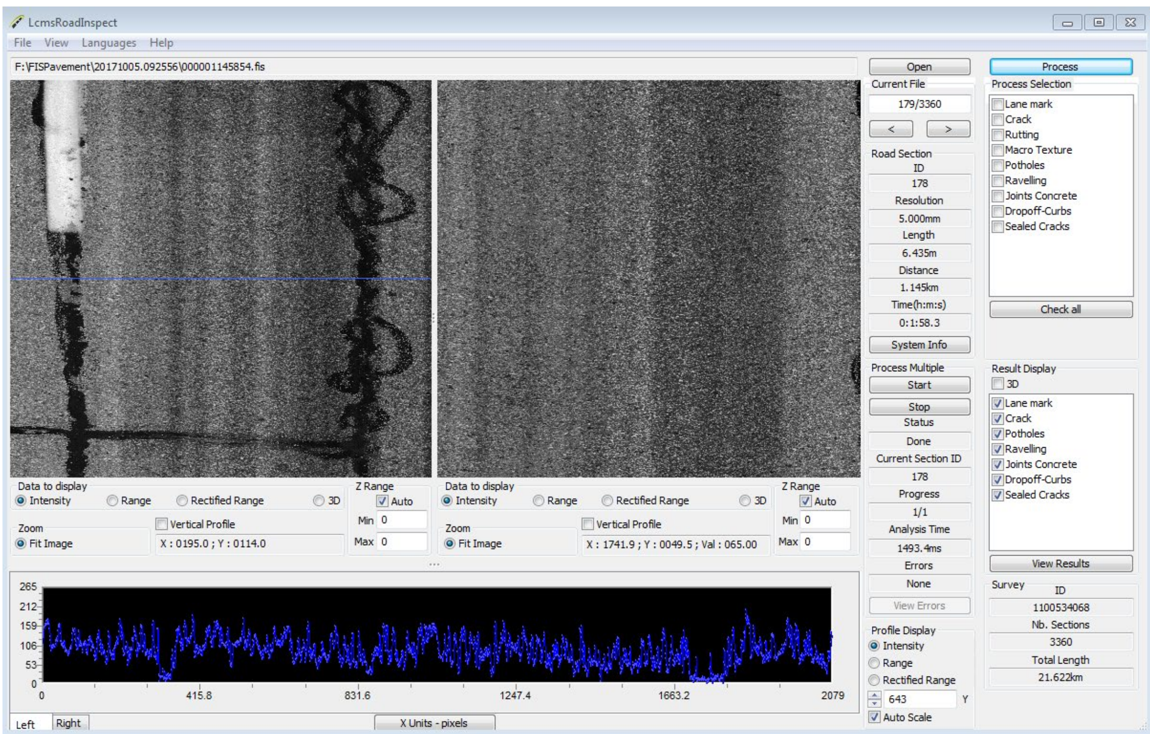
Step 19. Scroll down to folder with today’s data and double click.

Step 20. Select random image in folder.

Step 21. Click “Clear All” on right of window.

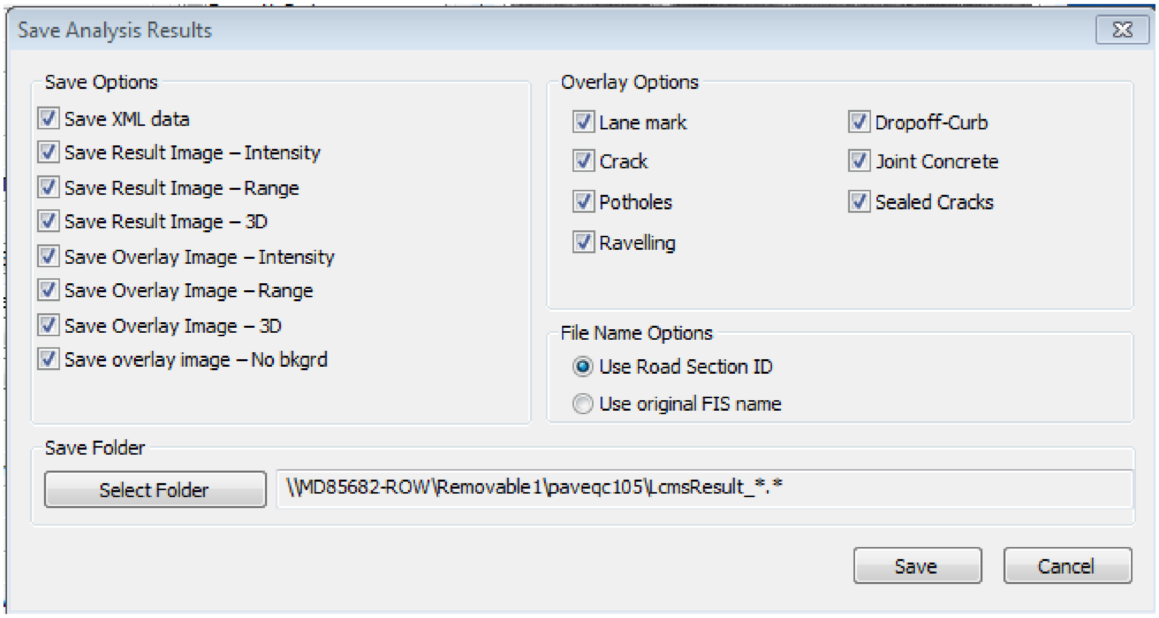
Step 22. Click “Process.” A new window will appear when image processing is complete (see below image).

Step 23. Check image for quality. Right and left Laser Crack Measurement System (LCMS) images should line up well, image should be clear and pavement defects/markings should be visible. Otherwise, note the name of the section and communicate issue to Supervisor for further review of collected data and troubleshooting.



Step 24. Click “Save Result” and a new dialogue box will appear (see below image).

Step 25. Check all boxes in new dialogue box (see below image). Click “Save.”



Step 26. Click "Select Folder" (see above image). Navigate to "ROW PC", "Removable."

Step 27. Create new folder at this location and name it as "pavqc[MMDD]" using today's date at the end (e.g. "pavqc1122").

Step 28. Click "Open."

Step 29. Click "Save." Window disappears.

Step 30. Click "Save" on the "Process Result" window. This window will disappear.

Step 31. Return to Step 16 and repeat procedure for 2 more images in the same data folder[06/12/2019]. If one of the images reviewed identifies issues or raises concerns, it may be necessary to inspect additional images.

Step 32. Close Program.

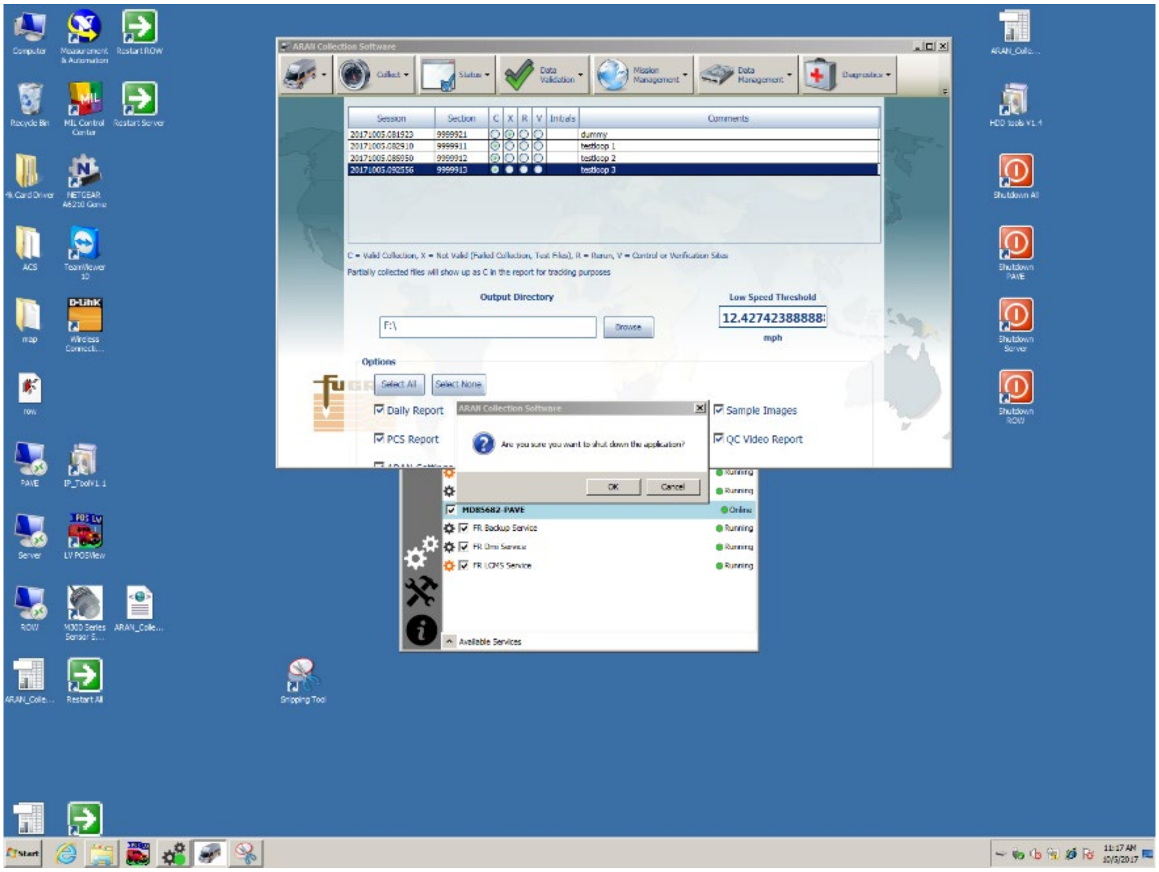
Step 33. Click the "ROW" computer icon on desktop to return to ROW computer.

5- Computer Shut Down and Hard Drive Removal – *performed by Operator*

Summary: This task completes computer shut down in the ARAN and removes the hard drives from the vehicle for data processing.

Step 34. While back on the ROW computer, close the ACS.

Step 35. Click "OK" (see below image).



Step 36. Double-click on the shutdown icon for each computer on the ROW desktop (ROW, PAVE, Server).

Step 37. Turn off inverter using controls on the center console.

Step 38. Remove six hard drives from back of van and turn them in to supervisor[06/12/2019].

Step 39. Confirm all computers and inverter have powered down successfully.

Turn off van engine and lock doors.

3.04 ARAN DMI CALIBRATION

3.04.01 *General*

This section describes the standard operating procedure (SOP) followed by the Automatic Road Analyzer (ARAN) crew members from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Field Explorations Divisions (FED) to calibrate the Distance Measuring Instrument (DMI) mounted on the ARAN vans. The steps described in this SOP are based on the ARAN Collection System (ACS) software Version 2.3[06/12/2019] developed for operating ARAN 9000 vans (hereafter referred to as ARAN). The reference measurements used for the calibrating procedure described in this SOP consist of two one-mile long pavement sections marked on the shoulder lanes along both directions of a road segment on MD Route 100, which have been measured by a state surveyor using thermally compensated steel tape.

3.04.02 *Frequency*

This SOP should be followed for the calibration of the DMI mounted on ARAN vans once per month during the data collection period[06/12/2019].

3.04.03 *Purpose*

The purpose of this SOP is to check the accuracy of the distance measurements taken by the DMI mounted on ARAN vans and, if necessary, perform corrective actions for recalibration.

3.04.04 *Resource Requirements*

Calibration of the ARAN's DMI is performed by the crew of the ARAN van, composed of a driver and an operator. The estimated effort levels in the table below represent the total time, in man-hours, required for driving from the SHA's Office of Materials Technology (OMT) location to the current calibration sites on MD 100, performing three repeat runs of the test, and driving back to the OMT location.

Position	Function	Resources	Effort Level (man-hrs)
ARAN Testing Crew	Driver	1	1.5
ARAN Testing Crew	Operator	1	1.5

3.04.05 *Procedure*

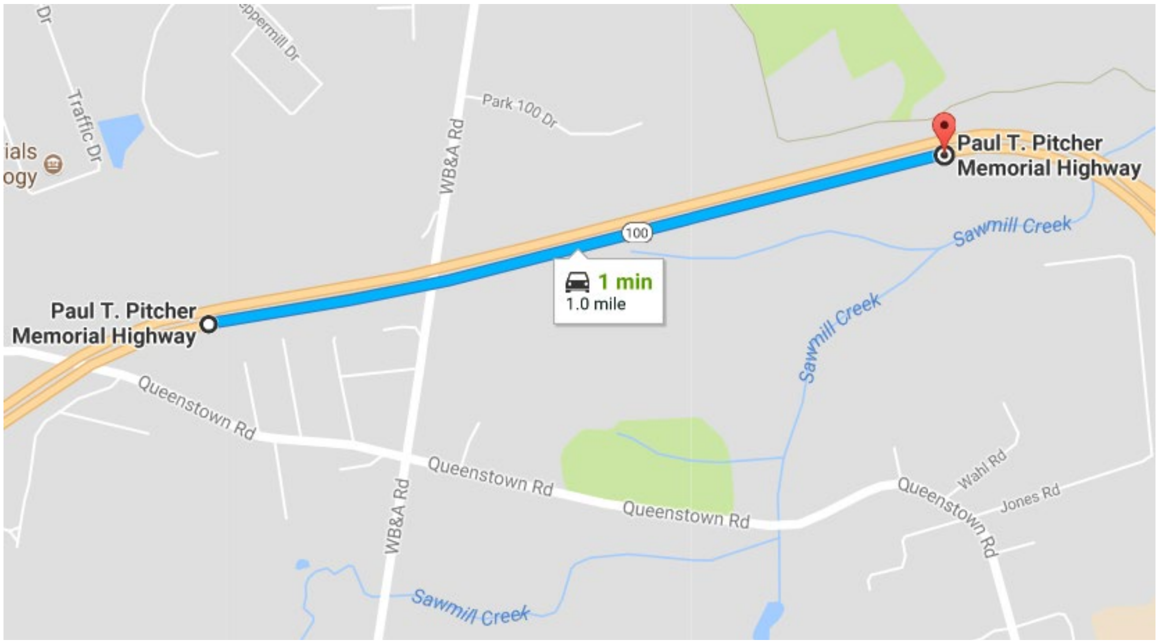
The procedure to calibrate the DMI mounted on ARAN 9000 vans using ACS software Version 2.3 is comprised of a single task:

(1) calibrating DMI.

1- Calibrating DMI – *performed by driver and operator*

Summary: This task performs a DMI calibration for the ARAN 9000 van using ACS software at the MDOT-SHA OMT DMI calibration site.

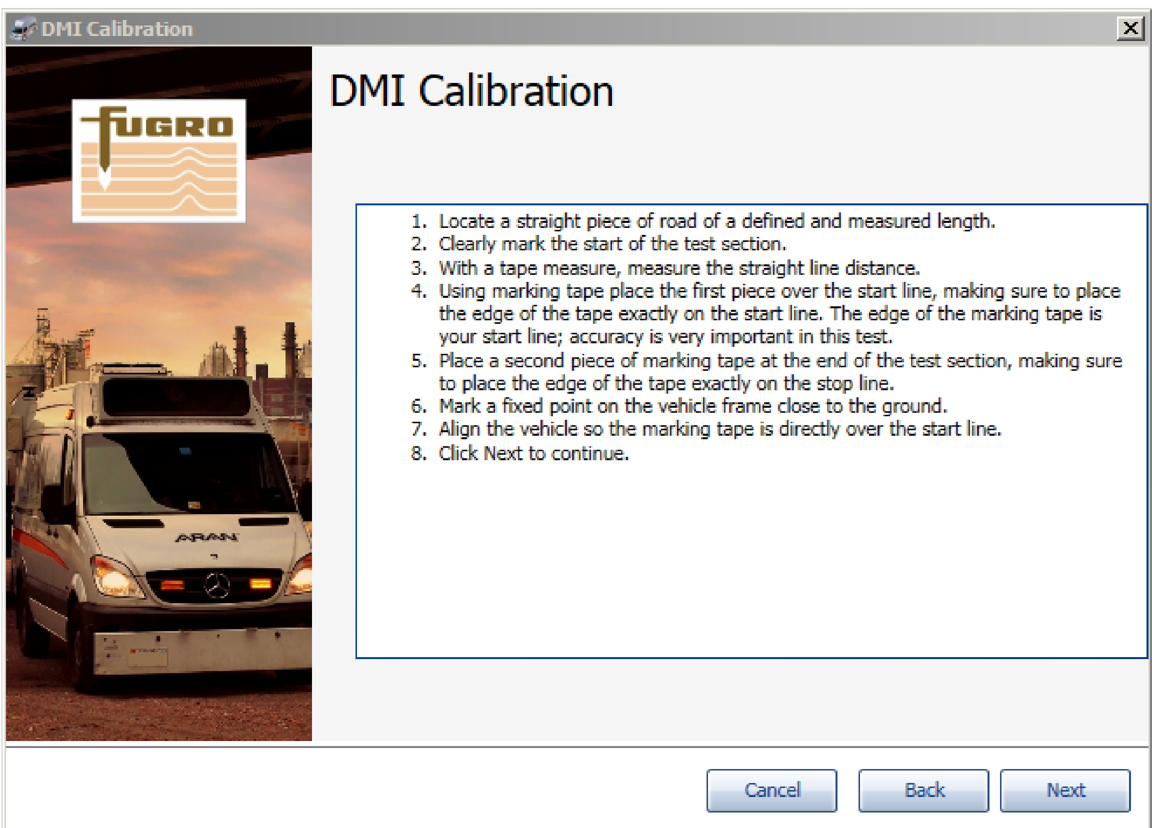
The two calibration sites consist of one-mile long marked sections located near the OMT on the shoulder lanes of MD 100: one in the east-bound direction and the other in the west-bound direction (see map screenshot below).



Step 1. Driver: Drive the ARAN van to the starting point of the calibration site in the east-bound direction. The starting point can be identified by multiple markings (see below photos):

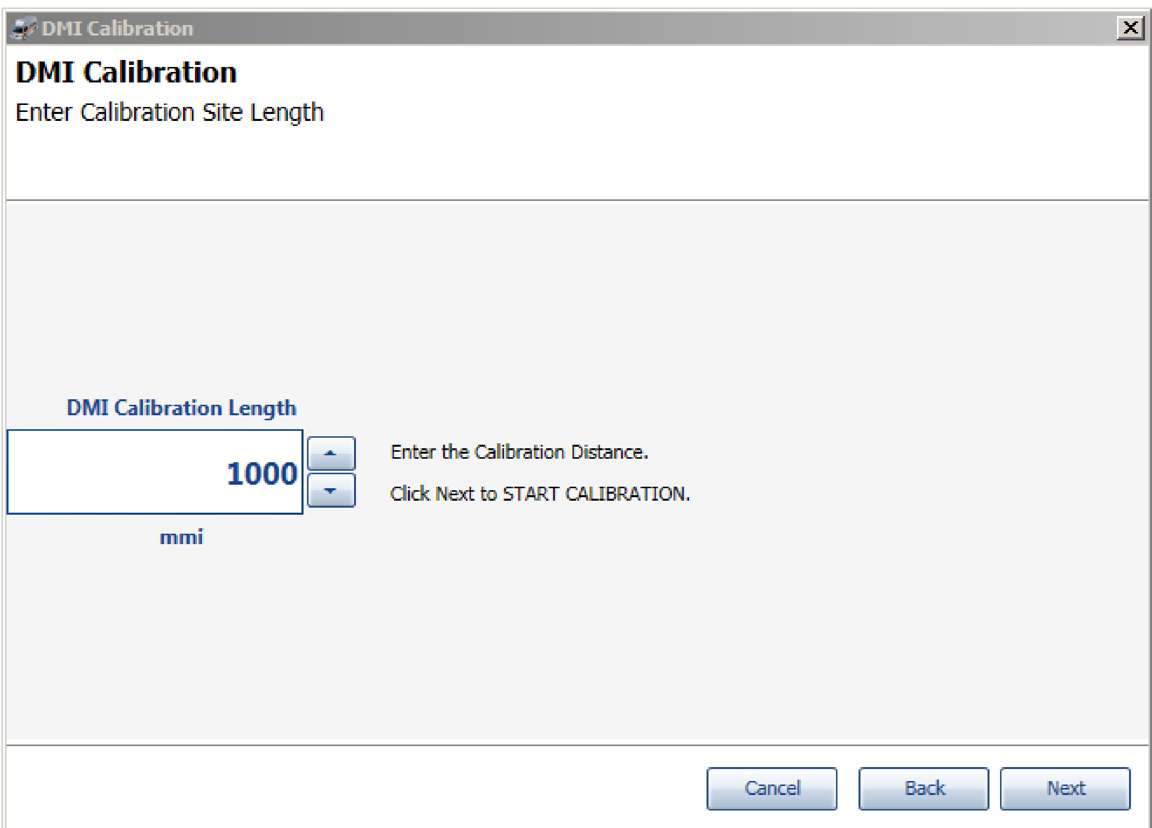
(1) an orange paint mark on a tree to the right of the road,
(2) a metal pole just beyond the pavement shoulder,
(3) paint markings on the pavement shoulder (line and “ST”), and
(4) a survey nail in the pavement shoulder.

Step 2. Operator: Select the “Calibration” drop down menu from the main ACS ribbon at the top of the screen. Select “DMI.” This will open the ACS’s “DMI Calibration Wizard” application (see below image).



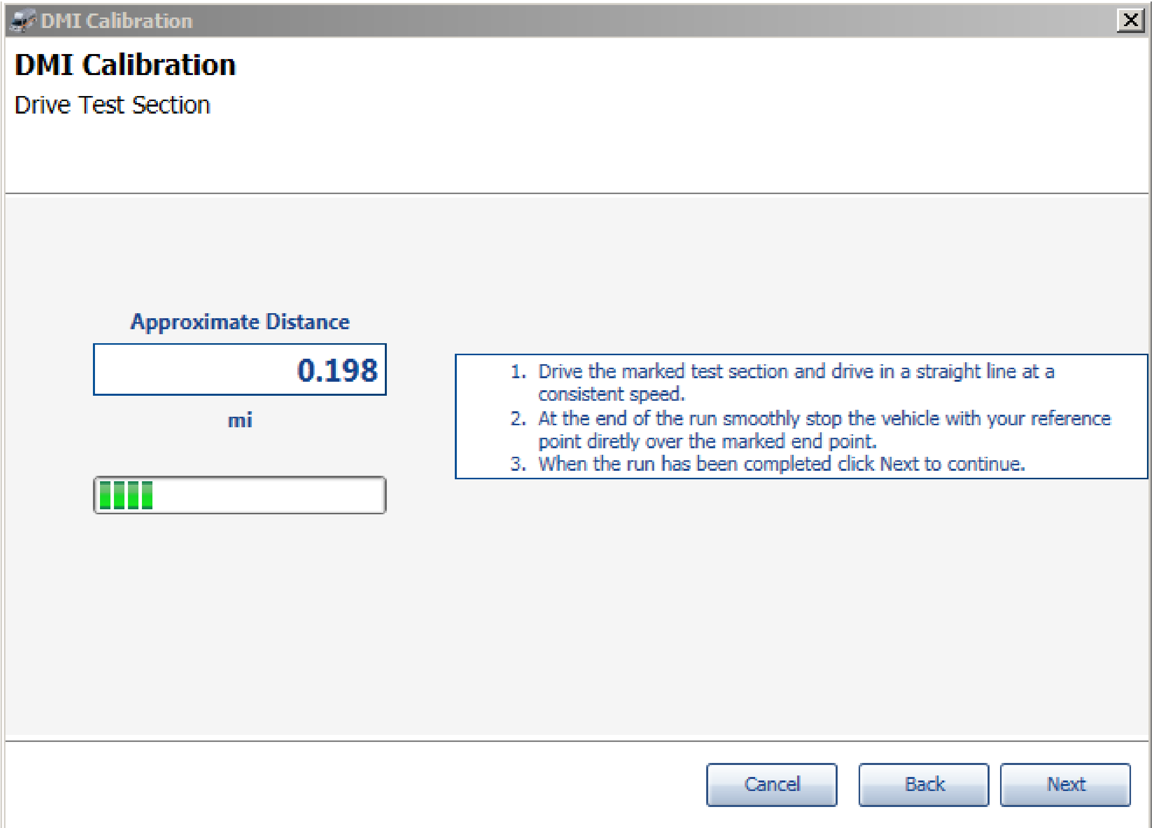
Step 3. Driver: Drive the ARAN van until the front bar of van is aligned to the “start” position marking on pavement surface and survey nail as shown in below image[06/12/2019].

Step 4. Operator: Enter calibration site length on “DMI Calibration Wizard” (see below image). The length of the current calibration site is 1000 mmi.

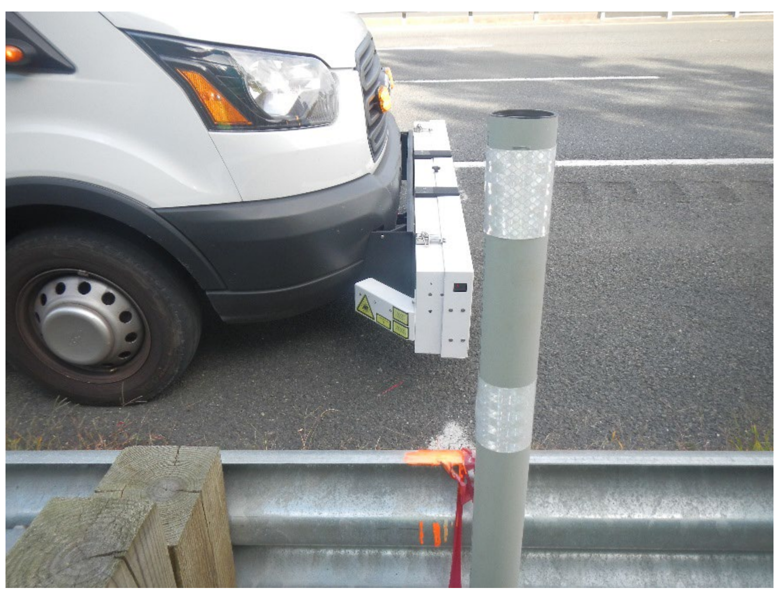


Step 5. Operator: Click “Next” on the DMI Calibration Wizard to start calibration.

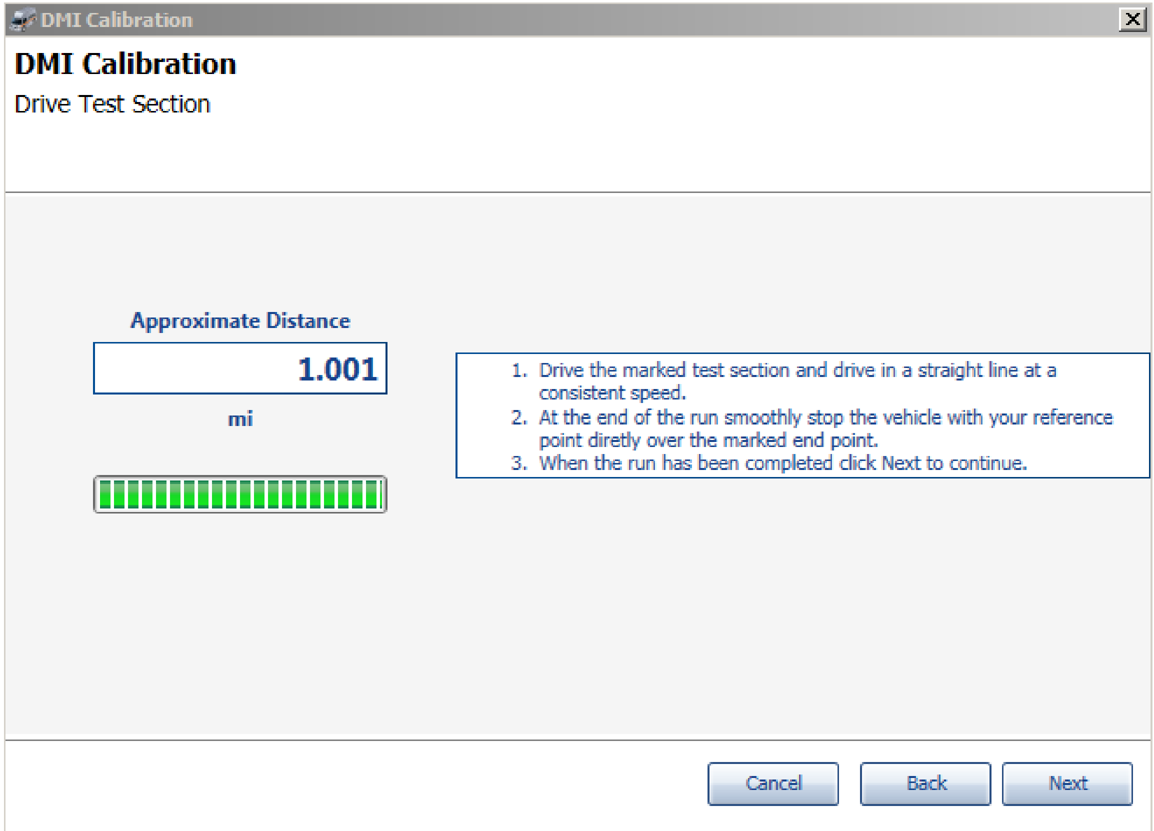
Step 6. Driver: Drive forward on shoulder lane from the start mark until a few feet before the end mark. The “DMI Calibration Wizard” should register travelled distance on screen (see below image). Attempt to stay as straight as possible in the shoulder lane using the white stripe, edge of pavement, and guardrail (where present) as references.



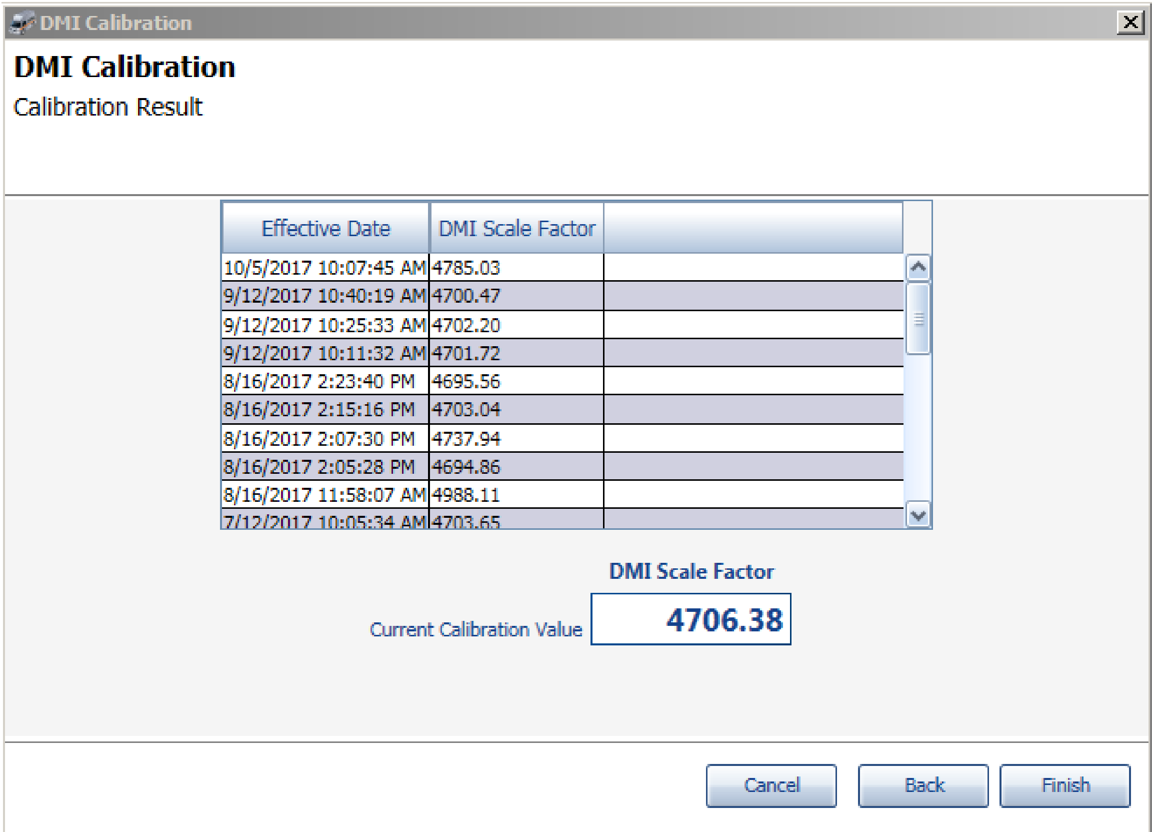
Step 7. Driver: Drive ARAN van until front bar of van is aligned to "end" position marking on pavement surface and survey nail as shown in the below image[06/12/2019].



Step 8. Operator: Click "Next" to end the DMI calibration (see below image).



Step 9. Operator: Click "Finish" on ACS's "DMI Calibration Wizard" and save results (see below image). The ACS's DMI Calibration application will perform the necessary adjustments to the DMI readings to match the measured distance during the calibration procedure to the reference measurement (scale factor).



Step 10. Driver: Drive the ARAN van to starting point of the calibration site in the west-bound direction and repeat Step 2 to Step 9 to perform second run of DMI calibration. See photos below for similar markers in the west-bound direction.

Step 11. Driver: Drive the ARAN van to starting point of the calibration site in the east-bound direction and repeat Step 2 to Step 9 to perform third run of DMI calibration.

The DMI calibration procedure is completed once the three runs (two at the calibration site in the east-bound direction and one at the calibration site in the west-bound direction) are performed. The calibration factors for the 3 runs must agree within 0.1 percent and preferably within 0.05 percent. If they do not agree, consult Supervisor and discuss next steps for remedial actions.

3.05 PREVENTIVE MAINTENANCE OF ARAN VAN

3.05.01 *General*

This section describes the standard operating procedure (SOP) followed by the Automatic Road Analyzer (ARAN) crew members from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Field Explorations Divisions (FED) to support and to document the preventive maintenance activities performed annually by Fugro Roadware (Roadware) on the ARAN van and its sub-components.

3.05.02 *Frequency*

This SOP should be followed for the support and documentation of the annual ARAN preventive maintenance activities. Typically, these preventive maintenance activities are performed in early March, before commencement of the annual data collection season, and takes approximately one week.

3.05.03 *Purpose*

The purpose of this procedure is to support and to document the preventive maintenance activities performed by Roadware on the ARAN vans, and, if necessary, to perform follow-up actions. Preventive maintenance is done annually to ensure the ARAN vans are functioning properly prior to the start of the data collection season.

3.05.04 *Resource Requirements*

Preventive maintenance work on the ARAN and its documentation on a check-list are performed by a representative from Roadware. Support with the preventive maintenance work and follow-up activities are performed by the crew of the ARAN van, composed of a driver and an operator. The FED team leader is required for oversight and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, required for completion and documentation of the annual preventive maintenance activities on the ARAN van and its sub-components. Time estimates assume only minor issues, if any, are encountered during the conduct of the required work.

Position	Function	Resources	Effort Level (man-hrs)
ARAN Testing Crew	Driver	1	40
ARAN Testing Crew	Operator	1	40
FED Team Leader (TL)	Supervisor	1	5

3.05.05 *Procedure*

The procedure to support and document preventive maintenance activities of the ARAN van and its sub-components is comprised of a single task:

(1) supporting and documenting ARAN preventive maintenance.

1- **Supporting and Documenting ARAN Preventive Maintenance** – *performed by driver and operator with support from Supervisor*

Summary: This task provides support for ARAN Preventive Maintenance operations, documents results of the maintenance, and makes decisions regarding follow-up actions.

Step 1. ARAN Testing Crew: Provide technical support as requested by the Roadware technician during the conduct of the preventive maintenance activities.

Step 2. Supervisor: Obtain preventive maintenance report[06/12/2019] from the Roadware technician at completion of the work. Refer to the beginning pages of the report for a checklist of preventive maintenance activities. Check the following items on the list to confirm their completion:

i. Server computer updates and maintenance.
ii. Right-of-way (ROW) computer updates and maintenance.
iii. Pavement computer updates and maintenance.
iv. Alternating Current (AC) distribution box checks.
v. LSDP junction box enclosure checks.
vi. Cables, racks, dog house, and miscellaneous checks.
vii. Distance Measurement Instrument (DMI) checks.
viii. Chassis, generator, inverter, and charger checks.

Step 3. Supervisor: Refer to the “Recommendations” section of the report. Note suggestions or outstanding issues noted by Roadware and decide if further follow-up actions are required.

Step 4. Supervisor: Refer to the “System Calibration” section of the report. Review the following calibrations and their results:

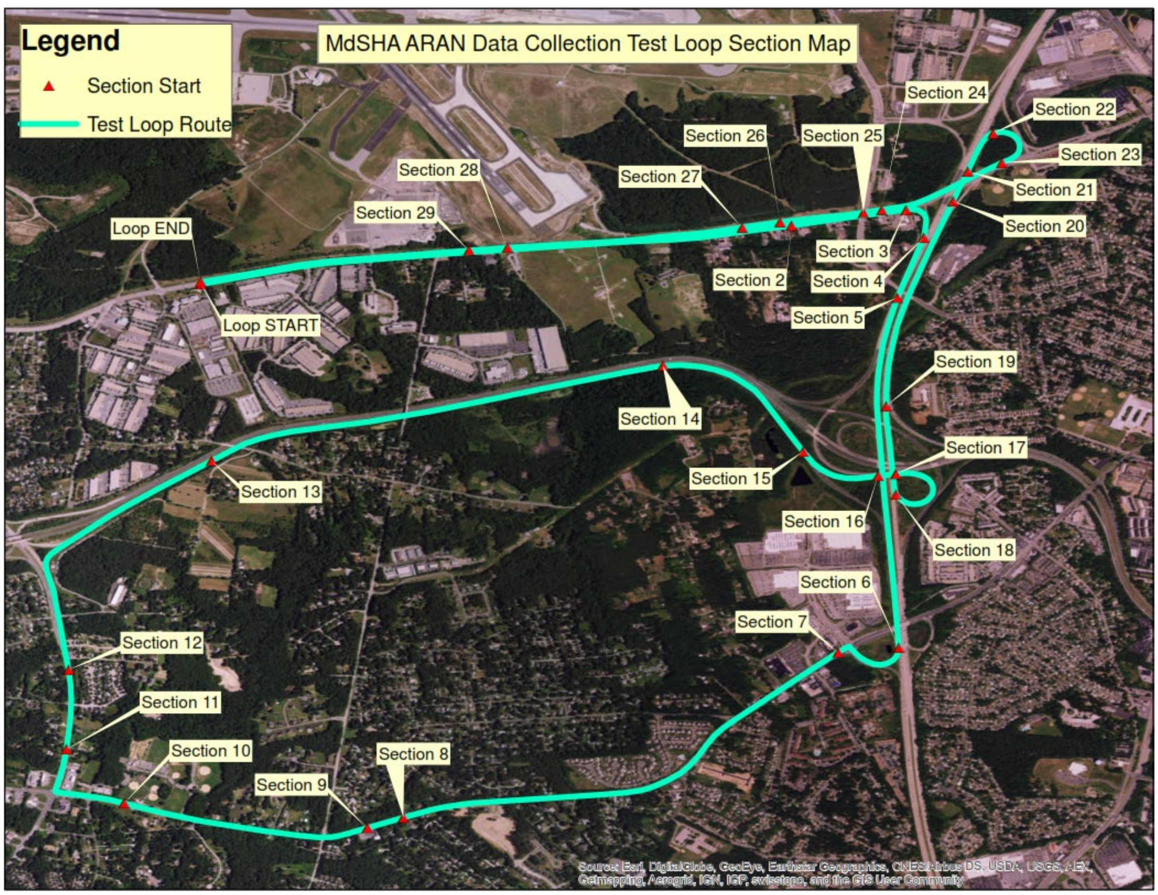
i. DMI calibration.
ii. Roughness Calibration.
iii. Static Roughness Test Results.
iv. Static Block Test Results.
v. Roughness Bounce Test Results.
vi. Reverse Runs to Verify Roll, Pitch, and Heading.
vii. Frame Angle.
viii. Static Grade Test.
ix. Static Rock Test.
x. Grade Verification.
xi. Test Loop 10 Repeat Runs[06/12/2019] – Review metrics including IRI, cross-fall, rutting, etc.

Decide if follow-up remedial actions are required based on the results from the individual checks.

3.06 TEST LOOP ARAN DATA COLLECTION

3.06.01 *General*

This section describes the standard operating procedure (SOP) followed by the Automatic Road Analyzer (ARAN) crew members from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Field Explorations Division (FED) to perform data collection on a carefully selected designated test loop using an ARAN 9000 survey van with ARAN Collection System (ACS) software Version 2.3[06/12/2019] (hereafter referred to as ARAN). The data collection route is called the "test loop." The test loop begins and ends near the Office of Materials Technology (OMT) location. It is approximately 13.1 miles in length and is divided into segments of varying length based on surface type, intersection locations, ramp locations, and other common road features. The route was selected specifically because it includes a variety of surface types and road textures. The map[06/12/2019] below depicts the route for the test loop. The data collected on this test loop are used to validate all ARAN sub-component data.



The required preliminary actions and diagnostic checks outlined in [ARAN Pre-Data Collection Actions] should be completed prior to the beginning of ARAN data collection runs on the referenced test loop.

3.06.02 *Frequency*

This SOP requires that three ARAN data collection runs be performed on the test loop once a month throughout the data collection period[06/12/2019].

3.06.03 *Purpose*

The purpose of this SOP is to perform ARAN data collection runs on the test loop[06/12/2019].

3.06.04 *Resource Requirements*

The test loop data collection is performed by the crew of the ARAN van, composed of a driver and an operator. The estimated effort levels in the table below represent the total time, in man-hours, required for completion of all test loop activities, including preliminary checks and diagnostics, three data collection runs, and data export and management. These time estimates assume no issues are encountered during the required work.

Position	Function	Resources	Effort Level (man-hrs)
ARAN Testing Crew	Driver	1	2.0
ARAN Testing Crew	Operator	1	2.0
FED Team Leader (TL)	Supervisor	1	AR[06/12/2019]

3.06.05 *Procedure*

The procedure to complete data validation on the test loop is comprised of a single task:
(1) completing data validation on ARAN Test Loop.

1- Completing Data Validation on ARAN Test Loop – *performed by driver and operator*

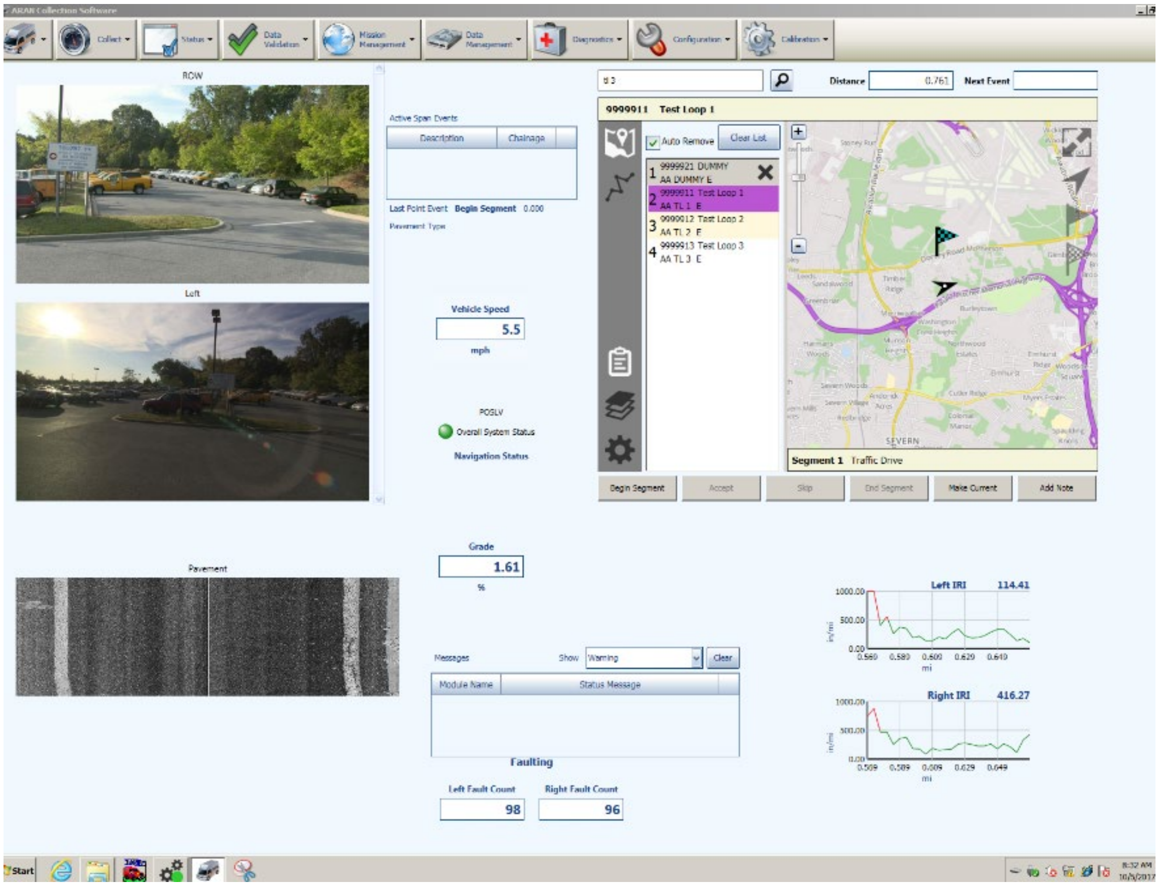
Summary: This task is performed to complete three runs on the ARAN test loop.

Step 1. Operator: Follow ARAN Pre-Data Collection Actions, beginning with Step 3, for vehicle and diagnostic checks.

i. If checks do not identify equipment issues, proceed to Step 2.

ii. If checks identify equipment issues, consult ARAN Pre-Data Collection Actions for troubleshooting methods. Communicate issue(s) to the Supervisor and suspend test loop data collection until all sub-systems are functioning properly.

Step 2. Operator: Select the “Collect” drop down menu from the main ACS ribbon at the top of the screen. Click on “Summary.” Data collection window appears (see below image).



Step 3. Operator: In the search bar above the map window, type in “TL 1”. Click the magnifying glass to begin the search.

Step 4. Operator: A list of search results will appear. The section for the first test loop will read “999911 Test Loop 1, AA TL 1 E”. Click “Add to List.” Repeat search for “TL 2” and “TL 3”. All three test loop runs should now be listed in the section queue to the left of the map (see above image).

Step 5. Operator: In the queue list of selected sections, click on “Test Loop 1.” Click “Make Current” at the bottom of the map window (see above image). Confirm the beginning and end of the selected section by the flag icons in the map window.

Step 6. Driver and Operator: Follow ARAN Data Collection, beginning with Step 14, for completing the first test loop data collection run.

i. If run is completed successfully, proceed to Step 7.

ii. If run is not completed successfully or if one or more sub-systems malfunctioned during data collection, attempt to resolve the issue(s). If Operator is not able to resolve the issue(s), contact Roadware’s Technical Service for assistance. If still not able to resolve the issue(s), communicate issue(s) to the Supervisor and suspend test loop data collection activities until all sub-systems are again functioning properly. When resolved, return to Step 5 and recollect first test loop run.

Step 7. Operator: In the queue list of selected sections, click on "Test Loop 2". Click "Make Current" at the bottom of the map window. Confirm the beginning and end of the selected section by the flag icons in the map window.

Step 8. Driver and Operator: Follow ARAN Data Collection, beginning with Step 14, for completing the second test loop data collection run.

i. If is completed successfully, proceed to Step 9.

ii. If run is not completed successfully or if one or more sub-systems malfunctioned during data collection, attempt to resolve the issue(s). If Operator is not able to resolve the issue(s), contact Roadware's Technical Service for assistance. If still not able to resolve the issue(s), communicate issue(s) to the Supervisor and suspend test loop data collection activities until all sub-systems are again functioning properly. When resolved, return to Step 7 and recollect second test loop run.

Step 9. Operator: In the queue list of selected sections, click on "Test Loop 3". Click Make Current at the bottom of the map window. Confirm the beginning and end of the selected section by the flag icons in the map window.

Step 10. Driver and Operator: Follow ARAN Data Collection, beginning with Step 14, for completing the third test loop data collection run.

i. If run is completed successfully, proceed to Step 11.

ii. If run is not completed successfully or if one or more sub-systems malfunctioned during data collection, attempt to resolve the issue(s). If Operator is not able to resolve the issue(s), contact Roadware's Technical Service for assistance. If still not able to resolve the issue(s), communicate issue(s) to the Supervisor and suspend test loop data collection activities until all sub-systems are again functioning properly. When resolved, return to Step 9 and recollect third test loop run.

Step 11. Operator: Follow ARAN Post-Data Collection Actions, beginning with Step 1, for data export and management following the completion of the third test loop run[06/12/2019].

3.07 TEST LOOP DATA ANALYSIS

3.07.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Field Explorations Division (FED), Data Processing Team (DPT), and Data Analysis Team (DAT) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to help assure the Automatic Road Analyzer (ARAN) quality controlled (QC'd) and quality assured (QA'd) deliverables (pavement data and imagery) are precise, accurate, and consistent throughout the collection season.

The MDOT-SHA test loop is a collection of 45 sections creating an approximately 13.1 miles long run near the Office of Materials Technology (OMT) location. The test loop is divided into 45 segments of varying length according to surface type, construction history, intersection locations, ramp locations, number of lanes, other common road features, and historic ground truth study locations. The route was selected specifically because it includes a variety of pavement structures, surface types, and road textures. The data collected on the test loop are used to validate ARAN sub-component data. Details regarding the test loop ARAN data collection process is described in Test Loop ARAN Data Collection. Test Loop Analysis Details provides further information on the data analysis procedure.

3.07.02 *Frequency*

This procedure detailed in this SOP is performed by the MDOT-SHA staff once per year as part of the initial data collection program (pre-collection), where the MDOT-SHA operated ARAN vehicles complete 10 runs of the MDOT-SHA test loop prior to the start of the data collection season, and thereafter every 3 weeks throughout the FED collection and delivery season, as part of the 3 week test loop data collection program, where the ARAN vehicle completes 3 runs of the test loop.

3.07.03 *Purpose*

The purpose of this SOP is to perform analysis on the MDOT-SHA test loop data and imagery collected by the ARAN vehicles order to:

- confirm collected and processed data are precise, accurate, and consistent;
- determine the acceptable range of variance or standard deviation for each performance measure to be used for outlier review; and
- conduct research on topics such pavement data collection and data processing techniques, and pavement performance and deterioration modeling.

3.07.04 *Resource Requirements*

The MDOT-SHA test loop data analysis involves the following three MDOT-SHA staff members: (1) a DPT staff member who is knowledgeable in the Vision software to perform pavement imagery quality control (QC) and lane adjustment, (2) a DAT staff member to perform condition data QC and to generate the test loop QC report, and (3) the DPT Team Leader (TL) to perform quality assurance (QA) functions and who, as required, provides guidance and decision-making. The FED TL and Assistant Division Chief (ADC) may also be required for error resolution and decision-making.

The estimated effort levels shown in the table below represent the total time, in man-hours, required for completion of MDOT-SHA test loop data analysis. These time estimates assume no issues are encountered while performing the required work.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff Member	Imagery QC	1	4.0
DAT Staff Member	Condition Data QC	1	4.0
DPT TL	QA	1	As Required[06/12/2019]
FED TL	Error Resolution	1	As Required
ADC	Error Resolution	1	As Required

3.07.05 *Procedure*

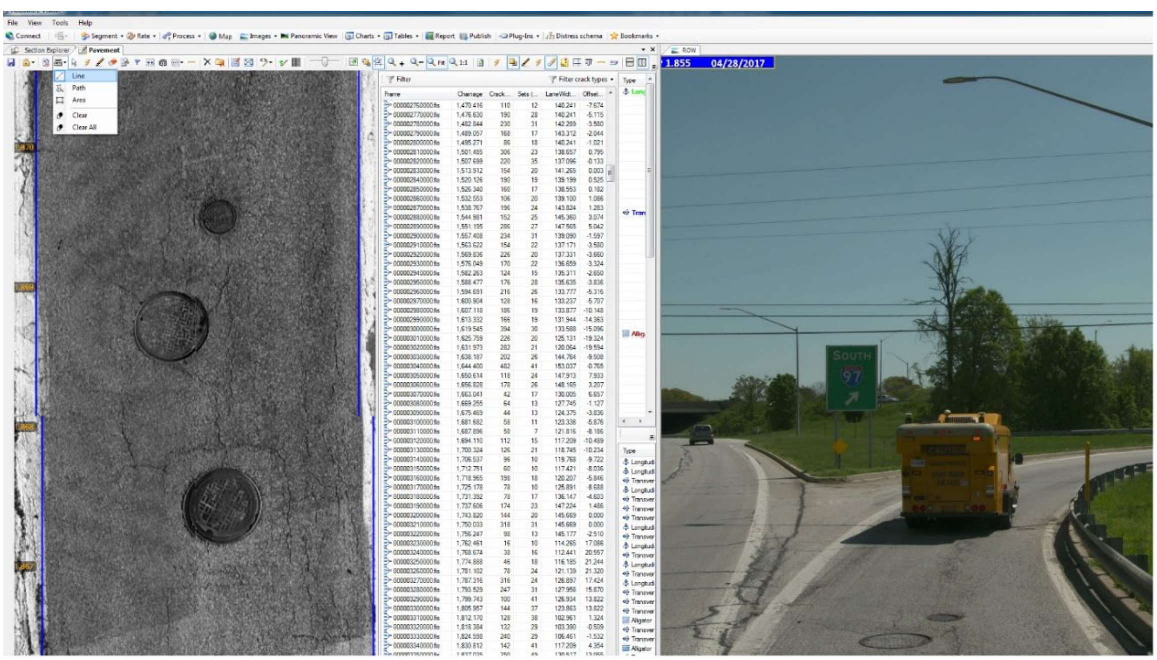
The procedure to perform the MDOT-SHA test loop data analysis is comprised of the following four tasks:

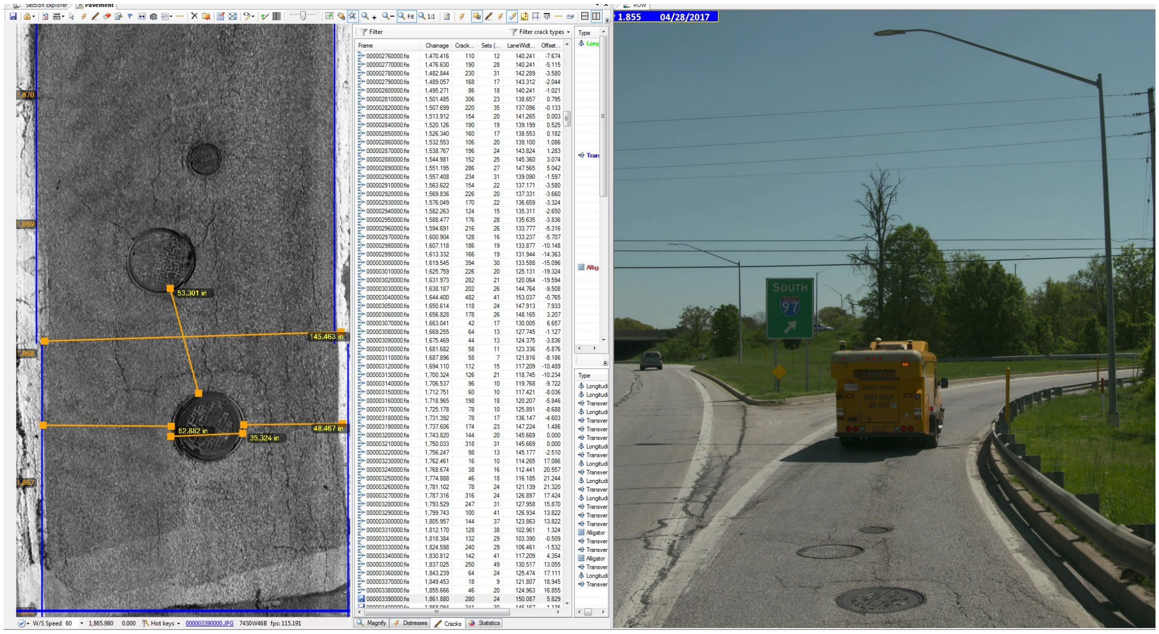
(1) perform pavement imagery QC,
(2) perform drive-through for lane adjustment and pavement event flagging and generate test loop QC report,
(3) perform condition data QC and update test loop QC report, and
(4) submit test loop QC report.

1- Perform Pavement Imagery QC – *performed by DPT Staff Member*

Summary: Under this task, the pavement images collected by the ARAN on the MDOT-SHA test loop are checked for correct aspect ratios, correct imaging intervals, and proper quality.

Step 1. After data have been loaded into Vision (see Loading of ARAN Data Vision) and LCMS Global Processor ran (see Running Global LCMS Processor), take measurements using the measurement tools in Vision (see below images).





Step 2. Compare measurements taken in Step 1 to the corresponding ground truth measurements to confirm that the images are not distorted (see markings in image below).

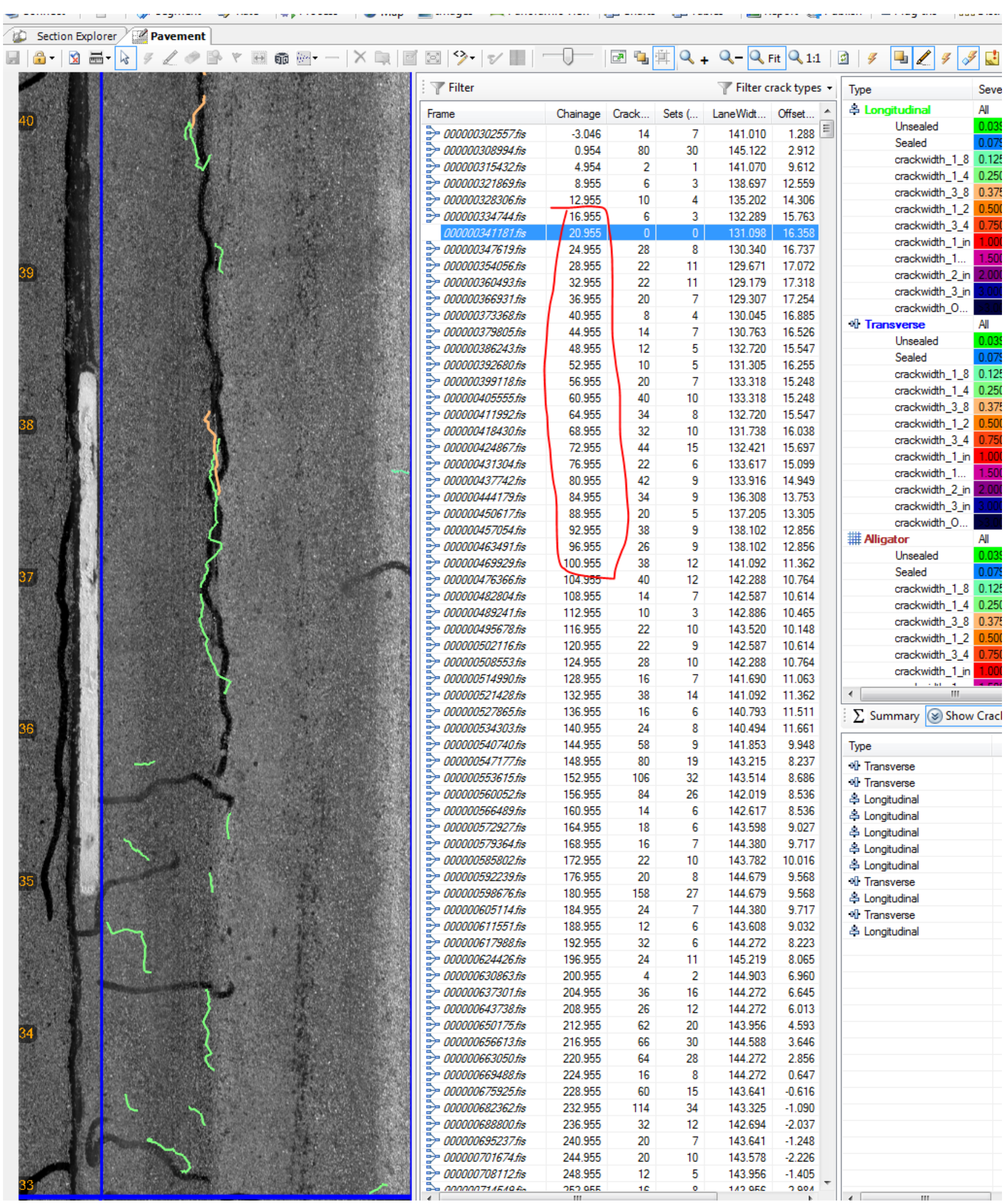
i. If images are within tolerance of +/- 3% of the actual measured length, proceed to Step 3.

ii. Otherwise, refer to Test Loop Data Analysis Details for error resolution guidelines.

Step 3. Once the LCMS Global Processor has been run and the images created, check to confirm that the chainages have an interval of 0.004 miles (see chainage values in image below).

i. If the chainage values are at the correct interval, proceed to Step 4.

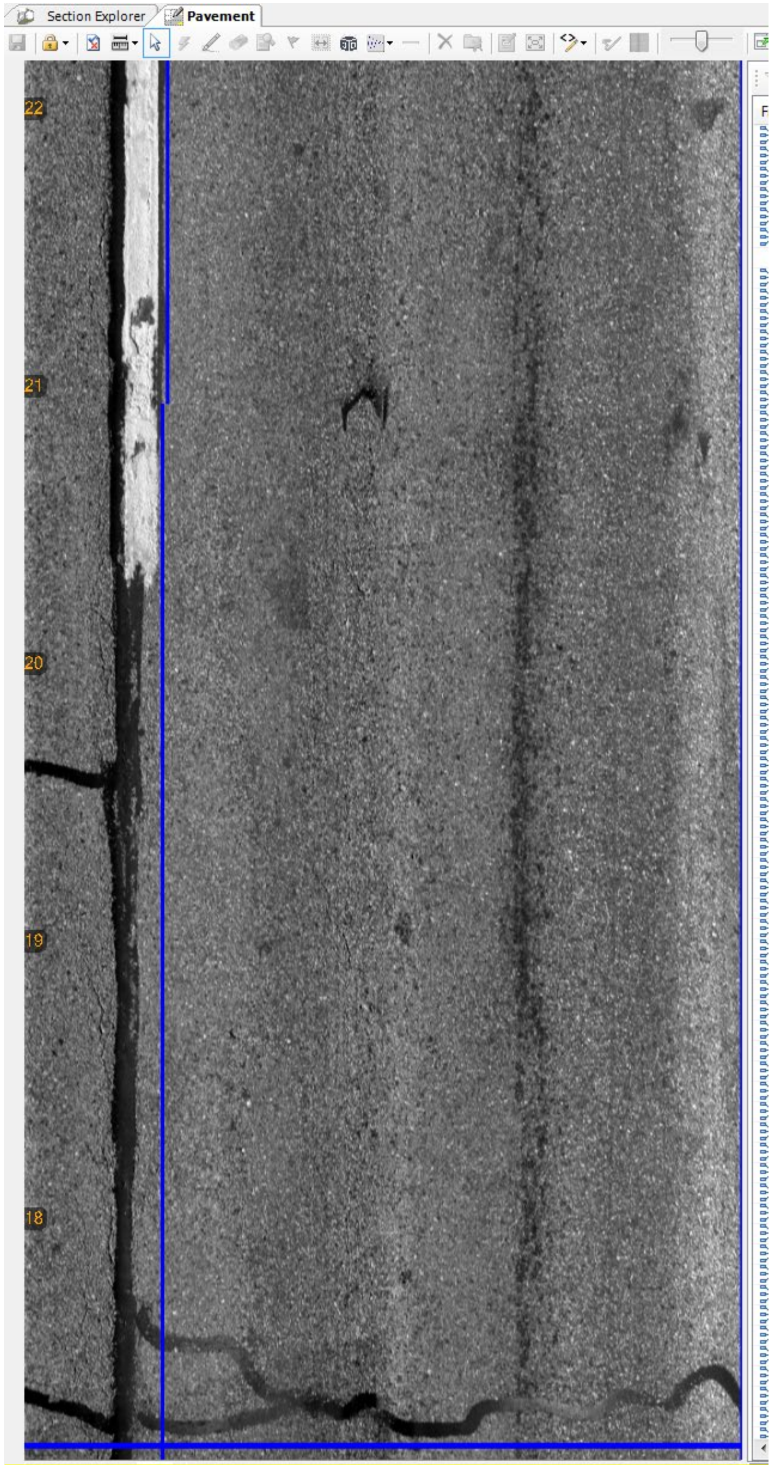
ii. Otherwise, refer to Test Loop Data Analysis Details for error resolution guidelines.



Step 4. Visually check the pavement images to make sure there is no image distortion or gap/overlap in the middle and along the length of the images (see below image).

i. If the images do not have issues, proceed to Step 5.

ii. Otherwise, refer to [Test Loop Data Analysis Details](#) for error resolution guidelines.



2- Perform Drive-through for Lane Adjustment and Pavement Event Flagging and Generate Test Loop QC Report – *performed by DPT Staff Member*

Summary: Under this task, the Vision software is used to analyze the LCMS output, correct errors in crack or joint detection, and mark events. Additionally, a QC report in MS Excel is created and results of the DPT QC checks are populated prior to submittal to the DAT for the subsequent tasks.

Step 5. Follow Performing 100% Drive Through for performing drive-through of pavement images and LCMS output. Confirm the accuracy of GPS readings.

Step 6. Open the "Test Loop Quality Control Summary Report" MS Excel template and create a new file with the following naming scheme: "ARAN#_ COLLECTIONDATETL_QC_REPORT_ANALYSISDATE"[06/12/2019]. Complete the required fields and submit MS Excel template to the DAT staff member that will perform the subsequent tasks (see below image).

Date: 7/18/2018

TEST LOOP QUALITY CONTROL SUMMARY REPORT

Attribute		Checked By	Satisfactory	Unsatisfactory	Comment	Action
Upload / Import		VC	✓			
Pavement Cracking Imagery	Image Aspect Ratio	VC	✓			
	Imaging Interval	VC	✓			
	Overlap/Gap	VC	✓			
Test Loop Locators	GPS Accuracy	VC	✓			
	DMI	SS	✓			
Performance Measures	IRI	SS	✓			
	SCD (Crack)	SS	✓			
	FCD (Crack)	SS	✓			
	RUT	SS	✓			
	Crossfall	SS	✓			

Done by DPT

Done by DAT

List of Files:		General Comments: The report has been uploaded into EDW. A number of sections had values that fell outside the expected range with a very small margin. However, the measured values were consistent for the three runs.
87I0T4Q2		
87I0U4OM		
87I0V4SY		

i. Under "List of Files," enter the names of the files being reviewed.

ii. Next to "Upload/Import," place a check mark under the "Satisfactory" cell heading and enter reviewer initials under the "Checked By" cell heading (see above image). If the upload/import was not successfully completed, resolve issue before continuing.

iii. Next to "Image Aspect Ratio," place a check mark under the "Satisfactory" or "Unsatisfactory" cell heading based on the review completed in Step 2 and enter reviewer initials under the "Checked By" cell heading. If the review was "Unsatisfactory," provide an explanation under the "Comment" cell heading and the required action under the "Action" cell heading (see above image).

iv. Next to "Imaging Interval," place a check mark under the "Satisfactory" or "Unsatisfactory" cell heading based on the review completed in Step 3 and enter reviewer initials under the "Checked By" cell heading. If the review was "Unsatisfactory," provide an explanation under the "Comment" cell heading and the required action under the "Action" cell heading (see above image).

v. Next to “Overlap/Gap,” place a check mark under the “Satisfactory” or “Unsatisfactory” cell heading based on the review completed in Step 4 and enter reviewer initials under the “Checked By” cell heading. If the review was “Unsatisfactory”, provide an explanation under the “Comment” cell heading and the required action under the “Action” cell heading (see above image).

vi. Next to “GPS Accuracy,” place a check mark under the “Satisfactory” or “Unsatisfactory” cell heading based on the review completed in Step 5 and enter reviewer initials under the “Checked By” cell heading. If the review was “Unsatisfactory,” provide an explanation under the “Comment” cell heading and the required action under the “Action” cell heading (see above image).

3- Perform Condition Data QC and Update Test Loop QC Report – *performed by DAT Staff Member*

Summary: Under this task, the various condition data metrics from the MDOT-SHA test loop are reviewed against ground truth measurements. Additionally, the QC report created during the DPT QC checks is updated with the results of the DAT review.

Step 7. Open the “TL Condition QC” MS Excel template and create a new file with the date of the test loop data collection being reviewed[06/12/2019].

Step 8. Paste raw data from the test loop collection effort as directed in the “Paste” worksheet” (see below image).

select	MP_SUFFIX	SEC_LENGTH	AVG_IRI	AVG_SCD	AVG_FCD	AVG_RUT	AVG_CROSSFALL
PASTE HERE →	1	626.647	215.158	17.16	13.187	0.4381	1.709
	2	911.902	134.894	16.9	23.707	0.2744	1.532
	3	320.485	204.875	20.787	23.74	0.2359	2.561
	4	110.753	244.531	22.983	46.263	0.4208	5.221
	5	218.556	123.35	1.493	5.643	0.1794	1.741
	6	896.532	85.697	0.873	5.073	0.1589	-0.88
	7	225.441	104.589	0.673	3.91	0.3006	1.771
	8	67.728	147.546	0.363	2.28	0.3163	1.733
	9	189.044	169.978	1.45	4.517	0.3483	5.893
	10	107.994	235.688	1.283	2.003	0.3906	1.597
	11	360.513	133.755	0.463	1.49	0.3925	0.605
	12	875.785	68.889	0.883	1.787	0.2471	1.678
	13	103.264	64.892	0.707	2.177	0.0975	1.947
	14	473.894	83.486	1.29	4.183	0.1165	2.782
	15	193.118	161.267	2.933	6.4	0.157	2.977
	16	183.14	153.833	2.357	14.6	0.2918	-2.779
	17	131.849	96.504	0.533	0.5	0.1111	-0.516

Step 9. Click over to the “Main” worksheet. Values for the current test loop data collection will populate in the spreadsheet for the following metrics under the “2018 Measured”[06/12/2019] column: International Roughness Index (IRI), Rut, Structural Cracking (SC) Density, Functional Cracking (FC) Density, CrossFall, and Distance Measuring Instrument (DMI).

Step 10. Review DMI data in Columns “AM” and “AN.” There is only one section for evaluating DMI. The cell in Column “AN” with a bold box around it should be populated with "Pass." Further details regarding the comparison criteria can be found in Test Loop Data Analysis Details.

i. If the bold box reads "Pass," check is complete.

ii. If the bold box reads "Fail," investigate the magnitude of the range error before continuing.

Step 11. Review the IRI data in Columns "I" and "J" (see below image). Any cell in Column "J" with a bold box around should be populated with "Pass." Further details regarding the comparison criteria can be found in Test Loop Data Analysis Details.

i. If all or most bold boxes read "Pass," check is complete.

ii. If there are several bold boxes that read "Fail", investigate the magnitude of the range errors before continuing.

	A	B	C	D	E	F	G	H	I	J
1	MP_SUFFIX	Route Name	SEC_LENGTH	IRI						
2				2017 5th	2017 95th	2018 AVG	2018 Low	2018 High	2018 Measured	Check
3	1	1-MD-176 E - Res 2000 Comp-Sealed Crack - Asphalt	627.34	180.524	227.602	217.18	193.641	240.719	215.158	Pass
4	2	2-MD-176 E - Res 2002 Comp-Asphalt	912.66	125.109	142.635	133.918	125.155	142.681	134.894	Pass
5	3	3-MD-176 E - Transition and Exit lane Comp-Sealed Crack - Asphalt	317.55	172.159	200.412	199.604	185.4775	213.7305	204.875	Pass
6	4	4-Ramp from MD-176 E to I-97 S Asphalt - Ramp	109.09	206.445	235.993	263.139	248.365	277.913	244.531	Fail
7	5	5-I-97 S Lane Transition JCP	223.47	111.155	124.887	128.004	121.138	134.87	123.35	Pass
8	6	6-I-97 S CRCP	894.89	83.897	88.607	85.656	83.301	88.011	85.697	Pass
9	7	7-I-97 S Lane Transition CRCP/JCP	225.09	96.527	110.45	103.358	96.3965	110.3195	104.589	Pass
10	8	8-I-97 S Decel Lane JCP	67.28	135.568	171.861	160.912	142.7655	179.0585	147.546	Pass
11	9	9-Ramp from I-97 S to MD-174 W Asphalt - Ramp	188.94	150.744	184.739	166.469	149.4715	183.4665	169.978	Pass
12	10	10-MD-174 W RS2004 Asphalt	108.57	226.593	266.458	249.252	229.3195	269.1845	235.688	Pass
13	11	11-MD-174 W 2Lane (Resurfaced 2005) Asphalt	360.28	115.204	127.824	122.249	115.939	128.559	133.755	Fail
14	12	12-MD-174 W 1Lane (Resurfaced 2005) Asphalt	874.9	67.832	76.392	71	66.72	75.28	68.889	Pass
15	13	13-MD-174 W (Rut section # 1) Asphalt	105.4	61.889	72.148	64.858	59.7285	69.9875	64.892	Pass
16	14	14-MD-174 W 1Lane (Resurfaced 2005) Asphalt	472.05	77.496	89.8	79.912	73.76	86.064	83.486	Pass
17	15	15-MD-174 W 2Lane (Resurfaced 2005) Asphalt	192.6	122.032	170.035	149.636	125.6345	173.6375	161.267	Pass
18	16	16-MD-174 W Transition Decel Lane Asphalt	185.22	137.058	166.778	157.105	142.245	171.965	153.833	Pass
19	17	17-MD-170 N 2Lane Asphalt	134.58	68.342	113.095	87.671	65.2945	110.0475	96.504	Pass
20	18	18-MD-170 N 1Lane Asphalt	360.1	91.61	98.978	94.531	90.847	98.215	93.858	Pass
21	19	19-MD-170 N 2Lane Asphalt	170.22	78.378	92.355	88.944	81.9555	95.9325	89.988	Pass
22	20	20-Ramp from MD-170 N to MD 100 E Asphalt	570.03	78.348	84.197	81.219	78.2945	84.1435	82.764	Pass
23	21	21-MD-100 Asphalt	301.94	70.741	76.061	74.139	71.479	76.799	73.679	Pass
24	22	22-MD-100 (one mile survey-dmi) Asphalt	1002.15	75.444	79.212	77.077	75.193	78.961	77.191	Pass
25	23	23-Exit Ramp from MD-100 Asphalt	505.89	92.504	105.392	101.102	94.658	107.546	102.012	Pass
26	24	24-ramp from MD 100 E to I 97 N Asphalt	259.18	122.633	139.993	137.95	129.27	146.63	131.945	Pass
27	25	25-Bridge on the ramp from MD 100 E to I 97 N Concrete Bridge Deck	39.9	136.323	188.265	169.39	143.419	195.361	162.69	Pass
28	26	26-ramp from MD-100 E to I-97 N Asphalt	268.82	119.542	130.877	126.802	121.1345	132.4695	127.37	Pass
29	27	27-I-97 N Accel Lane Transition JCP	263.61	99.211	136.123	115.257	96.801	133.713	124.009	Pass
30	28	28-I-97 N CRCP	108.28	102.022	117.481	106.724	98.9945	114.4535	110.651	Pass
31	29	29-I-97 N - lane change - exit 15 JCP	249.91	94.16	111.077	101.216	92.7575	109.6745	102.06	Pass
32	30	30-I-97 N CRCP	369.11	106.909	116.477	111.508	106.724	116.292	109.624	Pass
33	31	31-I-97 N Bridge App - IRI Ground Truth Asphalt Approach	50.96	94.463	123.993	110.226	95.461	124.991	105.807	Pass
34	32	32-I-97 N Bridge Concrete Bridge Deck	55.84	139.608	155.853	147.85	139.7275	155.9725	148.225	Pass
35	33	33-I-97 N Asphalt Departure Asphalt	23.42	148.395	227.004	305.895	266.5905	345.1995	264.783	Fail
36	34	34-I-97 N Decel lane - Exit 15 B CRCP (Left)/JCP (Right)	60.43	130.487	153.713	136.647	125.034	148.26	158.697	Fail
37	35	35-Ramp from I-97 N to MD-176 W JCP	60.86	224.325	253.923	239.715	224.916	254.514	231.862	Pass
38	36	36-Ramp from I-97 N to MD-176 W Asphalt	179.49	180.539	203.864	194.402	182.7395	206.0645	195.364	Pass
39	37	37-MD-176 W (Resurfaced 1997) Asphalt	301.12	119.232	130.49	127.648	122.019	133.277	120.43	Fail
40	38	38-MD-176 W (Resurfaced 2002) Asphalt	43.55	124.805	147.586	135.875	124.4845	147.2655	133.81	Pass
41	39	39-MD-176 W (Rut section # 2) Asphalt	53.49	112.84	212.266	143.107	93.394	192.82	128.1	Pass
42	40	40-MD-176 W Asphalt	213.13	111.858	132.384	129.8	119.537	140.063	144.529	Fail
43	41	41-MD-176 W (Rut section # 3) Asphalt	100.41	95.34	116.661	107.294	96.6335	117.9545	107.391	Pass
44	42	42-MD-176 W Asphalt	622.12	114.189	127.987	124.502	117.603	131.401	127.708	Pass
45	43	43-MD-176 W (Rut section # 4) Asphalt	105.37	125.015	143.462	133.825	124.6015	143.0485	142.345	Pass
46	44	44-MD-176 W Asphalt	97.61	128.515	162.132	141.811	125.0025	158.6195	172.747	Fail
47	45	45-MD-176 W Asphalt	627.49	104.348	112.868	107.539	103.279	111.799	113.037	Fail

Step 12. Review the rutting data in Columns "P" and "Q" (see below image). Any cell in Column "Q" with a bold box around it should be populated with "Pass." Further details regarding the comparison criteria can be found in Test Loop Data Analysis Details.

i. If all or most bold boxes read "Pass," check is complete.

ii. If there are several bold boxes that read "Fail," investigate the magnitude of the range errors before continuing.

	A	B	C	K	L	M	N	O	P	Q
1	MP_SUFFIX	Route Name	SEC_LENGTH	RUT						
2				2017 5th	2017 95th	2018 AVG	2018 Low	2018 High	2018 Measured	Check
3	1	1-MD-176 E - Res 2000 Comp-Sealed Crack - Asphalt	627.34	0.4097	0.4435	0.4327	0.4158	0.4496	0.4381	Pass
4	2	2-MD-176 E - Res 2002 Comp-Asphalt	912.66	0.2434	0.2634	0.2718	0.2618	0.2818	0.2744	Pass
5	3	3-MD-176 E - Transition and Exit lane Comp-Sealed Crack - Asphalt	317.55	0.2051	0.2607	0.2367	0.2089	0.2645	0.2359	Pass
6	4	4-Ramp from MD-176 E to I-97 S Asphalt - Ramp	109.09	0.3682	0.4134	0.4136	0.391	0.4362	0.4208	Pass
7	5	5-I-97 S Lane Transition JCP	223.47	0.1763	0.24	0.1775	0.14565	0.20935	0.1794	Pass
8	6	6-I-97 S CRCP	894.89	0.1378	0.1683	0.1549	0.13965	0.17015	0.1589	Pass
9	7	7-I-97 S Lane Transition CRCP/JCP	225.09	0.2613	0.3748	0.279	0.22225	0.33575	0.3006	Pass
10	8	8-I-97 S Decel Lane JCP	67.28	0.2743	0.3297	0.3106	0.2829	0.3383	0.3163	Pass
11	9	9-Ramp from I-97 S to MD-174 W Asphalt - Ramp	188.94	0.2832	0.3311	0.3236	0.29965	0.34755	0.3483	Fail
12	10	10-MD-174 W RS2004 Asphalt	108.57	0.3602	0.4387	0.3926	0.35335	0.43185	0.3906	Pass
13	11	11-MD-174 W 2Lane (Resurfaced 2005) Asphalt	360.28	0.3426	0.3826	0.3688	0.3488	0.3888	0.3925	Fail
14	12	12-MD-174 W 1Lane (Resurfaced 2005) Asphalt	874.9	0.1996	0.2412	0.2264	0.2056	0.2472	0.2471	Pass
15	13	13-MD-174 W (Rut section # 1) Asphalt	105.4	0.0822	0.1029	0.0984	0.08805	0.10875	0.0975	Pass
16	14	14-MD-174 W 1Lane (Resurfaced 2005) Asphalt	472.05	0.1065	0.1251	0.1098	0.1005	0.1191	0.1165	Pass
17	15	15-MD-174 W 2Lane (Resurfaced 2005) Asphalt	192.6	0.1399	0.1745	0.1517	0.1344	0.169	0.157	Pass
18	16	16-MD-174 W Transition Decel Lane Asphalt	185.22	0.2901	0.3794	0.3186	0.27395	0.36325	0.2918	Pass
19	17	17-MD-170 N 2Lane Asphalt	134.58	0.0832	0.1148	0.1005	0.0847	0.1163	0.1111	Pass
20	18	18-MD-170 N 1Lane Asphalt	360.1	0.087	0.1086	0.1091	0.0983	0.1199	0.1245	Fail
21	19	19-MD-170 N 2Lane Asphalt	170.22	0.1316	0.1608	0.1474	0.1328	0.162	0.1849	Fail
22	20	20-Ramp from MD-170 N to MD 100 E Asphalt	570.03	0.1229	0.1437	0.1392	0.1288	0.1496	0.1578	Fail
23	21	21-MD-100 Asphalt	301.94	0.2123	0.2394	0.2201	0.20655	0.23365	0.2259	Pass
24	22	22-MD-100 (one mile survey-dmi) Asphalt	1002.15	0.267	0.2975	0.2843	0.26905	0.29955	0.299	Pass
25	23	23-Exit Ramp from MD-100 Asphalt	505.89	0.2033	0.2275	0.2133	0.2012	0.2254	0.225	Pass
26	24	24-ramp from MD 100 E to I 97 N Asphalt	259.18	0.1572	0.1736	0.1684	0.1602	0.1766	0.1777	Fail
27	25	25-Bridge on the ramp from MD 100 E to I 97 N Concrete Bridge Deck	39.9	0.1226	0.1627	0.1407	0.12065	0.16075	0.1449	Pass
28	26	26-ramp from MD-100 E to I-97 N Asphalt	268.82	0.1268	0.1574	0.136	0.1207	0.1513	0.1466	Pass
29	27	27-I-97 N Accel Lane Transition JCP	263.61	0.2064	0.2804	0.2061	0.1691	0.2431	0.2471	Fail
30	28	28-I-97 N CRCP	108.28	0.1783	0.2331	0.1831	0.1557	0.2105	0.189	Pass
31	29	29-I-97 N - lane change - exit 15 JCP	249.91	0.2046	0.271	0.2019	0.1687	0.2351	0.2158	Pass
32	30	30-I-97 N CRCP	369.11	0.1079	0.1382	0.1113	0.09615	0.12645	0.1158	Pass
33	31	31-I-97 N Bridge App - IRI Ground Truth Asphalt Approach	50.96	0.1482	0.1897	0.1777	0.15695	0.19845	0.1964	Pass
34	32	32-I-97 N Bridge Concrete Bridge Deck	55.84	0.1201	0.1526	0.1364	0.12015	0.15265	0.1388	Pass
35	33	33-I-97 N Asphalt Departure Asphalt	23.42	0.1119	0.1423	0.122	0.1068	0.1372	0.1237	Pass
36	34	34-I-97 N Decel lane - Exit 15 B CRCP (Left)/JCP (Right)	60.43	0.199	0.2425	0.214	0.19225	0.23575	0.2252	Pass
37	35	35-Ramp from I-97 N to MD-176 W JCP	60.86	0.1779	0.2297	0.1984	0.1725	0.2243	0.2157	Pass
38	36	36-Ramp from I-97 N to MD-176 W Asphalt	179.49	0.2052	0.2289	0.2232	0.21135	0.23505	0.228	Pass
39	37	37-MD-176 W (Resurfaced 1997) Asphalt	301.12	0.1453	0.1943	0.1617	0.1372	0.1862	0.1573	Pass
40	38	38-MD-176 W (Resurfaced 2002) Asphalt	43.55	0.179	0.2424	0.2039	0.1722	0.2356	0.2069	Pass
41	39	39-MD-176 W (Rut section # 2) Asphalt	53.49	0.2621	0.3772	0.3399	0.28235	0.39745	0.3383	Pass
42	40	40-MD-176 W Asphalt	213.13	0.2424	0.2841	0.2772	0.25635	0.29805	0.2781	Pass
43	41	41-MD-176 W (Rut section # 3) Asphalt	100.41	0.2508	0.2813	0.2702	0.25495	0.28545	0.2838	Pass
44	42	42-MD-176 W Asphalt	622.12	0.3485	0.433	0.4201	0.37785	0.46235	0.4292	Pass
45	43	43-MD-176 W (Rut section # 4) Asphalt	105.37	0.6069	0.7959	0.7365	0.642	0.831	0.757	Pass
46	44	44-MD-176 W Asphalt	97.61	0.4307	0.5033	0.4879	0.4516	0.5242	0.494	Pass
47	45	45-MD-176 W Asphalt	627.49	0.225	0.2571	0.2378	0.22175	0.25385	0.2465	Pass

Step 13. Review the SC Density data in Columns “W” and “X” (see below image). Any cell in Column “X” with a bold box around it should be populated with “Pass.” Further details regarding the comparison criteria can be found in Test Loop Data Analysis Details.

i. If all or most bold boxes read “Pass,” check is complete.

ii. If there are several bold boxes that read “Fail,” investigate the magnitude of the range errors before continuing.

	A	B	C	R	S	T	U	V	W	X
1	MP_SUFFIX	Route Name	SEC_LENGTH	SC DENSITY						
2				2017 5th	2017 95th	2018 AVG	2018 Low	2018 High	2018 Measured	Check
3	1	1-MD-176 E - Res 2000 Comp-Sealed Crack - Asphalt	627.34	9.274	16.466	17.709	14.113	21.305	17.16	Pass
4	2	2-MD-176 E - Res 2002 Comp-Asphalt	912.66	9.494	16.372	16.814	13.375	20.253	16.9	Pass
5	3	3-MD-176 E - Transition and Exit lane Comp-Sealed Crack - Asphalt	317.55	10.55	19.952	21.555	16.854	26.256	20.787	Pass
6	4	4-Ramp from MD-176 E to I-97 S Asphalt - Ramp	109.09	13.586	23.2	21.718	16.911	26.525	22.983	Pass
7	5	5-I-97 S Lane Transition JCP	223.47	0.85	1.506	1.157	0.829	1.485	1.493	Fail
8	6	6-I-97 S CRCP	894.89	0.402	0.752	0.618	0.443	0.793	0.873	Fail
9	7	7-I-97 S Lane Transition CRCP/JCP	225.09	0.27	0.636	0.579	0.396	0.762	0.673	Pass
10	8	8-I-97 S Decel Lane JCP	67.28	0.116	0.528	0.277	0.071	0.483	0.363	Pass
11	9	9-Ramp from I-97 S to MD-174 W Asphalt - Ramp	188.94	0.576	3.376	2.029	0.629	3.429	1.45	Pass
12	10	10-MD-174 W RS2004 Asphalt	108.57	0.386	1.406	1.113	0.603	1.623	1.283	Pass
13	11	11-MD-174 W 2Lane (Resurfaced 2005) Asphalt	360.28	0.182	0.824	0.828	0.507	1.149	0.463	Fail
14	12	12-MD-174 W 1Lane (Resurfaced 2005) Asphalt	874.9	0.438	1.336	1.275	0.826	1.724	0.883	Pass
15	13	13-MD-174 W (Rut section # 1) Asphalt	105.4	0.21	0.81	0.709	0.409	1.009	0.707	Pass
16	14	14-MD-174 W 1Lane (Resurfaced 2005) Asphalt	472.05	0.548	1.488	1.225	0.755	1.695	1.29	Pass
17	15	15-MD-174 W 2Lane (Resurfaced 2005) Asphalt	192.6	1.552	4.076	2.977	1.715	4.239	2.933	Pass
18	16	16-MD-174 W Transition Decel Lane Asphalt	185.22	1.524	5.224	3.686	1.836	5.536	2.357	Pass
19	17	17-MD-170 N 2Lane Asphalt	134.58	0.144	1.358	0.722	0.115	1.329	0.533	Pass
20	18	18-MD-170 N 1Lane Asphalt	360.1	0.08	0.654	0.474	0.187	0.761	0.237	Pass
21	19	19-MD-170 N 2Lane Asphalt	170.22	0.08	1.48	0.18	-0.52	0.88	0.907	Fail
22	20	20-Ramp from MD-170 N to MD 100 E Asphalt	570.03	0.206	1.098	0.906	0.46	1.352	0.597	Pass
23	21	21-MD-100 Asphalt	301.94	0.112	1	0.506	0.062	0.95	0.44	Pass
24	22	22-MD-100 (one mile survey-dmi) Asphalt	1002.15	0.25	1.088	0.869	0.45	1.288	0.64	Pass
25	23	23-Exit Ramp from MD-100 Asphalt	505.89	3.006	5.578	6.174	4.888	7.46	6.397	Pass
26	24	24-ramp from MD 100 E to I 97 N Asphalt	259.18	0.9	2.727	2.522	1.6085	3.4355	2.147	Pass
27	25	25-Bridge on the ramp from MD 100 E to I 97 N Concrete Bridge Deck	39.9	0.016	0.195	0.103	0.0135	0.1925	0.087	Pass
28	26	26-ramp from MD-100 E to I-97 N Asphalt	268.82	1.19	2.36	1.82	1.235	2.405	2.163	Pass
29	27	27-I-97 N Accel Lane Transition JCP	263.61	0.24	0.65	0.477	0.272	0.682	0.36	Pass
30	28	28-I-97 N CRCP	108.28	0.806	2.266	1.359	0.629	2.089	1.233	Pass
31	29	29-I-97 N - lane change - exit 15 JCP	249.91	0.776	1.488	1.257	0.901	1.613	1.23	Pass
32	30	30-I-97 N CRCP	369.11	0.92	1.495	1.28	0.9925	1.5675	1.48	Pass
33	31	31-I-97 N Bridge App - IRI Ground Truth Asphalt Approach	50.96	0.21	1.307	0.792	0.2435	1.3405	0.767	Pass
34	32	32-I-97 N Bridge Concrete Bridge Deck	55.84	0.793	2.174	1.946	1.2555	2.6365	1.72	Pass
35	33	33-I-97 N Asphalt Departure Asphalt	23.42	0	0.492	0.117	-0.129	0.363	0.35	Pass
36	34	34-I-97 N Decel lane - Exit 15 B CRCP (Left)/JCP (Right)	60.43	0.07	0.355	0.191	0.0485	0.3335	0.23	Pass
37	35	35-Ramp from I-97 N to MD-176 W JCP	60.86	0.146	1.061	0.511	0.0535	0.9685	0.487	Pass
38	36	36-Ramp from I-97 N to MD-176 W Asphalt	179.49	11.333	19.761	17.615	13.401	21.829	19.133	Pass
39	37	37-MD-176 W (Resurfaced 1997) Asphalt	301.12	4.055	7.863	7.125	5.221	9.029	7.61	Pass
40	38	38-MD-176 W (Resurfaced 2002) Asphalt	43.55	6.263	14.387	13.465	9.403	17.527	13.207	Pass
41	39	39-MD-176 W (Rut section # 2) Asphalt	53.49	6.15	13.478	11.551	7.887	15.215	13.493	Pass
42	40	40-MD-176 W Asphalt	213.13	12.326	22.864	21.382	16.113	26.651	21.957	Pass
43	41	41-MD-176 W (Rut section # 3) Asphalt	100.41	24.325	41.601	41.024	32.386	49.662	42.847	Pass
44	42	42-MD-176 W Asphalt	622.12	22.314	36.063	35.492	28.6175	42.3665	36.78	Pass
45	43	43-MD-176 W (Rut section # 4) Asphalt	105.37	25.625	43.665	39.845	30.825	48.865	45.56	Pass
46	44	44-MD-176 W Asphalt	97.61	19.599	35.215	32.614	24.806	40.422	34.49	Pass
47	45	45-MD-176 W Asphalt	627.49	5.672	9.858	9.717	7.624	11.81	10.44	Pass

Step 14. Review the FC Density data in Columns “AD” and “AE” (see below image). Any cell in Column “AE” with a bold box around it should be populated with “Pass.” Further details regarding the comparison criteria can be found in Test Loop Data Analysis Details.

i. If all or most bold boxes read “Pass,” check is complete.

ii. If there are several bold boxes that read “Fail,” investigate the magnitude of the range errors before continuing.

	A	B	C	Y	Z	AA	AB	AC	AD	AE
1	MP_SUFFIX	Route Name	SEC_LENGTH	FC DENSITY						
2				2017 5th	2017 95th	2018 AVG	2018 Low	2018 High	2018 Measured	Check
3	1	1-MD-176 E - Res 2000 Comp-Sealed Crack - Asphalt	627.34	5.95	12.926	13.256	9.768	16.744	13.187	Pass
4	2	2-MD-176 E - Res 2002 Comp-Asphalt	912.66	11.942	23.212	23.472	17.837	29.107	23.707	Pass
5	3	3-MD-176 E - Transition and Exit lane Comp-Sealed Crack - Asphalt	317.55	11.088	23.332	22.368	16.246	28.49	23.74	Pass
6	4	4-Ramp from MD-176 E to I-97 S Asphalt - Ramp	109.09	24.834	47.632	46.733	35.334	58.132	46.263	Pass
7	5	5-I-97 S Lane Transition JCP	223.47	2.09	5.528	3.874	2.155	5.593	5.643	Fail
8	6	6-I-97 S CRCP	894.89	4.006	4.878	4.684	4.248	5.12	5.073	Pass
9	7	7-I-97 S Lane Transition CRCP/JCP	225.09	2.69	5.184	4.252	3.005	5.499	3.91	Pass
10	8	8-I-97 S Decel Lane JCP	67.28	1.604	3.61	2.045	1.042	3.048	2.28	Pass
11	9	9-Ramp from I-97 S to MD-174 W Asphalt - Ramp	188.94	1.89	4.568	4.355	3.016	5.694	4.517	Pass
12	10	10-MD-174 W RS2004 Asphalt	108.57	0.92	4.448	1.54	0	3.304	2.003	Pass
13	11	11-MD-174 W 2Lane (Resurfaced 2005) Asphalt	360.28	0.896	3.678	2.927	1.536	4.318	1.49	Fail
14	12	12-MD-174 W 1Lane (Resurfaced 2005) Asphalt	874.9	1.096	2.334	1.881	1.262	2.5	1.787	Pass
15	13	13-MD-174 W (Rut section # 1) Asphalt	105.4	0.972	3.824	1.967	0.541	3.393	2.177	Pass
16	14	14-MD-174 W 1Lane (Resurfaced 2005) Asphalt	472.05	2.262	4.714	3.898	2.672	5.124	4.183	Pass
17	15	15-MD-174 W 2Lane (Resurfaced 2005) Asphalt	192.6	3.42	7.814	6.988	4.791	9.185	6.4	Pass
18	16	16-MD-174 W Transition Decel Lane Asphalt	185.22	9.86	18.496	17.715	13.397	22.033	14.6	Pass
19	17	17-MD-170 N 2Lane Asphalt	134.58	0.136	1.106	0.475	0	0.96	0.5	Pass
20	18	18-MD-170 N 1Lane Asphalt	360.1	0.076	0.566	0.248	0.003	0.493	1.14	Fail
21	19	19-MD-170 N 2Lane Asphalt	170.22	0.07	0.392	0.529	0.368	0.69	1.46	Fail
22	20	20-Ramp from MD-170 N to MD 100 E Asphalt	570.03	0.466	0.994	0.71	0.446	0.974	0.533	Pass
23	21	21-MD-100 Asphalt	301.94	1.338	5.152	3.89	1.983	5.797	2.843	Pass
24	22	22-MD-100 (one mile survey-dmi) Asphalt	1002.15	1.694	4.938	3.984	2.362	5.606	3.127	Pass
25	23	23-Exit Ramp from MD-100 Asphalt	505.89	3.278	6.774	7.446	5.698	9.194	7.957	Pass
26	24	24-ramp from MD 100 E to I 97 N Asphalt	259.18	1.792	3.48	3.306	2.462	4.15	3.18	Pass
27	25	25-Bridge on the ramp from MD 100 E to I 97 N Concrete Bridge Deck	39.9	0.184	1.611	0.862	0.1485	1.5755	0.583	Pass
28	26	26-ramp from MD-100 E to I-97 N Asphalt	268.82	2.303	11.718	5.468	0.7605	10.1755	6.657	Pass
29	27	27-I-97 N Accel Lane Transition JCP	263.61	1.323	2.277	1.9	1.423	2.377	1.753	Pass
30	28	28-I-97 N CRCP	108.28	5.906	9.576	7.758	5.923	9.593	7.16	Pass
31	29	29-I-97 N - lane change - exit 15 JCP	249.91	1.362	3.581	2.065	0.9555	3.1745	1.58	Pass
32	30	30-I-97 N CRCP	369.11	9.411	12.801	12.099	10.404	13.794	13.137	Pass
33	31	31-I-97 N Bridge App - IRI Ground Truth Asphalt Approach	50.96	0.14	2.034	0.872	0	1.819	0.84	Pass
34	32	32-I-97 N Bridge Concrete Bridge Deck	55.84	0.887	3.215	2.231	1.067	3.395	1.613	Pass
35	33	33-I-97 N Asphalt Departure Asphalt	23.42	0.04	2.378	0.575	0	1.744	0.363	Pass
36	34	34-I-97 N Decel lane - Exit 15 B CRCP (Left)/JCP (Right)	60.43	1.054	3.392	2.64	1.471	3.809	2.55	Pass
37	35	35-Ramp from I-97 N to MD-176 W JCP	60.86	2.103	7.13	3.29	0.7765	5.8035	4.177	Pass
38	36	36-Ramp from I-97 N to MD-176 W Asphalt	179.49	17.546	46.219	37.216	22.8795	51.5525	43.06	Pass
39	37	37-MD-176 W (Resurfaced 1997) Asphalt	301.12	12.162	24.529	20.263	14.0795	26.4465	22.813	Pass
40	38	38-MD-176 W (Resurfaced 2002) Asphalt	43.55	14.908	29.377	24.105	16.8705	31.3395	28.787	Pass
41	39	39-MD-176 W (Rut section # 2) Asphalt	53.49	10.969	26.912	22.368	14.3965	30.3395	27.02	Pass
42	40	40-MD-176 W Asphalt	213.13	17.225	39.64	34.914	23.7065	46.1215	35.793	Pass
43	41	41-MD-176 W (Rut section # 3) Asphalt	100.41	30.984	59.489	53.81	39.5575	68.0625	59.093	Pass
44	42	42-MD-176 W Asphalt	622.12	38.059	64.137	61.626	48.587	74.665	69.85	Pass
45	43	43-MD-176 W (Rut section # 4) Asphalt	105.37	36.133	67.429	62.116	46.468	77.764	72.957	Pass
46	44	44-MD-176 W Asphalt	97.61	25.011	47.368	42.428	31.2495	53.6065	45.54	Pass
47	45	45-MD-176 W Asphalt	627.49	9.682	18.076	16.426	12.229	20.623	19.89	Pass

Step 15. Review the crossfall data in Columns "AK" and "AL" (see below image). Any cell in Column "AL" with a bold box around it should be populated with "Pass," Further details regarding the comparison criteria can be found in Test Loop Data Analysis Details.

i. If all or most bold boxes read "Pass", check is complete.

ii. If there are several bold boxes that read "Fail", investigate the magnitude of the range errors before continuing.

	A	B	C	AF	AG	AH	AI	AJ	AK	AL
1	MP_SUFFIX	Route Name	SEC_LENGTH	CrossFall						
2				2017 5th	2017 95th	2018 AVG	2018 Low	2018 High	2018 Measured	Check
3	1	1-MD-176 E - Res 2000 Comp-Sealed Crack - Asphalt	627.34	1.702	1.867	1.758	1.6755	1.8405	1.709	Pass
4	2	2-MD-176 E - Res 2002 Comp-Asphalt	912.66	1.536	1.686	1.603	1.528	1.678	1.532	Pass
5	3	3-MD-176 E - Transition and Exit lane Comp-Sealed Crack - Asphalt	317.55	2.256	2.757	2.483	2.2325	2.7335	2.561	Pass
6	4	4-Ramp from MD-176 E to I-97 S Asphalt - Ramp	109.09	5.221	5.424	5.267	5.1655	5.3685	5.221	Pass
7	5	5-I-97 S Lane Transition JCP	223.47	1.593	1.913	1.744	1.584	1.904	1.741	Pass
8	6	6-I-97 S CRCP	894.89	-0.931	-0.696	-0.855	-0.9725	-0.7375	-0.88	Pass
9	7	7-I-97 S Lane Transition CRCP/JCP	225.09	1.787	2.027	1.874	1.754	1.994	1.771	Pass
10	8	8-I-97 S Decel Lane JCP	67.28	1.794	1.971	1.872	1.7835	1.9605	1.733	Fail
11	9	9-Ramp from I-97 S to MD-174 W Asphalt - Ramp	188.94	5.855	6.2	5.983	5.8105	6.1555	5.893	Pass
12	10	10-MD-174 W RS2004 Asphalt	108.57	1.581	2.015	1.719	1.502	1.936	1.597	Pass
13	11	11-MD-174 W 2Lane (Resurfaced 2005) Asphalt	360.28	0.59	0.826	0.693	0.575	0.811	0.605	Pass
14	12	12-MD-174 W 1Lane (Resurfaced 2005) Asphalt	874.9	1.715	1.899	1.803	1.711	1.895	1.678	Fail
15	13	13-MD-174 W (Rut section # 1) Asphalt	105.4	1.99	2.42	2.305	2.09	2.52	1.947	Fail
16	14	14-MD-174 W 1Lane (Resurfaced 2005) Asphalt	472.05	2.715	2.971	2.883	2.755	3.011	2.782	Pass
17	15	15-MD-174 W 2Lane (Resurfaced 2005) Asphalt	192.6	2.622	3.241	2.963	2.6535	3.2725	2.977	Pass
18	16	16-MD-174 W Transition Decel Lane Asphalt	185.22	-2.784	-2.605	-2.716	-2.8055	-2.6265	-2.779	Pass
19	17	17-MD-170 N 2Lane Asphalt	134.58	-1.615	1.12	-0.828	-2.1955	0.5395	-0.516	Pass
20	18	18-MD-170 N 1Lane Asphalt	360.1	-1.633	-1.454	-1.588	-1.6775	-1.4985	-1.613	Pass
21	19	19-MD-170 N 2Lane Asphalt	170.22	1.344	1.52	1.405	1.317	1.493	1.385	Pass
22	20	20-Ramp from MD-170 N to MD 100 E Asphalt	570.03	1.532	2.011	1.829	1.5895	2.0685	1.856	Pass
23	21	21-MD-100 Asphalt	301.94	3.545	3.774	3.579	3.4645	3.6935	3.519	Pass
24	22	22-MD-100 (one mile survey-dmi) Asphalt	1002.15	1.075	1.269	1.097	1	1.194	1.023	Pass
25	23	23-Exit Ramp from MD-100 Asphalt	505.89	4.051	4.202	4.117	4.0415	4.1925	4.072	Pass
26	24	24-ramp from MD 100 E to I 97 N Asphalt	259.18	-4.281	-3.994	-4.118	-4.2615	-3.9745	-4.164	Pass
27	25	25-Bridge on the ramp from MD 100 E to I 97 N Concrete Bridge Deck	39.9	1.833	2.034	1.919	1.8185	2.0195	1.856	Pass
28	26	26-ramp from MD-100 E to I-97 N Asphalt	268.82	7.169	7.472	7.284	7.1325	7.4355	7.232	Pass
29	27	27-I-97 N Accel Lane Transition JCP	263.61	1.839	2.162	1.943	1.7815	2.1045	1.778	Fail
30	28	28-I-97 N CRCP	108.28	3.021	3.226	3.062	2.9595	3.1645	3.037	Pass
31	29	29-I-97 N - lane change - exit 15 JCP	249.91	3.091	3.779	3.533	3.189	3.877	3.581	Pass
32	30	30-I-97 N CRCP	369.11	2.288	2.482	2.343	2.246	2.44	2.312	Pass
33	31	31-I-97 N Bridge App - IRI Ground Truth Asphalt Approach	50.96	1.466	1.637	1.516	1.4305	1.6015	1.474	Pass
34	32	32-I-97 N Bridge Concrete Bridge Deck	55.84	1.401	1.595	1.462	1.365	1.559	1.415	Pass
35	33	33-I-97 N Asphalt Departure Asphalt	23.42	1.378	1.611	1.451	1.3345	1.5675	1.399	Pass
36	34	34-I-97 N Decel lane - Exit 15 B CRCP (Left)/JCP (Right)	60.43	1.665	1.806	1.699	1.6285	1.7695	1.624	Fail
37	35	35-Ramp from I-97 N to MD-176 W JCP	60.86	4.568	4.722	4.577	4.5	4.654	4.512	Pass
38	36	36-Ramp from I-97 N to MD-176 W Asphalt	179.49	6.791	6.959	6.829	6.745	6.913	6.787	Pass
39	37	37-MD-176 W (Resurfaced 1997) Asphalt	301.12	1.397	1.775	1.593	1.404	1.782	1.638	Pass
40	38	38-MD-176 W (Resurfaced 2002) Asphalt	43.55	1.945	2.169	2.048	1.936	2.16	1.956	Pass
41	39	39-MD-176 W (Rut section # 2) Asphalt	53.49	1.538	1.793	1.562	1.4345	1.6895	1.465	Pass
42	40	40-MD-176 W Asphalt	213.13	0.534	0.709	0.586	0.4985	0.6735	0.536	Pass
43	41	41-MD-176 W (Rut section # 3) Asphalt	100.41	2.01	2.229	2.1	1.9905	2.2095	2.075	Pass
44	42	42-MD-176 W Asphalt	622.12	2.222	2.397	2.274	2.1865	2.3615	2.202	Pass
45	43	43-MD-176 W (Rut section # 4) Asphalt	105.37	2.525	2.757	2.589	2.473	2.705	2.334	Fail
46	44	44-MD-176 W Asphalt	97.61	2.488	2.738	2.576	2.451	2.701	2.554	Pass
47	45	45-MD-176 W Asphalt	627.49	1.906	2.038	1.968	1.902	2.034	1.898	Fail

Step 16. Open the "Test Loop Quality Control Summary Report" MS Excel file created by the DPT. Complete the fields listed and submit to the DPT, DAT, and FED team leaders for review (see below image).

Date: 7/18/2018

TEST LOOP QUALITY CONTROL SUMMARY REPORT

Attribute		Checked By	Satisfactory	Unsatisfactory	Comment	Action
Upload / Import		VC	✓			
Pavement Cracking Imagery	Image Aspect Ratio	VC	✓			
	Imaging Interval	VC	✓		Done by DPT	
	Overlap/Gap	VC	✓			
Test Loop Locators	GPS Accuracy	VC	✓			
	DMI	SS	✓			
Performance Measures	IRI	SS	✓			
	SCD (Crack)	SS	✓		Done by DAT	
	FCD (Crack)	SS	✓			
	RUT	SS	✓			
	Crossfall	SS	✓			

List of Files:		General Comments: The report has been uploaded into EDW. A number of sections had values that fell outside the expected range with a very small margin. However, the measured values were consistent for the three runs.
87I0T4Q2		
87I0U4OM		
87I0V4SY		

i. Place the correct date in the “Date” cell (see above image).

ii. Next to “DMI,”, place a check mark under the “Satisfactory” or “Unsatisfactory” cell heading based on the review completed in Step 10 and enter reviewer initials under the “Checked By” cell heading. If the review was “Unsatisfactory,” meaning that the section value failed and the magnitude of the range error was high, provide an explanation under the “Comment” cell heading and the required action under the “Action” cell heading (see above image).

iii. Next to “IRI,” place a check mark under the “Satisfactory” or “Unsatisfactory” cell heading based on the review completed in Step 11 and enter reviewer initials under the “Checked By” cell heading. If the review was “Unsatisfactory,” meaning that the number of failed sections was substantial and the magnitude of range errors was high, provide an explanation under the “Comment” cell heading and the required action under the “Action” cell heading (see above image).

iv. Next to “RUT”, place a check mark under the “Satisfactory” or “Unsatisfactory” cell heading based on the review completed in Step 12 and enter reviewer initials under the “Checked By” cell heading. If the review was “Unsatisfactory,” meaning that the number of failed sections was substantial and the magnitude of range errors was high, provide an explanation under the “Comment” cell heading and the required action under the “Action” cell heading (see above image).

v. Next to “SCD (Crack)”, place a check mark under the “Satisfactory” or “Unsatisfactory” cell heading based on the review completed in Step 13 and enter reviewer initials under the “Checked By” cell heading If the review was “Unsatisfactory,” meaning that the number of failed sections was substantial and the magnitude of range errors was high, provide an explanation under the “Comment” cell heading and the required action under the “Action” cell heading (see above image).

vi. Next to “FCD (Crack)”, place a check mark under the “Satisfactory” or “Unsatisfactory” cell heading based on the review completed in Step 14 and enter reviewer initials under the “Checked By” cell heading. If the review was “Unsatisfactory,” meaning that the number of failed sections was substantial and the magnitude of range errors was high, provide an explanation under the “Comment” cell heading and the required action under the “Action” cell heading (see above image).

vii. Next to “Crossfall”, place a check mark under the “Satisfactory” or “Unsatisfactory” cell heading based on the review completed in Step 15 and enter reviewer initials under the “Checked By” cell heading. If the review was “Unsatisfactory,” meaning that the number of failed sections was substantial and the magnitude of range errors was high, provide an explanation under the “Comment” cell heading and the required action under the “Action” cell heading (see above image).

4- Submit Test Loop QC Report – *performed by DAT Staff Member and Team Leaders*

Summary: Under this task, the results of the MDOT-SHA test loop data analysis are documented and reported.

Step 17. Ensure that MDOT-SHA "Test Loop Quality Control Summary Report" is fully populated (see below image). This is done by a DAT staff member.

i. If report is complete, send report to DAT, DPT, and FED TLs.

ii. If report is incomplete, fill in missing sections or ask DPT Staff Member to fill in those missing sections, depending on which portion of the report is incomplete.

Date: 7/18/2018

TEST LOOP QUALITY CONTROL SUMMARY REPORT

Attribute		Checked By	Satisfactory	Unsatisfactory	Comment	Action
Upload / Import		VC	✓			
Pavement Cracking Imagery	Image Aspect Ratio	VC	✓			
	Imaging Interval	VC	✓			
	Overlap/Gap	VC	✓			
	GPS Accuracy	VC	✓			
Test Loop Locators	DMI	SS	✓			
Performance Measures	IRI	SS	✓			
	SCD (Crack)	SS	✓			
	FCD (Crack)	SS	✓			
	RUT	SS	✓			
	Crossfall	SS	✓			

Done by DPT

Done by DAT

List of Files:	
87I0T4Q2	
87I0U4OM	
87I0V4SY	

General Comments: The report has been uploaded into EDW. A number of sections had values that fell outside the expected range with a very small margin. However, the measured values were consistent for the three runs.

Step 18. The report resulting from Step 17 is checked by the DAT, DPT, and FED TLs.

i. If no issues are identified, communicate results to other team leaders and save report to proper location.

ii. If issues are identified, discuss with relevant parties and determine proper course of action. Once issues have been resolved, save report to proper location.

3.08 SKID PRE-DATA COLLECTION ACTIONS

3.08.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Field Explorations Division (FED) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to perform route planning, safety checks, and diagnostic checks prior to the start of skid data collection each day. The steps described in this SOP are based on the ICC MDRPro 2.5[06/12/2019] software developed for operating Skid Trailers 7 and 8[06/12/2019]. This SOP is one of three to be utilized for daily data collection with the referenced skid trailers – it is succeeded by Skid Data Collection and then Skid Post-Data Collection Actions. This SOP utilizes the Skid Collection List (see Production of Skid Collection List) for the current year.

Note: due to the frequent changes in skid collection software and the differences between the skid trailers, the main body of this SOP contains general steps to perform the required pre-data collection tasks. The skid user manual for the specific skid trailer should be used as supporting documentation to this SOP. The steps for using the current version of the skid data collection software, ICC MDRPro 2.5, in support of this SOP are provided at the end of this SOP.

3.08.02 *Frequency*

This SOP is to be performed daily by MDOT-SHA FED staff throughout the skid data collection period[06/12/2019], prior to the first data collection run each day.

3.08.03 *Purpose*

The purposes of this SOP are to develop an efficient route plan for skid data collection and to check the skid trailer to confirm it is safe to operate and functioning properly prior to data collection each day. This is accomplished by:

- Planning of data collection route such that the possible effect of environmental factors on data quality is reduced,
- conducting vehicle-related safety checks, and
- validating the functionality of the skid trailer components.

3.08.04 *Resource Requirements*

The actions detailed in this SOP are performed by the MDOT-SHA FED skid trailer crew, which is comprised of a driver and an operator. The estimated effort levels shown in the table below represent the total time, in man-hours, required for completion of the daily planning, safety checks, and diagnostics checks. These time estimates assume adequate weather conditions and that the diagnostic checks do not produce results that require additional troubleshooting.

Position	Function	Resources	Effort Level (man-hrs)
Skid Testing Crew	Driver	1	1.5
Skid Testing Crew	Operator	1	1.5
FED Team Leader (TL) or Coordinator	Supervisor	1	As Required[06/12/2019]

3.08.05 *Procedure*

The procedure required to perform pre-data collection actions on the skid trailer is comprised of the following three tasks:

(1) planning of data collection routes,
(2) performing vehicle safety checks, and
(3) performing daily equipment component diagnostic checks.

1- Planning of Data Collection Route – *performed by driver and operator, with input from Supervisor*

Summary: Under this task, the planned skid data collection route for the day is created and environmental conditions are assessed to determine whether data collection should proceed or be postponed.

Step 1. Develop an initial skid data collection route for the day using the selected sections from the Skid Collection List (see Production of Skid Collection List). The route is to be selected based on several logistic and practical factors – e.g., proximity to office and to gas stations – with the objective of maximizing the collected mileage for the day.

Step 2. Assess weather conditions for the day in order to decide whether to perform or to cancel skid data collection. Typical weather factors affecting this decision include:

i. Fog, snow, or ice – skid data collection must be cancelled if there is fog, rain, snow, or ice regardless of intensity[06/12/2019].

ii. Surface wetness or ice – If it is not raining or snowing, but the pavement surface is wet (standing water) or icy after a visual inspection, data collection is to be delayed until the surface is dry[06/12/2019].

iii. Below freezing – if the temperature is below freezing, data collection is delayed until the temperature rises above freezing.

If weather considerations do not result in the cancelation or delay of data collection, proceed Step 3.

2- Performing Vehicle Safety Checks – *performed by driver and operator*

Summary: This task performs vehicle-related safety assessments to check that the skid trailer is in proper working order and safe to operate.

Step 3. Driver: Turn on skid vehicle ignition.

Step 4. Driver: Ensure mirrors (left, right, and rear view) and seat position are properly set for safe driving.

Step 5. Operator: Check pressure of all tires, including skid trailer test tires. Vehicle tires should have pressure as specified by the vehicle manufacturer for given conditions and skid trailer tires should read 24 psi.

Step 6. Driver: Make sure water tank is filled.

Step 7. Driver: Check that skid trailer lights are functioning properly. This includes beacons, hazards, turning signals, and brake lights. If any lights or beacons are not functioning, communicate issue to Supervisor for further remedial action and suspend data collection until issue has been resolved.

3- Performing Daily Equipment Component Diagnostic Checks – *performed by driver and operator*

Summary: This task initiates the skid data collection computer system and runs diagnostic tests on the skid trailer sub-components to check that they are functioning properly for data collection.

Step 8. Driver: Position the skid trailer on level ground and out of the way of traffic.

Step 9. Operator: After confirming that engine is running, turn on the "Air" and "Trailer Power." The specific location of these switches may vary between vehicles; consult the user manual of the specific skid trailer for details.

Step 10. Operator: Turn on computers. The specific location of these switches may vary between vehicles; consult the user manual of the specific skid trailer for details.

Step 11. Operator: Login to the proper computer user profile with the appropriate user name and password. The specific details of the user profiles may vary between vehicles; consult the user manual of the specific skid trailer for details.

Step 12. Operator: Login to the current skid data collection software by double-clicking on the MDRPro desktop icon and entering the appropriate sign-in credentials; consult the user manual of the specific skid trailer for details and the end of this SOP for instructions on using the ICC MDRPro 2.5 software.

Step 13. Operator: Perform pre-data collection diagnostic tests to ensure the skid trailer sub-components are functioning properly; consult the user manual of the specific skid trailer for details and the end of this SOP for instructions on using the ICC MDRPro 2.5 software.

i. If the calibration values are within the required tolerance, proceed to Skid Data Collection for commencement of daily skid data collection.

ii. If the calibration values are out of range with respect to the required tolerance, contact Supervisor for remedial action and suspend data collection until the issue has been resolved.

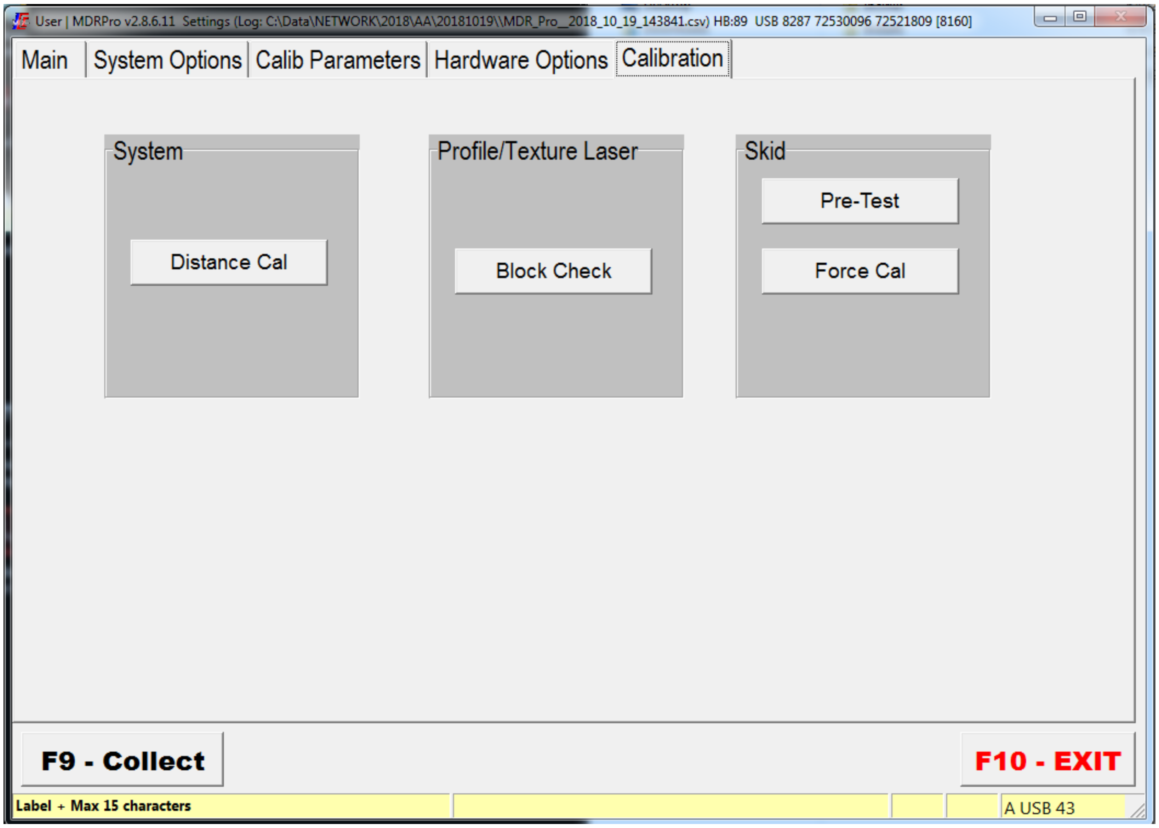
ICC MDRPro 2.5 Skid Pre-Data Collection Software Instructions

The following instructions can be followed to supplement Task 3 of this SOP when using the ICC MDRPro 2.5 skid data collection software to perform the required pre-test diagnostic checks.

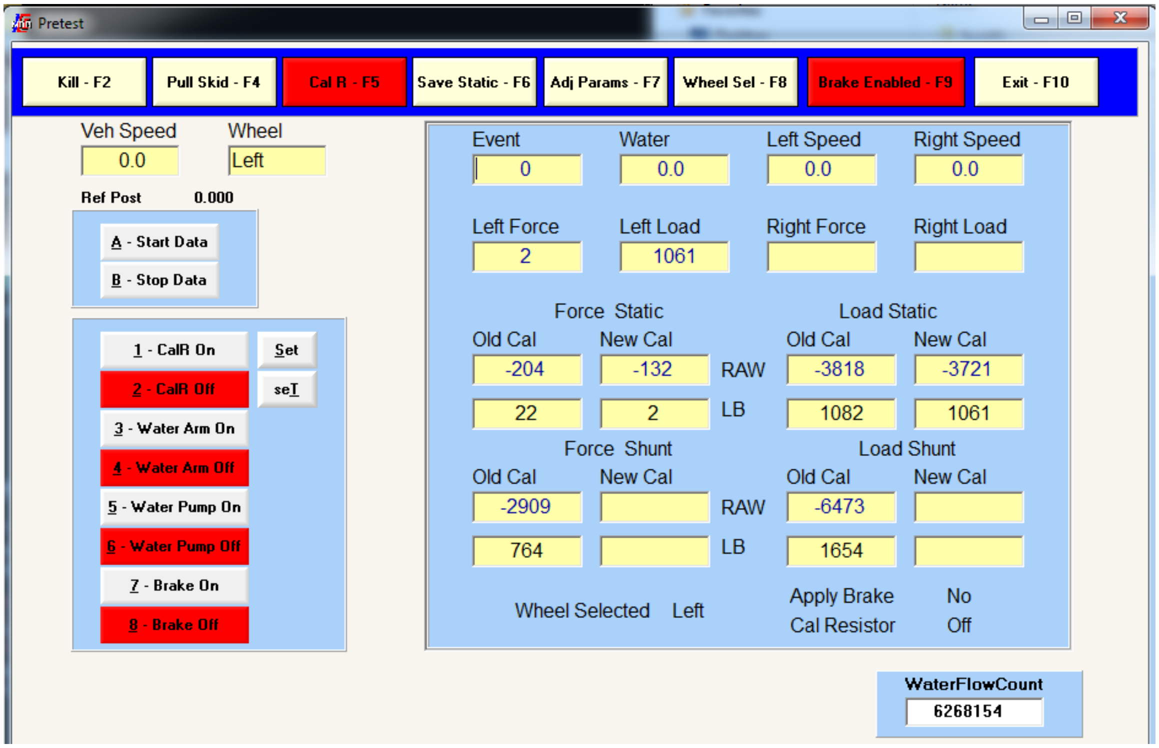
Double-click on the MDRPro desktop icon (see below image).

In the “Enter Password” dialogue box, type “user” (see below image).

Click on the “Calibration” tab and then select “Pre Test” (see below image).



Observe the values on the screen for “Left Force” and “Left Load” (see below image). Record both numbers in the record book kept in the skid vehicle. If values are out of range, move to more level ground and repeat test.



i. The “Left Force” value should be close to 0 (less than 10 is acceptable).

ii. The “Left Load” value should be approximately 1085 (+/- 15 is acceptable). If out-of-range, move the trailer to make sure it is level and take another measurement.

iii. If values continue to be out of range, contact Supervisor for further remedial action and suspend data collection until the issue has been resolved.

Exit “Pre Test” window by pressing the “F10” key. Pre-data collection actions are now complete.

3.09 SKID DATA COLLECTION

3.09.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Field Explorations Division (FED) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to perform daily skid data collection. The steps described in this SOP are based on the ICC MDRPro 2.5[06/12/2019] software developed for operating Skid Trailers 7 and 8[06/12/2019]. This SOP is one of three to be utilized for daily data collection with the referenced skid trailers – it is preceded by Skid Pre-Data Collection Actions and succeeded by Skid Post-Data Collection Actions. The data collection activities covered in this SOP start after the end of the daily diagnostic checks (see Skid Pre-Data Collection Actions) and they end prior to commencement of the daily data export (see Skid Post-Data Collection Actions) – i.e., it describes the procedure for completing a full day of skid data collection. This SOP utilizes the Skid Collection List (see Production of Skid Collection List) for the current year.

Note: due to the frequent changes in skid collection software and the differences between the skid trailers, the main body of this SOP contains general steps to perform the required data collection tasks. The skid user manual for the specific skid trailer should be used as a supporting documentation to this SOP. The steps for using the current version of the skid data collection software, ICC MDRPro 2.5, in support of this SOP are provided at the end of this SOP. This software should already be initialized from Skid Pre-Data Collection Actions.

3.09.02 *Frequency*

This SOP is to be performed daily by MDOT-SHA staff throughout the data collection period[06/12/2019].

3.09.03 *Purpose*

The purposes of this SOP are to perform daily skid data collection and to perform visual quality control (QC) checks on those data while they are being collected.

3.09.04 *Resource Requirements*

The actions detailed in this SOP are performed by the MDOT-SHA FED skid trailer crew, which is comprised of a driver and an operator. The estimated effort levels shown in the table below represent the total time, in man-hours, required for completion of a full day of skid data collection. These time estimates assume adequate weather conditions and a typical data collection schedule. Actual time to complete individual runs in the field will vary between routes.

Position	Function	Resources	Effort Level (man-hrs)
Skid Testing Crew	Driver	1	6.0
Skid Testing Crew	Operator	1	6.0
FED Team Leader (TL) or Coordinator	Supervisor	1	As Required[06/12/2019]

3.09.05 *Procedure*

The procedure required to perform daily skid data collection is comprised of the following single task:

(1) performing daily data collection.

4- Performing Daily Data Collection – *performed by driver and operator*

Summary: Under this task, daily skid data collection runs are completed using the skid trailer. The vehicle should be properly functioning and the computer system appropriately initiated after completion of the pre-data collection actions detailed in Skid Pre-Data Collection Actions.

Step 1. Operator: Navigate to the data collection screen on the current skid collection software; consult the skid user manual of the specific skid trailer for details.

Step 2. Operator: select the directory where data are to be stored by navigating to the appropriate folder; consult the skid user manual of the specific skid trailer for details.

Step 3. Operator: Enter the appropriate information for the specific run to be collected; consult the skid user manual of the specific skid trailer for details.

Step 4. Operator: Copy information from Step 3 into log book kept inside the skid vehicle.

Step 5. Driver: Once entry of information from Step 3 into the data collection software has been confirmed, drive towards beginning of test segment.

Step 6. Operator: Initiate the Distance Measuring Instrument (DMI) and data collection at the start of the test segment. Friction tests will occur approximately every 0.1 miles for mainline roads and 0.05 miles for shorter segments and ramps. The wheel will lock at these increments and a skid number will be recorded. If the speed limit is greater than 40 mph, operator should attempt to maintain a speed of 40 mph throughout the test. Otherwise, operator should maintain the posted speed limit. Consult the skid user manual of the specific skid trailer for details.

Step 7. Operator: Observe data collection screen during test, including: skid numbers, water output, and speed. If data does not seem reasonable, abandon test and restart. If data continues to appear unreasonable, contact Supervisor for further remedial action and suspend data collection until the issue has been resolved.

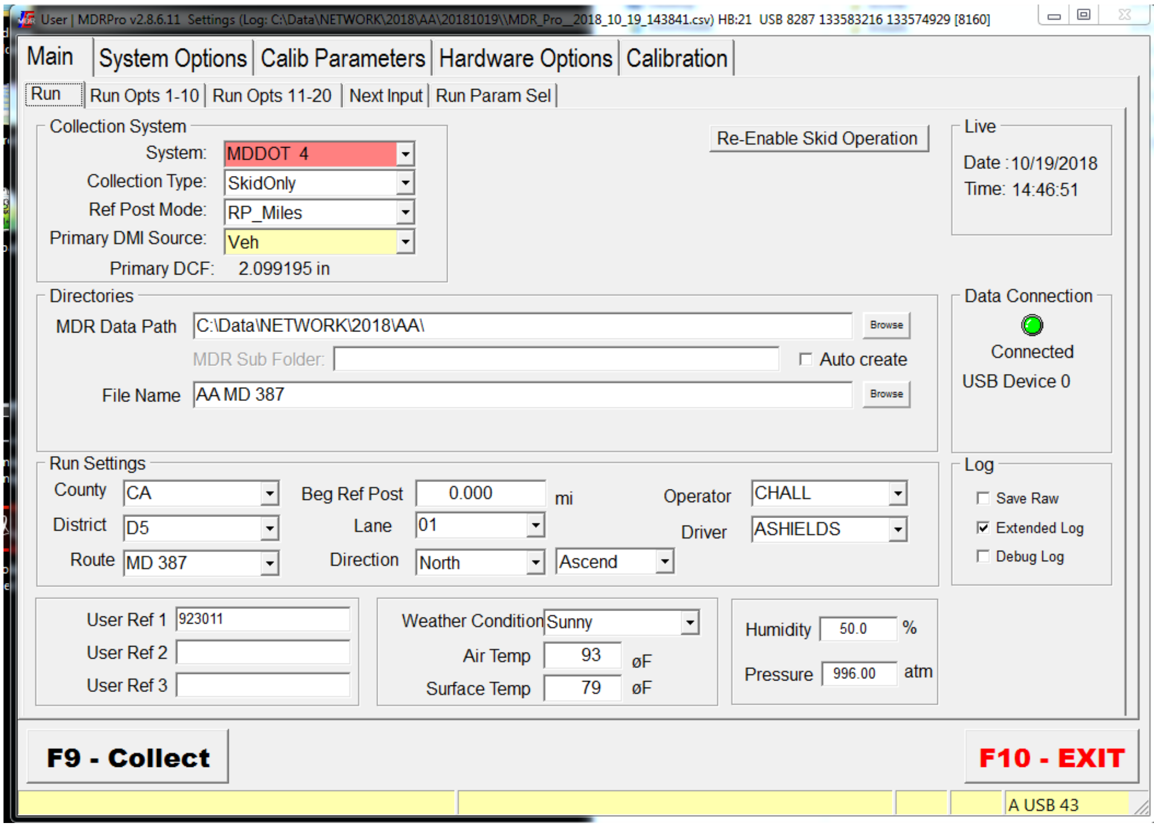
Step 8. Operator: At the end of the test segment, end the data collection and save the data; consult the skid user manual of the specific skid trailer for details.

Step 9. Repeat Step 1 through Step 8 for each data collection run during the day. After completion of the last data collection run, proceed to Skid Post-Data Collection Actions for end-of-day shut-down activities.

ICC MDRPro 2.5 Skid Data Collection Software Instructions

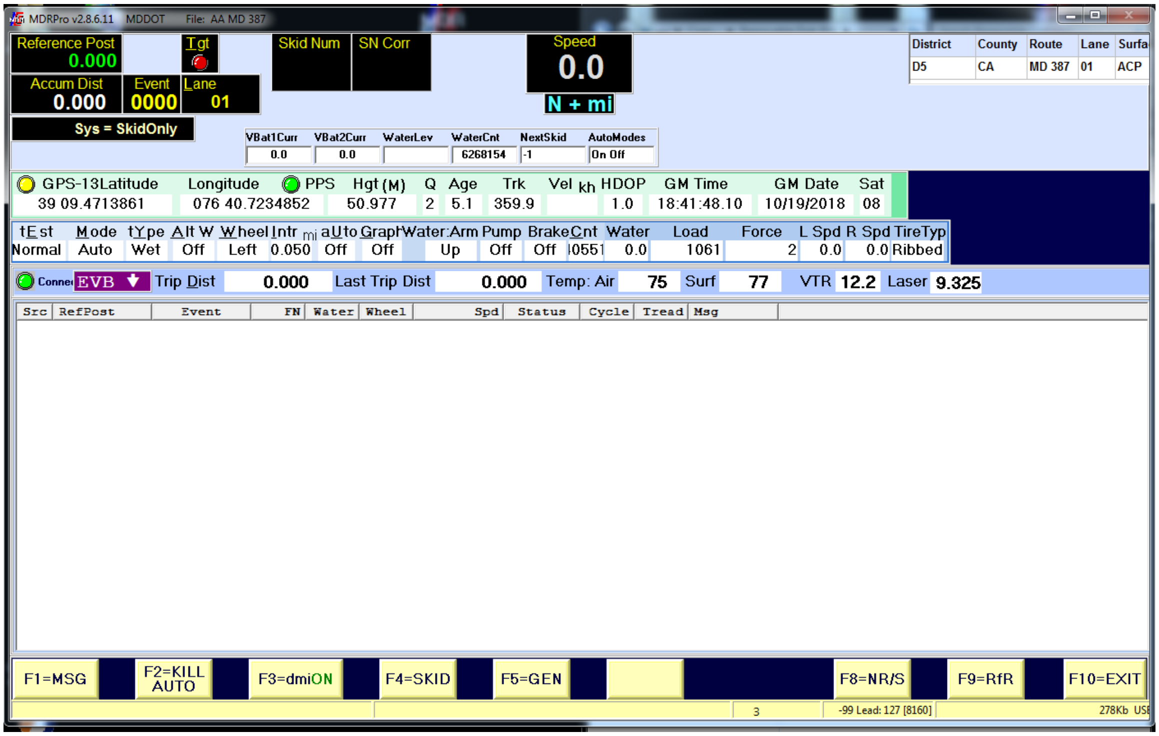
The following instructions can be followed to supplement Task 1 of this SOP when using the ICC MDRPro 2.5 skid data collection software to perform the required data collection.

Click on the “Main” tab. All collection information for a specific run will be entered in this window (see below image).



Select the proper directory under “MDR Data Path”[06/12/2019] by selecting the “Browse” button next to the dialogue box and navigating to the appropriate folder. Type in the file name in the dialogue box that reads “File Name” following the appropriate format[06/12/2019]. Fill in all required fields under “Run Settings” (see above image). This includes: County, District, Route Number, Beg Ref Post, Lane, Direction, Ascending/Descending, Operator, and Driver.

Press the “F9” key on the keyboard to open the data collection screen. Ensure the run setting information at the top of the screen is correct, including: Reference Post, Direction, District, County, Route Number, Beginning Mile Post, and Ending Mile Post (see below image). If information is incorrect, return to “Main” tab and update information before continuing with data collection.



Press the “F4” key to initiate the Distance Measuring Instrument (DMI) and data collection.

At the end of the data collection run, press the “F3” key on the keyboard to end the test.

Press the “F10” key to exit the data collection screen. Click “Yes” to save data collection run. Click “Yes” again to return to main software screen

3.10 SKID POST-DATA COLLECTION ACTIONS

3.10.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Field Explorations Division (FED) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to perform end-of-day data management and shut-down actions following completion of the daily skid data collection. The steps described in this SOP are based on the ICC MDRPro 2.5[06/12/2019] software developed for operating Skid Trailers 7 and 8[06/12/2019]. This SOP is one of three to be utilized for daily data collection with the referenced skid trailers – it is preceded by Skid Pre-Data Collection Actions and Skid Data Collection. The post-data collection actions covered in this SOP start from the completion of the last data collection run of the day (see Skid Data Collection) to system shut down.

Note: due to the frequent changes in skid collection software and the differences between the skid trailers, the main body of this SOP contains general steps to perform the required end-of-day data management and shut down tasks. The skid user manual for the specific skid trailer should be used as a supporting documentation to this SOP. The steps for using the current version of the skid collection software, ICC MDRPro 2.5, in support of this SOP are provided at the end of this SOP. The software should already be ready for the post data collection tasks.

3.10.02 *Frequency*

This SOP is to be performed daily by MDOT-SHA staff throughout the data collection period[06/12/2019], following the last data collection run of the day.

3.10.03 *Purpose*

The purpose of this SOP is perform end-of-day data management and shut-down actions following completion of the daily skid data collection.

3.10.04 *Resource Requirements*

The actions detailed in this SOP are performed by the MDOT-SHA FED skid trailer crew, which is comprised of a driver and an operator. The estimated effort levels shown in the table below represent the total time, in man-hours, required for completion of the post-data collection actions. These time estimates assume no issues are encountered.

Position	Function	Resources	Effort Level (man-hrs)
Skid Testing Crew	Driver	1	0.5
Skid Testing Crew	Operator	1	0.5
FED Team Leader (TL) or Coordinator	Supervisor	1	As Required[06/12/2019]

3.10.05 *Procedure*

The procedure required to perform the skid post-data collection actions is comprised of the following tasks:

(1) transferring collected skid data, and
(2) shutting down skid trailer system and scanning log book records.

1- Transferring Collected Skid Data – *performed by operator*

Summary: Under this task, the collected skid data is transferred from the on-board computer to a flashdrive for transmittal to the FED TL. This task is only performed at the completion of a county or during the collection of the Test Loop (see Skid Test Loop Data Collection).

Step 1. If all segments for the county have been collected, or if the collection effort is on the Skid Test Loop (see Skid Test Loop Data Collection), proceed to Step 2. Otherwise, skip to the system shut-down task that starts in Step 3.

Step 2. Plug in flashdrive to USB port of on-board computer and navigate to the data storage folder. Copy data and safely eject flashdrive. Consult the skid user manual of the specific skid trailer for details.

2- Shutting Down Skid Trailer System and Scanning Log Book Records – *performed by driver and operator*

Summary: Under this task, the on-board computer system and vehicle are shut down.

Step 3. Operator: Safely shut down all on-board computers; consult the skid user manual of the specific skid trailer for details.

Step 4. Operator: Turn off "Trailer Power", "Air Compressor", and "Beacon;" consult the skid user manual of the specific skid trailer for details.

Step 5. Driver: Record vehicle mileage in log book and turn off ignition. Lock all doors.

Step 6. Once back in the office, scan log book records for the county and deliver flashdrive and scans to FED TL if Task 1 was required.

ICC MDRPro 2.5 Skid Post-Data Collection Software Instructions

The following instructions can be followed to supplement Tasks 1 and 2 of this SOP using ICC MDRPro 2.5 skid data collection software to perform the required post-data collection actions.

To copy data to flashdrive:

- Double-click on the “My Computer” icon on the computer desktop screen.
- Double-click on “C Drive” and then “Data.”
- Scroll down to the folder of the county that was just completed. Right-click and select “Copy.”
- Navigate to the flashdrive (“Removable Disk (F:)”). Right-click and select “Paste.”
- On the bottom right-hand corner of the screen, right-click on the USB icon and select “Eject Flash Disk.” A message will appear when it is safe to remove the flashdrive. Unplug flashdrive from computer.

To shut down computers:

- Click on the Windows icon at the bottom left-hand corner of the screen and select “Shut Down.”
- Toggle to second computer screen by pressing the black button on the back of the computer monitor.
- On the second computer desktop screen, click on the red power button and select “Shut Down.”
- Wait for a message on the screen to read “It is now safe to turn off computer” and then press the red button below the keyboard (hold until it beeps). Confirm that both computers are now off.
- On the middle console, turn off “Trailer Power”, “Air Compressor”, and “Beacon.”

3.11 SKID DMI CALIBRATION

3.11.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Field Explorations Division (FED) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to calibrate the Distance Measuring Instrument (DMI) mounted on the skid trailers. The steps described in this SOP are based on the ICC MDRPro 2.5[06/12/2019] software developed for operating Skid Trailers 7 and 8[06/12/2019]. The reference measurements used in the DMI calibration procedure described in this SOP are obtained by a state surveyor using thermally compensated steel tape. These reference measurements are obtained along two one-mile long pavement sections, marked on the shoulder lanes in both directions, on a segment of MD Route 100.

Note: due to the frequent changes in skid collection software and the differences between the skid trailers, the main body of this SOP contains general steps to perform the required DMI calibration tasks. The skid user manual for the specific skid trailer should be used as a supporting documentation to this SOP. The steps for using the current version of the skid collection software, ICC MDRPro 2.5, are provided at the end of this SOP.

3.11.02 *Frequency*

This SOP should be performed monthly by MDOT-SHA FED staff throughout the data collection period[06/12/2019].

3.11.03 *Purpose*

The purpose of this SOP is to check the accuracy of the distance measurements taken by the DMI mounted on Skid Trailers 7 and 8 using the ICC MDRPro 2.5 software and, if deemed necessary, to recalibrate the DMI.

3.11.04 *Resource Requirements*

Calibration of the DMI is performed by the MDOT-SHA FED skid trailer crew, which is comprised of a driver and an operator. The estimated effort levels shown in the table below represent the total time, in man-hours, required for driving from the SHA's Office of Materials Technology (OMT) location to the calibration pavement sections on Route MD 100, performing three data collection runs on these two calibration pavement sections, and driving back to the OMT location.

Position	Function	Resources	Effort Level (man-hrs)
Skid Testing Crew	Driver	1	1.5
Skid Testing Crew	Operator	1	1.5
FED Team Leader (TL) or Coordinator	Supervisor	1	As Required[06/12/2019]

3.11.05 *Procedure*

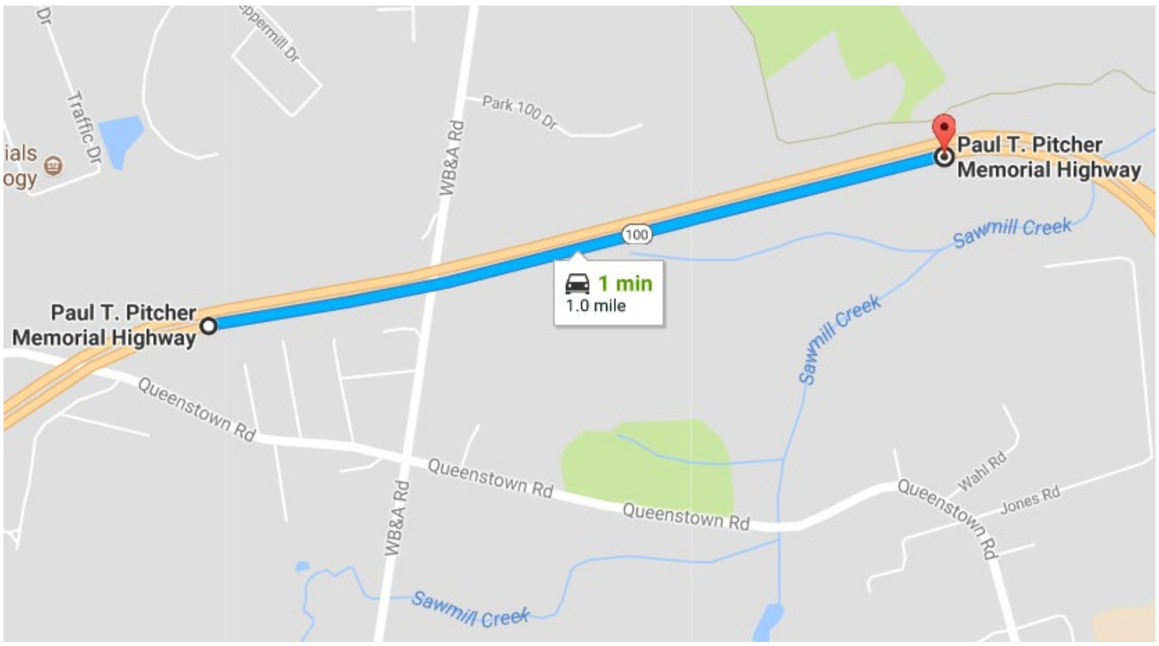
The procedure required to calibrate the DMI mounted on Skid Trailers 7 and 8 using the ICC MDRPro 2.5 software consists of the following two tasks:

(1) performing repeat calibration runs, and
(2) saving data and performing data QC.

1- Performing Repeat Calibration Runs – *performed by driver and operator*

Summary: Under this task, data from three runs are collected along the two calibration pavement sections on Route MD 100 for use in checking the accuracy of the distance measurements taken by the DMI mounted on Skid Trailers 7 and 8 using the ICC MDRPro 2.5 software and, if deemed necessary, for recalibrating the DMI.

The calibration sites consist of two one-mile long pavement sections on Route MD 100, located near the OMT and marked along the shoulder lanes – one in the east-bound direction and the other in the west-bound direction (see map screenshot below). Two runs are performed on the east-bound direction and one run in the west-bound direction, for a total of 3 data collection runs.



Step 1. Operator: Follow start-up procedures for initiating the computer system and performing standard vehicle checks as described in Skid Pre-Data Collection Actions.

Step 2. Driver: Drive the skid trailer to the starting point of the calibration site in the east-bound direction. The starting point can be identified by the following markings):

i. an orange paint mark on a tree to the right of the road (see first photo that follows this list),

ii. a metal pole just beyond the pavement shoulder (see second photo that follows this list),

iii. paint markings on the pavement shoulder (line and "ST"; see second photo that follows this list),

iv. a survey nail in the pavement shoulder, and

v. a yellow sign that reads "DMI Calibration Site."

Step 3. Operator: Initiate the skid data collection software and navigate to the "DMI Calibration" window; consult the skid user manual of the specific skid trailer for details

Step 4. Driver: Drive the skid trailer until the front bumper of the vehicle is aligned with the starting position, as identified by one or more of the earlier referenced markings[06/12/2019].

Step 5. Operator: Begin the first test run in the software; consult the skid user manual of the specific skid trailer for details

Step 6. Driver: Drive forward on shoulder lane at a safe speed, from the starting position until a few feet before the end mark as identified by metal pole just beyond the pavement shoulder and survey nail shown in the photo below. The calibration interface should display travelled distance on the computer screen.

Attempt to stay as straight as possible in the shoulder lane using the white stripe, edge of pavement, and guardrail (where present) as references.

Step 7. Driver: Drive skid trailer until front bumper of vehicle is aligned with "ending" position, as identified by metal pole just beyond the pavement shoulder and survey nail shown in the photo above[06/12/2019].

Step 8. Operator: End the first test run; consult the skid user manual of the specific skid trailer for details

Step 9. Driver: Drive the skid trailer to starting point of the calibration site in the west-bound direction and repeat Step 2 to Step 8 to perform second DMI calibration run.

Step 10. Driver: Drive the skid trailer to starting point of the calibration site in the east-bound direction and repeat Step 2 to Step 8 to perform the third DMI calibration run.

2- Saving Data and Performing Data QC – *performed by operator*

Summary: Under this task, the DMI calibration results are saved and the resulting calibration factors are evaluated for acceptable accuracy.

Step 11. Once the third DMI calibration run has been completed, save the data set.

Step 12. Examine the calibration factors from the results reported in the software; consult the skid user manual of the specific skid trailer for details. The calibration factors for the 3 runs must agree within 0.1 percent and preferably within 0.05 percent.

i. If they do not agree, consult TL and discuss next steps for remedial actions.

ii. If they do agree, exit the calibration program. Consult the skid user manual of the specific skid trailer for details.

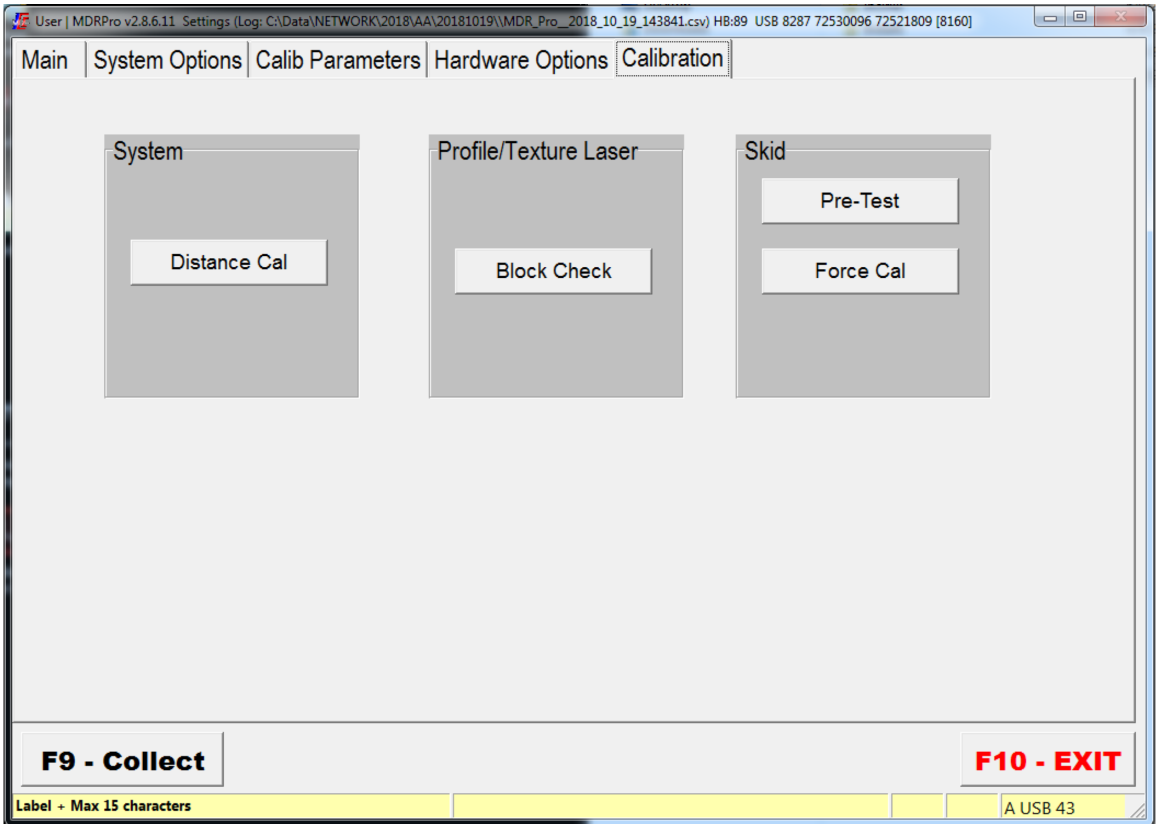
ICC MDRPro 2.5 DMI Calibration Software Instructions

The following instructions can be followed to supplement Task 1 of this SOP when using the ICC MDRPro 2.5 skid data collection software to perform the required DMI calibration.

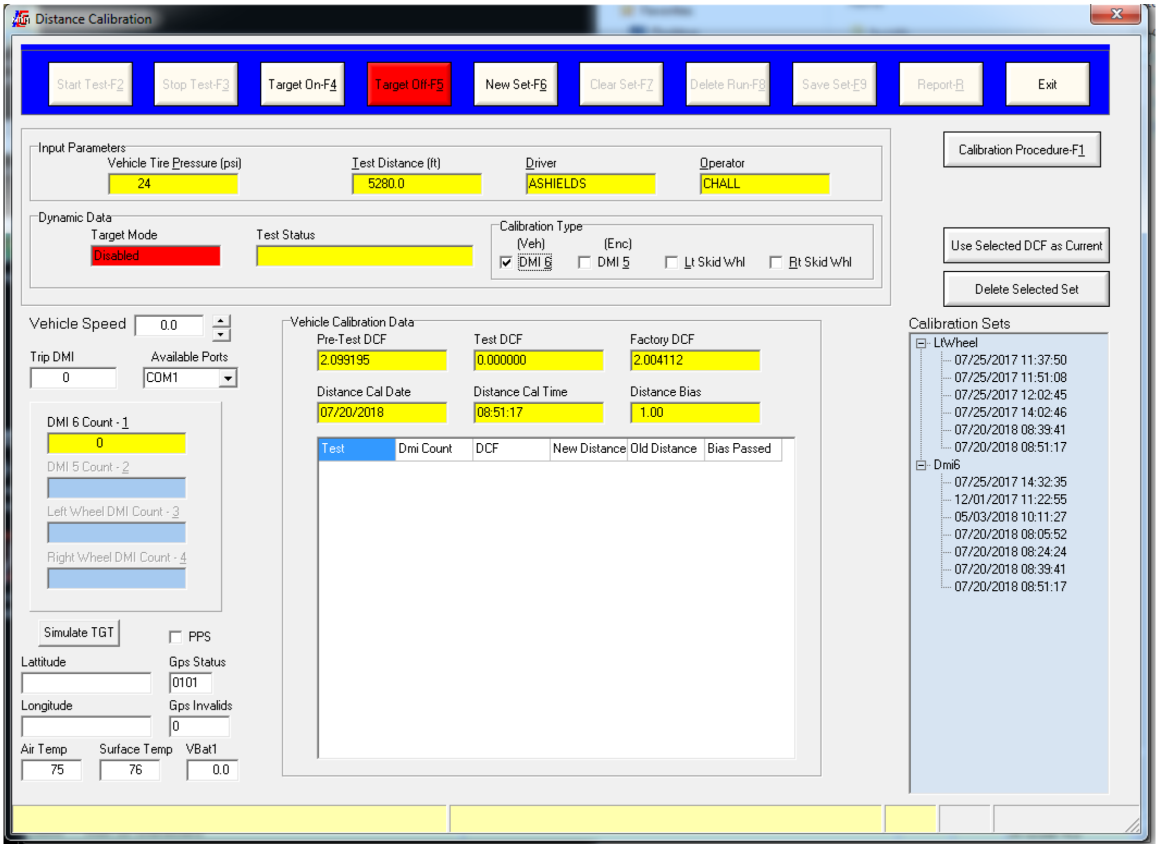
Click on the “MDRPro 2” icon on the desktop of the computer (see below image).

Login by typing “user” in the “Password” text box (see below image).

Click on the “Calibration” tab and then the “Distance Cal” button (see below image).



Press the “F6” key to start a new calibration set after the “Distance Calibration” window opens (see below image).



Press the “F2” key to start the DMI calibration run.

Press the “F3” key to stop the DMI calibration run.

The following details can be followed to supplement Task 2 of this SOP using ICC MDRPro 2.5 skid data collection software to save the DMI Calibration.

Once third run is complete, press the “F9” key to save the calibration set.

Press the “F10” key to exit the calibration program.

3.12 SKID WATER CALIBRATION

3.12.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Field Explorations Division (FED) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to perform the static water calibration of Skid Trailer 7, which is the smaller of the MDOT-SHA friction data collection vehicles. This skid trailer has a 450 gallon water tank and it is typically used in congested areas -- the counties of X1, X2 and X3. Skid Trailer 8, the larger of the MDOT-SHA friction data collection vehicles, uses a different water calibration procedure.

The static water calibration is performed at the Office of Materials Technology (OMT) calibration area.

Note: The user manual for Skid Trailer 7 should be used as supporting documentation to this SOP. The steps for using the current version of the Skid Trailer 7 data collection software, ICC MDRPro 2.5, are provided at the end of this SOP.

3.12.02 *Frequency*

The static water calibration of Skid Trailer 7 is performed by the MDOT-SHA FED staff once per year, prior to the start of the data collection season[06/12/2019].

3.12.03 *Purpose*

The purpose of this SOP is to check that the quantity of water being released by Skid Trailer 7 is consistent with the on-board equipment readings.

3.12.04 *Resource Requirements*

The static water calibration of Skid Trailer 7 involves the following MDOT-SHA FED staff members:

(1) an operator knowledgeable in the data collection software,
(2) a driver responsible for maintaining a steady speed of 40 mph,
(3) an assistant to oversee water released into the bucket and,
(4) a timer to indicate the start and end of the calibration test.

The estimated effort levels shown in the table below represent the total time, in man-hours, to complete the skid water calibration. These time estimates assume no issues are encountered during the calibration.

Position	Function	Resources	Effort Level (man-hrs)
FED Staff	Operator	1	0.5
FED Staff	Assistant	1	0.5
FED Staff	Driver	1	0.5
FED Staff	Timer	1	0.5
FED Team Leader	Supervisor	1	“As required”[06/12/2019]

3.12.05 *Procedure*

The procedure required to perform the static calibration of the water being released by Skid 7 is comprised of a single task:

(1) perform static water calibration.

3- Perform Static Water Calibration – *performed by driver, operator, assistant, and timer*

Summary: Under this task, a static water calibration of Skid Trailer 7 is performed at the MDOT-SHA OMT calibration area to check that the quantity of water being released by the referenced skid trailer is consistent with the on-board equipment readings.

Step 1. Driver: Position the vehicle so that the skid trailer is in the "test pit" in the garage and place wood blocks under the skid trailer tires.

Step 2. Assistant: Plug power cord from skid trailer in to a power source and initialize equipment.

Step 3. Assistant: Connect the air supply to the trailer "tongue" and turn on (for water pump).

Step 4. Assistant: Jack up the vehicle rear tires.

Step 5. Assistant: Place the splash guard on the water nozzle and place the test bucket underneath the water nozzle.

Step 6. Operator: Initialize the ICC MDRPro2 skid data collection software and login; see the end of this SOP. Navigate to the water calibration screen (see the end of this SOP); consult the user manual of Skid Trailer 7 for details.

Step 7. Driver: Turn on the vehicle and begin to "drive" the vehicle to spin the wheels elevated by the jacks. Attempt to maintain a speed of 40 mph.

Step 8. Operator: When the driver is ready (at a speed of 40 mph), signal "Go" to the timer.

Step 9. Timer: Start stopwatch.

Step 10. Operator: Turn on the water pump in the ICC MDRPo 2.5 software interface at the same time as the timer starting the stopwatch. Consult the Skid Trailer 7 user manual for details. Water will begin to fill the bucket.

Step 11. Timer: Monitor the stopwatch and signal "Stop" to the operator and assistant at the 15 second mark.

Step 12. Operator: On the timer's "Stop" signal, turn off the water pump in the ICC MDRPro 2.5 software interface. Consult the Skid Trailer 7 user manual for details.

Step 13. Assistant: On the timer's "Stop" signal, place the pan between the nozzle and bucket to prevent excess drip after the test has ended.

Step 14. Assistant: Remove the pan once the drip has stopped and dispose of the water in the drip pan.

Step 15. Assistant: With the help of the operator, remove the filled bucket and place on the scale. Measure the weight of the filled bucket.

Step 16. Operator: Remove tare (10.2 lbs) from the measured weight and divide the weight of the water (lbs) by 8.33 (lbs/gal) to convert the weight to gallons.

Step 17. Operator: Multiply the weight in gallons by four (15 second test) to compute a measurement of gallons per minute. The desired range is 27 to 28 gal/min.

Step 18. Operator: Normally, the first test is thrown out and a second test is run by repeating Step 6 to Step 17. Examine the results of the second test.

i. If the flow rate after the second test is in the desired range of 27 to 28 gal/min, the calibration is complete. Save the results of the calibration, power down the software, remove the vehicle from the blocks, remove the bucket and splash guard from the skid trailer, and remove all connections used during the calibration.

ii. If the flow rate is still not in the desired range of 27 to 28 gal/min after the second test, troubleshooting is required. Possible solutions include water pump replacement and filter cleaning. Discuss troubleshooting and problem resolution with TL.

ICC MDRPro 2.5 Post-Data Collection Software Instructions

The following instructions can be followed to supplement Task 1 of this SOP when using the ICC MDRPro 2.5 skid data collection software to perform the calibration of the water being released by Skid Trailer 7.

Click on the “MDRPro 2” icon on the desktop of the computer (see below image).

Login by typing “user” in the “Password” text box (see below image).

Click on the “Calibration” tab and then “Water Cal” then “Water Arm On” so that the water pump arm is angled downwards.

Click “Water Pump On” at the same time as the timer starting the stopwatch. Water will begin to fill the bucket.

On the timer’s “Stop” signal, click “Water Pump Off”.

3.13 SKID FORCE CALIBRATION

3.13.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Field Explorations Division (FED) of the Maryland Department of Transportation State Highway Administration's (MDOT-SHA) to perform skid force calibrations on the MDOT-SHA friction data collection vehicles. The procedure described in this document is specific to the MDOT-SHA Skid Trailers 7" and 8 data collection vehicles and to the use of the ICC MDRPro v2.5 skid data collection software. This procedure may not be applicable to other friction data collection vehicles or data collection software.

The skid force calibration is performed at the MDOT-SHA Office of Materials Technology (OMT) calibration area.

Note: The user manuals for Skid Trailers 7 and 8 should be used as supporting documentation to this SOP. The steps for using the current version of the skid collection software, ICC MDRPro 2.5, are provided at the end of this SOP.

3.13.02 *Frequency*

The skid force calibration of Skid Trailers 7 and 8 is performed by the MDOT-SHA FED staff once per year, prior to the start of the data collection season[06/12/2019], or when required.

3.13.03 *Purpose*

The purpose of this SOP is to check that the load applied to left tire of Skid Trailers 7 and 8 and the traction readings recorded by the force meter are consistent with the on-board equipment readings as well as within the calibration standards; and to make the necessary adjustments when required.

3.13.04 *Resource Requirements*

The skid force calibration involves the following MDOT-SHA FED staff members: (1) an operator knowledgeable in the data collection software, and (2) a load meter assistant responsible for increasing and decreasing load levels and monitoring traction readings. The estimated effort levels shown in the table below represent the total time, in man-hours, to complete the skid force calibration. These time estimates assume no issues encountered during the calibration.

Position	Function	Resources	Effort Level (man-hrs)
FED Staff	Operator	1	1.0
FED Staff	Assistant	1	1.0
FED Team Leader	Supervisor	1	"As required"[06/12/2019]

3.13.05 *Procedure*

The procedure required to perform the skid force calibration for Skid Trailers 7 and 8 is comprised of the following two tasks:

(1) perform Skid Force calibration, and
(2) evaluate Skid Force calibration results.

1- Perform Skid Force Calibration – *performed by operator and assistant*

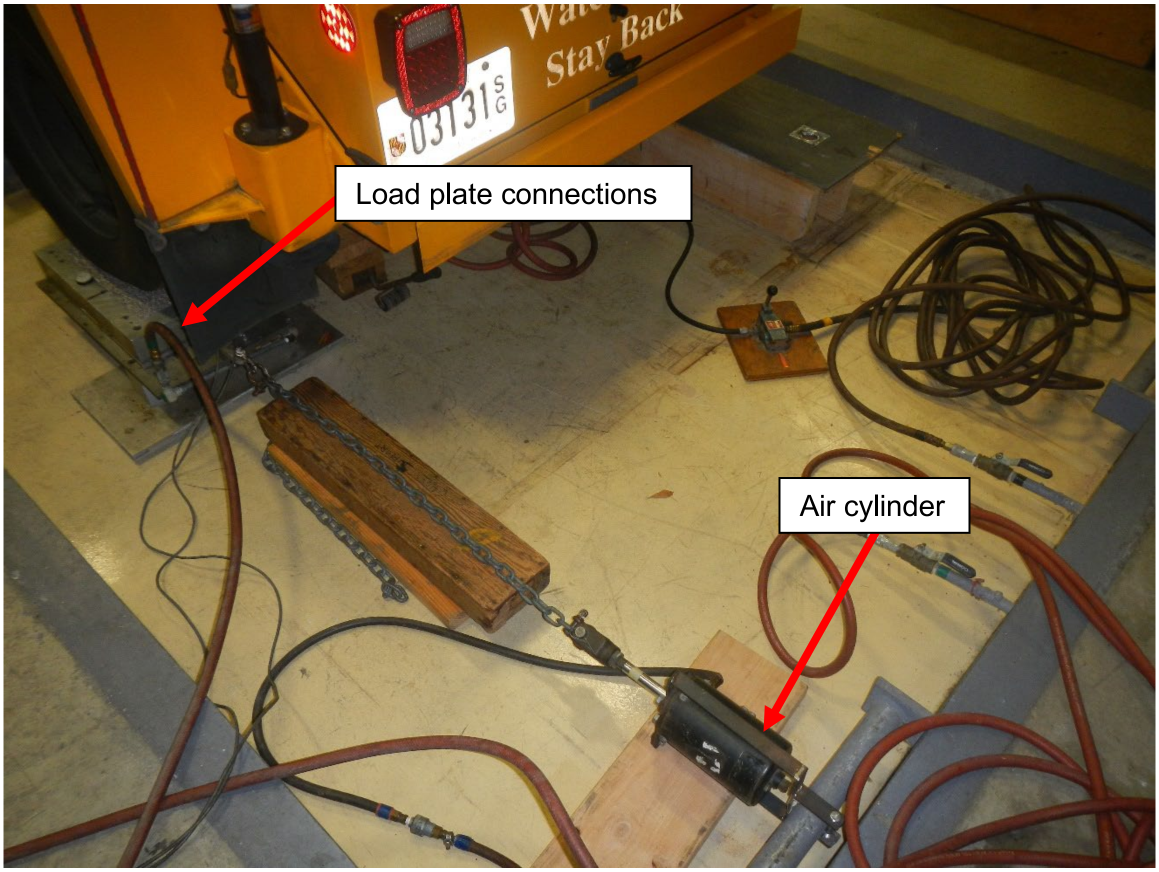
Summary: Under this task, a skid force calibration is performed at the MDOT-SHA OMT calibration area on Skid Trailers 7 and 8. This is accomplished by measuring force readings underneath the left tire of the referenced skid trailers at varying pressure levels.

Step 1. Operator: Position vehicle so that the skid trailer is in the “test pit” in the garage and place wood calibration blocks under the skid trailer right tire. Place load plate under the skid trailer left tire (see below photo[06/12/2019]).

Step 2. Operator: Plug skid trailer power cord into power source and initialize equipment.

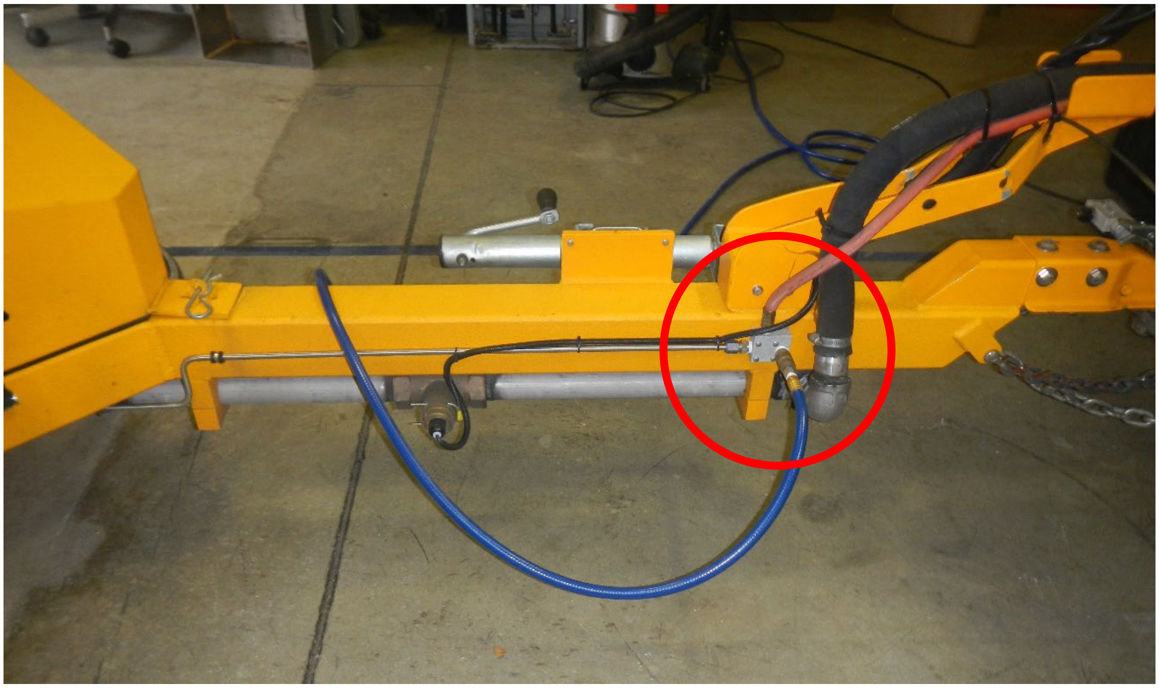
Step 3. Operator: Initialize the skid data collection software and login. Navigate to the water calibration screen (see details at the end of this SOP); consult user manual of specific skid trailer for details.

Step 4. Assistant: Connect air cylinder and chains to load plate (see below photo).



Step 5. Assistant: Connect load meter to load plate and to the ports in the vehicle.

Step 6. Assistant: Connect air supply to trailer "tongue" (see below photo) and turn on water pump.



Step 7. Allow 15 minutes for the equipment to warm up.

Step 8. Assistant: Raise left wheel using air jack behind trailer and push the "Zero" button on the force meter. The traction reading should be less than 5 and the load reading should be around 1,085 (see below photo). If not, make sure all components are connected and the software is initialized. Do not proceed to Step 9 until readings are acceptable.

Step 9. Operator: In software interface, turn on the break and check that the readings on the load meter have not changed. If they have changed, do not continue until issue is resolved. Observe that load and traction readings through the software's auto-test function are updating. If they are not, make sure the cable from the load meter is plugged into the correct vehicle serial ports before continuing; consult user manual of specific skid trailer for details

Step 10. Operator: Begin test; consult user manual of specific skid trailer for details.

Step 11. Operator: Instruct the load meter assistant to begin increasing the load by turning the pressure switch clockwise.

Step 12. Assistant: Visually monitor the traction reading and continue to increase the load until the traction reading is near 100. The traction reading can be within +/- 10 of 100, but it is crucial that the load does not decrease. If the traction reading goes slightly above 100, DO NOT decrease the load to reach the desired traction reading.

Step 13. Assistant: When the traction reading is near 100, signal to the operator.

Step 14. Operator: Click the test option in the skid data collection software. Repeat Step 11 to Step 13 for traction levels 200, 300, 400, 500, 600, 700, and 750.

Step 15. Assistant: After completion of testing at traction level 750, begin to decrease the load and repeat the process for traction levels 700, 600, 500, 400, 300, 200, 100, and 0.

2- Evaluate Skid Force Calibration Results – *performed by operator*

Summary: Under this task, the results of the skid force calibration are evaluated by comparing the force readings as measured by the force meter with the applied load as measured under the skid tire by the data collection software. The steps for using the current version of the skid collection software, ICC MDRPro 2.5, are provided at the end of this SOP.

Step 16. Operator: Once testing is complete, check the percent error for the force and load. Out of tolerance values will be flagged by the software.

Step 17. Operator: Check for non-linearity issues.

Step 18. Operator: Examine a best fit curve of force meter readings to truck readings. Skid Number (SN) values should be within 0.3 points (standard acceptance criteria is within 3 points).

Step 19. Operator: Exit software, power down the computer, remove connections, and break down the calibration setup.

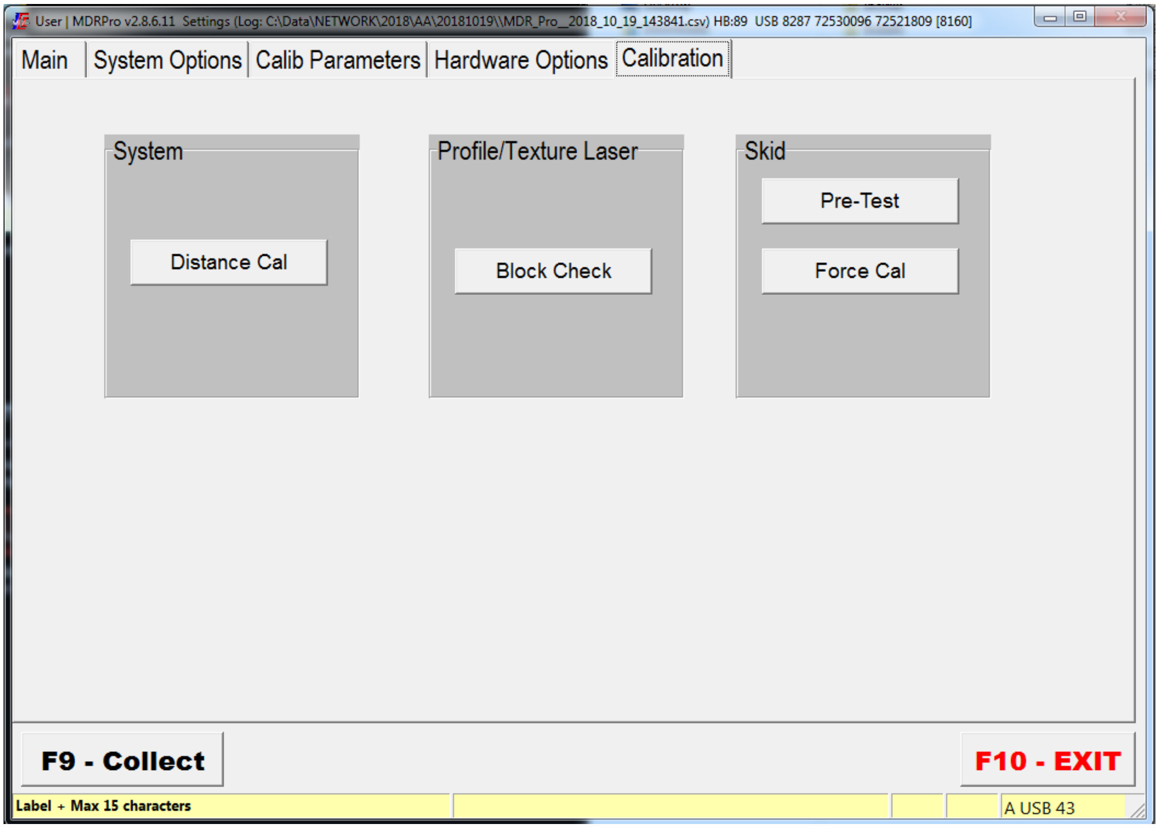
ICC MDRPro 2.5 Skid Force Calibration Software Instructions

The following instructions can be followed to supplement Task 1 of this SOP when using ICC MDRPro 2.5 skid data collection software to perform the required force calibration on Skid Trailers 7 and 8.

Click on the “MDRPro 2” icon on the desktop of the computer (see below image).

Login by typing “user” in the “Password” text box (see below image).

Click on the “Calibration” tab and then on “Force Cal” button (see below image).

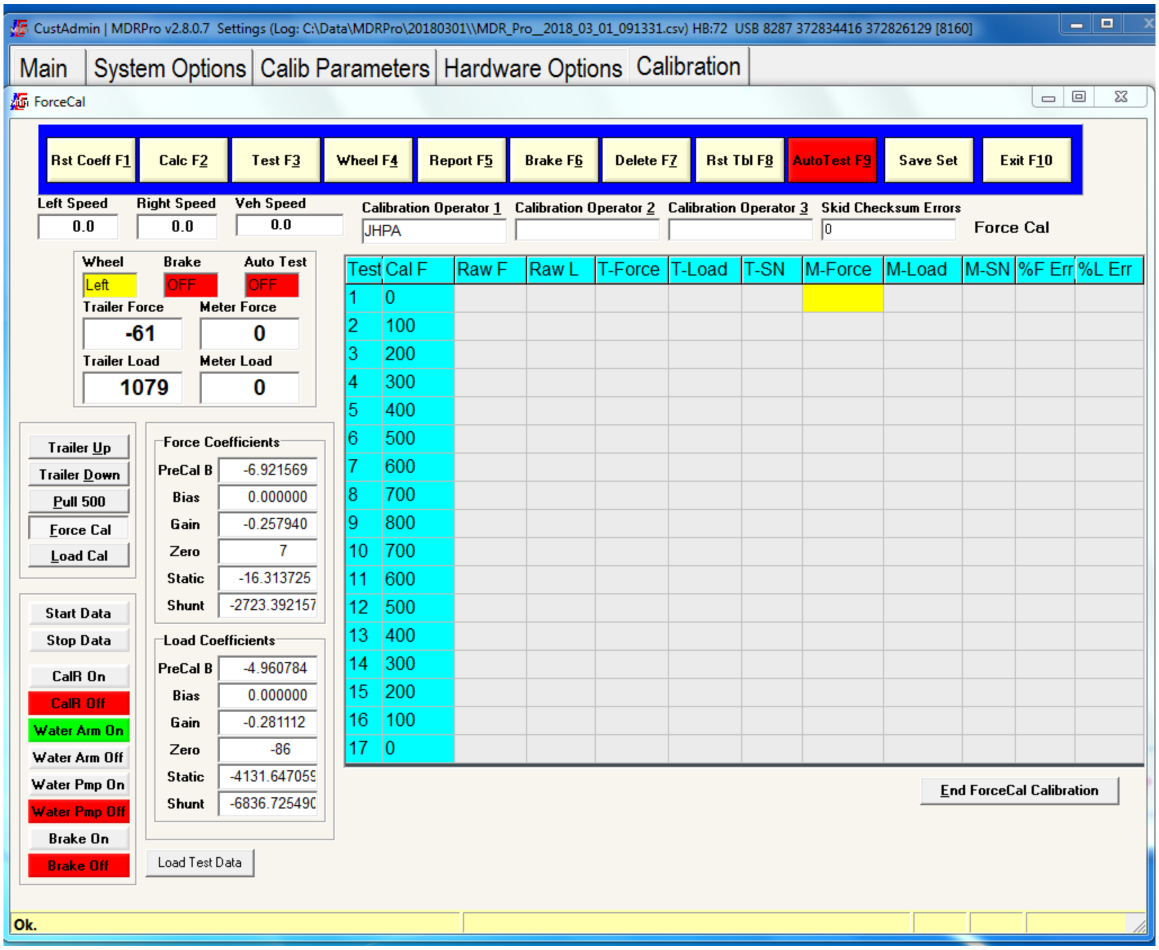


In the software interface, make sure the first “Calibration Team” field is populated with the name of the operator and assistant.

Click on the “Break On” button.

Click on the “Autotest” button and confirm that load and traction readings are updating.

Click on the “Test” button. The data will populate for the “0” load row under the “M-Force” column in the interface table (see below image).



Select the next cell down in the “M-Force” column that corresponds with the “100” “Cal F” row. The cell will turn yellow when selected.

Click the “Test” button when prompted by the Assistant. Data will be populated in the selected yellow cell.

Confirm that the correct cell is selected (colored yellow) in the “M-Force” column before clicking on the “Test” button at each traction level.

The following details can be followed to supplement Task 2 of this SOP using ICC MDRPro 2.5 skid data collection software to save and exit the required force calibration.

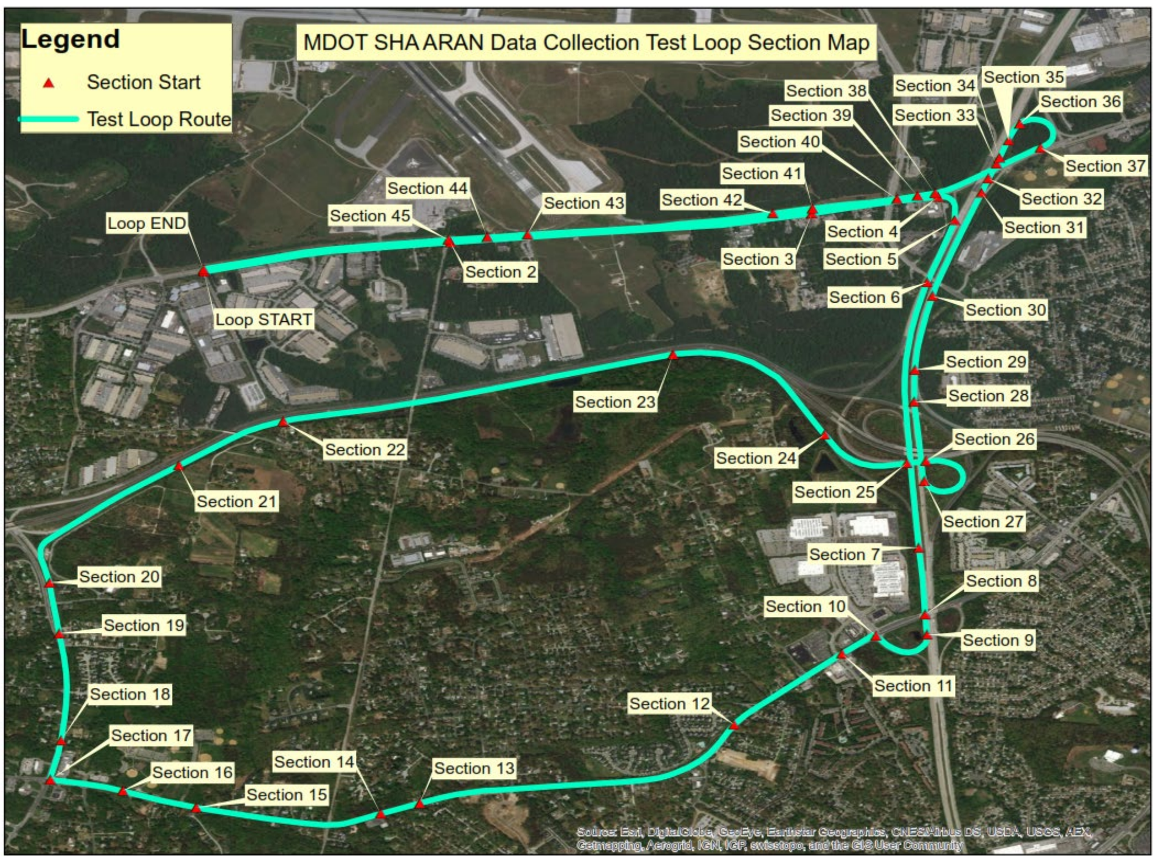
Click on the “Calc” button and the software will produce a best fit curve of force meter readings to truck readings.

When finished, click on the “Report”, “Break Off”, “Exit”, “Yes”, and “Exit” buttons, in that order.

3.14 SKID TEST LOOP DATA COLLECTION

3.14.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Field Explorations Division (FED) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to perform skid data collection on a route specifically selected for this purpose. The steps described in this SOP are based on the ICC MDRPro 2.5[06/12/2019] software developed for operating Skid Trailers 7 and 8[06/12/2019]. The data collection route is called the "test loop." As depicted in the map[06/12/2019] below, the test loop begins and ends near the Office of Materials Technology (OMT) location. It is approximately 13.1 miles in length and it is divided into segments of varying length based on surface type, intersection locations, ramp locations, and other common road features. This route was selected because it includes a variety of surface types and textures, which are used to validate the MDOT-SHA skid data.



The preliminary actions and diagnostic checks outlined in Skid Pre-Data Collection Actions must be completed prior to the beginning of skid data collection runs on the referenced test loop.

3.14.02 *Frequency*

This SOP requires that MDOT-SHA FED staff perform three skid data collection runs on the test loop once per month during the data collection season[06/12/2019].

3.14.03 *Purpose*

The purpose of this SOP is to perform skid data collection runs on the test loop to validate the MDOT-SHA skid data.

3.14.04 *Resource Requirements*

The actions detailed in this SOP are performed by the MDOT-SHA FED skid trailer crew, which is comprised of a driver and an operator. The estimated effort levels shown in the table below represent the total time, in man-hours, required for completion of all test loop activities, including preliminary checks and diagnostics, three data collection runs, and data export and management. These time estimates assume no issues are encountered during the required work.

Position	Function	Resources	Effort Level (man-hrs)
Skid Testing Crew	Driver	1	2.0
Skid Testing Crew	Operator	1	2.0
FED Team Leader (TL) or Coordinator	Supervisor	1	As Required[06/12/2019]

3.14.05 *Procedure*

The procedure required to complete skid data validation on the MDOT-SHA test loop is comprised of the following task:

(1) completing skid data collection on MDOT-SHA test loop.

1- Completing Skid Data Collection on MDOT-SHA Test Loop – *performed by driver and operator*

Summary: Under this task, three runs on the MDOT-SHA skid test loop are completed.

Step 1. Operator: Follow Skid Pre-Data Collection Actions, Step 3 through Step 16, for vehicle and diagnostic checks and system initialization.

i. If checks do not identify equipment issues, proceed to Step 2.

ii. If checks identify equipment issues, consult Skid Pre-Data Collection Actions for troubleshooting methods. Communicate issue(s) to the TL or Coordinator and suspend test loop data collection until all systems are functioning properly.

Step 2. Driver and Operator: Follow Skid Data Collection, Step 1 through Step 10, for completing each test loop data collection run. The file name should be "TESTLOOP[RUN#][DATE]". Three runs are to be completed.

i. If runs are successfully completed, proceed to **Error! Reference source not found.**

ii. If a run is not successfully completed or if one or more systems malfunctioned during data collection, attempt to resolve the issue(s). If Operator is not able to resolve the issue(s), communicate issue(s) to the TL or Coordinator and suspend test loop data collection activities until all systems are again functioning properly. When resolved, return to Step 2 and recollect the test loop runs.

Step 20. Driver and Operator: Follow Skid Post-Data Collection Actions, Step 1 through Step 14, for data management and system shut-down following the completion of the third and final test loop run[06/12/2019].

4 CONSTRUCTION DATA

Click to go to Processing Paving & Maintenance History Data
Click to go to Processing Access Permit Data
Click to go to Processing As Bid Unit Cost Data
Click to go to Processing As Built Unit Cost Data
Click to go to Reviewing Projects in MCMS
Click to go to Running Transport Application
Click to go to Looking Up Fund Type
Click to go to Making Lane Configuration Changes
Click to go to Adding to Project Engineer List
Click to go to Viewing Paving & Maintenance History by Route
Click to go to Promoting As Bid to Construction History
Click to go to Generating As Built Report
Click to go to HMA Tonnage Application

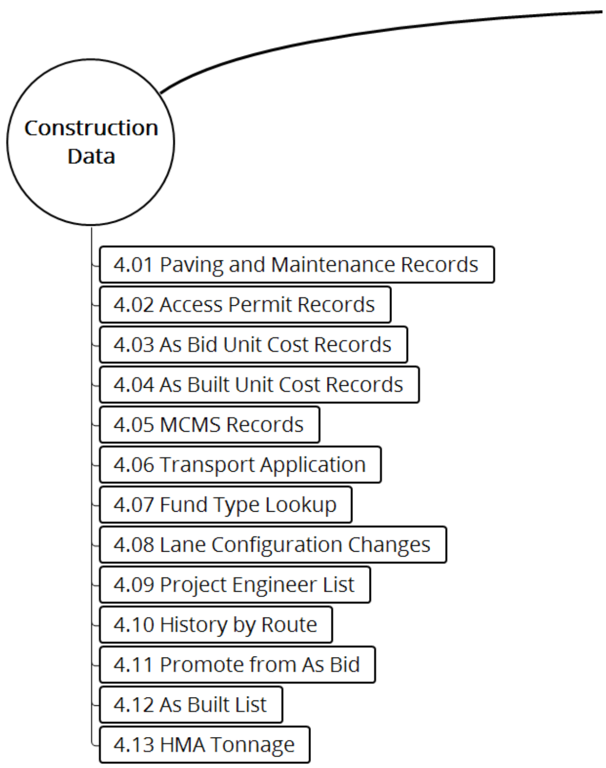


Figure 7: Construction SOPs Flowchart

This section describes the set of standard operating procedures (SOP) conducted by staff from the Data Processing Team (DPT) of the Maryland Department of Transportation State Highway Administration's (MDOT-SHA) Office of Materials Technology (OMT) to collect, import, and process construction data from various sources necessary to support PM activities. The information collected, imported, and processed in these SOPs are incorporated into the Business Plan Tables.

The first two construction SOPs involve collecting and importing construction data from various historical sources. The first SOP describes the process required to import construction data from paving and maintenance history data, while the second SOP describes the process required to import construction data from access permit information.

The next two construction SOPs involve collecting and importing construction data from cost data sources. The first SOP describes the process required to import construction data from As Bid unit cost information, while the second SOP describes the process required to import construction data from As Built unit cost information.

The final set of construction SOPs describe supplemental procedures designed to support the SOPs described above. This set includes nine SOPs: reviewing projects in the Maryland Construction Management System, running the Transport application, looking up fund type, making lane configuration changes, adding to the Project Engineer list, viewing paving and maintenance history by route, promoting As Bid to construction history, generating an As Built report, and running the Hot Mix Asphalt Tonnage application.

4.01 PROCESSING PAVING & MAINTENANCE HISTORY DATA

4.01.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to collect and update construction history data in the Engineering Data Warehouse (EDW). Projects are classified as either "Paving" or "Maintenance." Paving projects consist of a continuous treatment applied to the roadway (i.e. mill and overlay, reconstruction, etc.). Maintenance projects consist of spot improvements applied to the roadway (i.e. patching, crack sealing, slurry/micro sealing, etc.). Construction history is used within the Pavement Management System (PMS) to fuel pavement inventory information, assist in the development of performance models, assist the Pavement Design Team, and assist external customers with knowledge concerning the structural history, composition, and traffic information for MDOT-SHA controlled roadways. There are various external and internal data sources for the collection of construction history information.

4.01.02 *Frequency*

The updating of construction history is a continuous process that occurs year-round.

4.01.03 *Purpose*

The purpose of this SOP is to collect and update paving and maintenance construction history data, verify and update inventory information associated with the project, perform quality control (QC) of gathered data, and update the data in the EDW.

4.01.04 *Resource Requirements*

Data collection and upload of paving and maintenance information involves two people: (1) a user knowledgeable in collection of construction history data from various sources and the EDW software to perform data collection, QC, and uploading, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	EDW user and QC	1	1.0-16.0[06/12/2019]
DPT TL	Supervisor	1	AR[06/12/2019]

4.01.05 *Procedure*

The procedure to collect and update paving and maintenance history data is comprised of the following three tasks:

(1) collection of paving and maintenance data,
(2) input of collected paving data into the EDW, and
(3) input of collected maintenance data into the EDW.

1- Paving and Maintenance Data Collection – *performed by EDW user*

Summary: This task collects and reviews paving and maintenance construction data from a variety of sources in order to retrieve the necessary inputs for data entry into the EDW.

	Data Item	Source
Project Information	Contract (and FMIS) #	Project Plans/IFB
	Fund Type	IFB/FMIS Lookup (Internal function)
	State Construction P.E.	Assignment List Database
	Functional Class	HLR/P & G Report
	Project Description	IFB
Location	Code	Contract Number (BA,AA,etc)
	Route	Bid Tab (single Ad)/IFB/HLR/Project Plans/P & G Report
	BMP & EMP	IFB/HLR/Project Plans/P&G Report/Visidata
	Inventory Direction	HLR/Visidata
Project Rehab Info	Thickness	IFB/Project Plans/P&G Report
	Design Life	IFB/P&G Report
	Construction Type	Project Plans/IFB
	Construction Layers	Project Plans/IFB/P&G Report
	Mix Design	HMA Tonnage Database/IFB/P&G Report
	Paving/Patching/Milling Dates	MCMS

Step 1. For each project where available, review the Right-of-Way (ROW) video collected by the Automated Road Analyzer (ARAN) vehicle, “Visidata.exe.” Review the video to determine the limits of work for the project and verify, where possible, the type of construction action.

Step 2. Check the **Invitation for Bid (IFB)** for relevant pavement history data. IFBs can be received directly from the Office of Maintenance (OOM) and the Office of Highway Design (OHD). They may also come from either the Pavement Design (PD) Team or General Test team.

Step 3. Obtain pertinent pages of the IFBs that relate to construction history and dispose of remaining pages. The pertinent pages are (but not limited to): **Title Page, Project Description, Category 500 Paving –Asphalt Cement Price Index, Paving Typical Sections, Plans Sheet, Soil Boring, Pavement Coring Log,** and **2000, 5000 & 6000 series items in Schedule of Prices section** (located near end of document).

Step 4. Retrieve Project **Plan Set** from the source. Review pertinent pages that relate to construction history. Ensure that all the pertinent data is enclosed in the plan set – paving typical sections, plan sheets, etc.

Step 5. Identify the project limits using the **Highway Location Reference (HLR) Guide**. The HLR Guide is categorized by county and route. Verify the mile points. The HLR also gives the Functional Class and AADT (Refer to Highway Location Referencing Guide).

Step 6. Access the **MCMS database** through the EDW application (see Reviewing Projects in MCMS). Export the relevant spreadsheets to Excel. Relevant pages are: Items Report and IDR Detail. For area-wide projects, ensure the appropriate Financial Management Information System (FMIS) number is chosen when exporting the spreadsheet to Excel. In the Items Report, all 2000, 5000 and 6000 series items should be evaluated to determine which items are relevant.

Step 7. Check **Hot Mix Asphalt (HMA) Tonnage** production database. Sort the data by "Contract Number" and hide all the unnecessary fields in the database. Keep **Paving Location, Mix Number Production Date,** and **Actual Tonnage**. Compare the total project estimated tonnage to the accumulated "actual" tonnage (see HMA Tonnage Application).

i. If the values are close, copy both tables (Estimated & Actual) into an Excel spreadsheet. Proceed to Step 8.

ii. If the values are not close, further investigation is required before proceeding. Cross reference MCMS report and contact Project Engineer to reconcile any differences.

Step 8. Access the **Assignment List database** and print a summary with the State Construction P.E. listed.

Step 9. Check PM records for the **PM – 003 form**. This form contains the mile points (or station numbers), location information, mix design, project engineer, and type of construction.

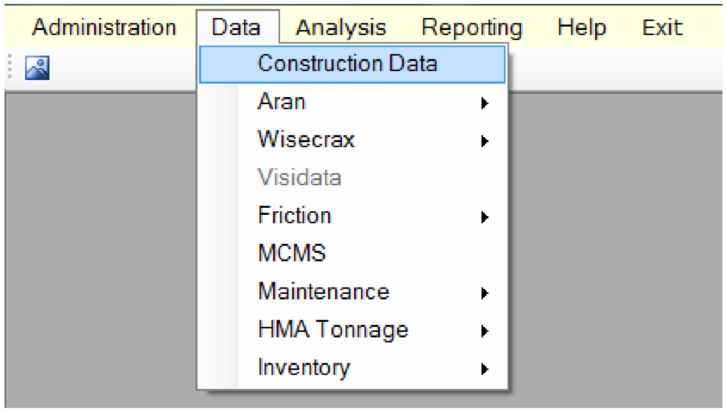
2- Paving Data Input into EDW and QC – *performed by EDW user*

Summary: This task inputs collected paving construction data into the EDW.

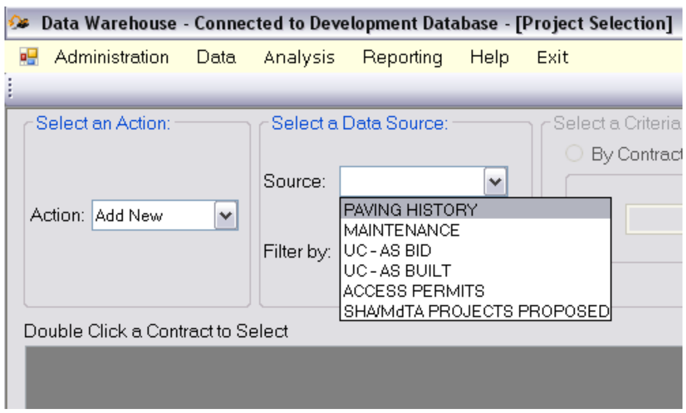
Step 10. If the construction history data was paving, proceed to Step 11. If the construction history data was maintenance, skip to Step 26.

Step 11. Open the EDW application.

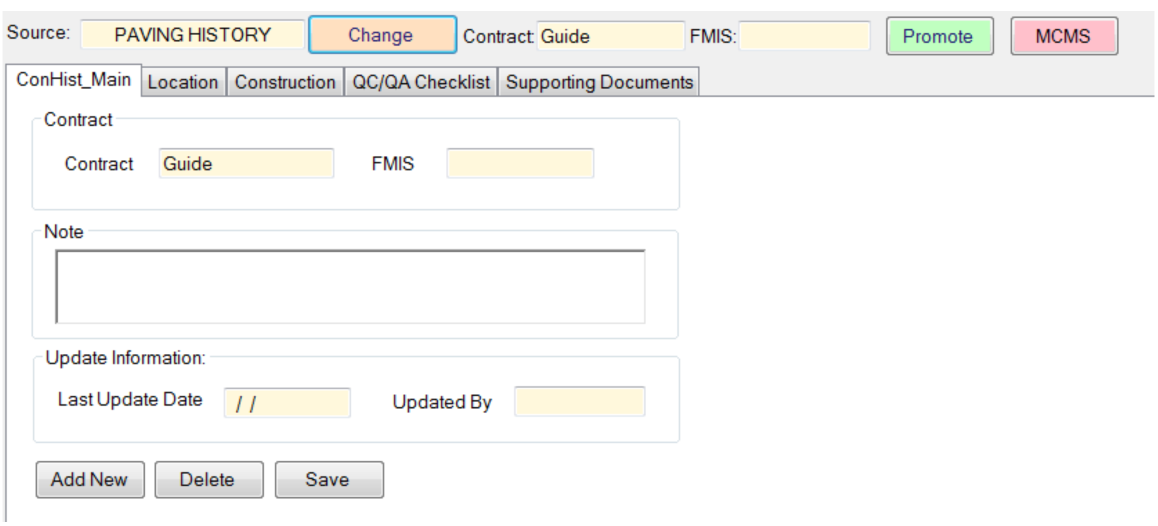
Step 12. On the Main Menu, click on "Data." From the "Data" drop-down menu, choose "Construction Data" (see below image).



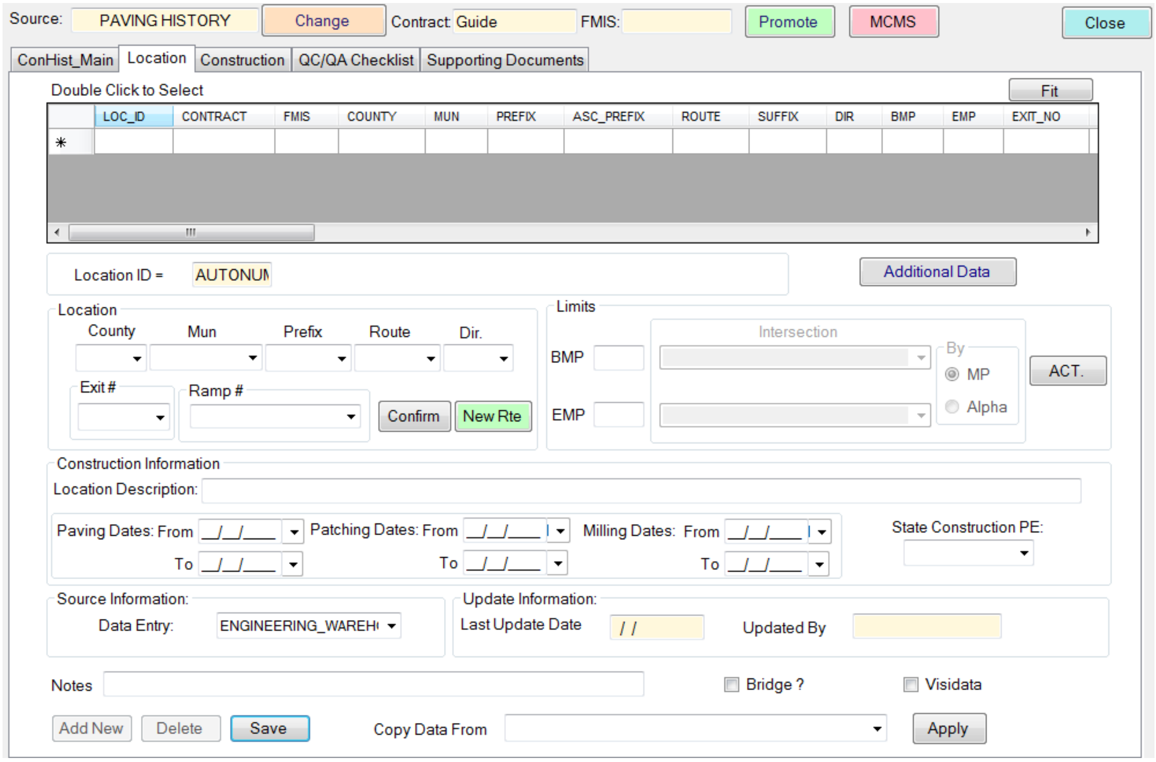
Step 13. In the “Select an Action” section choose “Add New” and then “Paving History” from the “Source” drop-down menu (see below image).



Step 14. Enter the required “Contract No” (and FMIS number if applicable). Click “Save” and then “OK” in the dialogue box that appears (see below image).

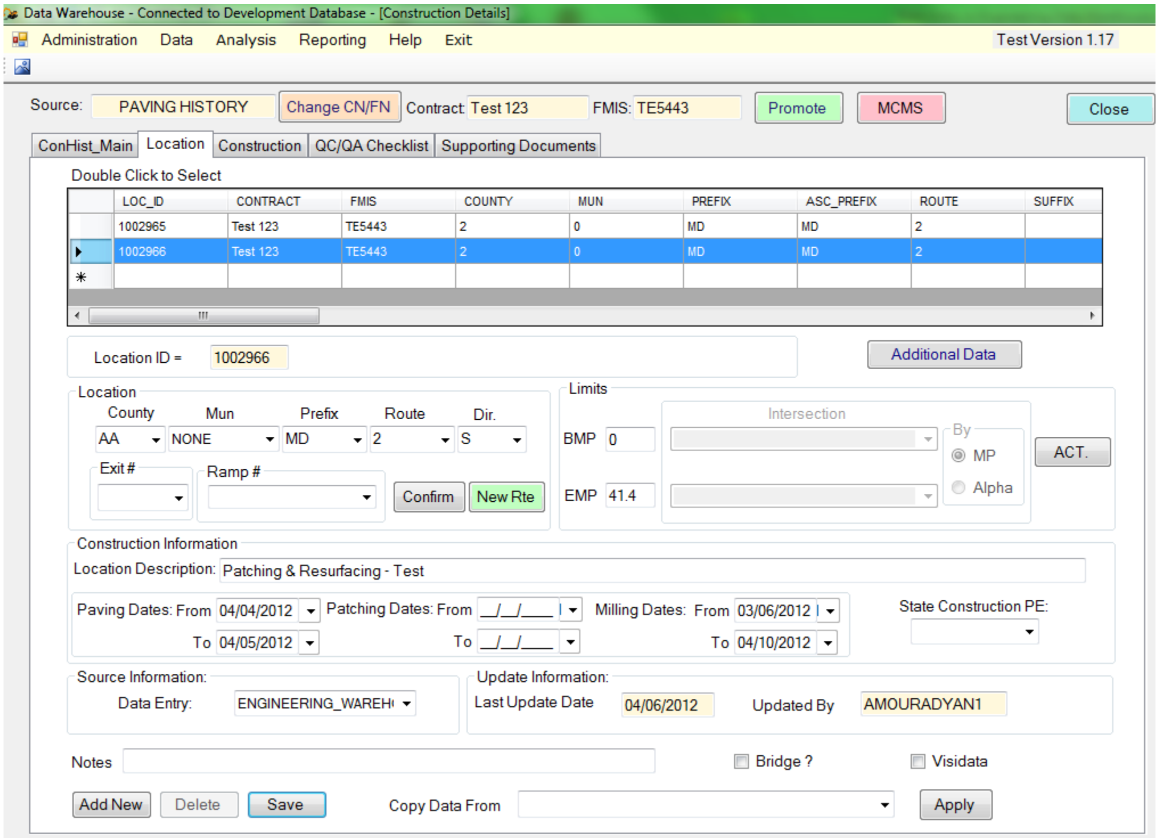


Step 15. Click the “Locations” tab. Click “Add New” at bottom of screen (see below image).



Step 16. Enter route information: County, Municipal (if needed), Prefix, Route, and Direction. Click "Confirm." The "BMP" & "EMP" will automatically populate under the "Limits" section. Adjust the mile points to fit the specific project. When entering a ramp, always chose the Main Inventory direction in the "Location" section denoted by the asterisk (*). Click "Confirm" and then proceed by inputting the "Exit #" and "Ramp."

Step 17. Enter construction information: Location Description, Paving, Patching and Milling Dates, and State Construction P.E. Click "Save" at the bottom of the screen. The locations that were entered will now appear in the location table (see below image). If the State Construction P.E. is not listed in the drop-down menu, then he/she will need to be added to the list before continuing (see Adding to Project Engineer List).



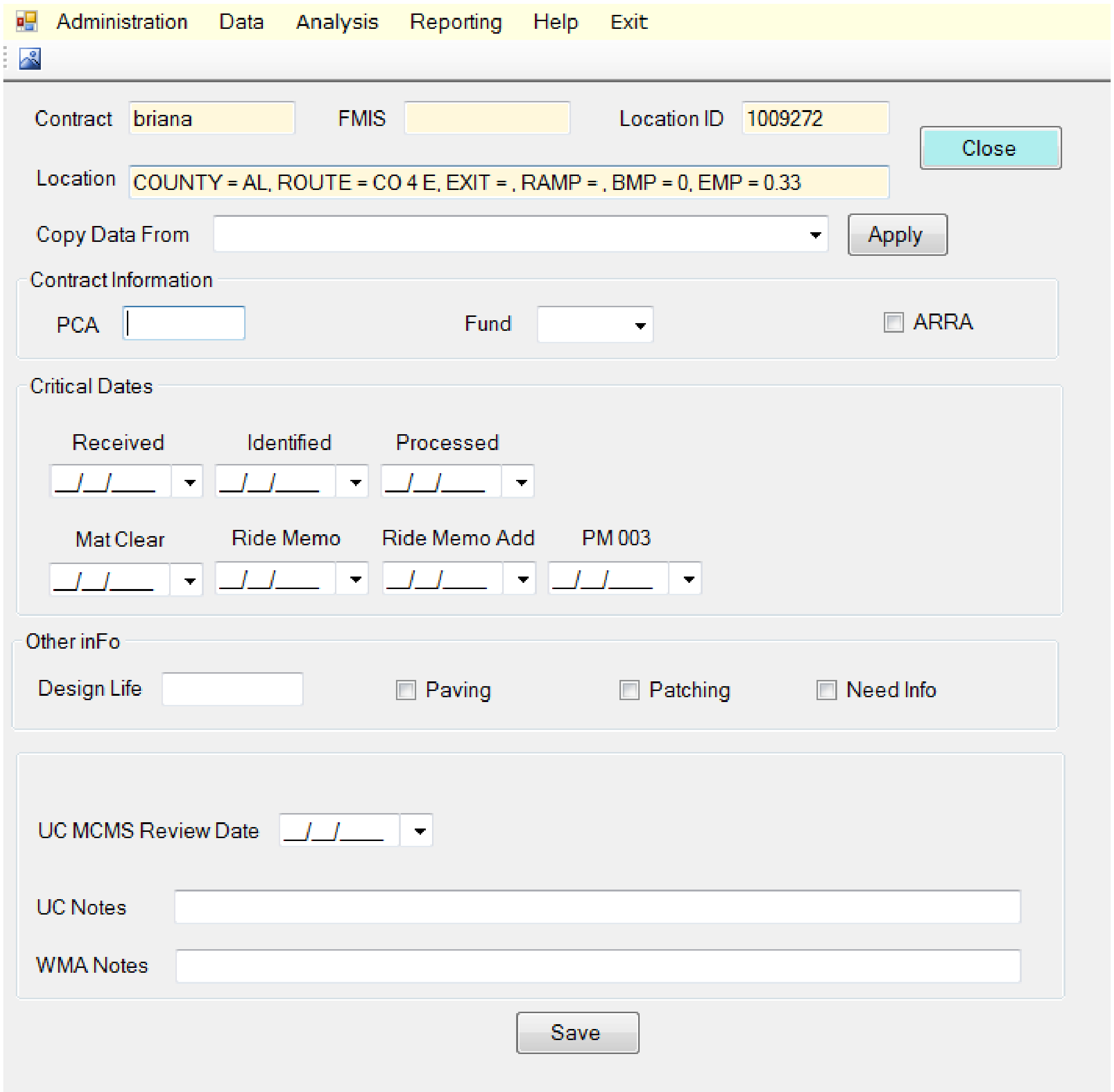
Step 18. Double-click on a location (it will be highlighted in blue when selected), then click on “Additional Data.” Select the “Fund Type.” To verify the “Fund Type,” refer to Looking Up Fund Type. In the “Critical Dates” section, the definitions for each critical date are as follows:

i. Received – any correspondence received from the Districts or the P.E.

ii. Identified – project was identified by the PM team.

iii. Processed – the data entry began for the project.

Fill in the fields and click “Save” (see below image). Repeat this step for each location in the project.

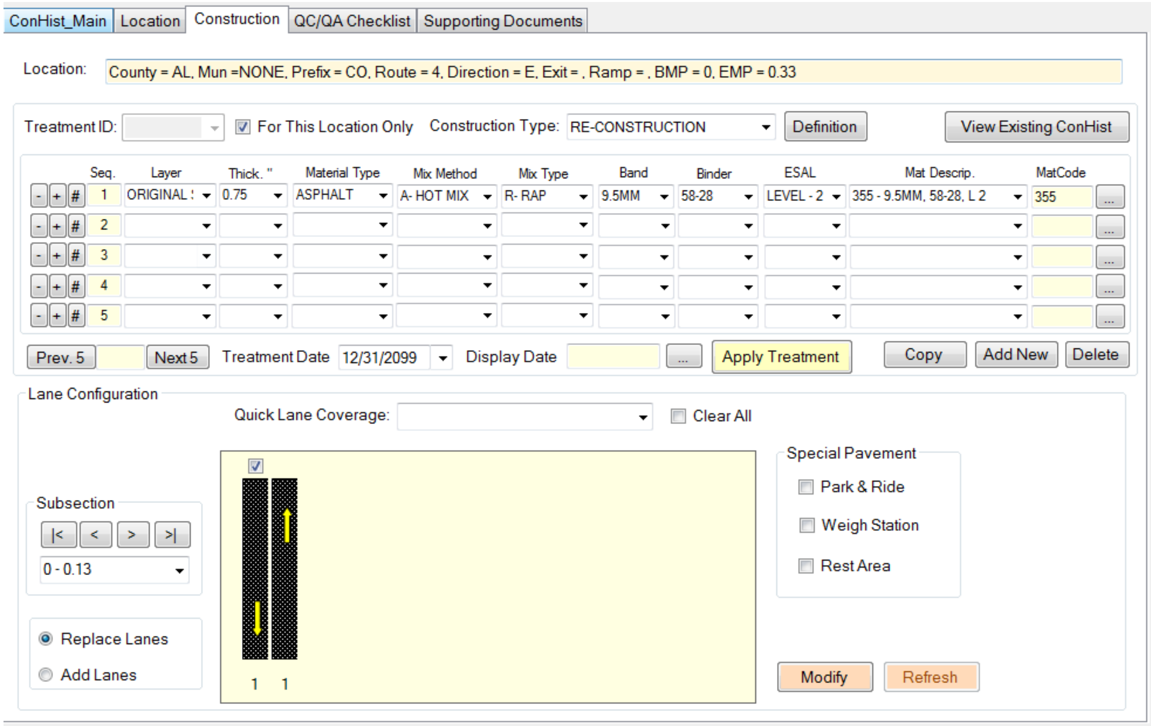


Step 19. Double-click on a location (it will be highlighted in blue when selected). Click on the "Construction" tab.

Step 20. Click "Add New." Select a "Construction Type" from the drop-down menu. Click the "Definition" button for details regarding each type.

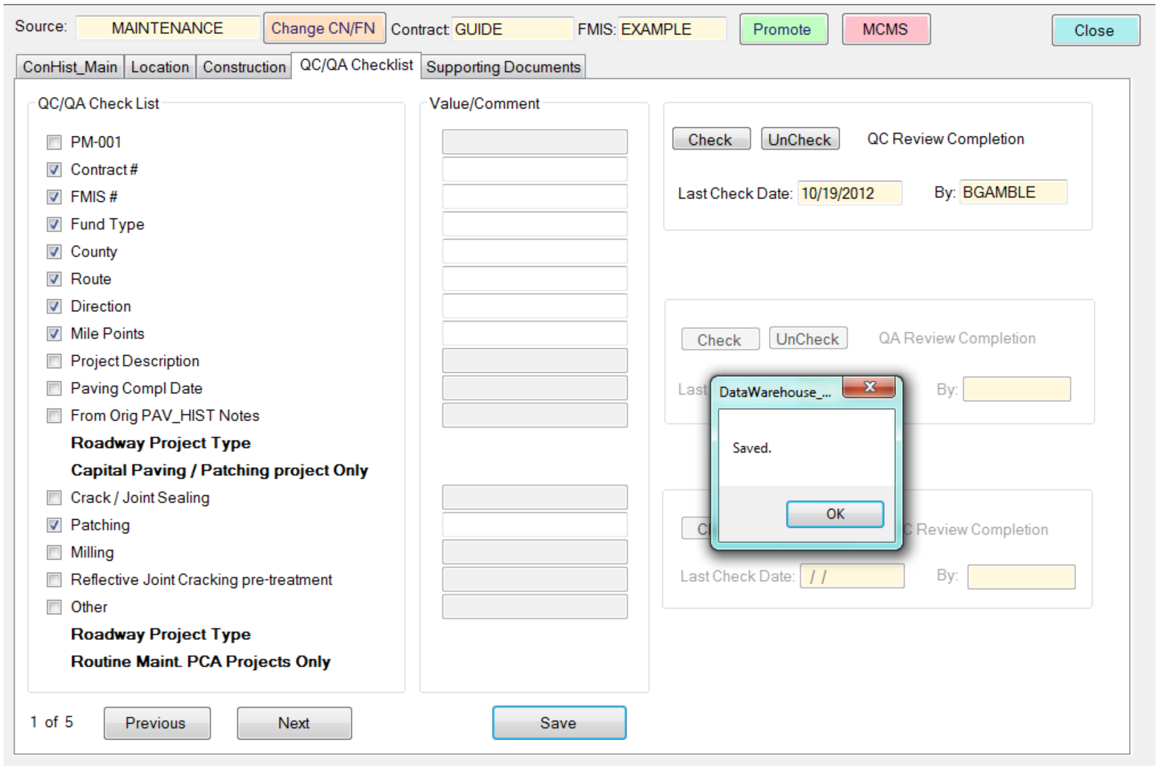
Step 21. Fill in all the appropriate fields: Layer, Thickness, Material Type, Mix Method, Mix Type, Band, and ESAL. Then, select the correct "Material Description."

Step 22. Click on the boxes above each lane at the bottom of the screen or select the appropriate option from the "Quick Lane Coverage" drop-down menu. Click on "Apply Treatment" to save the treatment for the selected section (see below image).

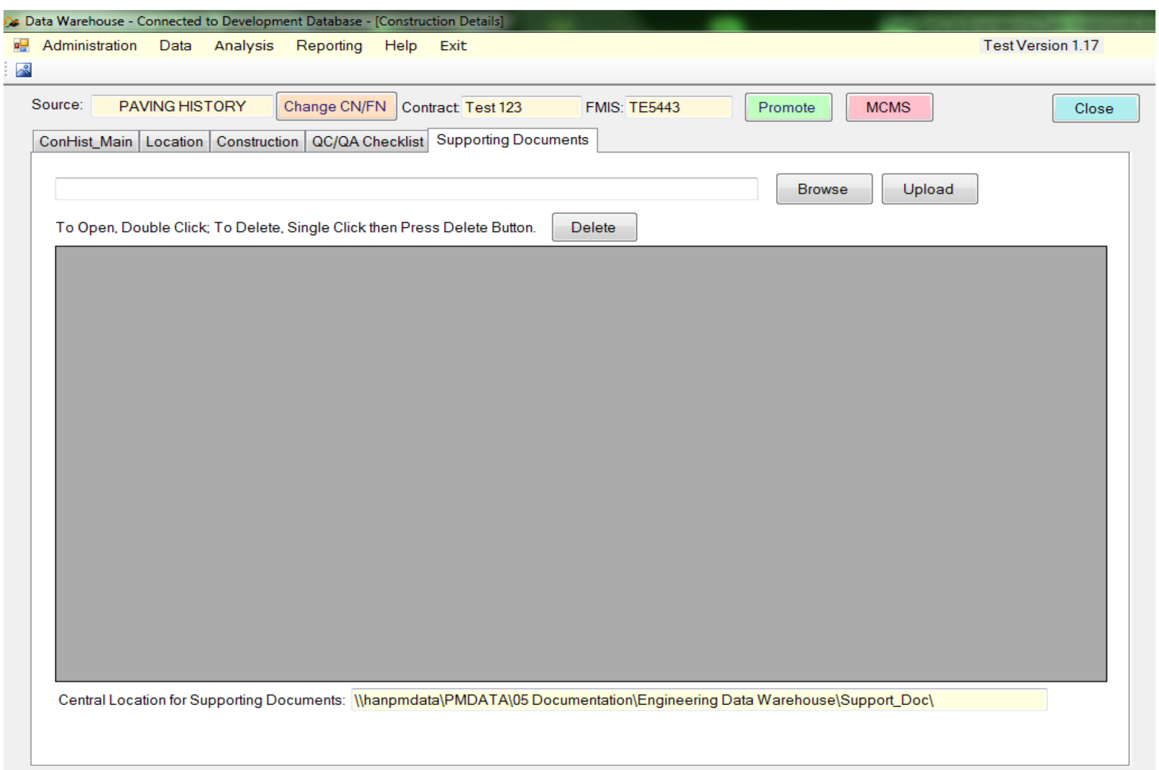


Step 23. Repeat Step 19 to Step 22 for all locations on the project.

Step 24. Click on “QC/QA Checklist” tab. Click on the relevant boxes on “QC/QA Check List” (left side of screen) and then click the “Save” button on the bottom of screen. If all data for the project is entered completely, click the “Check” button (see below image). Otherwise, return to incomplete data and input before proceeding.



Step 25. Click on “Supporting Documents” tab and upload any supporting documents using the “Upload” button (see below image). After this step, the procedure is complete (next section is for promotion through maintenance history only).

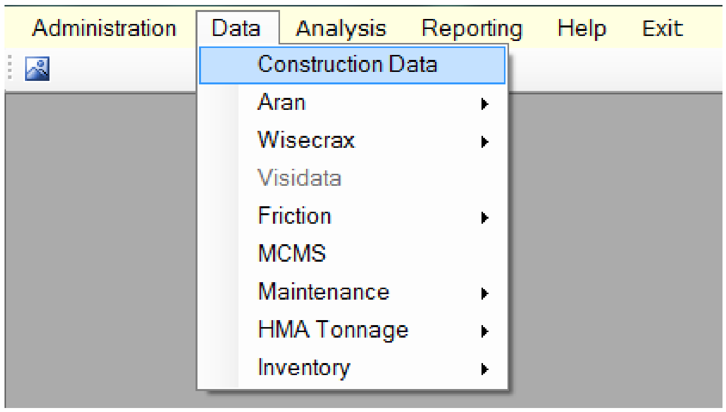


3- Maintenance Data Input into EDW and QC – *performed by EDW user*

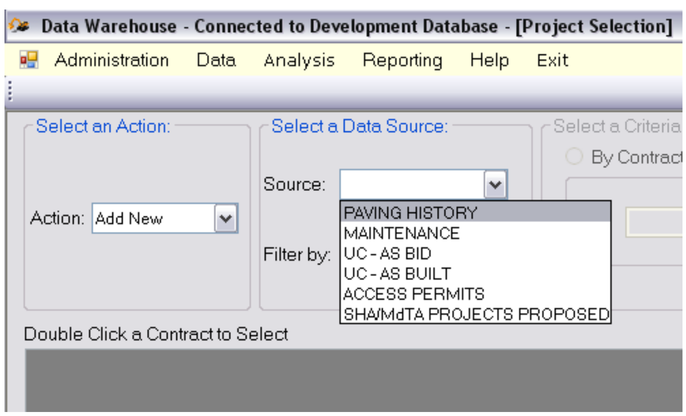
Summary: This task inputs collected maintenance construction data into the EDW.

Step 26. Open the EDW application.

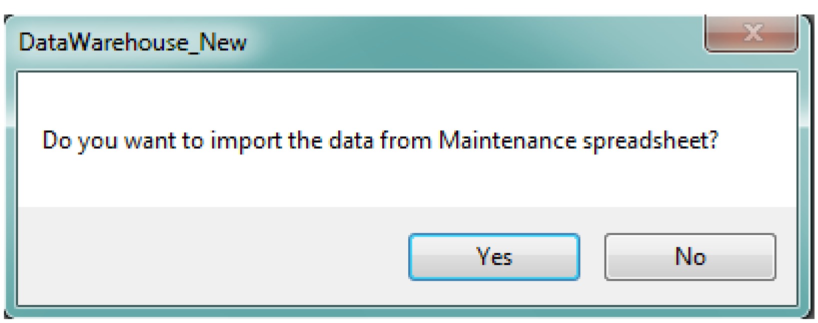
Step 27. On the Main Menu, click on "Data." From the "Data" drop-down menu, choose "Construction Data" (see below image).



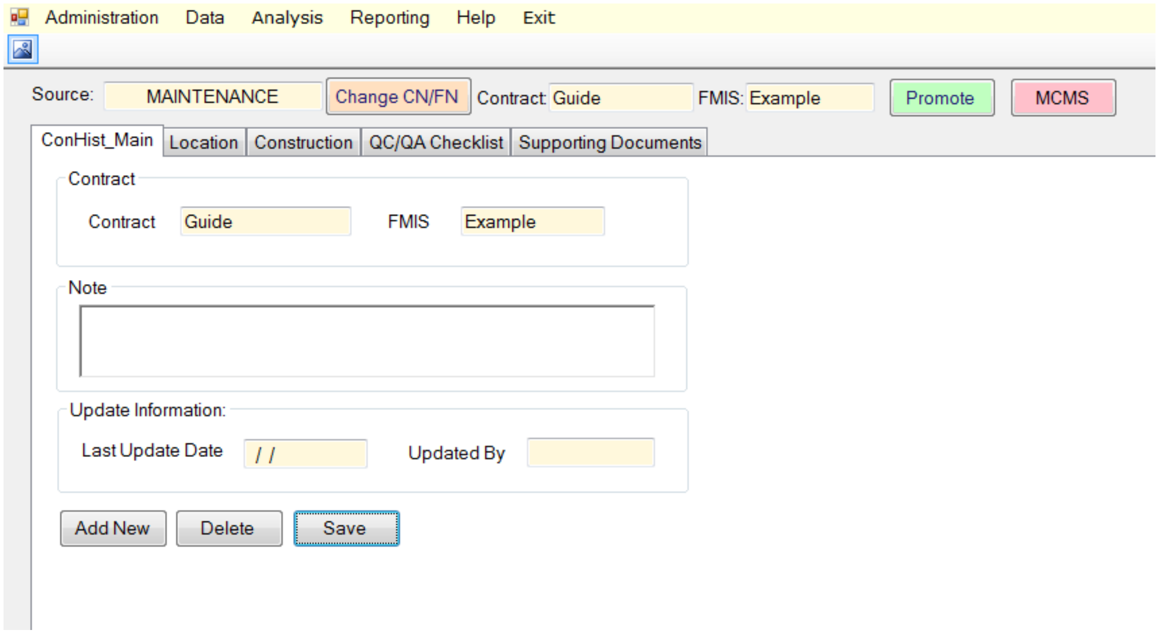
Step 28. In the "Select an Action" section choose "Add New" and then "Maintenance" from the "Source" drop-down menu (see below image).



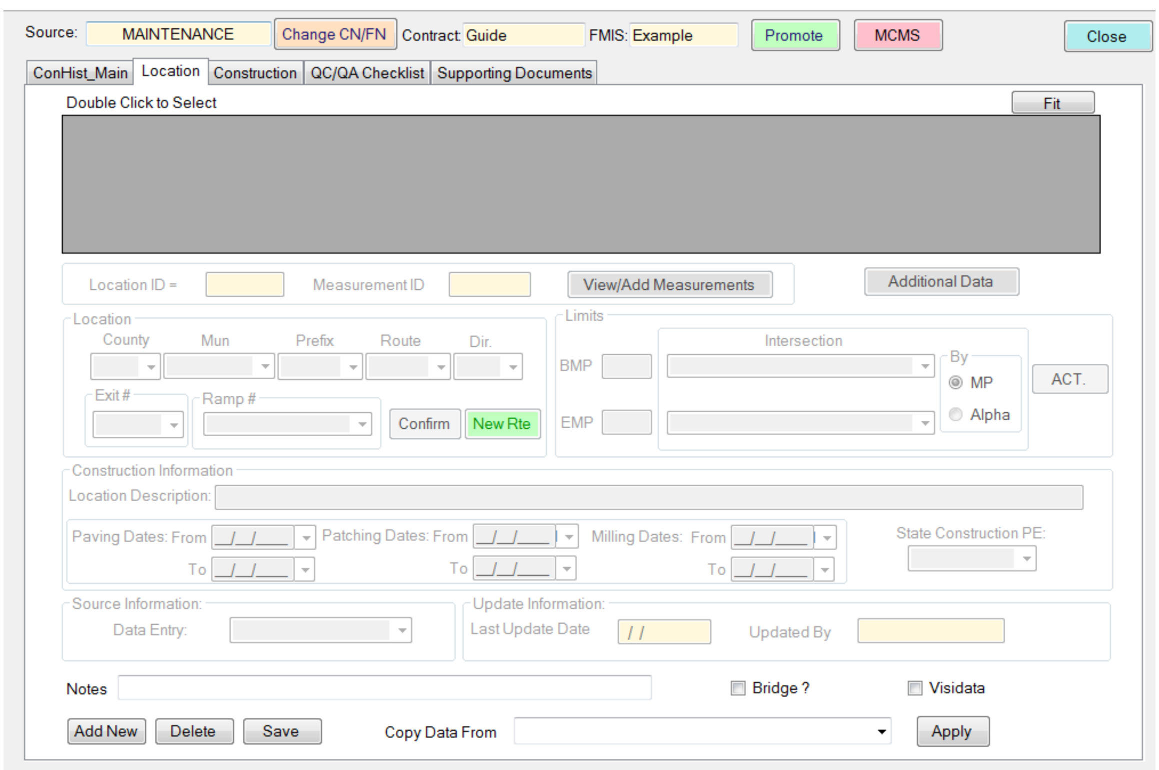
Step 29. A dialogue box will appear: "Do you want to import the data from Maintenance spreadsheet?" Click "No" except for the reports from Office of Maintenance (see below image).



Step 30. Enter the required "Contract No" (and FMIS number if applicable). Click "Save" and then "OK" in the dialogue box that appears (see below image).

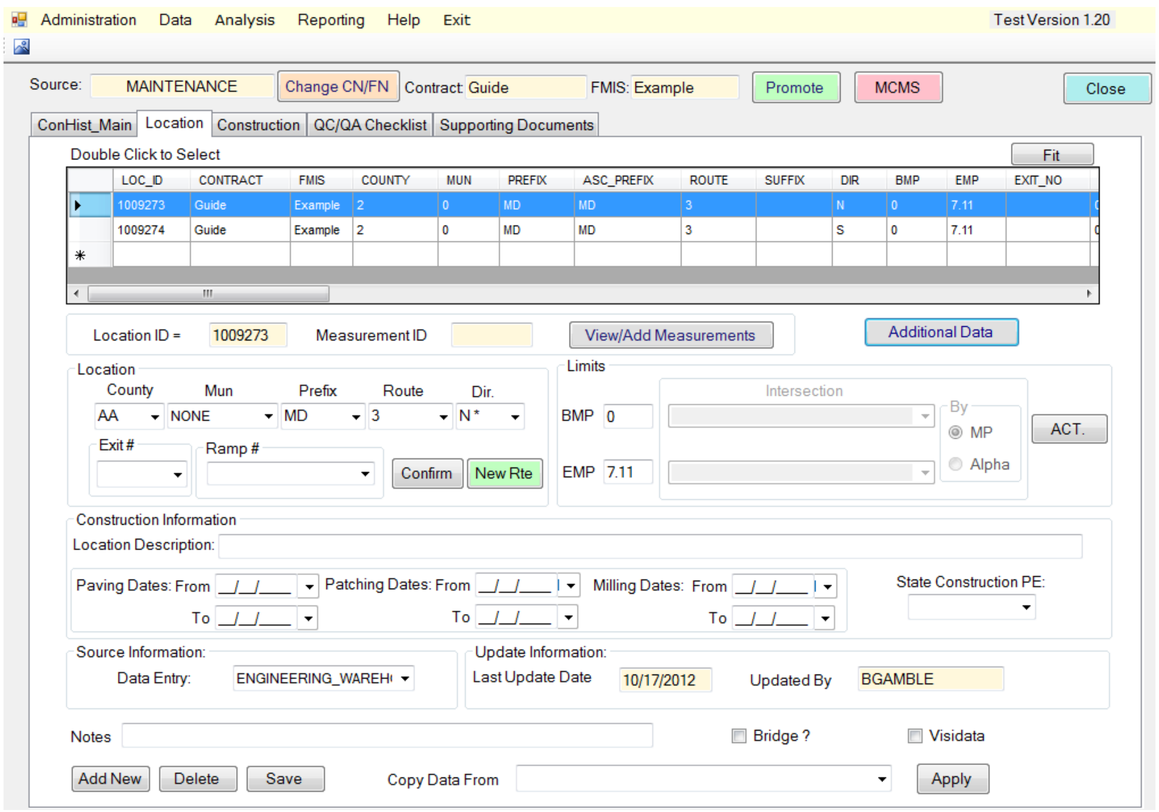


Step 31. Click the "Locations" tab. Click "Add New" at bottom of screen (see below image).



Step 32. Enter route information: County, Prefix, Route, and Direction. Click “Confirm.” The “BMP” & “EMP” will automatically populate under the “Limits” section. Adjust the mile points to fit the specific project. When entering a ramp, always chose the Main Inventory direction in the “Location” section denoted by the asterisk (*). Click “Confirm” and then proceed by inputting the “Exit #” and “Ramp.”

Step 33. Enter construction information: Location Description, Paving, Patching and Milling Dates, and State Construction P.E. Click “Save” at the bottom of the screen. The locations that were entered will now appear in the location table (see below image). If the State Construction P.E. is not listed in the drop-down menu, then he/she will need to be added to the list before continuing (Adding to Project Engineer List).



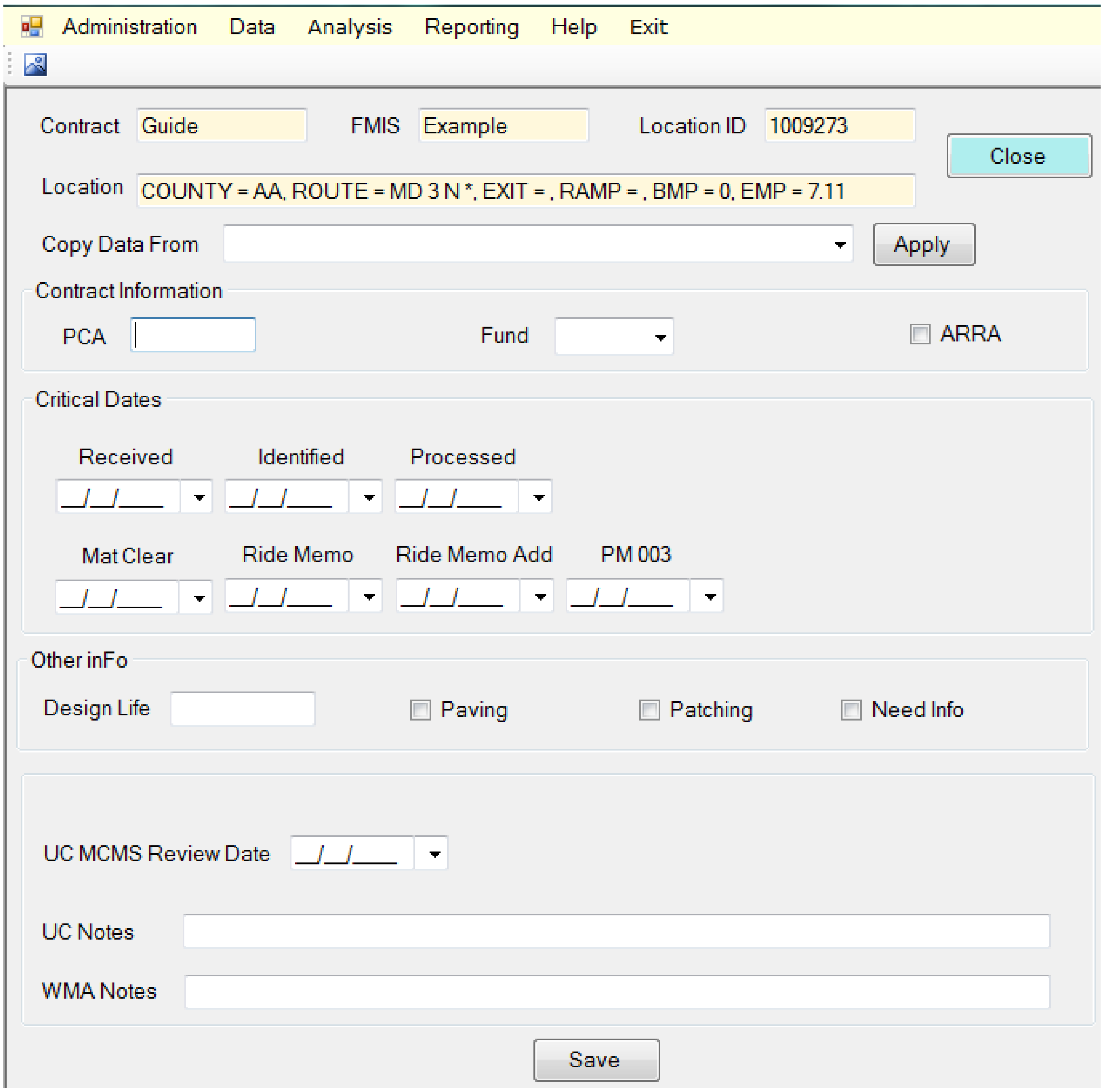
Step 34. Double-click on a location (it will be highlighted in blue when selected), then click on “Additional Data.” Select the “Fund Type.” To verify the “Fund Type,” refer to Looking Up Fund Type. In the “Critical Dates” section, the definitions for each critical date are as follows:

i. Received – any correspondence received from the Districts or the P.E.

ii. Identified – project was identified by the PM team.

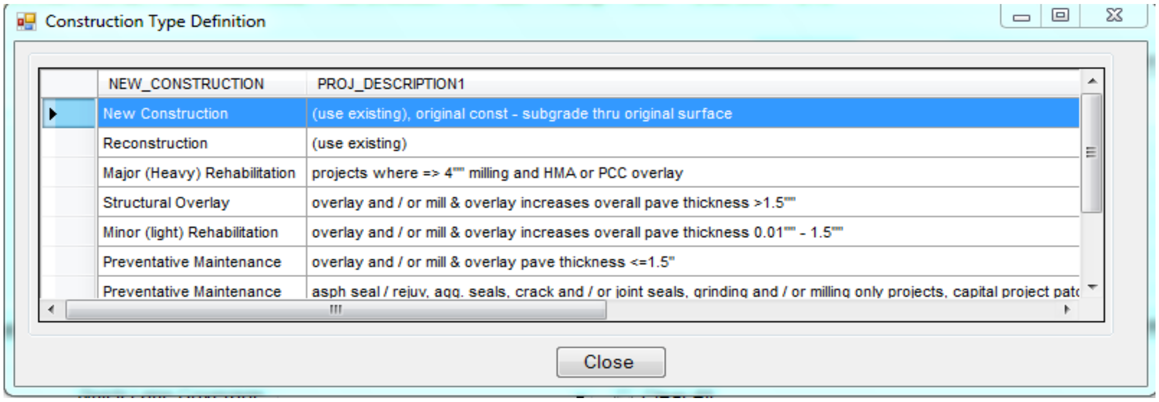
iii. Processed – the data entry began for the project.

Fill in the fields and click “Save” (see below image). Repeat this step for each location in the project.



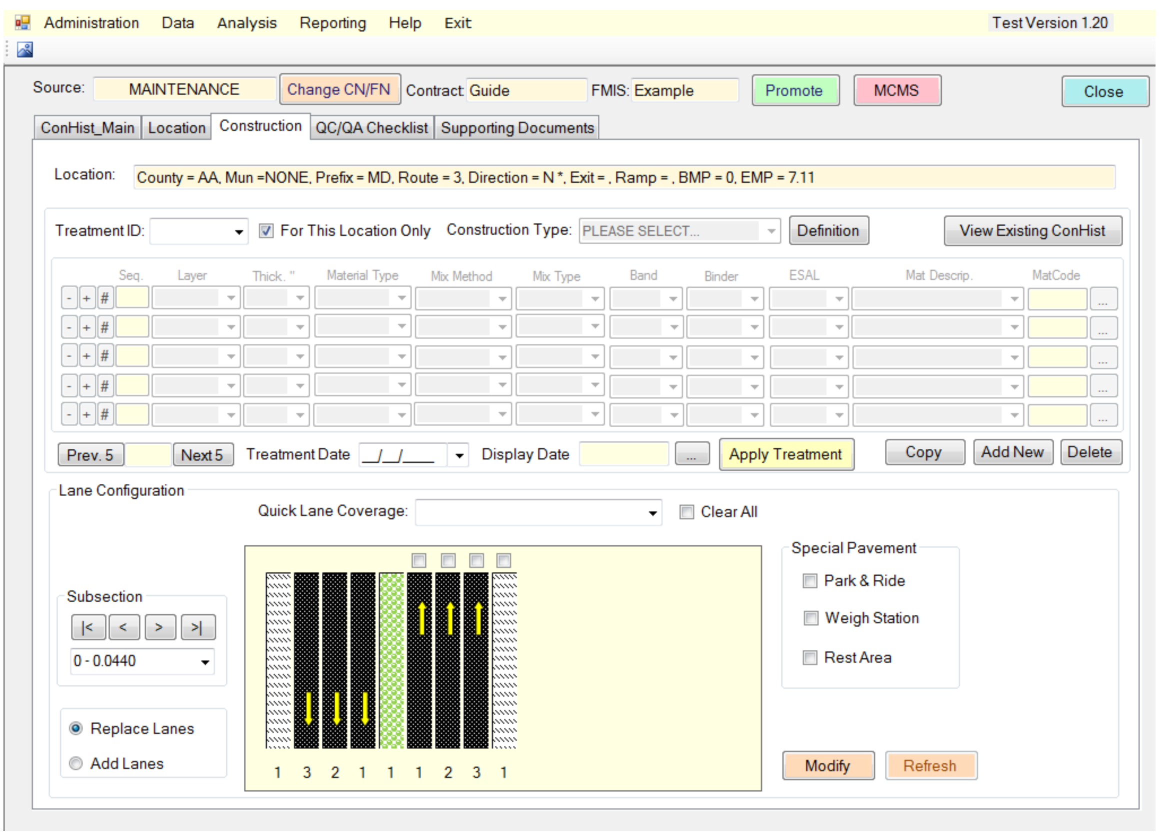
Step 35. Double-click on a location (it will be highlighted in blue when selected). Click on the “Construction” tab.

Step 36. Click “Add New.” Select a “Construction Type” from the drop-down menu. Click the “Definition” button for details regarding each type (see below image).



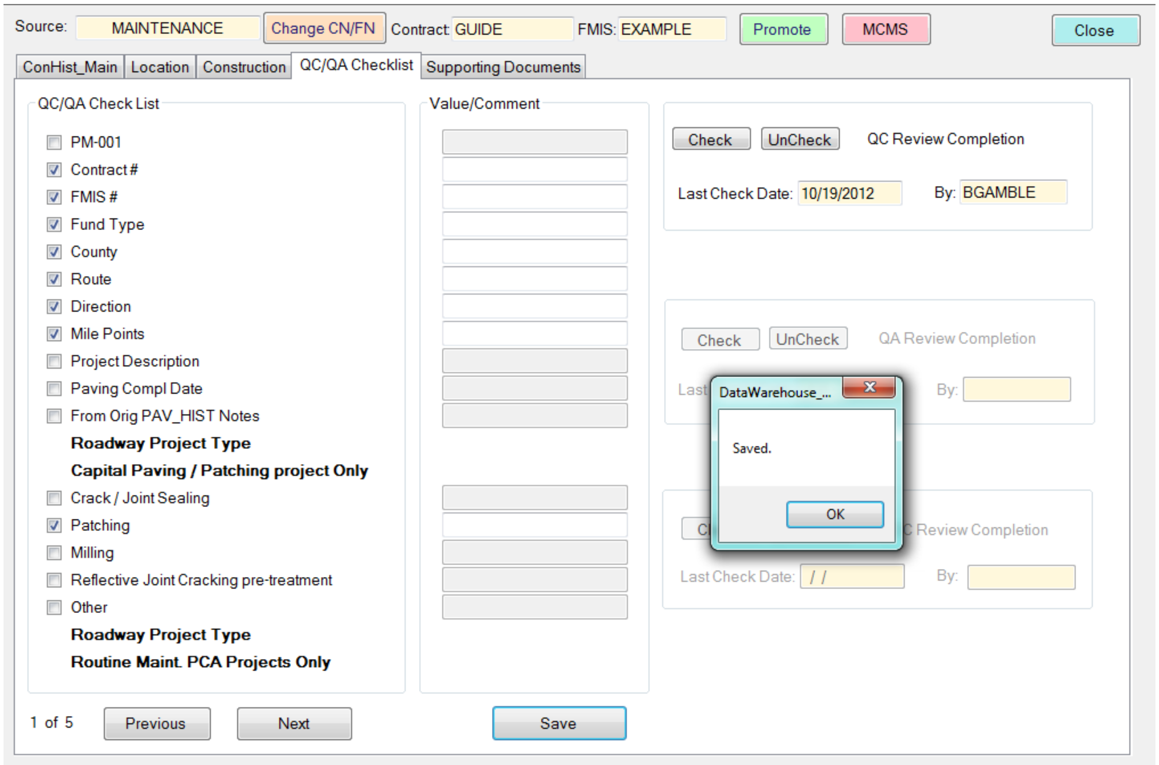
Step 37. Fill in all the appropriate fields: Layer, Thickness, Material Type, Mix Method, Mix Type, Band, and ESAL. Then, select the correct "Material Description."

Step 38. Click on the boxes above each lane at the bottom of the screen or select the appropriate option from the "Quick Lane Coverage" drop-down menu. Click on "Apply Treatment" to save the treatment for the selected section (see below image).

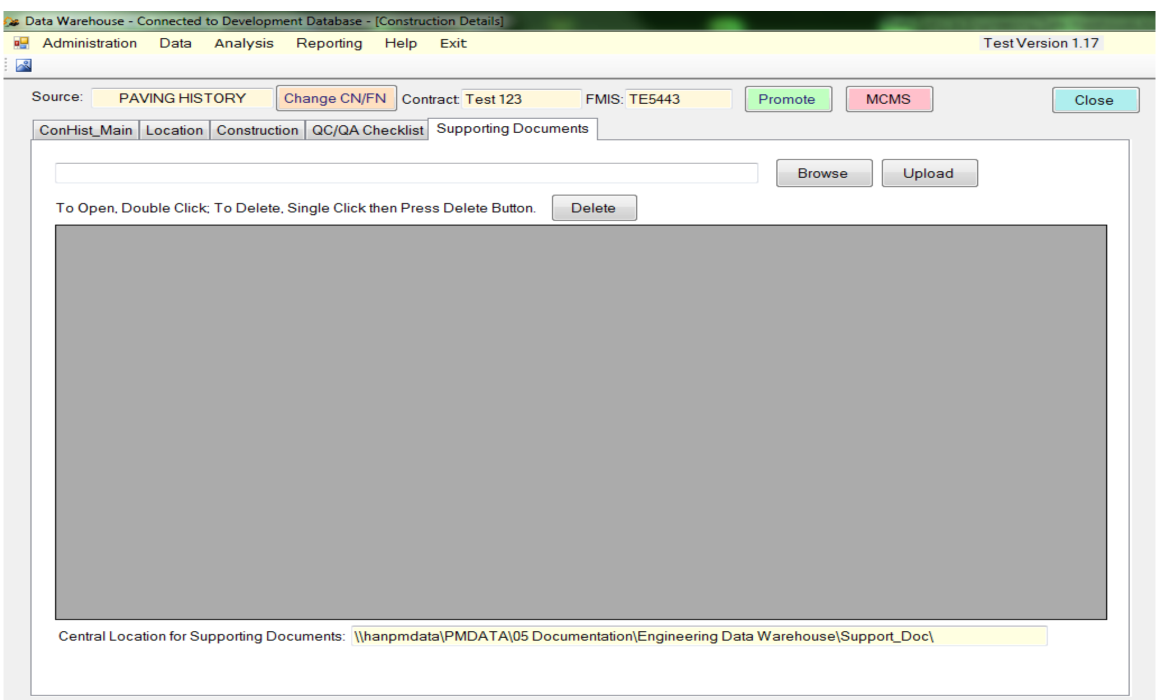


Step 39. Repeat Step 19 to Step 22 for all locations on the project.

Step 40. Click on "QC/QA Checklist" tab. Click on the relevant boxes on "QC/QA Check List" (left side of screen) and then click the "Save" button on the bottom of screen. If all data for the project is entered completely, click the "Check" button (see below image). Otherwise, return to incomplete data and input before proceeding.



Step 41. Click on "Supporting Documents" tab and upload any supporting documents using the "Upload" button (see below image). After this step, the procedure is complete.



4.02 PROCESSING ACCESS PERMIT DATA

4.02.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to collect and update access permit data in the Engineering Data Warehouse (EDW). Access Permits have limited information available. Relevant inventory information is gathered from a variety of sources including but not limited to: Highway Location Reference (HLR), Plan Sets, Access Permit Contracts, and Material Managements reports.

4.02.02 *Frequency*

The updating of access permit data is a continuous process that occurs year-round.

4.02.03 *Purpose*

The purpose of this SOP is to collect access permit data, verify and update inventory information associated with the project, perform quality control (QC) of gathered data, and update the data in the Unit Cost Database of the EDW.

4.02.04 *Resource Requirements*

Data collection and upload of access permit information involves two people: (1) a user knowledgeable in collection of access permit data from various sources and EDW software to perform data collection, QC, and uploading, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	EDW user and QC	1	1.0-16.0 [06/12/2019]
DPT TL	Supervisor	1	AR [06/12/2019]

4.02.05 *Procedure*

The procedure to collect and upload access permit data is comprised of the following two tasks:

(1) collection of access permit data
(2) input of collected data into EDW.

1- Access Permit Data Collection – *performed by EDW user*

Summary: This task collects and reviews access permit data from a variety of sources in order to retrieve the necessary inputs for data entry into the EDW.

Step 1. Retrieve Project **Plan Set** from the source. Extract Permit #, Project Description, Location, and Rehab Information.

Step 2. Identify the project limits using the **Highway Location Reference (HLR) Guide**. The HLR guide is categorized by county and route. Verify the mile points. The HLR also gives the Functional Class and AADT (Refer to Highway Location Referencing Guide).

Step 3. Locate the **Project File** in the Materials Management file room. The files are not in numerical order but in sequential order. Therefore, ensure that the appropriate file folder is acquired.

Step 4. Scan all **Contracts** in the folder.

2- Access Permit Data Input into EDW and QC – *performed by EDW user*

Summary: This task inputs collected access permit construction data into the EDW.

Step 5. Refer to Processing Paving & Maintenance History Data, Section 2 for step by step directions. The steps for "Access Permit" projects are the same as "Paving History." Be sure that the **Contract #** is entered in the **Access Permit** format.

4.03 PROCESSING AS BID UNIT COST DATA

4.03.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to collect and update As Bid unit cost data in the Engineering Data Warehouse (EDW). As Bid projects are single advertised projects. As Bid data is processed and analyzed prior to the commencement of construction. The primary data source for this information is bid tabulations published by the Office of Highway Design, extracted from the MDOT-SHA website. Relevant inventory information to supplement the cost data is gathered from a variety of sources, including, but not limited to: Pavement & Geotechnical Reports (P&G Report), Pavement Management (PM) Base, project plans, Visidata, Vision and the Highway Location Referencing (HLR) System.

4.03.02 *Frequency*

The updating of As Bid unit costs is a continuous process that occurs year-round.

4.03.03 *Purpose*

The purpose of this SOP is to collect As Bid unit cost data, verify and update inventory information associated with the project, perform quality control (QC) of gathered data, and update the data in the Unit Cost Database of the EDW.

4.03.04 *Resource Requirements*

Data collection and upload of As Bid unit cost information involves two people: (1) a user knowledgeable in collection of As Bid unit cost data from various sources and the EDW software to perform data collection, QC, and uploading, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff (Fund 77)	EDW user and QC	1	1.5
DPT Staff (Non- Fund 77)	EDW user and QC	1	2.0
DPT TL	Supervisor	1	AR[06/12/2019]

4.03.05 *Procedure*

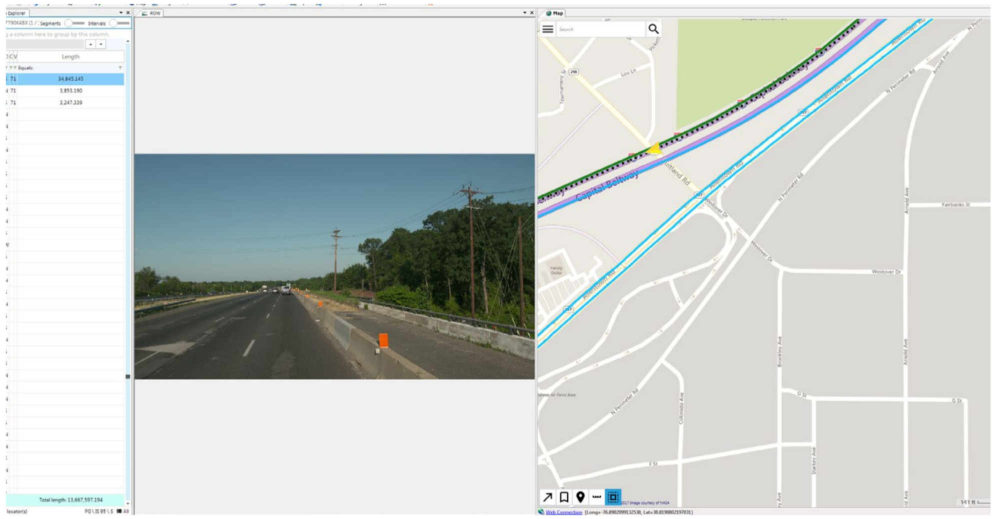
The procedure to collect and upload As Bid unit cost data is comprised of the following two tasks:

(1) collection of As Bid unit cost data
(2) input of collected data into EDW and QC.

1- As Bid Data Collection – *performed by EDW user*

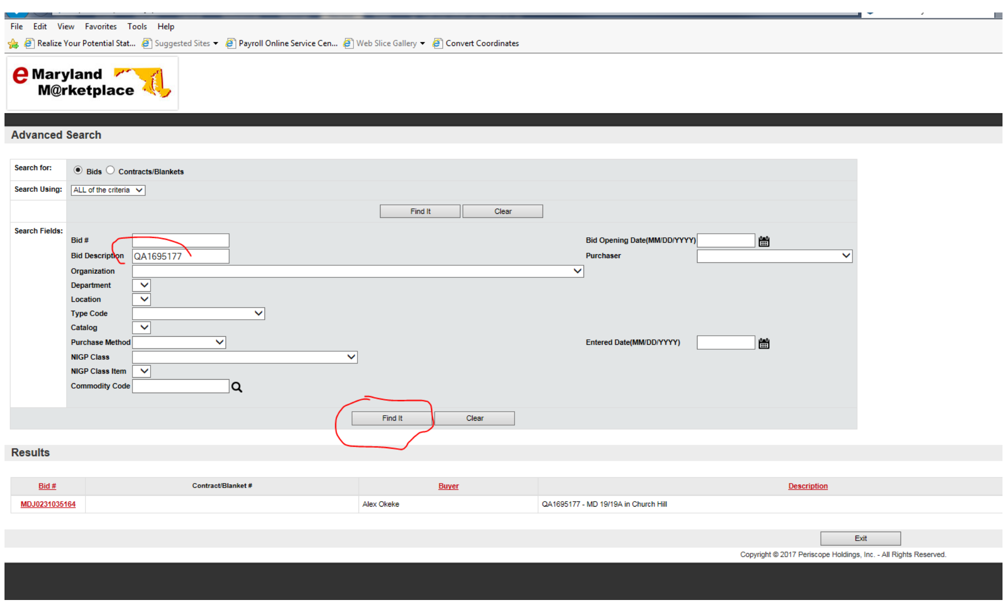
Summary: This task collects and reviews As Bid unit cost data from a variety of sources in order to retrieve the necessary inputs for data entry into the EDW.

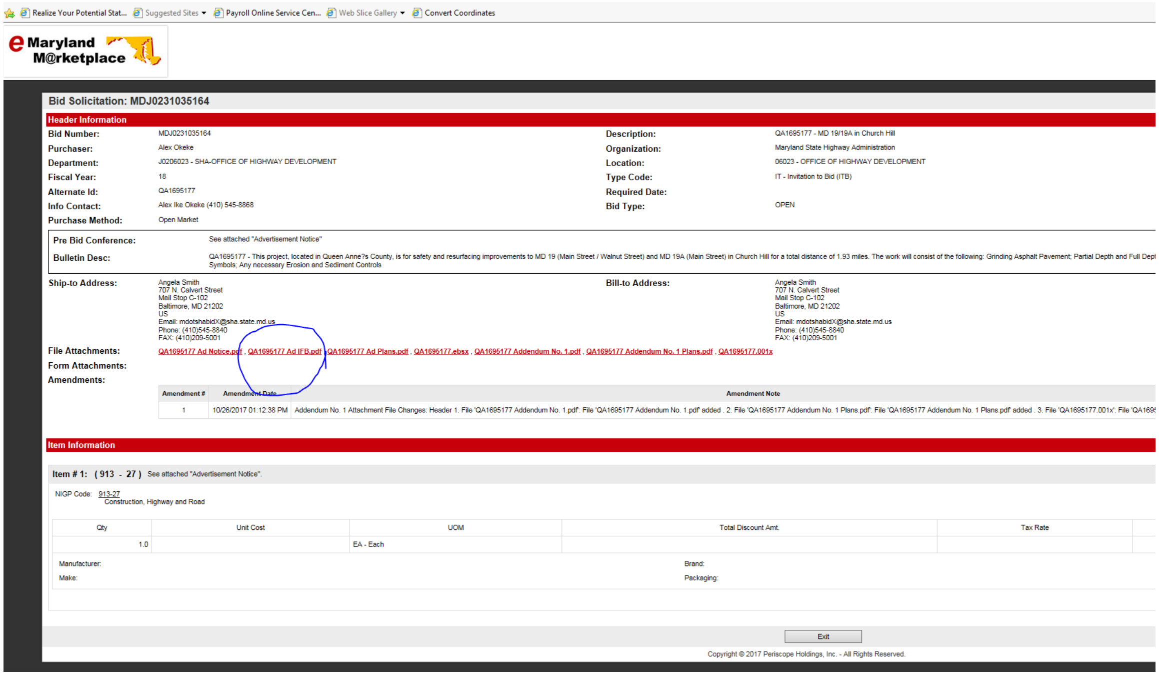
Step 1. For each project where available, review the Right-of-Way (ROW) video collected by the Automated Road Analyzer (ARAN) vehicle, "Vision." Review the video to determine the limits of work for the project and verify, where possible, the type of construction action (see image below).



Step 2. Identify the project limits using the **Highway Location Reference (HLR) Guide** in conjunction with the **Project Description from the Invitation for Bids (IFB)**. The HLR Guide is categorized by county and route. Verify the mile points. The HLR also gives the Functional Class and AADT (Refer to Highway Location Referencing Guide and Project Description).

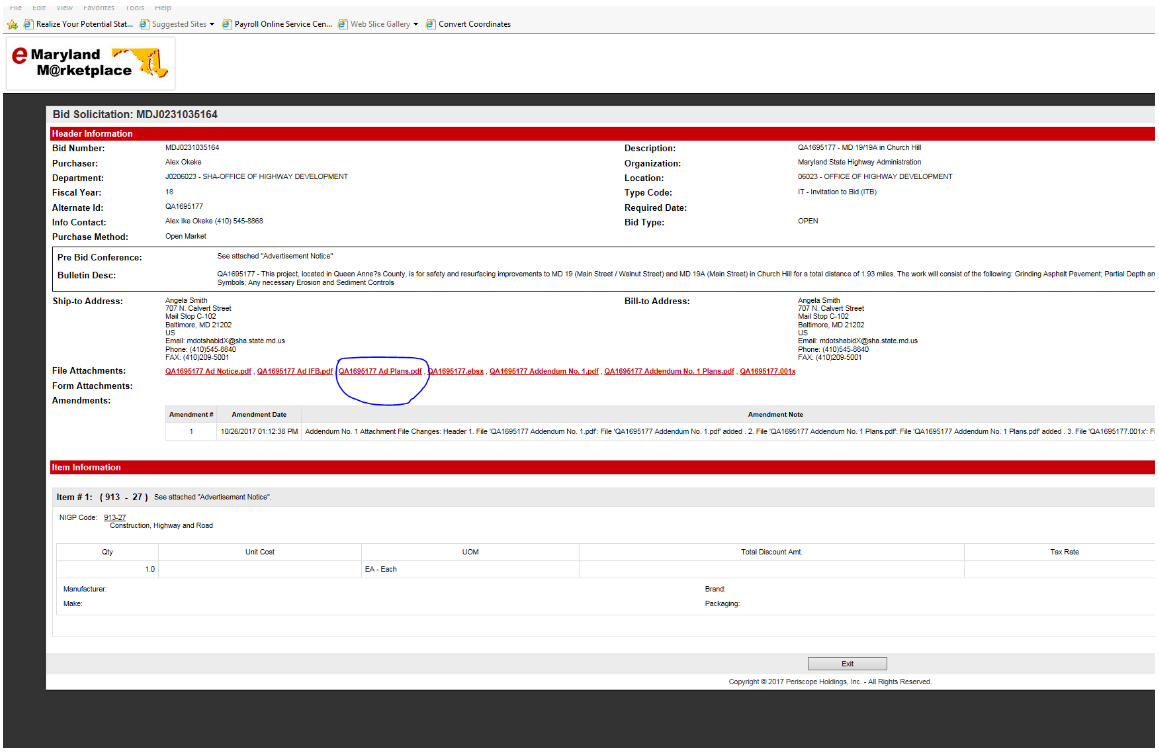
Step 3. Check the **IFB** for relevant pavement history data. IFBs can be received directly from the Office of Maintenance (OOM) and the Office of Highway Design (OHD). They may also come from either the Pavement Design (PD) Team or General Test team. Maryland eMarketplace is also a location where the IFBs can be found (see below images).





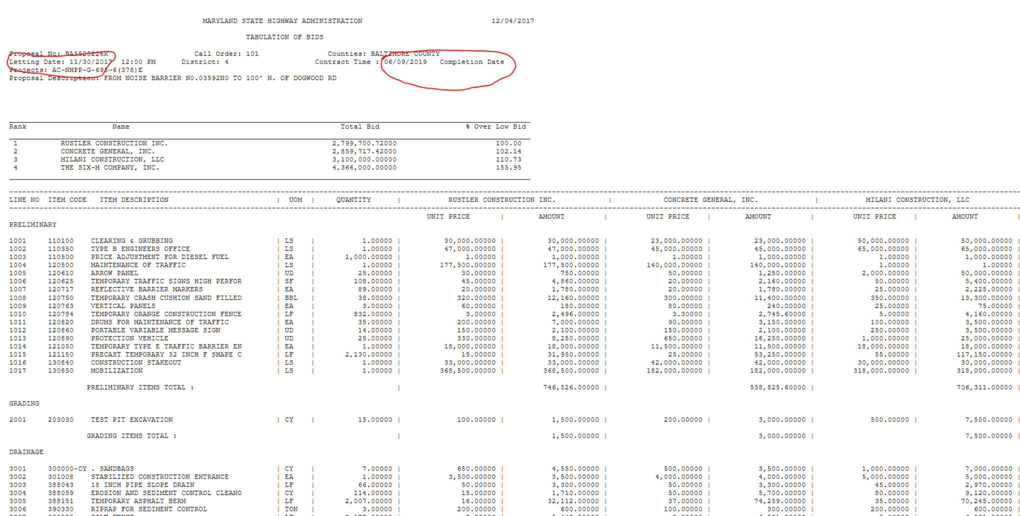
Step 4. Remove pertinent pages of the IFBs that relate to construction history and dispose of remaining pages. The pertinent pages are (but not limited to): **Title Page, Project Description, Category 500 Paving –Asphalt Cement Price Index, Paving Typical Sections, Plans Sheet, Soil Boring, Pavement Coring Log,** and **2000, 5000 & 6000 series items in Schedule of Prices section** (located near end of document).

Step 5. Retrieve Project **Plan Set** from the source. Review pertinent pages that relate to construction history. Ensure that all the pertinent data is enclosed in the plan set – paving typical sections, plan sheets, etc. The plan set can be found on the Maryland eMarketplace site (see below image).



Step 6. Access **Transport** database through the EDW application (see Running Transport Application). Export the spreadsheet to Excel. Identify the paving related items (typically **2000, 5000 & 6000** series items).

Step 7. Access the **Bid Tabulation** on the SHA homepage. Select the contract number for the project and print. The Bid Tabulation contains the contract number, letting date (date of bid opening) and the completion date (see below image).



Step 8. Access the **PMbase** from the Office of Materials Technology (OMT) homepage. Enter the route information required and retrieve the Construction

History for the route. The construction history data includes the last treatment applied to the roadway and the pavement type.

Step 9. Locate the **PAGD Geotechnical Report** on the "OMTOOCShared:\OMT\Design Projects" drive which is categorized by district. The folders are categorized by the contract number, by route, or by project description (or a combination thereof). Extract from the contract folder the **Pavement Recommendation Memorandum** and an excel spreadsheet entitled "Design Help." The report will indicate the design life (if not, ask the pavement engineer who worked on the project). Use the "Design Help" to compute the ESALs as follows:

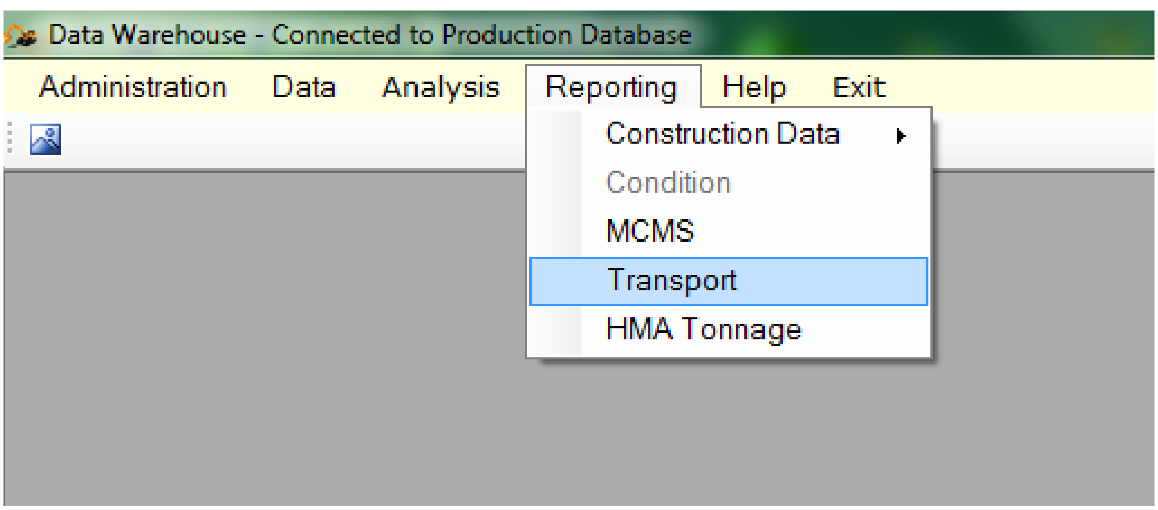
ESALs = ADT x 18 Kip Truck Factor x (% Truck ADT/100) x (% Directional Distribution/100).

2- As Bid Data Input into EDW and QC – *performed by EDW user*

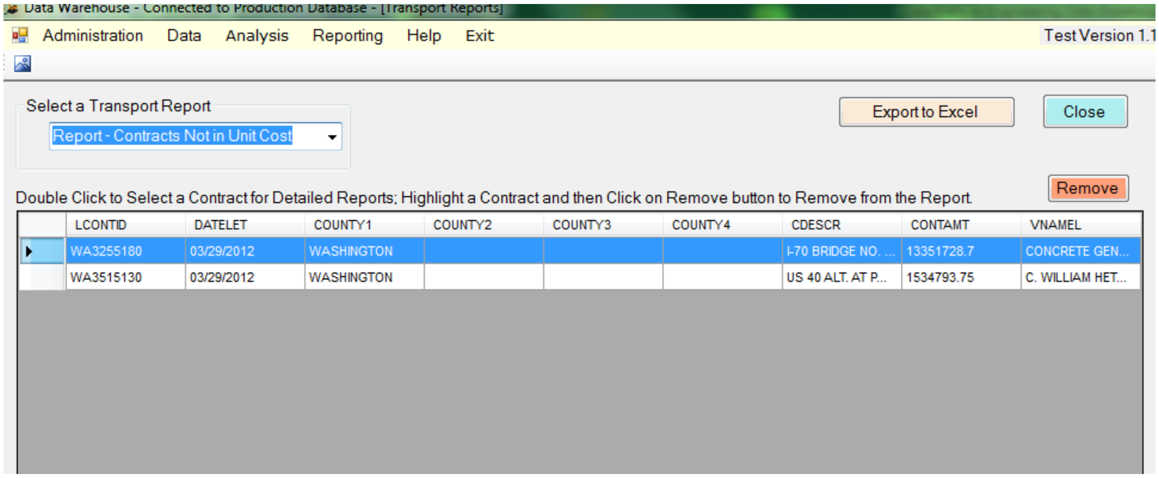
Summary: This task inputs collected As Bid data into the EDW.

Step 10. Open the EDW application.

Step 11. On the Main Menu click on "Reporting." From the "Reporting" drop-down menu, choose "Transport" (see below image).



Step 12. In the "Select a Transport Report" section choose "Report – Contracts Not in Unit Cost" from the drop-down menu (see below image).



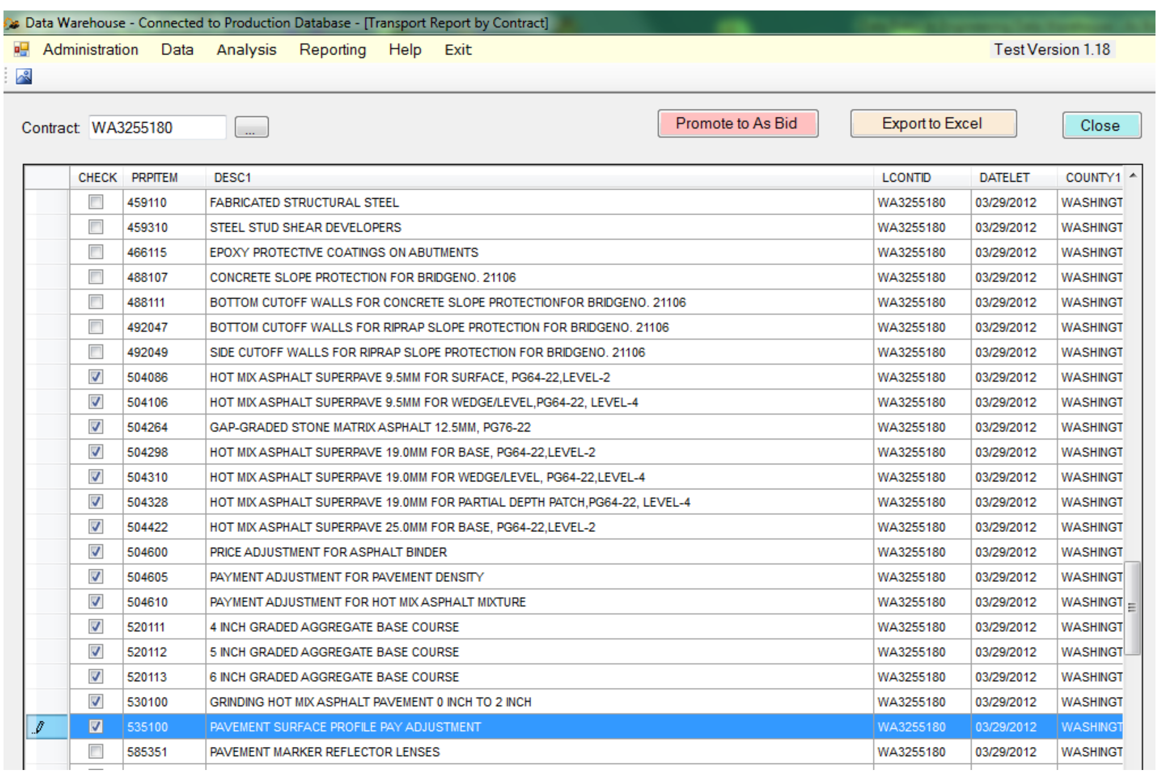
LCONTID	DATELET	COUNTY1	COUNTY2	COUNTY3	COUNTY4	CDESCR	CONTAMT	VNAMEL
WA3255180	03/29/2012	WASHINGTON				I-70 BRIDGE NO. ...	13351728.7	CONCRETE GEN...
WA3515130	03/29/2012	WASHINGTON				US 40 ALT. AT P...	1534793.75	C. WILLIAM HET...

Step 13. Highlight and remove all the projects that are not good candidates such as projects not having pavement related items in the 5000 series (tree teaming, Snow removal, guardrail repairs).

Step 14. Double-click on a contract for the detailed item report.

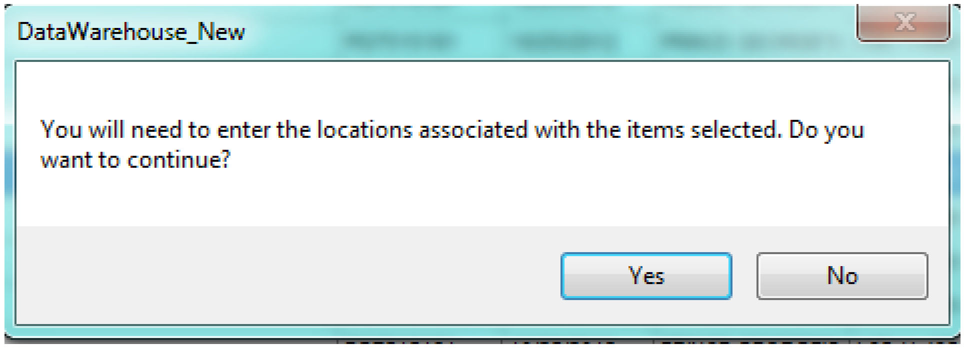
Step 15. Examine and identify all the mainline and shoulder related items – include Excavation, GAB, common borrow, HMA, concrete, patching, milling/grinding, rumble strips and topsoil. These items are located in the following codes: 2000 – Borrow and Excavation, 5000 – Paving, and 6000 – Shoulder items.

Step 16. Check the pavement-related Items and click "Promote to As Bid" button (see below image).

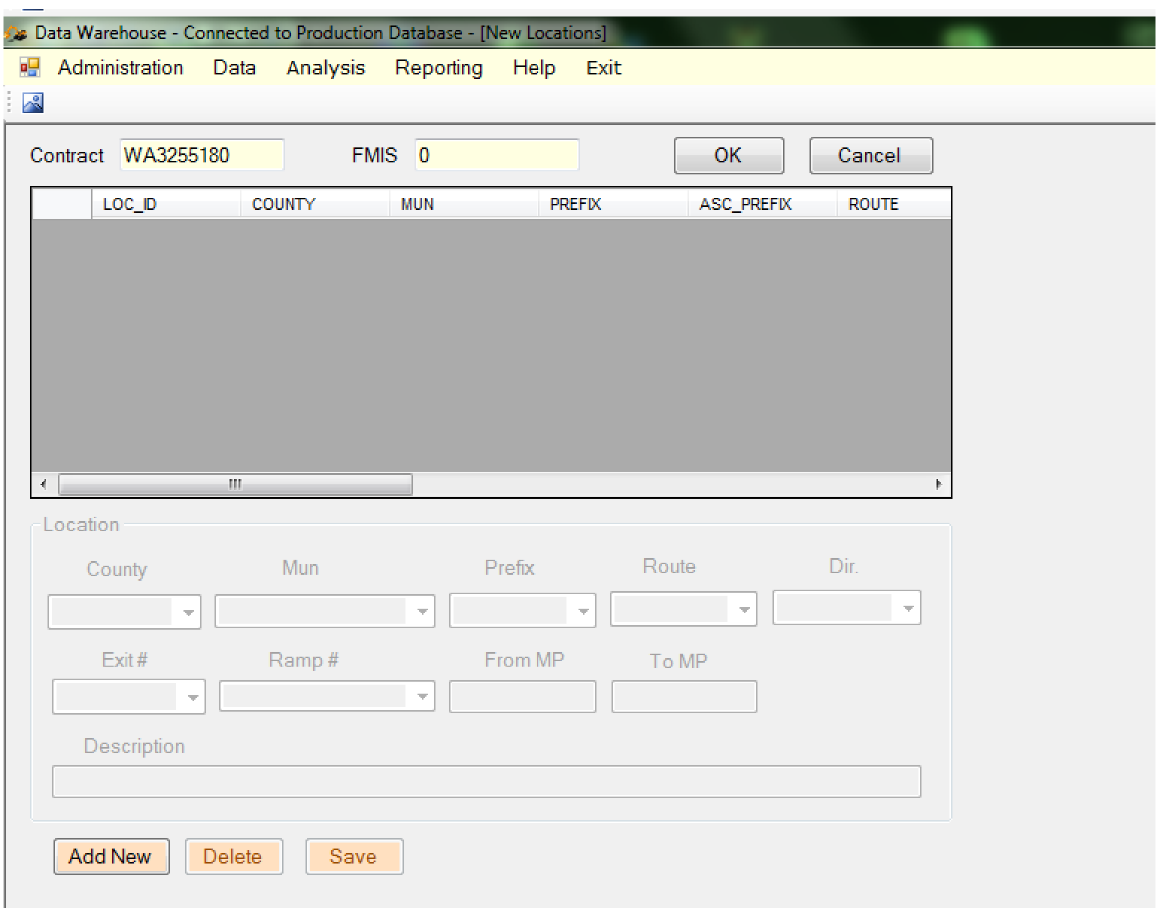


CHECK	PRPITEM	DESC1	LCONTID	DATELET	COUNTY1
☐	459110	FABRICATED STRUCTURAL STEEL	WA3255180	03/29/2012	WASHINGT
☐	459310	STEEL STUD SHEAR DEVELOPERS	WA3255180	03/29/2012	WASHINGT
☐	466115	EPOXY PROTECTIVE COATINGS ON ABUTMENTS	WA3255180	03/29/2012	WASHINGT
☐	488107	CONCRETE SLOPE PROTECTION FOR BRIDGENO. 21106	WA3255180	03/29/2012	WASHINGT
☐	488111	BOTTOM CUTOFF WALLS FOR CONCRETE SLOPE PROTECTIONFOR BRIDGENO. 21106	WA3255180	03/29/2012	WASHINGT
☐	492047	BOTTOM CUTOFF WALLS FOR RIPRAP SLOPE PROTECTION FOR BRIDGENO. 21106	WA3255180	03/29/2012	WASHINGT
☐	492049	SIDE CUTOFF WALLS FOR RIPRAP SLOPE PROTECTION FOR BRIDGENO. 21106	WA3255180	03/29/2012	WASHINGT
☑	504086	HOT MIX ASPHALT SUPERPAVE 9.5MM FOR SURFACE, PG64-22,LEVEL-2	WA3255180	03/29/2012	WASHINGT
☑	504106	HOT MIX ASPHALT SUPERPAVE 9.5MM FOR WEDGE/LEVEL,PG64-22, LEVEL-4	WA3255180	03/29/2012	WASHINGT
☑	504264	GAP-GRADED STONE MATRIX ASPHALT 12.5MM, PG76-22	WA3255180	03/29/2012	WASHINGT
☑	504298	HOT MIX ASPHALT SUPERPAVE 19.0MM FOR BASE, PG64-22,LEVEL-2	WA3255180	03/29/2012	WASHINGT
☑	504310	HOT MIX ASPHALT SUPERPAVE 19.0MM FOR WEDGE/LEVEL, PG64-22,LEVEL-4	WA3255180	03/29/2012	WASHINGT
☑	504328	HOT MIX ASPHALT SUPERPAVE 19.0MM FOR PARTIAL DEPTH PATCH,PG64-22, LEVEL-4	WA3255180	03/29/2012	WASHINGT
☑	504422	HOT MIX ASPHALT SUPERPAVE 25.0MM FOR BASE, PG64-22,LEVEL-2	WA3255180	03/29/2012	WASHINGT
☑	504600	PRICE ADJUSTMENT FOR ASPHALT BINDER	WA3255180	03/29/2012	WASHINGT
☑	504605	PAYMENT ADJUSTMENT FOR PAVEMENT DENSITY	WA3255180	03/29/2012	WASHINGT
☑	504610	PAYMENT ADJUSTMENT FOR HOT MIX ASPHALT MIXTURE	WA3255180	03/29/2012	WASHINGT
☑	520111	4 INCH GRADED AGGREGATE BASE COURSE	WA3255180	03/29/2012	WASHINGT
☑	520112	5 INCH GRADED AGGREGATE BASE COURSE	WA3255180	03/29/2012	WASHINGT
☑	520113	6 INCH GRADED AGGREGATE BASE COURSE	WA3255180	03/29/2012	WASHINGT
☑	530100	GRINDING HOT MIX ASPHALT PAVEMENT 0 INCH TO 2 INCH	WA3255180	03/29/2012	WASHINGT
☑	535100	PAVEMENT SURFACE PROFILE PAY ADJUSTMENT	WA3255180	03/29/2012	WASHINGT
☐	585351	PAVEMENT MARKER REFLECTOR LENSES	WA3255180	03/29/2012	WASHINGT

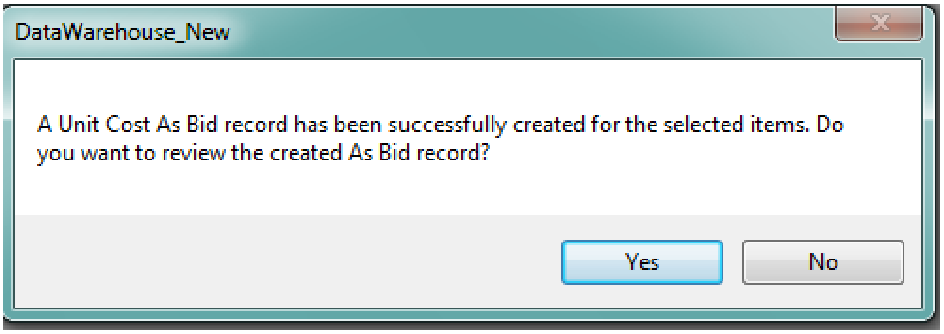
Step 17. A dialogue box will appear: “You will need to enter the location associated with the items selected. Do you want to continue?” Click “Yes” (see below image).



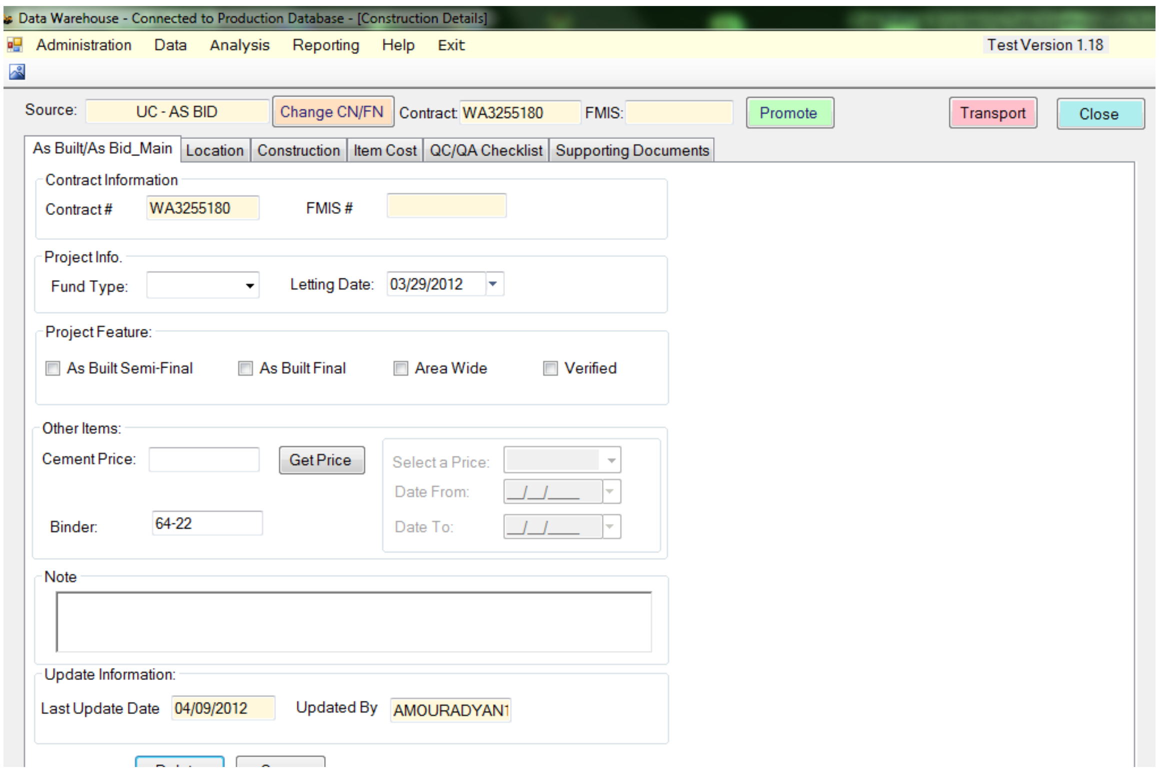
Step 18. Click “Add New” at the bottom left hand corner of the screen to add a new location. Fill in the route information: **County, Prefix, Route, Direction, From MP, To MP, and Description**. Click “Save.” Repeat this step until all the locations for the project are entered. When all the locations have been entered and appear in the table, click “OK” (see below image).



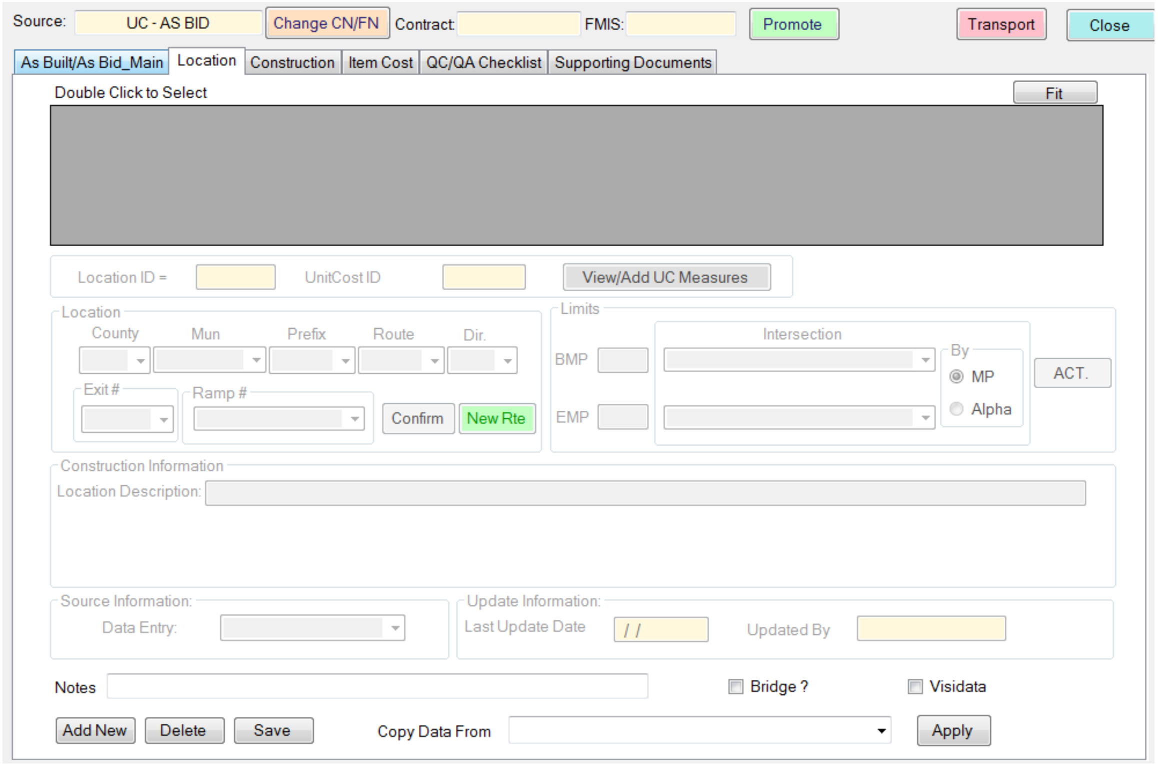
Step 19. A dialogue box will appear: “A Unit Cost As Bid record has been successfully created for the selected items. Do you want to review the created As Bid record?” Click “Yes” (see below image).



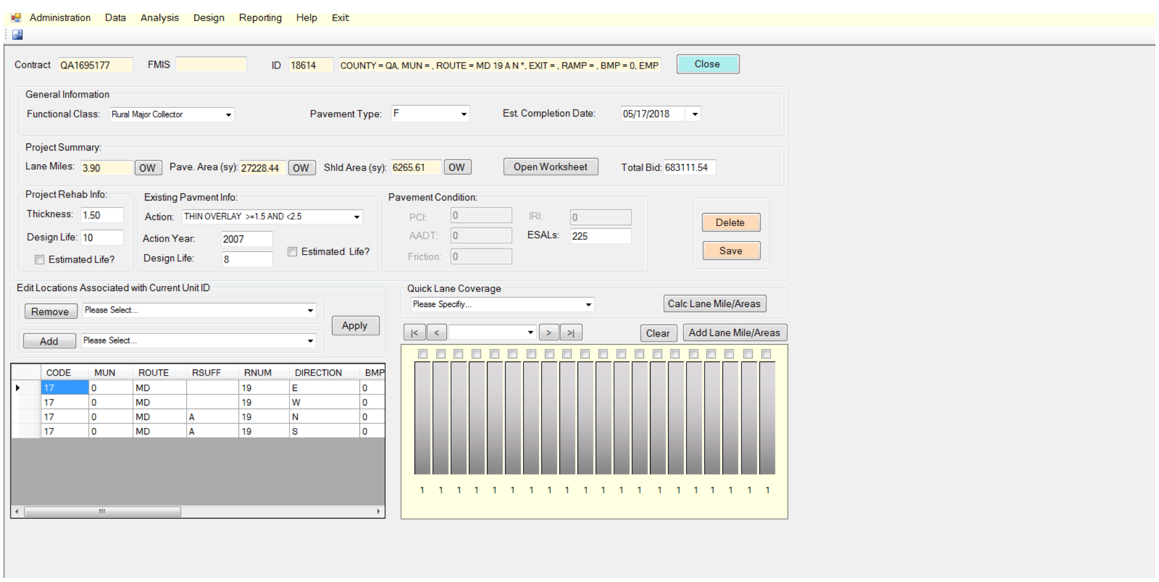
Step 20. Enter data for: **Fund Type, Letting Date, Cement Price, and Binder** (should automatically appear). Click "Save" (see below image).



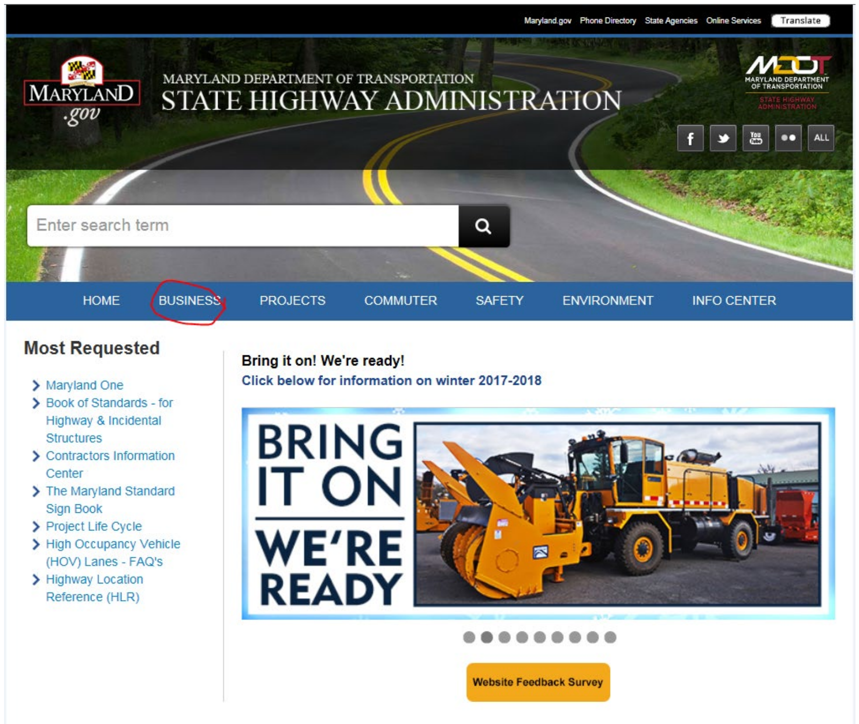
Step 21. Click the "Location" tab to enter the location information. The locations entered for the project during Step 19 will appear in the location table. Click "Save." Double-click on a location in the location table. When it is highlighted in blue, click "View/Add UC Measures" (see below image).



Step 22. Enter the required information: **Functional Class, Pavement type, Est. Completion Date, Thickness, Design Life, Action, Action Year, and ESALs**. The Total Bid should automatically populate if the contract was promoted through the Transport feature. See Step 24 to automatically populate Lane Miles, Pavement Area, and Shoulder Area (see below image).



To attain the completion date, go to the SHA Intranet page and click on the Business Tab (see below image).



Click on the “Contracts, Bids & Proposals” link on the left side and then click on the “Bid Tabulations” link. Search for the contract and click on the “Contract Number” (see below images).

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

Maryland.gov Phone Directory State Agencies Online Services

Search

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Home> Business Center> Contracts, Bids & Proposals > Contractors Information Center

CONTRACTORS INFORMATION CENTER

Welcome to the MDOT State Highway Administration (MDOT SHA) Contractors Information Center (CIC) Web Site. MDOT SHA advertises and awards construction and maintenance contracts for the state highway system. This web site is designed to provide contractors with information on highway construction projects, it is not to be used as a substitute for the current bidding process. If you would like to find out more about the bidding process see the How to Bid section of the site. If you require additional information related to **advertised contracts, bids or proposals** please contact us at cic@sha.state.md.us. **Please call 410-545-8840 or email us at MdotSHABidX@sha.state.md.us for questions regarding MDOT's implementation of the Bid Express system.** If you require assistance related to other topics, please consult Contact Us for the appropriate contact email addresses.

CONTRACTOR NEWS

CONTRACTORS....Update your company's vendor information for MDOT SHA'S Engineer's Estimate and Construction Contract System AASHTO'S TRNS*PORT!

IMPORTANT NEWS!

E-Bid Update (December 08, 2017): There are three situations when a bidder **MUST** re-attach **ALL** the attachment files when resubmitting a bid:

- MDOT SHA postpones a proposal to a different letting date;
- MDOT SHA postpones a proposal and then re-uploads the proposal to the same letting where it was originally uploaded; or
- MDOT SHA withdraws a proposal and then reposts that proposal to the same letting where it was originally uploaded.

Re-attaching attachments means navigating to **EVERY** attachment location in the ".ebsx file" and **re-selecting** the attachment using the 'Browse' button, prior to re-submission.

E-Bid Update (August 29, 2017): For all highway improvement and highway maintenance projects advertised henceforth the Maryland Department of Transportation's State Highway Administration will accept only electronic bids. The bid needs to be submitted at https://www.bidx.com/maryland/main. Paper bids will not be accepted. Instructions on electronic bidding are available here.

Standard Specification for Construction and Materials

The 2017 Edition of the Standard Specification for Construction and Materials is now available. This edition is available exclusively in an online MediaWiki format, a physical copy is not available for sale. The Standard Specification and Supplemental documents may be found on the MDOT SHA web site under the Business Standards - Business Standards and Specifications section, or at the following link:

Standard and Supplemental Specifications For Construction and Materials

Please direct any questions regarding the standard specification to specifications@sha.state.md.us.

eMaryland Marketplace

Since August 4, 2015, MDOT SHA has been posting project links for eMaryland Marketplace (eMM) on the Contractors Information Center (CIC) project page. This option makes it easier for contractors to find the project information on eMM. As of **March 15, 2016** MDOT SHA will not post the actual pre-bid documents for the advertisements, addenda and project quantities on the CIC. These documents along with the "qty.z" file will be found on eMM for each project link provided. The last addendum with revised quantities will have the all-inclusive list of items in the contract, if applicable.

All post-bid documents such as bid results, bid tabulations and final Plan purchasers' list will continue to be posted on the CIC.

MDOT State Highway Administration has a new process for administering Construction Documents through eMaryland Marketplace (eMM). Bidders must register, login, and verify amendments in order to receive a Contract Award. Registration is free and there is no cost for the Contract Documents.

Refer to the "Notice to the Contractor" in "Invitations for Bid Book" for additional instructions.

With the implementation of eMaryland Marketplace processes, please note that MDOT SHA's Cashier's Office at 211 East Madison Street will be **CLOSED** effective **August 28, 2015**. Bidders will no longer be required to purchase Contract Documents. All Contract Documents will be available on eMaryland Marketplace and can be downloaded at no cost.

The 2008 Standard Specification for Construction and Materials book, which was previously available for purchase at the Cashier's Office, is no longer being sold. You may obtain an electronic version from the Standard Specification for Construction and Materials site.

Click to go to eMARYLAND MARKETPLACE
Click to view eMM - MDOT SHA Contracts and Bids' Plan Holders List (log in required)

Use the following dropdown list to select the topic that you are looking for.

Bid Tabulations

BID TABULATIONS

1 2 3 4 5 6 7 8 9 10 ... >>

CONTRACTNO	DATE	FILE	
QA1695177	11/10/2017	View Text View Excel	Download
827R201420	11/10/2017	View Text View Excel	Download

If you would like to download a copy of this file click here
For additional information on Contract Number (QA1695177) click here

MARYLAND STATE HIGHWAY ADMINISTRATION 11/09/2017

TABULATION OF BIDS

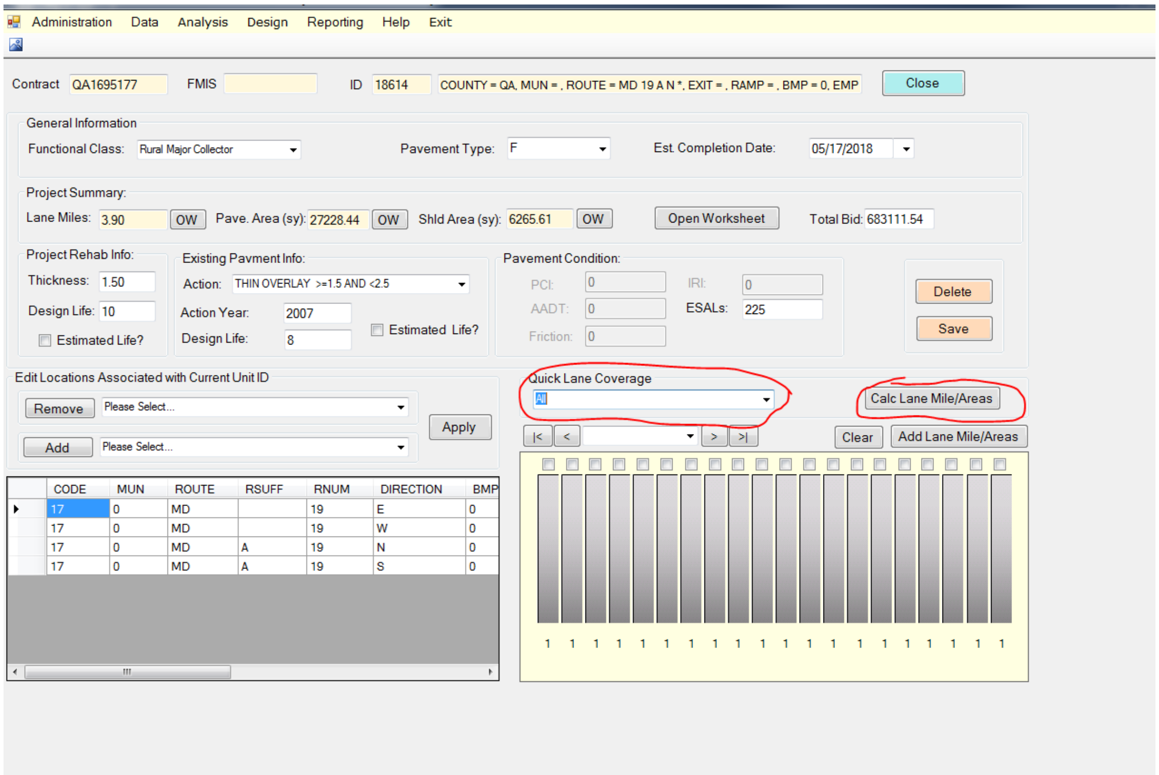
Proposal No: QA1695177 Call Order: 102 Counties: QUEEN ANNE'S
Letting Date: 11/09/2017 12:00 PM District: 2 Contract Time : 05/17/2018 Completion Date
Projects: N/A
Proposal Description: MD 19 FROM MD 300A TO NEW STREET, MD 19A FROM NEW STREET TO MD 19

Rank	Name	Total Bid	% Over Low Bid
1	DAVID A. BRAMBLE, INC.	683,111.54000	100.00
2	GEORGE & LYNCH, INC.	735,085.79000	107.61
3	ALLAN MYERS MD, INC.	795,777.00000	116.49

LINE NO	ITEM CODE	ITEM DESCRIPTION	UOM	QUANTITY	DAVID A. BRAMBLE, INC.		GEORGE & LYNCH, INC.		ALLAN MYERS MD, INC.	
					UNIT PRICE	AMOUNT	UNIT PRICE	AMOUNT	UNIT PRICE	AMOUNT
PRELIMINARY										
1001	110500	PRICE ADJUSTMENT FOR DIESEL FUEL	EA	1,000.00000	1.00000	1,000.00000	1.00000	1,000.00000	1.00000	1,000.0
1002	114006	5 INCH YELLOW PAVEMENT MARKING PAIN	LF	19,205.00000	.25000	4,801.25000	.25000	4,801.25000	.25000	4,801.2
1003	114011	5 INCH WHITE PAVEMENT MARKING PAINT	LF	9,779.00000	.25000	2,444.75000	.25000	2,444.75000	.25000	2,444.7
1004	114021	10 INCH WHITE PAVEMENT MARKING PAIN	LF	110.00000	.55000	60.50000	.50000	55.00000	.50000	55.0
1005	114036	12 INCH WHITE PAVEMENT MARKING PAIN	LF	288.00000	2.30000	662.40000	2.14000	616.32000	2.20000	633.6
1006	114041	16 INCH WHITE PAVEMENT MARKING PAIN	LF	213.00000	3.00000	639.00000	2.70000	575.10000	2.75000	585.7
1007	114216	5 INCH YELLOW REMOVABLE PAVEMENT LI	LF	961.00000	1.50000	1,441.50000	1.82000	1,749.02000	1.85000	1,777.8
1008	114236	12 INCH WHITE REMOVABLE PAVEMENT LI	LF	288.00000	3.20000	921.60000	4.28000	1,232.64000	4.40000	1,267.2
1009	114241	16 INCH WHITE REMOVABLE PAVEMENT LI	LF	213.00000	4.00000	852.00000	5.35000	1,139.55000	5.50000	1,171.5
1010	114276	REMOVAL OF REMOVABLE PAVEMENT MARKI	LF	1,461.00000	1.00000	1,461.00000	.42000	613.62000	.40000	584.4
1011	120500	MAINTENANCE OF TRAFFIC	LS	1.00000	30,000.00000	30,000.00000	41,100.00000	41,100.00000	41,357.56000	41,357.5
1012	120625	TEMPORARY TRAFFIC SIGNS HIGH PERFOR	SF	350.00000	50.00000	17,500.00000	23.00000	8,050.00000	21.95000	7,682.5
1013	120747	FLAGGER	HR	1,120.00000	35.00000	39,200.00000	28.20000	31,584.00000	28.85000	32,312.0
1014	120773	RELOCATE SIGN	SF	14.00000	50.00000	700.00000	30.15000	422.10000	32.95000	461.3
1015	120820	DRUMS FOR MAINTENANCE OF TRAFFIC	EA	41.00000	60.00000	2,460.00000	84.60000	3,468.60000	27.45000	1,125.4
1016	120860	PORTABLE VARIABLE MESSAGE SIGN	UD	114.00000	40.00000	4,560.00000	66.80000	7,615.20000	82.00000	9,348.0
1017	120890	PROTECTION VEHICLE	UD	14.00000	.01000	.14000	237.00000	3,318.00000	.01000	.1
1018	130840	CONSTRUCTION STAKEOUT	LS	1.00000	5,000.00000	5,000.00000	5,900.00000	5,900.00000	1,000.00000	1,000.0
1019	130850	MOBILIZATION	LS	1.00000	25,000.00000	25,000.00000	39,000.00000	39,000.00000	35,000.00000	35,000.0
		PRELIMINARY ITEMS TOTAL :				138,704.14000		154,685.15000		142,608.2

Step 23. In the "Edit Location Associated with Current Unit ID" section of the screen click on the "Add" pull-down menu and make sure all the locations are added to this unit cost measures. If the As Bid was promoted from the "Transport" feature, the locations will already appear in the table. If the project wasn't promoted from the "Transport" feature, the locations must be enter manually using the aforementioned steps.

Step 24. Click on the drop-down menu in the "Quick Lane Coverage" section of the screen. Select "All" then press "Calc Lane Miles/Area" and the EDW will automatically generate the quantities for lane miles, pavement area and shoulder area (see image below).



Step 25. Verify the accuracy of the quantities that the EDW generated. Click on "Open Worksheet." Fill in the appropriate fields (extracted from the typical section within the Plans Set): **Lanes, Lane Mi, L (length), m/l W (width), Shoulder W (width), and Shoulder SY**. The total at the bottom of the worksheet should be within 5% of the EDW auto generated quantity (see below image).

i. If the total is within 5% of the EDW auto generated quantity, proceed to Step 26.

ii. If the total is not within 5% of the EDW, further investigation is required to reconcile any differences. Click on the SY Pavement tab of the spreadsheet and plug in the surface tonnage and the thickness. The SY surface will automatically populate. Compare that result to the worksheet and the EDW result. In addition, if there is any grinding, compare the grinded SY to the result.

Clipboard Font Alignment Number Styles

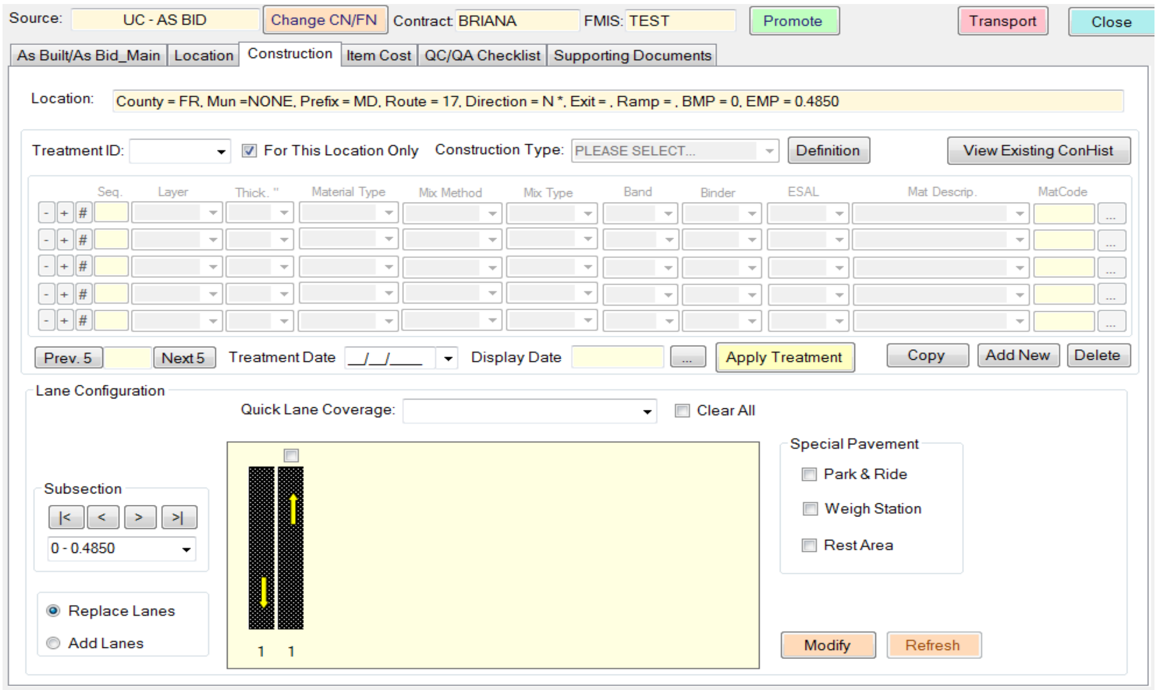
M46

	A	B	C	D	E	F	G	H
1	Lanes	Lane Mi	L	m/l W	m/l SY	shldr W	shldr SY	Source
2	2	3.05	8052	24	21472	5	4473.333	
3	2	0.541667	1430	22	3495.555556		0	
4	2	0.270076	713	22	1742.888889	7	554.5556	
5		0			0		0	
6		0			0		0	
7		0			0		0	
8		0			0		0	
9		0			0		0	
10		0			0		0	
11		0			0		0	
12		0			0		0	
13		0			0		0	
14		0			0		0	
15		0			0		0	
16		0			0		0	
17		0			0		0	
18		0			0		0	
19		0			0		0	
20		0			0		0	
21		0			0		0	
22		0			0		0	
23		0			0		0	
24		0			0		0	
25		0			0		0	
26		0			0		0	
27		0			0		0	
28		0			0		0	
29		0			0		0	
30		0			0		0	
31		0			0		0	
32		0			0		0	
33		0			0		0	
34		0			0		0	
35	totals	3.861742			26710.44444		5027.889	
36								
37					31738.33333			

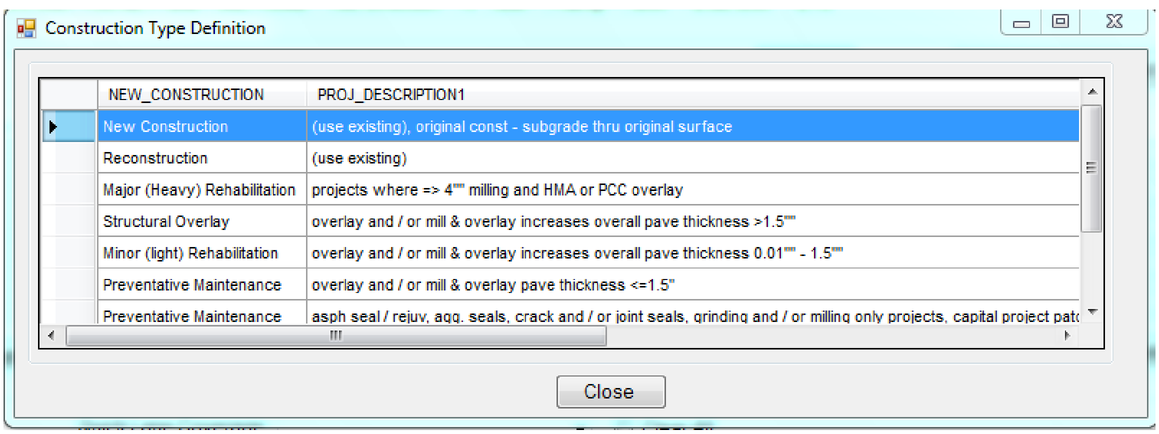
	A	B
1	Surf Ton	Surf Thickness"
2	3020	1.5
3		
4	34226.67	SY surface
5		
6	0	sy EDW est
7	34224	sy MCMS grind
8	0	sy Visidata

Step 26. Click "Save" and then "Close." The EDW will automatically return to the "Location" tab.

Step 27. Double-click on a location in the table while on the "Location" Tab. Make sure the location is highlighted in blue. Click on the "Construction" Tab (see below image).

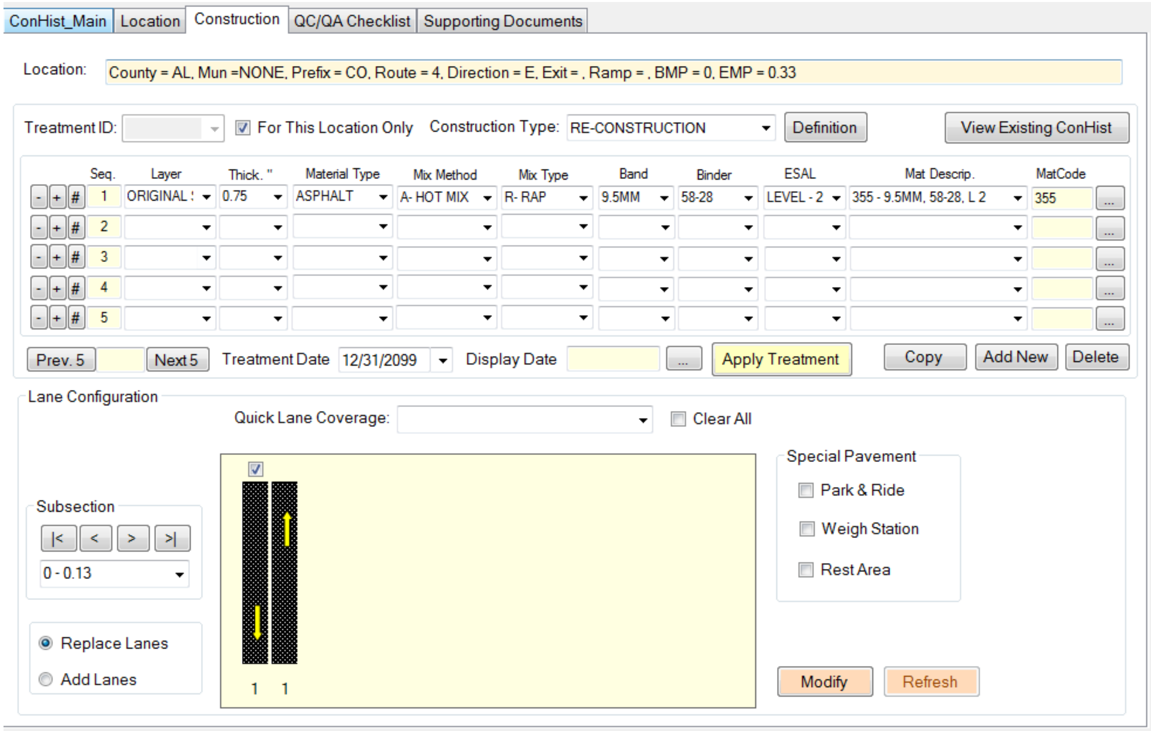


Step 28. Click on “Add New.” Select a “Construction Type” from the drop-down menu. The definition of each “Construction Type” can be viewed by clicking the “Definition” button (see below image).



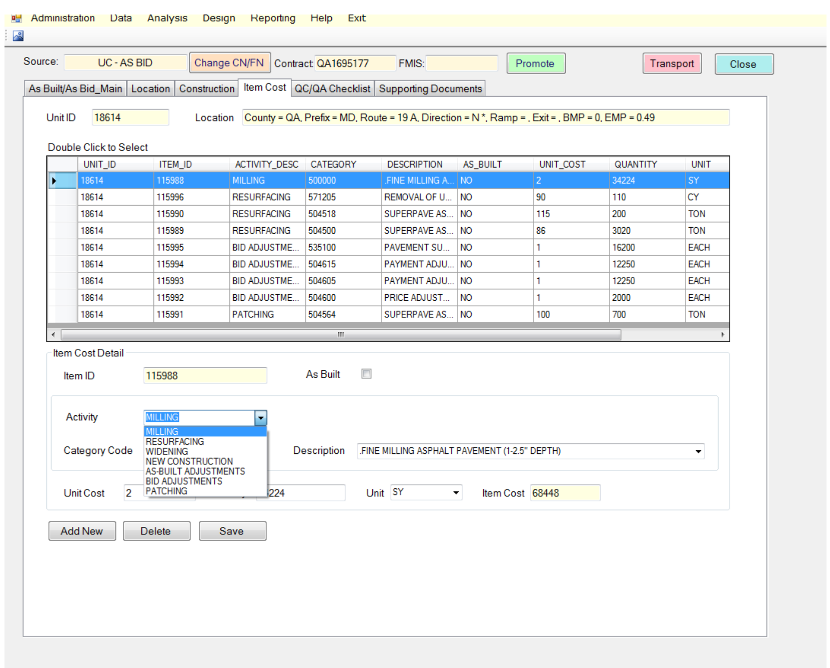
Step 29. Fill in all the appropriate fields: **Layers, Thickness, Material Type, Mix Method, Mix Type, Band, and ESAL**. Select the correct “Material Description.”

Step 30. Click on the boxes above each lane on the bottom of the screen or select the appropriate option from the “Quick Lane Coverage” drop-down menu. For all Unit Cost - As Bid, the treatment date is the “Completion Date.” Click on “Apply Treatment” to save the treatment for the selected section (see below image).

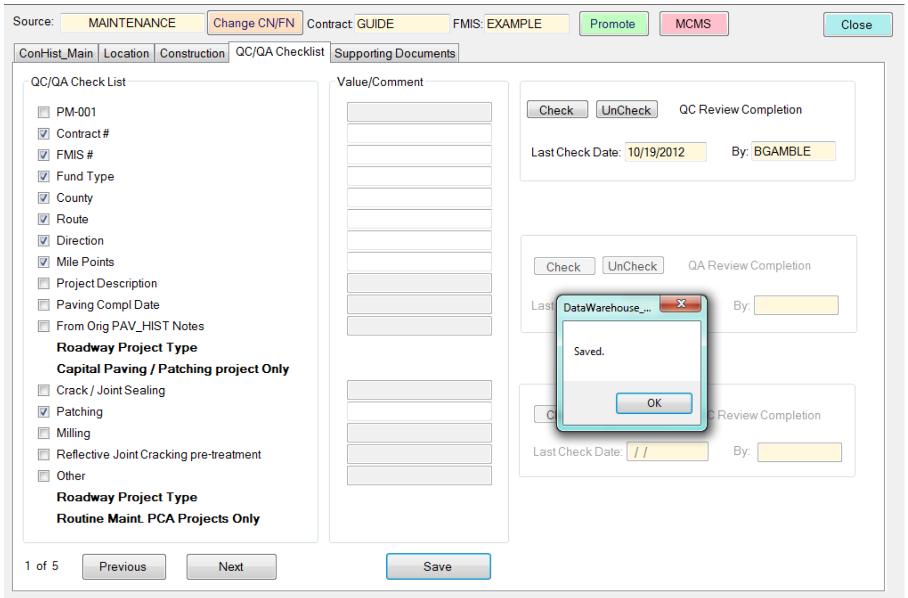


Step 31. Repeat Step 27 to Step 30 for all locations of the project. Then, proceed to Step 24.

Step 32. Click on the “Item Cost” tab. Double-click on each item (highlighting the item in blue) in the table and assign the relevant activity under the “Activity” drop-down menu. Click “Save.” Repeat for each item in the table. For Bid Adjustments, the unit must be assigned as “Each” (see below image).

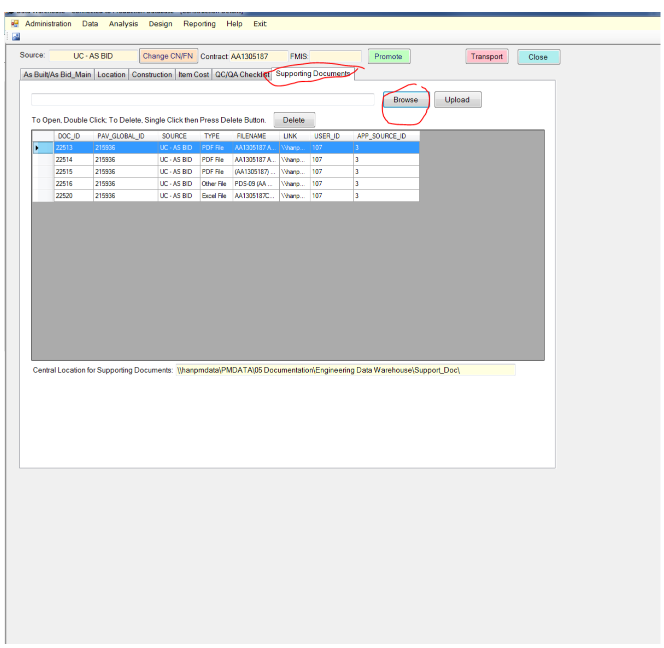


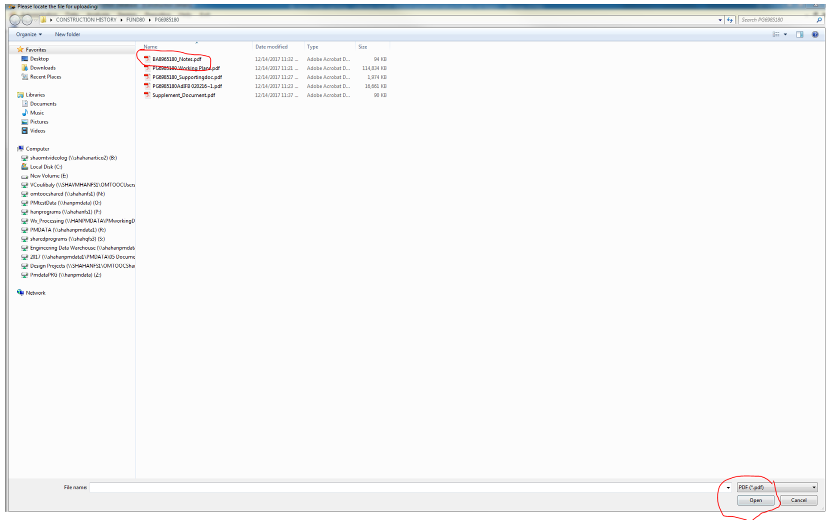
Step 33. Click on “QC/QA Checklist” tab. Click on the relevant boxes on “QC/QA Check List” (left side of screen) and then click the “Save” button on the bottom of screen. If all data for the project is entered completely, click the “Check” button (see below image). Otherwise, return to incomplete data and input before proceeding.



Step 34. Scan, download and save all the supporting documents in a folder (local driver, PRG).

Step 35. Click on “Supporting Documents” tab and click on the “Browse” button to open the files location, select the file and click “OK” and then click on the “Upload” button (see below image).





Step 36. The supporting documents should include, but is not limited to:

i. IFB
ii. Plans
iii. Notes and other draft used by the user
iv. The spreadsheet used to verify the accuracy of the quantities
v. A screenshot of the first page of the bid tabulation showing the completion date
vi. The “Design Help” spreadsheet showing the calculation the ESALs
vii. PAGD Geotechnical Report
viii. PMBase Report

4.04 PROCESSING AS BUILT UNIT COST DATA

4.04.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to collect and update As Built unit cost data in the Engineering Data Warehouse (EDW). As Built projects are area-wide projects. As Built data is processed and analyzed approximately three months after the completion of construction. The primary data source for this information is bid tabulations published by the Office of Highway Design (OHD), extracted from the MDOT-SHA website. Relevant inventory information to supplement the cost data is gathered from a variety of sources, including, but not limited to: Pavement & Geotechnical Reports (P&G Report), Pavement Management (PM) Base, project plans, Visidata, and the Highway Location Referencing (HLR) System. As Built projects can be promoted either from the Maryland Construction Management System (MCMS) or from paving or maintenance history.

4.04.02 *Frequency*

The updating of As Built unit costs is a continuous process that occurs year-round.

4.04.03 *Purpose*

The purpose of this SOP is to collect As Built unit cost data, verify and update inventory information associated with the project, perform quality control (QC) of gathered data, and update the data in the Unit Cost Database of the EDW.

4.04.04 *Resource Requirements*

Data collection and upload of As Built unit cost information involves two people: (1) a user knowledgeable in collection of As Built unit cost data from various sources and the EDW software to perform data collection, QC, and uploading, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	EDW user and QC	1	4.0
DPT TL	Supervisor	1	AR[06/12/2019]

4.04.05 *Procedure*

The procedure to collect and upload As Built unit cost data is comprised of the following three tasks:

(1) collection of As Built unit cost data
(2) input of collected data into the EDW by promotion from MCMS, and
(3) input of collected data into the EDW by promotion from paving or maintenance history.

1- As Built Data Collection – *performed by EDW user*

Summary: This task collects and reviews As Built construction data from a variety of sources in order to retrieve the necessary inputs for data entry into the EDW.

Step 1. For each project where available, review the Right-of-Way (ROW) video collected by the Automated Road Analyzer (ARAN) vehicle, "Visidata.exe." Review the video to determine the limits of work for the project and verify, where possible, the type of construction action.

Step 2. Identify the project limits using the **Highway Location Reference (HLR) Guide**. The HLR Guide is categorized by county and route. Verify the mile points. The HLR also gives the Functional Class and AADT (Refer to Highway Location Referencing Guide).

Step 3. Check the **Invitation for Bid (IFB)** for relevant pavement history data. IFBs can be received directly from the Office of Maintenance (OOM) and the OHD. They may also come from either the Pavement Design (PD) Team or General Test team.

Step 4. Remove pertinent pages of the IFBs that relate to construction history and dispose of remaining pages. The pertinent pages are (but not limited to): **Title Page, Project Description, Category 500 Paving – Asphalt Cement Price Index, Paving Typical Sections, Plans Sheet, Soil Boring, Pavement Coring Log,** and **2000, 5000 & 6000 series items in Schedule of Prices section** (located near end of document).

Step 5. Retrieve Project **Plan Set** from the source. Review pertinent pages that relate to construction history. Ensure that all the pertinent data is enclosed in the plan set – paving typical sections, plan sheets, etc.

Step 6. Access the **MCMS database** through the EDW application (see Reviewing Projects in MCMS). Export the relevant spreadsheets to Excel. Relevant pages are: Items Report and IDR Detail. For area-wide projects, ensure the appropriate Financial Management Information System (FMIS) number is chosen when exporting the spreadsheet to excel. In the Items Report, all 2000, 5000 and 6000 series items should be evaluated to determine which items are relevant.

Step 7. Check **Hot Mix Asphalt (HMA) Tonnage** production database. Sort the data by "Contract Number" and hide all the unnecessary fields in the database. Keep **Paving Location, Mix Number Production Date,** and **Actual Tonnage**. Compare the total project estimated tonnage to the accumulated "actual" tonnage (see HMA Tonnage Application).

i. If the values are close, copy both tables (Estimated & Actual) into an Excel spreadsheet. Proceed to Step 8.

ii. If the values are not close, further investigation is required before proceeding. Cross reference MCMS report and contact Project Engineer to reconcile any differences.

Step 8. Access the **Bid Tabulation** on the MDOT-SHA homepage. Select the contract number for the project and print. The Bid Tabulation contains the contract number and letting date (date of bid opening).

Step 9. Access the **PMbase** from the Office of Materials Technology (OMT) homepage. Enter the route information required and retrieve the Construction History for the route, IRI, and Friction. The construction history data includes the last treatment applied to the roadway and the pavement type.

Step 10. Locate the **PAGD Geotechnical Report** on the "OMTOOCShared:\OMT\Design Projects" drive which is categorized by district. The folders are categorized by the contract number, by route, or by project description (or a combination thereof). Extract from the contract folder the **pavement recommendation memorandum** and an excel spreadsheet entitled "Design Help."

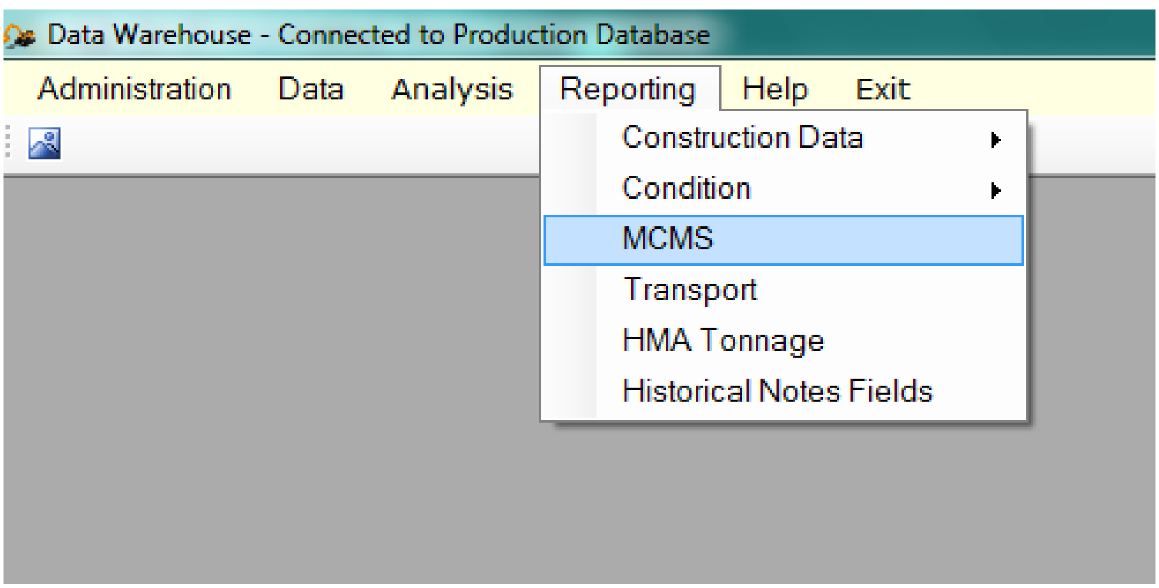
2- As Built Data Input into EDW and QC (Promotion from MCMS) – *performed by EDW user*

Summary: This task inputs collected As Built data that was promoted from MCMS into the EDW.

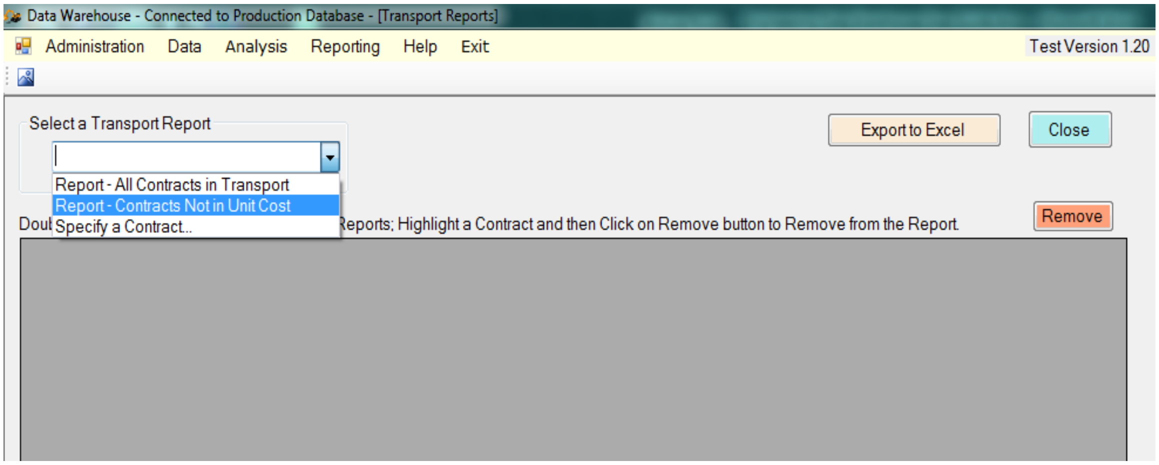
Step 11. If the As Built data was promoted from the MCMS, proceed to Step 11. If the As Built data was promoted from paving or maintenance history, skip to Step 33.

Step 12. Open the EDW application.

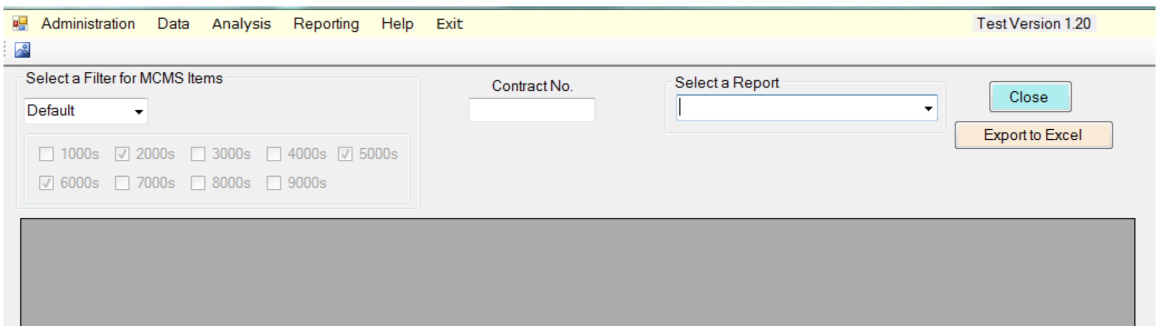
Step 13. On the Main Menu click on "Reporting." From the "Reporting" drop-down menu, choose "MCMS" (see below image).



Step 14. In the "Select a MCMS Report" section choose "Specify a Contract" from the drop-down menu (see below image).



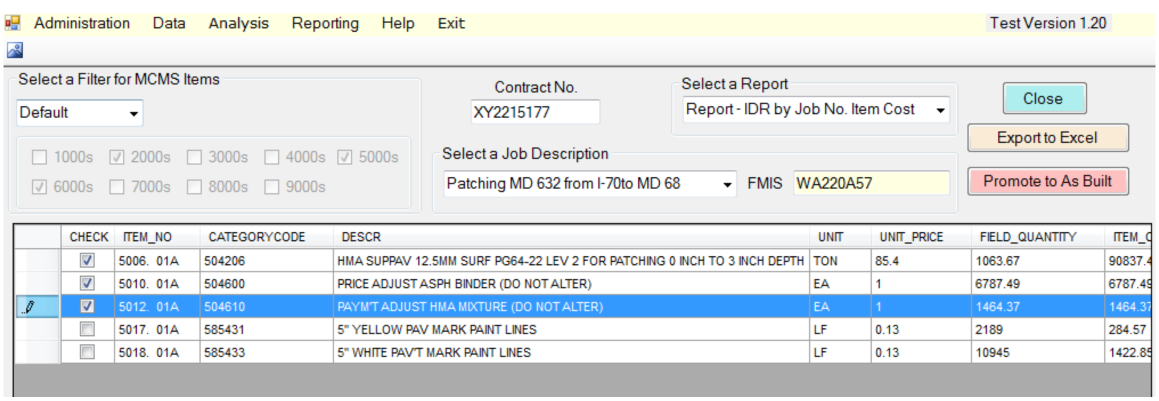
Step 15. Enter the required "Contract No." Click on the "Select a Report" drop-down menu and select "Report – IDR by Job No. Detail" (see below image).



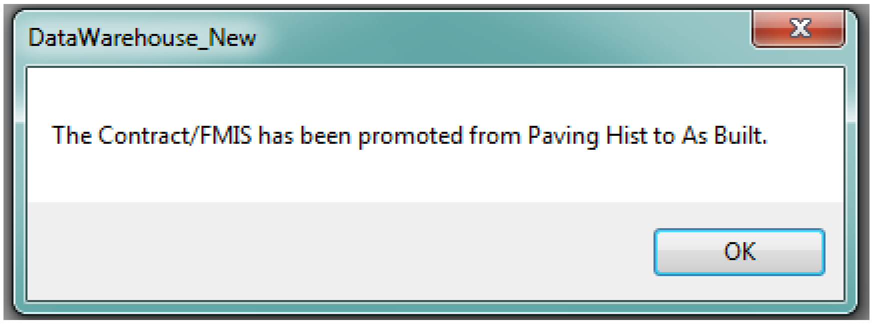
Step 16. Select the specific "Project Description" from the drop-down menu. Make sure the FMIS matches the specific project needed. Click "Export to Excel" and when promoted, save the document in the desired location.

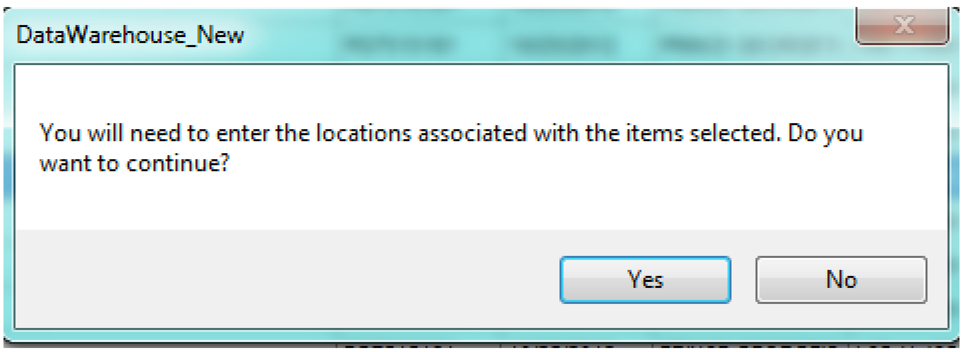
Step 17. Repeat Step 14 to Step 15, except in the "Select a Report" drop-down menu, select "Report – IDR by Job No. Item Cost."

Step 18. With the "Report – IDR by Job No. Item Cost" open in the EDW window, check the boxes of the items that apply to pavement and then press the "Promote to As Built" button (see below image).

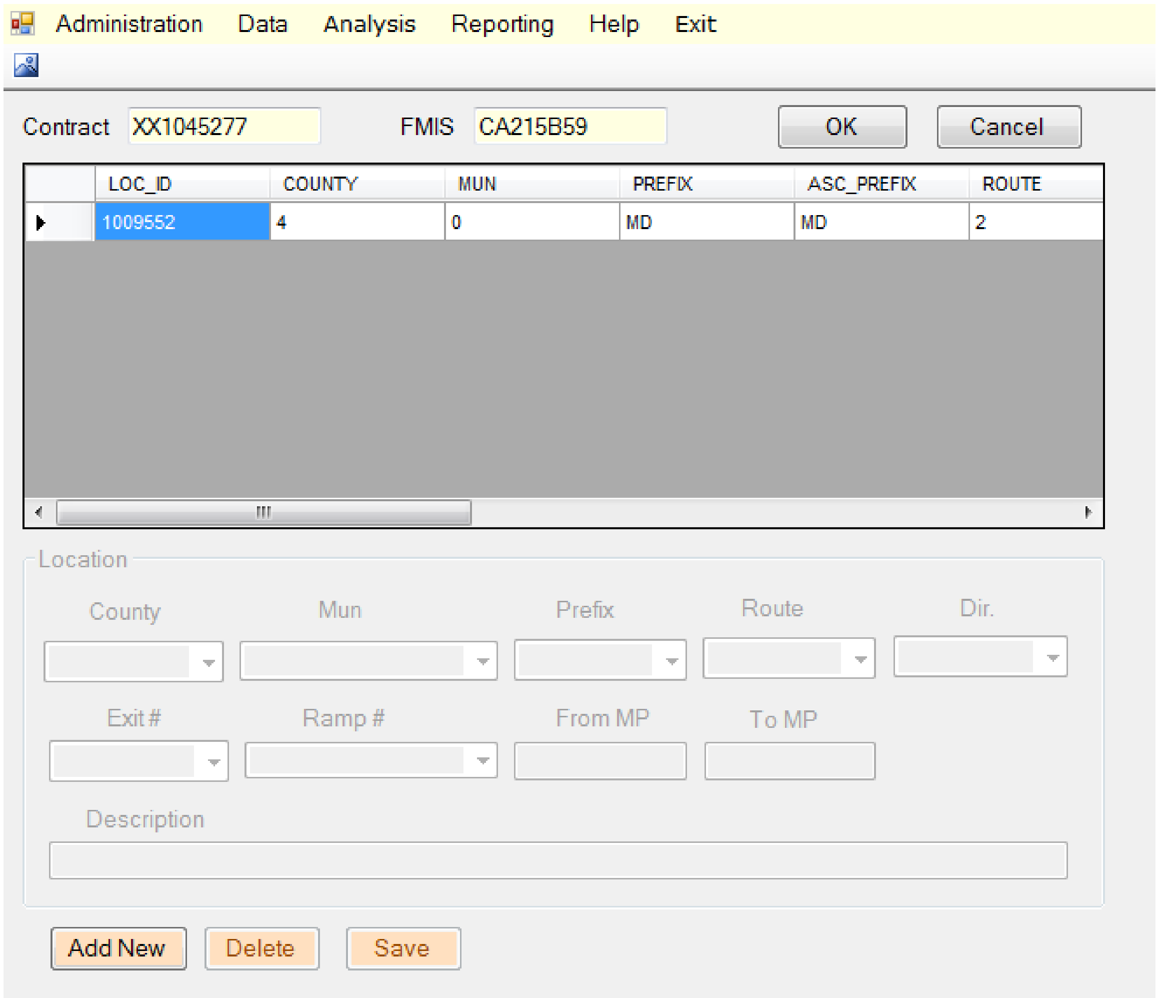


Step 19. A dialogue box will appear: "The Contract/FMIS has been promoted from Paving Hist to As Built." Click "OK." Another dialogue box will appear: "You will need to enter the location associated with the items selected. Do you want to continue?" Click "Yes" (see below images).

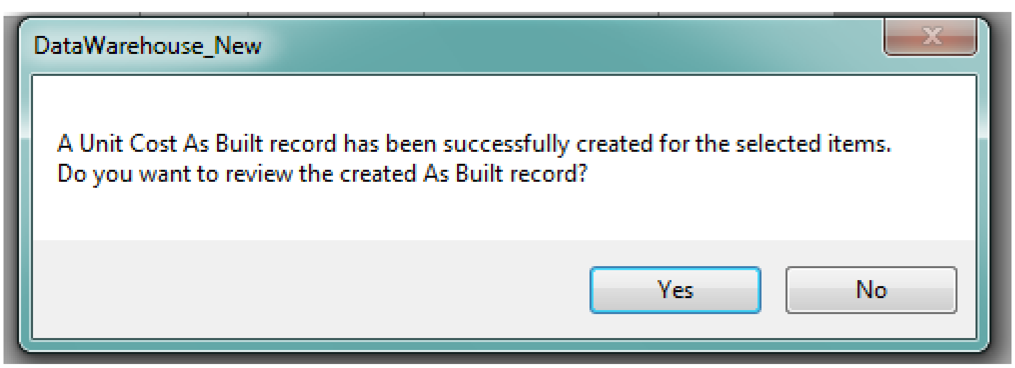




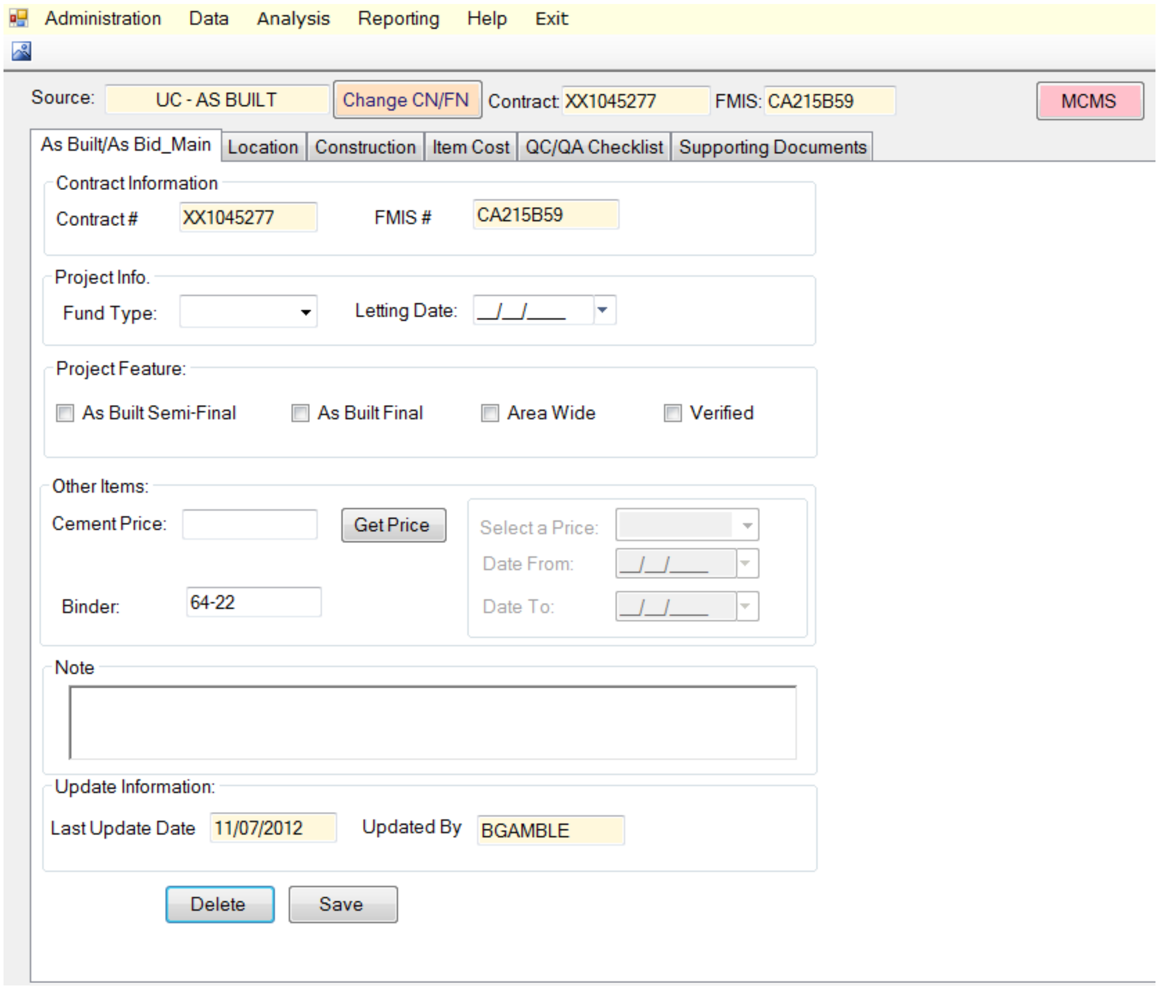
Step 20. The EDW automatically retrieves the paving or maintenance associated with this contract and FMIS number. Therefore, the location should automatically appear in the location tab. Double-click a location in the location table (it will be highlighted in blue when selected). Edit the description and mile points if needed. Click "Save" (see below image). If all the locations are not listed, click "Add New" and enter required information before clicking "Save."



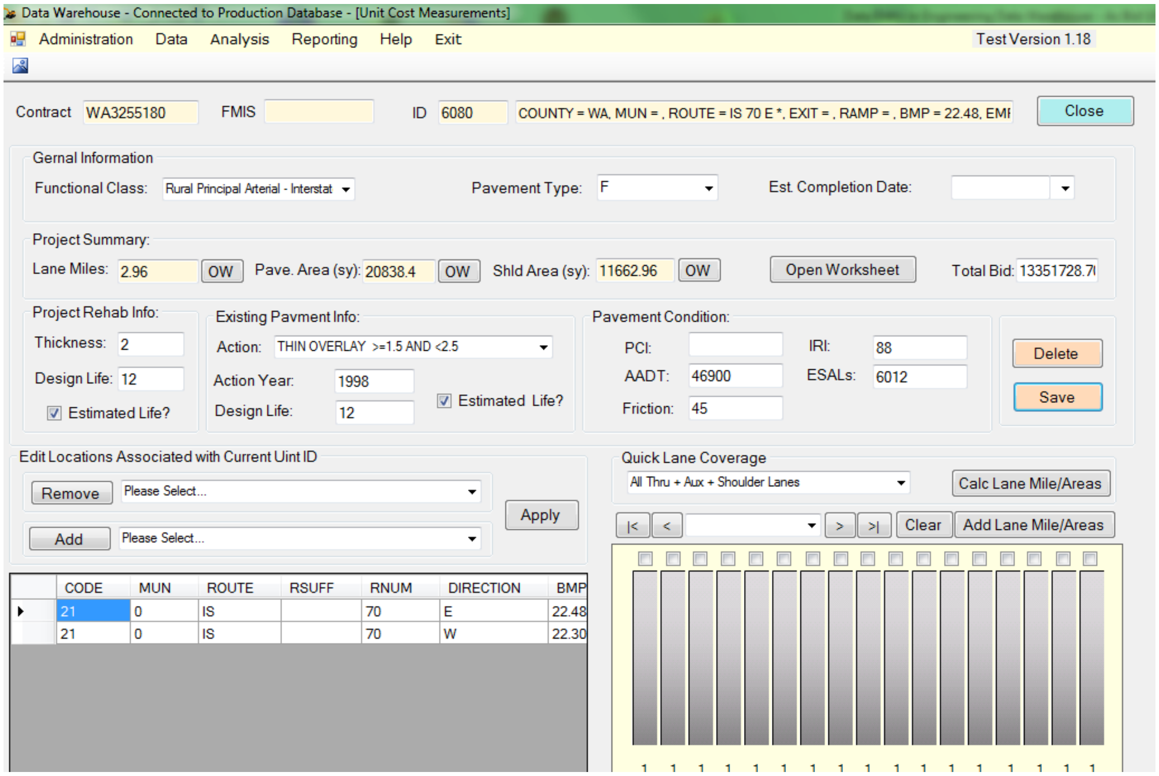
Step 21. A dialogue box will appear: “A Unit Cost As Built record has been successfully created for the selected items. Do you want to review the created As Bid record?” Click “Yes” (see below image).



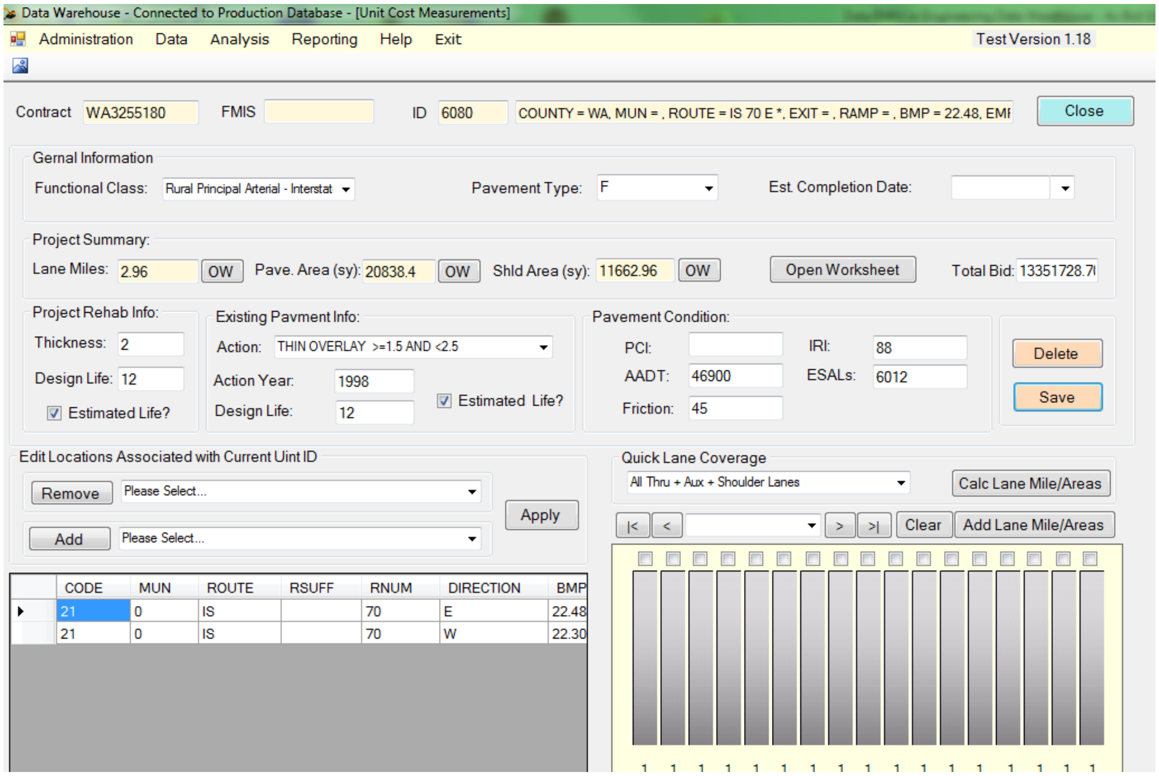
Step 22. Enter data for: **Fund Type, Letting Date, Cement Price, and Binder** (should automatically appear). Check the appropriate boxes in the “Project Feature” section and click “Save” (see below image).



Step 23. Click the “Location” tab to enter the location information. The locations entered for the project during Step 19 will appear in the location table. Click “Save.” Double-click on a location in the location table. When it is highlighted in blue, click “View/Add UC Measures” (see below image).

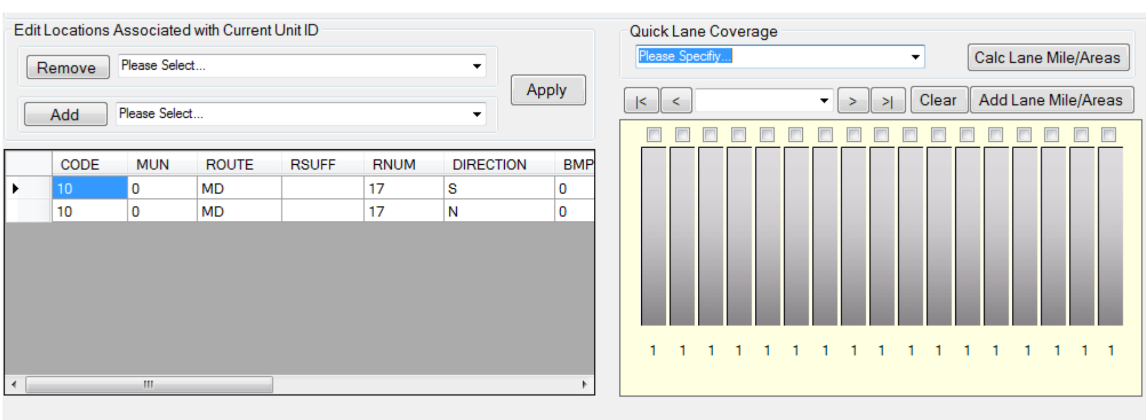


Step 24. Enter the required information: **Functional Class, Pavement type, Est. Completion Date, Thickness, Design Life, Action, Action year, Design Life, PCI, IRI, AADT, ESALs, Friction.** The Total Bid should automatically appear if the contract was promoted through the MCMS feature. The Lane Miles, Pavement Area, and Shoulder can be automatically generated by the EDW application (see below image).



Step 25. In the “Edit Location Associated with Current Unit ID” section of the screen, click on the “Add” pull-down menu and make sure all the locations are added to this unit cost measures. If the As Built was promoted from the MCMS feature, the locations will already appear in the table.

Step 26. Click on the drop-down menu in the “Quick Lane Coverage” section of the screen. Select “All Thru” then press “Calc Lane Miles/Area” and the EDW will automatically generate the quantities for lane miles, pavement area and shoulder area (see below image).



Step 27. Verify the quantities that the EDW generated. Click on “Open Worksheet.” Fill in the appropriate fields (extracted from the typical section within the Plans Set): **Lanes, Lane Mi, L (length), m/l W (width), Shoulder W (width), and**

Shoulder SY. The total at the bottom of the worksheet should be within 5% of the EDW auto generated quantity (see below image).

i. If the total is within 5% of the EDW auto generated quantity, proceed to Step 28.

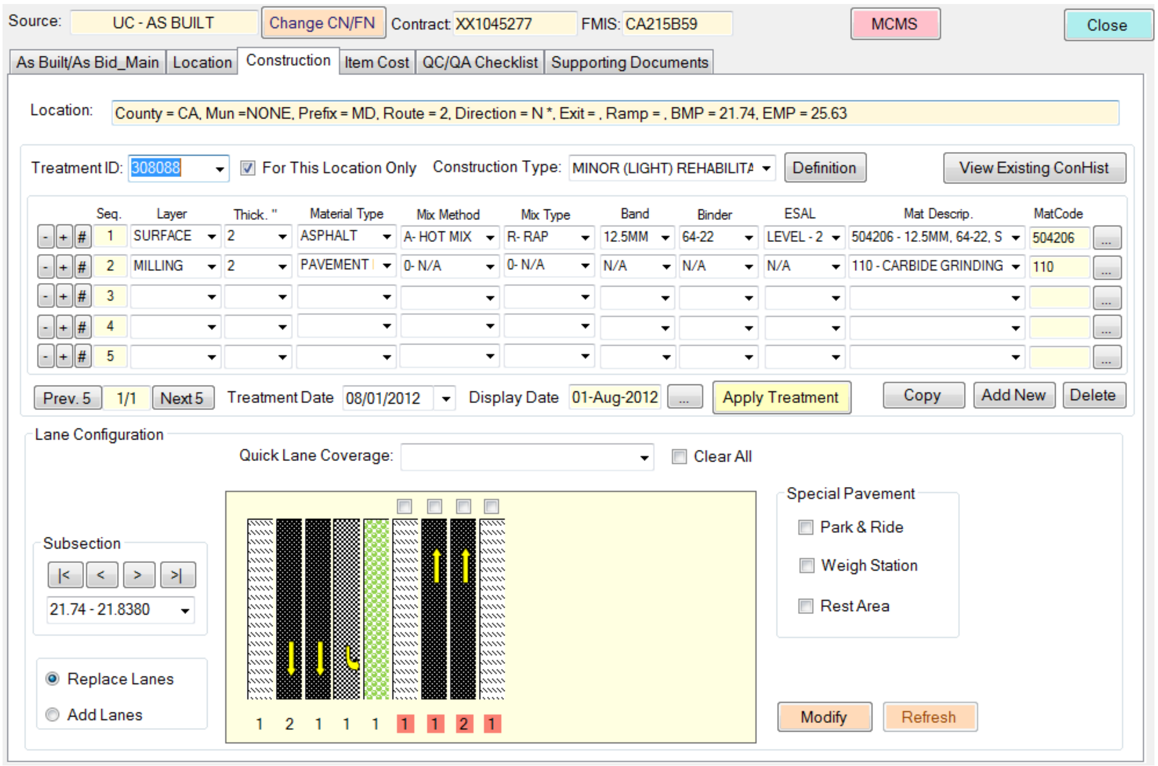
ii. If the total is not within 5% of the EDW, further investigation is required to reconcile any differences.

D6 *fx*

	A	B	C	D	E	F	G	H
1	Lanes	Lane Mi	L	m/l W	m/l SY	shldr W	shldr SY	Source
2		0			0		0	
3		0			0		0	
4		0			0		0	
5		0			0		0	
6		0			0		0	
7		0			0		0	
8		0			0		0	
9		0			0		0	
10		0			0		0	
11		0			0		0	
12		0			0		0	
13		0			0		0	
14		0			0		0	
15		0			0		0	
16		0			0		0	
17		0			0		0	
18		0			0		0	
19		0			0		0	
20		0			0		0	
21		0			0		0	
22		0			0		0	
23		0			0		0	
24		0			0		0	
25		0			0		0	
26		0			0		0	
27		0			0		0	
28		0			0		0	
29		0			0		0	
30		0			0		0	
31		0			0		0	
32		0			0		0	
33		0			0		0	
34		0			0		0	
35	totals	0			0		0	
36								
37					0			

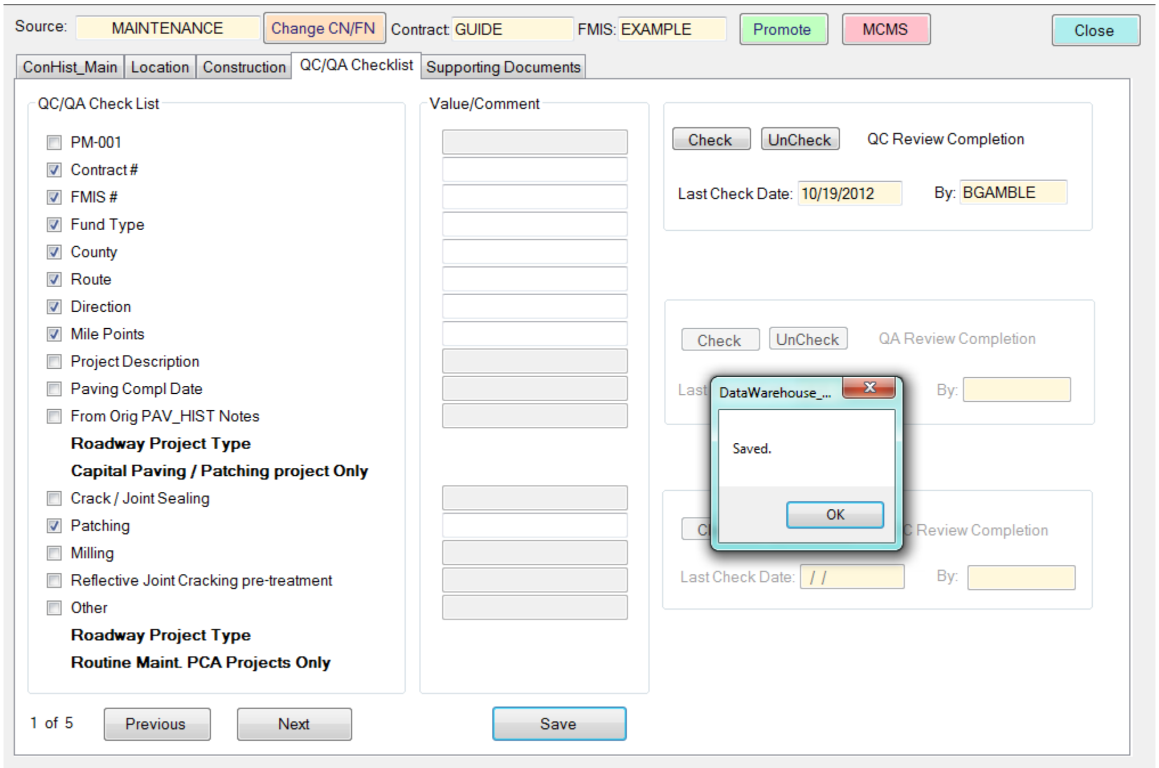
Step 28. Click "Save" and then "Close." The EDW will automatically return to the "Location" tab.

Step 29. Double-click on a location in the table while on the "Location" tab. Make sure the location is highlighted in blue. Click on the "Construction" tab. Since the project has been promoted from MCMS and the EDW retrieved the construction history from the paving or maintenance history, the construction layers should already be populated (see below image). Make sure the construction data is correct using the information gathered in the "Data Collection" section. If the data is not accurate, make the necessary adjustments to correct the construction data. However, the **"Construction History"** must be edited as well. Repeat this step for all locations on the project.

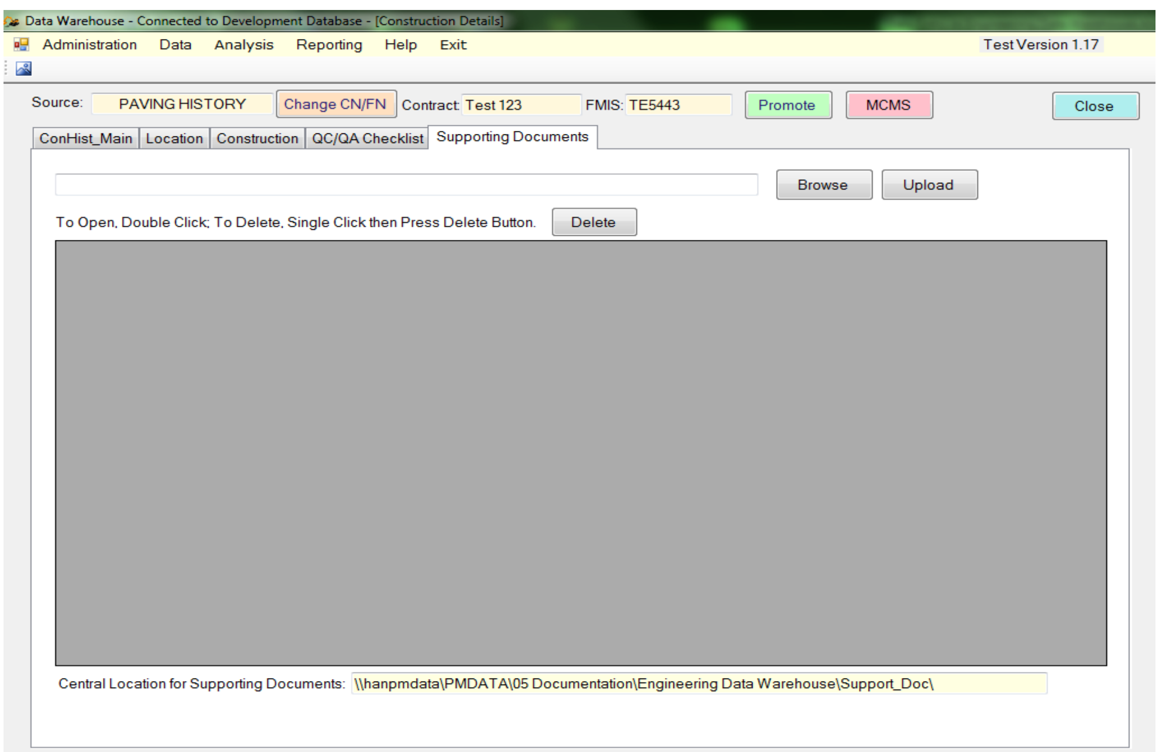


Step 30. Click on the “Item Cost” tab. Double-click on each item (highlighting the item in blue) in the table and assign the relevant activity under the “Activity” drop-down menu. Click “Save.” Repeat for each item in the table. For As Built Adjustments, the unit must be assigned as “Each.” Make sure the “As Built” box is checked for every item.

Step 31. Click on “QC/QA Checklist” tab. Click on the relevant boxes on “QC/QA Check List” (left side of screen) and then click the “Save” button on the bottom of screen. If all data for the project is entered completely, click the “Check” button (see below image). Otherwise, return to incomplete data and input before proceeding.



Step 32. Click on “Supporting Documents” tab and upload any supporting documents using the “Upload” button (see below image). After this step, the procedure is complete (next section is for promotion through paving or maintenance history only).

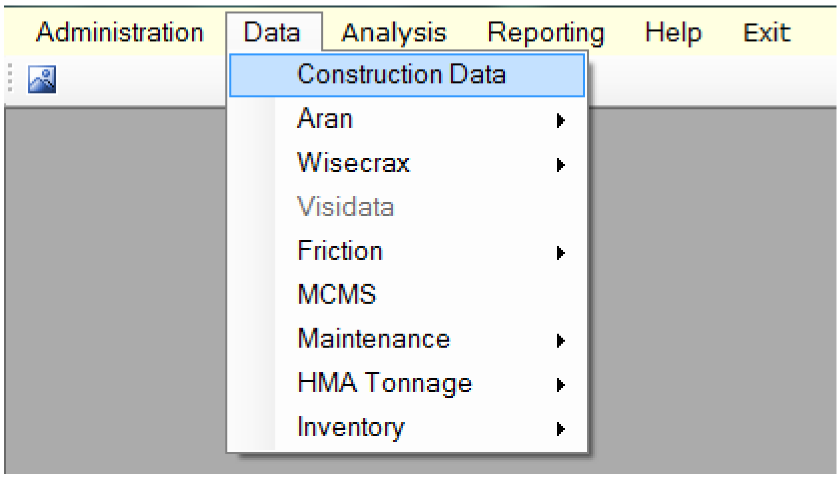


3- As Built Data Input into EDW and QC (Promotion from Paving or Maintenance History) – *performed by EDW user*

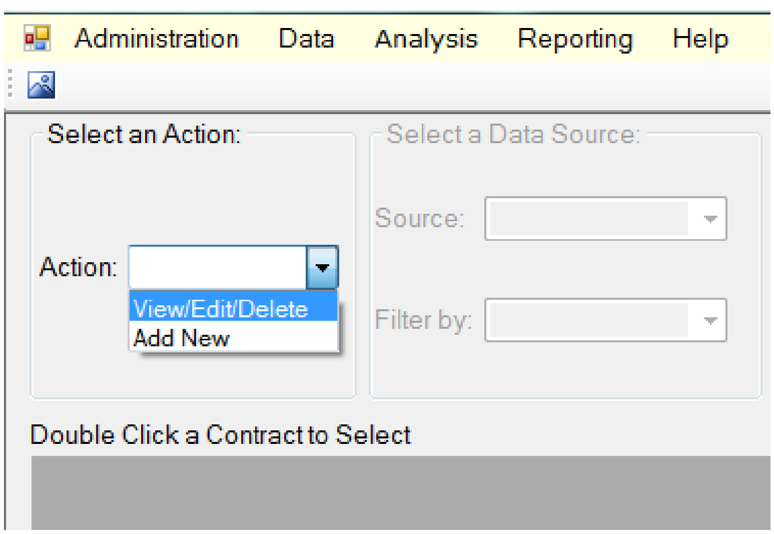
Summary: This task inputs collected As Built data that was promoted from Paving or Maintenance History into the EDW.

Step 33. Open the EDW application.

Step 34. On the Main Menu click on "Data." From the "Data" drop-down menu, choose "Construction Data" (see below image).

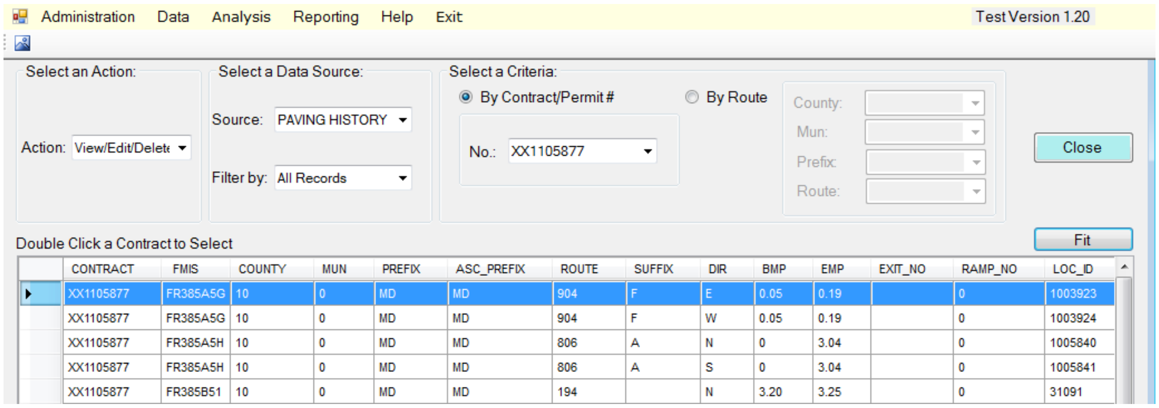


Step 35. Click on the "Action" drop-down menu and select "View/Edit/Delete" (see below image).



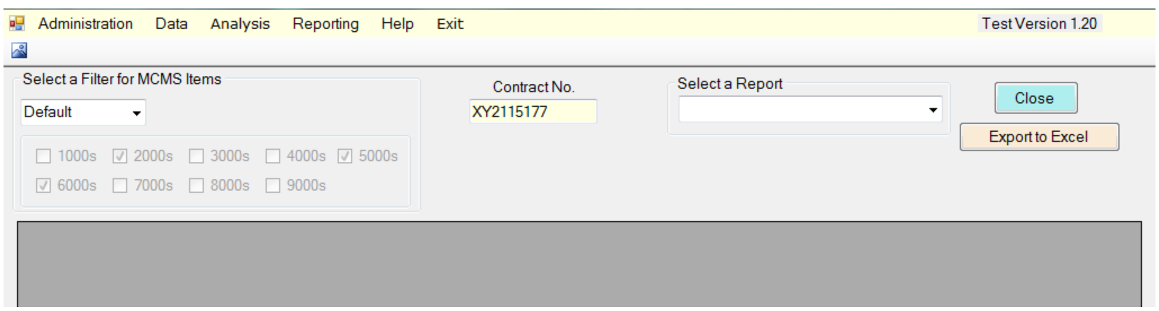
Step 36. Select either "Paving" or "Maintenance" from the "Source" drop-down menu.

Step 37. Enter the "Contract No." of the projected to be promoted to Unit Cost – As Built (see below image).

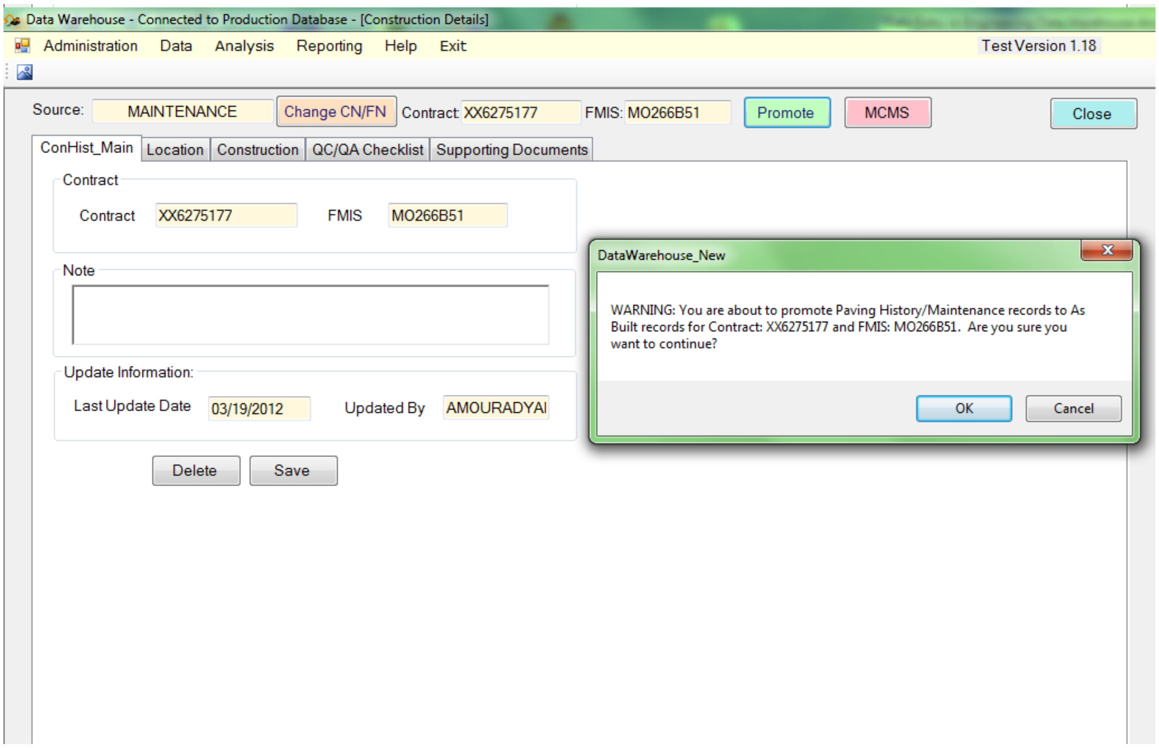


Step 38. Double-click the Contract & FMIS number of the specific project that will be promoted to Unit Cost – As Built. The EDW will open the "Construction" main tab for that specific contract.

Step 39. Click the "MCMS" button. A MCMS window with the contract number already entered will open. Click "Export to Excel" for the relevant spreadsheets and press Close" (see below image).



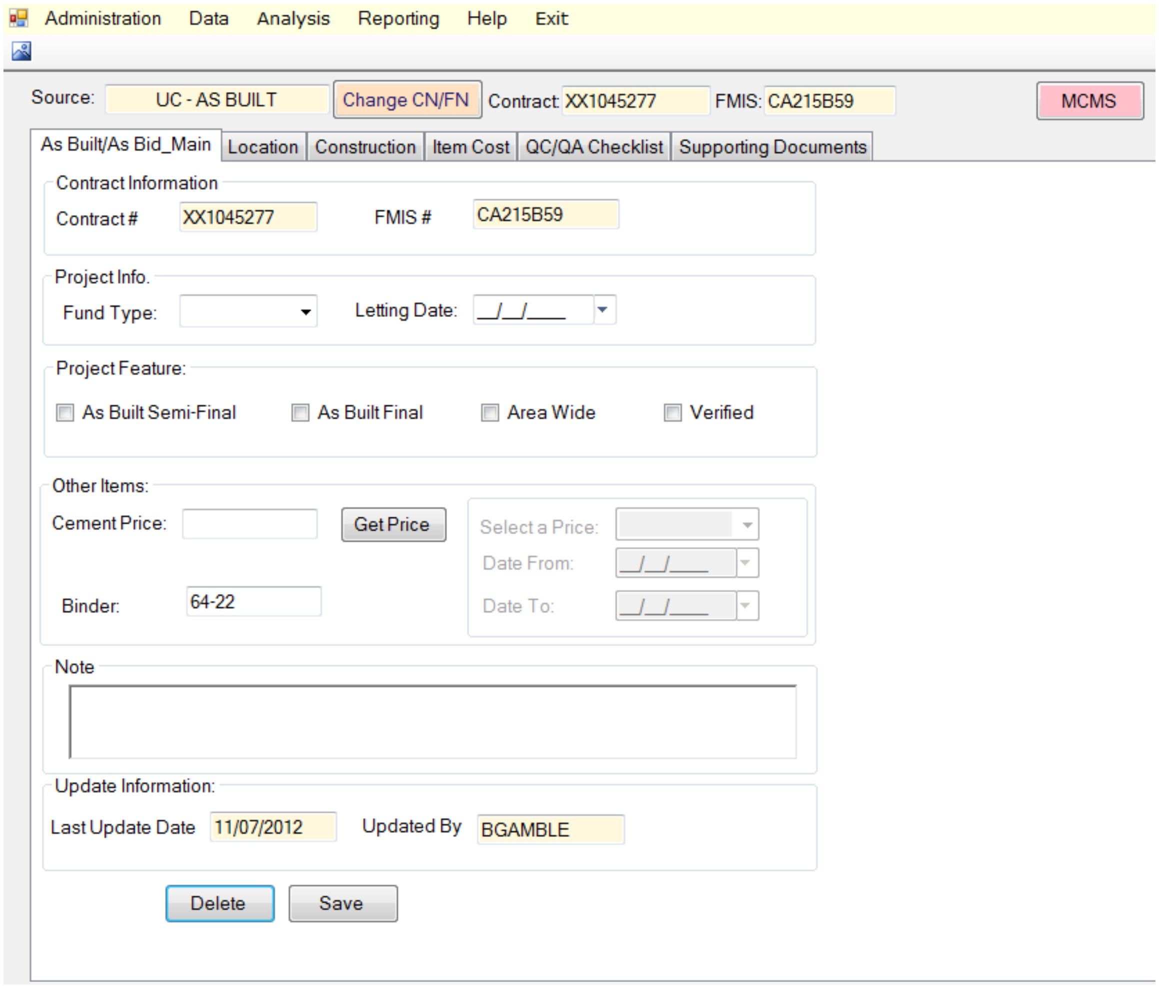
Step 40. Click the "Promote" button. A dialogue box will appear: "WARNING. You are about to promote Paving History/Maintenance records to As Built records for Contract: ______ and FMIS ______. Are you sure you want to continue?" Click "OK" (see below image).



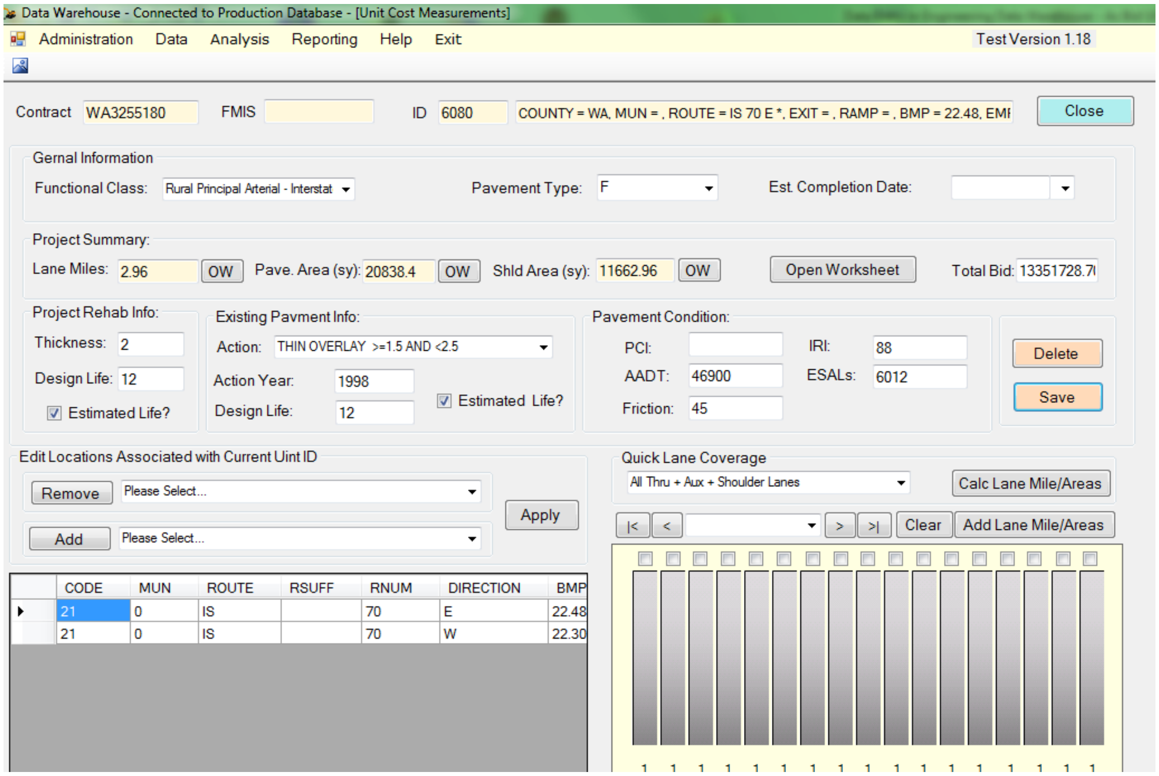
Step 41. Once the promotion is complete a dialogue box will appear: “Promotion done!” Click “OK.” Then close the “Construction History” project.

Step 42. Click on “Data.” Select the “Construction Data” option from the drop-down menu. Click on the “Action” drop-down menu and select “View/Edit/Delete.” Select “UC- As Built” from the “Source” drop-down menu

Step 43. Enter data for: **Fund Type, Letting Date, Cement Price, and Binder** (should automatically appear). Check the appropriate boxes in the “Project Feature” section. Click “Save” (see below image).



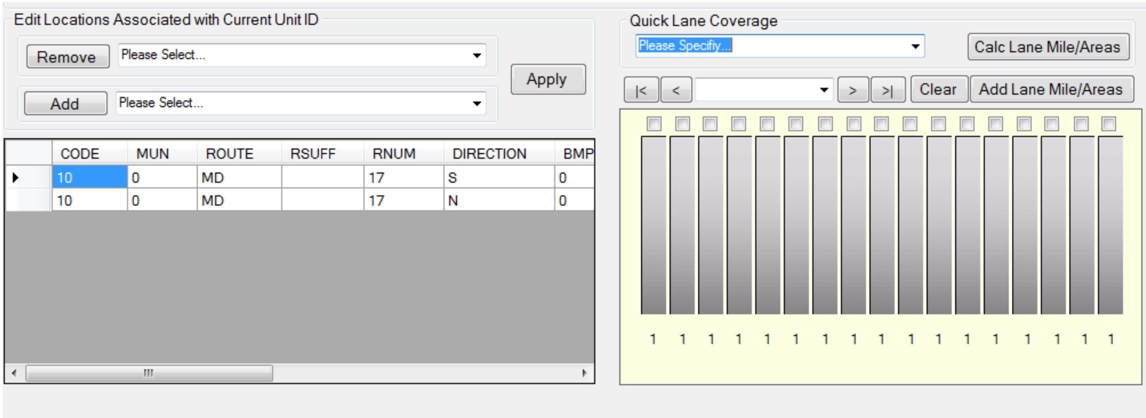
Step 44. Click the “Location” tab and make changes if necessary. Click “Save.” Double-click on a location in the location table. When it is highlighted in blue, click “View/Add UC Measures” (see below image).



Step 45. Enter the required information: **Total Bid, Functional Class, Pavement type, Est. Completion Date, Thickness, Design Life, Action, Action year, Design Life, PCI, IRI, AADT, ESALs, Friction**. The Total Bid will not appear automatically because the contract was promoted from Construction History. The Lane Miles, Pavement Area, and Shoulder can be automatically generated by the EDW application.

Step 46. In the “Edit Location Associated with Current Unit ID” section of the screen, click on the “Add” pull-down menu and make sure all the locations are added to this unit cost measures. The locations will not automatically populate in the location table because the project was promoted from Construction History.

Step 47. Click on the drop-down menu in the “Quick Lane Coverage” section of the screen. Select “All Thru” then press “Calc Lane Miles/Area” and EDW will automatically generate the quantities for lane miles, pavement area and shoulder area (see below image).



Step 48. Verify the quantities that the EDW generated. Click on “Open Worksheet.” Fill in the appropriate fields (extracted from the typical section within the Plans Set): **Lanes, Lane Mi, L (length), m/l W (width), Shoulder W (width), and Shoulder SY**. The total at the bottom of the worksheet should be within 5% of the EDW auto generated quantity (see below image).

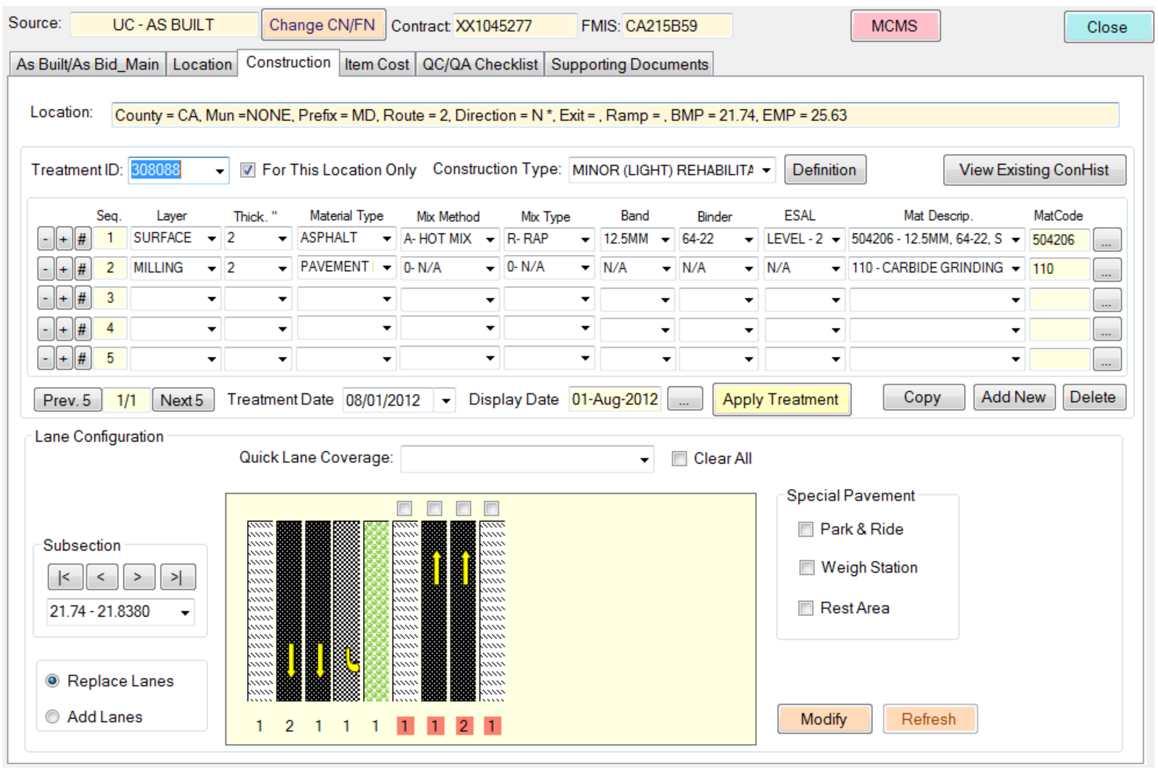
i. If the total is within 5% of the EDW auto generated quantity, proceed to Step 49.

ii. If the total is not within 5% of the EDW, further investigation is required to reconcile any differences.

	A	B	C	D	E	F	G	H
1	Lanes	Lane Mi	L	m/l W	m/l SY	shldr W	shldr SY	Source
2		0			0		0	
3		0			0		0	
4		0			0		0	
5		0			0		0	
6		0			0		0	
7		0			0		0	
8		0			0		0	
9		0			0		0	
10		0			0		0	
11		0			0		0	
12		0			0		0	
13		0			0		0	
14		0			0		0	
15		0			0		0	
16		0			0		0	
17		0			0		0	
18		0			0		0	
19		0			0		0	
20		0			0		0	
21		0			0		0	
22		0			0		0	
23		0			0		0	
24		0			0		0	
25		0			0		0	
26		0			0		0	
27		0			0		0	
28		0			0		0	
29		0			0		0	
30		0			0		0	
31		0			0		0	
32		0			0		0	
33		0			0		0	
34		0			0		0	
35	totals	0			0		0	
36								
37					0			

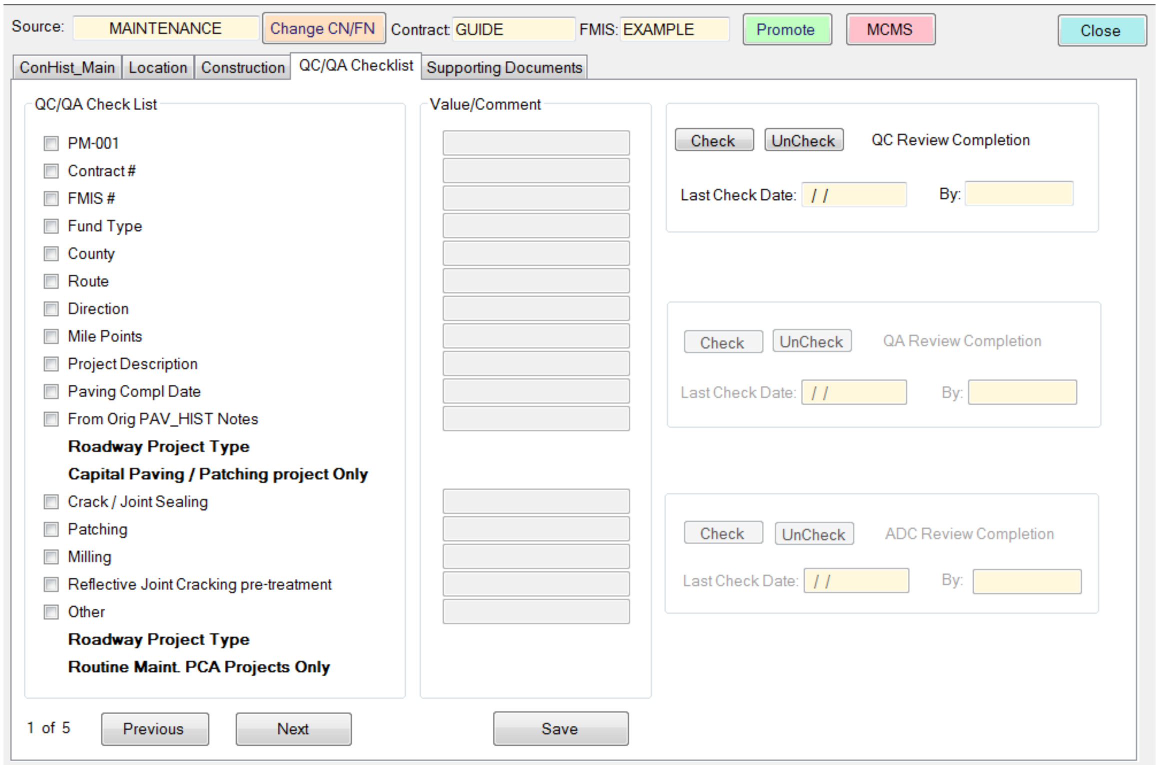
Step 49. Click "Save" and then "Close." The EDW will automatically return to the "Location" tab.

Step 50. Double-click on a location in the table while on the "Location" tab. Make sure the location is highlighted in blue. Click on the "Construction" tab. Since the project has been promoted from Construction History, the EDW should have populated the construction layer (see below image). Make sure the construction data is correct using the information gathered in the "Data Collection" section. If the data is not accurate, make the necessary adjustments to correct the construction data. However, the **"Construction History"** must be edited as well. Repeat this step for all locations on the project.

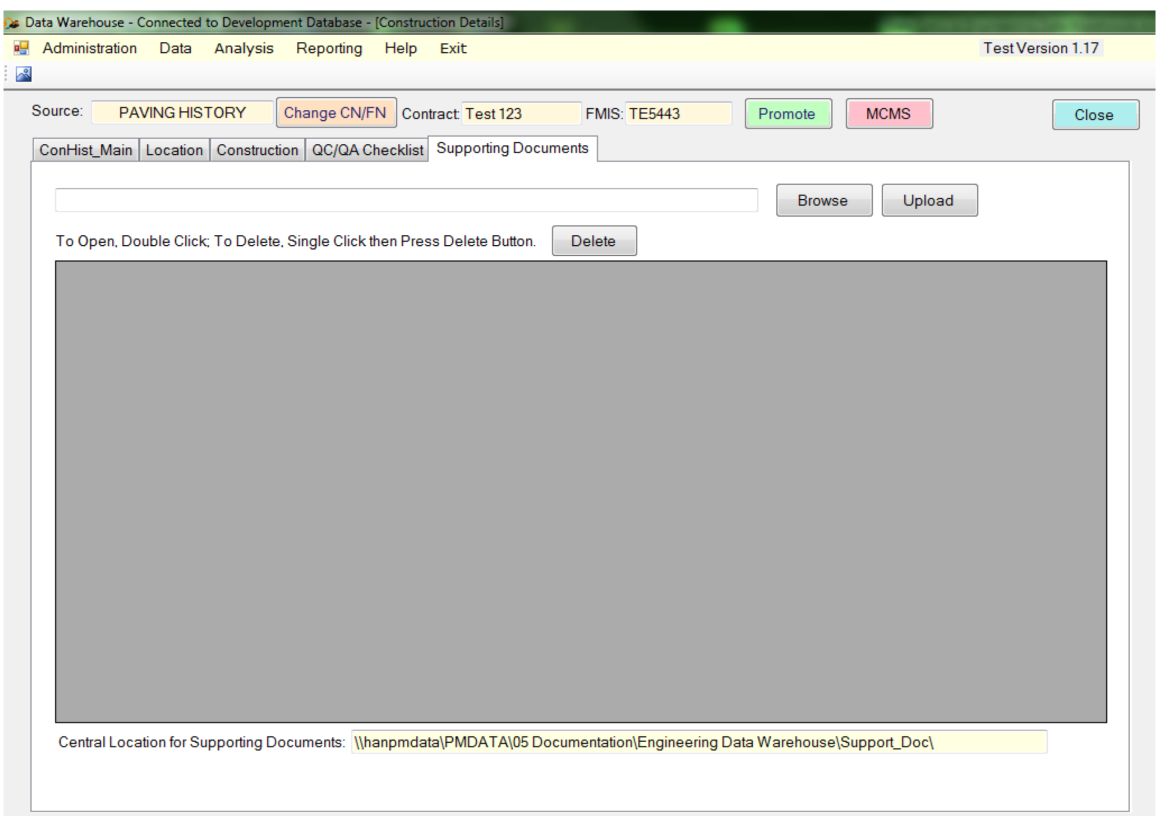


Step 51. Click on the "Item Cost" tab. Double-click on each item (highlighting the item in blue) in the table and assign the relevant activity under the "Activity" drop-down menu. Click "Save." Repeat for each item in the table. For As Built Adjustments, the unit must be assigned as "Each." Make sure the "As Built" box is checked for every item.

Step 52. Click on "QC/QA Checklist" tab. Click on the relevant boxes on "QC/QA Check List" (left side of screen) and then click the "Save" button on the bottom of screen. If all data for the project is entered completely, click the "Check" button (see below image). Otherwise, return to incomplete data and input before proceeding.



Step 53. Click on “Supporting Documents” tab and upload any supporting documents using the “Upload” button (see below image).



4.05 REVIEWING PROJECTS IN MCMS

4.05.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to review construction information for single-ad and area-wide projects using the Maryland Construction Management System (MCMS) within the Engineering Data Warehouse (EDW). MCMS is a standalone application run by the inspection division of MDOT-SHA. The database contains detailed construction information that is significant to data collection and processing of MDOT-SHA construction projects. MCMS is the primary source for construction information for single-ad and area-wide projects. Three spreadsheets created by MCMS are utilized: an itemized report with quantities and unit cost, a detailed construction report categorized by item, and the job order (applies only to area-wide projects). The EDW has an internal MCMS feature to streamline the data collection process.

4.05.02 *Frequency*

The use of the MCMS application within the EDW is a continuous process that occurs year-round.

4.05.03 *Purpose*

The purpose of this SOP is to review construction information using the MCMS application and produce reports of the desired information for use in construction data collection (see Processing Paving & Maintenance History Data, Processing Access Permit Data], and Processing As Built Unit Cost Data.

4.05.04 *Resource Requirements*

The running of the MCMS application involves two people: (1) a user knowledgeable in EDW software to run the application, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	EDW user	1	4.0
DPT TL	Supervisor	1	AR[06/12/2019]

4.05.05 *Procedure*

The procedure to run the MCMS application for construction information reporting is comprised of a single task:

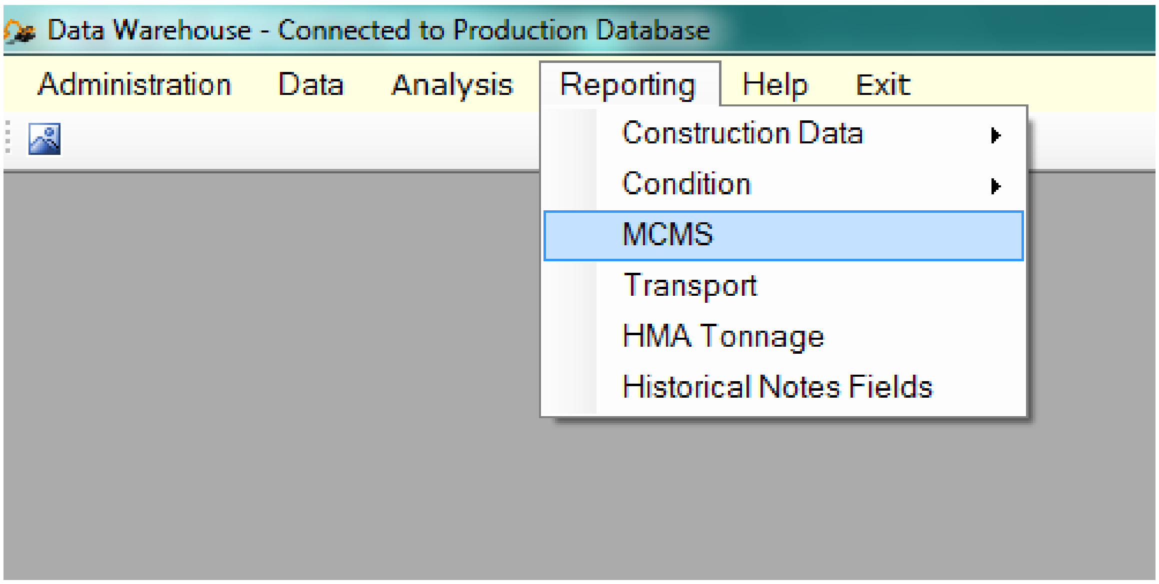
(1) generating an MCMS report in the EDW.

1- Generating an MCMS Report in the EDW – *performed by EDW user*

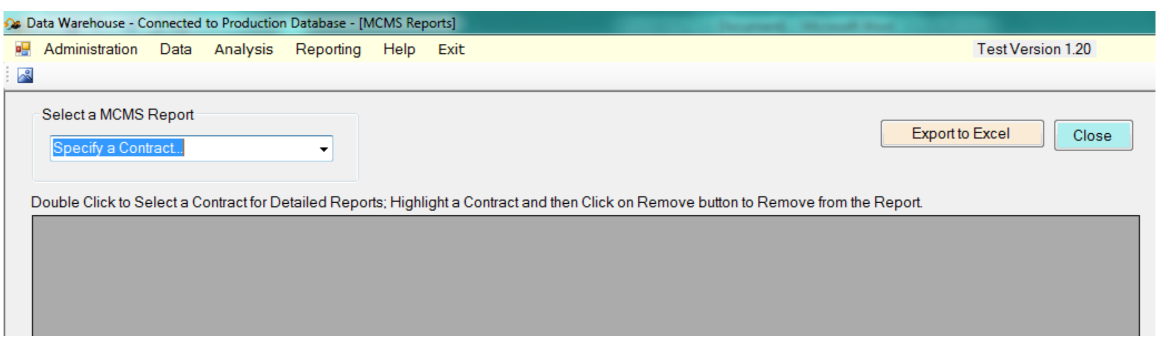
Summary: This task generates a report from the MCMS application within the EDW. The output of this task is an Excel spreadsheet with a list of desired contracts and associated construction information.

Step 1. Open the EDW application.

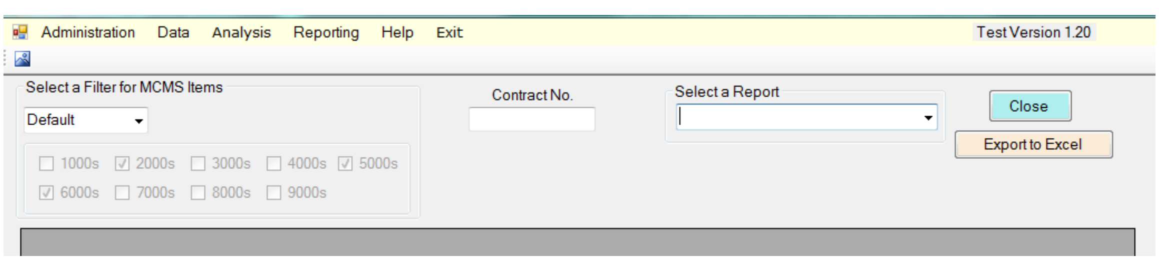
Step 2. Select the “Reporting” button from the main menu and click “MCMS” from the drop-down list (see below image).



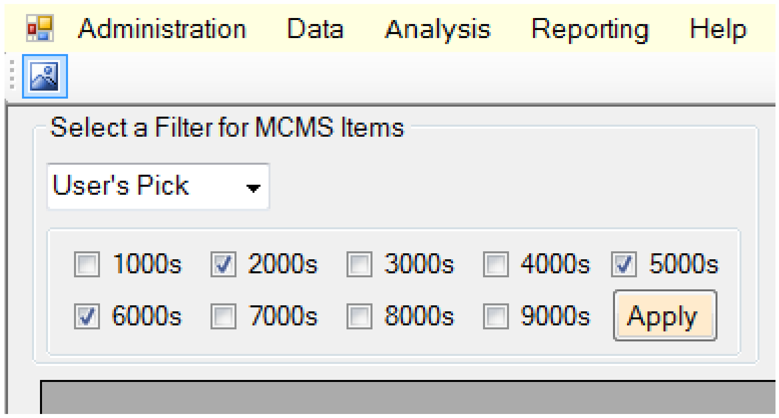
Step 3. In the “Select a MCMS Report” drop-down list, click “Specify a Contract” (see below image).



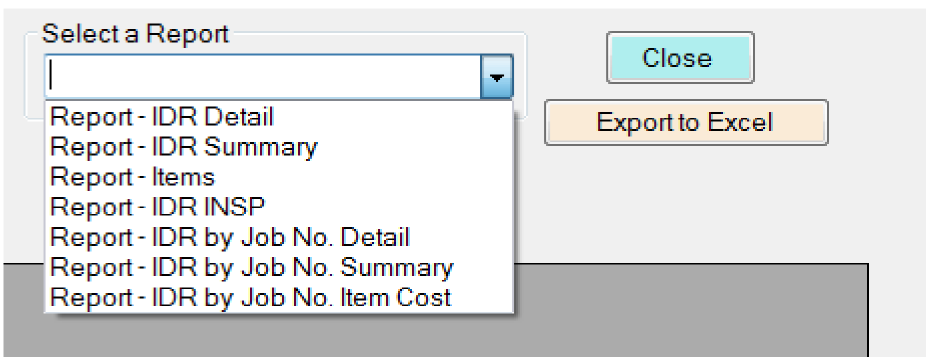
Step 4. Another window will automatically open. Enter the “Contract No” (see below image).



Step 5. On the left side of the window, change the “Select a Filter for MCMS Items” to “User’s Pick” and check the boxes for all the desired item series (see below image).



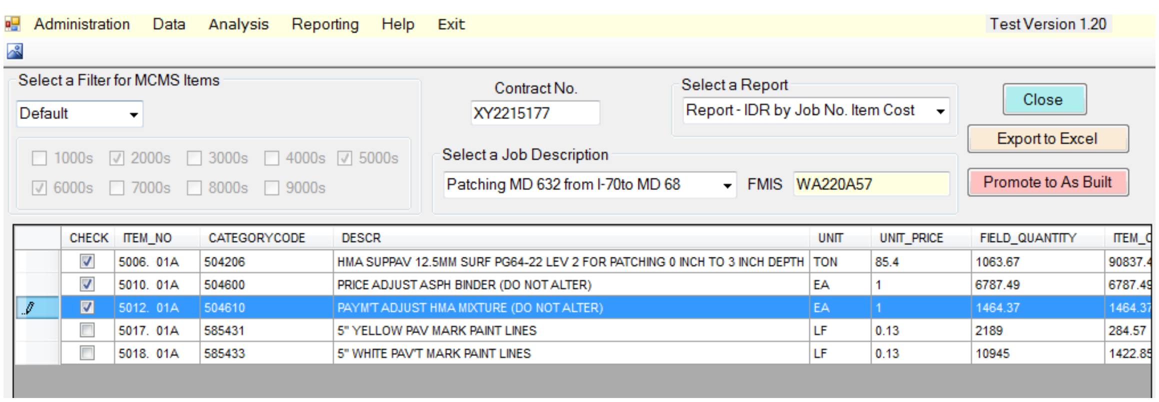
Step 6. On the “Select a Report” drop-down menu, choose the desired option. The first four reports apply to single-ad projects, while the last three reports apply to area-wide projects (see below image).



i. If a single-ad project option is chosen, proceed to Step 8.

ii. If an area-wide project option is chosen, proceed to Step 7.

Step 7. Choose the correct description from the “Select a Job Description” drop-down menu and confirm the “FMIS” matches the specific project needed. If it does not match, confirm the correct job description was selected (see below image).



Step 8. Once the desired contracts are displayed, click the “Export to Excel” button. Name the document in the save prompt window, choose the proper save location, and click “Save.” The spreadsheet will automatically open in Excel.

Step 9. Repeat Step 2 to Step 8 for each desired MCMS report.

4.06 RUNNING TRANSPORT APPLICATION

4.06.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to review bid tabulation information for single-ad projects in the Engineering Data Warehouse (EDW) prior to Unit Cost – As Bid data processing (see Processing As Bid Unit Cost Data). The Transport application within the EDW is used to accomplish this task. It is operated by the Office of Construction within the MDOT-SHA as a means to prompt the DPT when contracts are ready.

4.06.02 *Frequency*

The use of the Transport application within the EDW is a continuous process that occurs year-round.

4.06.03 *Purpose*

The purpose of this SOP is to review bid information and determine if the contracts are good candidates for promotion to the Unit Cost - As Bid processing.

4.06.04 *Resource Requirements*

The running of the Transport application involves two people: (1) a user knowledgeable in EDW software to run the application, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	EDW user	1	1.0
DPT TL	Supervisor	1	AR[06/12/2019]

4.06.05 *Procedure*

The procedure to run the Transport application is comprised of a single task:

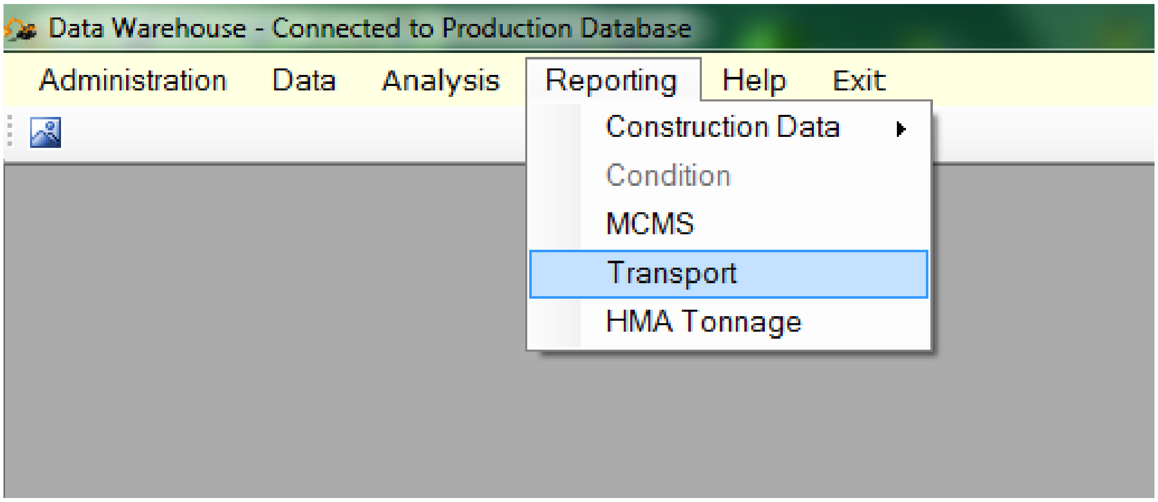
(1) running Transport application in the EDW.

1- Running Transport Application in the EDW – *performed by EDW user*

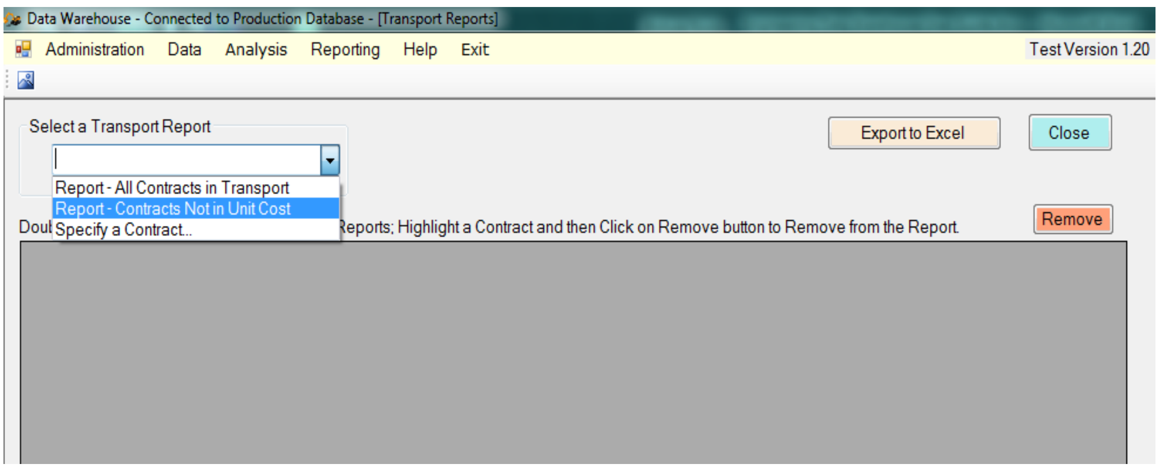
Summary: This task generates a list from the Transport application within the EDW for contracts that are good candidates for Unit Cost – As Bid. This task is completed prior to data processing of Unit Cost – As Bid contracts as outlined in Processing As Bid Unit Cost Data.

Step 1. Open the EDW application.

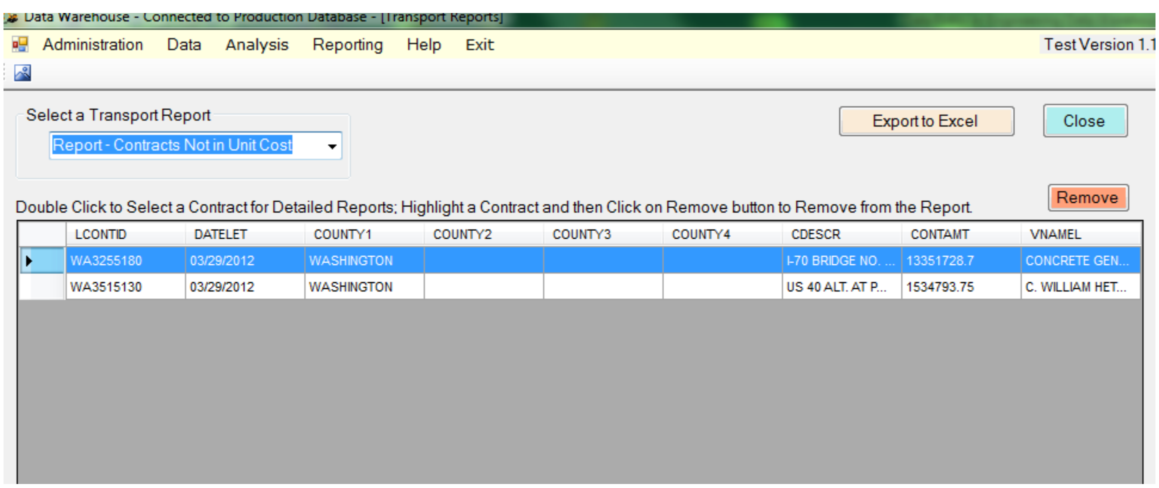
Step 2. Select the "Reporting" button from the main menu and click "Transport" from the drop-down list (see below image).



Step 3. In the “Select a Transport Report” drop-down list, click “Report – Contracts Not in Unit Cost” (see below image).

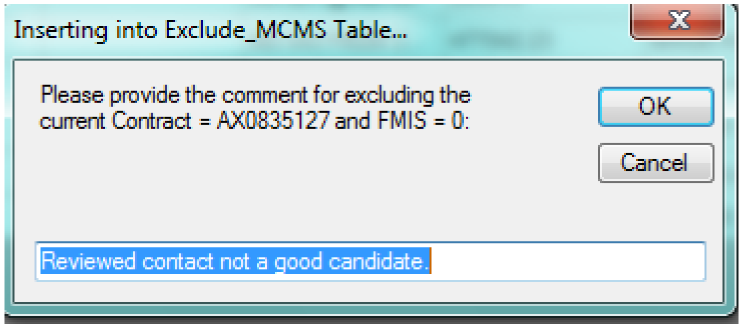


Step 4. Double-click on a contract to see the detailed item report (see below image). The EDW will automatically open the detailed item report. Not every project that is displayed in the Transport application qualifies as a good candidate for “Unit Cost – As Bid”, the project **must** contain **5000s** series paving items.



i. If the project is a good candidate for Unit Cost – As Bid, continue to Processing As Bid Unit Cost Data.

ii. If the project is not a good candidate for Unit Cost – As Bid, click the “Remove” button. A dialogue box will appear (see below image). “Reviewed contract not a good candidate” will already be populated in the text area. Click “OK.”



4.07 LOOKING UP FUND TYPE

4.07.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to look up the fund type for a specific project using an application within the Engineering Data Warehouse (EDW). MDOT-SHA has a numbering convention for projects and the last two digits in the contract number indicate the type of construction project. However, this is not always the case for area-wide projects. The Mother Contract could indicate a rehab project while the Financial Management Information System (FMIS) number could represent an intersection improvement. The FMIS lookup application gives fund type directly from the Office of Finance. Area-wide projects have a contract and FMIS number, whereas single-ad projects are assigned a single contract number. However, using the county and the next five digits, an FMIS can be created and used as the FMIS for lookup purposes (e.g., "AL3805177" is a single-ad contract number, while "AL380(A/B/C)51" is the FMIS number). The list of fund types has been included as an appendix (see Fund Type).

4.07.02 *Frequency*

The use of the fund type lookup application within the EDW is a continuous process that occurs year-round.

4.07.03 *Purpose*

The purpose of this SOP is to look up the fund type for a specific construction project.

4.07.04 *Resource Requirements*

Looking up a construction project fund type involves two people: (1) a user knowledgeable in the EDW software to run the application, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	EDW user	1	0.5
DPT TL	Supervisor	1	AR[06/12/2019]

4.07.05 *Procedure*

The procedure to look up a construction project fund type is comprised of a single task:

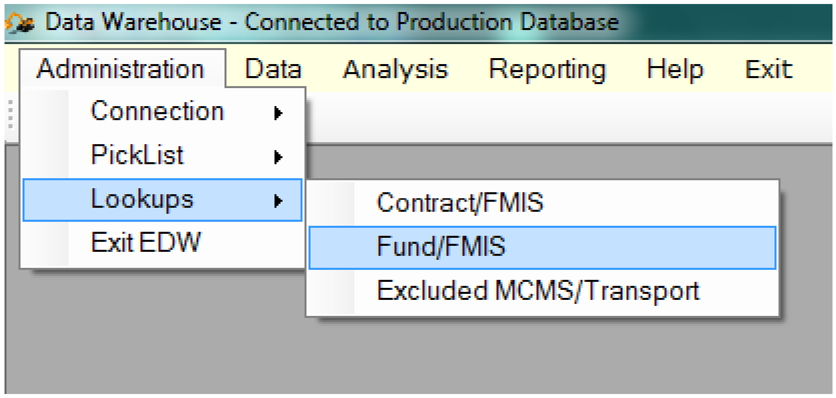
(1) running fund type lookup application in the EDW.

1- Running Fund Type Lookup Application in the EDW – *performed by EDW user*

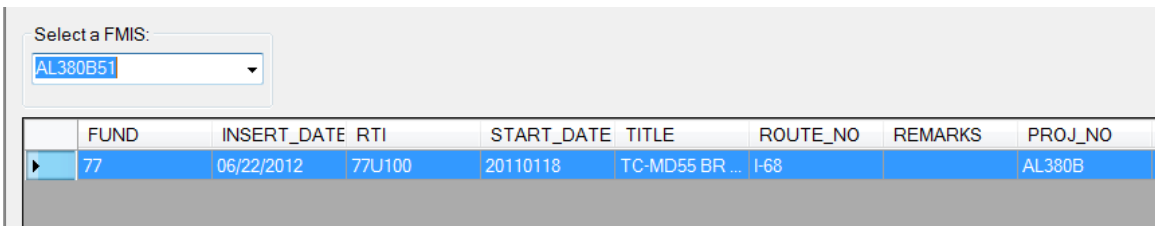
Summary: This task utilizes the fund type lookup application in the EDW to identify the fund type for a specific contract.

Step 1. Open the EDW application.

Step 2. Select the “Administration” button from the main menu and click “Lookups” from the drop-down list, then “Fund/FMIS” (see below image).



Step 3. A new window will automatically appear. In the “Select a FMIS” drop-down list, select the appropriate FMIS number (see below image).



Step 4. The FMIS information will populate in the window. The first column in the table of the appendix (“Fund”) indicates the fund type. Reference Fund Type.

4.08 MAKING LANE CONFIGURATION CHANGES

4.08.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to make changes to lane configurations using an application within the Engineering Data Warehouse (EDW). MDOT-SHA construction projects can modify, extend, or create new lanes and roadways. These changes need to be reflected in the EDW. Lane modification changes (modified lane, new lane or extended lane) in the EDW are only allowed for completed projects. Proposed projects, As-Bid, or incomplete projects are prohibited from making lane modifications.

4.08.02 *Frequency*

Making changes to lane configurations within the EDW is a continuous process that occurs year-round.

4.08.03 *Purpose*

The purpose of this SOP is to obtain pertinent data relating to changes in lane configuration and then to modify or extend existing routes or create new routes in the EDW.

4.08.04 *Resource Requirements*

Making changes to lane configurations within the EDW involves two people: (1) a user knowledgeable in the EDW software to run the application, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	EDW user	1	4.0
DPT TL	Supervisor	1	AR[06/12/2019]

4.08.05 *Procedure*

The procedure to make changes to lane configurations within the EDW is comprised of the following four tasks:

(1) identifying lane configuration changes,
(2) viewing or modifying an existing route,
(3) creating a new route, and
(4) extending an existing route.

1- Identifying Lane Configuration Changes – *performed by EDW user*

Summary: This task obtains and verifies several key pieces of construction data in order to determine the extents and type of lane configuration change to be made. Plan sets are required for all lane configuration changes.

Step 1. Retrieve Project **Plan Set** from the source. Review pertinent pages that relate to construction history. Check that all the pertinent data is enclosed in the plan set (including paving typical sections, plan sheets, etc.). Using the plan set, determine where the lane modification should occur (Beginning Milepost, Ending Milepost, and Lane Width).

Step 2. Review the **Right-of-Way (ROW)** video collected by the Automated Road Analyzer (ARAN) vehicle (**Visidata.exe)**. Use the video to determine the project limits and where the lane configuration changes occurred.

Step 3. Identify the project limits using the **Highway Location Reference (HLR) Guide**. The HLR Guide is categorized by county and route. Verify the mile points (Refer to Highway Location Referencing Guide).

Step 4. Determine the appropriate type of lane configuration change.

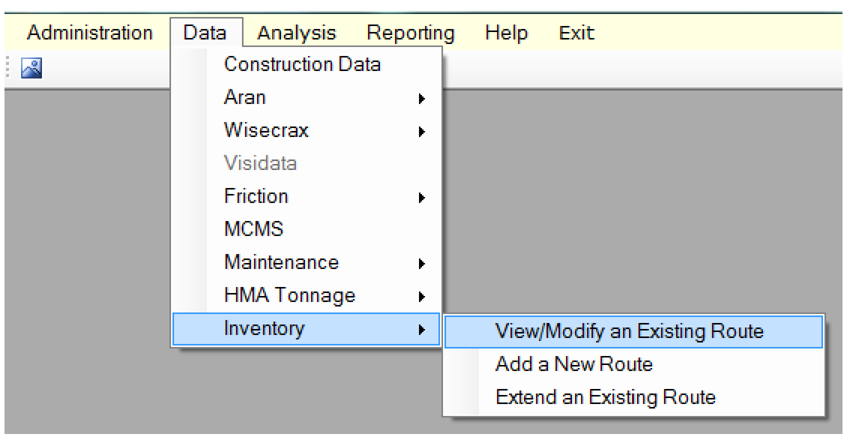
- i. If an existing route needs to be modified, proceed to Step 5.
- ii. If a new route needs to be created, proceed to Step 14.
- iii. If an existing route needs to be extended, proceed to Step 22.

2- Viewing or Modifying Existing Route – *performed by EDW user*

Summary: This task uses the EDW software to modify an existing route based on determined lane configuration changes. The “View/Modify Existing Route” feature within the EDW allows for modifications of the route, such as creation or removal of lanes, construction of turning lanes, etc. When modifying a lane within the EDW system, all of the history associated with that lane is modified as well. Check the accuracy of the changes that will be made to the route prior to completion.

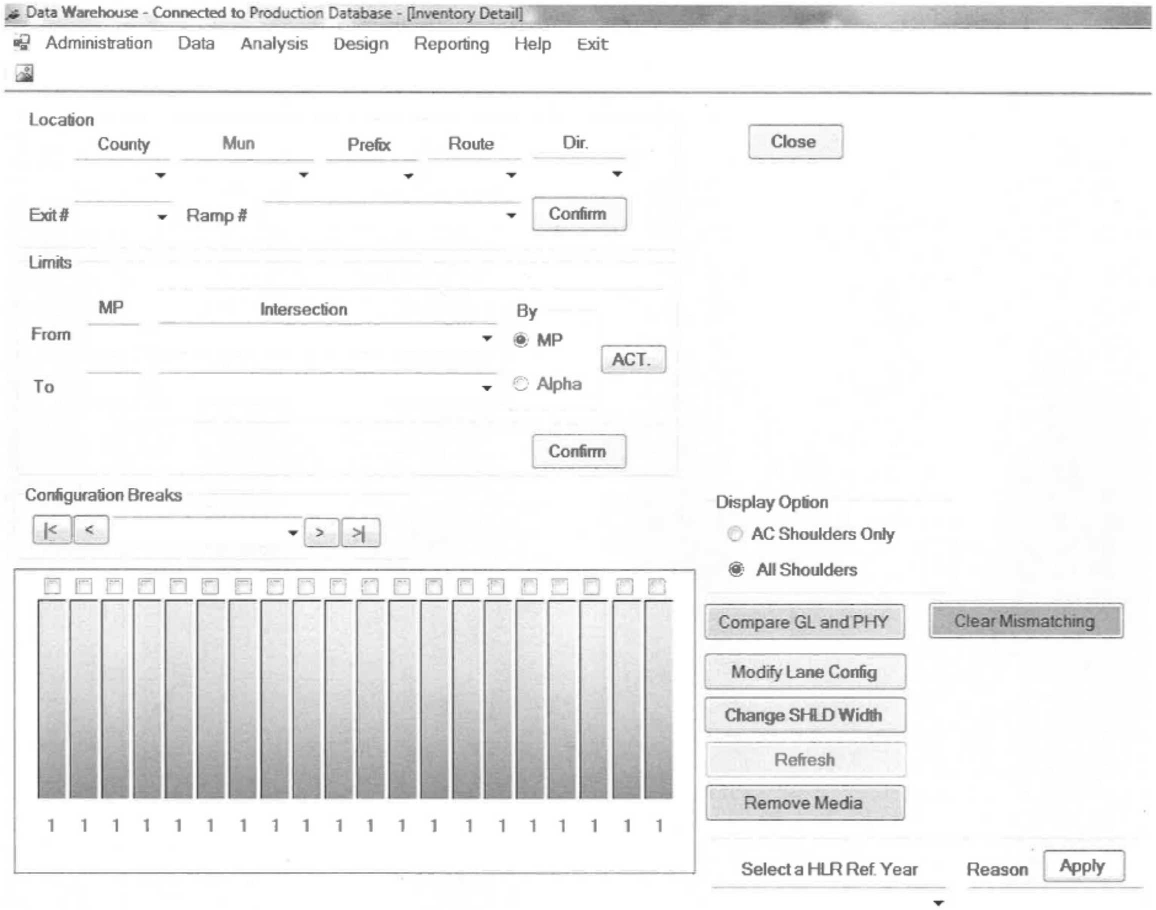
Step 5. Open the EDW application.

Step 6. Select the “Data” button from the main menu and click “Inventory” from the drop-down list, then “View/Modify an Existing Route” (see below image).

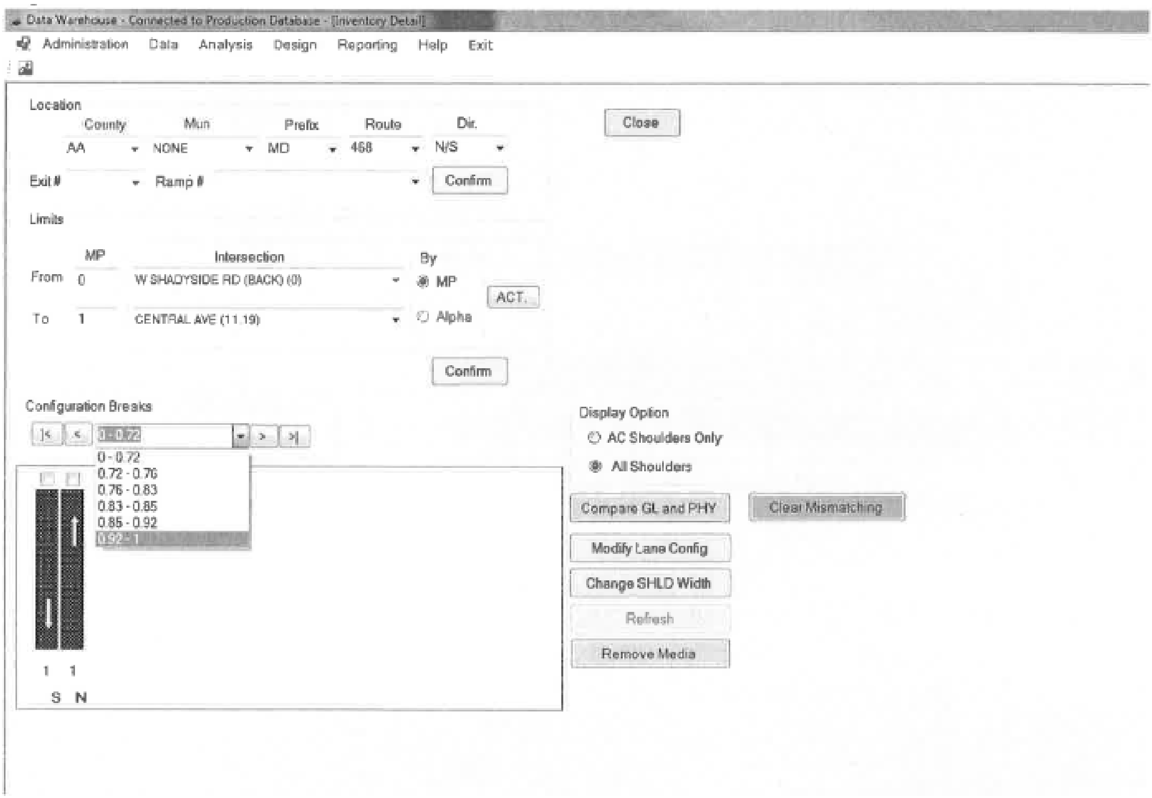


Step 7. A new window will automatically appear. Enter the required information for the route to be modified: **County, Municipal (if needed), Prefix, Route, and Direction**. Press “Confirm.” In the “Limits” section, enter the Beginning Milepost and the Ending Milepost for the area where the lane modification will

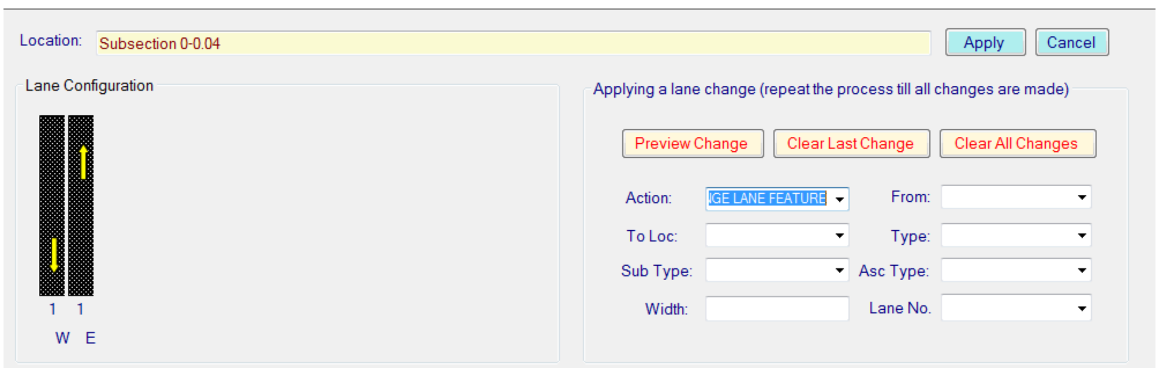
occur. Press “Confirm.” The existing lane configuration will be displayed at the bottom of the screen (see below image).



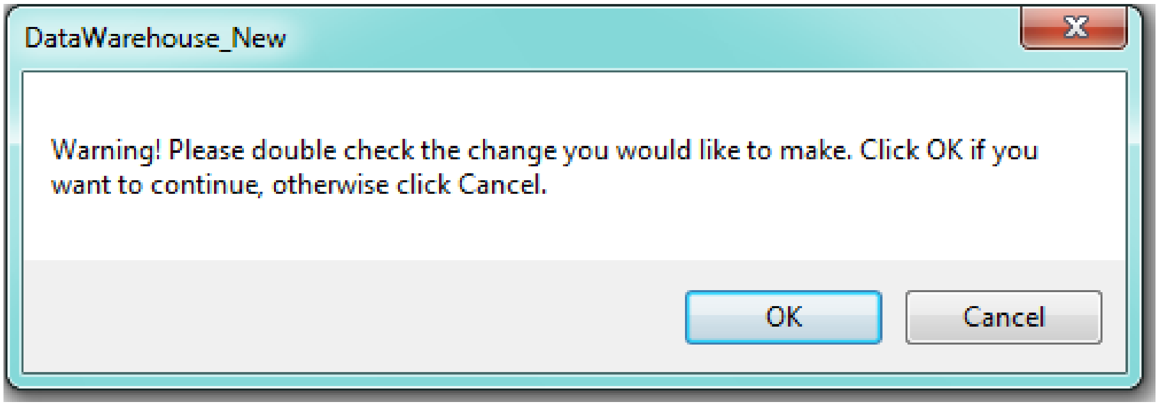
Step 8. In the EDW lane configuration system, roadways have “breaks” which are sections of the roadway. These breaks can occur where turn lanes begin or end, shoulders exist, acceleration or deceleration lanes begin or end, etc. These breaks are displayed in the drop-down menu in the “Configuration Breaks” section. Select the range where the lane configuration will be modified from the drop-down menu. Click the “Modify Lane Config” button (see below image).



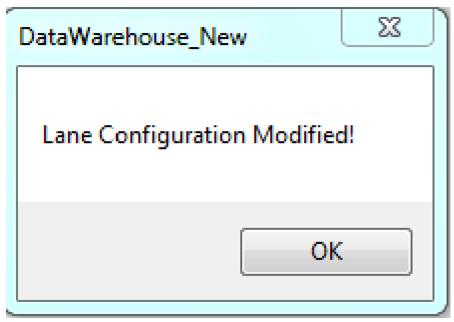
Step 9. A new window will automatically appear. In the "Action" drop-down menu, choose "Change Lane Feature." Enter required information for: **From, To Location, Type, Sub Type, Asc. Type, Width, and Lane No.** Click "Preview Change" (see below image).



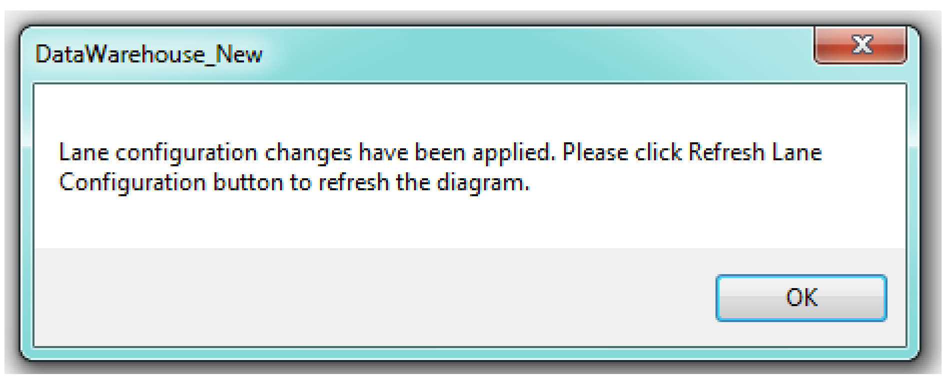
Step 10. A dialogue box will appear with a warning regarding the proposed changes. Double-check that the changes are correct and click "OK" (see below image).



Step 11. Click "Apply." A dialogue box will appear. Click "OK" (see below image).



Step 12. Another dialogue box will appear indicating that the lane configuration changes have been applied and to refresh the inventory diagram to display the lane configuration changes. Click "OK" (see below image).



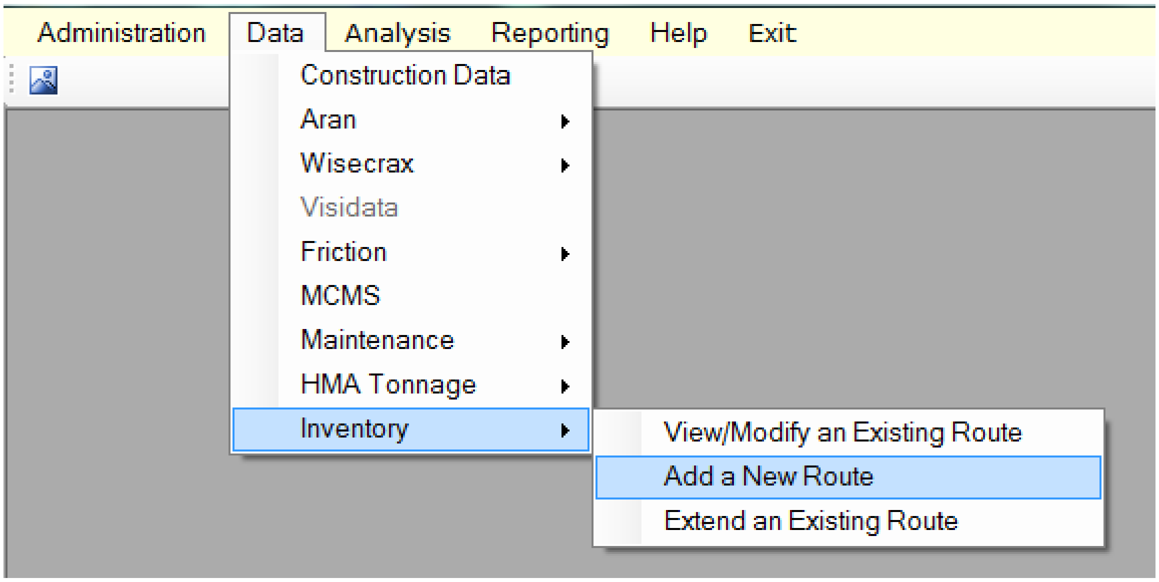
Step 13. Confirm the lane configuration changes were made successfully by running the Route History application as outlined in Viewing Paving & Maintenance History by Route.

3- Adding a New Route – *performed by EDW user*

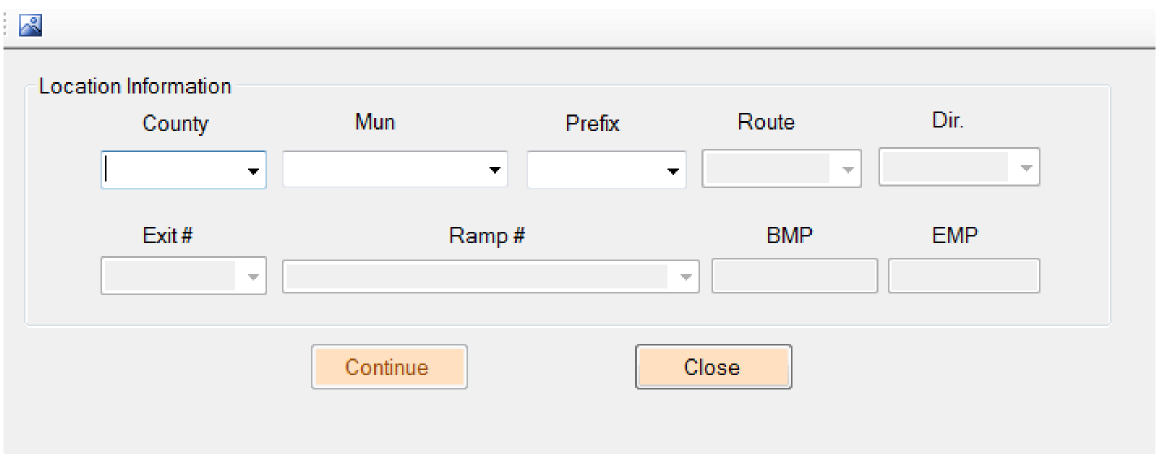
Summary: This task uses the EDW software to create a route that does not currently exist in the EDW. Currently, the "Add a New Route" function is in the draft phases. This feature has not been used in a practical application but only for testing purposes.

Step 14. Open the EDW application.

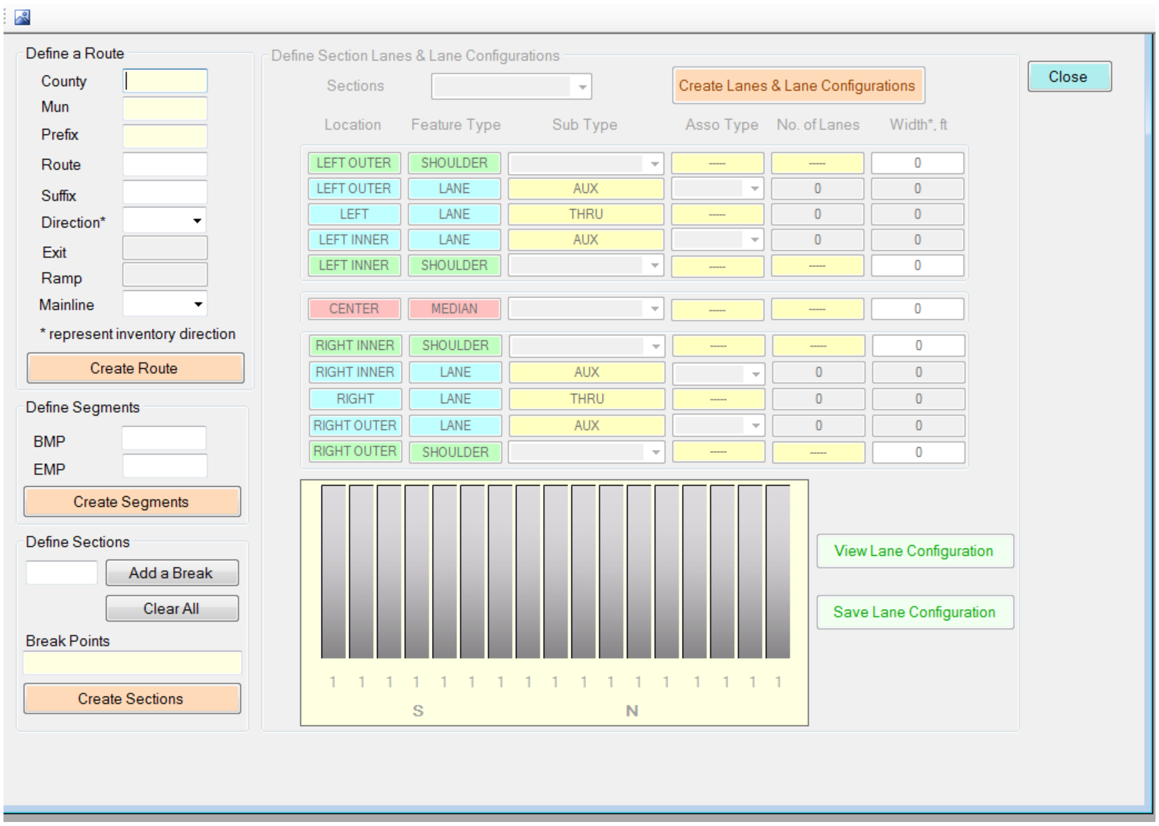
Step 15. Select the "Data" button from the main menu and click "Inventory" from the drop-down list, then "Add a New Route" (see below image).



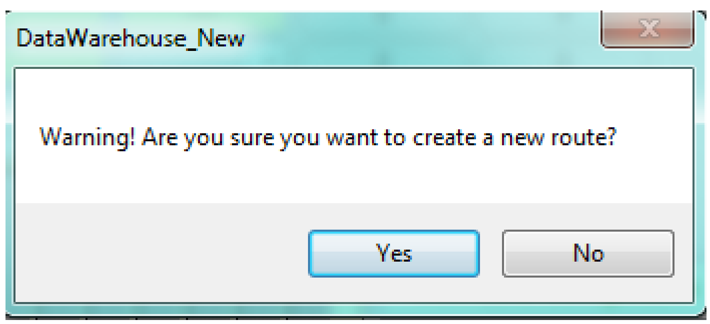
Step 16. A new window will automatically appear. Enter the required information for the route to be added: **County, Municipal (if needed), and Prefix**. Press "Continue" (see below image).



Step 17. A new window will automatically appear. Enter the required information for the route to be added: **County, Municipal (if needed), Prefix, Route, Suffix, and Mainline**. Click "Create Route" (see below image).



Step 18. A dialogue box will appear. Verify that all entered route information is correct and click "Yes" (see below image).



Step 19. Proceed to the "Define Segments" section of the screen. Enter the **Beginning Milepost and Ending Milepost** and click "Create Segments." In the "Define a Section" section, enter the break points to split the route into different subsections, each with a different lane configuration. Click "Create Sections."

Step 20. For each lane configuration break, define the lanes. Click the "View Lane Configuration" button to view the lanes graphically and click "Save Lane Configuration" to save the defined the lane configuration.

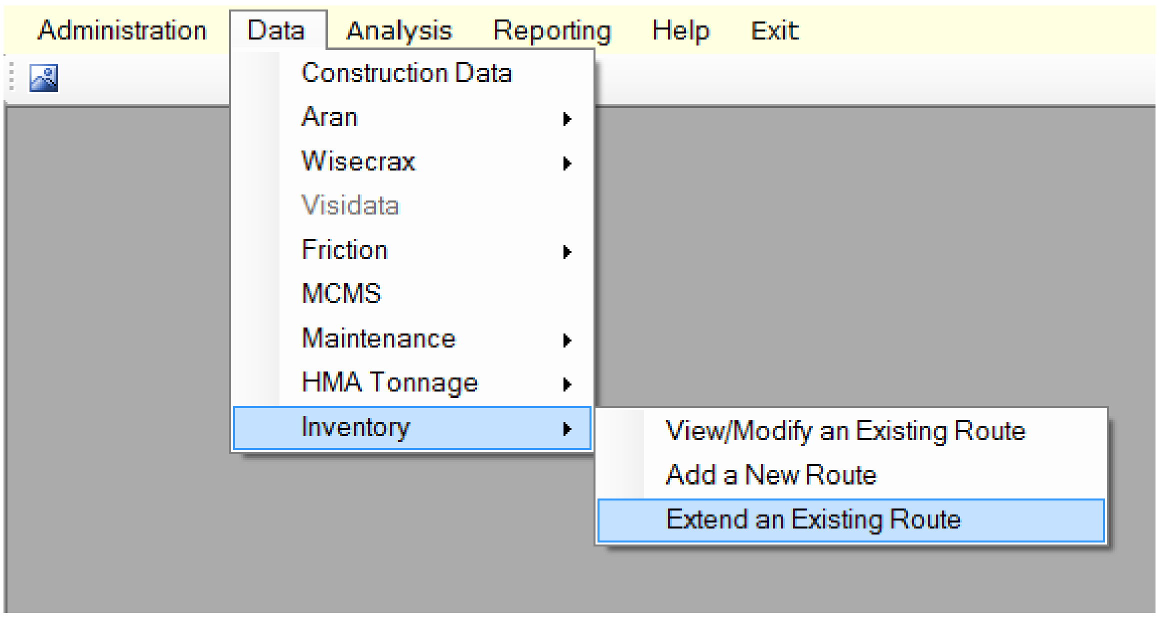
Step 21. Once all subsections have been defined (all items in the drop-down list have "defined" next to them), click the "Create Lanes and Lane Configuration" button to finish the entire process of creating a new route.

4- Extending a Route – *performed by EDW user*

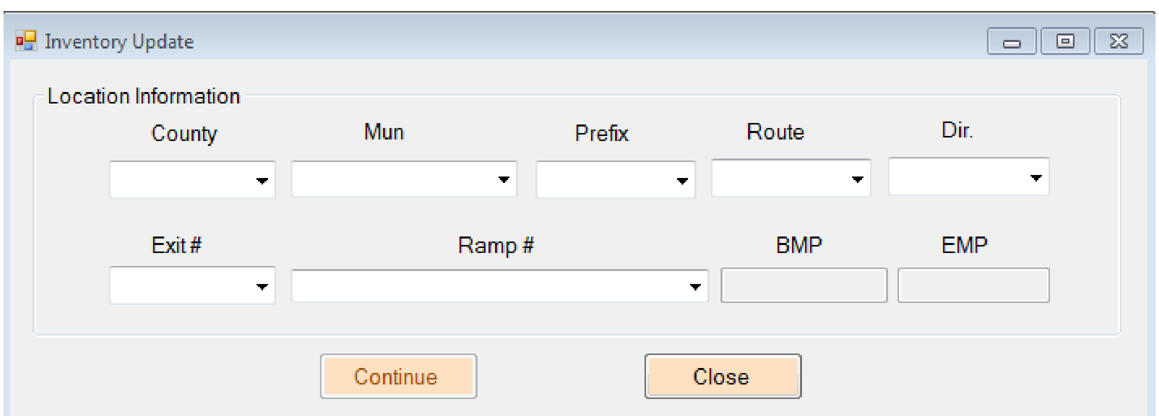
Summary: This task uses the EDW software to extend an existing route beyond the current inventory. Currently, the “Extend a Route” function is in the draft phases. This feature has not been used in a practical application but only for testing purposes.

Step 22. Open the EDW application.

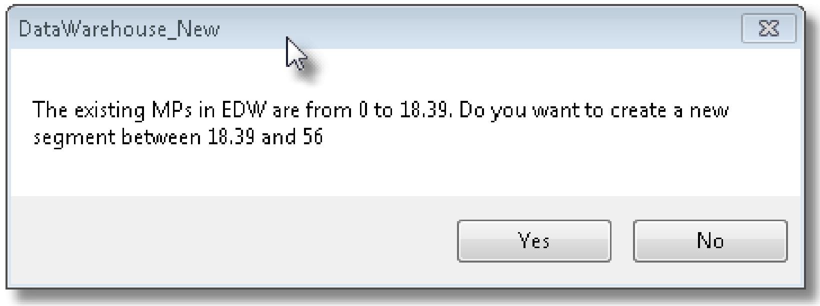
Step 23. Select the “Data” button from the main menu and click “Inventory” from the drop-down list, then “Extend an Existing Route” (see below image).



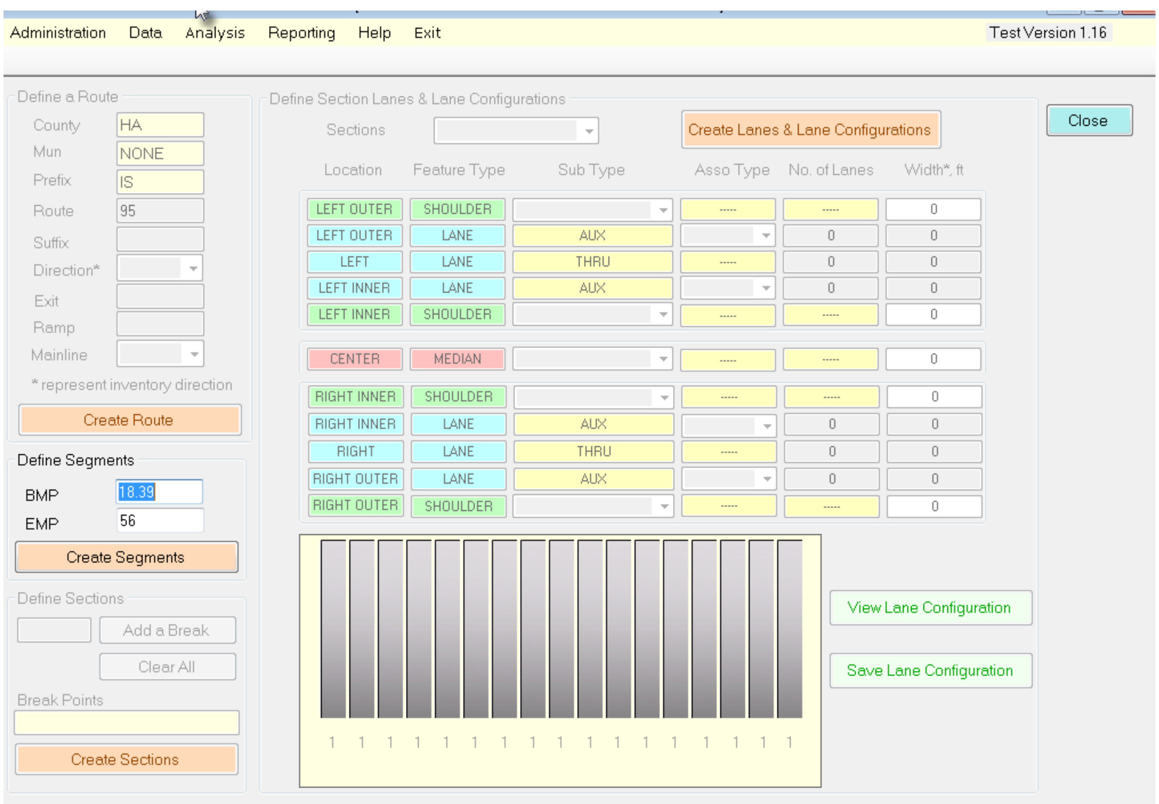
Step 24. A new window will automatically appear. Enter the required information for the route to be extended: **County, Municipal (if needed), Prefix, Route, Direction, Beginning Milepost of Extension, and Ending Milepost of Extension**. Press “Continue” (see below image).



Step 25. A dialogue box will appear confirming the beginning and ending mileposts for the extending portion of the existing route. Check that the mileposts are correct and click “Yes” (see below image).



Step 26. A new window will automatically appear. The "Define a Route" section will be grayed out because the extension is for an existing route. Enter the **Beginning Milepost and Ending Milepost** in the "Define Segments" section and click "Create Segments" (see below image).



Step 27. In the "Define a Section" section, enter the break points to split the route into different subsections, each with a different lane configuration. Click "Create Sections."

Step 28. For each lane configuration break, define the lanes. Click the "View Lane Configuration" button to view the lanes graphically and click "Save Lane Configuration" to save the defined the lane configuration.

Step 29. Once all subsections have been defined (all items in the drop-down list have "defined" next to them), click the "Create Lanes and Lane Configuration" button to finish the entire process of extending an existing route.

4.09 ADDING TO PROJECT ENGINEER LIST

4.09.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to add the name of a Project Engineer (PE) to the MDOT-SHA PE list within the Engineering Data Warehouse (EDW). The EDW tracks the Project Engineer for construction projects. In the event of a discrepancy in provided information or a question on the project the, PE is listed. During the data entry process, the name of the PE may not appear in the drop-down menu on the "Location" tab and requires an addition to the PE list. The list is an internal feature in the EDW system that can be modified to add additional names to the drop-down menu.

4.09.02 *Frequency*

Adding the name of a PE to the MDOT-SHA PE list within the EDW is a continuous process that occurs year-round.

4.09.03 *Purpose*

The purpose of this SOP is to add the name of a PE to the MDOT-SHA PE list.

4.09.04 *Resource Requirements*

Adding the name of a PE to the MDOT-SHA PE list within the EDW involves two people: (1) a user knowledgeable in the EDW software to run the application, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	EDW user	1	0.5
DPT TL	Supervisor	1	AR[06/12/2019]

4.09.05 *Procedure*

The procedure to add the name of a PE to the MDOT-SHA PE list within the EDW is comprised of a single task:

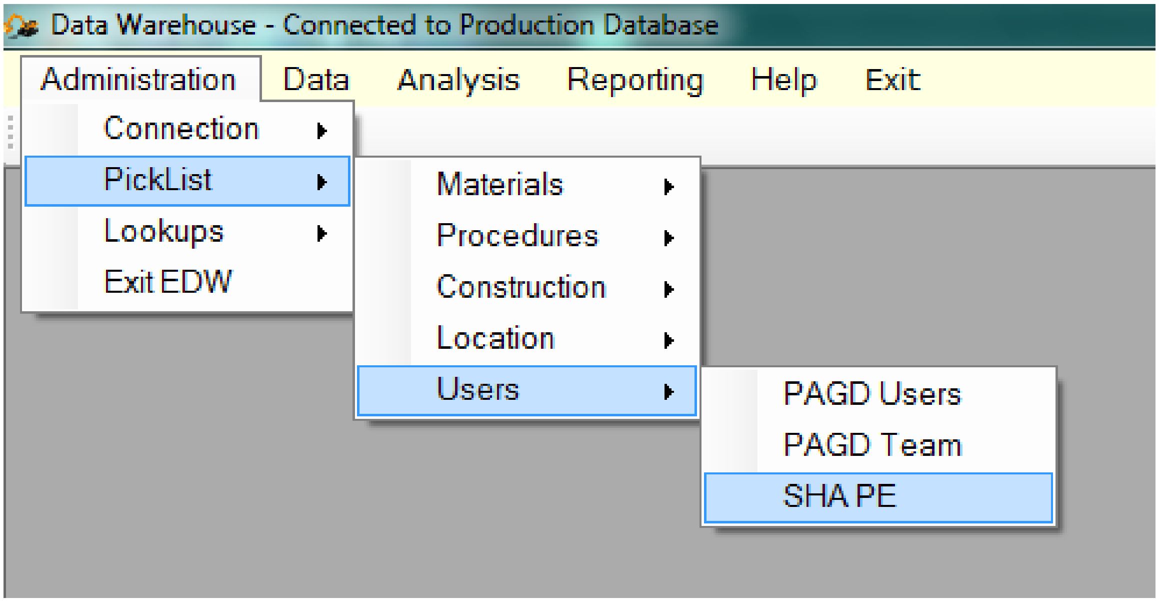
(1) adding PE name to the MDOT-SHA PE list in the EDW.

1- Adding PE name to the MDOT-SHA PE list in the EDW – *performed by EDW user*

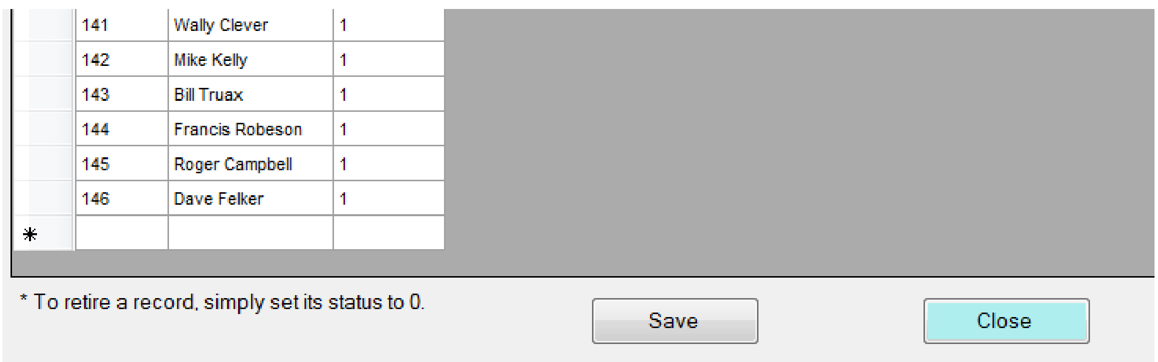
Summary: This task adds the name of a PE to the MDOT-SHA PE list within the EDW so that it will appear in the drop-down menu of the "Location" tab.

Step 1. Open the EDW application.

Step 2. Select the "Administration" button from the main menu and click "PickList" from the drop-down list, then "Users", then "SHA PE" (see below image).



Step 3. A new window will automatically appear. Scroll to the bottom of the list in the window and in the blank spot add the **next number in sequential order, P.E. First & Last Name,** and a **1**. The 1 indicates that the PE is still active while a 0 indicates that the PE has retired (see below image).



Step 4. Click "Save." Close any open tabs and close the EDW. Reopen the EDW application and confirm that the entered name appears in the drop-down menu on the "Location" tab.

4.10 VIEWING PAVING & MAINTENANCE HISTORY BY ROUTE

4.10.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to view paving and maintenance history by route within the Engineering Data Warehouse (EDW). The EDW application imported thousands of records from the old Access Database and new records are being created on a daily basis. Most projects fit together like puzzle pieces along the roadway; where project "A" stops, project "B" begins. The EDW has a feature that enables you to see all the construction history for a segment of roadway.

4.10.02 *Frequency*

Viewing paving and maintenance history by route within the EDW is a continuous process that occurs year-round.

4.10.03 *Purpose*

The purpose of this SOP is to view paving and maintenance history by route within the EDW. It should be utilized when lane configuration changes are made to a route in the EDW as outlined in Making Lane Configuration Changes.

4.10.04 *Resource Requirements*

Viewing paving and maintenance history by route within the EDW involves two people: (1) a user knowledgeable in the EDW software to run the application, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	EDW user	1	0.5
DPT TL	Supervisor	1	AR[06/12/2019]

4.10.05 *Procedure*

The procedure to view paving and maintenance history by route within the EDW is comprised of a single task:

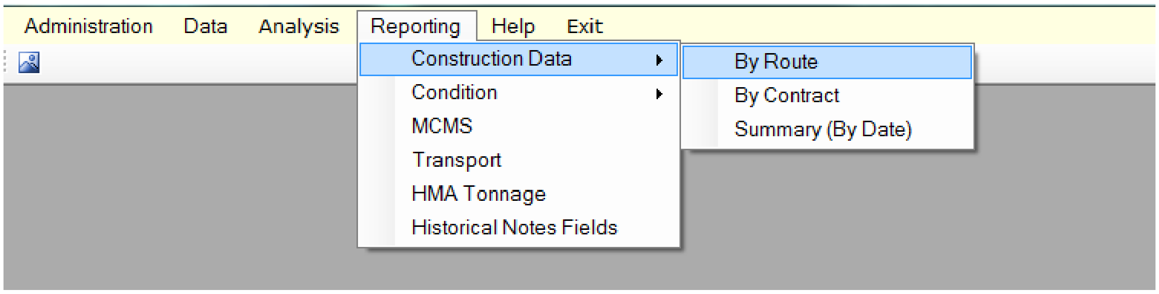
(1) viewing construction data by route in the EDW.

1- Viewing Construction Data by Route in the EDW – *performed by EDW user*

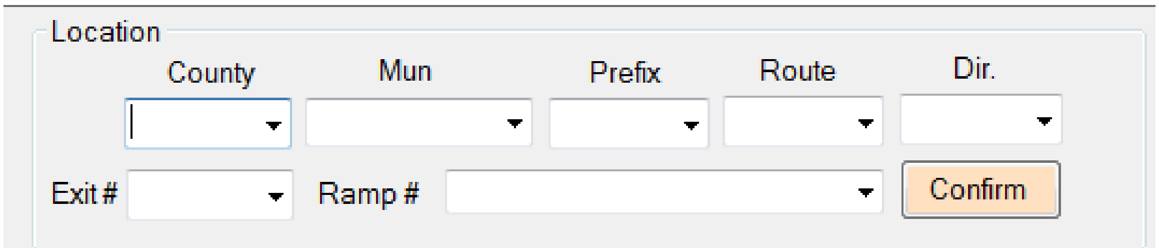
Summary: This task generates a report that displays all construction history (paving and maintenance) for a specified route.

Step 1. Open the EDW application.

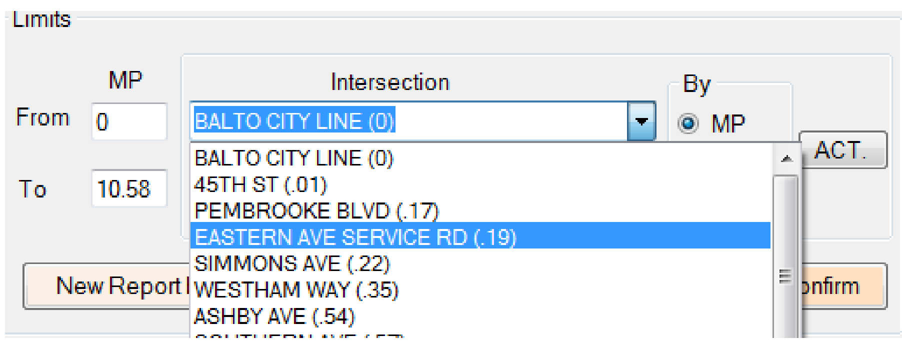
Step 2. Select the "Reporting" button from the main menu and click "Construction Data" from the drop-down list, then "By Route" (see below image).



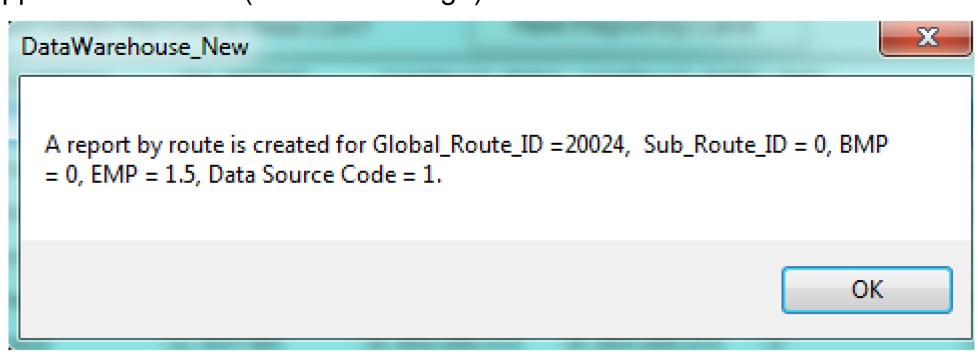
Step 3. A new window will automatically appear. Enter the required location information: **County, Municipal, Prefix, Route, and Direction**. Click "Confirm" (see below image).



Step 4. Choose the **Beginning Milepost and Ending Milepost** for the section for which the construction history is needed. This information can be manually entered, or the closest reference point can be selected from the drop-down menu. Click "Confirm" (see below image).



Step 5. A lane configuration diagram will appear on the left-hand side of the screen. Select the "Source" drop-down menu and choose "Paving Only" (or "Paving & Maintenance" if desired). Click "New Report by Route" and a dialogue box will appear. Click "OK" (see below image).



Step 6. Click “Larger View” to display the entire report. Click “Add Format” to make the window easier to read (see below image).

LAYER	LAYER_GROUP	THICK	MAT_CODE	DESCRIPTION	MIX_METHOD	CONTRACT_REPOI	CONTRACT_ENTRY	FMIS
Baltimore	MD 150	W	THRU LANE 1	BMP 0	EMP .45			
1034387	65774	38466	504250	12.5mm, 76-22, ...	A- HOT MIX	BA2225183	BA2225183	0
1034387	65774	38466	110	Carbide Grinding	0- N/A	BA2225183	BA2225183	0
1034387	65786	38467	10	Band SN	A- HOT MIX	M403	M403	0
1034387	26108	38468	1	Surface	A- HOT MIX	MAINTENANCE	99-5759	0
1034387	58016	38469	1	Surface	A- HOT MIX	B -655-000-415	B -655-000-415	0
1034387	10040	38470	1	Surface	A- HOT MIX	B -333-001-466	B -333-001-466	0
1034387	10040	38470	28	Base	A- HOT MIX	B -333-001-466	B -333-001-466	0
1034387	10040	38470	48	Penetration Mac...	0- N/A	B -333-001-466	B -333-001-466	0
1034387	10040	38470	47	Macadam - Stone	0- N/A	B -333-001-466	B -333-001-466	0
1034387	10040	38470	49	Screenings (scr...	0- N/A	B -333-001-466	B -333-001-466	0
Baltimore	**MD 150**	**W**	**THRU LANE 1**	**BMP .45**	**EMP .85**			
1034387	50135	38636	504250	12.5mm, 76-22, ...	A- HOT MIX	BA2225183	BA2225183	0
1034387	50135	38636	110	Carbide Grinding	0- N/A	BA2225183	BA2225183	0

Add Format

Close

4.11 PROMOTING AS BID TO CONSTRUCTION HISTORY

4.11.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to promote As Bid projects to Construction History within the Engineering Data Warehouse (EDW). Unit Cost – As Bid information is processed prior to construction; several pieces of data used for Unit Cost – As Bid are also needed in Construction History. The EDW application has a feature to easily promote these items.

4.11.02 *Frequency*

Promoting As Bid projects to Construction History within the EDW is a continuous process that occurs year-round.

4.11.03 *Purpose*

The purpose of this SOP is to promote As Bid projects to Construction History within the EDW.

4.11.04 *Resource Requirements*

Promoting As Bid projects to Construction History within the EDW involves two people: (1) a user knowledgeable in the EDW software to run the application, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	EDW user	1	0.5
DPT TL	Supervisor	1	AR[06/12/2019]

4.11.05 *Procedure*

The procedure to promote As Bid projects to Construction History within the EDW is comprised of a single task:

(1) promoting As Bid project to construction history in the EDW.

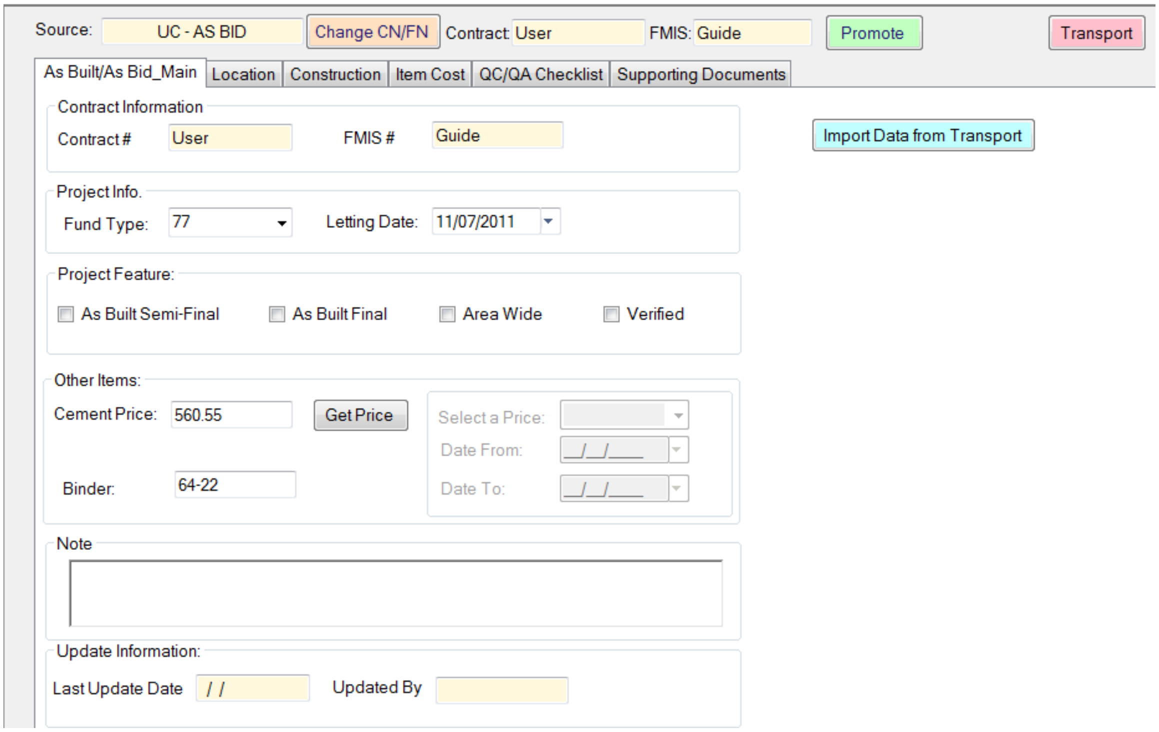
1- Promoting As Bid Project to Construction History in the EDW – *performed by EDW user*

Summary: This task promotes As Bid contracts to Construction History in the EDW.

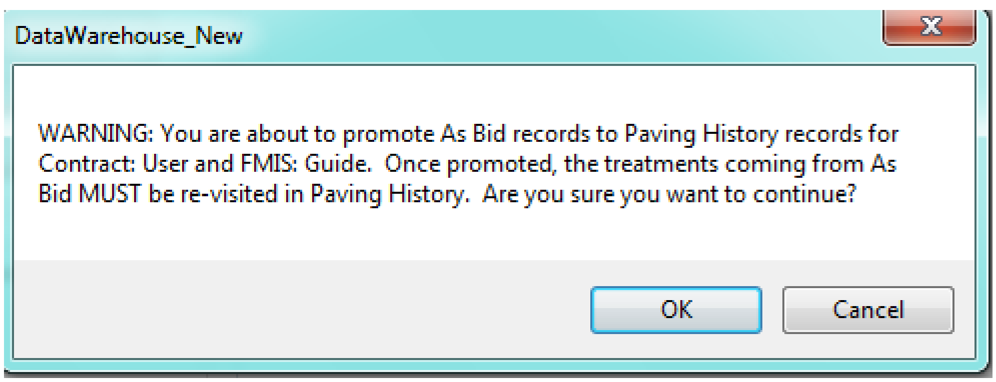
Step 1. Open the EDW application.

Step 2. Find the specific contract under "Unit Cost – As Bid."

Step 3. Open the contract and click on the "As Bid_Main" tab (see below image).



Step 4. Click the green “Promote” button at the top of the screen. A dialogue box will appear with a warning about the promotion to construction history. Click “OK” (see below image).



Step 5. Another dialogue box will appear that reads “Promotion Done!” Click “OK.”

Step 6. Close the As-Bid screen and proceed to the specific contract in Paving History.

4.12 GENERATING AS BUILT REPORT

4.12.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to generate an As Built report within the Engineering Data Warehouse (EDW). The Maryland Construction Management System (MCMS) internal application has several different reports that it can generate. For Unit Cost – As Built, a report by month in which paving was completed is essential to the data processing of Unit Cost – As Built information. This feature is helpful with the three-month rule used by the Pavement Management (PM) team with Unit Cost – As Built.

4.12.02 *Frequency*

Generating an As Built report within the EDW is a continuous process that occurs year-round.

4.12.03 *Purpose*

The purpose of this SOP is to generate an As Built report within the EDW.

4.12.04 *Resource Requirements*

Generating an As Built report within the EDW involves two people: (1) a user knowledgeable in the EDW software to run the application, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	EDW user	1	0.5
DPT TL	Supervisor	1	AR[06/12/2019]

4.12.05 *Procedure*

The procedure to generate an As Built report within the EDW is comprised of a single task:

(1) generating As Built report in the EDW

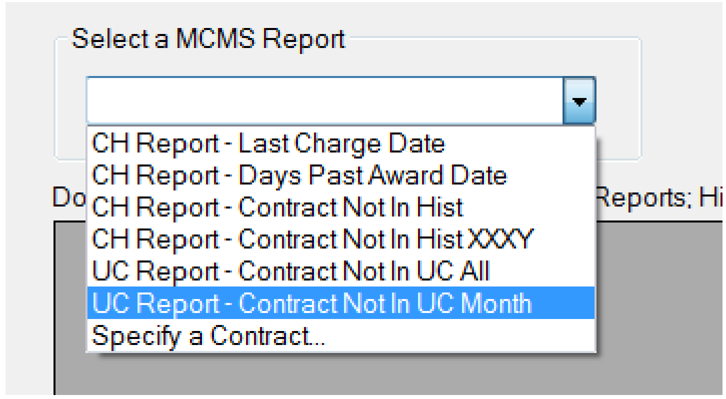
1- Generating As Built Report in the EDW – *performed by EDW user*

Summary: This task generates a report for As Built contracts in the EDW. The output of this task is an Excel spreadsheet with the desired As Built data.

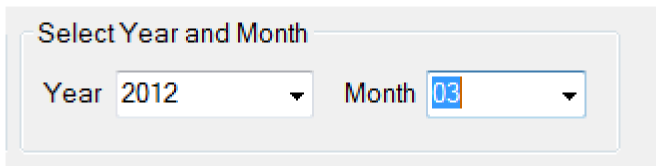
Step 1. Open the EDW application.

Step 2. Select the "Reporting" button from the main menu and click "MCMS" from the drop-down list.

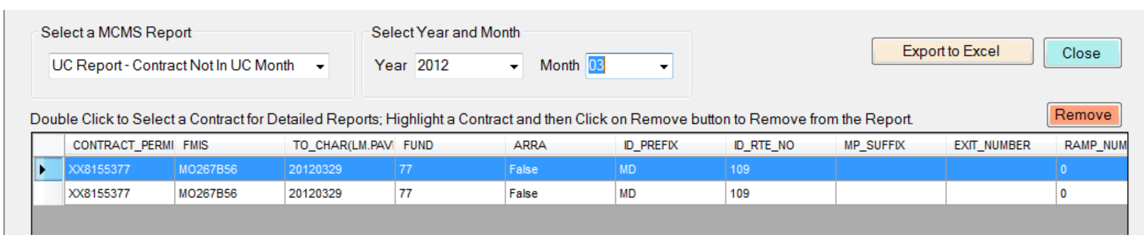
Step 3. In the "Select a MCMS Report" box, select "UC Report – Contract Not in UC Month" (see below image).



Step 4. In the "Select Year and Month" box, indicate the **Year** and **Month** desired (see below image).



Step 5. The contracts that are not currently in the Unit Cost database for that month will automatically appear. Review the contracts and remove any that are not good candidates for Unit Cost by highlighting the contract row and clicking "Remove" (see below image).



Step 6. When only the desired contracts remain in the window, click "Export to Excel." Name the document in the save prompt window, chose the proper save location, and click "Save."

4.13 HMA TONNAGE APPLICATION

4.13.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to validate asphalt tonnage values in construction records. This procedure uses the HMA_Tonnage dataset provided by the Office of Materials Technology's (OMT) Asphalt Technology Division and the submitted As-Built PM-003 forms to compare asphalt properties and tonnage values for all construction records entered into the Engineering Data Warehouse (EDW). The HMA_Tonnage dataset includes two tables that are reviewed by the DPT: "Actual" and "Estimated." The "Actual" table is used for the data validation, while the "Estimated" table provides supporting data (such as routing number). Important comparisons taken from this procedure include the mix design and tonnage values.

4.13.02 *Frequency*

The validation of asphalt tonnage values occurs quarterly as a minimum but can also occur as-requested.

4.13.03 *Purpose*

The purpose of this SOP is to validate asphalt tonnage values in construction records by comparing the dataset provided by the OMT Asphalt Technology Division with the As-Built PM-003 forms.

4.13.04 *Resource Requirements*

The validation of asphalt tonnage values involves one person: (1) a user, typically the DPT Team Leader (TL), knowledgeable in Microsoft Access and Excel, to validate the construction records and perform quality control (QC) checks. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT TL	Access user and QC	1	1.0

4.13.05 *Procedure*

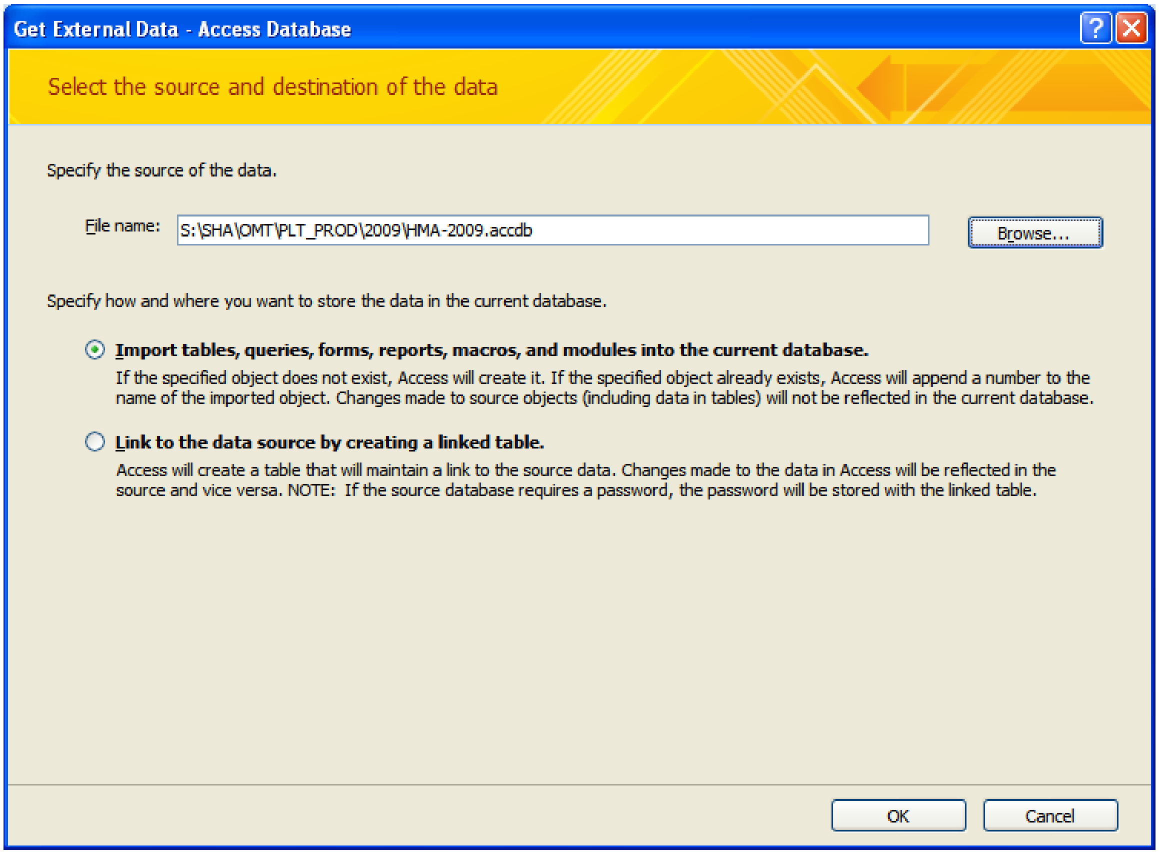
The procedure to validate asphalt tonnage values in construction records is comprised of two components:

(1) validating asphalt tonnage in Microsoft Access, and
(2) performing QC of validated tables.

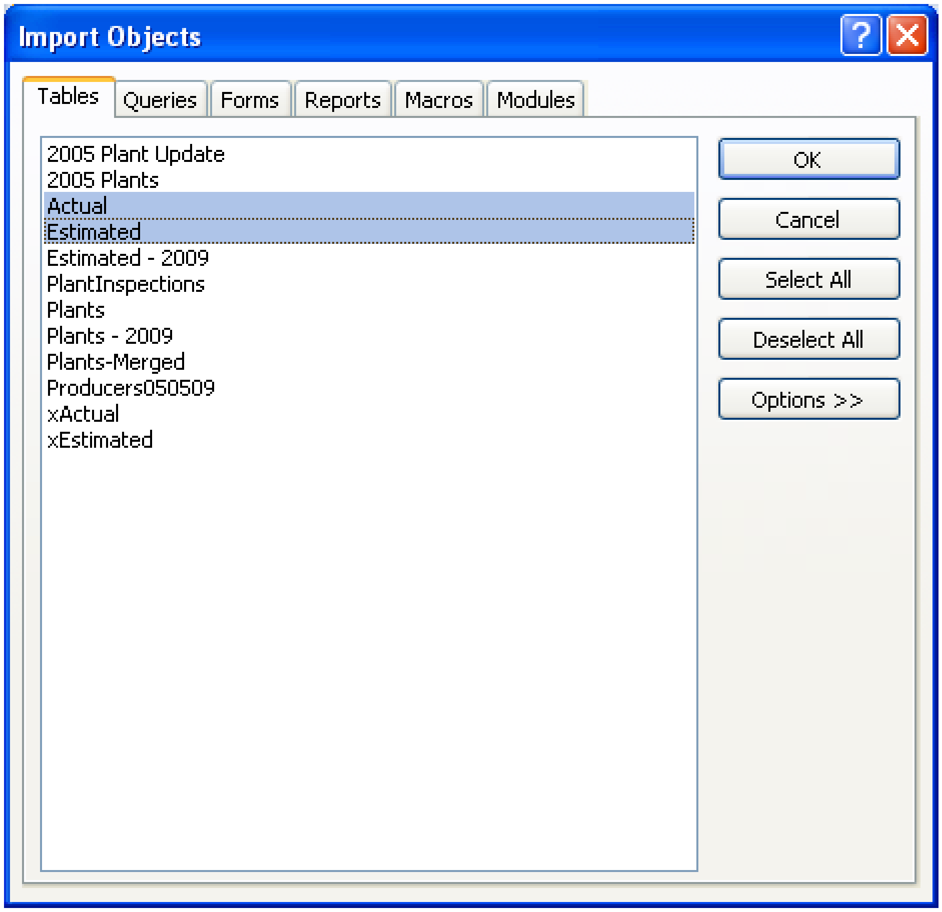
1- Validating Asphalt Tonnage in Microsoft Access – *performed by DPT TL*

Summary: This task validates asphalt tonnage values in construction records by comparing the dataset provided by the OMT Asphalt Technology Division with the As-Built PM-003 forms.

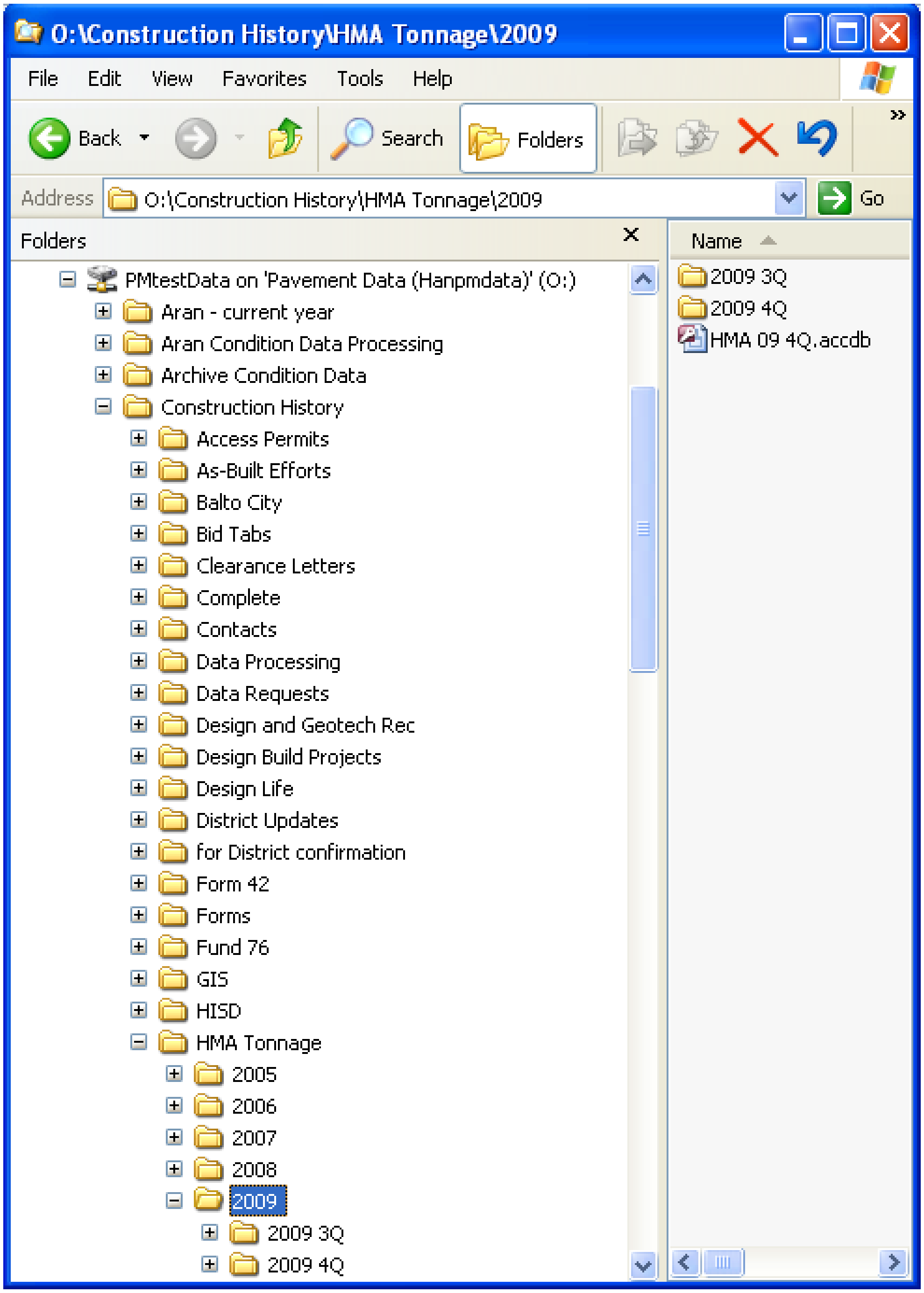
Step 1. Open Microsoft Access and select “Get External Data.” Browse and select the file at the following path: S:\SHA\OMT\PLT_PROD\2009\HMA-2009.accdb. Make sure “Import tables…” is selected and click “OK” (see below image)[06/12/2019].



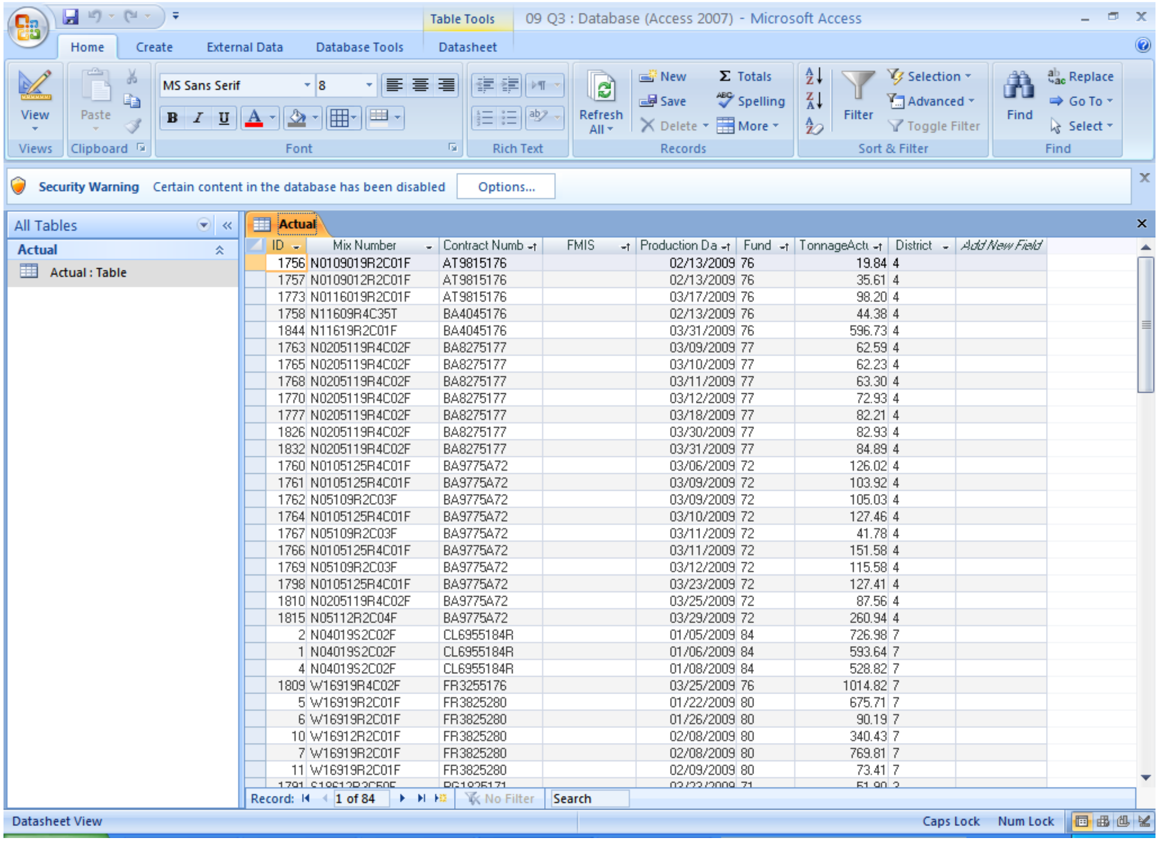
Step 2. Select the “Tables” tab and highlight “Actual” and “Estimated”, then click “OK” (see below image).



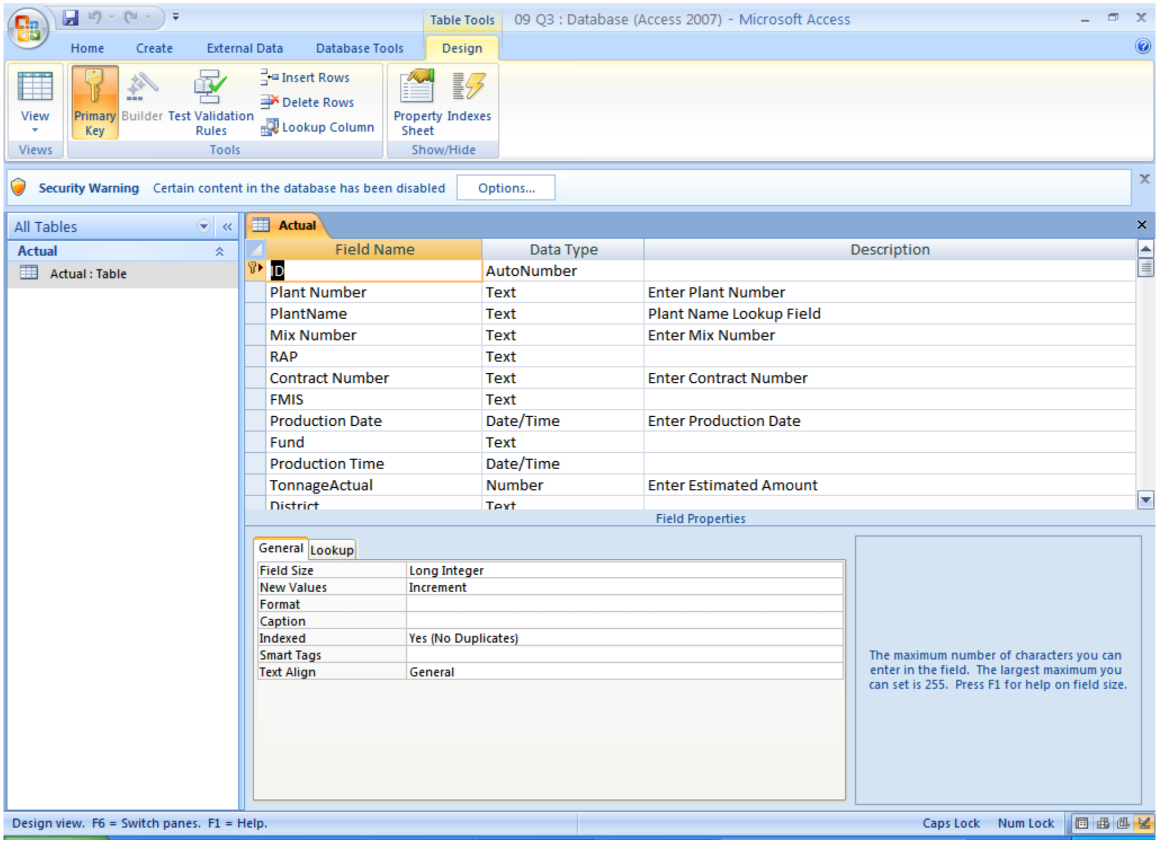
Step 3. Select the working directory: PMtestData\Construction History\HMA Tonnage\2009\2009 4Q (year & quarter).



Step 4. Add new fields in “Actual” table for “FMIS”, “Fund”, and “District” (see below image).

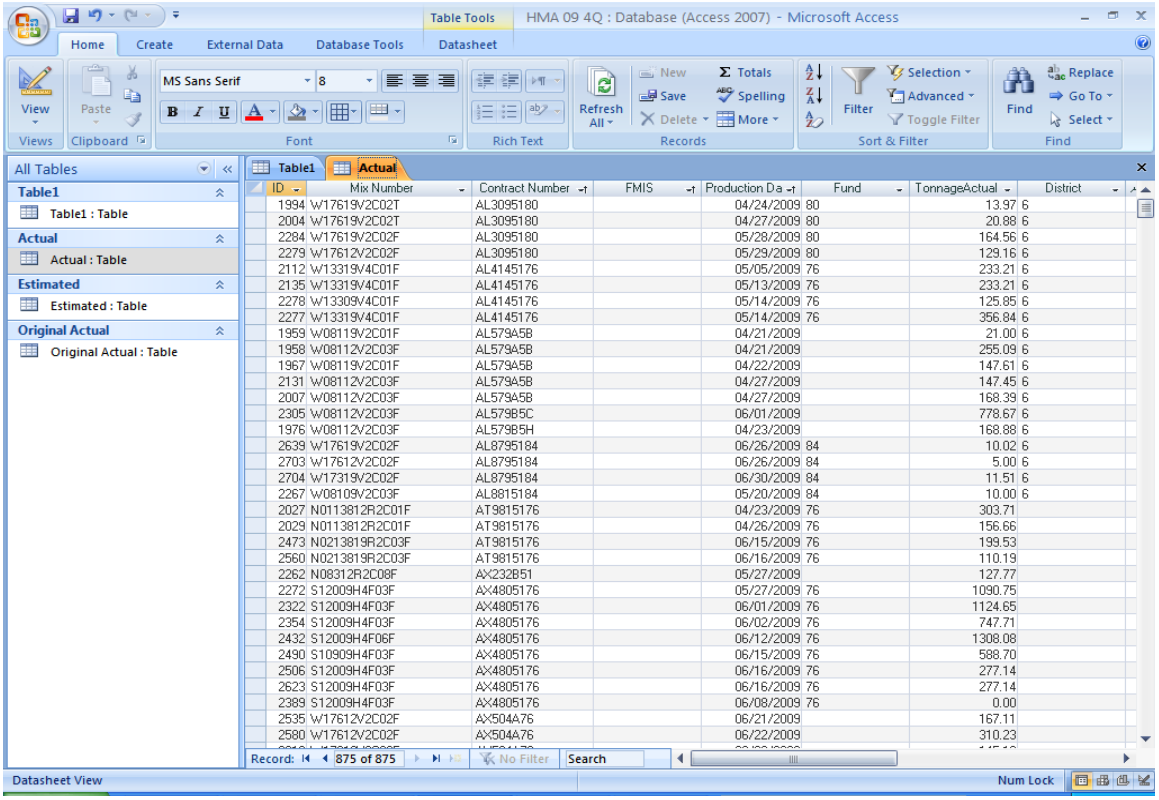


Step 5. Select Data Type for new fields by clicking on the “Design” tab along the top ribbon and changing the “Data Type” column to the appropriate type for each new field (see below image).

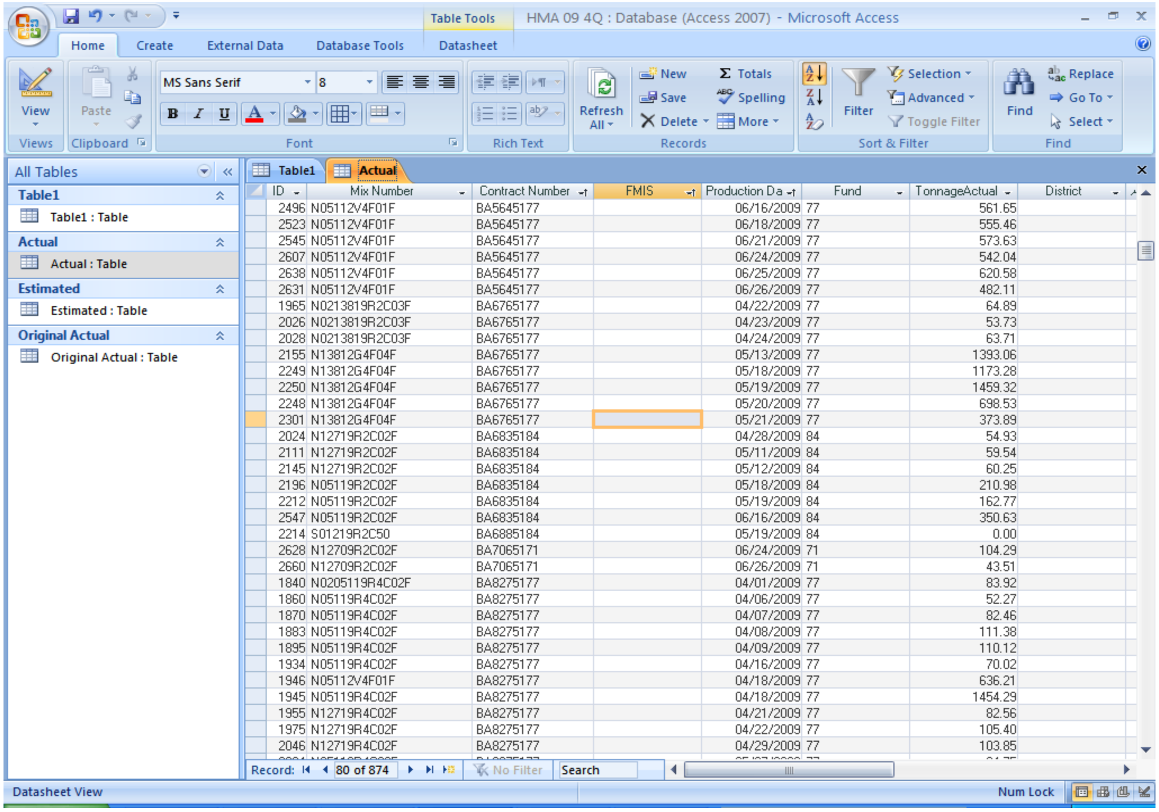


Step 6. Return to Access table and hide all fields except: Mix Number, Contract Number, FMIS, Production Date, Fund, Tonnage/Actual, District (see below image).

Step 7. Sort table by Contract and Production Date (see below image).

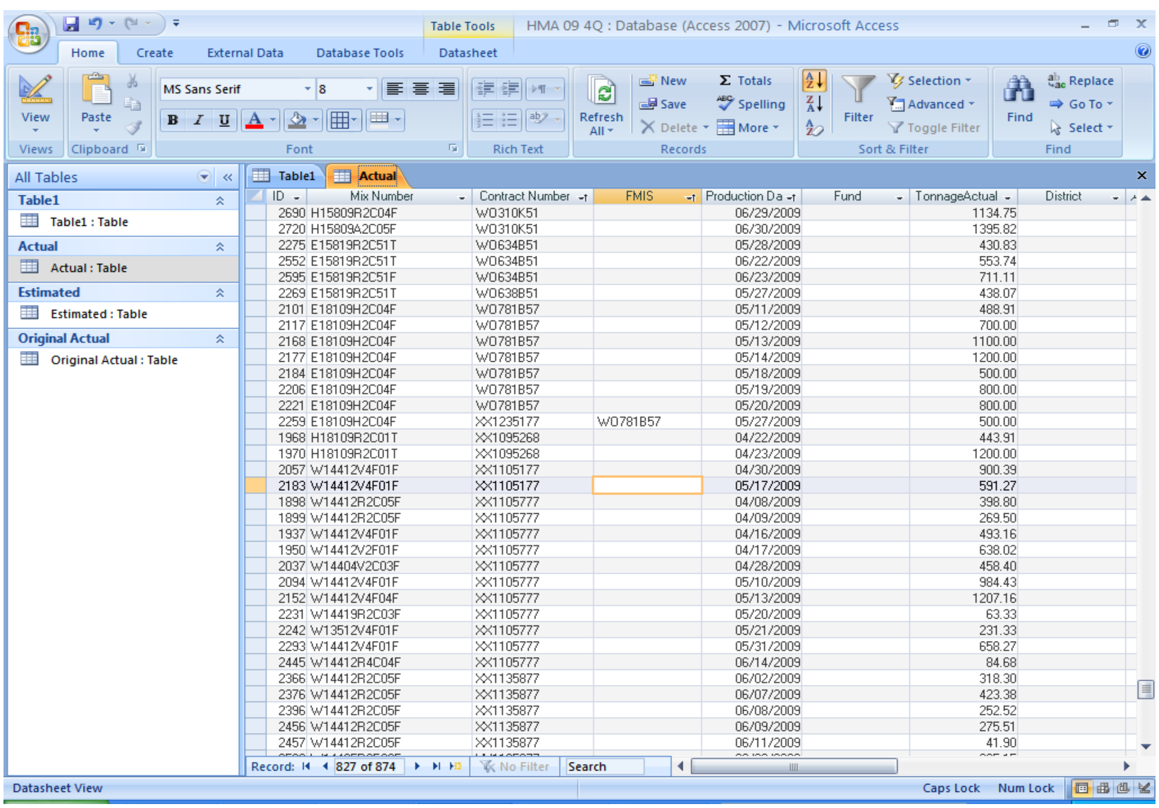


Step 8. Populate Fund Type (currently manual – see below image). In the future, could be automated with OOF supplied FMIS Data # spreadsheet.



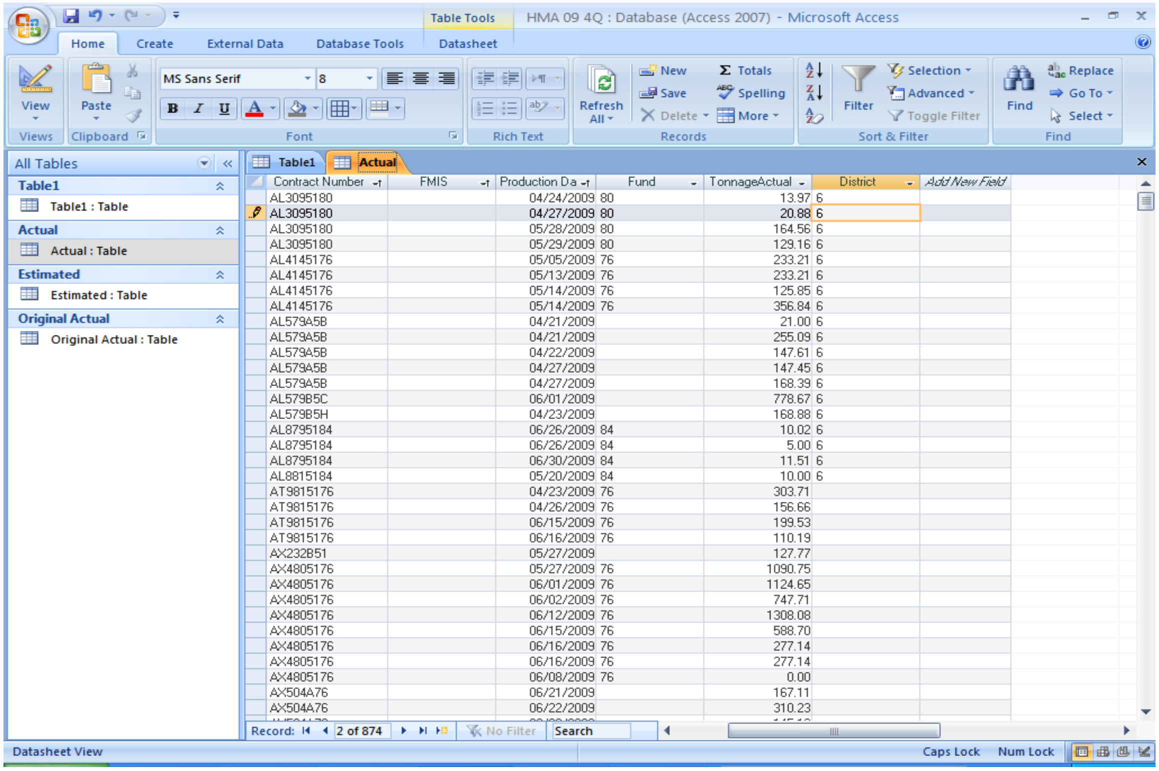
ID	Mix Number	Contract Number	FMIS	Production Da	Fund	TonnageActual	District
2496	N05112V4F01F	BA5645177		06/16/2009	77	561.65	
2523	N05112V4F01F	BA5645177		06/18/2009	77	555.46	
2545	N05112V4F01F	BA5645177		06/21/2009	77	573.63	
2607	N05112V4F01F	BA5645177		06/24/2009	77	542.04	
2638	N05112V4F01F	BA5645177		06/25/2009	77	620.58	
2631	N05112V4F01F	BA5645177		06/26/2009	77	482.11	
1965	N0213819R2C03F	BA6765177		04/22/2009	77	64.89	
2026	N0213819R2C03F	BA6765177		04/23/2009	77	53.73	
2028	N0213819R2C03F	BA6765177		04/24/2009	77	63.71	
2155	N13812G4F04F	BA6765177		05/13/2009	77	1393.06	
2249	N13812G4F04F	BA6765177		05/18/2009	77	1173.28	
2250	N13812G4F04F	BA6765177		05/19/2009	77	1459.32	
2248	N13812G4F04F	BA6765177		05/20/2009	77	698.53	
2301	N13812G4F04F	BA6765177		05/21/2009	77	373.89	
2024	N12719R2C02F	BA6835184		04/28/2009	84	54.93	
2111	N12719R2C02F	BA6835184		05/11/2009	84	59.54	
2145	N12719R2C02F	BA6835184		05/12/2009	84	60.25	
2196	N05119R2C02F	BA6835184		05/18/2009	84	210.98	
2212	N05119R2C02F	BA6835184		05/19/2009	84	162.77	
2547	N05119R2C02F	BA6835184		06/16/2009	84	350.63	
2214	S01219R2C50	BA6885184		05/19/2009	84	0.00	
2628	N12709R2C02F	BA7065171		06/24/2009	71	104.29	
2660	N12709R2C02F	BA7065171		06/26/2009	71	43.51	
1840	N0205119R4C02F	BA8275177		04/01/2009	77	83.92	
1860	N05119R4C02F	BA8275177		04/06/2009	77	52.27	
1870	N05119R4C02F	BA8275177		04/07/2009	77	82.46	
1883	N05119R4C02F	BA8275177		04/08/2009	77	111.38	
1895	N05119R4C02F	BA8275177		04/09/2009	77	110.12	
1934	N05119R4C02F	BA8275177		04/16/2009	77	70.02	
1946	N05112V4F01F	BA8275177		04/18/2009	77	636.21	
1945	N05119R4C02F	BA8275177		04/18/2009	77	1454.29	
1955	N12719R4C02F	BA8275177		04/21/2009	77	82.56	
1975	N12719R4C02F	BA8275177		04/22/2009	77	105.40	
2046	N12719R4C02F	BA8275177		04/29/2009	77	103.85	

Step 9. Clean up Contract and FMIS fields (see below image).



ID	Mix Number	Contract Number	FMIS	Production Da	Fund	TonnageActual	District
2690	H15809R2C04F	W0310K51		06/29/2009		1134.75	
2720	H15809A2C05F	W0310K51		06/30/2009		1395.82	
2275	E15819R2C51T	W0634B51		05/28/2009		430.83	
2552	E15819R2C51T	W0634B51		06/22/2009		553.74	
2595	E15819R2C51F	W0634B51		06/23/2009		711.11	
2269	E15819R2C51T	W0638B51		05/27/2009		438.07	
2101	E18109H2C04F	W0781B57		05/11/2009		488.91	
2117	E18109H2C04F	W0781B57		05/12/2009		700.00	
2168	E18109H2C04F	W0781B57		05/13/2009		1100.00	
2177	E18109H2C04F	W0781B57		05/14/2009		1200.00	
2184	E18109H2C04F	W0781B57		05/18/2009		500.00	
2206	E18109H2C04F	W0781B57		05/19/2009		800.00	
2221	E18109H2C04F	W0781B57		05/20/2009		800.00	
2259	E18109H2C04F	XX1235177	W0781B57	05/27/2009		500.00	
1968	H18109R2C01T	XX1095268		04/22/2009		443.91	
1970	H18109R2C01T	XX1095268		04/23/2009		1200.00	
2057	W14412V4F01F	XX1105177		04/30/2009		900.39	
2183	W14412V4F01F	XX1105177		05/17/2009		591.27	
1898	W14412R2C05F	XX1105777		04/08/2009		398.80	
1899	W14412R2C05F	XX1105777		04/09/2009		269.50	
1937	W14412V4F01F	XX1105777		04/16/2009		493.16	
1950	W14412V2F01F	XX1105777		04/17/2009		638.02	
2037	W14404V2C03F	XX1105777		04/28/2009		458.40	
2094	W14412V4F01F	XX1105777		05/10/2009		984.43	
2152	W14412V4F04F	XX1105777		05/13/2009		1207.16	
2231	W14419R2C03F	XX1105777		05/20/2009		63.33	
2242	W13512V4F01F	XX1105777		05/21/2009		231.33	
2293	W14412V4F01F	XX1105777		05/31/2009		658.27	
2445	W14412R4C04F	XX1105777		06/14/2009		84.68	
2366	W14412R2C05F	XX1135877		06/02/2009		318.30	
2376	W14412R2C05F	XX1135877		06/07/2009		423.38	
2396	W14412R2C05F	XX1135877		06/08/2009		252.52	
2456	W14412R2C05F	XX1135877		06/09/2009		275.51	
2457	W14412R2C05F	XX1135877		06/11/2009		41.90	

Step 10. Populate District field (currently manual – see below image). In the future, could be automated with OOF supplied FMIS Data # spreadsheet.

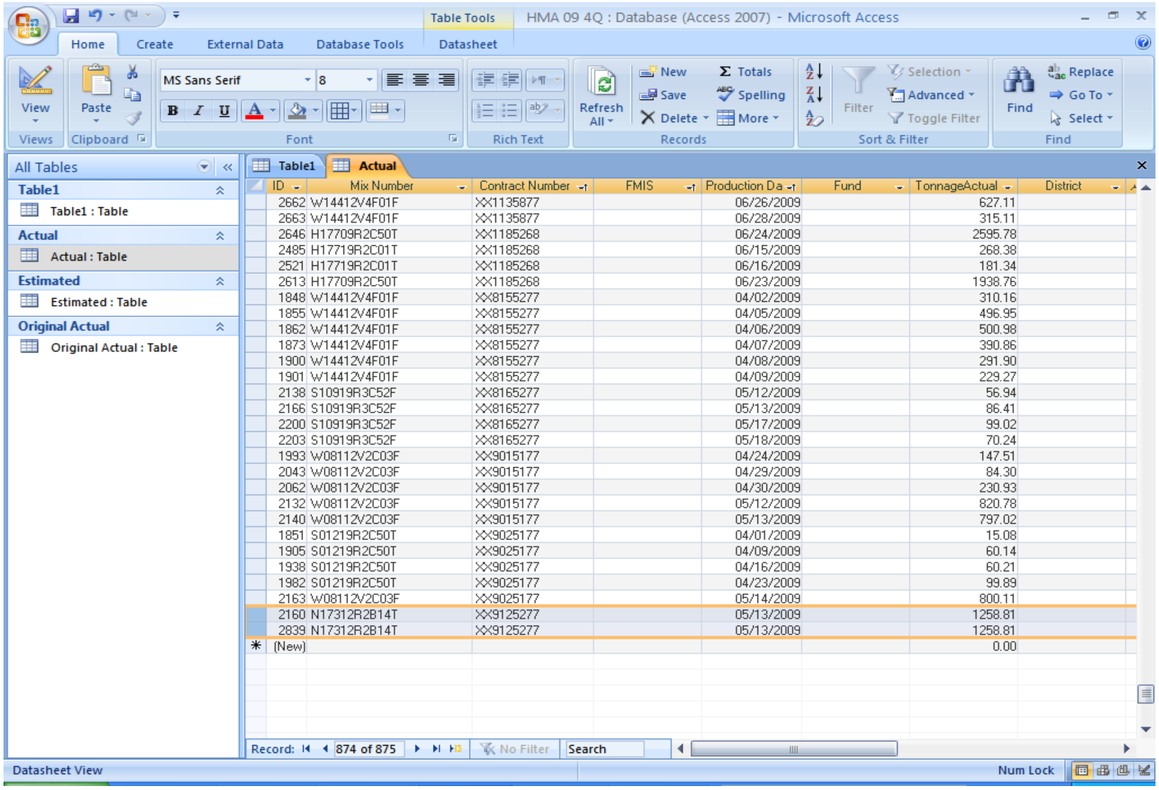


Contract Number	FMIS	Production Da	Fund	TonnageActual	District	Add New Field
AL3095180		04/24/2009	80	13.97	6	
AL3095180		04/27/2009	80	20.88	6	
AL3095180		05/28/2009	80	164.56	6	
AL3095180		05/29/2009	80	129.16	6	
AL4145176		05/05/2009	76	233.21	6	
AL4145176		05/13/2009	76	233.21	6	
AL4145176		05/14/2009	76	125.85	6	
AL4145176		05/14/2009	76	356.84	6	
AL579A5B		04/21/2009		21.00	6	
AL579A5B		04/21/2009		255.09	6	
AL579A5B		04/22/2009		147.61	6	
AL579A5B		04/27/2009		147.45	6	
AL579A5B		04/27/2009		168.39	6	
AL579B5C		06/01/2009		778.67	6	
AL579B5H		04/23/2009		168.88	6	
AL8795184		06/26/2009	84	10.02	6	
AL8795184		06/26/2009	84	5.00	6	
AL8795184		06/30/2009	84	11.51	6	
AL8815184		05/20/2009	84	10.00	6	
AT9815176		04/23/2009	76	303.71		
AT9815176		04/26/2009	76	156.66		
AT9815176		06/15/2009	76	199.53		
AT9815176		06/16/2009	76	110.19		
AX232B51		05/27/2009		127.77		
AX4805176		05/27/2009	76	1090.75		
AX4805176		06/01/2009	76	1124.65		
AX4805176		06/02/2009	76	747.71		
AX4805176		06/12/2009	76	1308.08		
AX4805176		06/15/2009	76	588.70		
AX4805176		06/16/2009	76	277.14		
AX4805176		06/16/2009	76	277.14		
AX4805176		06/08/2009	76	0.00		
AX504A76		06/21/2009		167.11		
AX504A76		06/22/2009		310.23		

2- Performing QC of Validated Tables – *performed by DPT TL*

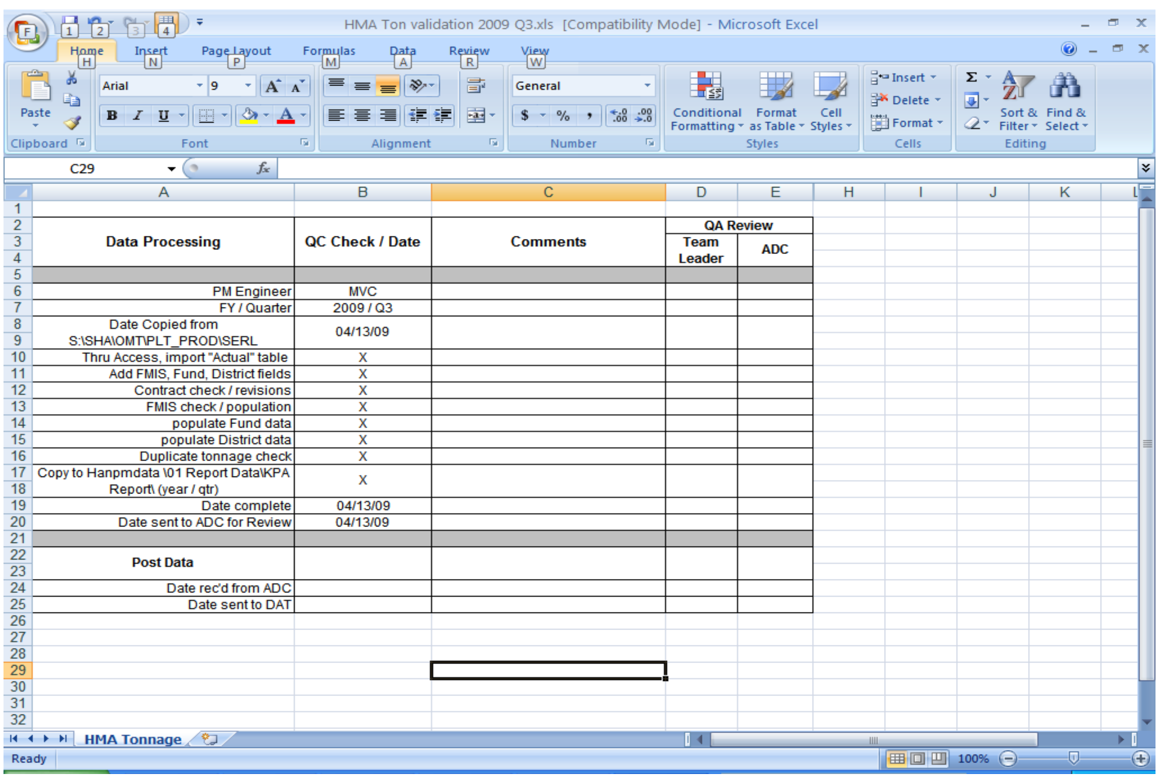
Summary: This task performs QC checks on the validated tonnage tables.

Step 11. Locate, analyze, and eliminate duplicates (look at Contract, FMIS, and Tonnage/Actual fields – see below image).



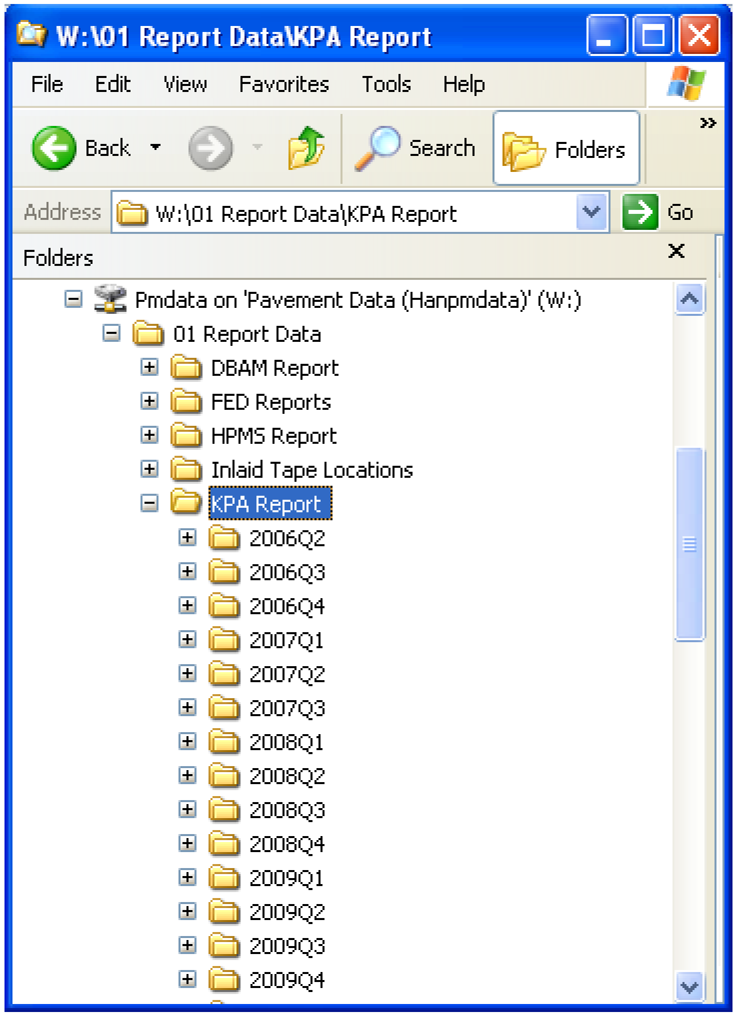
ID	Mix Number	Contract Number	FMIS	Production Da	Fund	TonnageActual	District
2662	W14412V4F01F	XX1135877		06/26/2009		627.11	
2663	W14412V4F01F	XX1135877		06/28/2009		315.11	
2646	H17709R2C50T	XX1185268		06/24/2009		2595.78	
2485	H17719R2C01T	XX1185268		06/15/2009		268.38	
2521	H17719R2C01T	XX1185268		06/16/2009		181.34	
2613	H17709R2C50T	XX1185268		06/23/2009		1938.76	
1848	W14412V4F01F	XX8155277		04/02/2009		310.16	
1855	W14412V4F01F	XX8155277		04/05/2009		496.95	
1862	W14412V4F01F	XX8155277		04/06/2009		500.98	
1873	W14412V4F01F	XX8155277		04/07/2009		390.86	
1900	W14412V4F01F	XX8155277		04/08/2009		291.90	
1901	W14412V4F01F	XX8155277		04/09/2009		229.27	
2138	S10919R3C52F	XX8165277		05/12/2009		56.94	
2166	S10919R3C52F	XX8165277		05/13/2009		86.41	
2200	S10919R3C52F	XX8165277		05/17/2009		99.02	
2203	S10919R3C52F	XX8165277		05/18/2009		70.24	
1993	W08112V2C03F	XX9015177		04/24/2009		147.51	
2043	W08112V2C03F	XX9015177		04/29/2009		84.30	
2062	W08112V2C03F	XX9015177		04/30/2009		230.93	
2132	W08112V2C03F	XX9015177		05/12/2009		820.78	
2140	W08112V2C03F	XX9015177		05/13/2009		797.02	
1851	S01219R2C50T	XX9025177		04/01/2009		15.08	
1905	S01219R2C50T	XX9025177		04/09/2009		60.14	
1938	S01219R2C50T	XX9025177		04/16/2009		60.21	
1982	S01219R2C50T	XX9025177		04/23/2009		99.89	
2163	W08112V2C03F	XX9025177		05/14/2009		800.11	
2160	N17312R2B14T	XX9125277		05/13/2009		1258.81	
2839	N17312R2B14T	XX9125277		05/13/2009		1258.81	
(New)						0.00	

Step 12. Complete Validation spreadsheet (see below image).

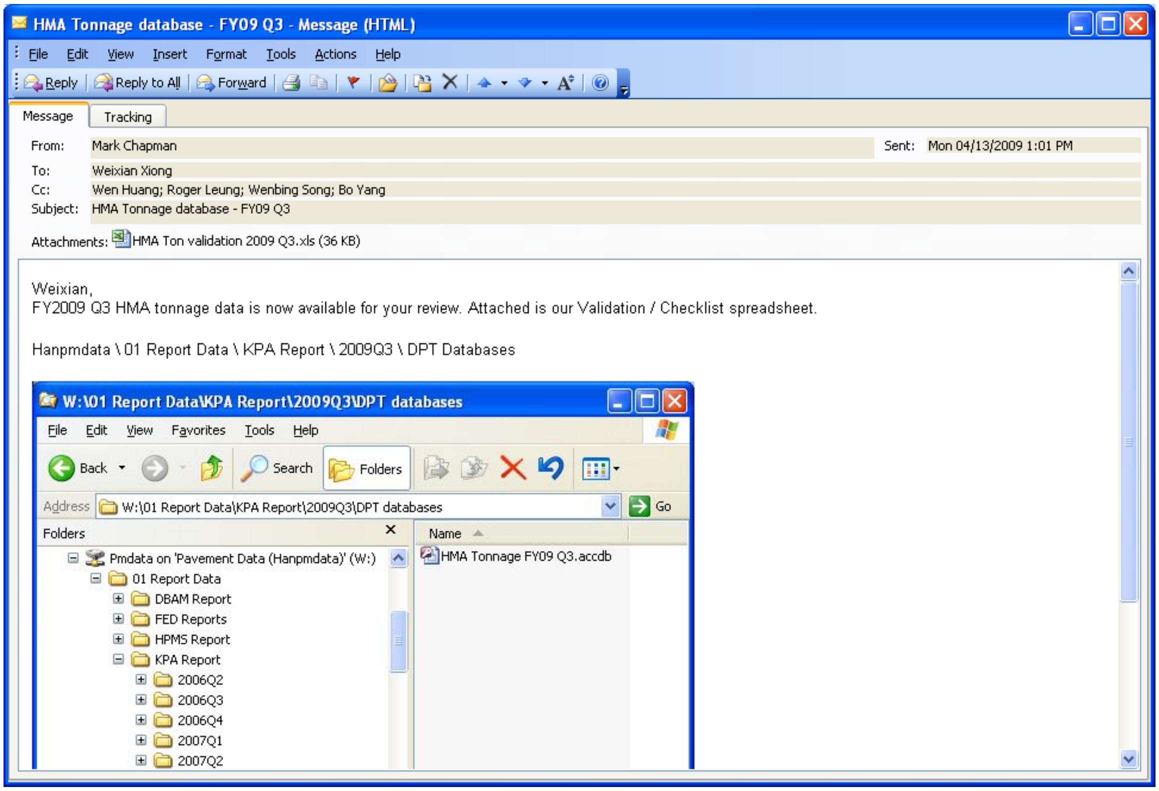


Data Processing	QC Check / Date	Comments	QA Review: Team Leader	QA Review: ADC
PM Engineer	MVC			
FY / Quarter	2009 / Q3			
Date Copied from S:\SHA\OMT\PLT_PROD\SERL	04/13/09			
Thru Access, import "Actual" table	X			
Add FMIS, Fund, District fields	X			
Contract check / revisions	X			
FMIS check / population	X			
populate Fund data	X			
populate District data	X			
Duplicate tonnage check	X			
Copy to Hanpmdata \01 Report Data\KPA Report\ (year / qtr)	X			
Date complete	04/13/09			
Date sent to ADC for Review	04/13/09			
Post Data				
Date rec'd from ADC				
Date sent to DAT				

Step 13. Post completed files to the following location: Pmdata\01 Report Data\KPA Report (see below image).



Step 14. Notify Assistant Division Chief (ADC) and Data Analysis Team (DAT) via email with Validation spreadsheet attached (see below image).



2- Performing QC of Validated Tables – *performed by DPT TL*

Summary: This task preforms QC checks on the HMA tonnage validated tables.

Step 15. Check the final HMA tonnage validated tables for accuracy and completeness.

5 DATA PROCESSING

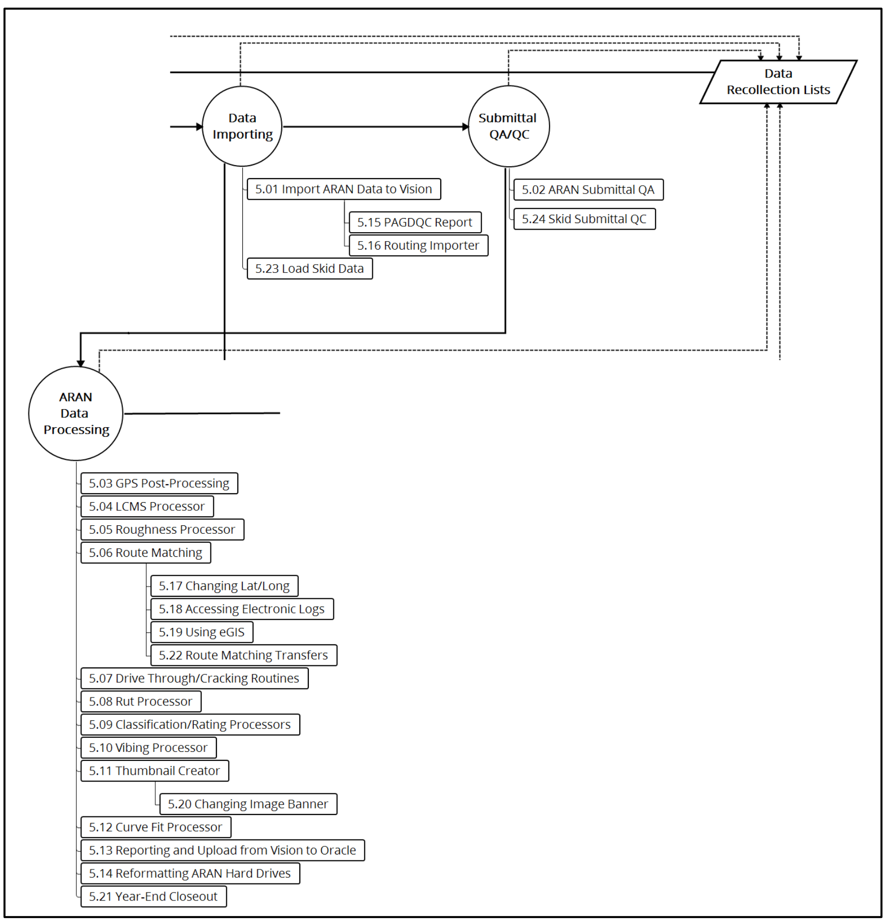


Figure 8: Data Processing SOPs Flowchart

This section describes the set of standard operating procedures (SOP) conducted mainly by staff from the Data Processing Team (DPT) of the Maryland Department of Transportation State Highway Administration's (MDOT-SHA) Office of Materials Technology (OMT) to process and manage data elements collected in the field with the ARAN survey vans and skid trailers by the Field Explorations Division (FED). The SOPs contained in this section begin with the loading of data into the Vision database. The subsequent processes are nearly all completed using the Vision program and involve running various "processors" and performing QC/QA checks on the data. The processing is completed with the transfer of the Vision database into Oracle.

The various processors run in the Vision program include: GPS (in conjunction with the POSPac program), Laser Crack Measurement System (LCMS), Roughness, Rut, Classification and Rating, Vibing, and Curve Fit. These processors are run for batches of data as they are delivered by the FED throughout the data collection season. The data processing is also supplemented by other manual procedures, including the matching of routes and performing a drive through of LCMS data by a user in Vision.

This section also describes supplemental procedures designed to support the SOPs described above. This set includes eight SOPs: creating a Pavement and Geotechnical Division Quality Control (PAGDQC) report, running the routing importer, accessing electronic ARAN logs, changing latitude/longitude, using eGIS, modifying the image banner or logo on the collected images, performing the year-end ARAN data closeout, and performing transfers during route matching.

The final two SOPs in this chapter describe the loading and QC of collected skid data. Once the skid data is loaded into the EDW, it is ready to be used for trend analysis. No further processing is performed on skid data.

5.01 LOADING OF ARAN DATA INTO VISION

5.01.01 *General*

This section describes the standard operating procedure (SOP) followed by the Maryland State Highway Administration's (MD SHA's) Data Processing Team (DPT) to load final deliverable submittals from Office of Materials Technology's (OMT) Field Explorations Division (FED) as acquired from their Automatic Road Analyzer (ARAN) pavement survey data and imagery collection program. Using vendor supplied DCS loading software, routines are performed to load the deliveries into a network imagery (Videolog) server and SQL database(s). Quality control (QC) and quality assurance (QA) routines are then performed on the loading process . The loading of the deliverables is performed in batches usually every 4 – 5 workdays throughout the annual data collection season and anytime year-round. This SOP applies to the data loading and QC/QA of each individual deliverable batch.

Each submittal consists of a survey data SQL database, Right-of-Way and Pavement imagery files, daily field QC files, and orientation (GPS) files. They are delivered by FED members to DPT members in six (or more) 1-terabyte (TB) external hard-disks. These disks are delivered to the DPT as-extracted from the ARAN van computers without any further processing. Each submittal consists of an original and a duplicate disk for the three different types of data and imagery sets. The three data elements are named (1) "ROW", which contains Right-of-Way (ROW) images and FED quality control information, (2) "PVT", which contains Laser Crack Measurement System (LCMS) images, and (3) "SVR", which contains left ROW camera images and all other measurements taken by other sensors (i.e., data measured by grade sensors, longitudinal profilers, inertial measurement unit, and global positioning system). More disks may be introduced into a batch when the amount of collected data of a particular dataset for the batch is larger than 1-TB.

Once the field survey data database is uploaded into the Vision software database(s) and imagery links are established with DCS loading software, Vision post-processing and analysis routines are performed. The results are then imported into the MD SHA Pavement Management System (PMS).

5.01.02 *Frequency*

The loading of FED ARAN submittals into the Videolog server and Vision database is completed every time a delivery is received by the DPT, which typically occurs every 4 to 5 days. Assuming an average of 60 lane miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data and imagery. The actual frequency varies according to the proximity of the collected routes to OMT's Hanover, MD office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring potential recollection. FED's annual ARAN collection season typically runs from April to October but deliveries sometimes occur year-round.

5.01.03 *Purpose*

The purpose of this SOP is to :

- record received disks with ARAN collected data and imagery and upload daily log sheets into the Engineering Data Warehouse (EDW),
- upload the measurements and imagery data collected by the ARAN equipment in the field to the Vision database using the Roadware Data Control Software (DCS),
- load the "Pavement and Geotechnical Division Quality Control" (PAGDQC) report[06/12/2019] to the EDW, and
- confirm that the ARAN collected data is successfully loaded into the Vision database and, if necessary, perform corrective actions.

5.01.04 *Resource Requirements*

The loading of ARAN data involves two people: (1) a user knowledgeable in Roadware DCS software to load the ARAN data batch and perform QC, and (2) a supervisor to perform QA of the loading process. The estimated effort levels in the table below represent the total time, in man-hours, to complete the data loading and QC/QA processes. These time estimates assume average batch quantities and that no issues need to be addressed during the QC and QA.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	DCS user and QC	1	4.0
DPT Team Leader (TL)	Supervisor - QA checks	1	0.5

5.01.05 *Procedure*

The procedure followed by the DPT staff for loading the ARAN data and performing QC/QA is comprised of five tasks:

(1) scanning of daily log sheets,
(2) recording of received ARAN drives,
(3) loading of ARAN Data,
(4) final data loading QC,
(5) creating PAGDQC report,
(6) DPT TL notification, and
(7) data loading QA.

1- Scanning of Daily Log Sheets – *to be completed by DPT Staff*

Summary: This task creates digital copies of the daily log sheets completed by the FED during data collection.

Step 1. Scan the paper copies of the field daily log sheets delivered by the FED along with the 1-TB hard disks.

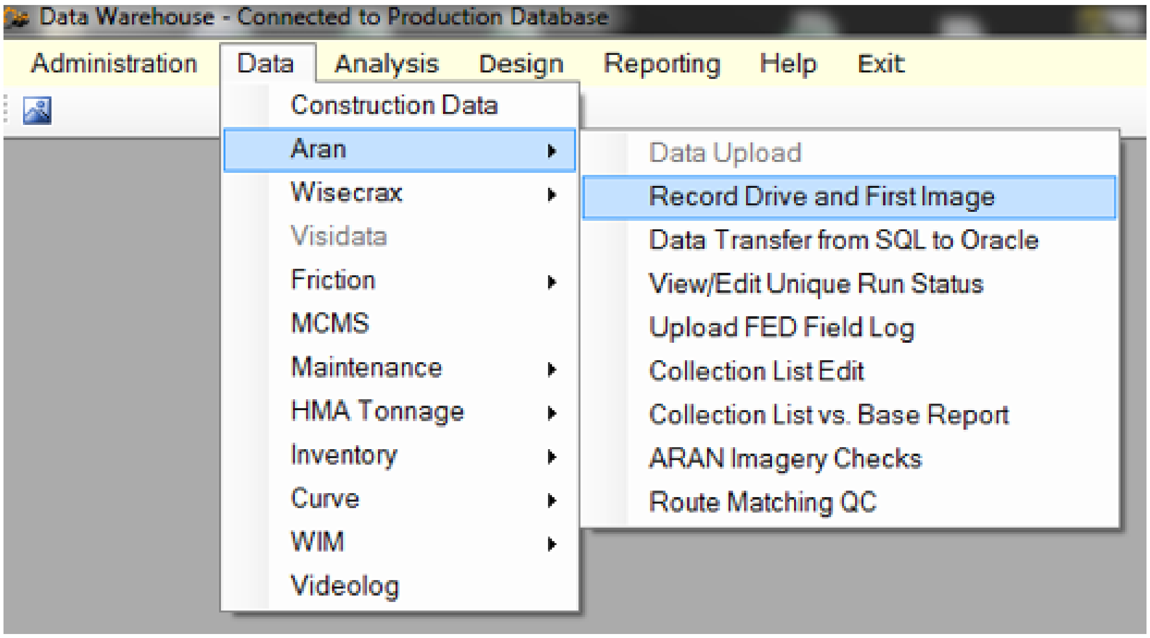
Step 2. Name each of the scanned files as "Rec[arrival date][ARAN Number]" (e.g., "Rec050517A3.pdf").

Step 3. Save each of the scanned sheets as a PDF in the server folder for the corresponding data collection year: \\shahanartico2\shaomtvideolog\[YEAR]\Data\Field Logs (e.g., "\\shahanartico2\shaomtvideolog\2017\Data\Field Logs").

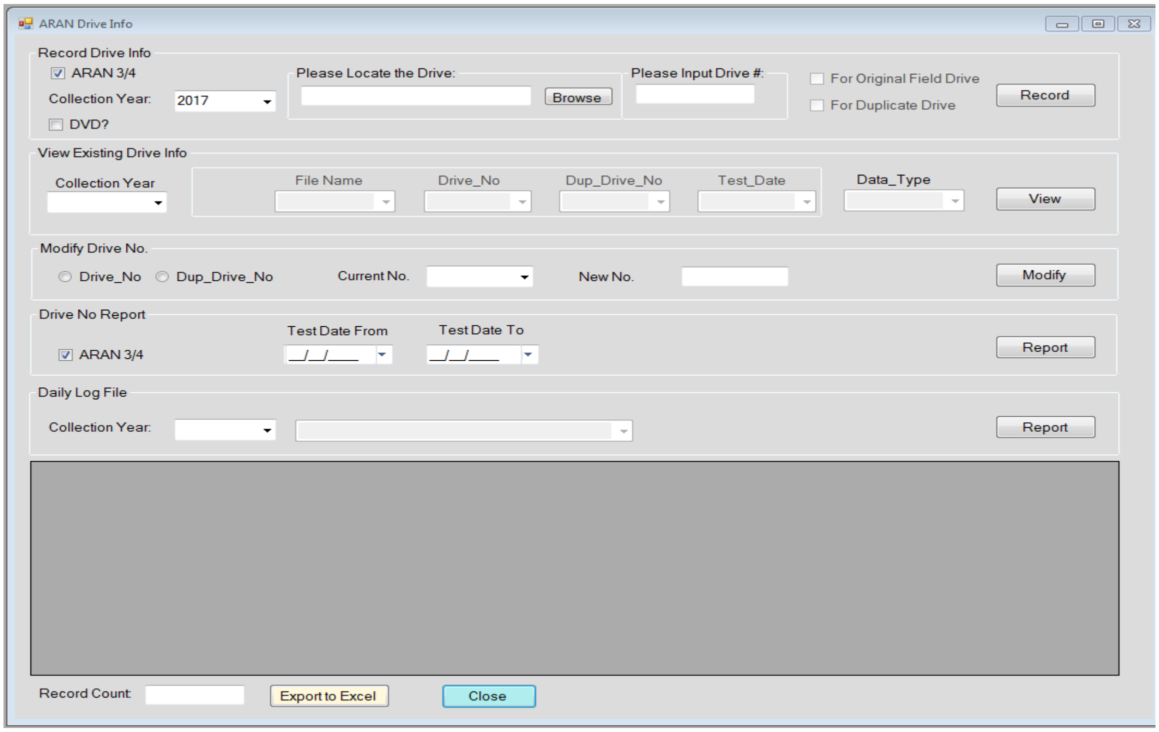
2- Recording of Received ARAN Drives – *to be completed by DPT Staff*

Summary: This task records the disks with ARAN collected data received from the FED into the EDW.

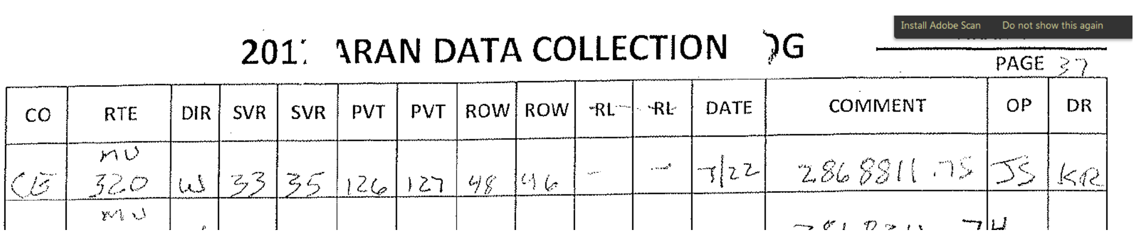
Step 4. Open the "Data Warehouse" program and click on "Data", "Aran", "Record Drive and First Image" (see below image).



"ARAN Drive Info" window will appear. The only two boxes in the window to be completed are "Record Drive Info" and "Daily Log File" (see below image).



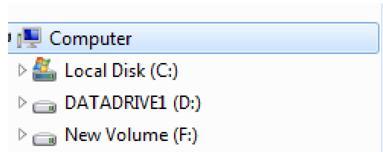
Step 5. Obtain labels of the received disks from the daily log sheets. Each disk with the ARAN data collected in the field is labeled using two numbers separated with a dash mark (e.g., "173-17"). The first number refers to the order at which the disk was used while the second number refers to the year the disk was purchased (some years the year of purchase is on the left while in other years it's on the right). The labels of the disks (original(s) and duplicate(s)) for each of the three sets of data elements, referred to by the FED as "server" (SVR), "pavement" (PVT), and "right-of-way" (ROW), are reported in columns 4 to 9, as shown in the image below. In some cases, the ARAN operators omit to write down the year of purchase part of the label (as is the case in the daily log sheet shown as example). The labels to be recorded into the Data Warehouse program must contain both the disk number and the purchase year (e.g., the labels of the hard disk from the daily log sheet in the image are 33-17 and 35-17 for SVR, 126-17 and 127-17 for PVT, and 48-17 and 46-17 for ROW).



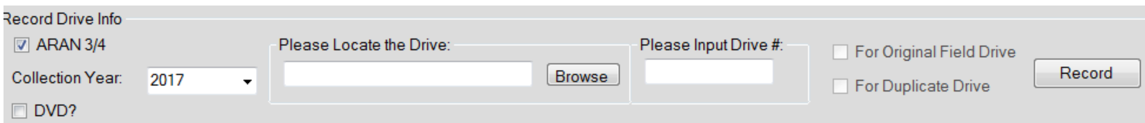
CO	RTE	DIR	SVR	SVR	PVT	PVT	ROW	ROW	RL	RL	DATE	COMMENT	OP	DR
CE	MU 320	W	33	35	126	127	48	46	-	-	7/22	286881175	JS	KR
	MU												7/4	

Step 6. Insert one of the "original" SVR disks into the external drive docking station.

Step 7. Identify what drive the disk was connected to. This information can be found in the "Windows Explorer" (see below image). If no new disk appears in the computer ("New Volume" does not appear), try to re-insert the disk into docking station until it is detected. If the disk is still not detected, contact MDOT-SHA Information Technology (IT) staff for assistance.

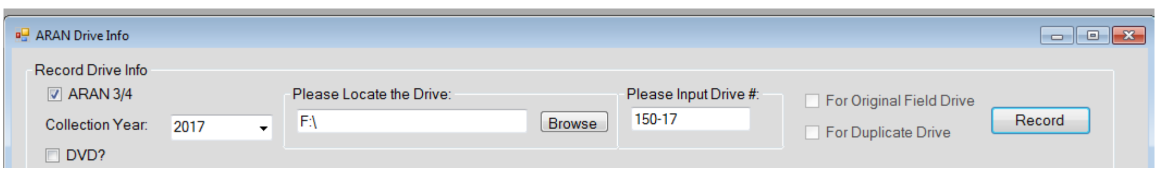


Step 8. In the Data Warehouse program, click the "Browse" button under the "Record Drive Info" box (see below image).

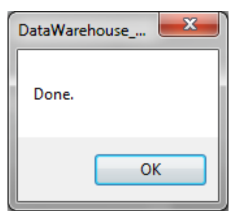


Step 9. Select the computer drive to which the disk with the ARAN collected data was connected to (computer drive "F:/" in the image shown as example).

Step 10. Type the complete label of the connected disk (i.e., including both the disk number and the purchase year) into the "Please Input Drive #" field of the "Record Drive Info" box (see below image).



Step 11. Click on the "Record" button. The "ARAN Drive Info" application will automatically populate the "Daily Log File". Once the following message window appears, click on the "OK" button (see below image).



Step 12. Repeat Step 8 to Step 11 for recording the label of the corresponding "duplicate" disk of the dataset being recorded (i.e., SVR data in first iteration). The label of the duplicate disk is recorded with the original disk of the corresponding dataset connected so the same information will be inputted into the "Please locate the driver" - only the label inputted into the "Please input Drive #" will be different.

Step 13. Unplug disk from external docking station.

Step 14. If more than one "original" disk with the analyzed dataset was received (e.g., SVR), repeat Step 6 to Step 13 until the labels of all the original and duplicates disks are recorded.

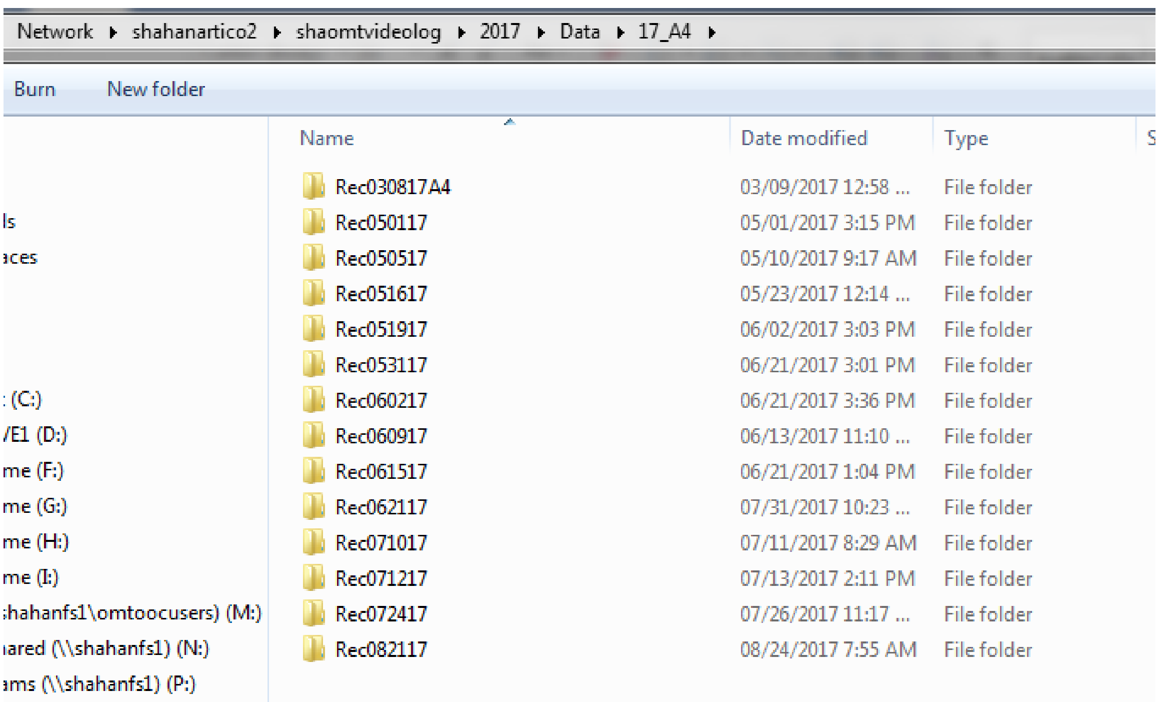
Step 15. Repeat Step 6 to Step 13 twice; one time for recording the labels of the original and duplicate disks with the PVT data and the second time for the disks with the ROW data.

3- Loading of ARAN data – *to be completed by DPT Staff*

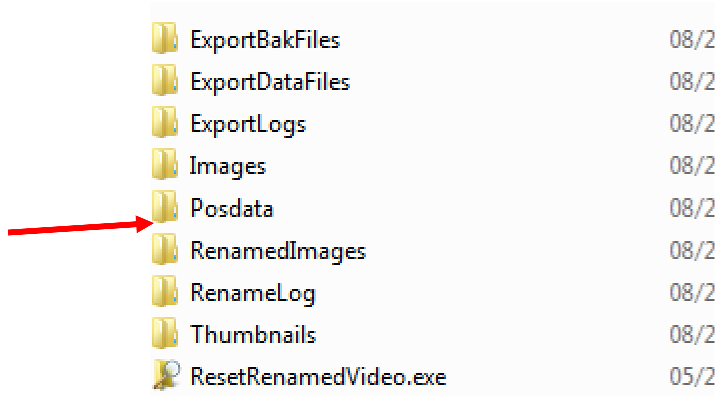
Summary: This task uploads the measurements and imagery data collected by the ARAN equipment in the field to the Vision database using the Roadware DCS and identifies any errors which may occur during the data upload.

Step 16. Connect the original (or duplicate, these will produce the same result) 1-TB hard disks with each of the three sets of data elements produced by the ARAN survey vans to the docking station of the computer with the Roadware DCS software. All three drives must be connected.

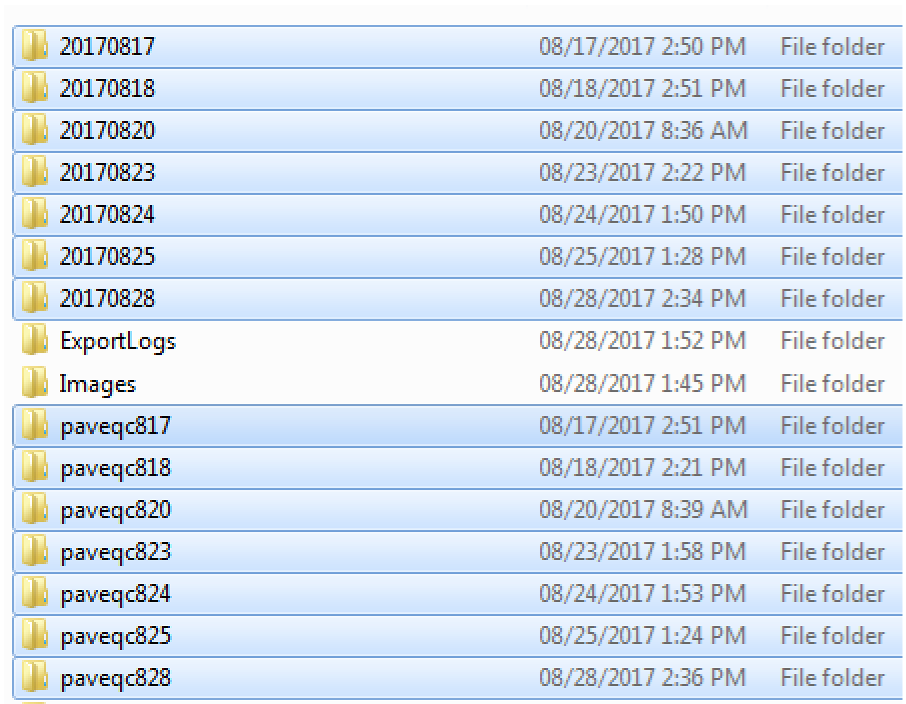
Step 17. Navigate to: \\shahanartico2\shaomtvideolog\2017\Data. Open the appropriate ARAN folder (named as “[YY]_A[#ARAN]”; e.g., “17_A3” for ARAN 3 and “17_A4” for ARAN 4. Right click and make a new folder. Name the folder “Rec [datereceived]” (see below image).



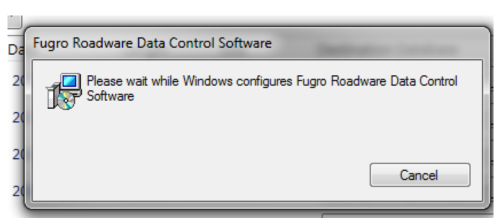
Step 18. Copy the folder named “Posdata” from the “SVR” hard disk drive to the “Rec” folder that was just created (see below image).



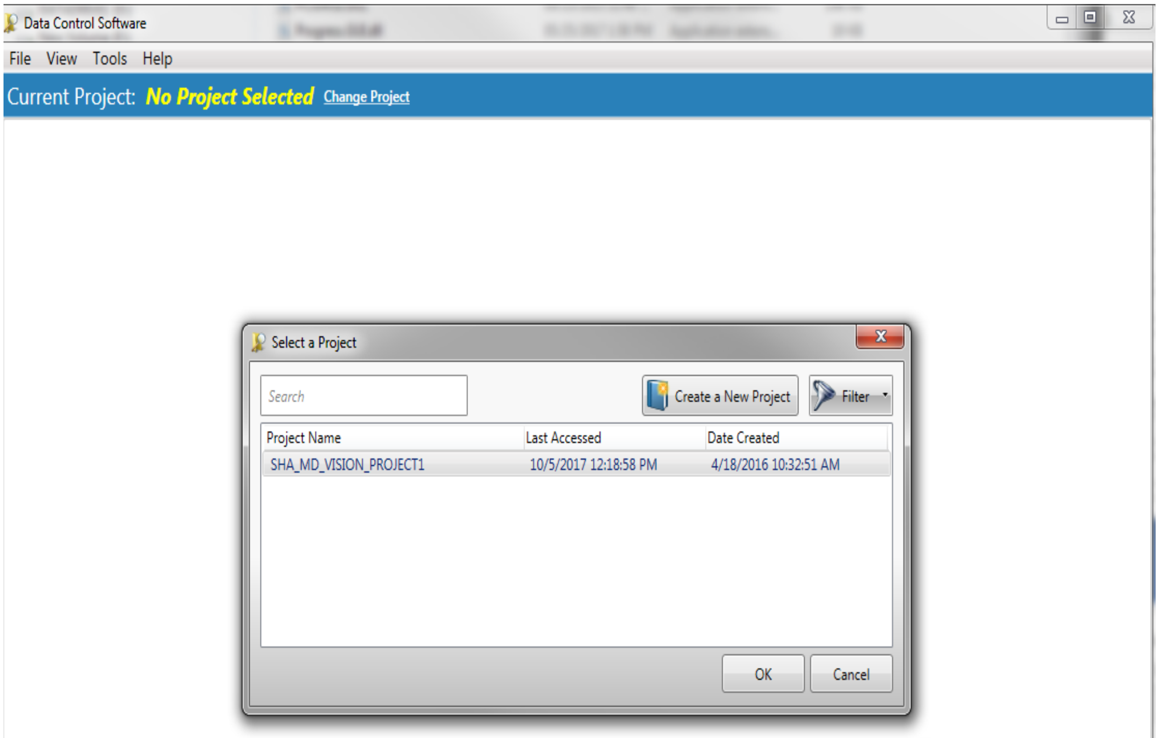
Step 19. Copy the log and Pavement QC folders from the "ROW" hard disk drive to the "Rec" folder that was just created (see below image).



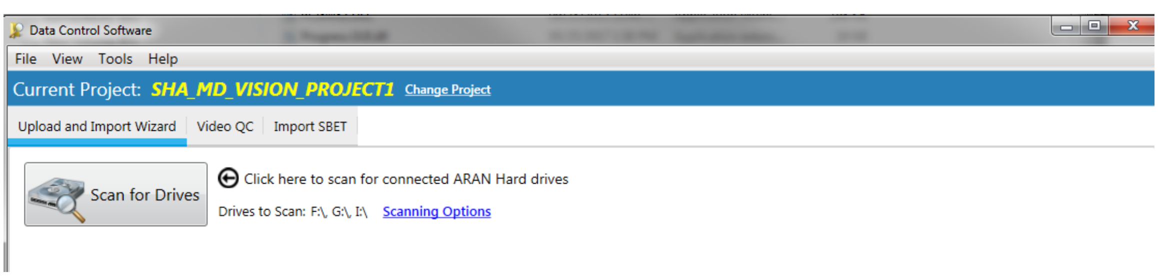
Step 20. Open the Roadware DCS.exe program. The default location of the Roadware DCS software is "C:\Program Files (x86)\Fugro Roadware\Data Control Software\Roadware.DCS.exe". A desktop shortcut of the software may also have been created, however, confirm that the shortcut directs to the Roadware.DCS.exe file as it is sometimes linked to an incorrect file. Click the "Cancel" button when the dialogue box appears (see below image).



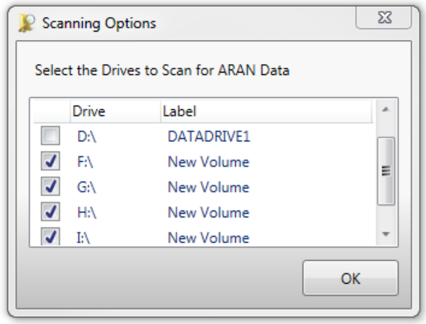
Step 21. The program will open. The "Select a Project" window should have project "SHA_MD_VISION_PROJECT1" listed under the "Project Name" column, as shown in the image below. If project "SHA_MD_VISION_PROJECT1" is not listed, contact the MDOT-SHA IT staff for assistance. Otherwise, click on the "OK" button to proceed (see below image).



Step 22. Confirm that all connected 1-TB disks with ARAN data are detected by the DCS software. For this, check if all the disks are listed after the "Drives to scan" message (see below image). The name of the computer drives to which the disks are connected ("F:/", "G:/" and "I:/" in the image) are variable. They will be randomly assigned to a letter from "E:/" to "Z:/". Also, the plug to which they are connected is not relevant.

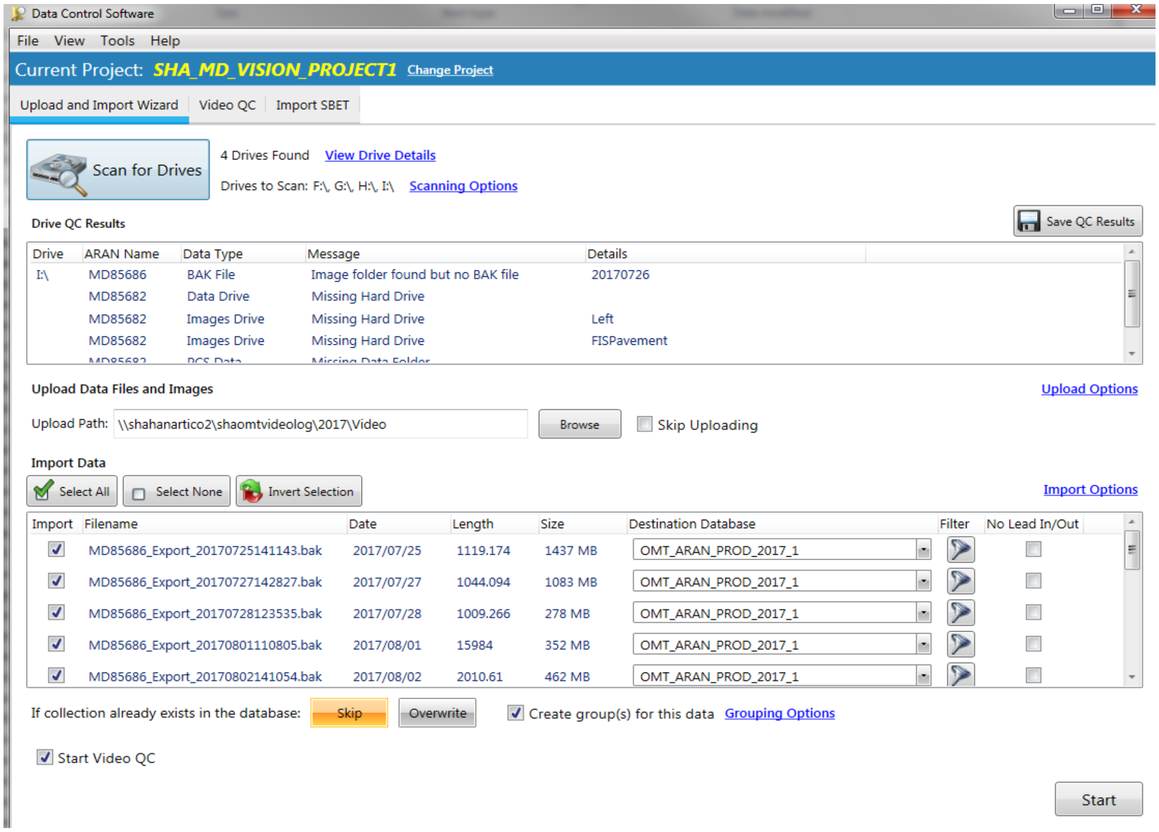


i. If one or more of the disks are not listed in the "Drives to scan" line, click on the "Scanning Options" link (appears in bold, blue text after the list of connected disks). Select all computer drives to which the disks with ARAN data are connected to and click on "OK" (see below image). If one, or more, of the connected disks are not detected by the computer, reconnect the disk to a different slot of the docking station and confirm that it was detected by the computer. If the disk is still not detected by the computer connect the duplicate disk to the docking station. If neither the original nor the duplicate disks are detectable by the computer after repeated trials, suspend the procedure and communicate issue with Supervisor and FED TL for remedial actions (e.g., recollection of data).



Step 23. Once all the drives with connected ARAN disks are listed on the "Drives to Scan" line, click on the "Scan for Drives" button. Next, the DCS software will perform QC checks to confirm that all the data elements collected by the ARAN survey vans are present in the connected disks (see below image).

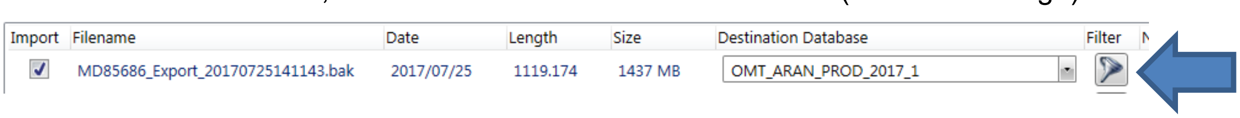
Step 24. The DCS software will finish scanning the connected drives (see below image).



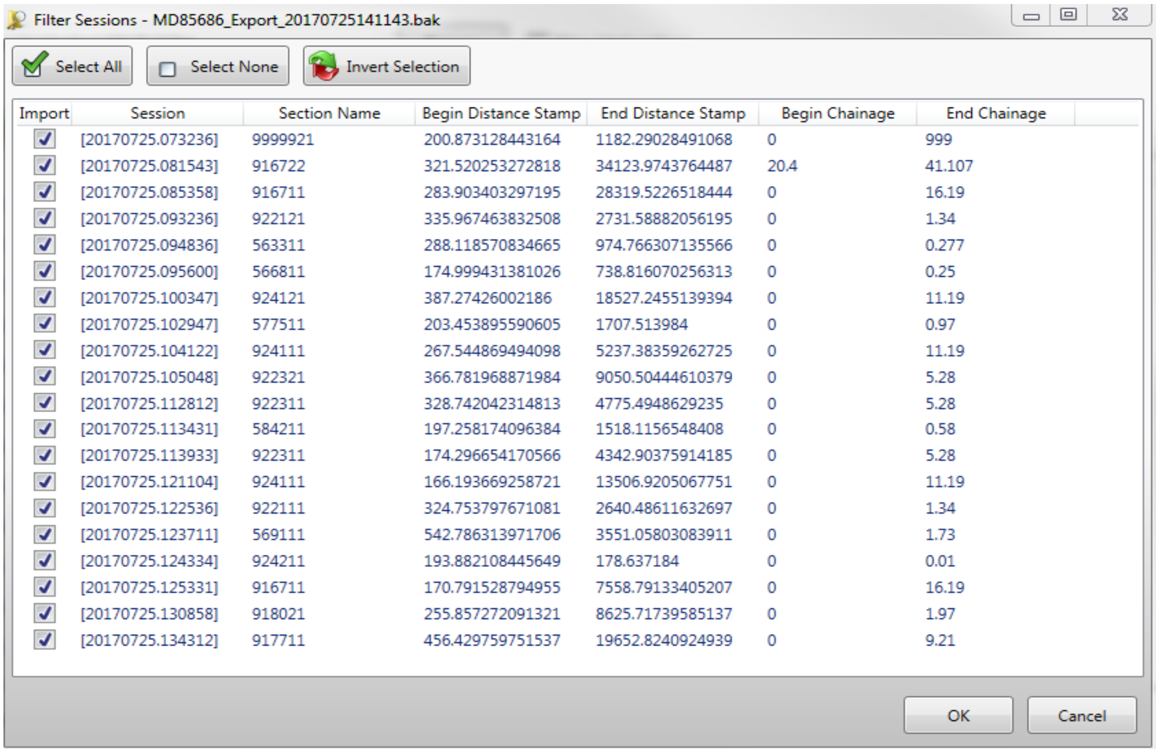
i. First, read the information provided in the “Drive QC Results” box. If all data elements collected by the ARAN survey vans were contained in the connected disks, then the “Drive QC Results” box would be empty. Otherwise, a list of error messages listing the data elements missing in the connected disks will appear (as shown in the image above. For example, the error messages listed from the “Drive QC Results” box shown in the image indicate that the data elements in the SVR and Pavement drives are missing). If one or more data elements were listed as missing, reconnect the corresponding disks to the docking station and repeat Steps 19 and 20. If data elements are still reported as missing in the “Drive QC Results” box, connect the duplicate of the corresponding disks. If it is not possible to detect the missing data elements from either the original or the duplicate disks, report the need for recollecting the routes contained in the affected disks.

ii. Once no missing elements are listed in the “Drive QC Results” box, check that the default upload path in the “Upload Data Files and Images” box is \\shahanartico2\shaomtvideolog\[YEAR]\Video. Otherwise, type in that upload path.

iii. Next compare the scanned copy of the daily log data to the filter in the imported data. For this, click on the “Filter” icon of the first row (see below image).



The following window will appear.



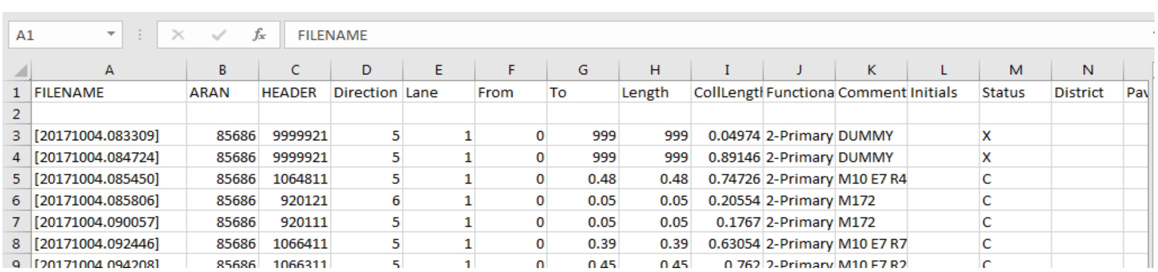
Filter Sessions - MD85686_Export_20170725141143.bak

Select All | Select None | Invert Selection

Import	Session	Section Name	Begin Distance Stamp	End Distance Stamp	Begin Chainage	End Chainage
☑	[20170725.073236]	9999921	200.873128443164	1182.29028491068	0	999
☑	[20170725.081543]	916722	321.520253272818	34123.9743764487	20.4	41.107
☑	[20170725.085358]	916711	283.903403297195	28319.5226518444	0	16.19
☑	[20170725.093236]	922121	335.967463832508	2731.58882056195	0	1.34
☑	[20170725.094836]	563311	288.118570834665	974.766307135566	0	0.277
☑	[20170725.095600]	566811	174.999431381026	738.816070256313	0	0.25
☑	[20170725.100347]	924121	387.27426002186	18527.2455139394	0	11.19
☑	[20170725.102947]	577511	203.453895590605	1707.513984	0	0.97
☑	[20170725.104122]	924111	267.544869494098	5237.38359262725	0	11.19
☑	[20170725.105048]	922321	366.781968871984	9050.50444610379	0	5.28
☑	[20170725.112812]	922311	328.742042314813	4775.4948629235	0	5.28
☑	[20170725.113431]	584211	197.258174096384	1518.1156548408	0	0.58
☑	[20170725.113933]	922311	174.296654170566	4342.90375914185	0	5.28
☑	[20170725.121104]	924111	166.193669258721	13506.9205067751	0	11.19
☑	[20170725.122536]	922111	324.753797671081	2640.48611632697	0	1.34
☑	[20170725.123711]	569111	542.786313971706	3551.05803083911	0	1.73
☑	[20170725.124334]	924211	193.882108445649	178.637184	0	0.01
☑	[20170725.125331]	916711	170.791528794955	7558.79133405207	0	16.19
☑	[20170725.130858]	918021	255.857272091321	8625.71739585137	0	1.97
☑	[20170725.134312]	917711	456.429759751537	19652.8240924939	0	9.21

OK | Cancel

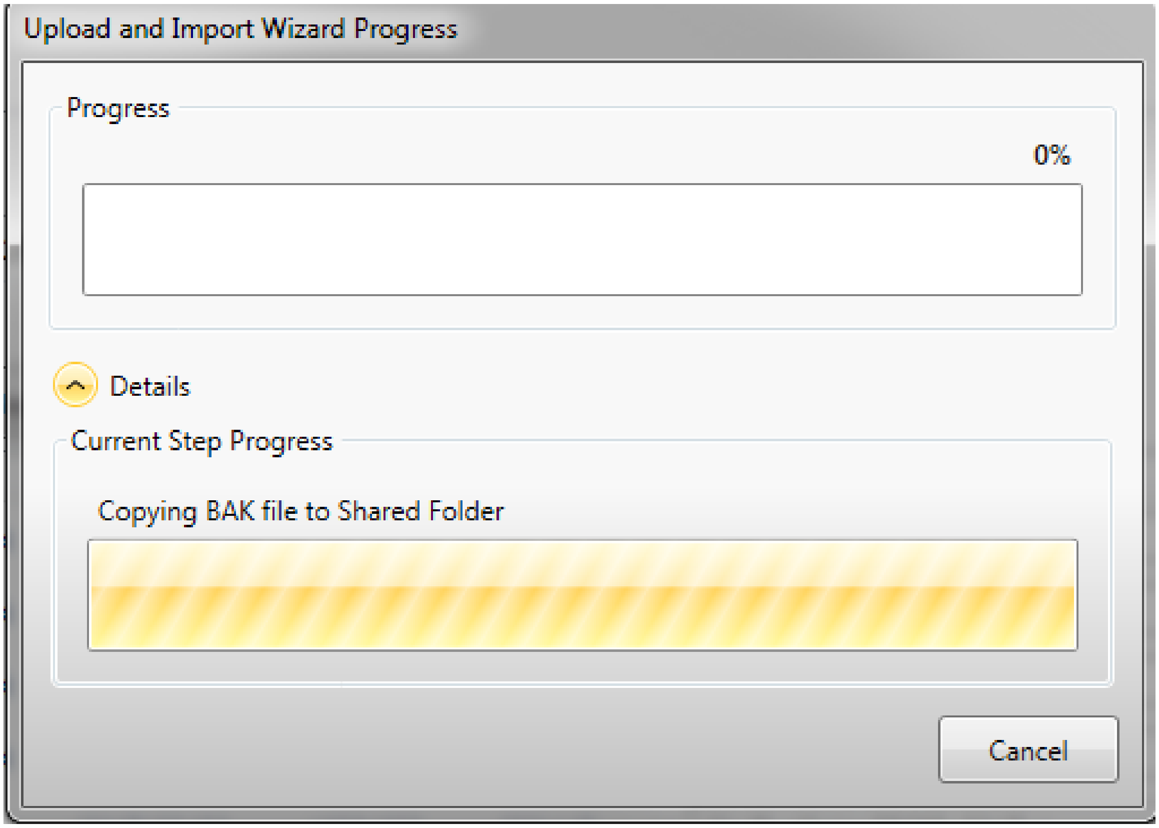
With the previous window open, access the electronic daily logs (see below image). To access the scanned daily logs, navigate to ("\\shahanartico2\shaomtvideolog\[YEAR]\Data\[YY]_A[ARAN Number]\Rec[MMDDYYYY]"). Compare the information in both windows. The "Session" column in Vision and the "FILENAME" column in Excel are the same (YYYYMMDD.24hrTime). Deselect any files with an "X" in the "Status" column in Excel. "DUMMY" files will always have an "X" in the "Status" column and "999921" in the "HEADER" column.



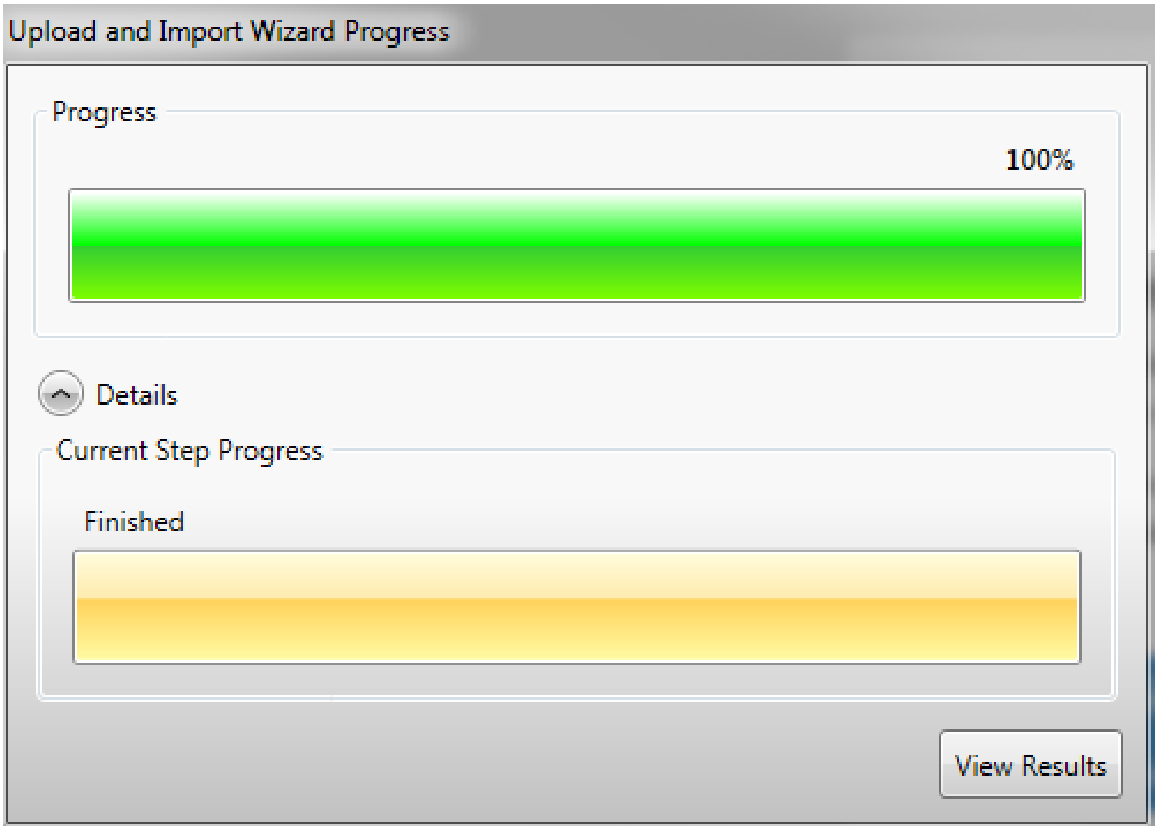
A1 | FILENAME

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
1	FILENAME	ARAN	HEADER	Direction	Lane	From	To	Length	CollLengtl	Functiona	Comment	Initials	Status	District	Pav
2															
3	[20171004.083309]	85686	9999921	5	1	0	999	999	0.04974	2-Primary	DUMMY		X		
4	[20171004.084724]	85686	9999921	5	1	0	999	999	0.89146	2-Primary	DUMMY		X		
5	[20171004.085450]	85686	1064811	5	1	0	0.48	0.48	0.74726	2-Primary	M10 E7 R4		C		
6	[20171004.085806]	85686	920121	6	1	0	0.05	0.05	0.20554	2-Primary	M172		C		
7	[20171004.090057]	85686	920111	5	1	0	0.05	0.05	0.1767	2-Primary	M172		C		
8	[20171004.092446]	85686	1066411	5	1	0	0.39	0.39	0.63054	2-Primary	M10 E7 R7		C		
9	[20171004.094208]	85686	1066311	5	1	0	0.45	0.45	0.762	2-Primary	M10 E7 R2		C		

Step 25. Once you have the correct files selected, click the "Start" button in Vision. The "Upload and Import Wizard Progress" window will open (see below image). Click the "Details button" to see what step the program has completed.



Step 26. After the program is complete, click the "View Results" button (see below image).



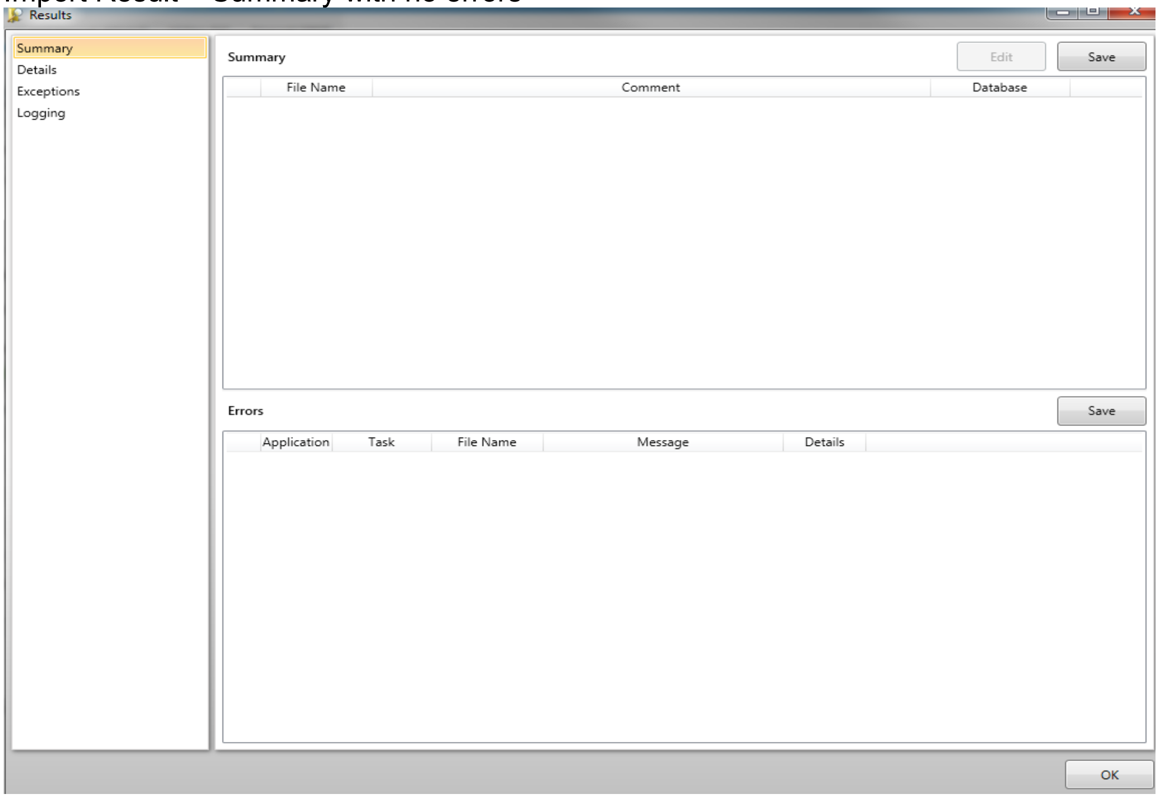
Click the "Details" tab on the left-hand window to view the results of the import. Check window for errors (see below images for examples).

i. If there are no errors, proceed to Step 27.

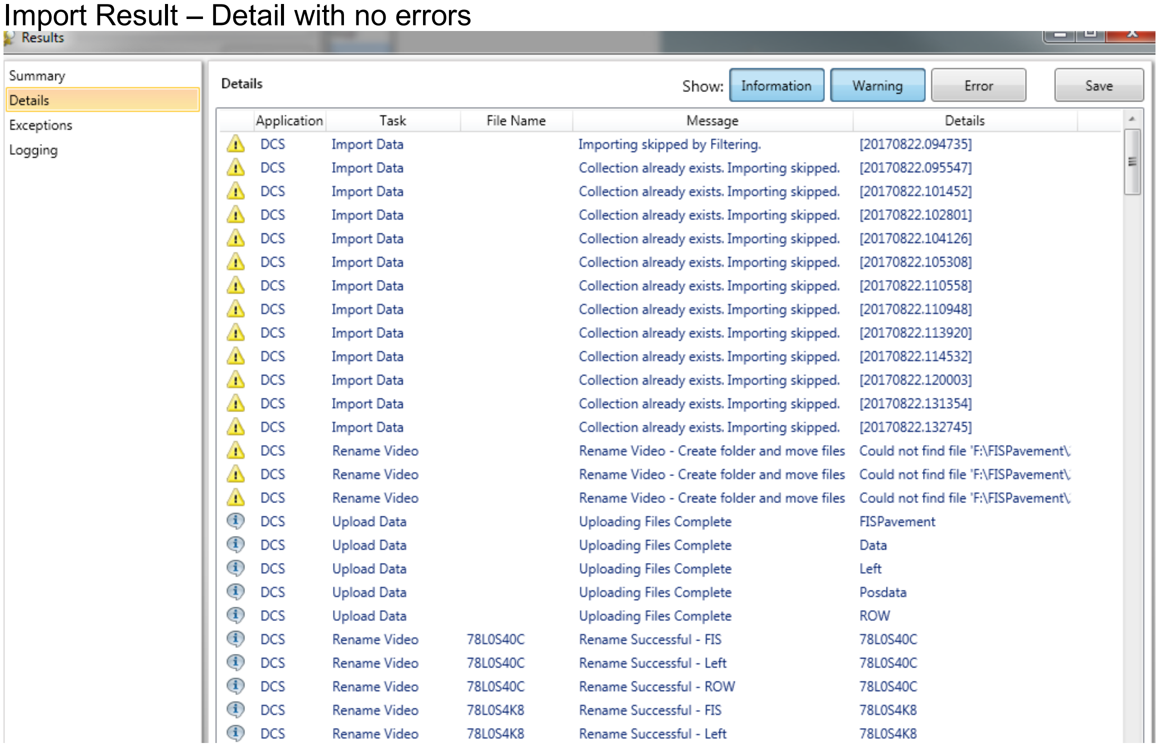
ii. If there are some errors, but not errors with every run, reimport the runs with errors by returning to Step 25.

iii. If every run received an error (such as all runs saying, "no images found in database," suspend data import and inform FED that recollection may be necessary.

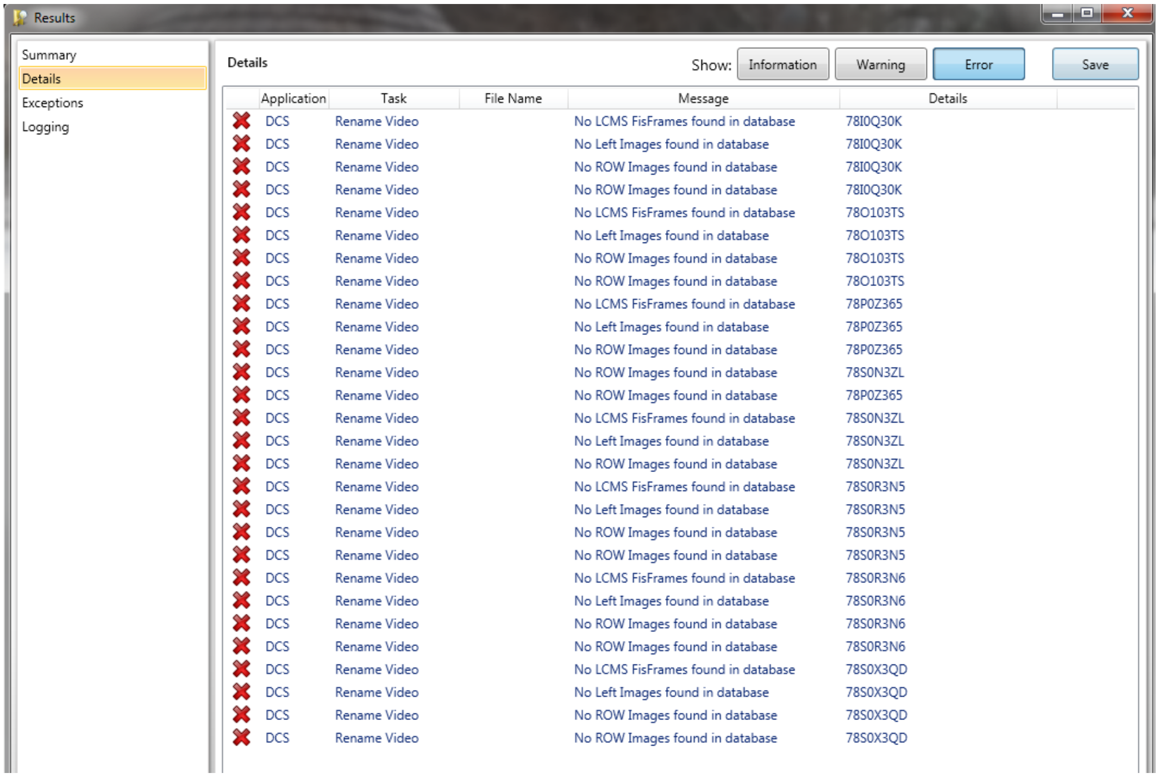
Import Result – Summary with no errors



Import Result – Detail with no errors



Import Result – Detail “no images found” errors (recollection may be necessary)

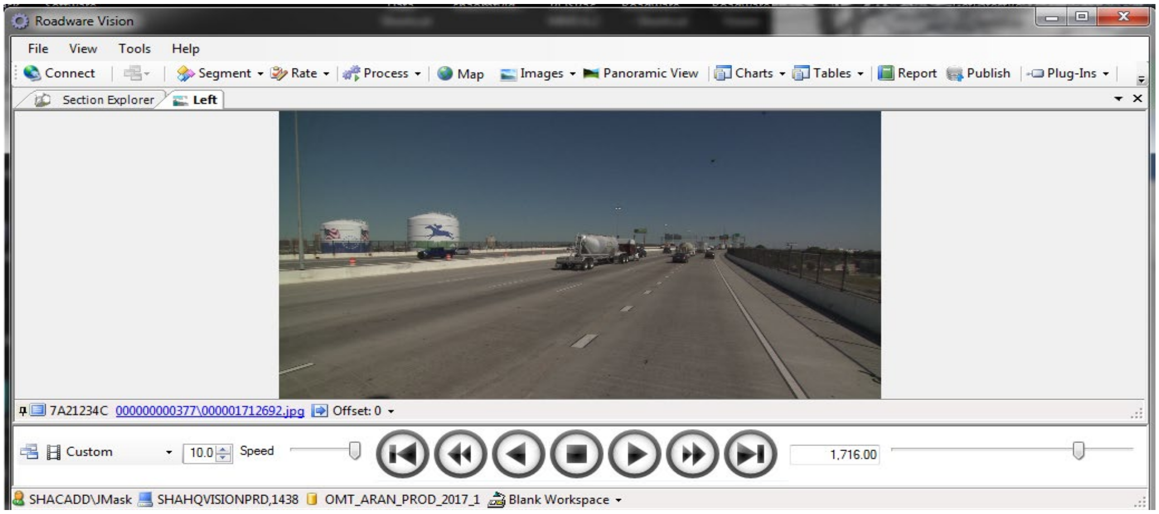


	Application	Task	File Name	Message	Details
✖	DCS	Rename Video		No LCMS FisFrames found in database	78I0Q30K
✖	DCS	Rename Video		No Left Images found in database	78I0Q30K
✖	DCS	Rename Video		No ROW Images found in database	78I0Q30K
✖	DCS	Rename Video		No ROW Images found in database	78I0Q30K
✖	DCS	Rename Video		No LCMS FisFrames found in database	78O103TS
✖	DCS	Rename Video		No Left Images found in database	78O103TS
✖	DCS	Rename Video		No ROW Images found in database	78O103TS
✖	DCS	Rename Video		No ROW Images found in database	78O103TS
✖	DCS	Rename Video		No LCMS FisFrames found in database	78P0Z365
✖	DCS	Rename Video		No Left Images found in database	78P0Z365
✖	DCS	Rename Video		No ROW Images found in database	78P0Z365
✖	DCS	Rename Video		No ROW Images found in database	78S0N3ZL
✖	DCS	Rename Video		No ROW Images found in database	78P0Z365
✖	DCS	Rename Video		No LCMS FisFrames found in database	78S0N3ZL
✖	DCS	Rename Video		No Left Images found in database	78S0N3ZL
✖	DCS	Rename Video		No ROW Images found in database	78S0N3ZL
✖	DCS	Rename Video		No LCMS FisFrames found in database	78S0R3N5
✖	DCS	Rename Video		No Left Images found in database	78S0R3N5
✖	DCS	Rename Video		No ROW Images found in database	78S0R3N5
✖	DCS	Rename Video		No ROW Images found in database	78S0R3N5
✖	DCS	Rename Video		No LCMS FisFrames found in database	78S0R3N6
✖	DCS	Rename Video		No Left Images found in database	78S0R3N6
✖	DCS	Rename Video		No ROW Images found in database	78S0R3N6
✖	DCS	Rename Video		No ROW Images found in database	78S0R3N6
✖	DCS	Rename Video		No LCMS FisFrames found in database	78S0X3QD
✖	DCS	Rename Video		No Left Images found in database	78S0X3QD
✖	DCS	Rename Video		No ROW Images found in database	78S0X3QD
✖	DCS	Rename Video		No ROW Images found in database	78S0X3QD

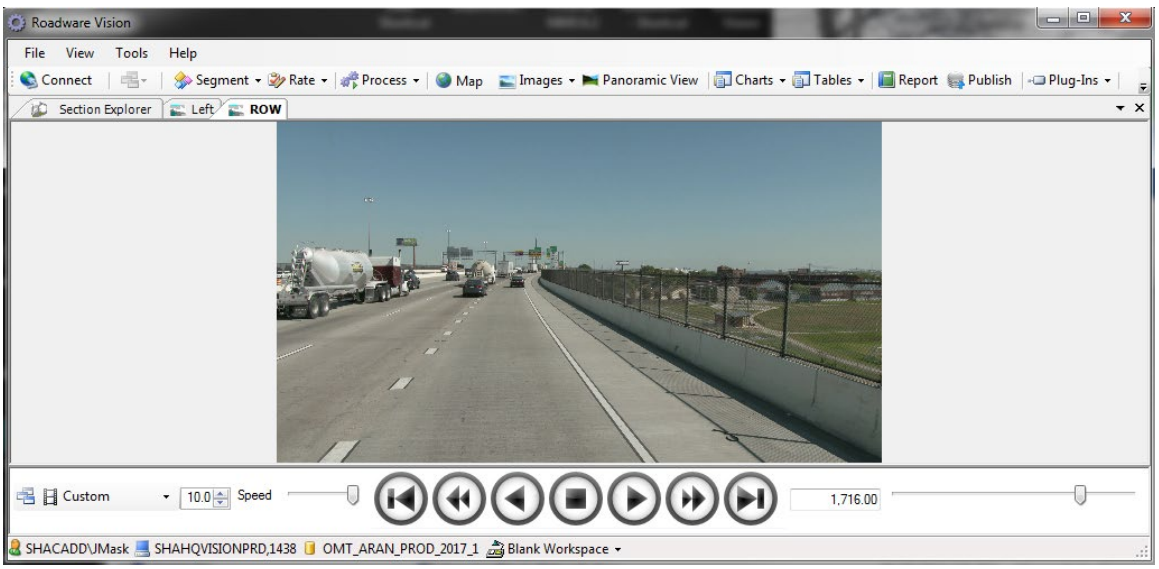
4- Final Data Loading QC – *to be completed by DPT Staff*

Summary: This task ensures that the collected “ROW” and “Left” images collected with the ARAN equipment in the field are acceptable and flags image data sets which may be incomplete or of unacceptable quality.

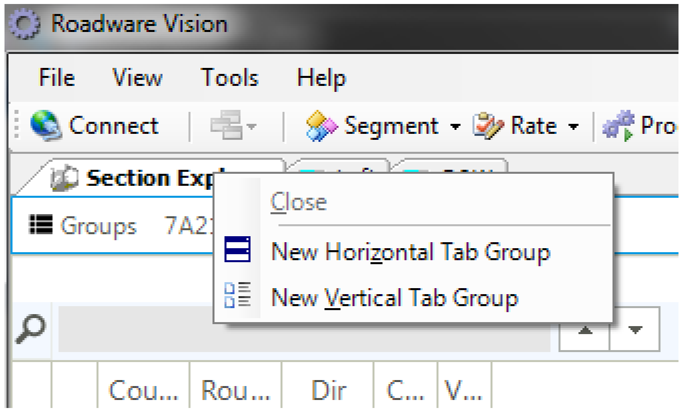
Step 27. Open Vision. Select the “Images” drop-down menu and select “Left”. “Left” viewer tab will appear (see below image). Images will only be displayed if a file is selected. If the window opens and there is no image, make sure a file is selected in the Section Explorer window.



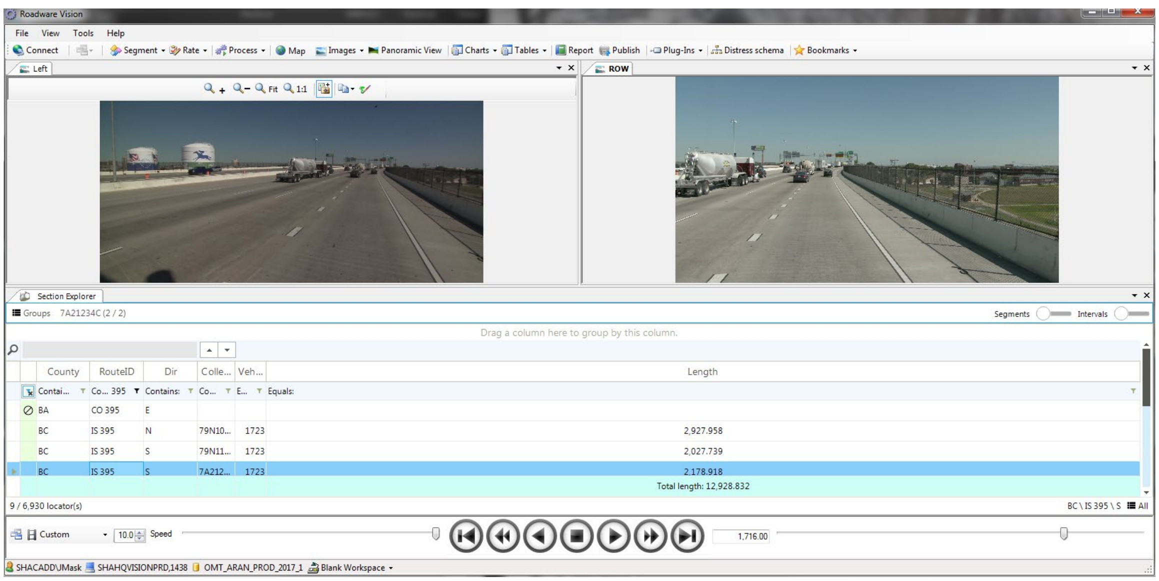
Step 28. Select the “Images” drop-down menu and select “ROW”. “ROW” viewer tab will appear (see below image). Images will only be displayed if a file is selected. If the window opens and there is no image, make sure a file is selected in the Section Explorer window



Step 29. Arrange “Section Explorer”, “ROW”, and “Left” windows so that they can be viewed simultaneously on the screen. Right-click on the “Section Explorer” tab and select “New Horizontal Tab Group” (see below image). The “Section Explorer” window will move to the bottom of the Vision display.



Step 30. Right-click on the “ROW” tab and select “New Vertical Tab Group.” The “ROW” window will move to the right of the Vision display, next to the “Left” window (see below image).



Step 31. Select one of the imported files in the “Section Explorer” window. The first image for both cameras will appear in the “Left” and “ROW” windows. Check the image for quality. Click the “skip to last” button to view the last image (see below image). Check the image for quality. Check at least one file for each day of data collection.

i. If images are of acceptable, proceed to Step 32.

ii. If images are missing (more than half) or otherwise not of acceptable quality, return to Step 25 and reimport the files.

5- Creating and Importing PAGDQC Report – *to be completed by DPT Staff*

Summary: This task creates and populates a PAGD_QC_CSV file for all collection runs imported into the Vision database for each FED submission. The file is then imported into the EDW to update the Edit/View Unique Run Status program to allow tracking, status, and notes of each collection run (FED QC/QA, Route Matching QC/QA, etc.).

Step 32. Refer to Creating PAGDQC Report for creation and uploading of the PAGD_QC Report. This step is essential for FED QC/QA staff can provide their feedback for each collection run as part of their QC/QA review. The FED review will determine if a collection run requires recollection and if it's ready for office post-processing.

6- DPT TL Notification – *to be completed by DPT Staff*

Summary: This task notifies the DPT TL of completion of data loading and results from QC.

Step 33. Notify DPT TL of completion of data loading and results from QC.

i. Compose an email to the DPT TL (cc the Assistant Division Chief for Pavement Management in the email).

ii. Indicate that the received data has been loaded into the Vision database.

iii. Attach the PAGD_QG Report and the PDF with the scanned ARAN Collection Daily Logs.

iv. Use the following email subject: "New Aran [ARAN NUMBER] Submission" (e.g., "New ARAN 3 Submission").

v. Include all problems or concerns with the received data found while performing the previous steps.

7- Data Loading QA and FED Notification – *to be completed by DPT TL*

Summary: This task confirms the completeness of the data loading and ensures the correct attachments were included in the notification email from DPT staff. This task also uploads the data via ProjectWise and alerts the FED TL when complete.

Step 34. Open the notification email sent from DPT Staff. Make sure the following files are provided as an attachment to the email:

i. FED QC Spreadsheet (PAGDQC Report renamed)

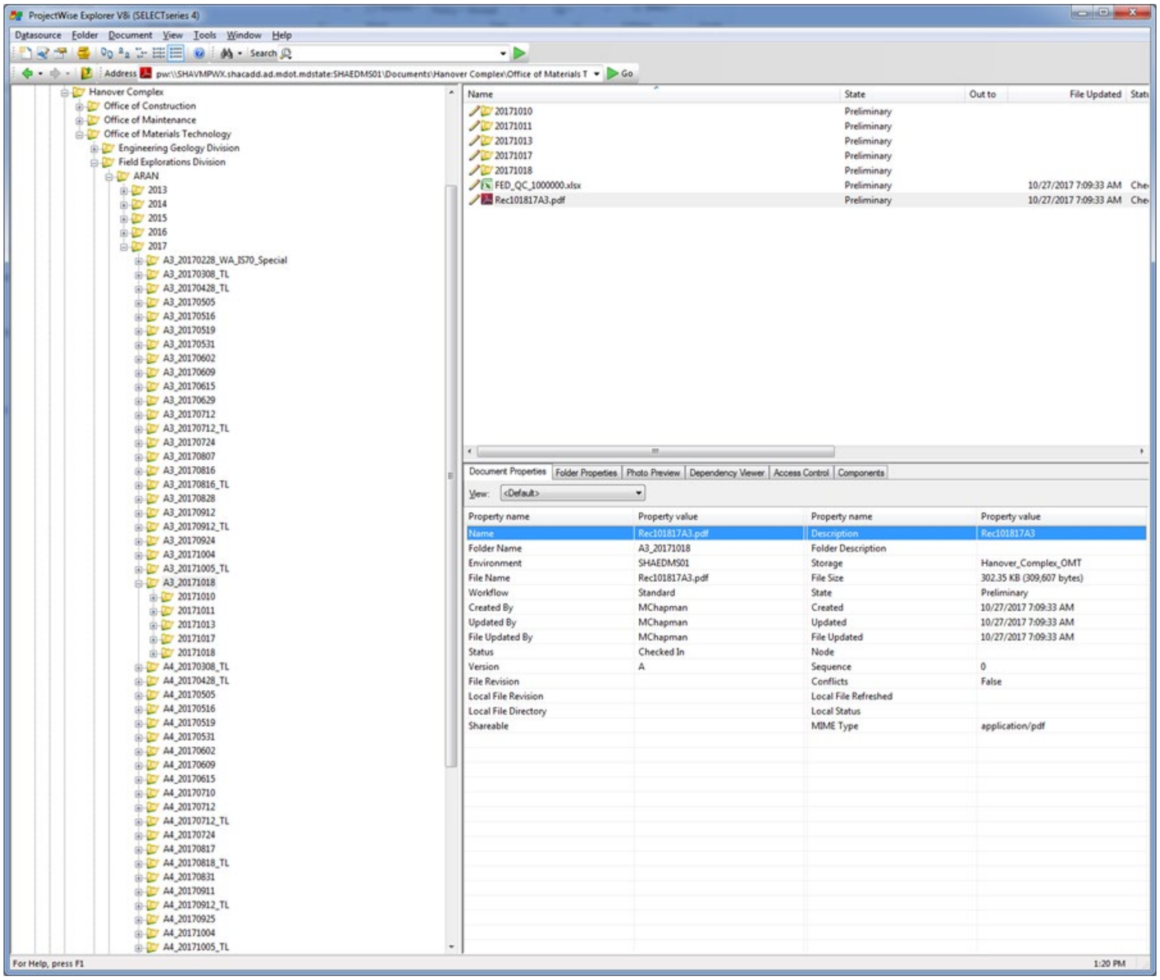
ii. ARAN Field Log

If one or both of these files were not attached to the email, contact the DPT Staff that submitted the notification and request to resubmit email with correct files.

Step 35. Navigate to folder location of the FED daily QC folders on the network: \\shahanartico2\shaomtvideolog\[YEAR]\Data\[YY]_A[ARANNumber]\Rec[MMDDYYYY]. Confirm that one folder per data collection date in the batch (use the ARAN Field Log to get the list of data collection days in the batch) has been created and that they have the necessary files. See image below for the list of files expected to be populated in each daily collection folder.

Name	Date modified	Type	Size
PAVQC725	9/5/2017 5:06 PM	File folder	
Collected_Length_By_Func_Class.csv	7/25/2017 5:07 PM	Microsoft Excel C...	1 KB
Daily_MD85686_20170725.csv	7/25/2017 5:06 PM	Microsoft Excel C...	6 KB
left1.jpg	7/25/2017 3:57 PM	JPEG Image	1,573 KB
left2.jpg	7/25/2017 3:58 PM	JPEG Image	1,550 KB
left3.jpg	7/25/2017 3:58 PM	JPEG Image	1,567 KB
MD85686_Export_20170725141143_log.csv	7/25/2017 5:15 PM	Microsoft Excel C...	2 KB
MD85686_Settings_20170725.xml	7/25/2017 5:07 PM	XML File	60 KB
MD85686_StatusMessages_20170725.csv	7/25/2017 5:07 PM	Microsoft Excel C...	13 KB
QC_Pcs_Files.csv	7/25/2017 5:06 PM	Microsoft Excel C...	4 KB
QC_Video.csv	7/25/2017 5:06 PM	Microsoft Excel C...	4 KB
row1.jpg	7/25/2017 3:58 PM	JPEG Image	1,056 KB
row2.jpg	7/25/2017 3:58 PM	JPEG Image	1,006 KB
row3.jpg	7/25/2017 3:58 PM	JPEG Image	1,014 KB
Sections_Collected_List.csv	7/25/2017 5:06 PM	Microsoft Excel C...	1 KB
Sections_Not_Collected_List.csv	7/25/2017 5:06 PM	Microsoft Excel C...	70 KB
thumbnail_left1.jpg	7/25/2017 3:57 PM	JPEG Image	74 KB
thumbnail_left2.jpg	7/25/2017 3:58 PM	JPEG Image	72 KB
thumbnail_left3.jpg	7/25/2017 3:58 PM	JPEG Image	73 KB
thumbnail_row1.jpg	7/25/2017 3:58 PM	JPEG Image	65 KB
thumbnail_row2.jpg	7/25/2017 3:58 PM	JPEG Image	63 KB
thumbnail_row3.jpg	7/25/2017 3:58 PM	JPEG Image	64 KB

Step 36. Use ProjectWise Explorer V8i to create folder in the corresponding data collection year within the FED's ARAN ProjectWise directory with the following name "[ARANNUMBER][YYYYMMDD (for last day of collection in batch)]" (e.g., "A3_20170725"). Import all items into the created folder including the FED QC Spreadsheet, the ARAN Field Log, and the folders for each data collection date with the corresponding files.



Step 37. Send email to FED TL to communicate completion of data loading into the Vision Database as well as completion of uploading FED daily field QC files and sample imagery. Include the ProjectWise link of the uploaded folder in the email. This allows the FED TL to start their QA review (ARAN Submittal QA) to determine if any collection is invalid and/or requires recollection prior to the post-processing procedures.

5.02 ARAN SUBMITTAL QA

5.02.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Field Explorations Division (FED) to perform quality assurance (QA) of the data collected using the Automatic Road Analyzer (ARAN) survey vans before those data are submitted to the Data Processing Team (DPT). The ARAN collected data are subject to additional quality checks by other teams of the MDOT-SHA Office of Materials Technology (OMT) in subsequent stages of their Pavement Management System (PMS)[06/12/2019].

5.02.02 *Frequency*

The QA of an ARAN data submittal starts every time a batch of ARAN collected data is uploaded to a Vision Database by the DPT, which typically occurs every 4 to 5 days. Assuming an average of 60 miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data. The actual frequency varies according to the proximity of the routes on which data were collected for the data batch to the OMT office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring data recollection. The annual ARAN data collection season typically lasts from March to Mid-December.

5.02.03 *Purpose*

The purpose of this SOP is for the FED staff to assure that the data collected using the ARAN survey vans are of acceptable quality before they are delivered to other OMT teams and SHA offices for their use in various PMS applications. For example, Right-of-Way (ROW) images are submitted by the FED to SHA offices other than the OMT.

5.02.04 *Resource Requirements*

The QA of the ARAN data submittal involves two people: (1) a reviewer of ARAN data who performs the QA checks and (2) a supervisor who, as required, makes decisions based on the QA results on whether or not to recollect data on one or more routes where data have already been collected. The estimated effort levels in the table below represent the total time, in man-hours, to perform the QA of the ARAN data submittal.

Position	Function	Resources	Effort Level (man-hrs)
FED Staff	Reviewer	1	1.0-24.0[06/12/2019]
FED TL	Supervisor	1	AR[06/12/2019]

5.02.05 *Procedure*

The procedure to perform QA of the ARAN data submittal is comprised of the following six tasks:

(1) preliminary actions,
(2) QA of International Roughness Index (IRI) data,
(3) QA of ARAN daily settings,
(4) QA of images,
(5) reporting of QA results, and
(6) decision to recollect.

The ARAN data elements inspected during the quality checks in this SOP are IRI measurements, settings used during data collection, and the different images produced by the system: Right-of-Way (ROW), Left Camera (Left), and laser crack measurement system range (LCMSRange) and intensity (LCMS3D) images. The QA of IRI data checks for completeness and validity of testing conditions. The QA of ARAN daily settings is performed to verify that the setting used during each data collection day were the ones intended. The QA of images checks for their completeness and fidelity.

The following steps describe the process conducted by members of the FED to QA the ARAN data submittal:

1- Preliminary Actions - *performed by Reviewer*

Summary: This task identifies the ARAN submittal to be checked, removes previously reviewed runs from QA list and initializes a new submission spreadsheet.

Step 1. Open the server folder containing the ARAN submittal data. A link to the ARAN submittal's folder is provided in the email sent by the DPT to notify completion of the data loading into the Vision database (see Loading of ARAN Data into Vision). Clicking the link will automatically navigate to the submittal folder. If the link is not included in the completion notification, then contact the DPT TL to request information on the location of the server folder with the ARAN submittal data.

Step 2. Identify previously collected routes – Print a copy of the scanned field daily log and compare it with the log from the submittal immediately prior to the one in question for the corresponding ARAN survey van to detect if any of reported runs have already been reviewed. Duplicate runs are sometimes collected by the ARAN crew due to routing strategies and other reasons. Cross off the duplicate runs, if any.

Step 3. Initialize sheet for new submission in yearly spreadsheet (see image below). Run MS Excel and open the "QA yearly spreadsheet" corresponding to the specific ARAN survey van associated with the submittal under review. The QA yearly spreadsheet is named as "[YYYY]_Aran[VanNumber] [ReviewerInitials]" (e.g., "2017_Aran4_BE") and it is stored in the reviewer's computer. Create a new sheet and name it as "[ARAN_Number] [YYYYMMDD]" (e.g., "A3_20170807"). Once the new sheet has been named, copy the columns and sections for "FED QC Report," "Settings", and "Images" from the sheet with the last ARAN submittal information, paste them into the new sheet, and clear out each of the sections.

	A	B	C	D	E	F	G	H
1	FED QC Report	County	Route	Direction	Error (s)			
2								
3								
4	Settings							
5								
6								
7	Images	County	Route	Direction	Error (s)			
8								
9								
10								

2- QA of IRI Data - performed by Reviewer

Summary: This task creates and populates a spreadsheet which evaluates the fidelity of the collected IRI data. The spreadsheet checks both completeness of IRI data and the speed at which the measurements were taken.

Step 4. Open the following two files using MS Excel:

i. "FED_QC_100000.csv," located in the submittal's folder (see Step 1), and

ii. "IRI Review" spreadsheet, located on the Reviewer's computer. This spreadsheet has the IRI QA checks pre-loaded.

Step 5. Copy all the data from the "FED_QC_1000000" spreadsheet (do not copy the column headers) and paste it into the "IRI Review" spreadsheet at cell "J3" (see image below). The IRI QA results for each run are reported on columns "Right IRI Check," "Left IRI Check" and "Avg Speed." The values in these three columns will refresh automatically once the new values are pasted. Flagged values are marked with a red cell background, as illustrated in the image below.

	A	B	C	F	I	J	K	L	M	N	O	P	
1						Paste Data							
2	Unique Run	Right IRI Check	Left IRI Check	Avg Speed		IDLocator	L_Cou	L_RouteID	L_Di	UniqueRun	CollectionVehicle	DCSTimeStamp	IDS
3	77O0S3O7	101%	101%	31.72905089		4333	MO	MD 117	W	77O0S3O7	1723	7/24/2017 10:19	
4	77O0T3KT	100%	100%	31.3110018		4340	MO	MD 121	N	77O0T3KT	1723	7/24/2017 10:38	
5	77O0U3D0	103%	103%	28.21060558		4342	MO	MD 121 A	N	77O0U3D0	1723	7/24/2017 10:55	
6	77O0U3KO	102%	101%	25.05675947		4343	MO	MD 121 A	S	77O0U3KO	1723	7/24/2017 11:00	
7	77O0W3TT	100%	100%	32.37654446		4341	MO	MD 121	S	77O0W3TT	1723	7/24/2017 11:49	
8	77O0X3BM	101%	100%	35.29115523		4333	MO	MD 117	W	77O0X3BM	1723	7/24/2017 11:59	
9	77O0X3XT	100%	100%	33.86766013		4332	MO	MD 117	E	77O0X3XT	1723	7/24/2017 12:13	
10	77O0Z3JB	102%	102%	23.84680658		4335	MO	MD 117 A	W	77O0Z3JB	1723	7/24/2017 12:47	
11	77O0Z3N9	106%	105%	24.91380385		4334	MO	MD 117 A	E	77O0Z3N9	1723	7/24/2017 12:49	
12	77O103HI	101%	101%	40.45615741		4338	MO	MD 119	N	77O103HI	1723	7/24/2017 13:08	
13	77O113WA	100%	100%	41.82077466		4339	MO	MD 119	S	77O113WA	1723	7/24/2017 13:38	
14	77P0X3FX	106%	105%	23.17114576		4458	MO	MD 594 A	E	77P0X3FX	1723	7/25/2017 12:02	
15	77P0Y38A	106%	105%	21.5523209		4459	MO	MD 594 A	W	77P0Y38A	1723	7/25/2017 12:19	
16	77P0Y38B	131%	116%	13.19156374		4462	MO	MD 594 C	E	77P0Y38B	1723	7/25/2017 12:19	
17	77P0Y3TE	154%	135%	10.62384887		4463	MO	MD 594 C	W	77P0Y3TE	1723	7/25/2017 12:32	
18	77P0Z331	115%	113%	12.46492211		4460	MO	MD 594 B	E	77P0Z331	1723	7/25/2017 12:37	
19	77P0Z330	116%	114%	12.14573228		4461	MO	MD 594 B	W	77P0Z330	1723	7/25/2017 12:37	
20	77P1031D	102%	102%	22.21893811		4376	MO	MD 195	N	77P1031D	1723	7/25/2017 12:58	
21	77P103PZ	105%	109%	17.86084131		4378	MO	MD 195 A	N	77P103PZ	1723	7/25/2017 13:13	

Step 6. Report every flagged run from the IRI completeness check or the IRI measuring speed check into the "FED QC Report" section of the "QA submittal review" spreadsheet by copying their "Unique Run" number and commenting on with the "Unique Run" number and the text "Bad IRI" (see below image). The IRI completeness check consists of reviewing the percentage of IRI values (either from the left or right sensor) missing for the run. Flagged values in the "Right IRI Check" and "Left IRI Check" columns indicate that 25% or more of the IRI measured data for the run are missing. The IRI measuring speed check is performed to detect if the speed at which the ARAN van collected the IRI values was under the acceptable threshold of 35 miles per hour. Flagged values in the "Avg Speed" column indicate the testing speed for the run was lower than acceptable. Once reporting of all flagged runs has been completed, save the "IRI Review" spreadsheet under the name "Aran_[ARAN_Number]_ [MMDD]_IRI_Fidelity" using the MS Excel file extension.

FED QC Report	
7970X4PX	Bad IRI
797164NW	Bad IRI
79B0P4JH	Bad IRI

3- QA of ARAN Daily Settings - performed by Reviewer

Summary: This task creates and populates a spreadsheet which evaluates the accuracy of ARAN settings. The spreadsheet performs a side by side comparison of setting values for the data submittal and the pre-loaded functions. Conflicts with setting inputs are reported as errors.

Step 7. Open the ARAN daily settings file corresponding to the first data collection day of the submittal using a text editor software. The ARAN settings file for each data collection day is located in the sub-folder for the corresponding day within the server submittal's folder (see Step 1). The ARAN settings files are named as "MD[Number]_Settings_[YYYYMMDD].xml" (e.g., "MD854682_Settings_20170713.xml).

Step 8. Open the ARAN settings review spreadsheet in MS Excel and select the sheet corresponding to the ARAN associated with the submittal data (e.g., ARAN 3). This spreadsheet contains the ideal setting values for each of the ARAN survey vans and it is used as the reference to check if the ARAN daily settings used in the field were the correct ones. The ARAN settings may differ between ARAN vans.

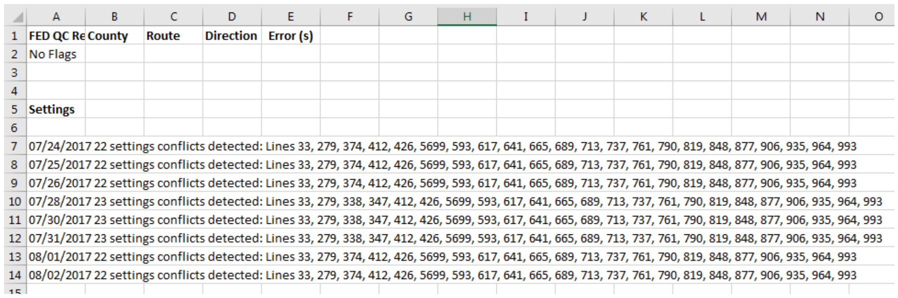
Step 9. Copy everything from the ARAN daily settings file, and paste it into the settings review spreadsheet in cell "A2" (see below image).

	A	N	P	R	AA	AB
1	PASTE ARAN 3 DATA INTO BLUE CELL	Difference	6/2/2017			
2	<?xml version="1.0" encoding="utf-8"?>	0		<?xml version="1.0" encoding="utf-8"?>		
3	<ARANSettings>	0		<ARANSettings>		
4	<misc>	0		<misc>	Error Count	15
5	<ACS_Version>	0		<ACS_Version>		
6	<Version>2.3.1.45</Version>	0		<Version>2.3.1.45</Version>		
7	<Platform>x64</Platform>	0		<Platform>x64</Platform>		
8	</ACS_Version>	0		</ACS_Version>		
9	<ARAN_Name>	0		<ARAN_Name>		
10	<Name>MD85682</Name>	0		<Name>MD85682</Name>		
11	</ARAN_Name>	0		</ARAN_Name>		
12	</misc>	0		</misc>		
13	<calibrations>	0		<calibrations>		
14	<AreaScanCalibration>	0		<AreaScanCalibration>		
15	<StrobeDelay DataType="float">0.055337</StrobeDelay>	0		<StrobeDelay DataType="float">0.055337</StrobeDelay>		
16	<TransOverlap DataType="int">0</TransOverlap>	0		<TransOverlap DataType="int">0</TransOverlap>		
17	<TopMargin DataType="int">0</TopMargin>	0		<TopMargin DataType="int">0</TopMargin>		
18	<LeftMargin DataType="int">0</LeftMargin>	0		<LeftMargin DataType="int">0</LeftMargin>		
19	<RightMargin DataType="int">0</RightMargin>	0		<RightMargin DataType="int">0</RightMargin>		
20	<BottomMargin DataType="int">0</BottomMargin>	0		<BottomMargin DataType="int">0</BottomMargin>		
21	<YDistPerPixel DataType="float">0.00154</YDistPerPixel>	0		<YDistPerPixel DataType="float">0.00154</YDistPerPixel>		
22	<XDistPerPixel DataType="float">0.00154</XDistPerPixel>	0		<XDistPerPixel DataType="float">0.00154</XDistPerPixel>		
23	<ImageOffset DataType="int">0</ImageOffset>	0		<ImageOffset DataType="int">0</ImageOffset>		
24	<EffectiveDate DataType="datetime">May 5 2016 11:12AM</EffectiveDate>			<EffectiveDate DataType="datetime">May 5 2016 11:12AM</EffectiveDate>		
25	</AreaScanCalibration>	0		</AreaScanCalibration>		
26	<BridgeClearanceCalibration>	0		<BridgeClearanceCalibration>		
27	<LeftOffset DataType="float">0</LeftOffset>	0		<LeftOffset DataType="float">0</LeftOffset>		
28	<CenterOffset DataType="float">0</CenterOffset>	0		<CenterOffset DataType="float">0</CenterOffset>		

Step 10. Once the ARAN daily settings values have been pasted into the settings review spreadsheet, the spreadsheet will automatically perform a line-by-line comparison between setting values through its pre-loaded functions. The output from this comparison consists of the count of lines with differences in the settings, referred to as "Error Count" (as presented in the top right corner

of the above image where 15 differences were found). Each line of the ARAN daily settings in conflict with the reference setting values is flagged in red color.

Step 11. Report the "Error Count" for the ARAN daily settings, as well as each of the line numbers in conflict with the reference settings, into the "Settings" section of the yearly spreadsheet separating by data collection date (as shown in the image below).



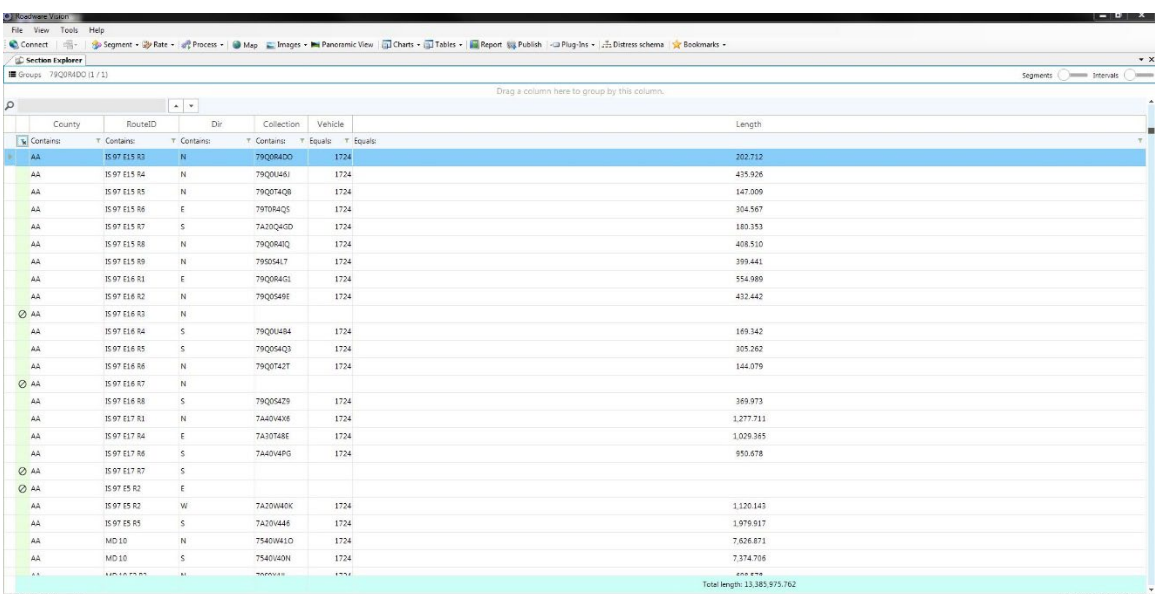
	A	B	C	D	E
1	FED QC Re	County	Route	Direction	Error (s)
2	No Flags				
3					
4					
5	Settings				
6					
7	07/24/2017 22 settings conflicts detected: Lines 33, 279, 374, 412, 426, 5699, 593, 617, 641, 665, 689, 713, 737, 761, 790, 819, 848, 877, 906, 935, 964, 993				
8	07/25/2017 22 settings conflicts detected: Lines 33, 279, 374, 412, 426, 5699, 593, 617, 641, 665, 689, 713, 737, 761, 790, 819, 848, 877, 906, 935, 964, 993				
9	07/26/2017 22 settings conflicts detected: Lines 33, 279, 374, 412, 426, 5699, 593, 617, 641, 665, 689, 713, 737, 761, 790, 819, 848, 877, 906, 935, 964, 993				
10	07/28/2017 23 settings conflicts detected: Lines 33, 279, 338, 347, 412, 426, 5699, 593, 617, 641, 665, 689, 713, 737, 761, 790, 819, 848, 877, 906, 935, 964, 993				
11	07/30/2017 23 settings conflicts detected: Lines 33, 279, 338, 347, 412, 426, 5699, 593, 617, 641, 665, 689, 713, 737, 761, 790, 819, 848, 877, 906, 935, 964, 993				
12	07/31/2017 23 settings conflicts detected: Lines 33, 279, 338, 347, 412, 426, 5699, 593, 617, 641, 665, 689, 713, 737, 761, 790, 819, 848, 877, 906, 935, 964, 993				
13	08/01/2017 22 settings conflicts detected: Lines 33, 279, 374, 412, 426, 5699, 593, 617, 641, 665, 689, 713, 737, 761, 790, 819, 848, 877, 906, 935, 964, 993				
14	08/02/2017 22 settings conflicts detected: Lines 33, 279, 374, 412, 426, 5699, 593, 617, 641, 665, 689, 713, 737, 761, 790, 819, 848, 877, 906, 935, 964, 993				

Step 12. Repeat Step 7 to Step 11 for each data collection day in the ARAN submittal data.

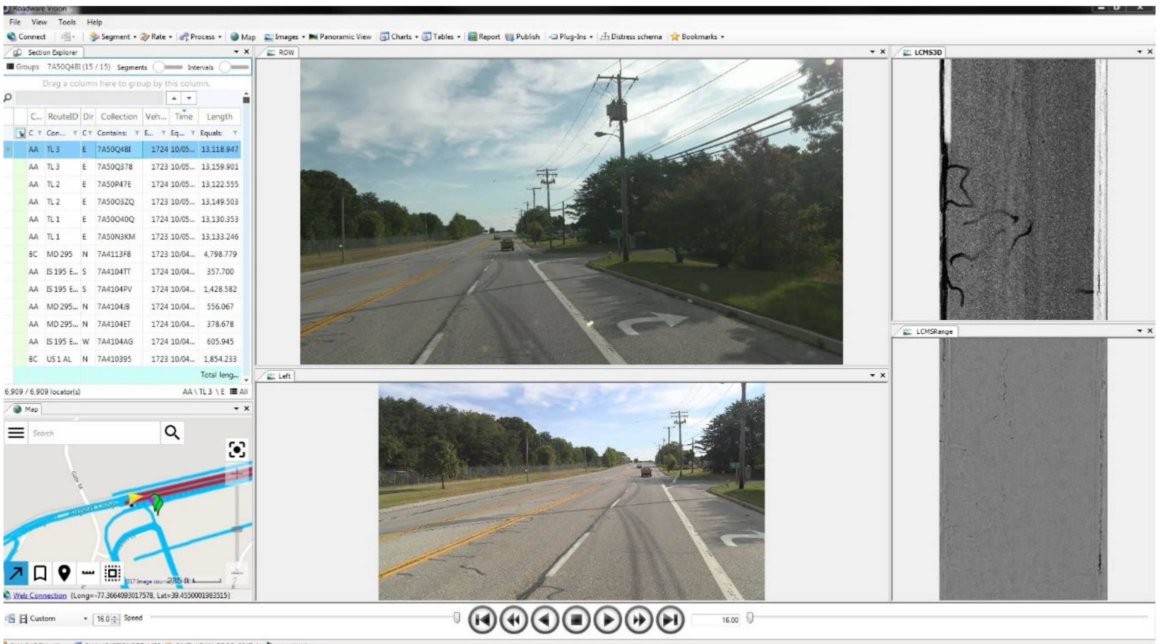
4- QA of Images - performed by Reviewer

Summary: This task uses Vision software to check for abnormalities in the collected images from the ARAN data submittal and reports any issues found in the "Submittal Review Spreadsheet."

Step 13. Open Roadware Vision software[06/12/2019]. A screen with a list of projects will appear (see below image). Select project "OMT_ARAN_PROD_2017_1" and click on the "OK" button. If the project is not listed, Reviewer should contact MDOT-SHA Information Technology (IT) staff for assistance with connecting the correct project folder to Reviewer's account.



Step 14. Load or set up Vision workspace. If no workspace in Vision is saved, or if the workspace is to be changed, set up the workspace as preferred containing, as a minimum, the Section Explorer, the ROW, Left, LCMS3D, and LCMSRange images, and the map window. The various image windows are opened using the "Images" button on the menu ribbon. With the map window open, click on the "Main Menu", "Base Maps" button within the "Map" window and add the basemap of choice (e.g., "Google Map"). Once workspace set up is finalized, save it using "File", "Save Workspace" to make it available for future QA of Images. If a workspace in Vision is available, load it from "File", "Select Workspace".



Step 15. The "Section Explorer" will show the list of all runs collected for the project. Double click on the first (see above image).

Step 16. Find runs to review from the list of runs marked in the printed daily logs reported by the ARAN crew members. Ignore duplicate runs previously checked as a part of the previous submittal (crossed out runs in the daily log, as described in Step 2). For this:

i. Right click anywhere at the top bar in the "Section Explorer" window in Roadware Vision. Double click on time to reveal the data collection date for each unique run. Scroll up or down to the point at which the ARAN submittal begins, as indicated in the field daily log.

ii. Type in code "1723"—if submittal data is from ARAN 3—or code "1724" —if submittal data is from ARAN 4—under the "Vehicle" column to filter out runs collected by ARAN vans other than the one corresponding to the submittal under review.

Step 17. Select the run to review and click on the "Play" button at the bottom of Roadware Vision to begin reviewing the images in the submittal. Set the image rate to 8 (every 1/8 frame of the submittal) and speed to ~80% (moderate percent). This should be done based on personal preference.

Step 18. Look for abnormalities during the visual inspection, such as:

i. Missing images,

ii. Improper lighting (images too bright or too dark),

iii. Presence of spots blocking the vision—such as water drops, and

iv. Other abnormalities in the images.

Hit the “Stop” button every time an abnormality is detected and report the issue in the “Image QC” section of the Submittal Review Spreadsheet annotating the collection name and the frame at which the issue occurred (as shown in the image below).

FED QC Report				
No Flags				
Settings				
09/26/2017 5 settings conflicts detected: Lines 33, 338, 347, 509, 543				
09/28/2017 5 settings conflicts detected: Lines 33, 338, 347, 509, 543				
09/29/2017 4 settings conflicts detected: Lines 33, 347, 509, 543				
10/02/2017 4 settings conflicts detected: Lines 33, 347, 509, 543				
10/03/2017 5 settings conflicts detected: Lines 33, 338, 347, 509, 543				
10/04/2017 4 settings conflicts detected: Lines 33, 347, 509, 543				
Images	**County**	**Route**	**Direction**	**Error (s)**
79Q0R4RE	AA	IS 97 E15 R 2	W	No left images after frame 316
79Q0S49E	AA	IS 97 E16 R2	N	No left images 288-320, 328-376, 392-432
79Q0S4J5	AA	IS 895 B E3B R2	E	No left image at 1,160
7A30S45G	AA	MD 3 E7 R7	N	ROW No input signal 96-290

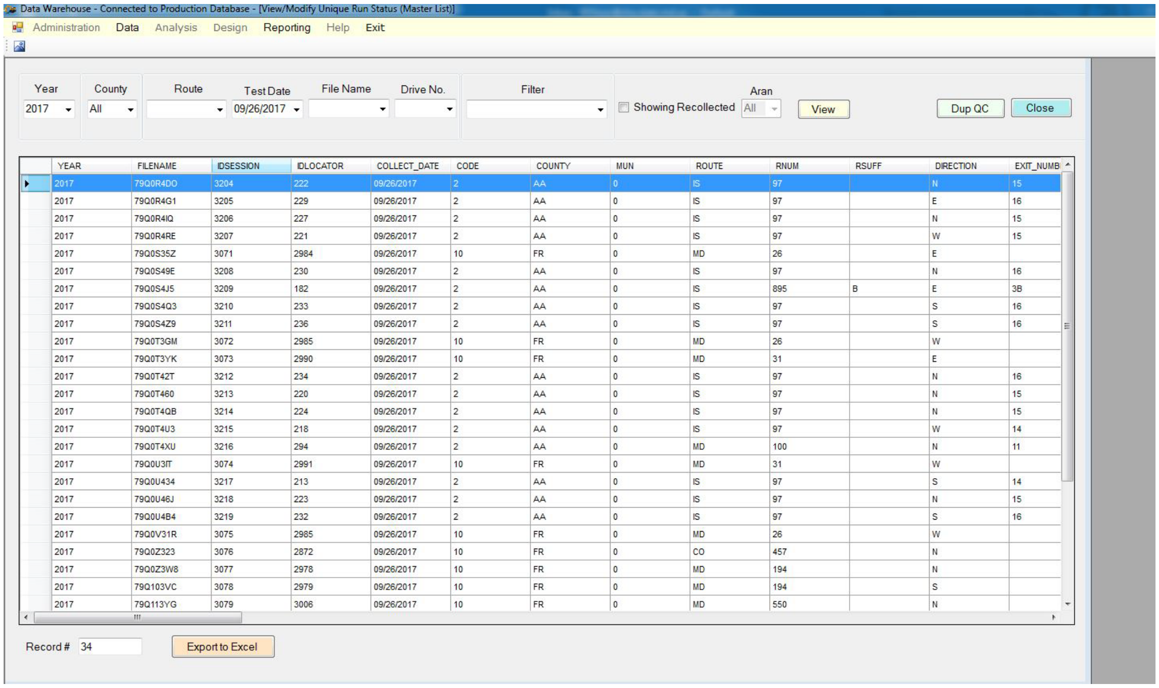
Step 19. Repeat Step 17 and Step 18 for each run in the submittal until all issues for every run have been reported in the Submittal Review Spreadsheet.

5- Reporting of QA Results - performed by Reviewer

Summary: This task uses the Engineering Data Warehouse software to input the results of the previous checks for each run collected in the ARAN data submittal. This task also results in an email submission indicating the reviewer’s portion of the data submittal QA is complete.

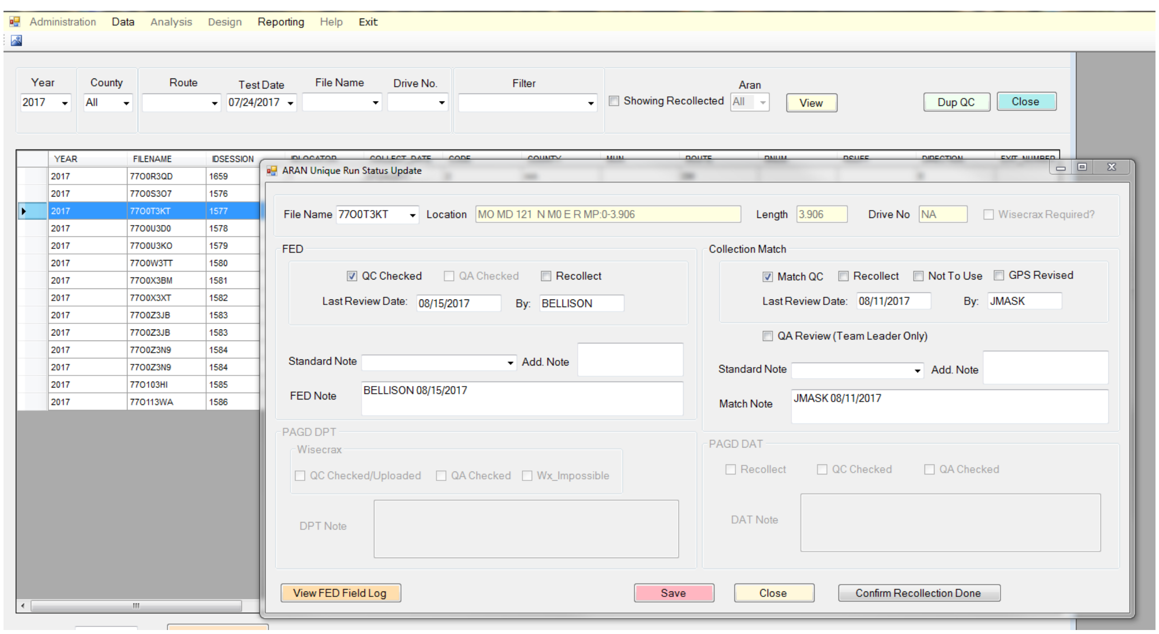
Step 20. Open the Engineering Data Warehouse (EDW) software and navigate to “Data”, “ARAN”, “View/Edit Unique Run Status.”

Step 21. The Engineering Data Warehouse will populate with list of runs completed (see below image). Complete the QA information for each data collection run of the submittal. (generally each run has one route)



i. Select “Year”, “County”, and “Test Date” to find the corresponding runs for each submittal (see above image).

ii. Double click on the reviewed runs, type in relevant notes (add a “Standard Note” using drop-down list or a custom note in the “Add Note” field), press Save, and check off the “QC reviewed” button in the next window that opens (see below image).



Repeat Step 21 until the QA information for each run in the ARAN data submittal is inputted into the Engineering Data Warehouse[06/12/2019].

Step 22. Reply to the original notification email from the DPT (see Step 1) communicating that the QA of the submittal has been completed (see below image).

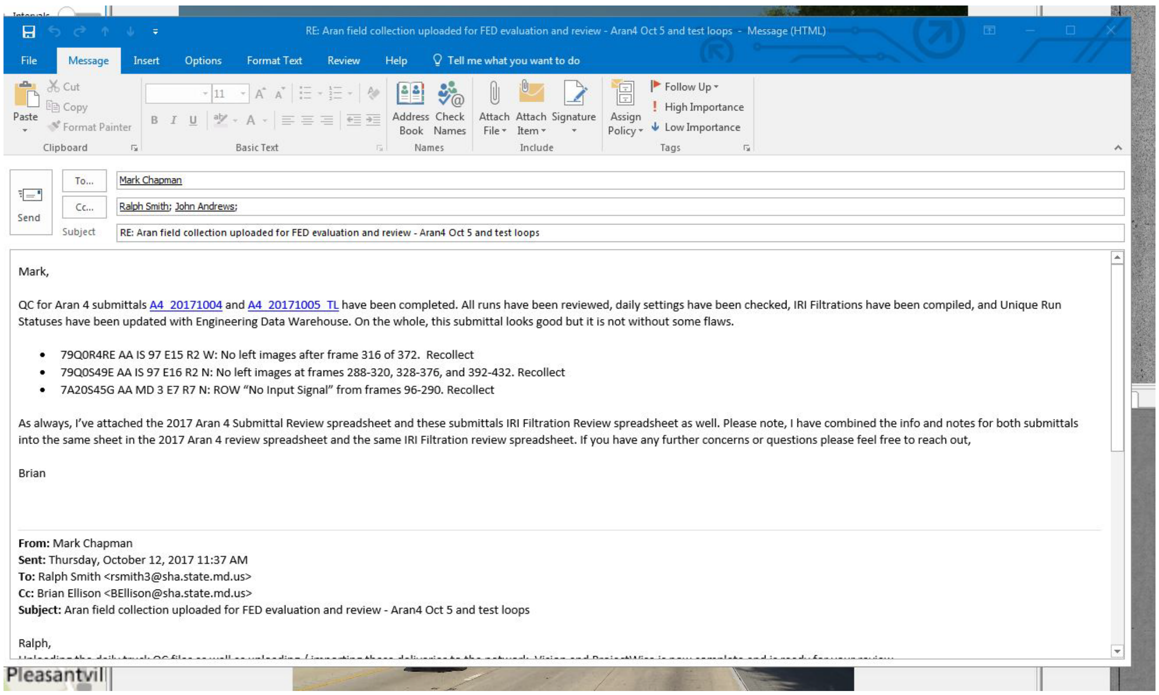
i. Post a link to the submittal's server folder in reviewer's email by copying the link that was provided in the original email.

ii. Attach Reviewer's Submittal Review Spreadsheet.

iii. Attach Reviewer's IRI Fidelity spreadsheet.

iv. Include list of major issues detected during conduct of QA review checks, if any, performed on the ARAN data submittal that Reviewer considers important to highlight.

v. Submit email to Supervisor and copy to DPT Team Leader and DWT Team Leader.



6- Decision To Recollect - *performed by Supervisor*

Summary: This task performs necessary checks of the reviewer's tasks for the review of an ARAN data submittal.

Step 23. Upon receipt of QA submittal email, Supervisor should review errors reported and decide if data should be recollected. The decision to recollect is based on several factors:

i. Data type and completeness.

1. Settings – some setting errors are expected, such as DMI calibration factor (would be different if vehicle was calibrated recently), others are unexpected and could have a more critical influence on data.

2. IRI – check the percentage of incomplete data. If it is determined that a large quantity of data is missing, recollection may be necessary.
3. Video – completeness is an essential component of the deliverable. Decision to recollect is based on percentage of data that is missing or of poor quality. Some cloudiness or minor visual obstructions may be allowable whereas a large amount of light (washed out) images may be a candidate for recollection.

ii. Extent to which the data quality is affected by errors.

iii. Length and type of road where errors occur.

1. Interstate or HPMS sections always get recollected (important to State).
2. Smaller local roads – recollection is typically based on the earlier stated factors, but sometimes decision is made that recollection is not necessary.

iv. Extent of error – Determine if errors are of a localized nature or if they exist across a large amount of data.

When decisions are made to recollect, communicate list of sections where data should be recollected to the ARAN crew.

5.03 POST-PROCESSING OF ARAN GPS DATA

5.03.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to process the Global Positioning System (GPS) data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff. The post-processing of ARAN GPS data is performed in batches throughout the annual data collection season. This SOP applies to the GPS post-processing of each individual ARAN data batch. The post-processing of ARAN GPS data is performed after completion of loading the ARAN data into Vision as outlined in Loading of ARAN Data into Vision. This process results in the generation of ARAN GPS location data for import into the Vision database.

5.03.02 *Frequency*

The post-processing of GPS data is completed every time a batch of ARAN collected data is received by the DPT, which typically occurs every 4 to 5 days. Assuming an average of 60 miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data. The actual frequency varies according to the proximity of the routes on which data were collected for the data batch to the Office of Materials Technology (OMT) office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring data recollection. The annual ARAN data collection season typically lasts from March to Mid-December.

5.03.03 *Purpose*

The purpose of this SOP is to process the ARAN GPS data and perform quality control (QC) and quality assurance (QA) checks.

5.03.04 *Resource Requirements*

The processing of GPS data involves two people: (1) a user knowledgeable in Roadware Vision and POSPac MMS 6.2[06/12/2019] software to process the GPS data and perform QC, and (2) a supervisor who, as required, provides guidance and decision-making and performs QA. The estimated effort levels in the table below represent the total time, in man-hours, to complete the GPS processing and QC/QA checks. These time estimates assume average batch quantities and no issues encountered during processing.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	POSPac/DCS user and QC	1	4.0
DPT TL	Supervisor and QA	1	AR[06/12/2019]

5.03.05 *Procedure*

The POSPac computer on the ARAN van starts collecting data as soon as it is powered on. The data files are around 8 MB in size – whenever a file reaches that general file size, a new file is automatically created. If the POSPac computer is running for the entire data collection day, there would be approximately 160 to 180 daily files. During a typical data collection day, the computer is shut down at least once, resulting in two sets of files (or more depending on the number of shut downs). The image below shows an example set of daily files.

LV201706220717.000	LV201706220842.000
LV201706220717.001	LV201706220842.001
LV201706220717.002	LV201706220842.002
LV201706220717.003	LV201706220842.003
LV201706220717.004	LV201706220842.004
LV201706220717.005	LV201706220842.005
LV201706220717.006	LV201706220842.006
LV201706220717.007	LV201706220842.007
LV201706220717.008	LV201706220842.008
LV201706220717.009	LV201706220842.009

Each set needs to be processed and imported separately. If the wrong POSPac data is imported into the wrong set of files, the GPS mapping for those days will be incorrect and will need reprocessing. The MS Excel Macro code for sorting the list of POSPac file names has been included as an appendix (see POSPac List Files Macro).

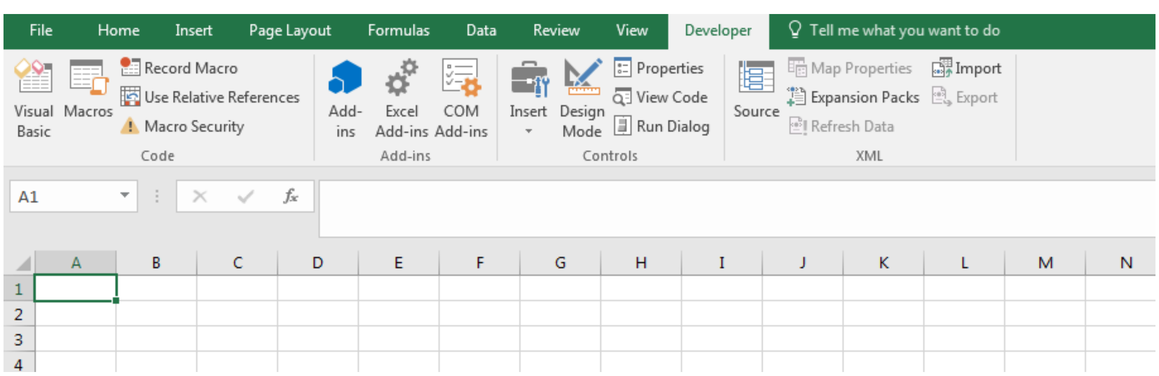
The procedure to process ARAN GPS data and perform QC/QA is comprised of the following three tasks:

(1) processing GPS data,
(2) performing QC of the processed GPS data, and
(3) performing QA of the processed GPS data.

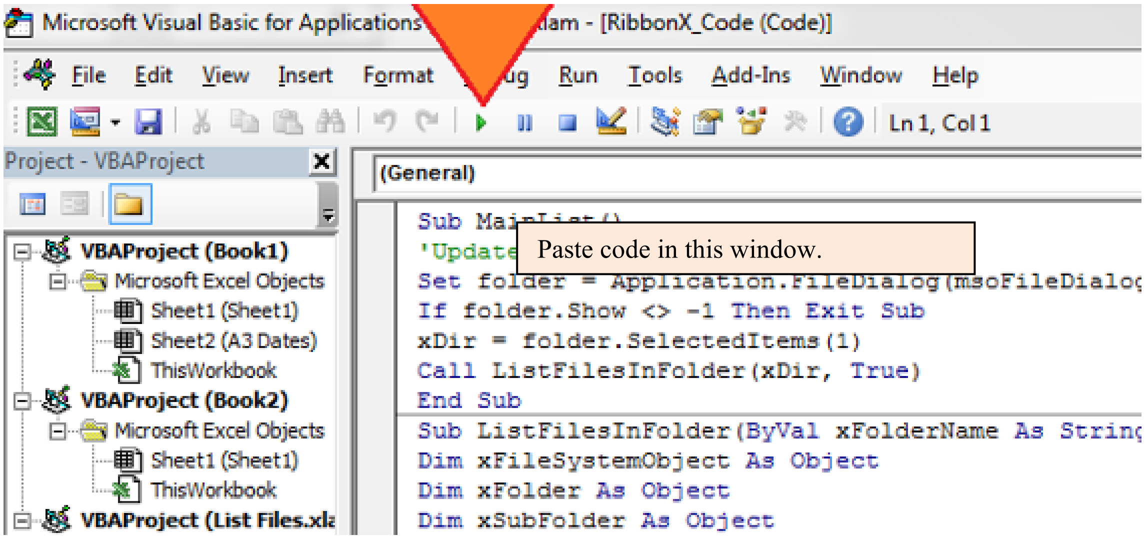
1- Processing GPS Data – *performed by POSPac and DCS user*

Summary: This task uses the POSPac software to process GPS files from the ARAN data submittal and Roadware DCS to import the results into Vision.

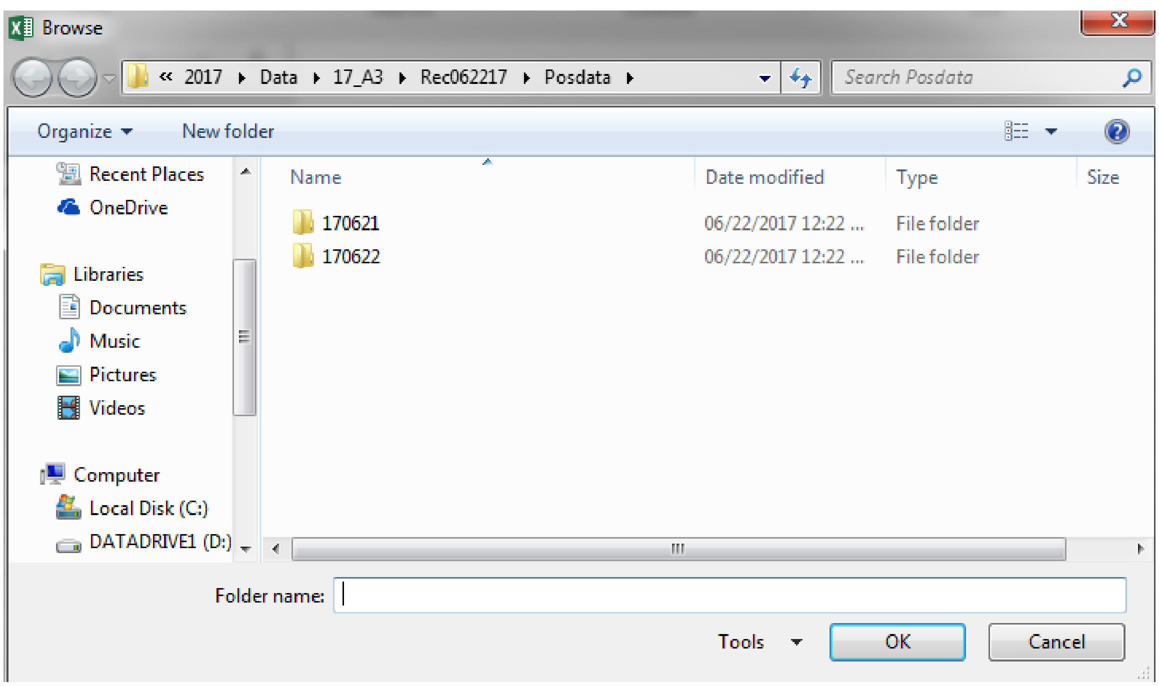
Step 1. Open a blank document in MS Excel. Click on the "Developer" tab. If the tab is not shown, consult the help tool within Excel for directions on how to enable it. Click the "Visual Basic" button (see below image).



Step 2. Copy the MS Excel Macro code provided in POSPac List Files Macro and paste it into the dialogue window in Excel. Click "Run" (see below image).



Step 3. A “Browse” window will pop-up requesting the location of the POSPac files (see below image). The POSPac files should be located in the “Videolog” server folder for the corresponding ARAN data batch, named as “[YYYY]\Data\[YY]_A[ARAN#]\Rec[MMDDYY]\Posdata” (e.g., “2017\Data\17_A3\Rec062217\Posdata”).



If the POSPac files are not on the “Videolog” server, they need to be copied from the hard drive. Roadware DCS copies the files to the video folder, but they are not separated by ARAN number.

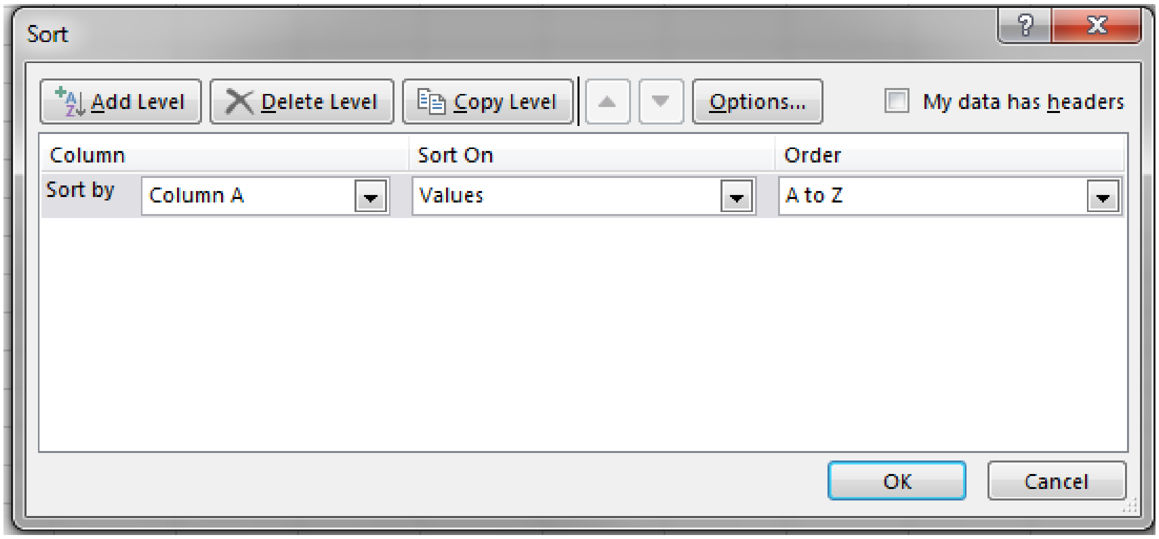
Once the POSPac files are located, select the “Posdata” folder at the above location and click “OK.”

Step 4. Sort the Excel results into different sections.

i. Select the column or highlight the cells that have files listed.

ii. Hit the “Alt” key, followed by the “D” key, followed by the “S” key (do not hold all keys down at once).

iii. The “Sort” window will appear (see below image). Click “OK.”

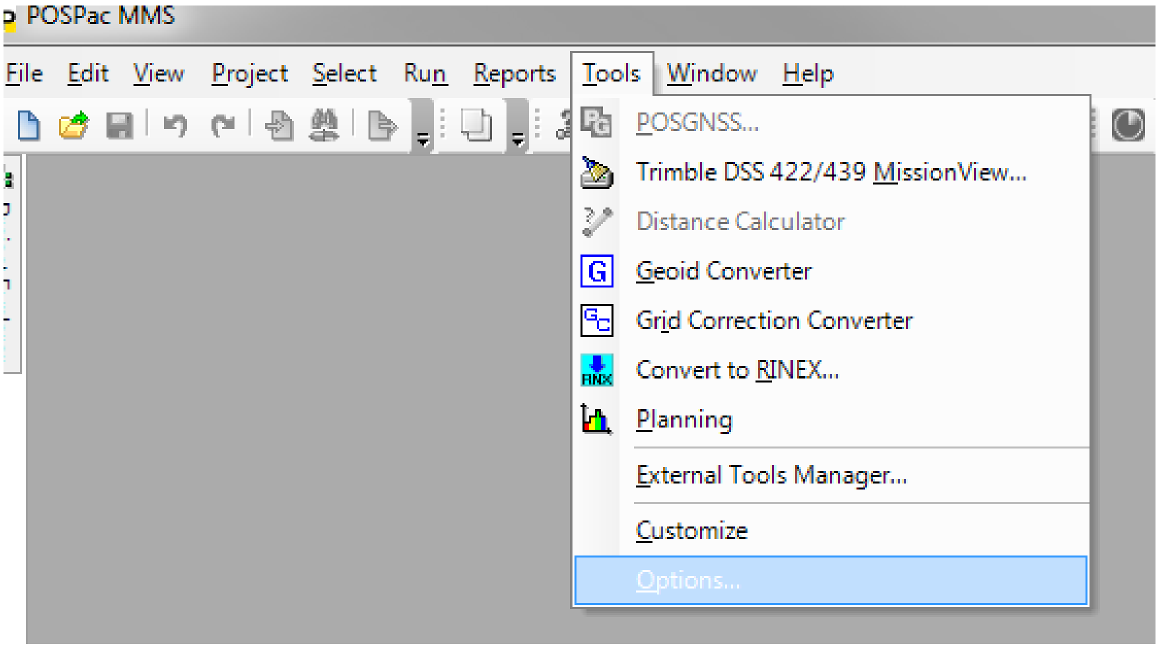


Step 5. Organize the entries by cutting and pasting file sets into separate columns. A file set is defined as a collection of files with the same characters prior to the “.XXX” extension. For example, an entry in Excel that reads “LV201706220717.001” belongs to the file set “LV201706220717” and should be included in the same column as all entries with that pre-extension name. Each file name should have its own column (see below image). The number of file sets is dependent upon the number of computer restarts performed throughout the day. Typically, there will be at least 2 different file sets, but it is not unusual to have more.

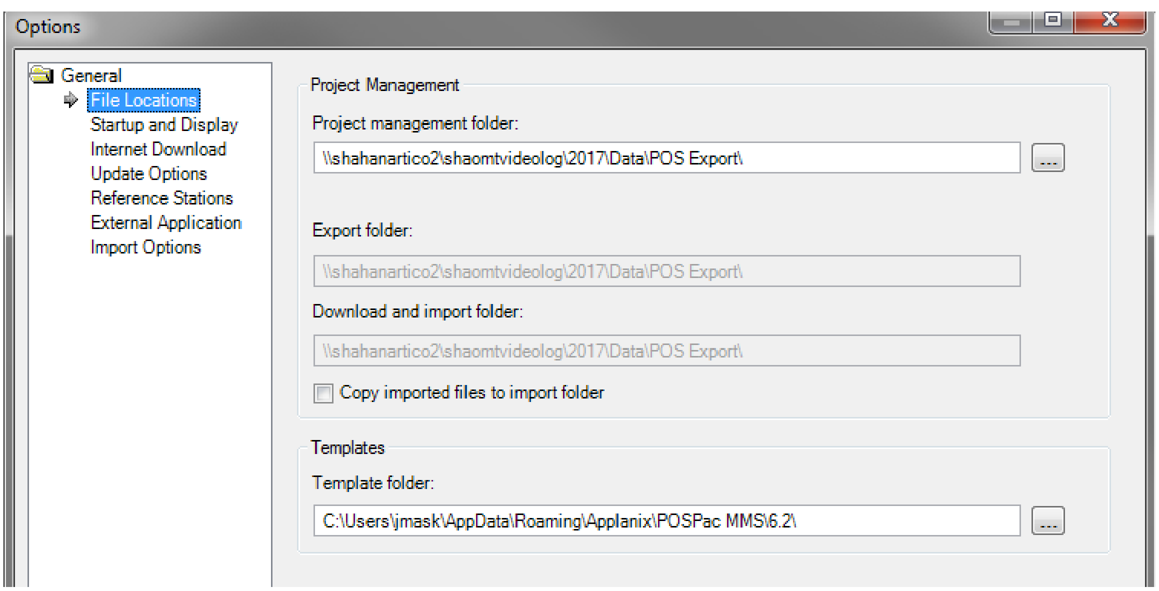
LV201706210751.000		LV201706220717.000		LV201706220842.000
		LV201706220717.001		LV201706220842.001
		LV201706220717.002		LV201706220842.002
		LV201706220717.003		LV201706220842.003
		LV201706220717.004		LV201706220842.004
		LV201706220717.005		LV201706220842.005
		LV201706220717.006		LV201706220842.006
		LV201706220717.007		LV201706220842.007
		LV201706220717.008		LV201706220842.008
		LV201706220717.009		LV201706220842.009
		LV201706220717.010		LV201706220842.010

Step 6. Open the POSPac MMS 6.2 program by clicking on the “POSPac” icon (see below image) located on the Desktop. Start-up screen once program is opened may appear different depending on user’s computer settings and previous experience with POSPac. Search for the POSPac MMS 6.2 file using the windows explorer if the desktop shortcut is not available.

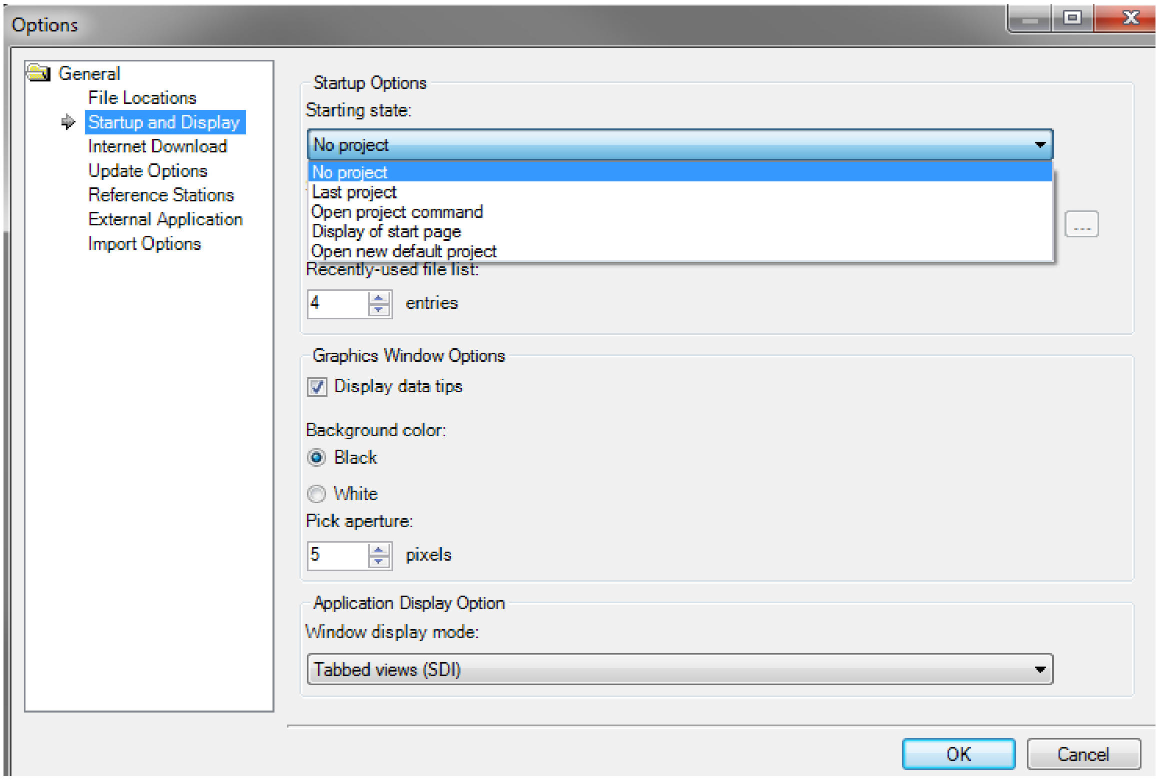
Step 7. Click on the “Tools” drop-down menu and select *Options* (see below image).



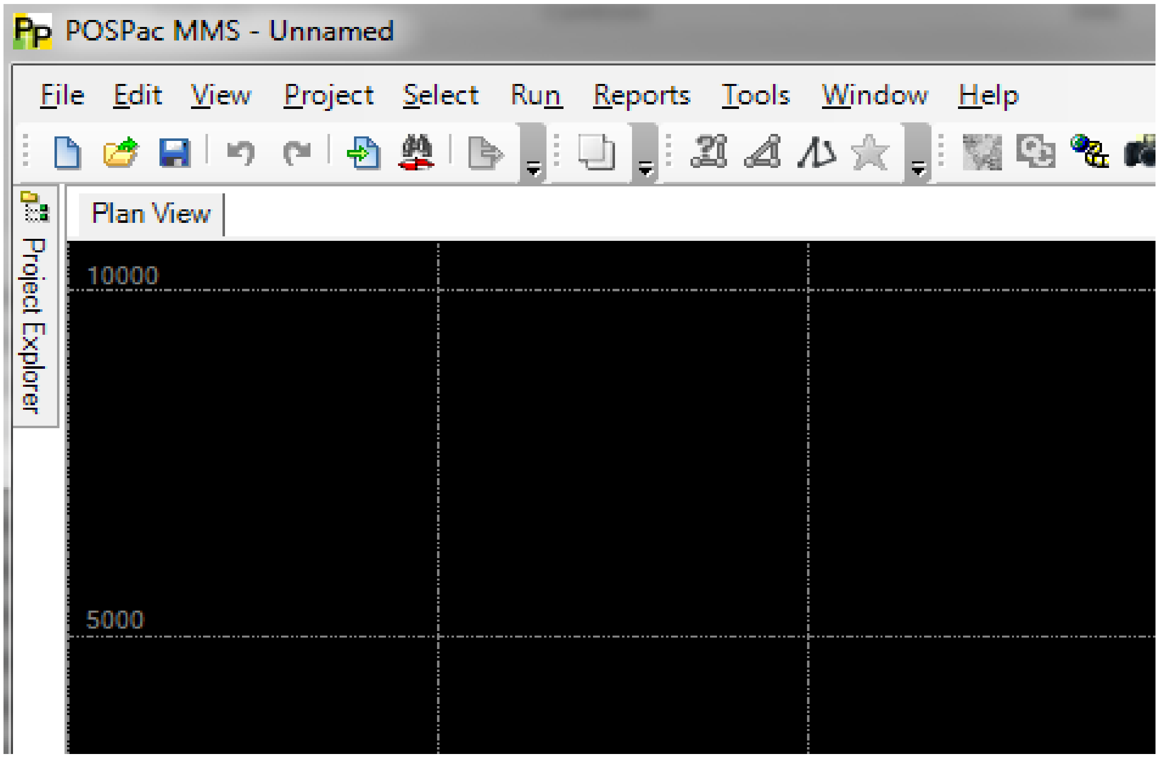
Confirm that the “Project management folder” location, under the “File Locations” menu (see below image), is pointed to the correct “Videolog” server folder location: “\\shahanartico2\shaomtvideolog\[YEAR]\Data\POS Export\”. Otherwise, click the “…” button and browse to that location. Click “OK.” If this is the beginning of the data collection season, the folders for “Data” and “POS Export” will need to be created before this step.



Step 8. If desired, the starting state may also be changed under the "Startup and Display" menu (see below image). In most cases, the most convenient setting is "Open new default project." Click "OK" to exit the "Options" window and save setting changes.

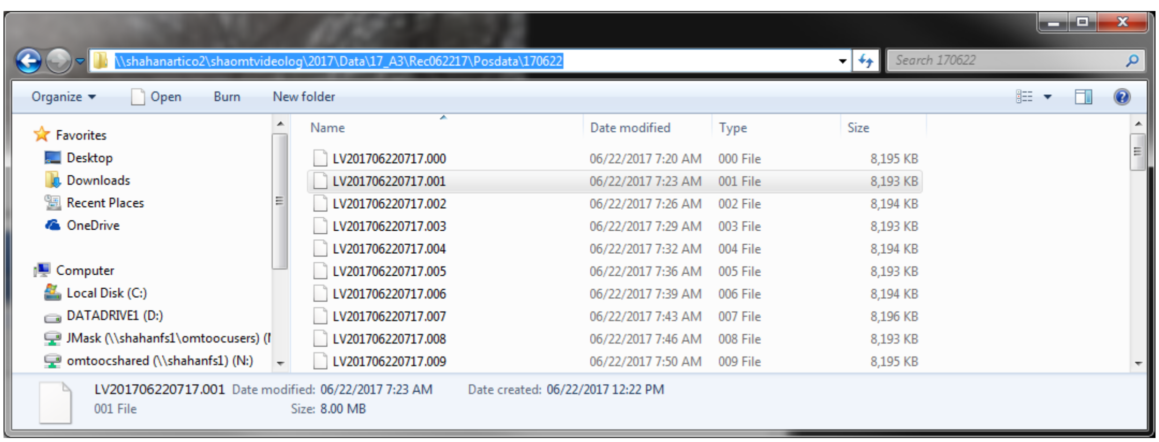


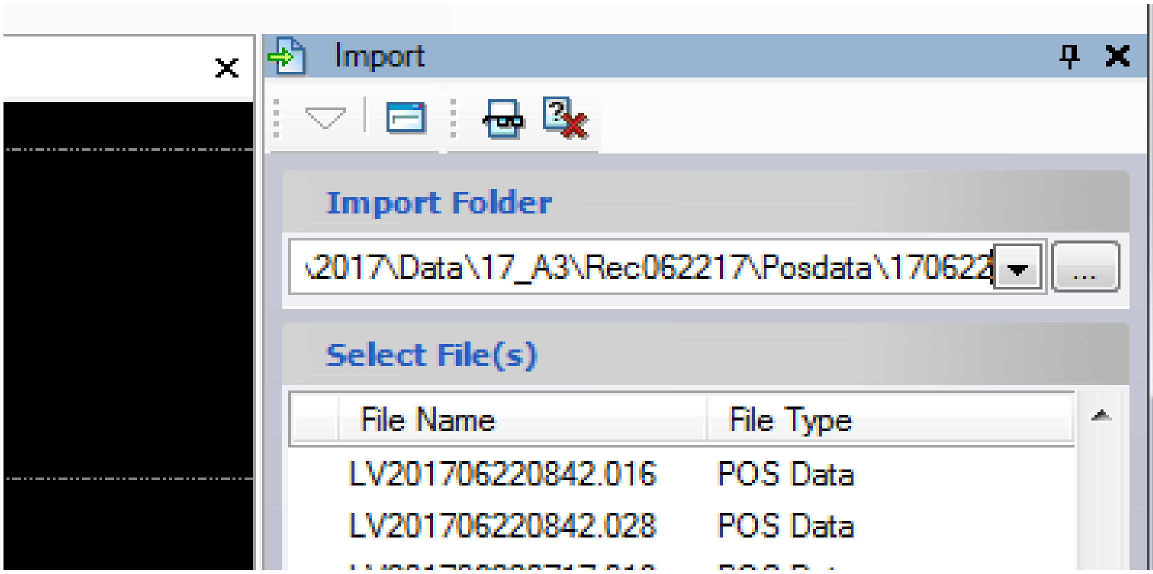
Step 9. A new project should now be created in POSPac MMS (see below image). If not, click the "New Default Project" button. Then, click the "Import" button.



An import window will appear on the right-hand side of the program. If the program has been used before, the window will display the last files that were imported. Otherwise, it will be blank.

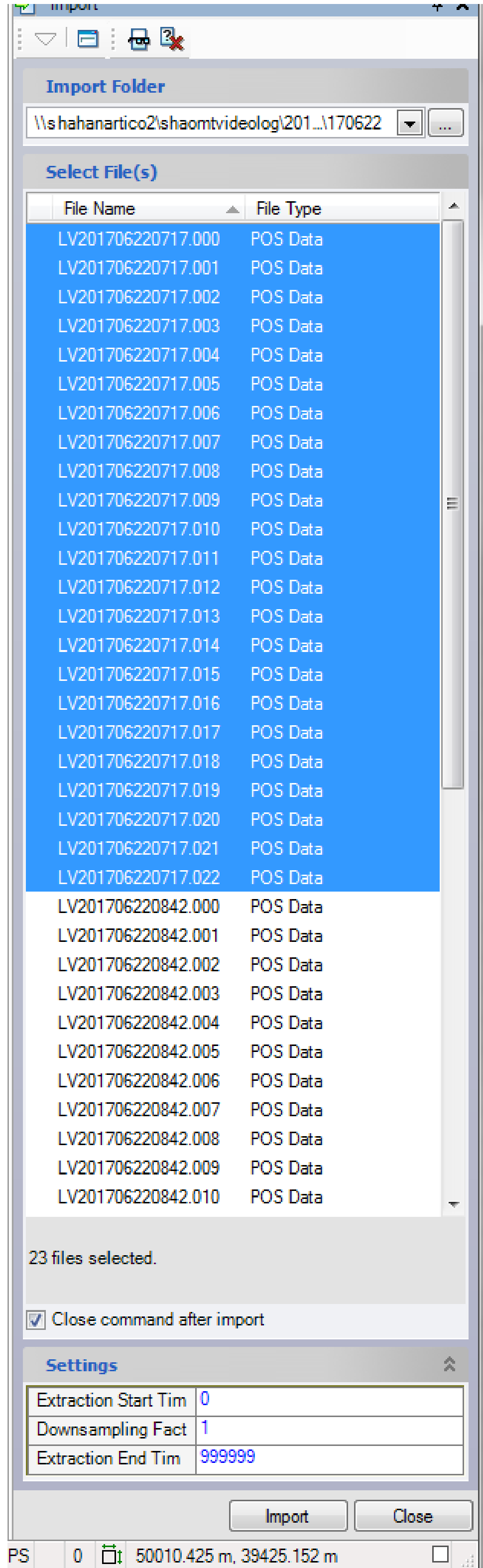
Step 10. Using "Windows Explorer", navigate to the file location of the POSPac files. Copy the address displayed at the top of the window. Paste the address in the "Import Folder" dialogue box in the POSPac Import window (see images below).



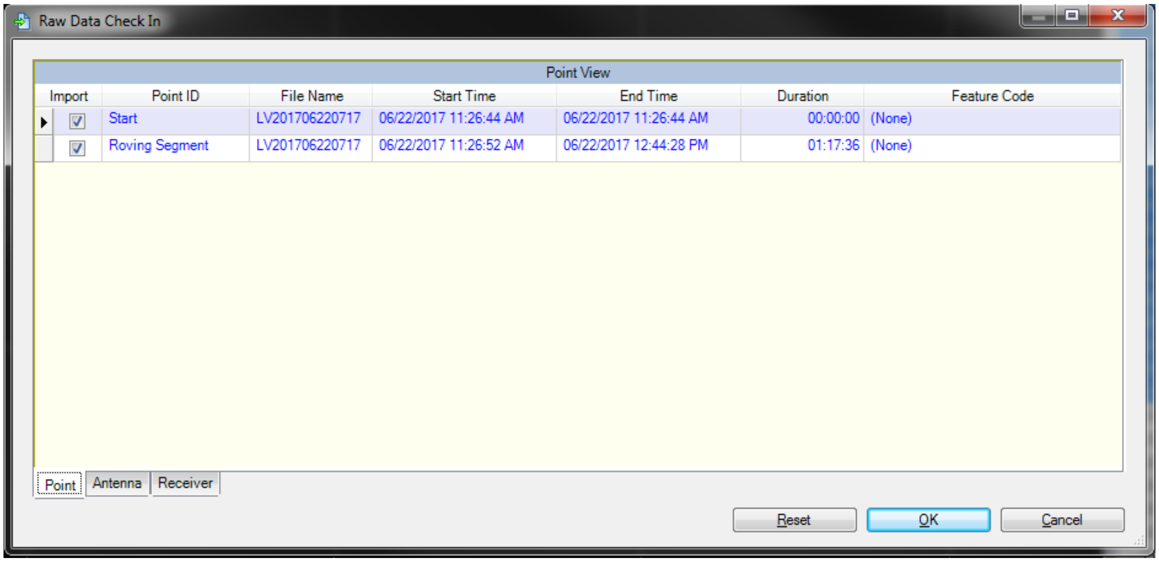


After pasting the address, do not hit enter. The program will automatically show the POSPac files after pasting the address.

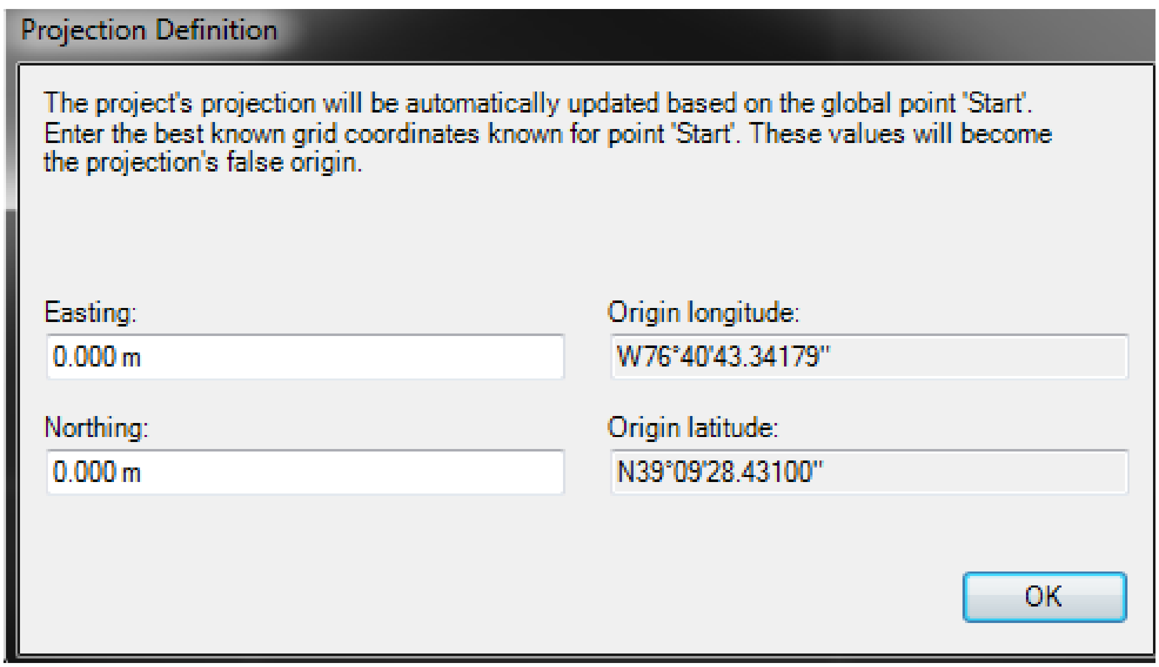
Step 11. Import the first file set. Click the "File Name" column. This will sort the file names (see below image). Compare the sorted list in the POSPac Import window to the Excel sheet with the sorted columns created in Step 1 to Step 5. All file sets will be displayed in the POSPac Import window. However, each set must be processed individually. Using the Excel sheet as a guide, select only the first set of files in the POSPac Import window. Make sure all files begin with a capital "LV." The case of the "L" and "V" at the beginning of the file names must match for a given set. If some of the files in the set begin with "lv", change them to "LV" in the data folder before importing into POSPac.



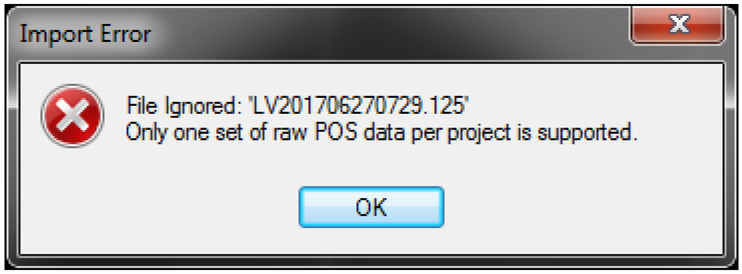
Click "Import" once all the files in a set are selected (see above image). Several boxes will open and close as the program takes a few minutes to process the files. Do nothing until the “Raw Data Check In” window appears (see below image). Click “OK.”



“Project Definition” window will appear (see below image). Click “OK.”

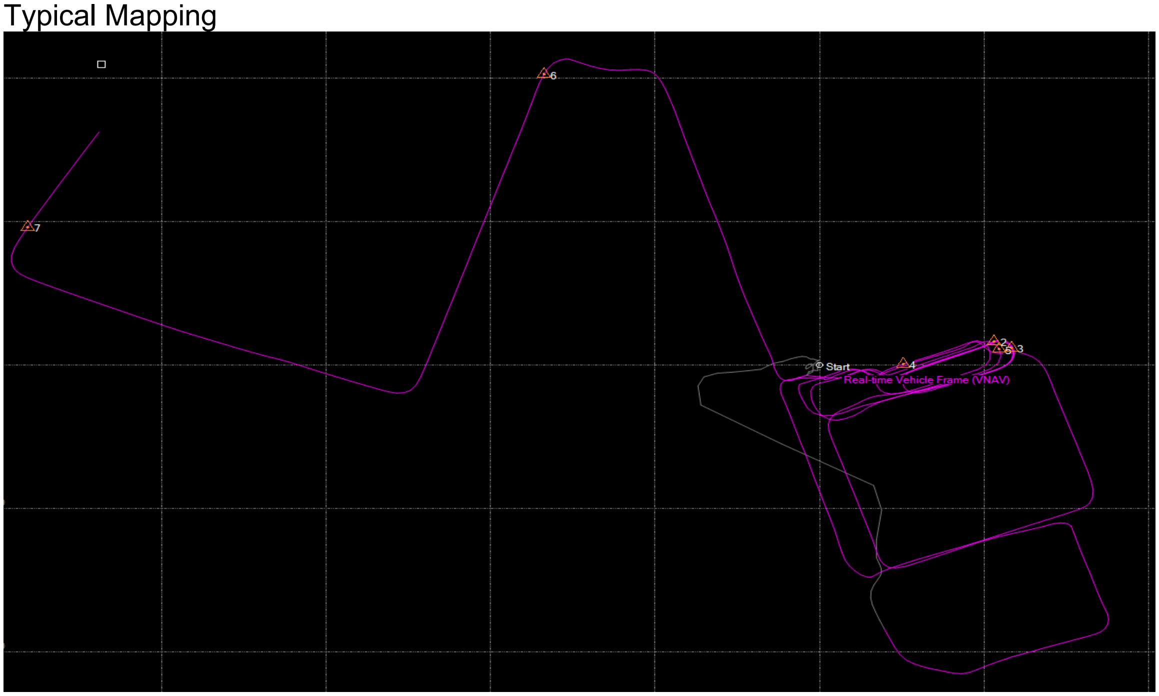


If the following error message appears, it’s due to an error in the file name (some files in the set have “LV” while others have “lv”). Click “OK” and return to Step 10 once all the files in a set have matching cases (see below image).

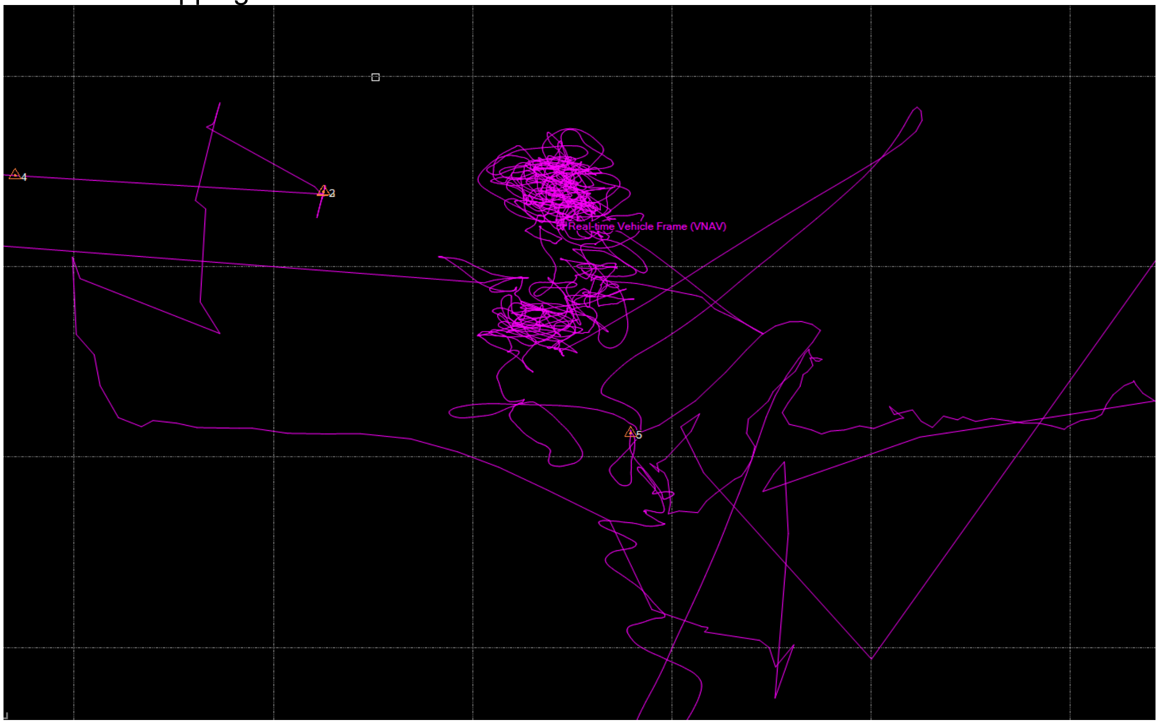


Step 12. Review map display of processed data in POSPac. The program will show a plot of the ARAN path for the processed file set (see typical image below). The map size will depend upon the size of the file set. If the map shows too many straight lines or strange overlaps are visible (indicating the road path may not have been followed and the GPS readings are incorrect), the data may need to be examined for validity (see abnormal image below).

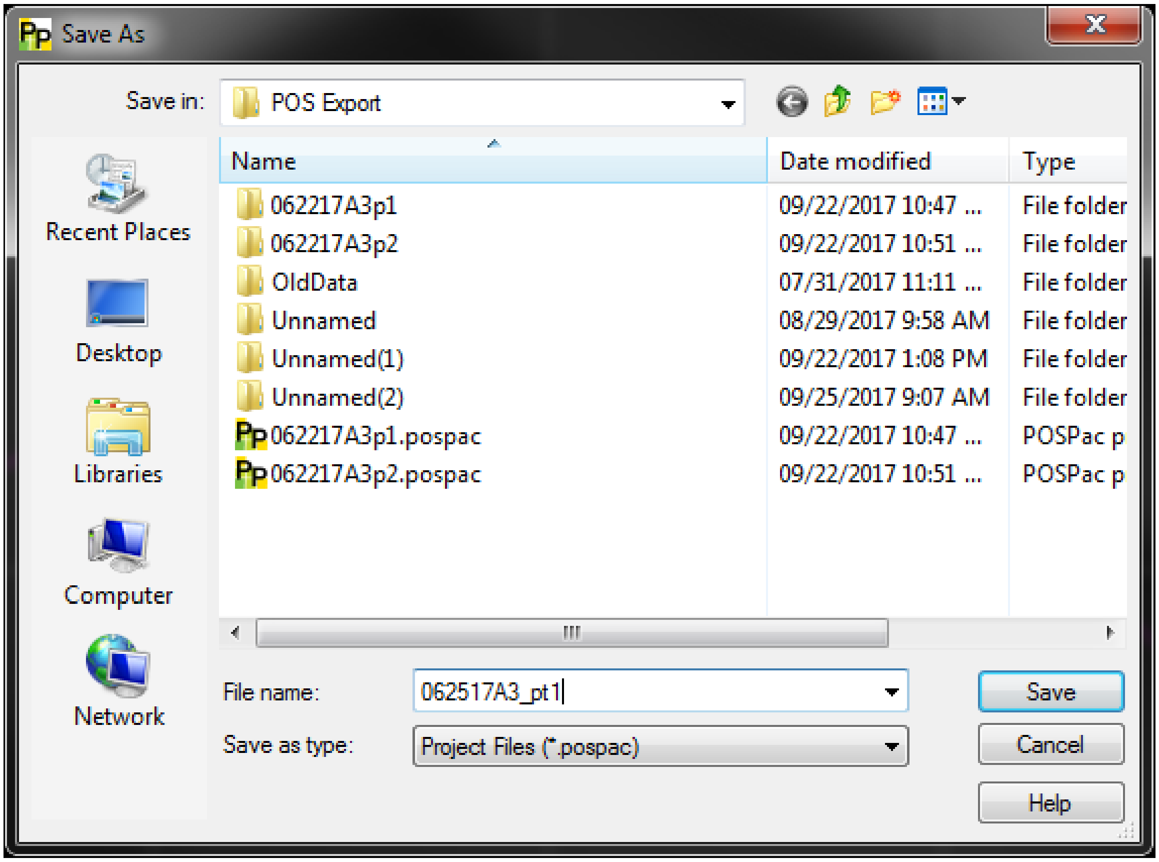
Typical Mapping



Abnormal Mapping

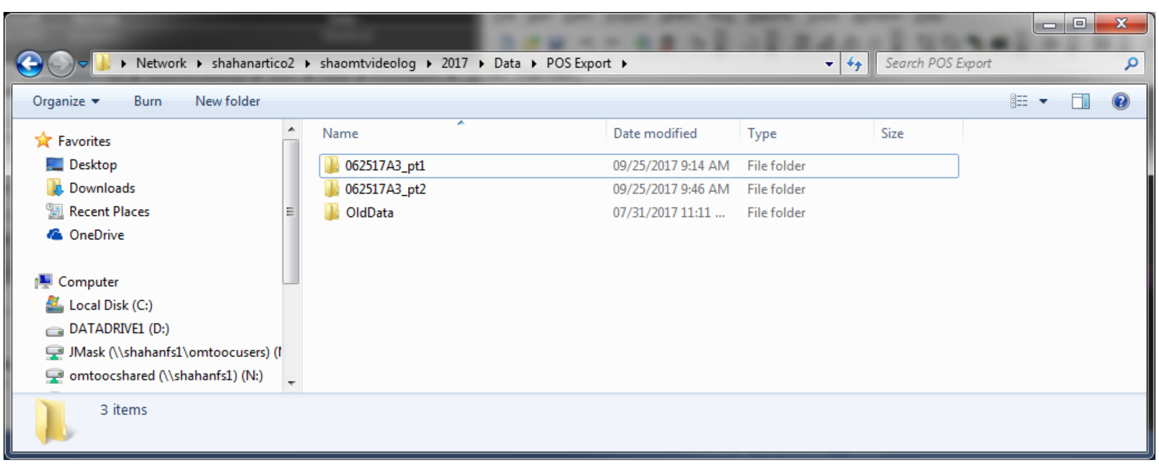


Step 13. Save the file. Select “Save As” from the main ribbon. The format for saving files is [MMDDYY][ARAN#]_pt[#FILEFORTHEDAY] (see below image). The “pt” in the filename is used to distinguish different sets of files in the same day. Repeat Step 11 to Step 13 for all file sets in the batch.

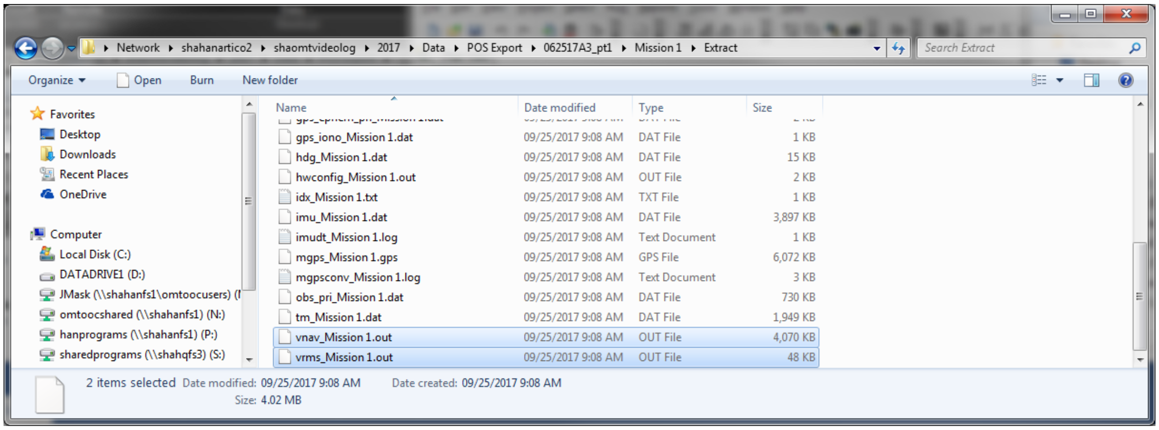


Step 14. Rename POSPac files so they may be loaded into Vision. Open two "Windows Explorer" windows.

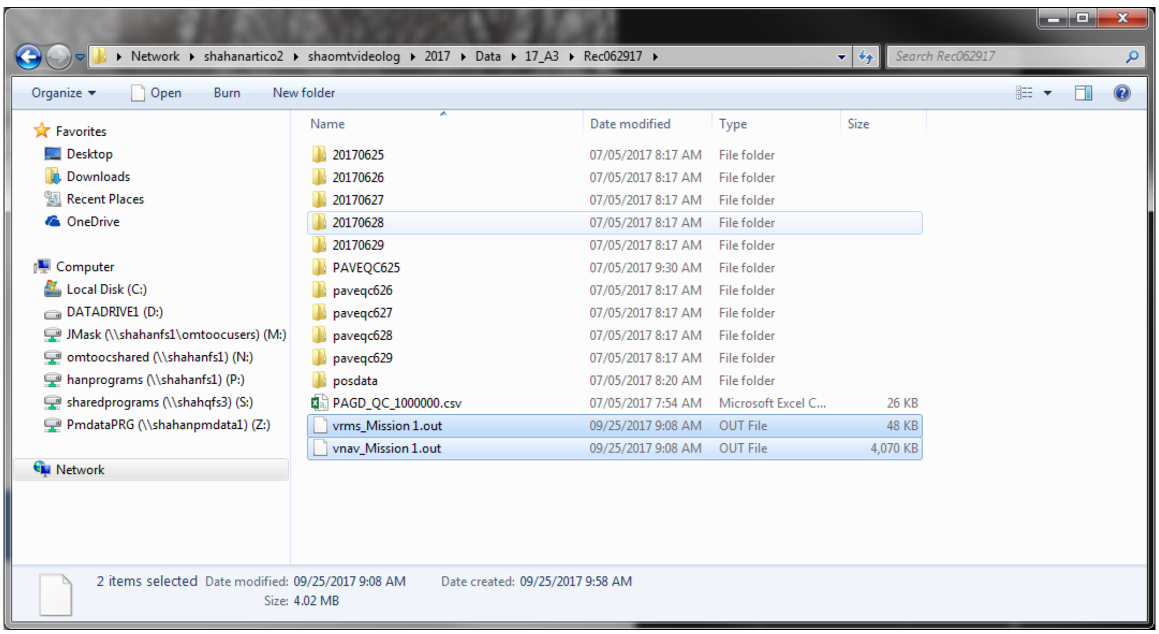
i. In the first "Explorer" window, navigate to the "POS Export" folder (see below image).



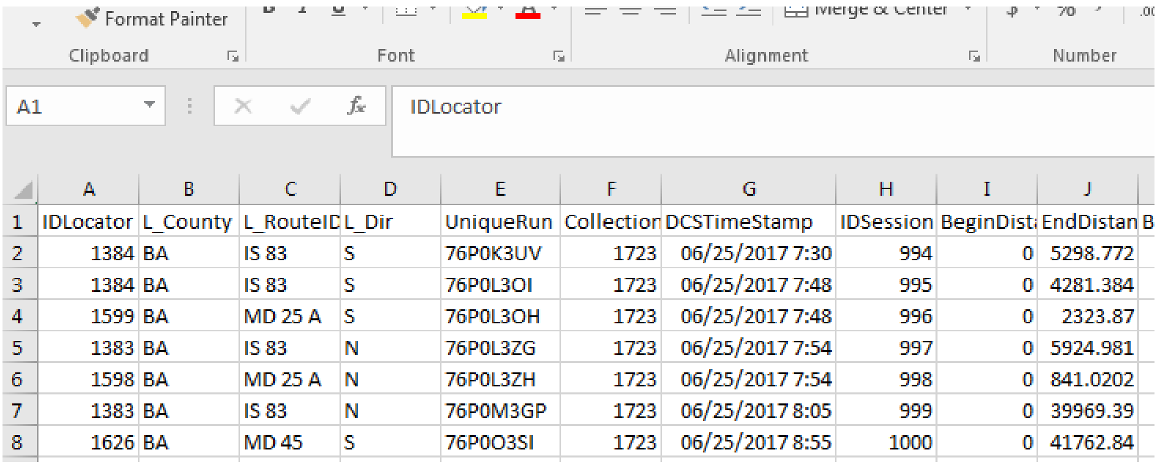
Select the first file set folder. Navigate to "Mission 1", then "Extract." Find the files named **vnav_Mission1.out** and **vrms_Mission1.out** (they will be listed last). Copy these files (see below image).



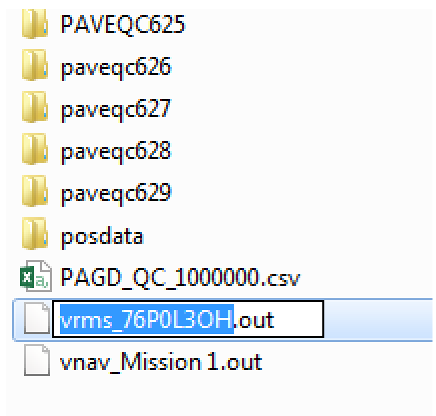
ii. In the second "Explorer" window, navigate to the ARAN Submission file (see below image).



Paste the copied files into this folder. The "Mission 1" part of the copied files must be renamed. To do this, open the "PAGD_QC_1000000" spreadsheet located in the same folder. Find a "UniqueRun" from the corresponding date of the POSPac file set. Replace "Mission 1" in both copied files with that "UniqueRun" value. Repeat this step for all file sets in the batch (see images below).

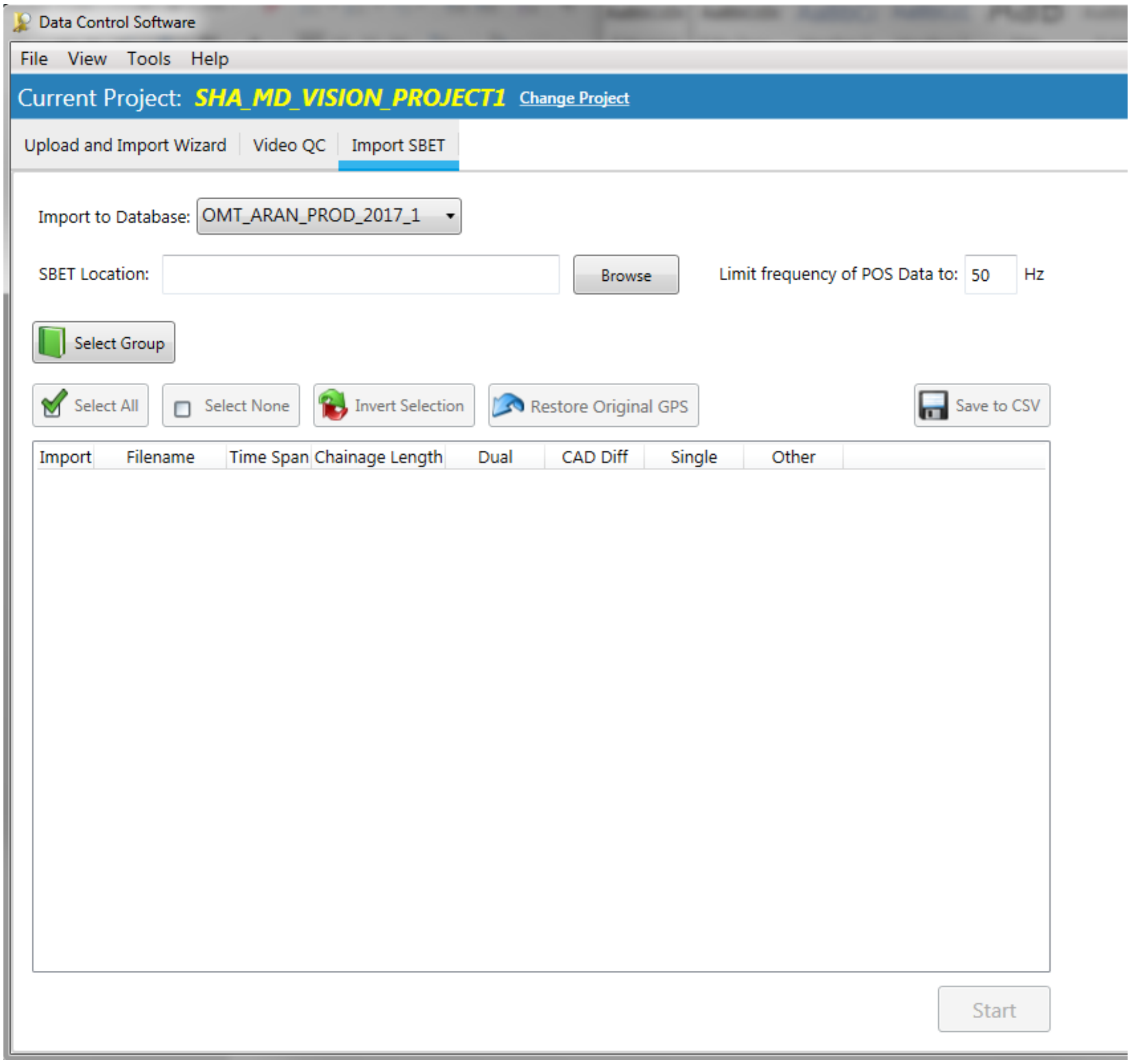


	A	B	C	D	E	F	G	H	I	J
1	IDLocator	L_County	L_RouteID	L_Dir	UniqueRun	Collection	DCSTimeStamp	IDSession	BeginDist	EndDistan
2	1384	BA	IS 83	S	76P0K3UV	1723	06/25/2017 7:30	994	0	5298.772
3	1384	BA	IS 83	S	76P0L3OI	1723	06/25/2017 7:48	995	0	4281.384
4	1599	BA	MD 25 A	S	76P0L3OH	1723	06/25/2017 7:48	996	0	2323.87
5	1383	BA	IS 83	N	76P0L3ZG	1723	06/25/2017 7:54	997	0	5924.981
6	1598	BA	MD 25 A	N	76P0L3ZH	1723	06/25/2017 7:54	998	0	841.0202
7	1383	BA	IS 83	N	76P0M3GP	1723	06/25/2017 8:05	999	0	39969.39
8	1626	BA	MD 45	S	76P0O3SI	1723	06/25/2017 8:55	1000	0	41762.84

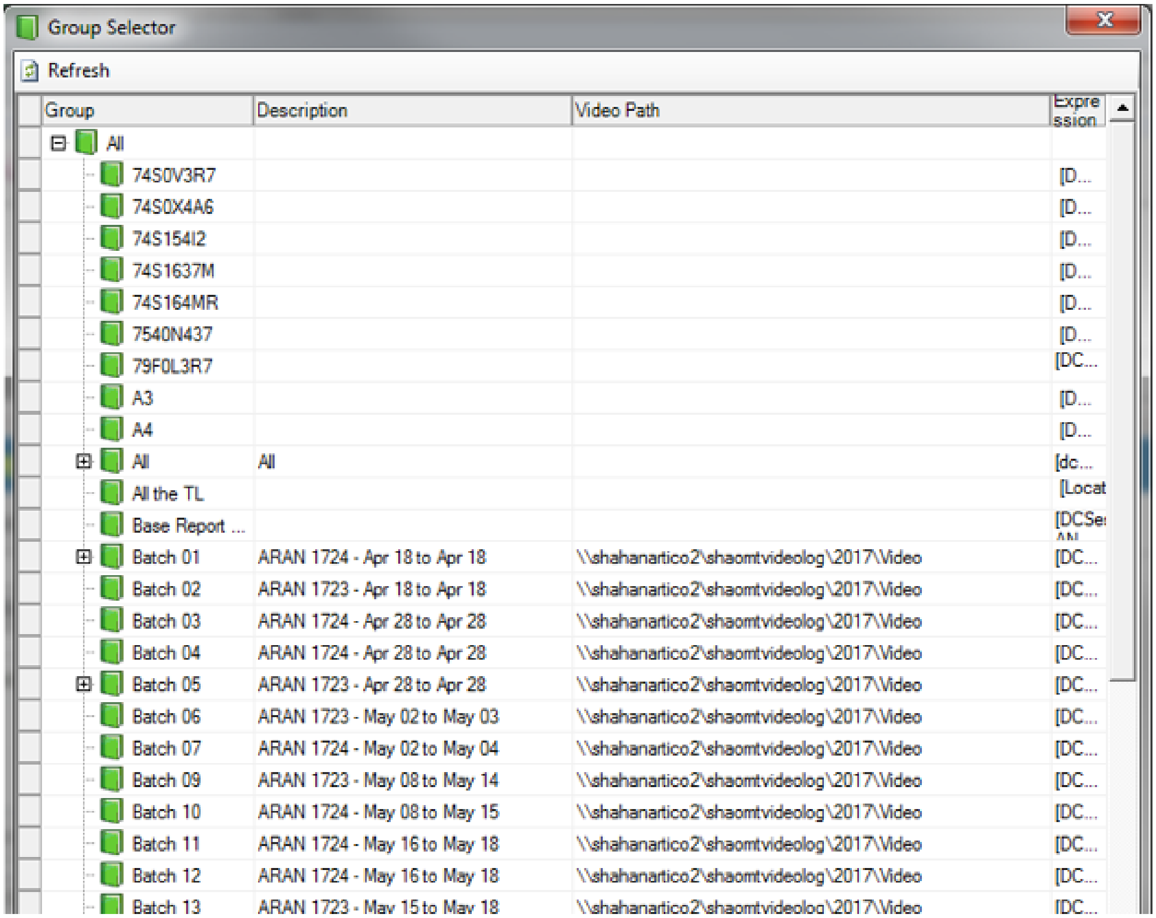


Step 15. Open the Data Control Software. Click "OK."

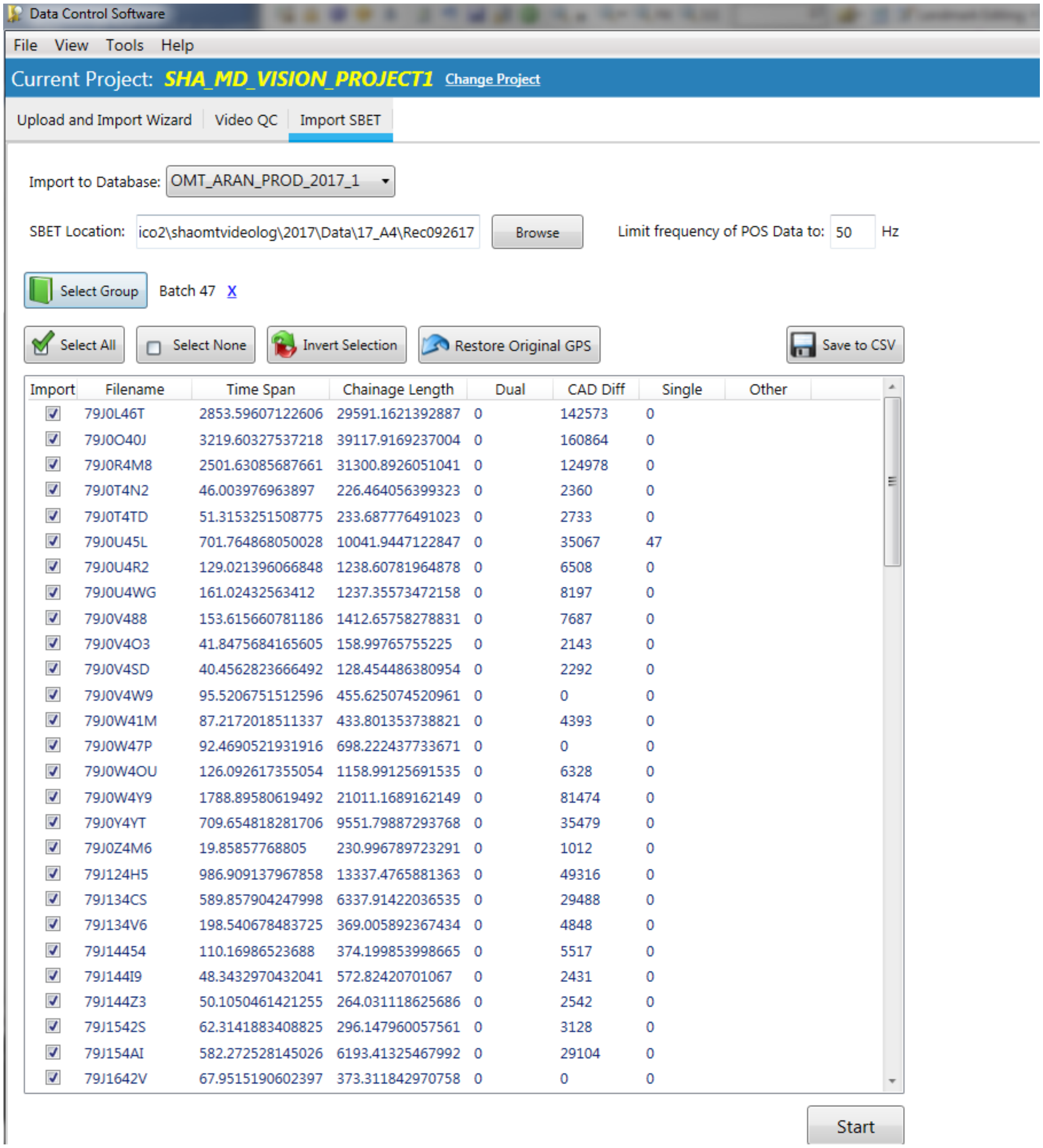
Step 16. Click the "Import SBET" tab. The "Import SBET" window will appear (see below image). SBET is a type of GPS file, which does not exist in the ARAN data output. However, this import also works for vnav and vrms files.



Step 17. Browse for the file location. The file location is the ARAN submission folder in which the vnav and vrms files were just copied and renamed in Step 14. Once the location is set, click the “Select Group” button (see above image). The “Group Selector” window will open (see below image).

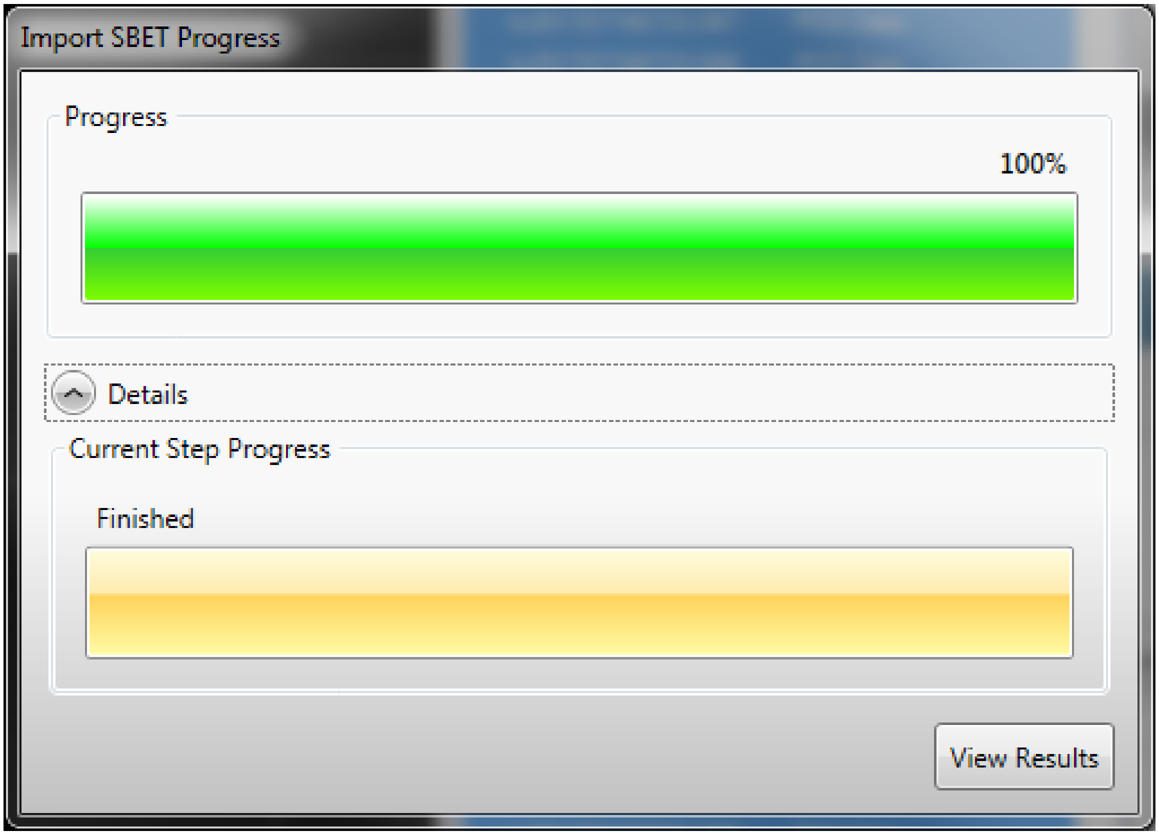


Step 18. Select the correct data batch in the window (corresponds to the proper ARAN number and collection date). Click "OK." The DCS will display all files in the selected batch. This may take a few minutes to process (see below image).



Import	Filename	Time Span	Chainage Length	Dual	CAD Diff	Single	Other
☑	79J0L46T	2853.59607122606	29591.1621392887	0	142573	0	
☑	79J0O40J	3219.60327537218	39117.9169237004	0	160864	0	
☑	79J0R4M8	2501.63085687661	31300.8926051041	0	124978	0	
☑	79J0T4N2	46.003976963897	226.464056399323	0	2360	0	
☑	79J0T4TD	51.3153251508775	233.687776491023	0	2733	0	
☑	79J0U45L	701.764868050028	10041.9447122847	0	35067	47	
☑	79J0U4R2	129.021396066848	1238.60781964878	0	6508	0	
☑	79J0U4WG	161.02432563412	1237.35573472158	0	8197	0	
☑	79J0V488	153.615660781186	1412.65758278831	0	7687	0	
☑	79J0V4O3	41.8475684165605	158.99765755225	0	2143	0	
☑	79J0V4SD	40.4562823666492	128.454486380954	0	2292	0	
☑	79J0V4W9	95.5206751512596	455.625074520961	0	0	0	
☑	79J0W41M	87.2172018511337	433.801353738821	0	4393	0	
☑	79J0W47P	92.4690521931916	698.222437733671	0	0	0	
☑	79J0W4OU	126.092617355054	1158.99125691535	0	6328	0	
☑	79J0W4Y9	1788.89580619492	21011.1689162149	0	81474	0	
☑	79J0Y4YT	709.654818281706	9551.79887293768	0	35479	0	
☑	79J0Z4M6	19.85857768805	230.996789723291	0	1012	0	
☑	79J124H5	986.909137967858	13337.4765881363	0	49316	0	
☑	79J134CS	589.857904247998	6337.91422036535	0	29488	0	
☑	79J134V6	198.540678483725	369.005892367434	0	4848	0	
☑	79J14454	110.16986523688	374.199853998665	0	5517	0	
☑	79J144I9	48.3432970432041	572.82420701067	0	2431	0	
☑	79J144Z3	50.1050461421255	264.031118625686	0	2542	0	
☑	79J1542S	62.3141883408825	296.147960057561	0	3128	0	
☑	79J154AI	582.272528145026	6193.41325467992	0	29104	0	
☑	79J1642V	67.9515190602397	373.311842970758	0	0	0	

Step 19. Click the “Start” button. An import progress window will appear. You can click the drop-down arrow next to “Details” to see the import status. When the program is done, the import progress window will show 100% (see below image).

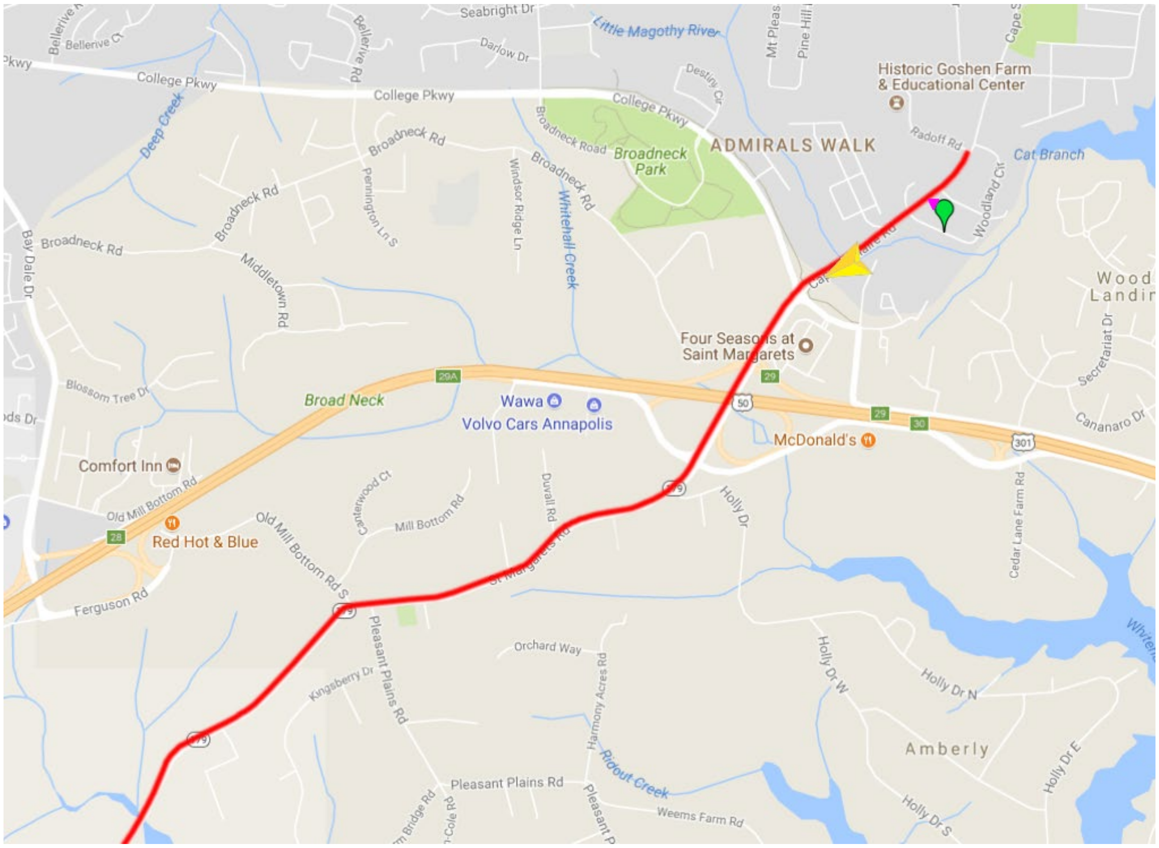


2- Performing QC of Processed GPS Data – *performed by DCS user*

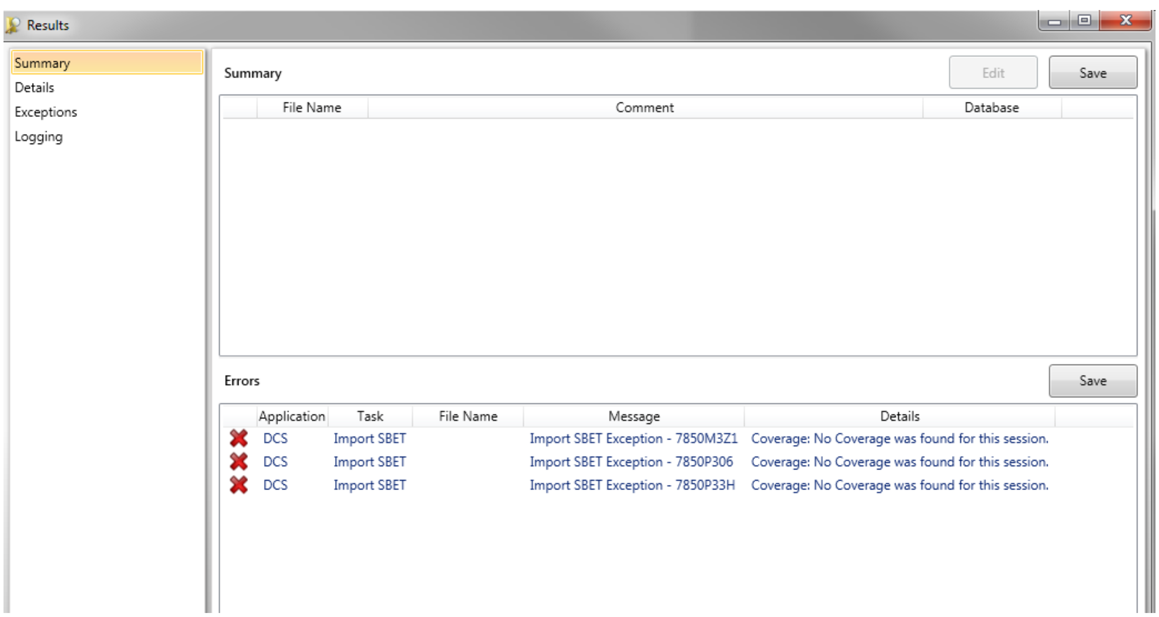
Summary: This task reviews errors encountered when importing and performs a visual check of the results in Vision's mapping window prior to completion.

Step 20. Click the "View Results" button.

i. If there are no errors, open Vision's mapping window to visually inspect the routes. Ensure the vehicle's routing (red line) is in close proximity to the green pins (see below image). When this is finished, the process is complete.



ii. If there are errors, they will appear in the bottom window (see below image). Proceed to Step 21.



Step 21. Check to make sure the files receiving errors are valid. Go to the Vision "Section Explorer" and filter for the "Collection ID" associated with the error. The Collection ID can be found in the "Message" column of the error window.

i. If the files which received errors are marked as "DUMMY", they are not valid, and the errors do not need to be corrected (process is complete).

ii. If the files are valid, their GPS files were not imported properly, and they will need to be found and imported. Proceed to Step 22.

Step 22. In the Vision window, first note the collection date and time. Then, navigate to the GPS files and find the corresponding files of that date and time. Run POSPac for those files by completing Step 6 to Step 14.

Step 23. Import revised files into Vision. Complete Step 15 to Step 19. When importing, make sure to deselect files that were already correctly imported.

i. If the files import this time with no error messages, the process is complete.

ii. If the files still do not import, contact Supervisor to discuss next steps.

3- Performing QA of Processed GPS Data – *performed by Supervisor*

Summary: This task performs QA checks on the processed GPS data.

Step 24. TL review of QC staff notification of recollection.

Step 25. Review of production status – receive weekly update from QC staff (last ARAN collection data fully processed).

Step 26. Verify ARAN collection path matches the route overlay in the Vision map.

5.04 RUNNING GLOBAL LCMS PROCESSOR

5.04.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to process the Laser Crack Measurement System (LCMS) data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff. The processing of LCMS data is performed in batches throughout the annual data collection season. This SOP applies to the LCMS processing, quality control (QC), and quality assurance (QA) of each individual ARAN data batch. The processing of LCMS data is performed after completion of loading the ARAN data into Vision as outlined in Loading of ARAN Data into Vision and post-processing of GPS data as outlined in Post-Processing of ARAN GPS Data. This process results in the generation of ARAN pavement imagery, transverse profiles, and population of cracking and lane width data on images.

5.04.02 *Frequency*

The LCMS Global Processor is run every time a batch of ARAN collected data is received by the DPT, which typically occurs every 4 to 5 days. Assuming an average of 60 miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data. The actual frequency varies according to the proximity of the routes on which data were collected for the data batch to the Office of Materials Technology (OMT) office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring data recollection. The annual ARAN data collection season typically lasts from April through October but deliveries sometimes can occur year-round.

5.04.03 *Purpose*

The purpose of this SOP is to process the LCMS data and perform QC/QA of the results.

5.04.04 *Resource Requirements*

The running of the LCMS Global Processor involves two people: (1) a user knowledgeable in Roadware Vision software to run the LCMS Global Processor and perform QC, and (2) a supervisor who, as required, provides guidance and decision-making and performs QA. The estimated effort levels in the table below represent the total time, in man-hours, to complete the LCMS processing and QC/QA checks. These time estimates assume average batch quantities and no issues encountered during processing.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision user and QC	1	4.0
DPT TL	Supervisor and QA	1	AR[06/12/2019]

5.04.05 *Procedure*

The procedure to run the LCMS Global Processor and perform QC/QA is comprised of the following three tasks:

(1) running LCMS Global Processor in Vision,
(2) performing QC of the processed LCMS data, and
(3) performing QA of the processed LCMS data.

1- Running LCMS Global Processor in Vision – *performed by Vision user*

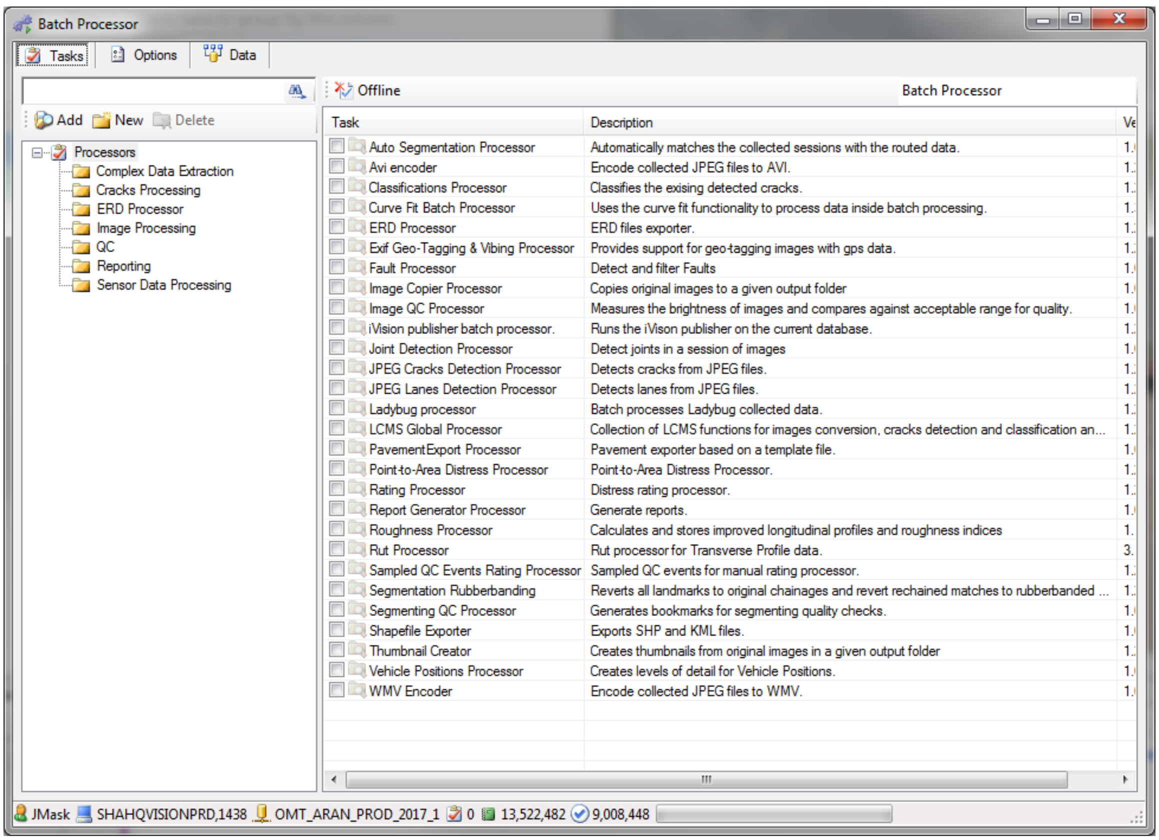
Summary: This task uses Vision software to process LCMS image files from the ARAN data submittal.

Step 1. Open Vision.

i. If the LCSM Global Processor has not been run on any of the files in the database, proceed to Step 2.

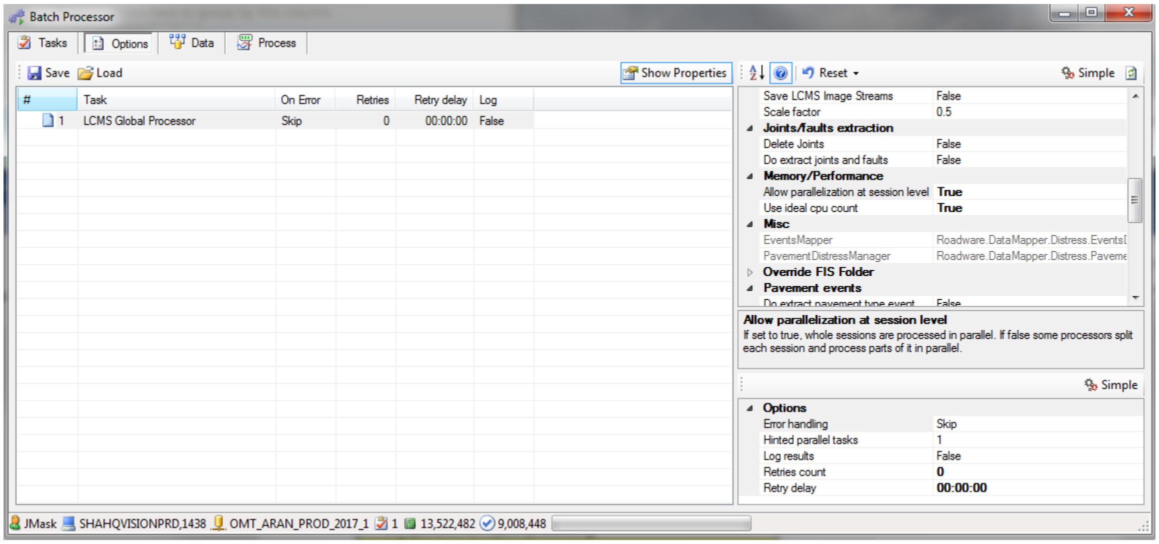
ii. If the LCSM Global Processor has been run on any of the files in the database, proceed to Step 17.

Step 2. Click the "Process" drop-down menu. Select "New Batch Processor." The "Batch Processor" window will open (see below image).

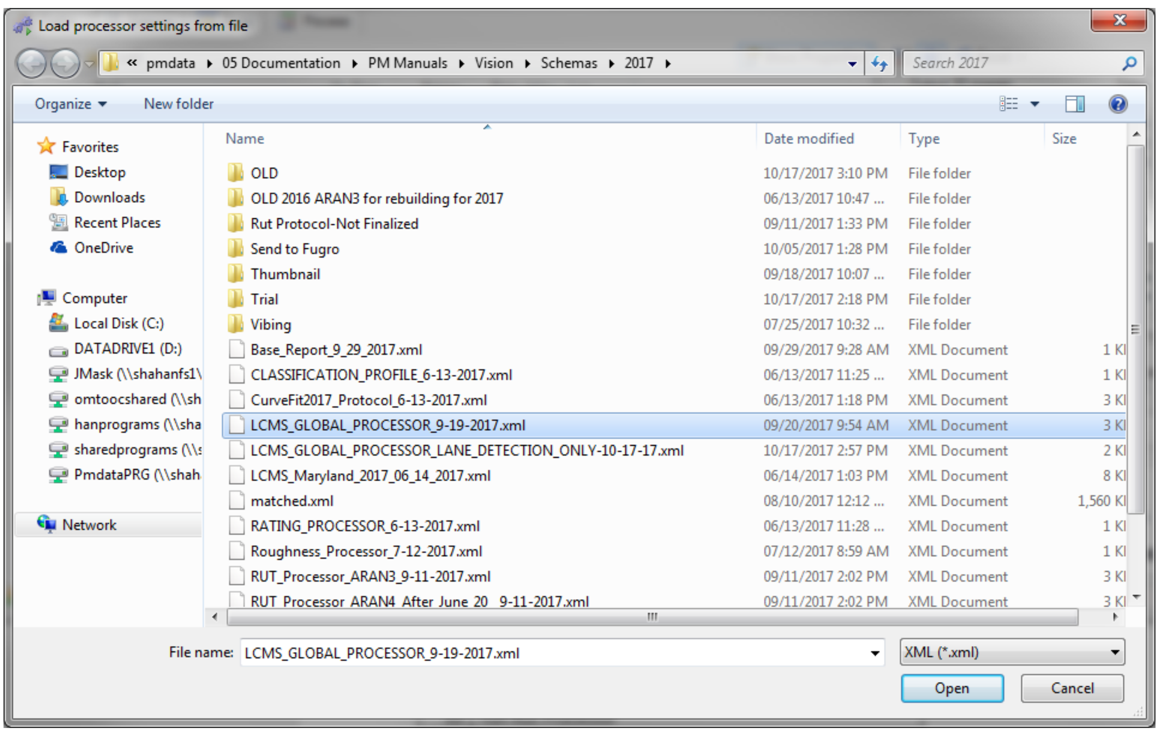


Step 3. Select "Crack Processing" from the window on the left. Click the box next to "LCMS Global Processor" in the window on the right. Then click the "Options" tab (see above image).

Step 4. Instead of changing settings manually, search for preset schemas. Click the "Load" button (see below image).



Navigate to the location: "\\shahanpmdata1\pmdata\05 Documentation\PM Manuals\Vision\Schemas\[YEAR]." In this folder, look for an XML file named "LCMS_GLOBAL_PROCESSOR_[MOST RECENTDATE]." Select the file and click "Open" (see below image).



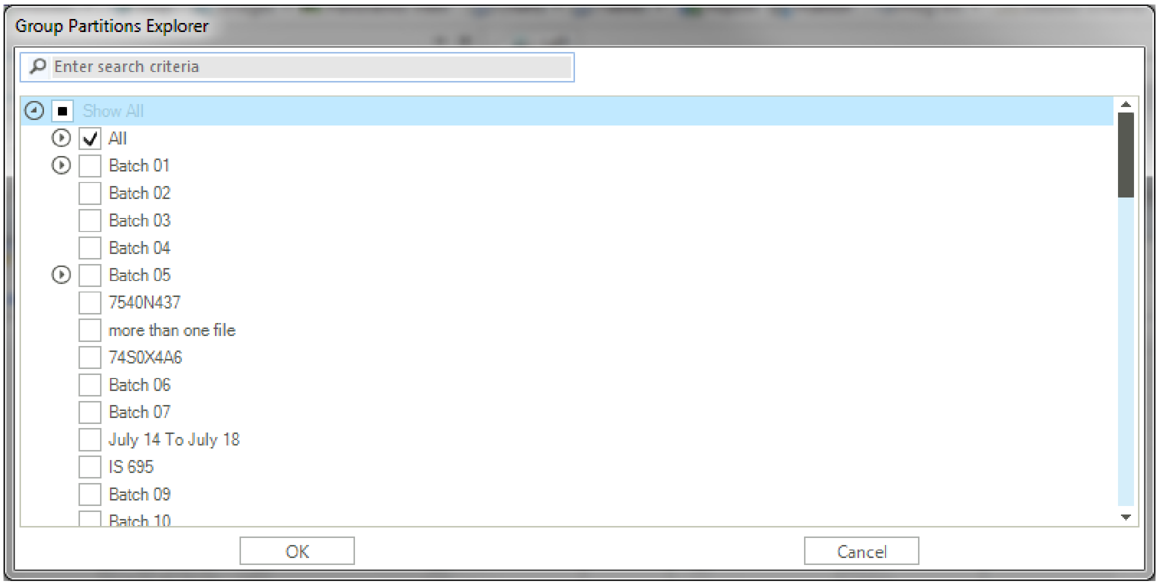
Step 5. Click "Data" from the top menu bar. Every file in the database will appear in the window. The list must be filtered to only include the sections from the current batch. This can be accomplished through two different methods:

i. Removing unwanted files, or

ii. Removing all files and selecting a batch to re-add.

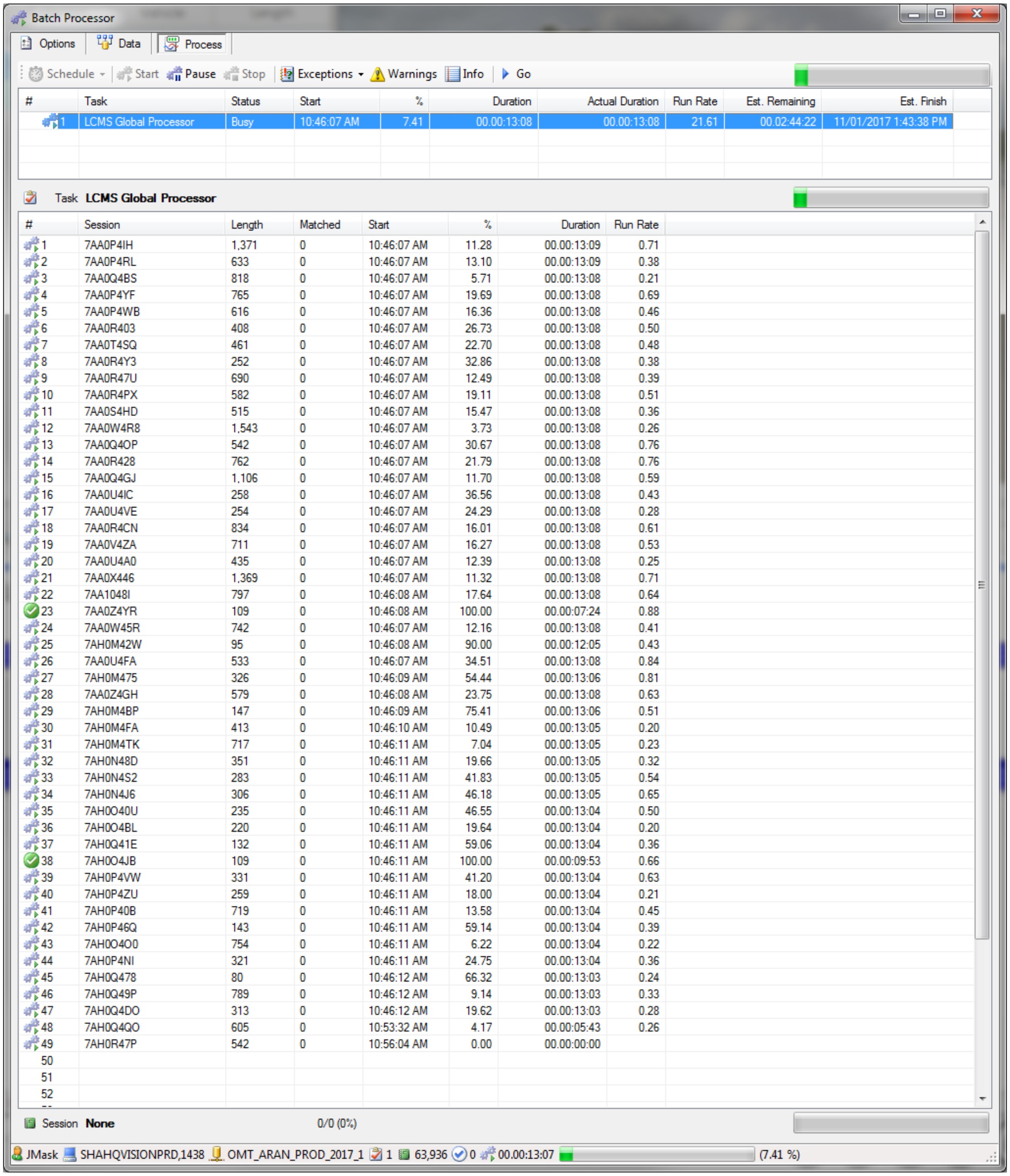
Step 6. Choose removal method. If removing all files and selecting a batch to re-add is preferred, skip to Step 7. Otherwise, use a combination of the Shift and Ctrl keys to highlight all unwanted files in the window. Click "Remove." Proceed to Step 8.

Step 7. To remove all files, click the "Check" drop-down menu and select "All." Click "Remove." Then, click the "Reload" (first blue arrow) button. The "Group Partitions" window will open (see below image).



Select the current batch by clicking the checkbox next to the appropriate batch name. Click the "OK."

Step 8. Once only the desired files appear in the "Batch Processor" window, they may be processed. Click "Process", then "Start." The files will begin to appear under the session window (see below image). The LCMS Global Processor will take anywhere from 1-3 hours to run. It will depend on the number of lane miles, the number of files, the number of cores in the computer, and database traffic.



Batch Processor

Options | Data | Process

Schedule | Start | Pause | Stop | Exceptions | Warnings | Info | Go

#	Task	Status	Start	%	Duration	Actual Duration	Run Rate	Est. Remaining	Est. Finish
1	LCMS Global Processor	Busy	10:46:07 AM	7.41	00.00:13:08	00.00:13:08	21.61	00.02:44:22	11/01/2017 1:43:38 PM

Task **LCMS Global Processor**

#	Session	Length	Matched	Start	%	Duration	Run Rate
1	7AA0P4IH	1,371	0	10:46:07 AM	11.28	00.00:13:09	0.71
2	7AA0P4RL	633	0	10:46:07 AM	13.10	00.00:13:09	0.38
3	7AA0Q4BS	818	0	10:46:07 AM	5.71	00.00:13:08	0.21
4	7AA0P4YF	765	0	10:46:07 AM	19.69	00.00:13:08	0.69
5	7AA0P4WB	616	0	10:46:07 AM	16.36	00.00:13:08	0.46
6	7AA0R403	408	0	10:46:07 AM	26.73	00.00:13:08	0.50
7	7AA0T4SQ	461	0	10:46:07 AM	22.70	00.00:13:08	0.48
8	7AA0R4Y3	252	0	10:46:07 AM	32.86	00.00:13:08	0.38
9	7AA0R47U	690	0	10:46:07 AM	12.49	00.00:13:08	0.39
10	7AA0R4PX	582	0	10:46:07 AM	19.11	00.00:13:08	0.51
11	7AA0S4HD	515	0	10:46:07 AM	15.47	00.00:13:08	0.36
12	7AA0W4R8	1,543	0	10:46:07 AM	3.73	00.00:13:08	0.26
13	7AA0Q4OP	542	0	10:46:07 AM	30.67	00.00:13:08	0.76
14	7AA0R428	762	0	10:46:07 AM	21.79	00.00:13:08	0.76
15	7AA0Q4GJ	1,106	0	10:46:07 AM	11.70	00.00:13:08	0.59
16	7AA0U4IC	258	0	10:46:07 AM	36.56	00.00:13:08	0.43
17	7AA0U4VE	254	0	10:46:07 AM	24.29	00.00:13:08	0.28
18	7AA0R4CN	834	0	10:46:07 AM	16.01	00.00:13:08	0.61
19	7AA0V4ZA	711	0	10:46:07 AM	16.27	00.00:13:08	0.53
20	7AA0U4A0	435	0	10:46:07 AM	12.39	00.00:13:08	0.25
21	7AA0X446	1,369	0	10:46:07 AM	11.32	00.00:13:08	0.71
22	7AA1048I	797	0	10:46:08 AM	17.64	00.00:13:08	0.64
23	7AA0Z4YR	109	0	10:46:08 AM	100.00	00.00:07:24	0.88
24	7AA0W45R	742	0	10:46:07 AM	12.16	00.00:13:08	0.41
25	7AH0M42W	95	0	10:46:08 AM	90.00	00.00:12:05	0.43
26	7AA0U4FA	533	0	10:46:07 AM	34.51	00.00:13:08	0.84
27	7AH0M475	326	0	10:46:09 AM	54.44	00.00:13:06	0.81
28	7AA0Z4GH	579	0	10:46:08 AM	23.75	00.00:13:08	0.63
29	7AH0M4BP	147	0	10:46:09 AM	75.41	00.00:13:06	0.51
30	7AH0M4FA	413	0	10:46:10 AM	10.49	00.00:13:05	0.20
31	7AH0M4TK	717	0	10:46:11 AM	7.04	00.00:13:05	0.23
32	7AH0N48D	351	0	10:46:11 AM	19.66	00.00:13:05	0.32
33	7AH0N4S2	283	0	10:46:11 AM	41.83	00.00:13:05	0.54
34	7AH0N4J6	306	0	10:46:11 AM	46.18	00.00:13:05	0.65
35	7AH0O40U	235	0	10:46:11 AM	46.55	00.00:13:04	0.50
36	7AH0O4BL	220	0	10:46:11 AM	19.64	00.00:13:04	0.20
37	7AH0Q41E	132	0	10:46:11 AM	59.06	00.00:13:04	0.36
38	7AH0O4JB	109	0	10:46:11 AM	100.00	00.00:09:53	0.66
39	7AH0P4VW	331	0	10:46:11 AM	41.20	00.00:13:04	0.63
40	7AH0P4ZU	259	0	10:46:11 AM	18.00	00.00:13:04	0.21
41	7AH0P40B	719	0	10:46:11 AM	13.58	00.00:13:04	0.45
42	7AH0P46Q	143	0	10:46:11 AM	59.14	00.00:13:04	0.39
43	7AH0O4O0	754	0	10:46:11 AM	6.22	00.00:13:04	0.22
44	7AH0P4NI	321	0	10:46:11 AM	24.75	00.00:13:04	0.36
45	7AH0Q478	80	0	10:46:12 AM	66.32	00.00:13:03	0.24
46	7AH0Q49P	789	0	10:46:12 AM	9.14	00.00:13:03	0.33
47	7AH0Q4DO	313	0	10:46:12 AM	19.62	00.00:13:03	0.28
48	7AH0Q4QO	605	0	10:53:32 AM	4.17	00.00:05:43	0.26
49	7AH0R47P	542	0	10:56:04 AM	0.00	00.00:00:00	
50							
51							
52							

Session **None** 0/0 (0%)

JMask SHAHQVISIONPRD,1438 OMT_ARAN_PROD_2017_1 1 63,936 0 00.00:13:07 (7.41 %)

Step 9. A dialogue box will appear when processing is complete.

i. If the box says, “Batch processing has completed”, proceed to Step 11.

ii. If the box says, “Batch processing has completed with errors”, proceed to Step 10.

Step 10. View the errors. Click the “*Exceptions”* drop-down menu and select “*View Exceptions*.”

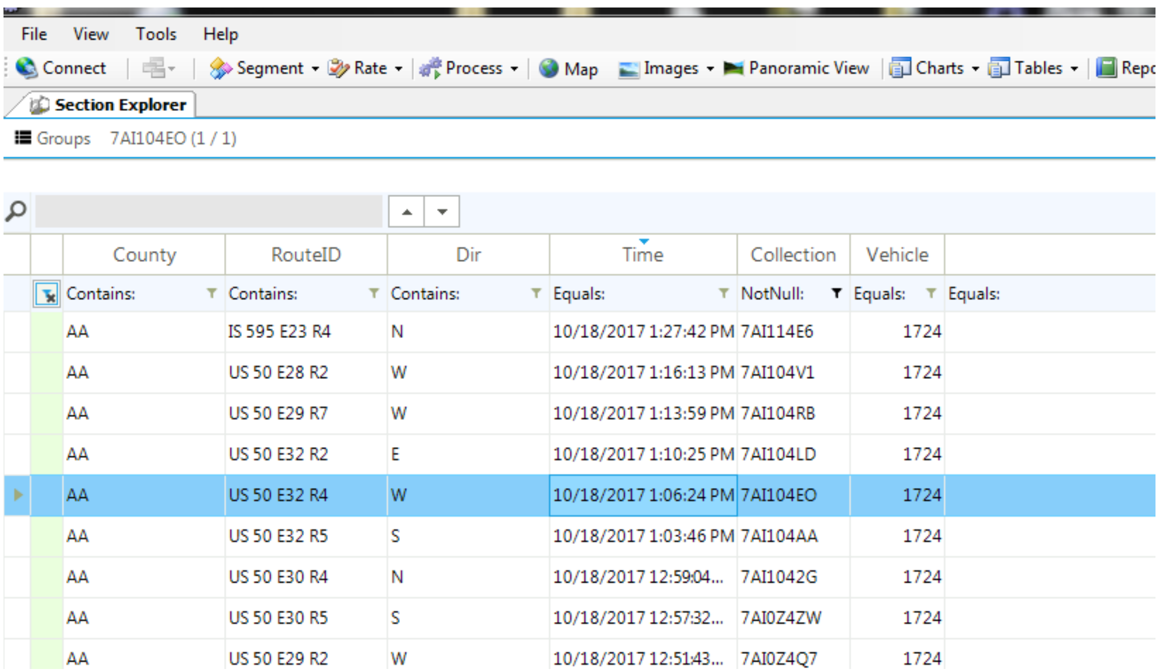
i. If the error is “Missing Images”, this is acceptable. Proceed to Step 11.

ii. If any other errors are present, reprocessing is required. Click the "Exceptions" drop-down menu and select "Reprocess Exceptions." This will remove all the files from the data screen except for the files that had exceptions. Next, click the "Start" button to reprocess.

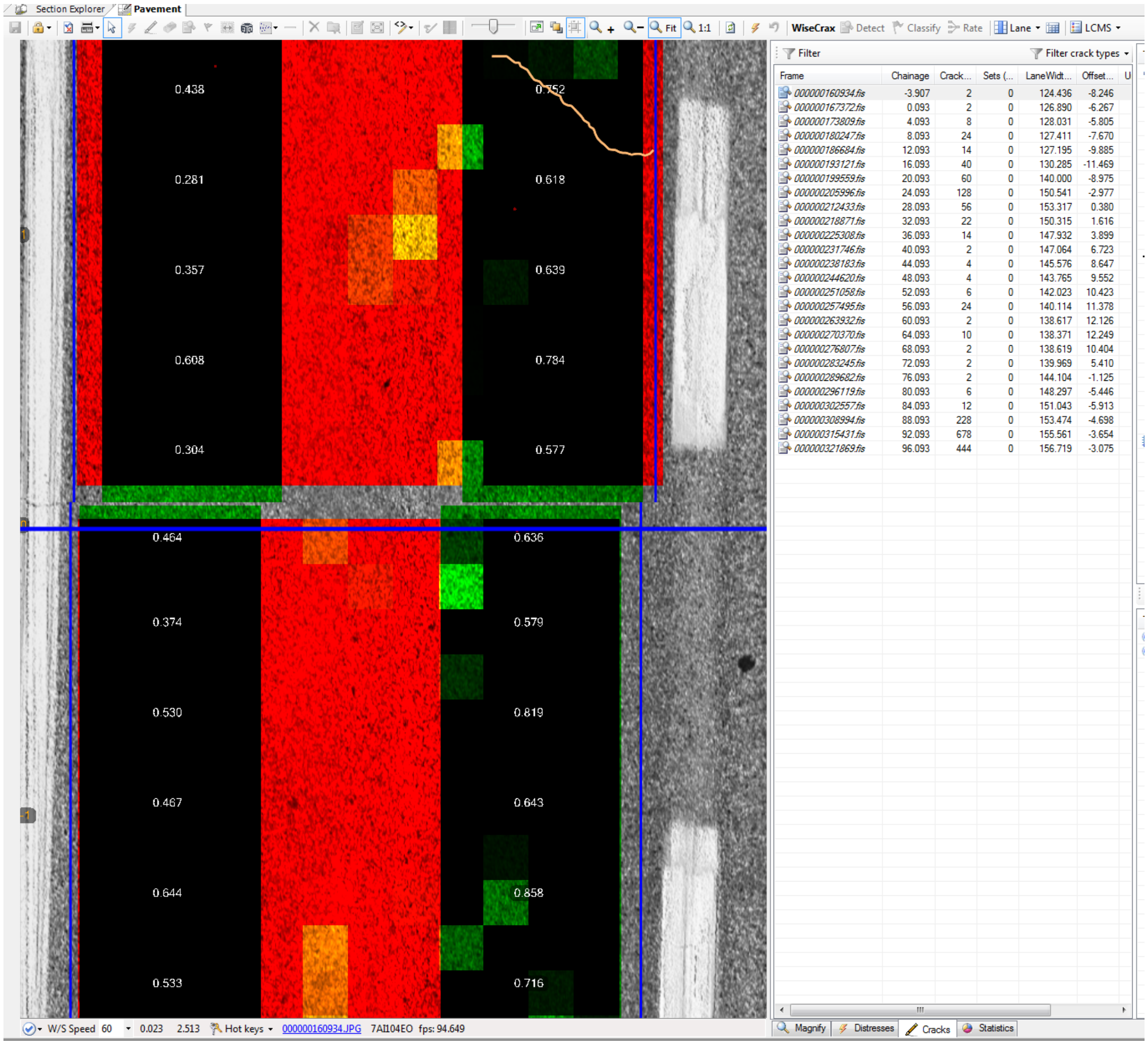
2- Performing QC of Processed LCMS Data – *performed by Vision user*

Summary: This task checks the quality of processed LCMS data through visual inspection of images and reasonableness of crack length values, as well as runs the "Process Monitor" application.

Step 11. Close the processor and restart Vision. In the "Section Explorer", select a file that was just run in the processor. Click the "Rate" drop-down menu and then click "Pavement Distress" (see below image).



Step 12. A "Pavement" window will appear (could take a few minutes). At the bottom right of the screen, select the "Cracks" tab. In the window on the right, a list of all the files, their chainage, number of cracks, and other information will be displayed (see below image).



Step 13. Check the “Crack” and “LaneWidth” columns for zeroes. There should be a minimal amount of zeroes in the “Crack” column and no zeroes in the “LaneWidth” column. If all zeroes are showing for both columns, the LCMS Global Processor was not processed successfully on the selected file.

i. If the file was not processed correctly, return to Step 1.

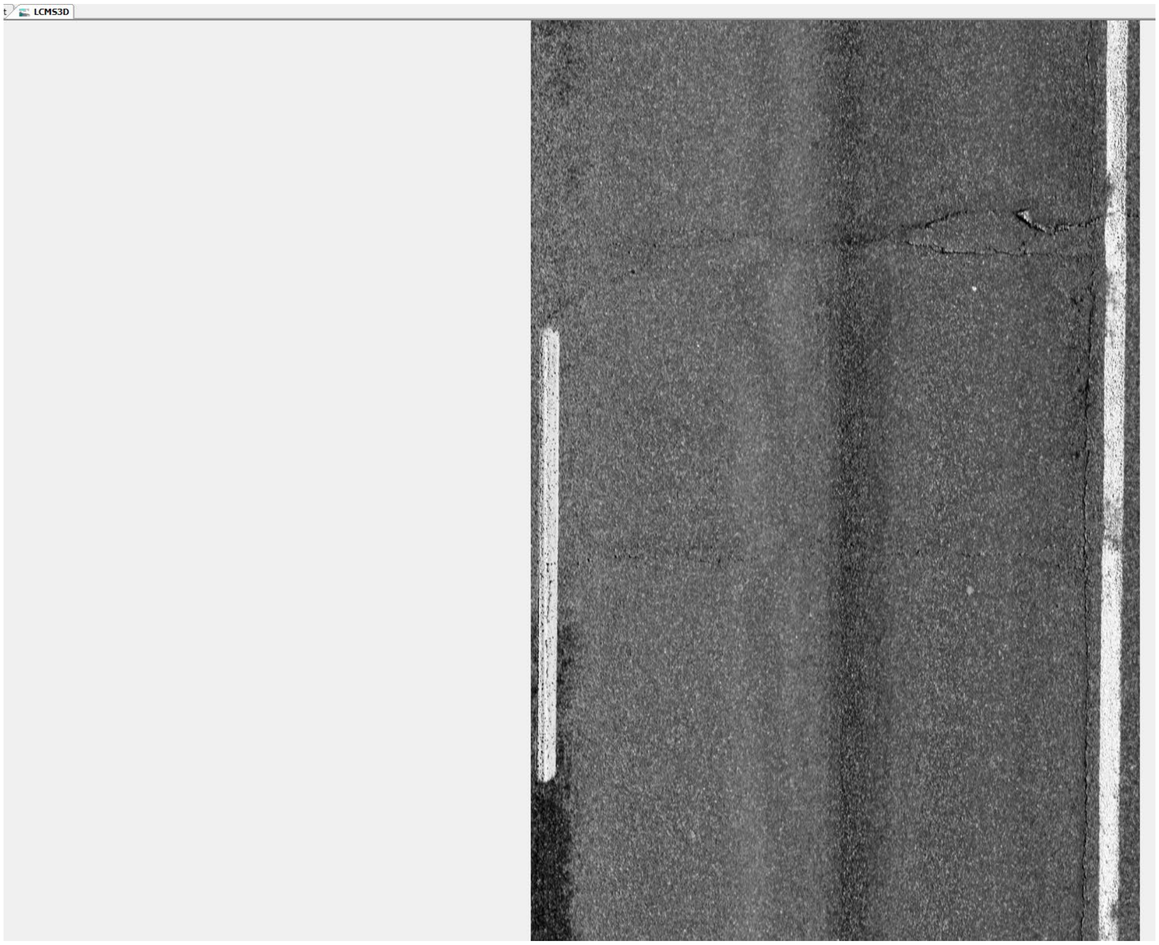
ii. If the file was processed correctly, but the wrong file was selected for the QC, return to Step 11 and select the correct file.

iii. If this check did not result in any issues, proceed to Step 14.

Step 14. Check the LCMS3D Images. Select a file that was processed and click on the “Images” drop-down menu. Click on “LCMS3D.” The image will appear in the window (see below image). At a minimum, check the first and last images.

i. If the images are displayed correctly, proceed to Step 15.

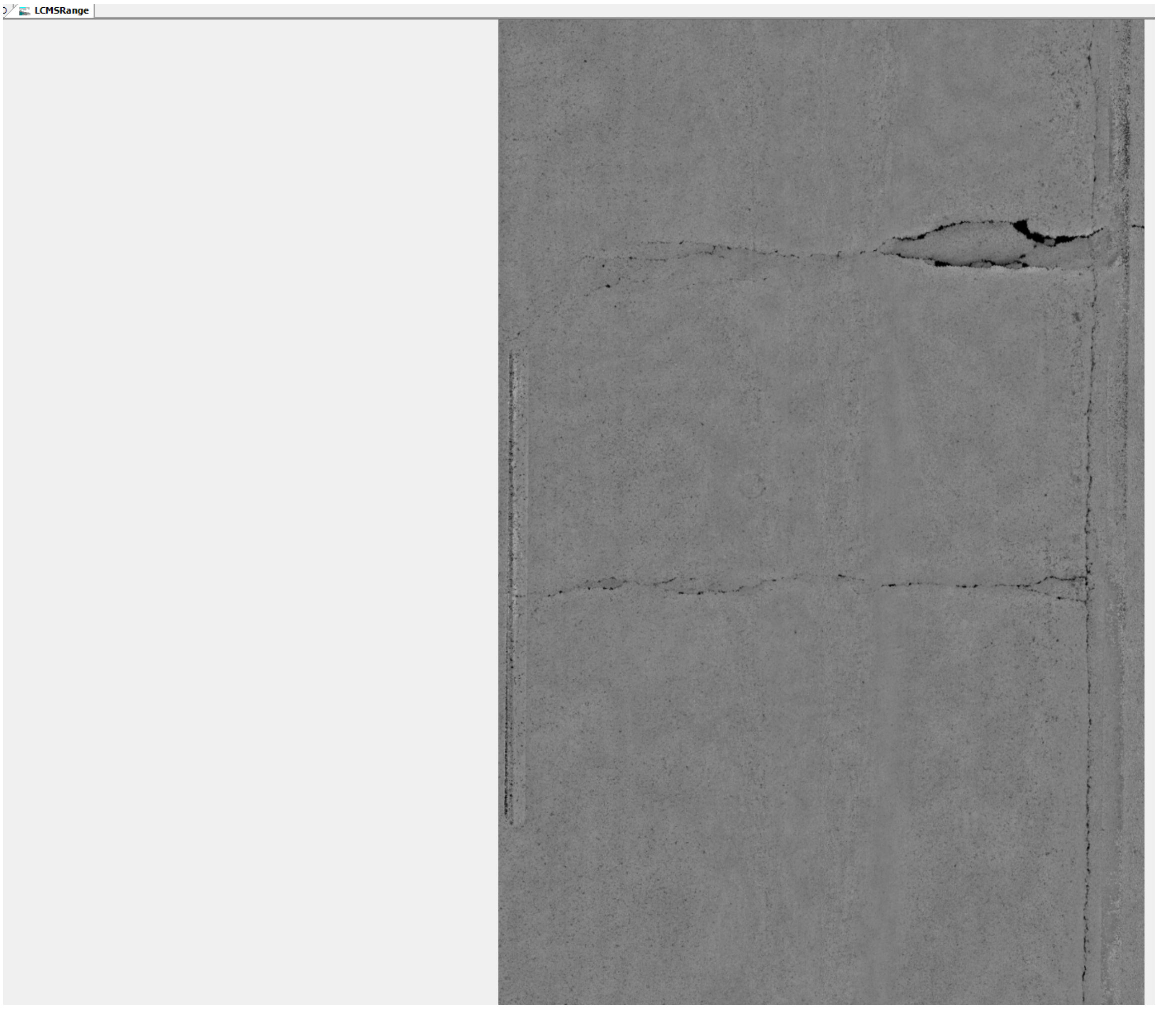
ii. If the images are not displayed correctly, the data will need to be reprocessed. Return to Step 2.



Step 15. Check the LCMSRange Images. Select a file that was processed and click on the “Images” drop-down menu. Click on “LCMSRange.” The image will appear in the window (see below image). At a minimum, check the first and last images.

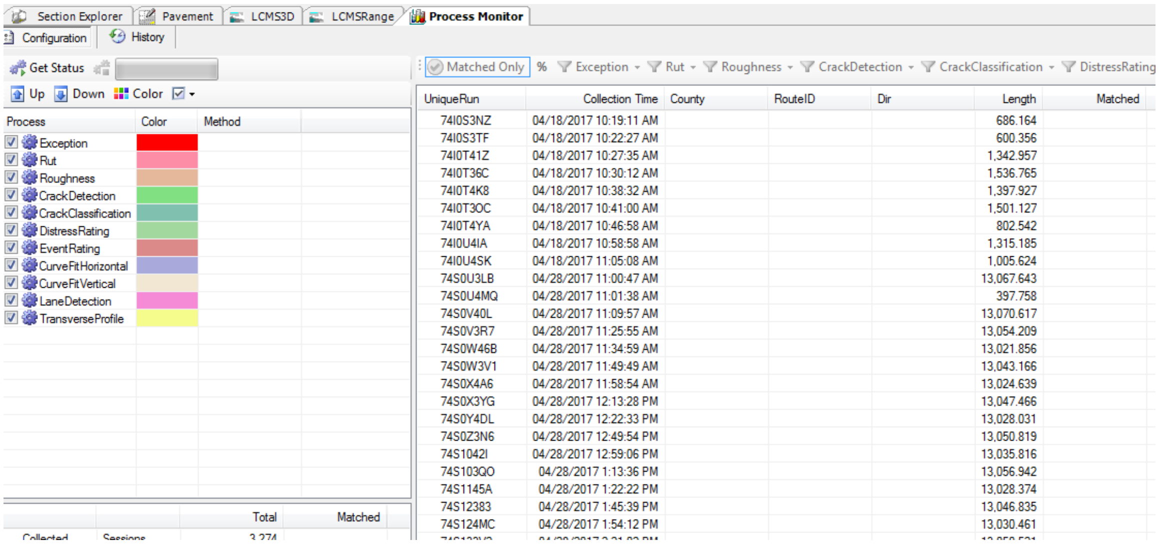
i. If the images are displayed correctly, proceed to Step 16.

ii. If the images are not displayed correctly, the data will need to be reprocessed. Return to Step 2.



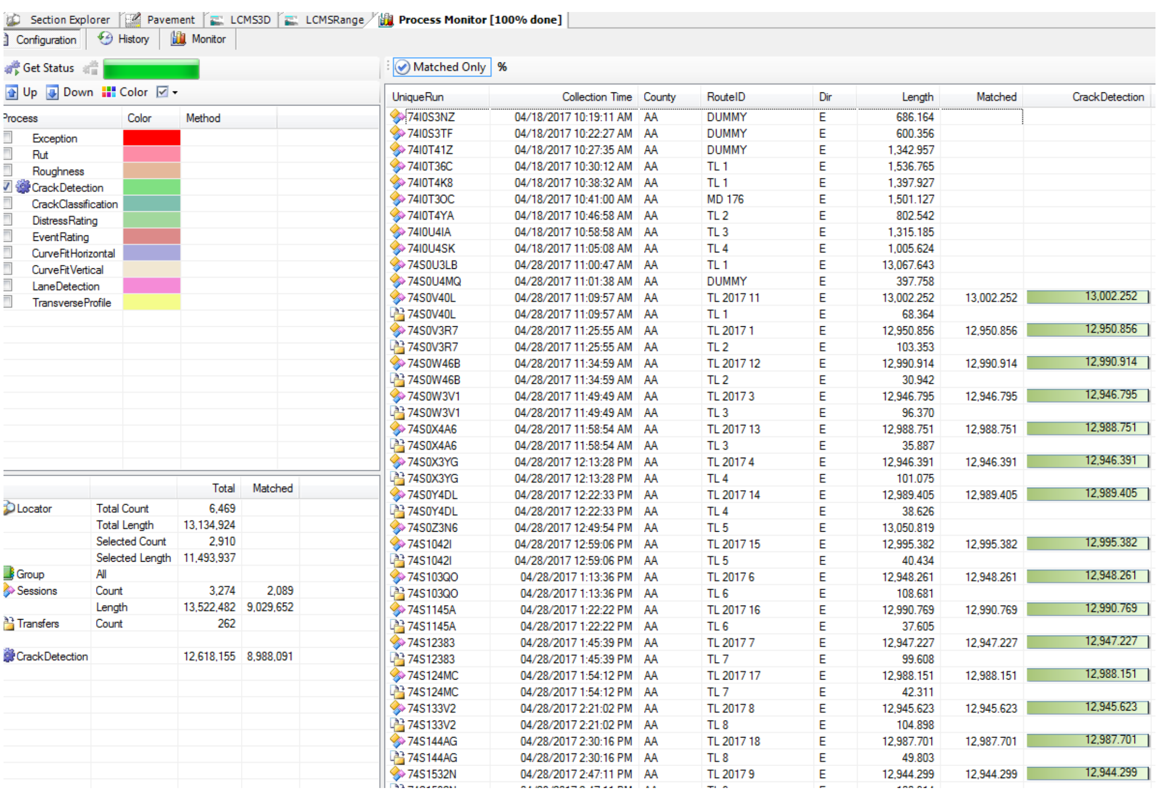
Step 16. Repeat Step 14 and Step 15 for at least 3 files from the batch.

Step 17. Perform the Process Monitor Check. Click the “Process” drop-down menu and select “Process Monitor.” The “Process Monitor” window will appear (see below image).



Step 18. Click on the “Checkbox” drop-down menu and select Clear. This will uncheck all the checked processes. Running the status check for all processes will take several hours to complete.

Step 19. Recheck the box next to “Crack Detection”. Click the “Get Status” button. The process will take a few minutes. A status bar at the top of the screen will estimate the remaining time to complete. When it is finished, the status bar will show all green and the “Crack Detection” field in the right window will show crack lengths in milimiles (see below image). Lane Detection is also done during the LCMS Global Processor, but it will be run in a later step.



Step 20. On the toolbar above the right window, deselect the “Matched Only” button. Find the first file that was part of the batch that was processed. Scroll through the other files in the batch. Make sure the values for “Crack Detection” are similar to the values for “Length.” They will never be exact. The “Crack Detection” value should never be less than half of the “Length” value.

i. If all the files in the batch show reasonable values for “Crack Detection,” proceed to Step 21.

ii. If one or more of the files in the batch show unreasonable values for “Crack Detection,” the data will need to be reprocessed. Return to Step 2.

Step 21. Repeat Step 2 to Step 10. This time, however, in Step 4, select the schema file titled “LCMS_GLOBAL_PROCESSOR_LANE_DETECTION_ONLY-[MOST RECENTDATE].” Never run this schema without first running the “LCMS_GLOBAL_PROCESSOR_[MOST RECENTDATE]” schema. Once these steps are repeated, process is complete (images do not need to be checked twice).

3- Performing QA of Processed LCMS Data – *performed by Supervisor*

Summary: This task performs QA checks on the processed LCMS data.

Step 22. TL review of QC staff notification of recollection.

Step 23. Review of production status – receive weekly update from QC staff (last ARAN collection data fully processed).

5.05 RUNNING ROUGHNESS PROCESSOR

5.05.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to run the Roughness Processor in the Roadware Vision software using data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff. The Roughness Processor is run in batches throughout the annual data collection season. This SOP applies to the processing of an ARAN data batch (or batches). The Roughness Processor is run after running the LCMS Global Processor (see Running Global LCMS Processor). This process results in the generation of ARAN pavement roughness profile data in the form of the International Roughness Index (IRI).

5.05.02 *Frequency*

The Roughness Processor is run on batches of ARAN collected data as they are received by the DPT. The frequency and timing varies according to schedule, available resources, and quantity of data received. The batches are processed in a continuous flow throughout the data collection season.

Each ARAN data batch is typically delivered to the DPT every 4 to 5 days. Assuming an average of 60 miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data. The actual frequency varies according to the proximity of the routes on which data were collected for the data batch to the Office of Materials Technology (OMT) office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring data recollection. The annual ARAN data collection season typically lasts from March to Mid-December.

5.05.03 *Purpose*

The purpose of this SOP is to run the Roughness Processor for collected ARAN data and perform quality control (QC) and quality assurance (QA) checks.

5.05.04 *Resource Requirements*

The running of the Roughness Processor involves two people: (1) a user knowledgeable in Roadware Vision software to run the processors and perform QC, and (2) a supervisor who, as required, provides guidance and decision-making and performs QA. The estimated effort levels in the table below represent the total time, in man-hours, to complete the processing and QC/QA checks. These time estimates assume average batch quantities and no issues encountered during processing.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision user and QC	1	3.0
DPT TL	Supervisor and QA	1	AR[06/12/2019]

5.05.05 *Procedure*

The procedure to run the Roughness Processor and perform QC/QA is comprised of the following three tasks:

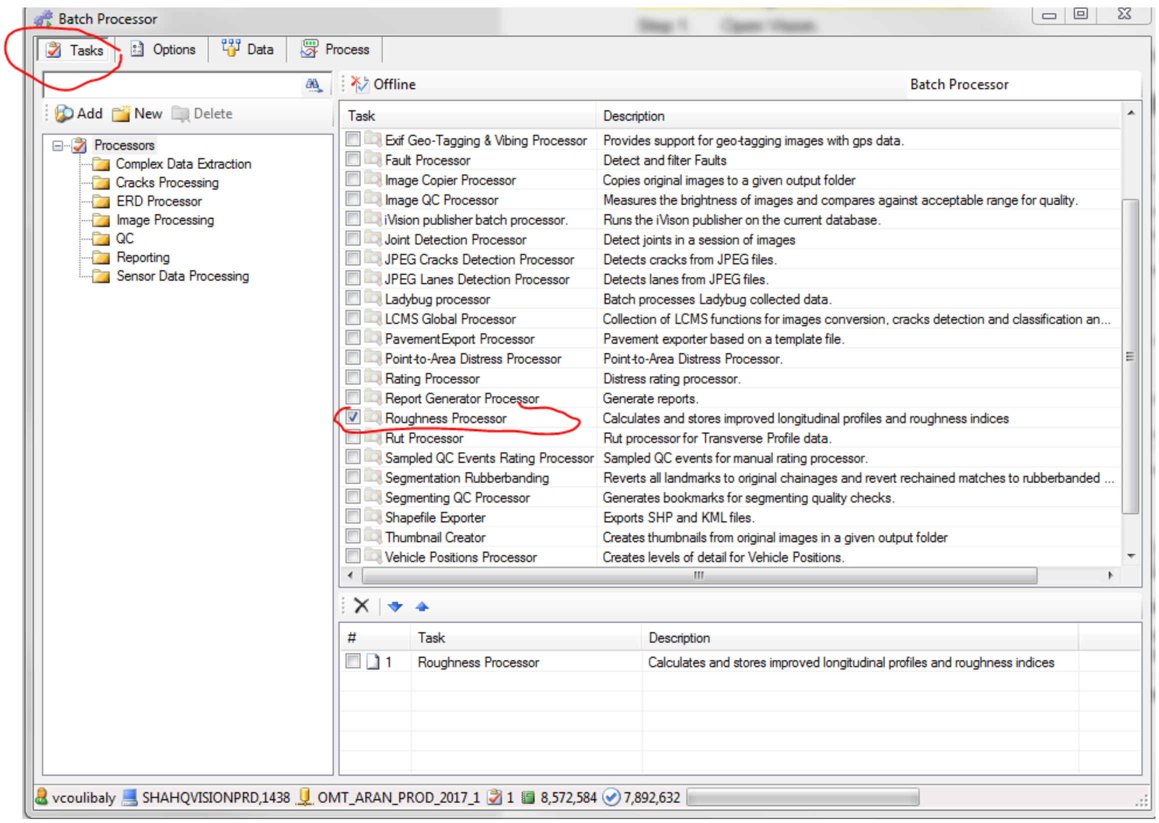
(1) running Roughness Processor in Vision,
(2) performing QC of the processed data, and
(3) performing QA of the processed data

1- Running Roughness Processor in Vision – *performed by Vision user*

Summary: This task uses Vision software to process IRI data from the ARAN data submittal.

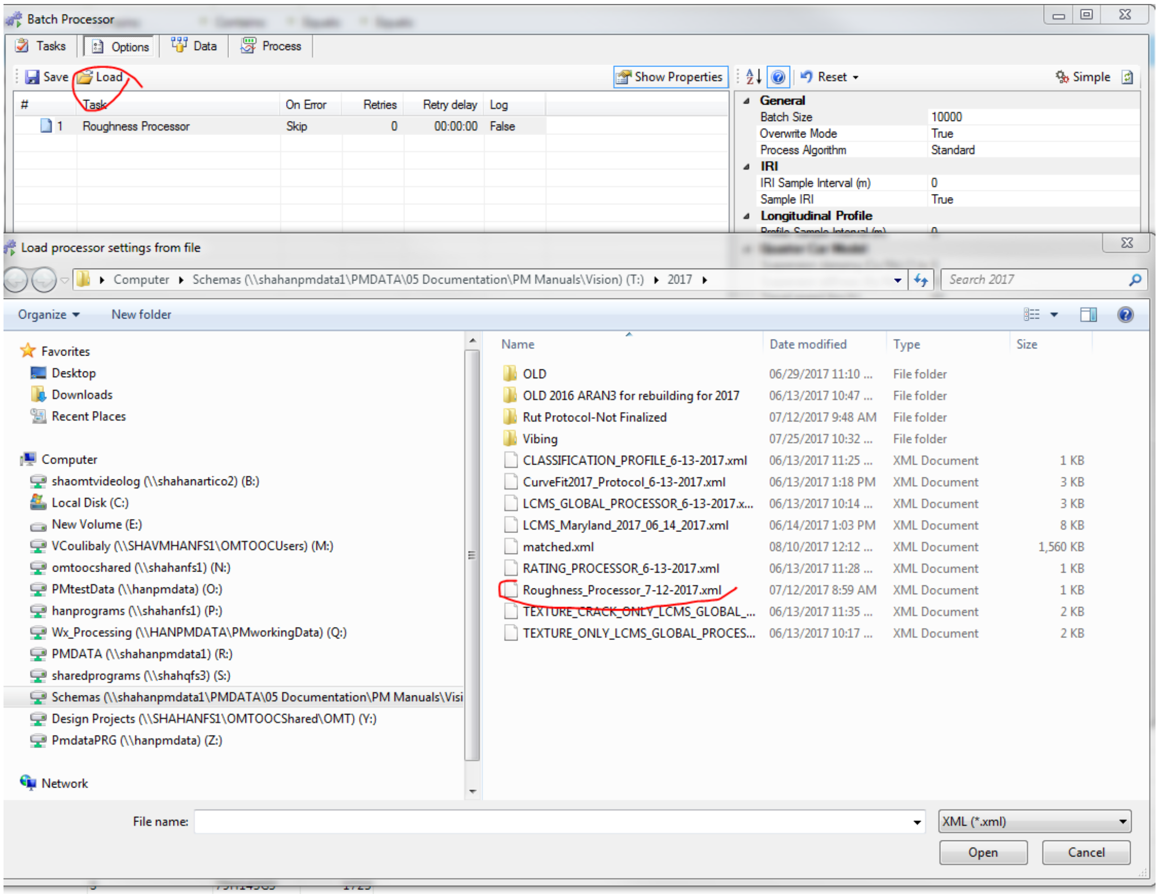
Step 1. Open Vision.

Step 2. Click the "Process" drop-down menu. Select "New Batch Processor." The "Batch Processor" window will open (see below image).



Step 3. Click the box next to "Roughness Processor" in the window on the right.

Step 4. Click the "Options" tab. Instead of changing settings manually, search for preset schemas. Click the "Load" button. Navigate to the folder where schema files are stored[06/12/2019]. In this folder, look for an XML file named "Roughness_Processor_[MOST RECENTDATE]." Select the file and click "Open" (see below image).

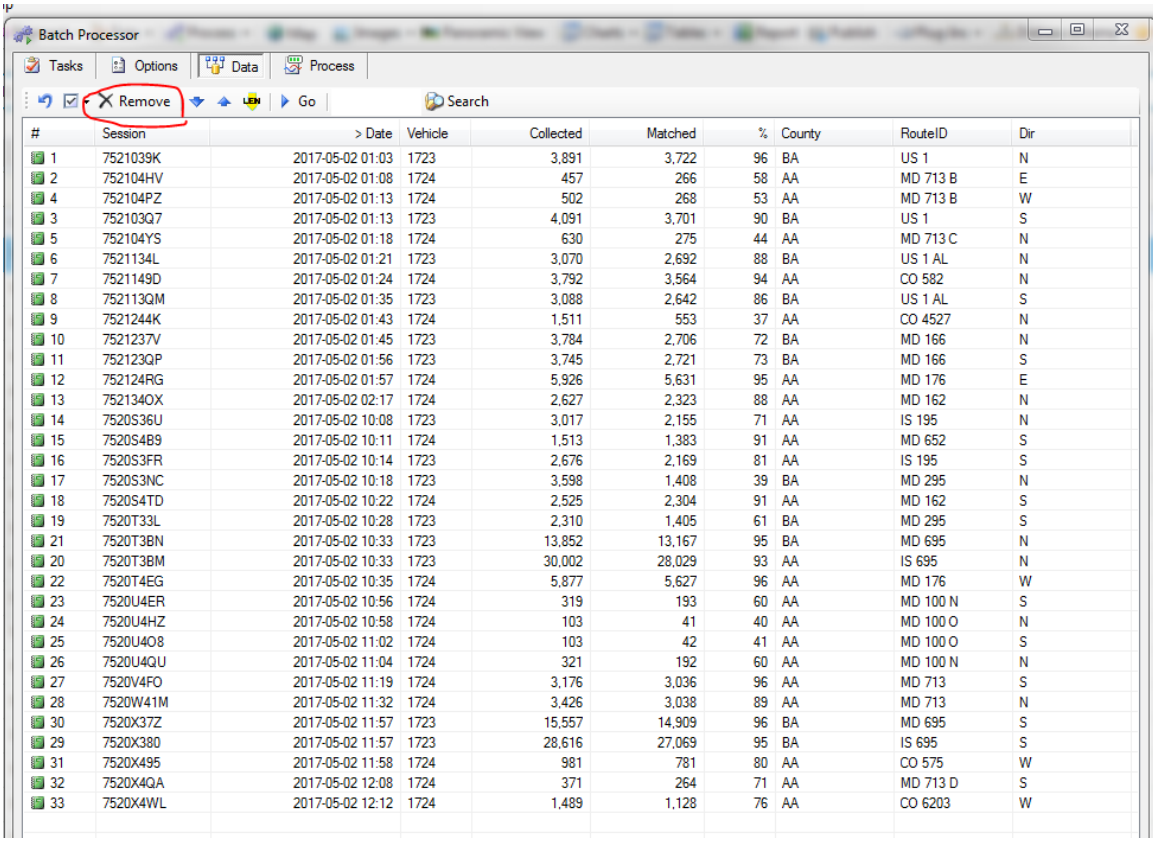


Step 5. Click “Data” from the top menu bar. Every file in the database will appear in the window. The list must be filtered to only include the sections from the current batch. This can be accomplished through two different methods:

i. Removing unwanted files, or

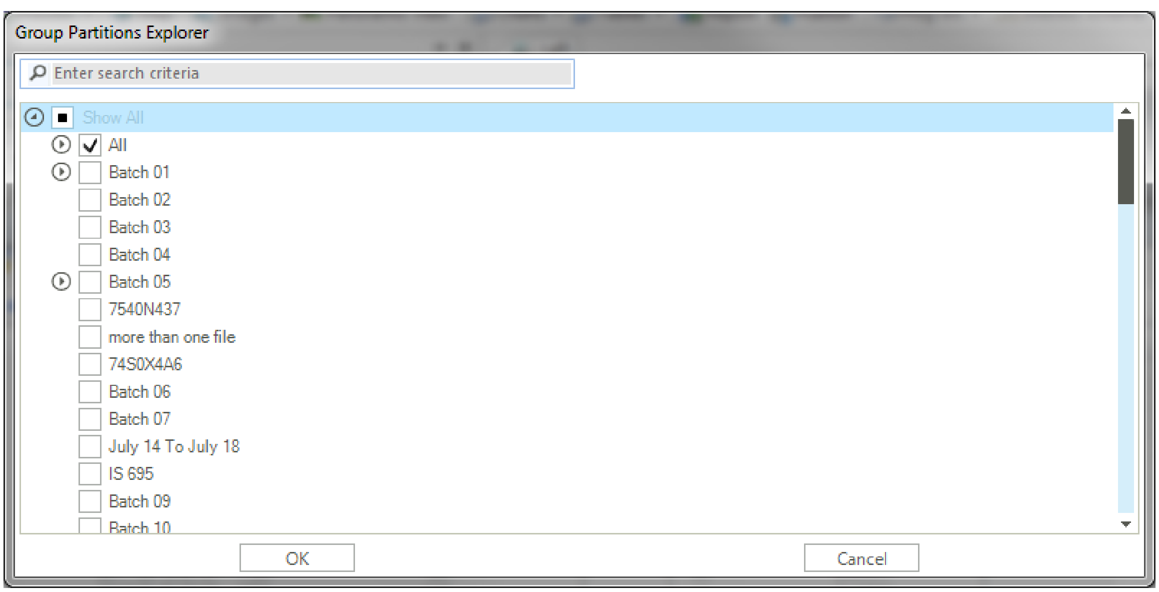
ii. Removing all files and selecting a batch to re-add.

Step 6. Choose removal method. If removing all files and selecting a batch to re-add is preferred, skip to Step 7. Otherwise, use a combination of the Shift and Ctrl keys to highlight all unwanted files in the window. Click “Remove.” Proceed to Step 8 (see below image).



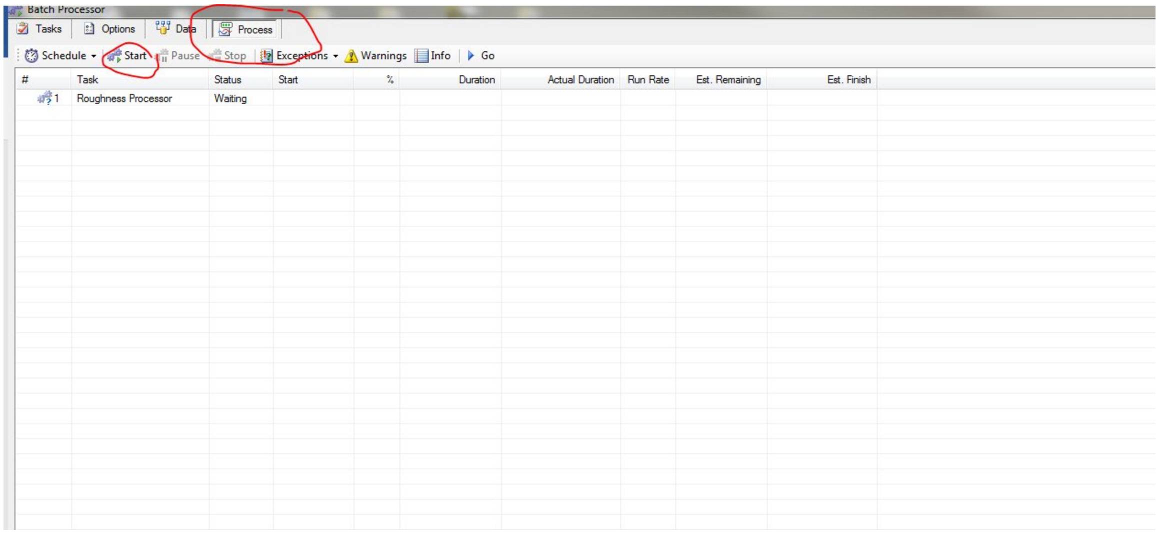
#	Session	> Date	Vehicle	Collected	Matched	%	County	RouteID	Dir
1	7521039K	2017-05-02 01:03	1723	3,891	3,722	96	BA	US 1	N
2	752104HV	2017-05-02 01:08	1724	457	266	58	AA	MD 713 B	E
4	752104PZ	2017-05-02 01:13	1724	502	268	53	AA	MD 713 B	W
3	752103Q7	2017-05-02 01:13	1723	4,091	3,701	90	BA	US 1	S
5	752104YS	2017-05-02 01:18	1724	630	275	44	AA	MD 713 C	N
6	7521134L	2017-05-02 01:21	1723	3,070	2,692	88	BA	US 1 AL	N
7	7521149D	2017-05-02 01:24	1724	3,792	3,564	94	AA	CO 582	N
8	752113QM	2017-05-02 01:35	1723	3,088	2,642	86	BA	US 1 AL	S
9	7521244K	2017-05-02 01:43	1724	1,511	553	37	AA	CO 4527	N
10	7521237V	2017-05-02 01:45	1723	3,784	2,706	72	BA	MD 166	N
11	752123QP	2017-05-02 01:56	1723	3,745	2,721	73	BA	MD 166	S
12	752124RG	2017-05-02 01:57	1724	5,926	5,631	95	AA	MD 176	E
13	752134OX	2017-05-02 02:17	1724	2,627	2,323	88	AA	MD 162	N
14	7520S36U	2017-05-02 10:08	1723	3,017	2,155	71	AA	IS 195	N
15	7520S4B9	2017-05-02 10:11	1724	1,513	1,383	91	AA	MD 652	S
16	7520S3FR	2017-05-02 10:14	1723	2,676	2,169	81	AA	IS 195	S
17	7520S3NC	2017-05-02 10:18	1723	3,598	1,408	39	BA	MD 295	N
18	7520S4TD	2017-05-02 10:22	1724	2,525	2,304	91	AA	MD 162	S
19	7520T33L	2017-05-02 10:28	1723	2,310	1,405	61	BA	MD 295	S
21	7520T3BN	2017-05-02 10:33	1723	13,852	13,167	95	BA	MD 695	N
20	7520T3BM	2017-05-02 10:33	1723	30,002	28,029	93	AA	IS 695	N
22	7520T4EG	2017-05-02 10:35	1724	5,877	5,627	96	AA	MD 176	W
23	7520U4ER	2017-05-02 10:56	1724	319	193	60	AA	MD 100 N	S
24	7520U4HZ	2017-05-02 10:58	1724	103	41	40	AA	MD 100 O	N
25	7520U4O8	2017-05-02 11:02	1724	103	42	41	AA	MD 100 O	S
26	7520U4QU	2017-05-02 11:04	1724	321	192	60	AA	MD 100 N	N
27	7520V4FO	2017-05-02 11:19	1724	3,176	3,036	96	AA	MD 713	S
28	7520W41M	2017-05-02 11:32	1724	3,426	3,038	89	AA	MD 713	N
30	7520X37Z	2017-05-02 11:57	1723	15,557	14,909	96	BA	MD 695	S
29	7520X380	2017-05-02 11:57	1723	28,616	27,069	95	BA	IS 695	S
31	7520X495	2017-05-02 11:58	1724	981	781	80	AA	CO 575	W
32	7520X4QA	2017-05-02 12:08	1724	371	264	71	AA	MD 713 D	S
33	7520X4WL	2017-05-02 12:12	1724	1,489	1,128	76	AA	CO 6203	W

Step 7. To remove all files, click the “Check” drop-down menu and select “All.” Click “Remove.” Then, click the “Reload” (first blue arrow) button. The “Group Partitions” window will open (see below image).

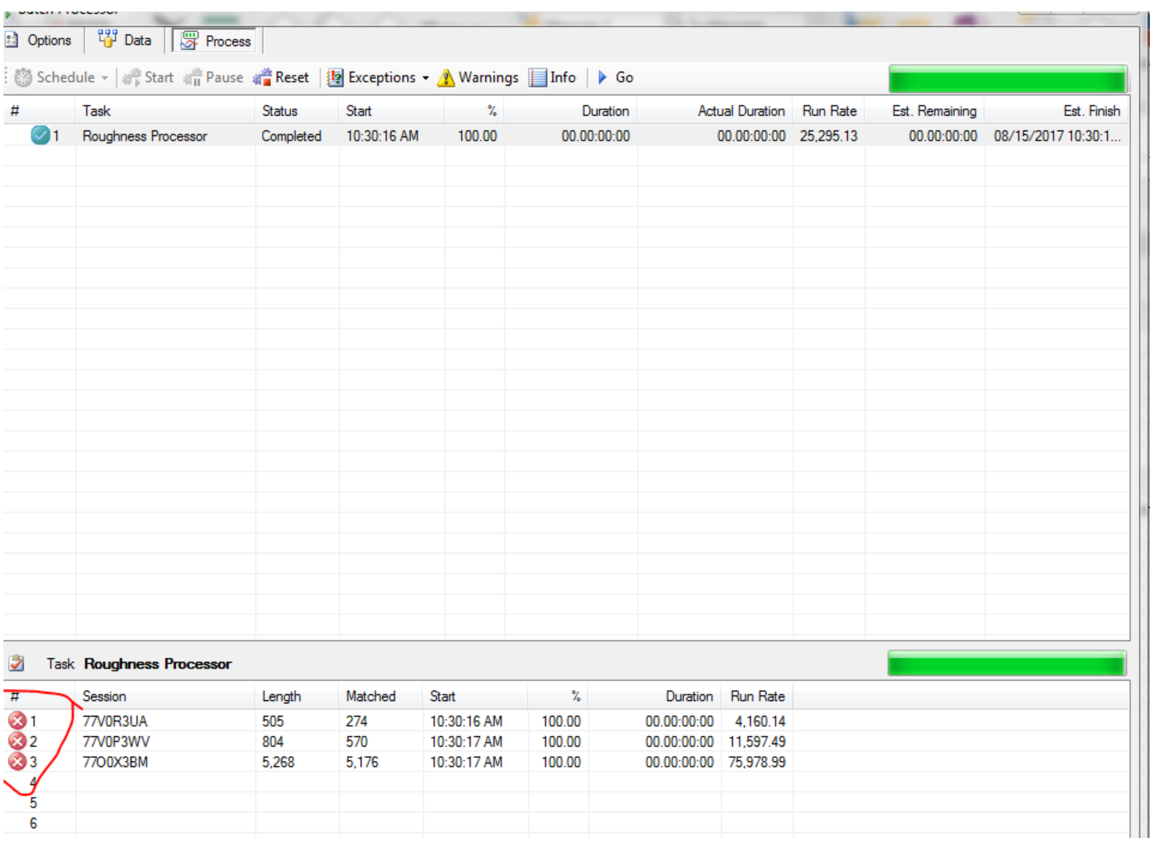


Select the current batch by clicking the checkbox next to the appropriate batch name. Click the “OK.”

Step 8. Once only the desired files appear in the "Batch Processor" window, they may be processed. Click "Process", then "Start." The files will begin to appear under the session window (see below image).



Note: if a red "X" appears next to the name of the run during processing, the Roughness Processor has already been ran for that file (see below image).



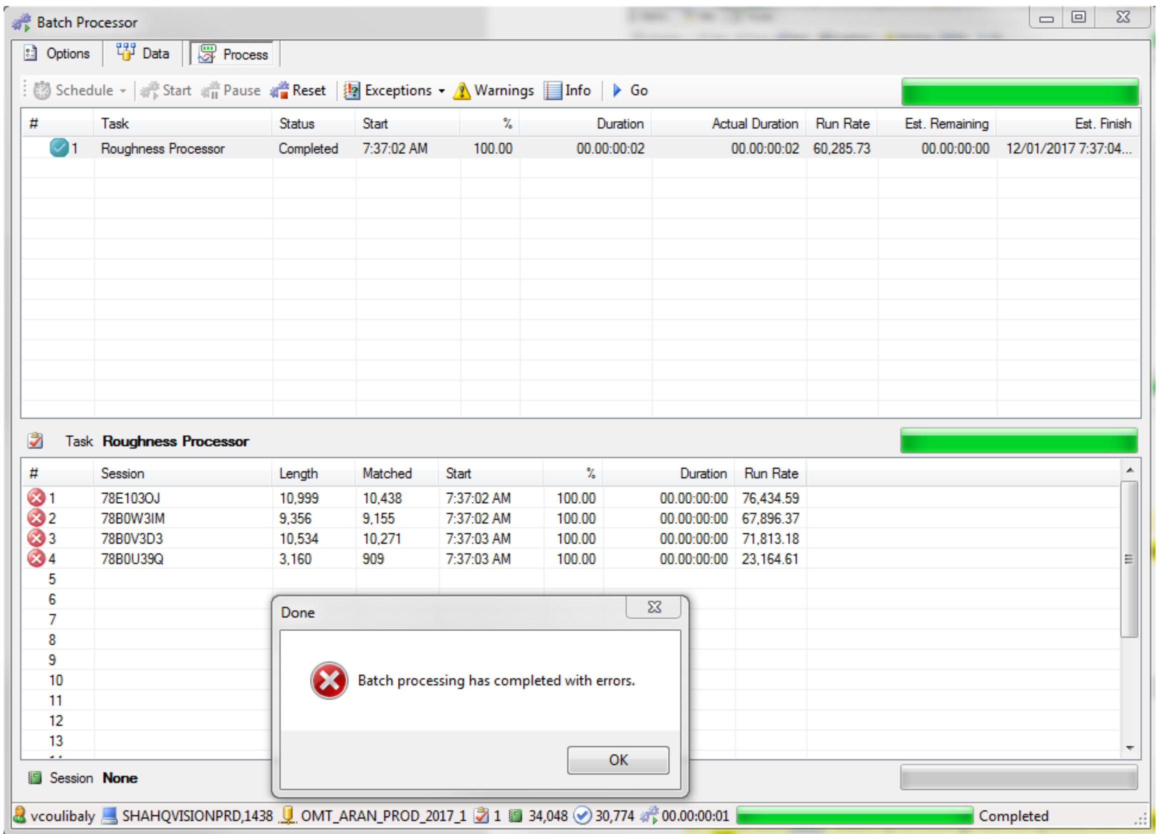
2- Performing QC of Processed IRI Data – *performed by Vision user*

Summary: This task checks the quality of processed IRI data through an inspection of errors reported by Vision during processing.

Step 9. A dialogue box will appear when processing is complete.

i. If the box says "Batch processing has completed", proceed to Step 11.

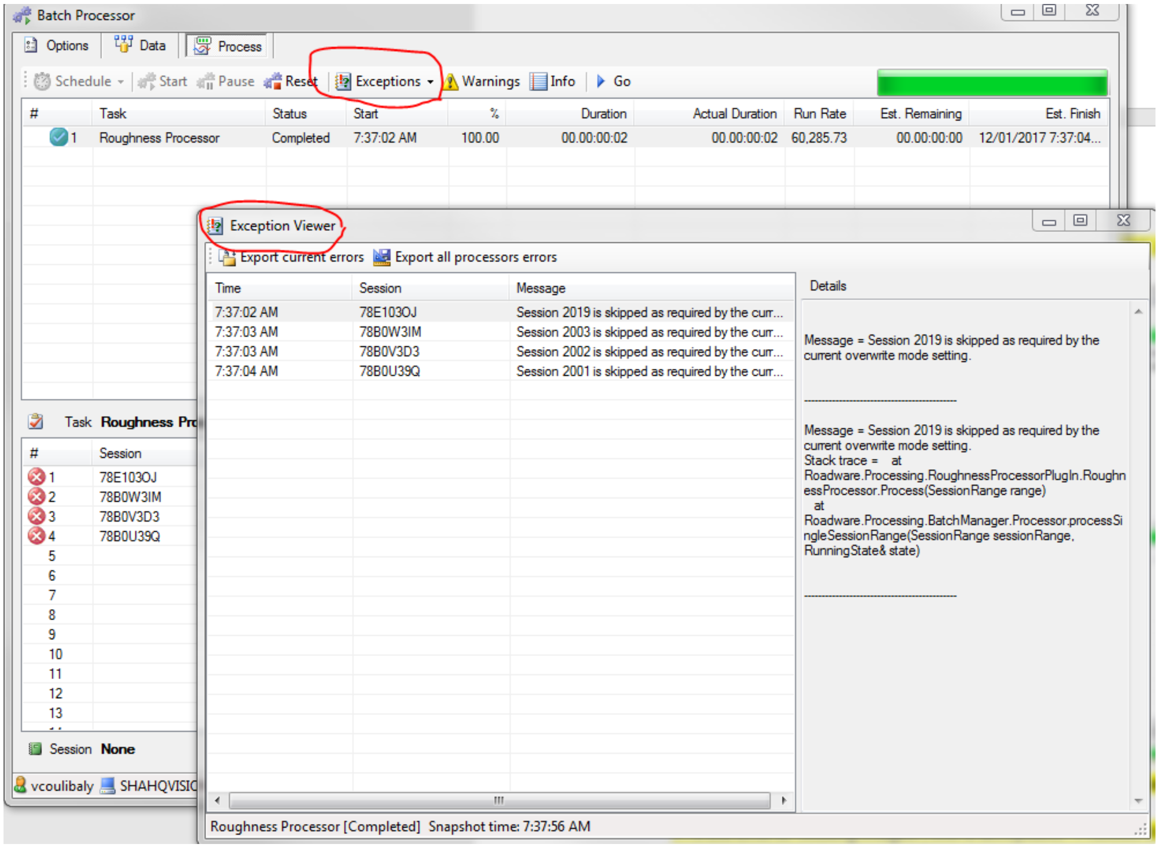
ii. If the box says "Batch processing has completed with errors", proceed to Step 10.



Step 10. View the errors. Click the "Exceptions" drop-down menu and select "View Exceptions."

i. If the error is "Missing Images", this is acceptable. Proceed to Step 11.

ii. If any other errors are present, reprocessing is required. Click the "Exceptions" drop-down menu and select "Reprocess Exceptions." This will remove all the files from the data screen except for the files that had exceptions. Next, click the "Start" button to reprocess.



3- Performing QA of Processed IRI Data – *performed by Supervisor*

Summary: This task performs QA checks on the processed IRI data.

Step 11. TL review of QC staff notification of recollection.

Step 12. Review of production status – receive weekly update from QC staff (last ARAN collection data fully processed).

5.06 ROUTE MATCHING

5.06.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to match the inventory data with the data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff. This SOP is performed after the running of the Roughness Processor (see Running Roughness Processor). Performing route matching may require the user to reference several additional SOPs developed to supplement the route matching procedure, including Accessing the Electronic ARAN Logs (Accessing Electronic ARAN Logs), Changing Lat/Long (Changing Latitude/Longitude), Using eGIS (Using eGIS), and Importing Inventory Changes (Running Routing Importer). For further information regarding route matching, including troubleshooting and common examples, refer to the "Vision Matching 2015" guide.

5.06.02 *Frequency*

Route matching is completed on batches of ARAN collected data as they are received by the DPT. The frequency and timing varies according to schedule, available resources, and quantity of data received. The batches are processed in a continuous flow throughout the data collection season.

Each ARAN data batch is typically delivered to the DPT every 4 to 5 days. Assuming an average of 60 miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data. The actual frequency varies according to the proximity of the routes on which data were collected for the data batch to the Office of Materials Technology (OMT) office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring data recollection. The annual ARAN data collection season typically lasts from March to Mid-December.

5.06.03 *Purpose*

The purpose of this SOP is to compare and match the expected set of routing inventory data with the ARAN data collected in the field and to perform quality control (QC) and quality assurance (QA) checks. It is also referred to as "segmenting.

5.06.04 *Resource Requirements*

Route matching involves two people: (1) a user knowledgeable in Vision software and the Engineering Data Warehouse (EDW) application to perform the route matching and QC, (2) a supervisor who, as required, provides guidance and decision-making and performs QA. The estimated effort levels in the table below represent the total time, in man-hours, to complete route matching and QA. These time estimates assume average batch quantities and no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision/EDW user and QC	1	40.0
DPT Team Leader (TL)	Supervisor and QA	1	AR[06/12/2019]

5.06.05 *Procedure*

The procedure to compare and match the inventory data with the ARAN data collected in the field is comprised of the following five components:

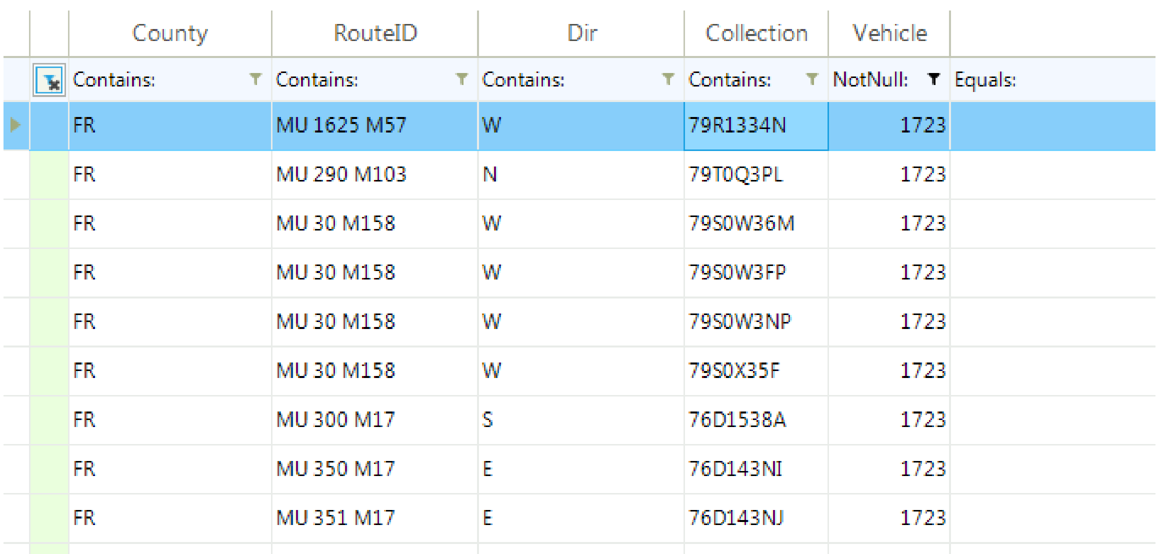
(1) changing workspaces in Vision,
(2) route matching,
(3) updating table in the EDW,
(4) performing QC of matched routes, and
(5) performing overall QA of the process.

1- Changing Workspaces in Vision – *performed by Vision user*

Summary: This task opens the appropriate windows in Vision and arranges them so that route matching can be performed efficiently.

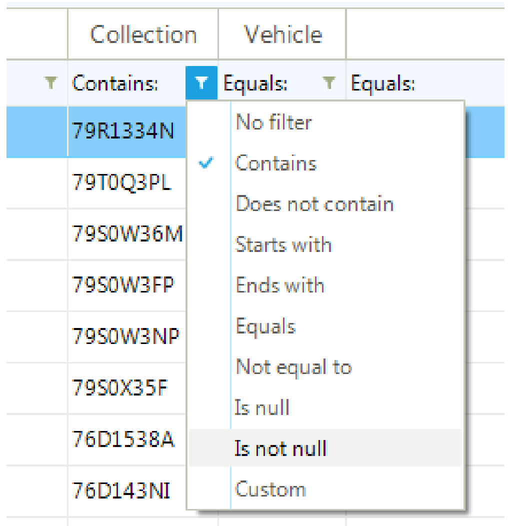
Step 19. Open Vision.

Step 20. The “Section Explorer” window will appear when the program opens. All routes that were imported via the Routing Importer (Running Routing Importer) are listed. If data has been collected for a specific route, the “Collection” and “Vehicle” fields will be populated (see below image).

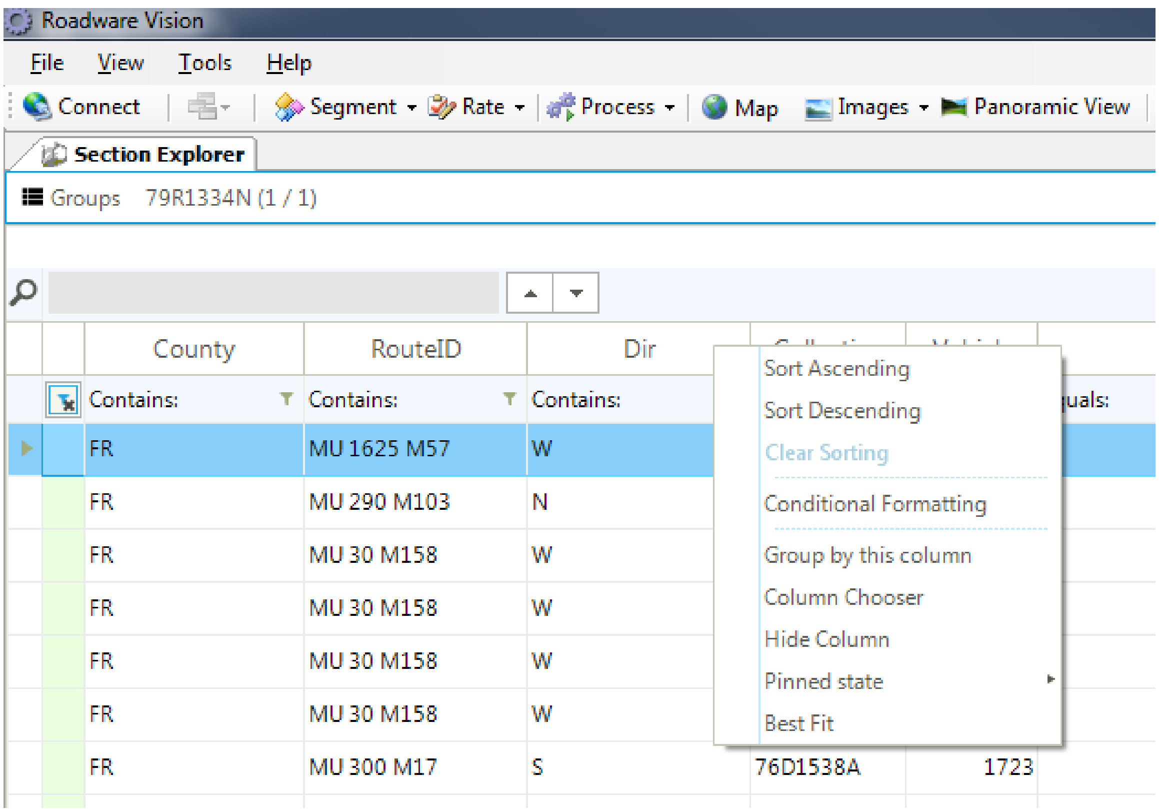


County	RouteID	Dir	Collection	Vehicle
Contains:	Contains:	Contains:	Contains:	NotNull:	Equals:
FR	MU 1625 M57	W	79R1334N	1723
FR	MU 290 M103	N	79T0Q3PL	1723
FR	MU 30 M158	W	79S0W36M	1723
FR	MU 30 M158	W	79S0W3FP	1723
FR	MU 30 M158	W	79S0W3NP	1723
FR	MU 30 M158	W	79S0X35F	1723
FR	MU 300 M17	S	76D1538A	1723
FR	MU 350 M17	E	76D143NI	1723
FR	MU 351 M17	E	76D143NJ	1723

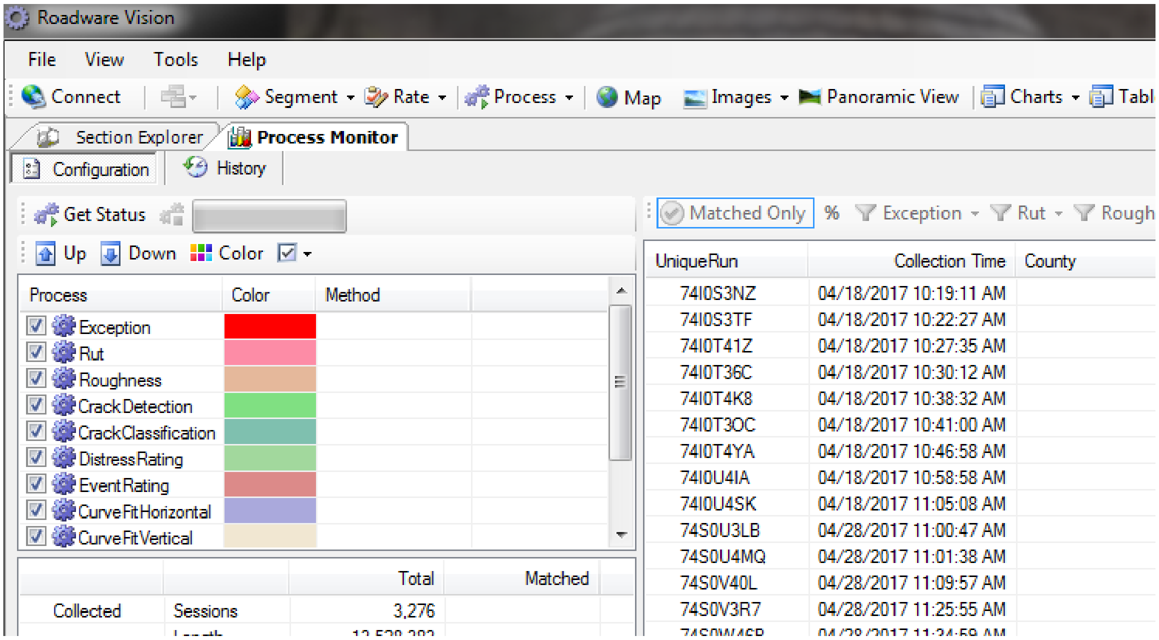
Step 21. Filter out routes that have not been collected. Select the “Filter” icon under the “Collection” column and select “Is not null” from the drop-down menu (see below image).



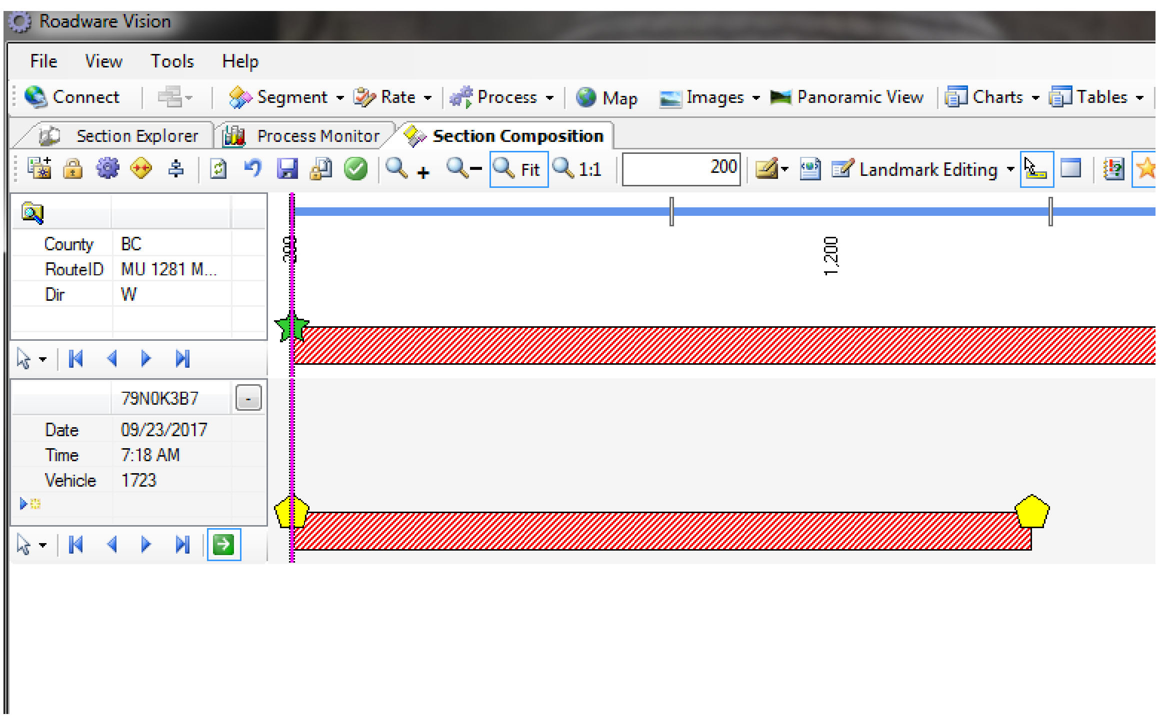
Step 22. Add Date/Time to the columns. Right-click on the header bar and select "Column Chooser" (see below image). Drag the "Time" column into the "Column Chooser" window, or double-click it in the list.



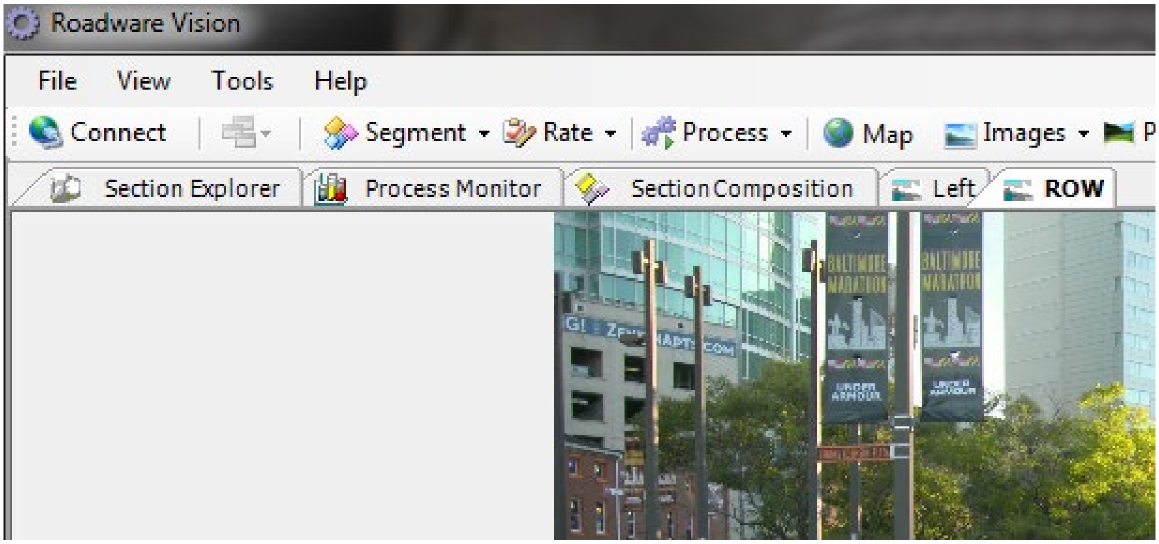
Step 23. Open "Process Monitor" window. Click the "Process" drop-down menu and then select "Process Monitor." The "Process Monitor" window will appear as a new tab with "Section Explorer", which was already open (see below image).



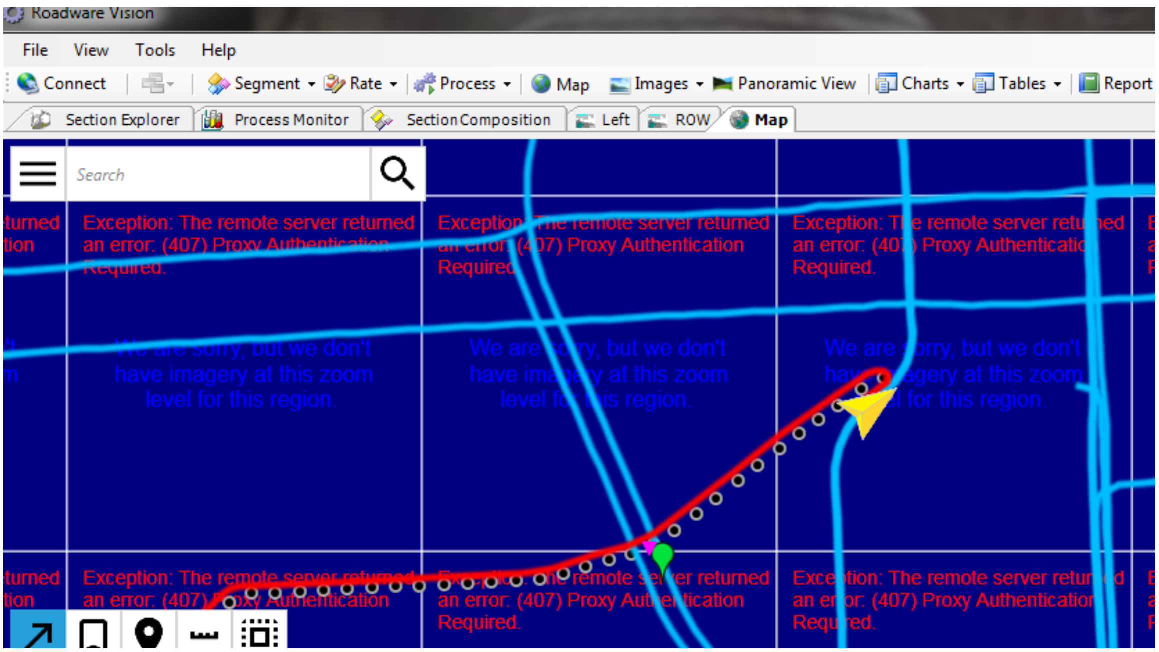
Step 24. Open “Section Composition” window. Click the “Segment” drop-down menu and then select “Section Composition.” The “Section Composition” window will appear as a new tab (see below image).



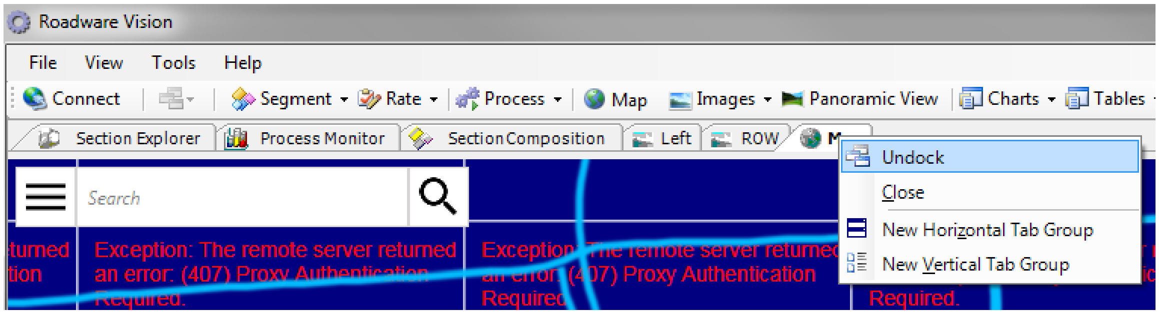
Step 25. Open image windows. Click the “Images” drop-down menu and then select “Left.”. Repeat the sequence for the “ROW” image window. Both image windows will appear as new tabs (see below image).



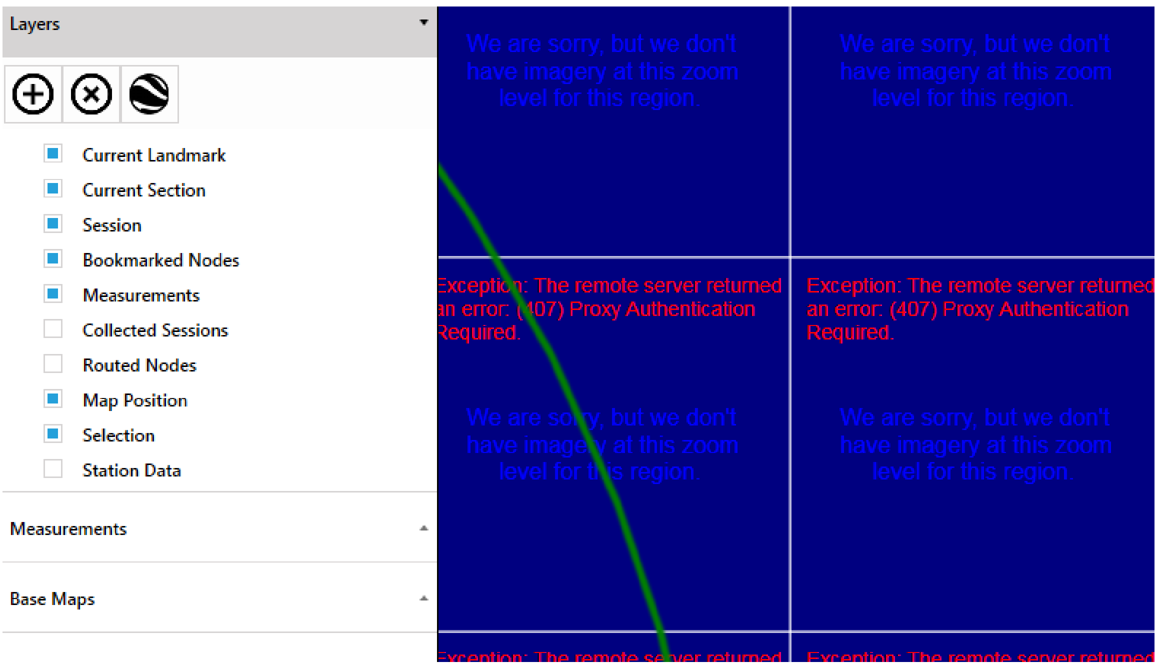
Step 26. Open the “Map” window. Click the “Map” button. The “Map” window will appear as a new tab (see below image).



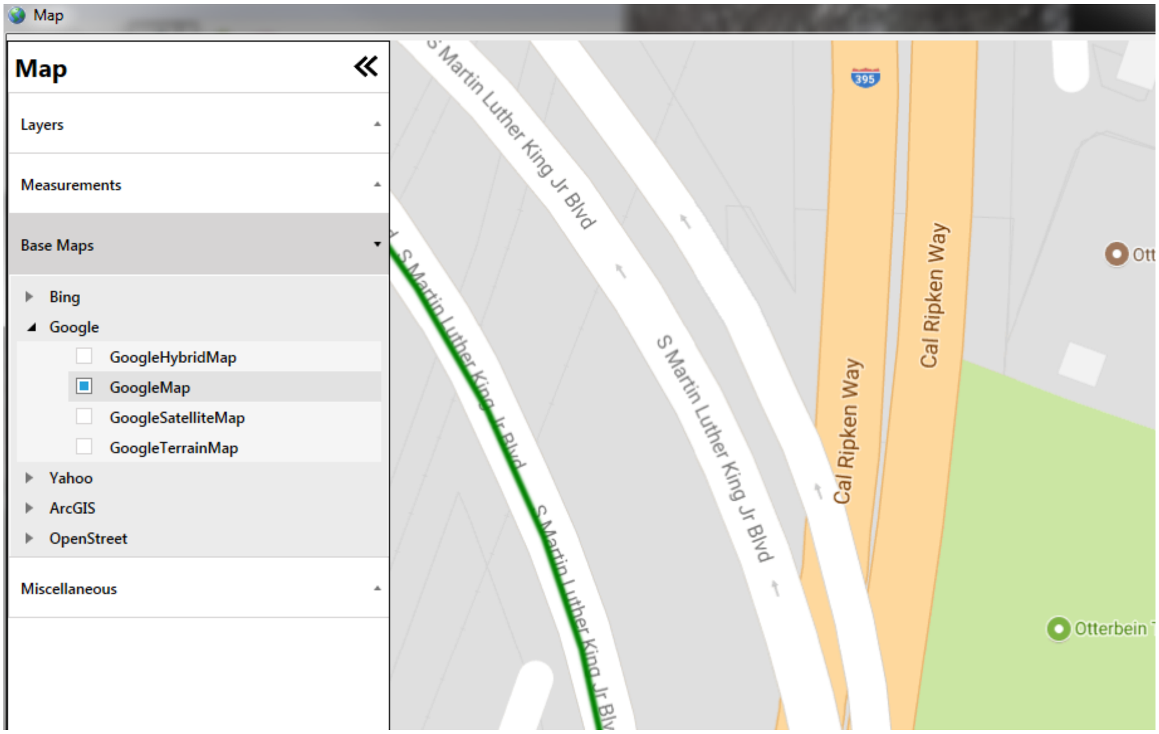
Step 27. Undock the map. Right-click on the “Map” tab and select “Undock” from the drop-down menu (see below image). The map will undock. Drag the new map window to the second monitor (the one without the Vision program). Maximize the map screen on the second monitor.



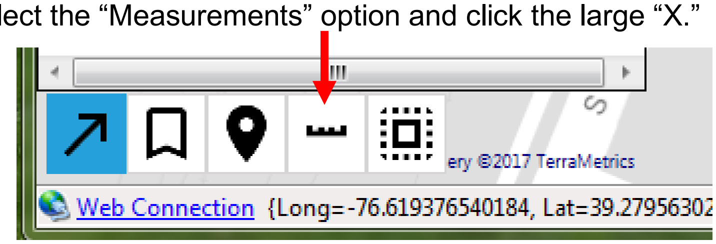
Step 28. Click the button with the horizontal lines on the top left of the map window. Click the “Layers” option. The default layer settings will appear. Uncheck the following: “Collected Sessions” and “Station Data” from the list (see below image).



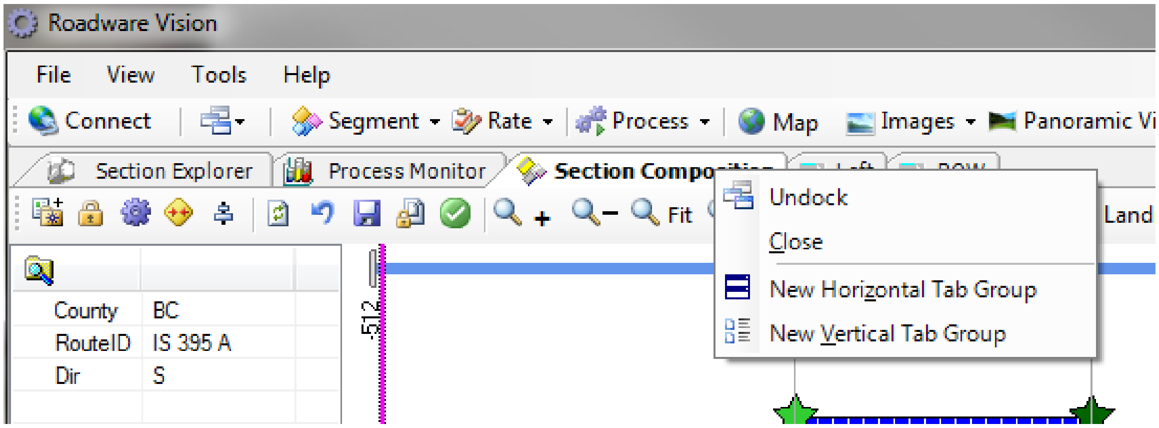
Step 29. Click on the “Base Maps” option. The typical preferred map is selected by clicking the “Google” tab and then checking “GoogleMap” in the map list. When the map selection is complete, click the two left-facing arrows at the top of the options window to close the tab (see below image).



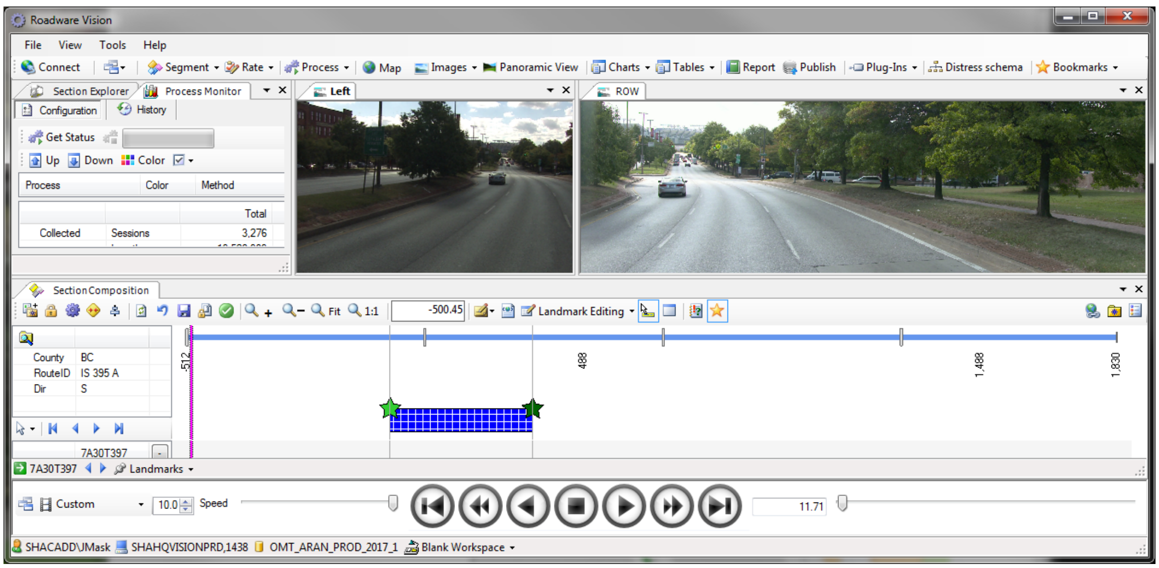
Step 30. At the bottom left corner of the window, select the "Measure Distance" icon. This will prevent the program from jumping to different routes during route matching (see below image). While this setting prevents the map from jumping to a different route, the "Measure Distance" setting will also draw a line on the map whenever it is clicked. To remove measurements from the screen when it gets cluttered, select the icon with the horizontal lines at the top left of the screen, select the "Measurements" option and click the large "X."



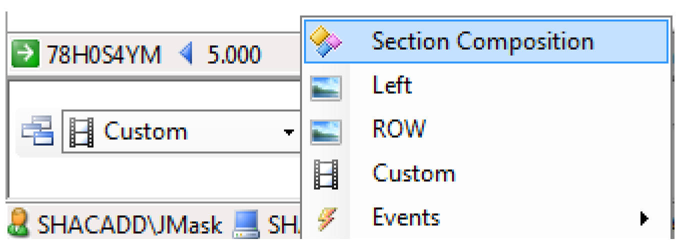
Step 31. Return to the remaining windows still docked in the Vision program. Right-click on the "Section Composition" tab header and select "New Horizontal Tab Group" (see below image).



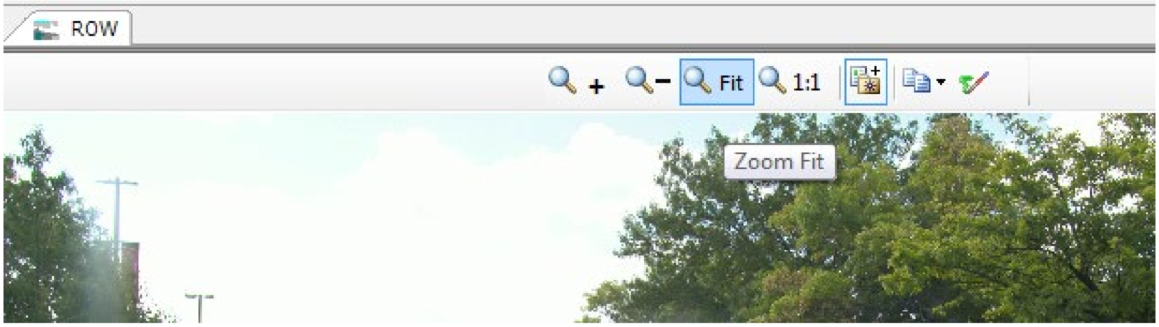
Step 32. Repeat Step 31 for the “Left” and “ROW” image windows (see below image).



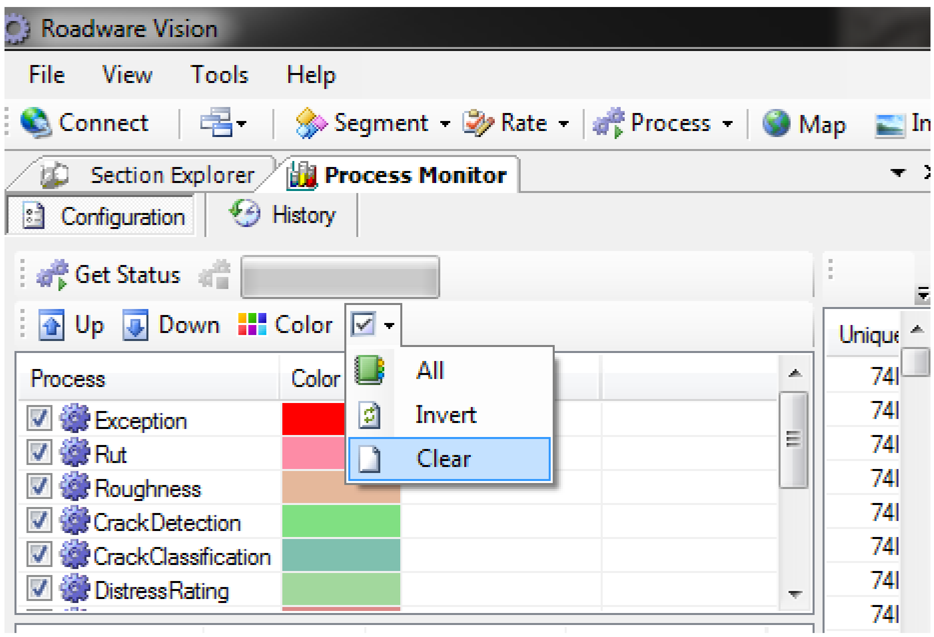
Step 33. In the “Section Composition” window, select the “Custom” drop-down menu and choose “Section Composition” (see below image). This will move the vehicle location on the map and the sensor bar in the “Section Composition” window twice for every single movement in the image windows.



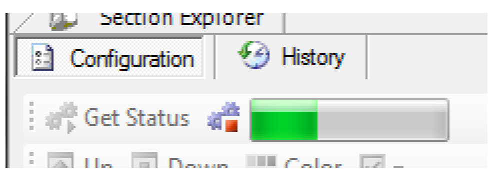
Step 34. Resize the images. Click the “Maximize” button in the upper right hand corner of the Vision program. Hover the mouse over the top of each image window. A toolbar will appear. Click the “Fit” button (see below image).



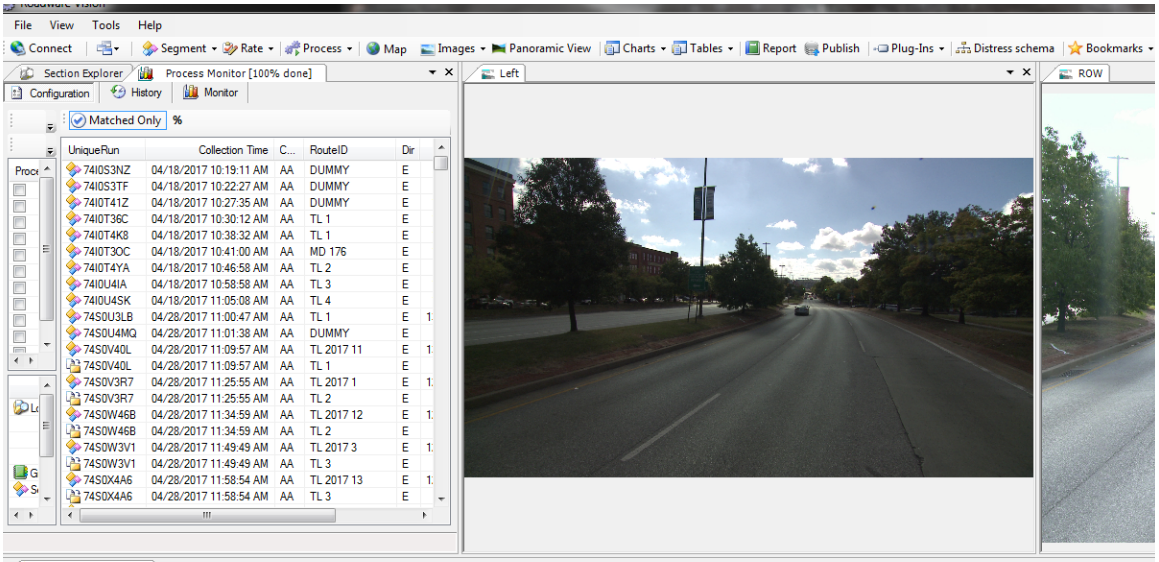
Step 35. In the “Process Monitor” tab, click the “Check” drop-down menu and select “Clear” (see below image). This will remove the checks beside the items listed in the process table.



Step 36. In the “Process Monitor” window, click the “Get Status” button. The status of the task will be shown in a progress bar beside the “Get Status” button (see below image).

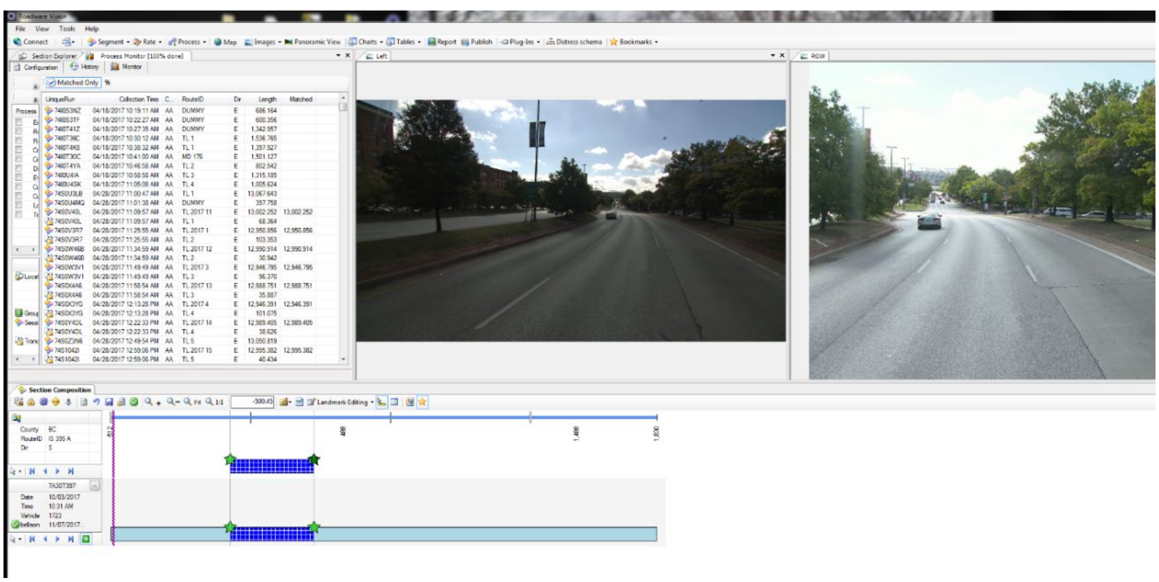


Step 37. Move the vertical bar which separates the two windows in the “Process Monitor” tab to the left so that the table with “Unique Run” as the first column can be seen on the right (see below image). It may be necessary to resize the image windows to accomplish the optimal view.

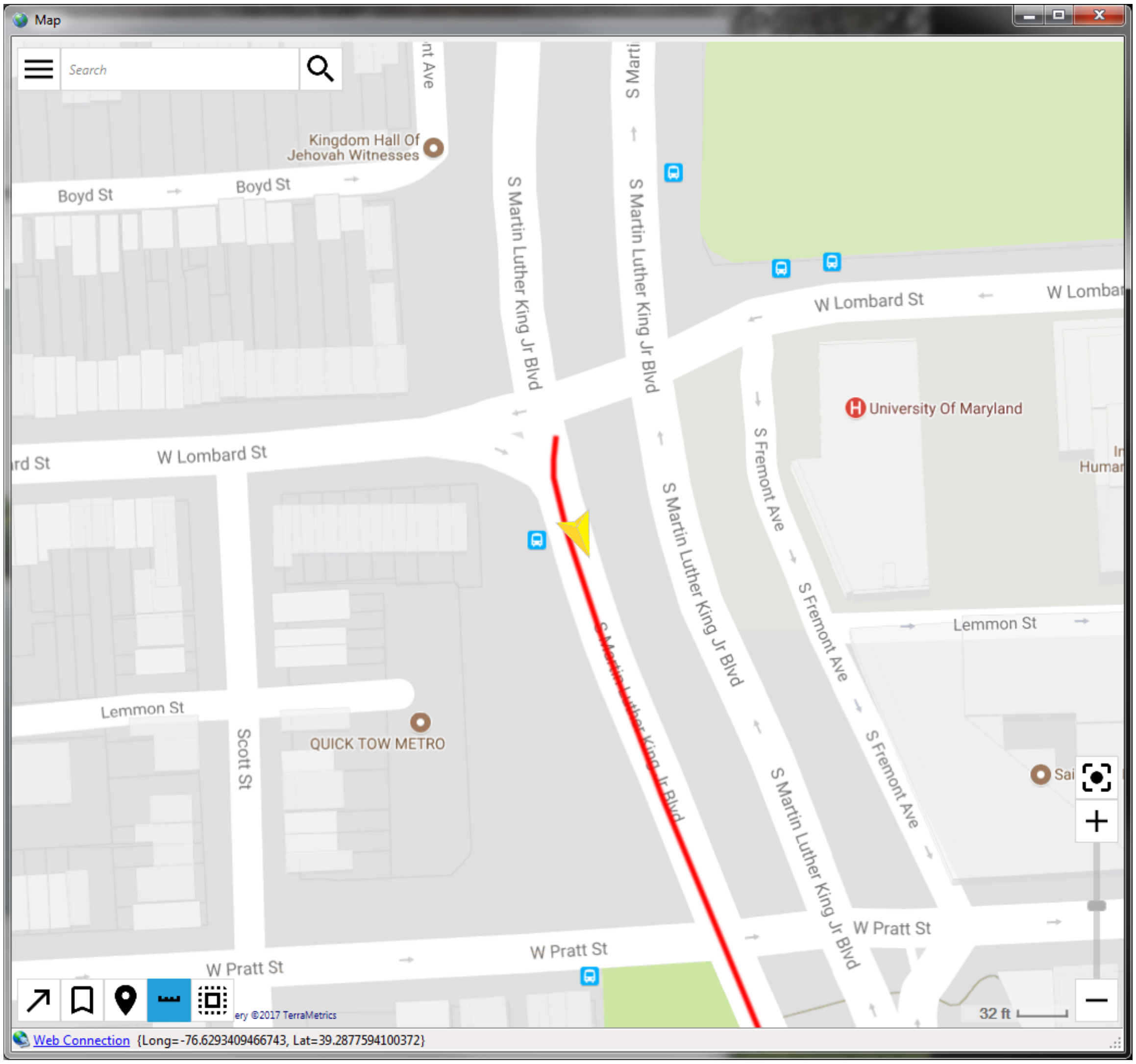


Step 38. Continue arranging windows until the “Matched” column can be seen in the “Process Monitor” window. If a file has already been matched, a distance value will appear in the “Matched” column. Otherwise, the column will be blank (if it has not been matched or if it was transferred to another route). Check that the Vision program windows and the map window look similar to the images below before continuing with route matching.

Vision window (Process Monitor, ROW, Left, Section Composition)



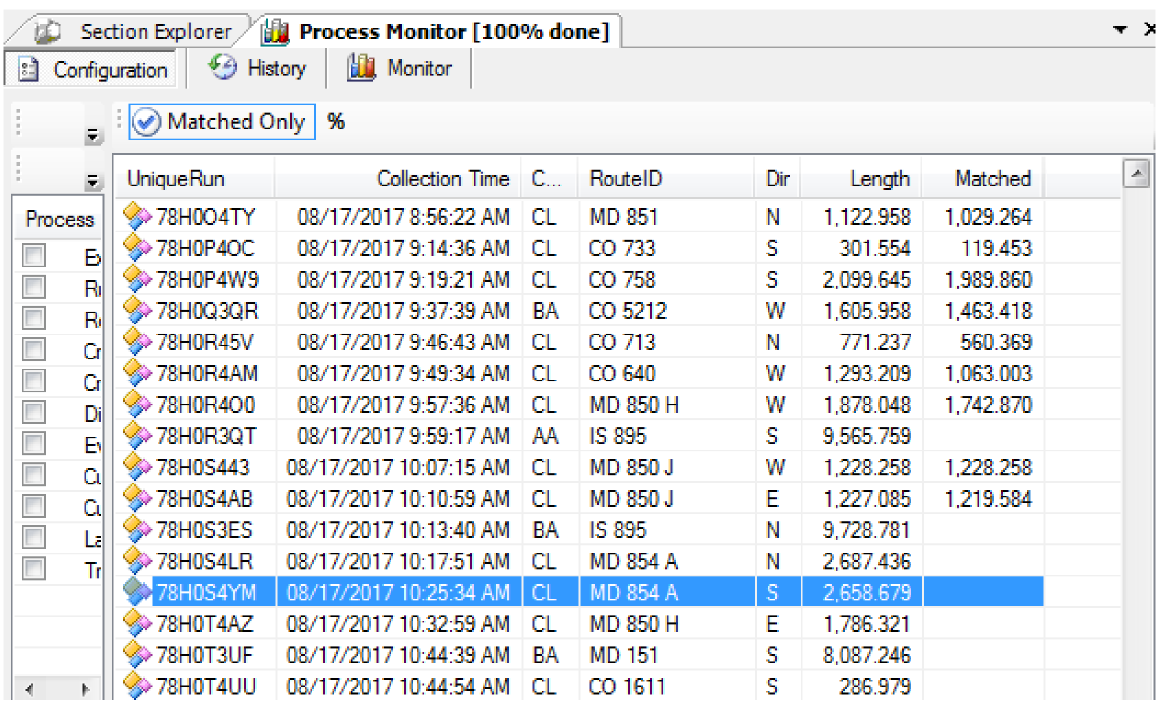
Map window



2- Route Matching – *performed by Vision user*

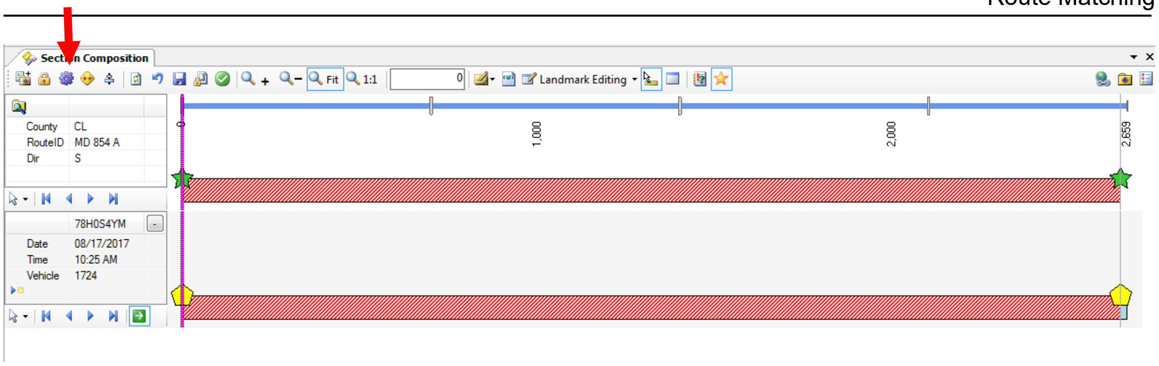
Summary: This task uses Vision software to compare and match a collected ARAN file to the appropriate inventory section. This task utilizes many Vision tools (see below image).

Step 39. In the "Process Monitor" window, select a file by clicking on the appropriate row in the table. The candidates for route matching will have blanks in the "Matched" column of the table (see below image).



UniqueRun	Collection Time	C...	RouteID	Dir	Length	Matched
78H0O4TY	08/17/2017 8:56:22 AM	CL	MD 851	N	1,122.958	1,029.264
78H0P4OC	08/17/2017 9:14:36 AM	CL	CO 733	S	301.554	119.453
78H0P4W9	08/17/2017 9:19:21 AM	CL	CO 758	S	2,099.645	1,989.860
78H0Q3QR	08/17/2017 9:37:39 AM	BA	CO 5212	W	1,605.958	1,463.418
78H0R45V	08/17/2017 9:46:43 AM	CL	CO 713	N	771.237	560.369
78H0R4AM	08/17/2017 9:49:34 AM	CL	CO 640	W	1,293.209	1,063.003
78H0R4O0	08/17/2017 9:57:36 AM	CL	MD 850 H	W	1,878.048	1,742.870
78H0R3QT	08/17/2017 9:59:17 AM	AA	IS 895	S	9,565.759	
78H0S443	08/17/2017 10:07:15 AM	CL	MD 850 J	W	1,228.258	1,228.258
78H0S4AB	08/17/2017 10:10:59 AM	CL	MD 850 J	E	1,227.085	1,219.584
78H0S3ES	08/17/2017 10:13:40 AM	BA	IS 895	N	9,728.781	
78H0S4LR	08/17/2017 10:17:51 AM	CL	MD 854 A	N	2,687.436	
78H0S4YM	08/17/2017 10:25:34 AM	CL	MD 854 A	S	2,658.679	
78H0T4AZ	08/17/2017 10:32:59 AM	CL	MD 850 H	E	1,786.321	
78H0T3UF	08/17/2017 10:44:39 AM	BA	MD 151	S	8,087.246	
78H0T4UU	08/17/2017 10:44:54 AM	CL	CO 1611	S	286.979	

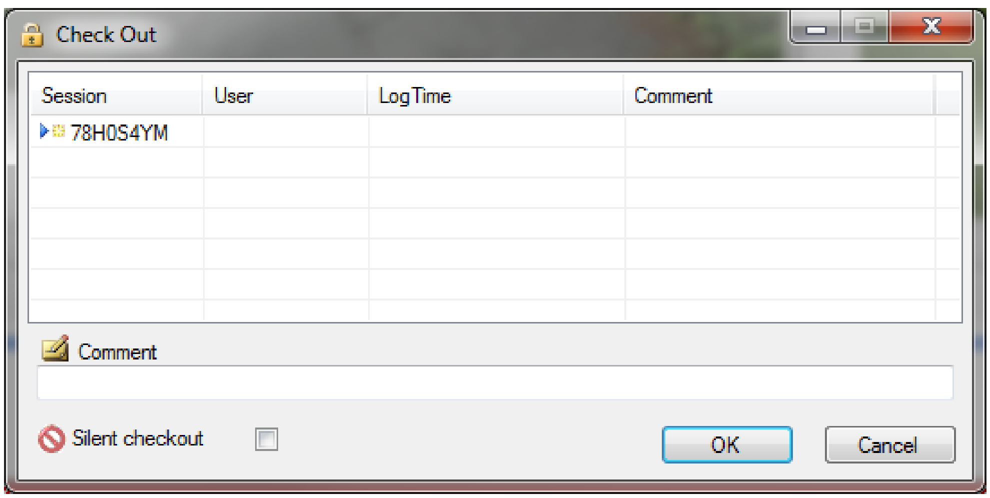
Step 40. Using the "Section Composition" window, click the "Auto-Match" button (see below image). 



Step 41. A "Check Out" window will open (see below image). In order to perform route matching on a file, it must first be checked out.

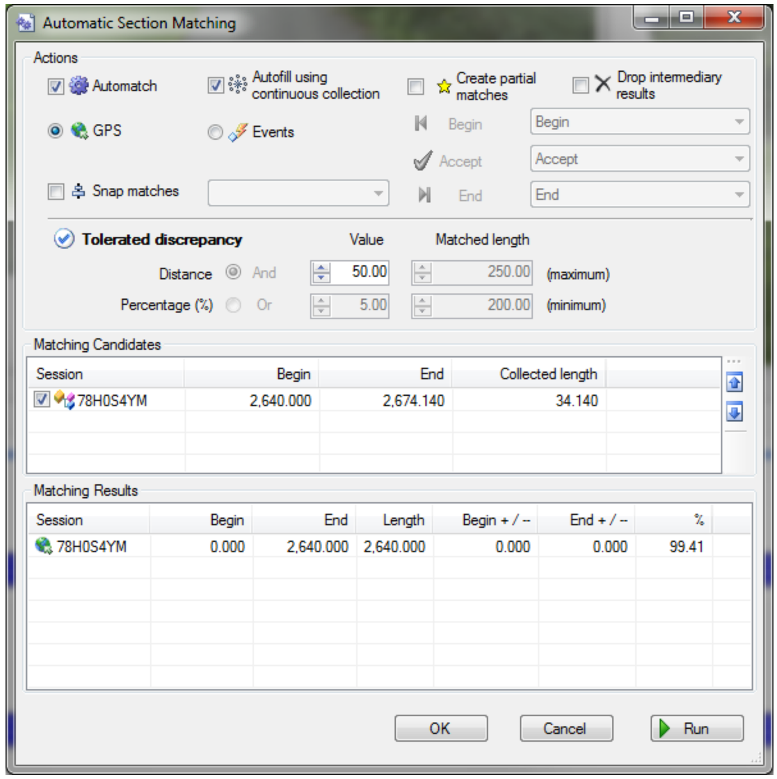
v. If the "OK" button on the "Check Out" window is grayed out and a user is listed under the "User" column, that user must check the file back in and save before continuing.

vi. Otherwise, click "OK."

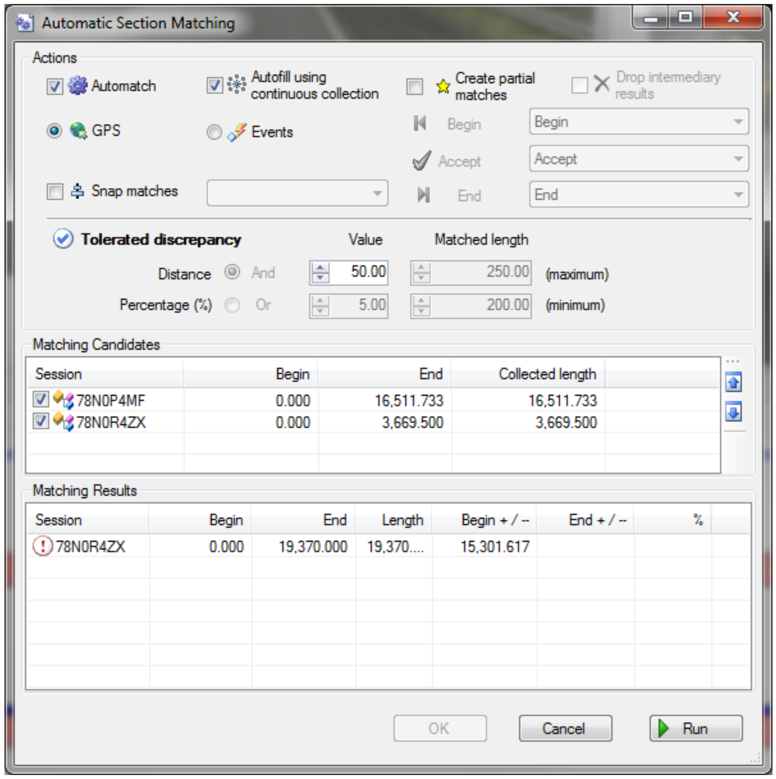


Step 42. The "Automatic Section Matching" window will appear. Click the "Run" button. Results will appear in the "Matching Results" dialogue box.

i. If there are no errors, a route will appear with a green arrow and a globe icon next to the session name. Click "OK" (see below image).



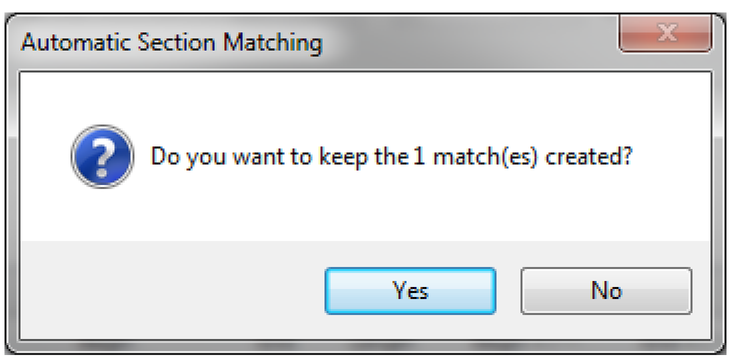
ii. If there are errors for a single route, a route will appear with an exclamation point icon next to the session name and the "OK" button will be grayed out. Investigate the possible causes and resolve issue with the specific file before continuing. The most common solution is using the snapping procedure to bypass auto-matching (see Step 71 and Step 72).



iii. If there are errors for multiple routes, the routes will appear with exclamation point icons next to the session name and the "OK" button will be grayed out. This typically indicates that there are multiple files for the same route. Investigate the possible causes and resolve issue with the specific files before continuing. Possible solutions include removing one of the files by: transferring one file to another route or rejecting an older route if the routes are duplicates.

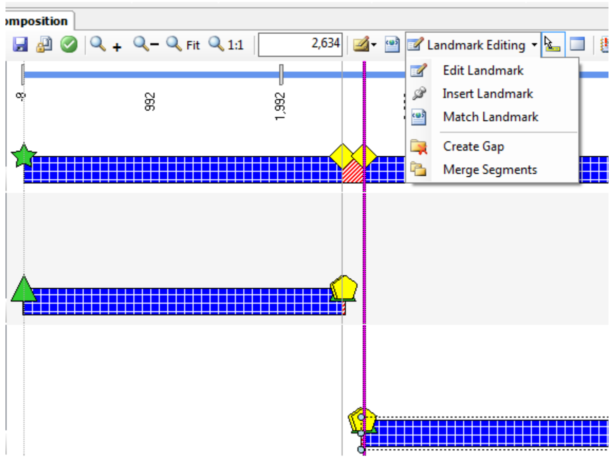
Step 43. A dialogue box will appear.

i. If no errors or irregularities are present, click "Yes" (see below image). Proceed to Step 48.



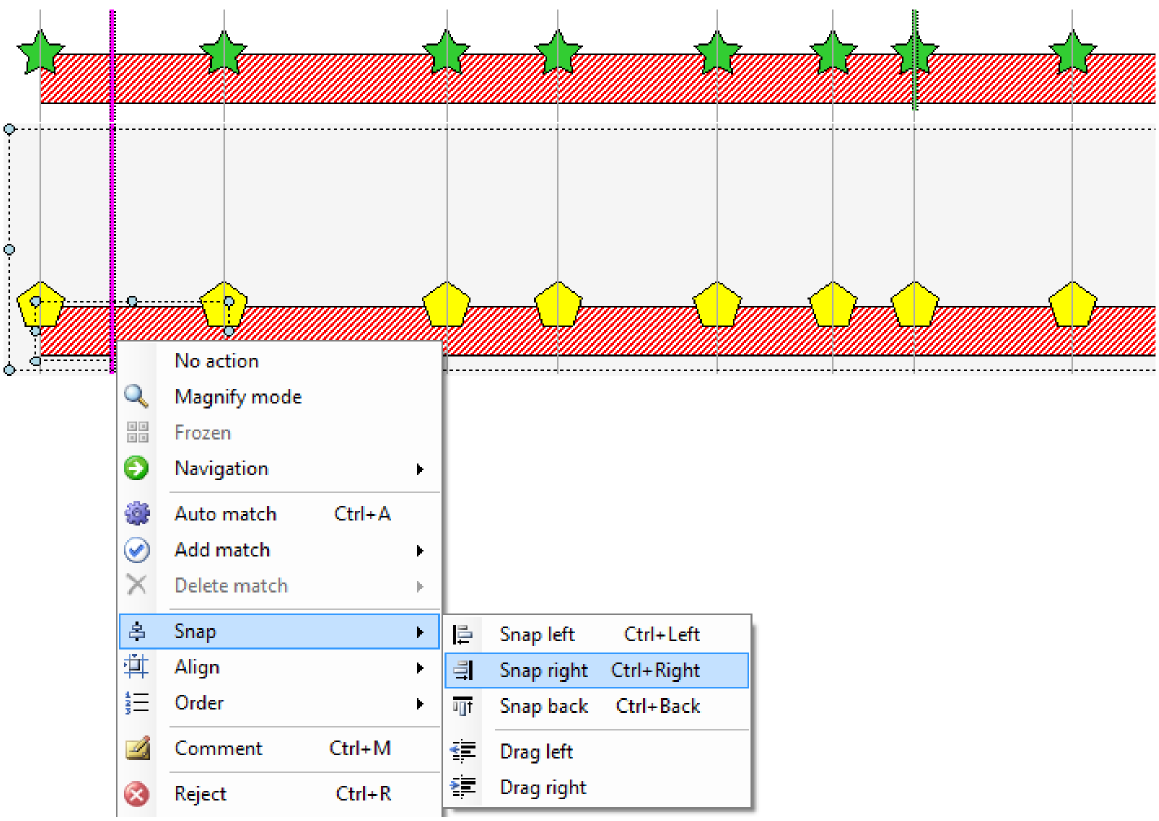
ii. If errors or irregularities are present, manual segmentation is required. Proceed to Step 44.

Step 44. In the "Section Composition" window, click the "Landmark Editing" drop-down menu and select "Insert Landmark" (see below image).



Step 45. Locate the appropriate reference location on the sensor bar and align the pink line with that location.

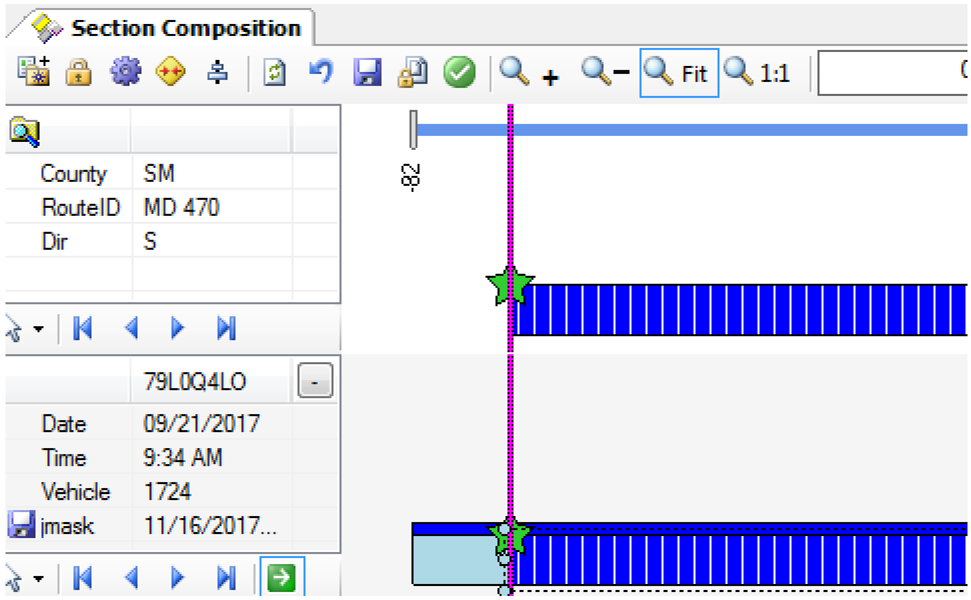
Step 46. Snap the appropriate marker to the location reference. Right-click on the marker, click "Snap" and then "Snap right" or "Snap left" depending on which way the marker needs to move (see below image).



Step 47. Apply the "Add Match" function and select "All." If any segments of the match require removal, tag the individual segment and select "Delete Match" to remove.

Step 48. Repeat Step 44 to Step 47 for all landmarks and segments.

Step 49. Check the starting point of the file. Click the sensor bar in the “Section Composition” window somewhere close to the starting landmark (green star before blue bar – see below image).

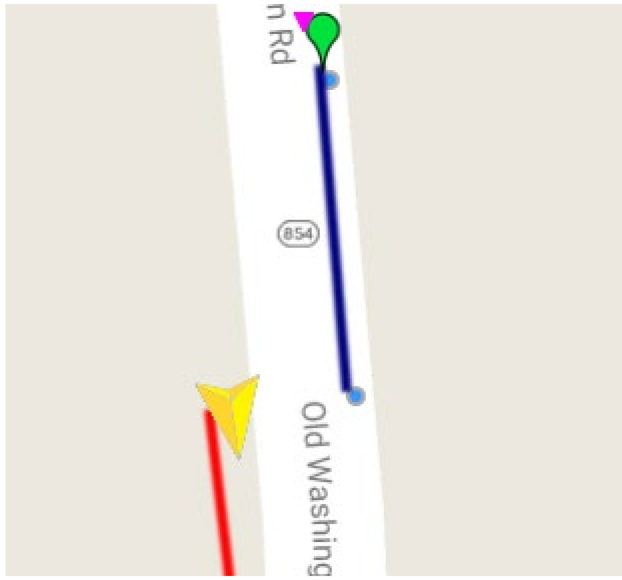


Step 50. In the “Map” window, zoom in to at least 16 feet. Make sure the vehicle position (yellow triangle) is close enough to the starting marker (green balloon). Use the measuring tool in the “Map” window if the distance cannot be determined visually.

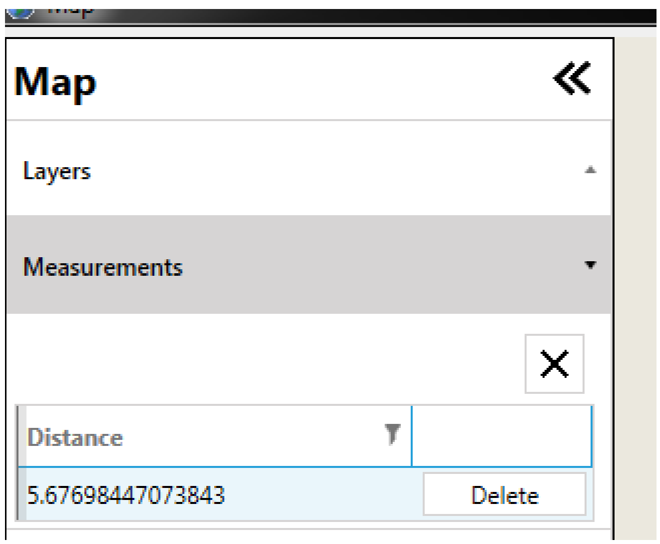
i. If the starting marker is greater than 4.2 mmi (approximately 22.176 feet) from the vehicle position, proceed to Step 51 to place a “gap” in the Section Composition.

ii. Otherwise, proceed to Step 61.

Step 51. In the “Map” window, use the measuring tool to draw a line from the base of the starting marker to the beginning vehicle position (see below image). Do not draw the line at an angle, which would add distance to the measurement.

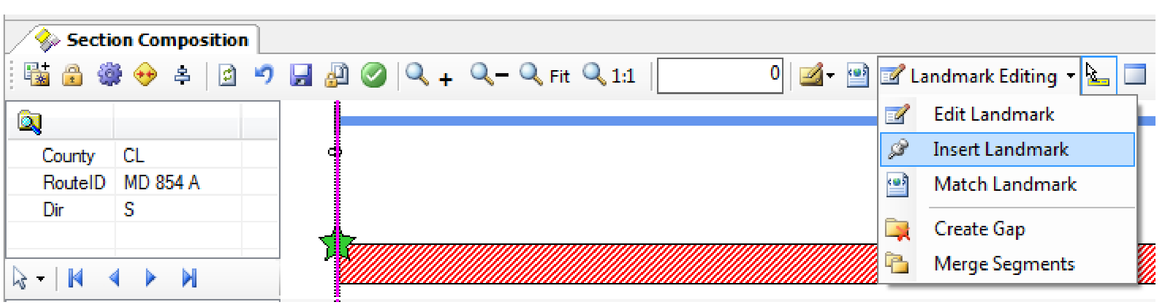


Step 52. View the distance of the line in the "Measurement" window of the map (see below image).

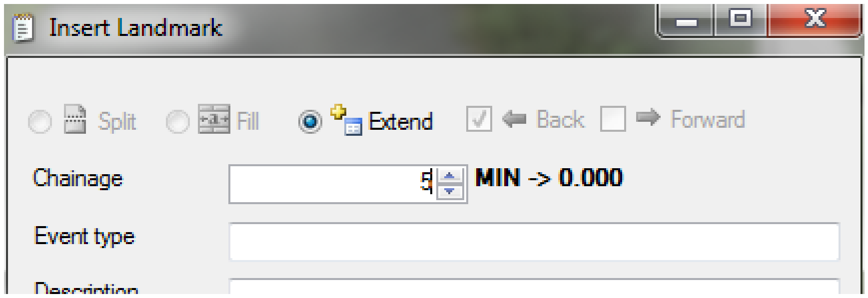


Step 53. Using the distance, calculate the gap needed (for the above distance, a gap would need to be placed from 0.0 to 0.05).

Step 54. Click the "Landmark Editing" drop-down menu and select "Insert Landmark" (see below image).

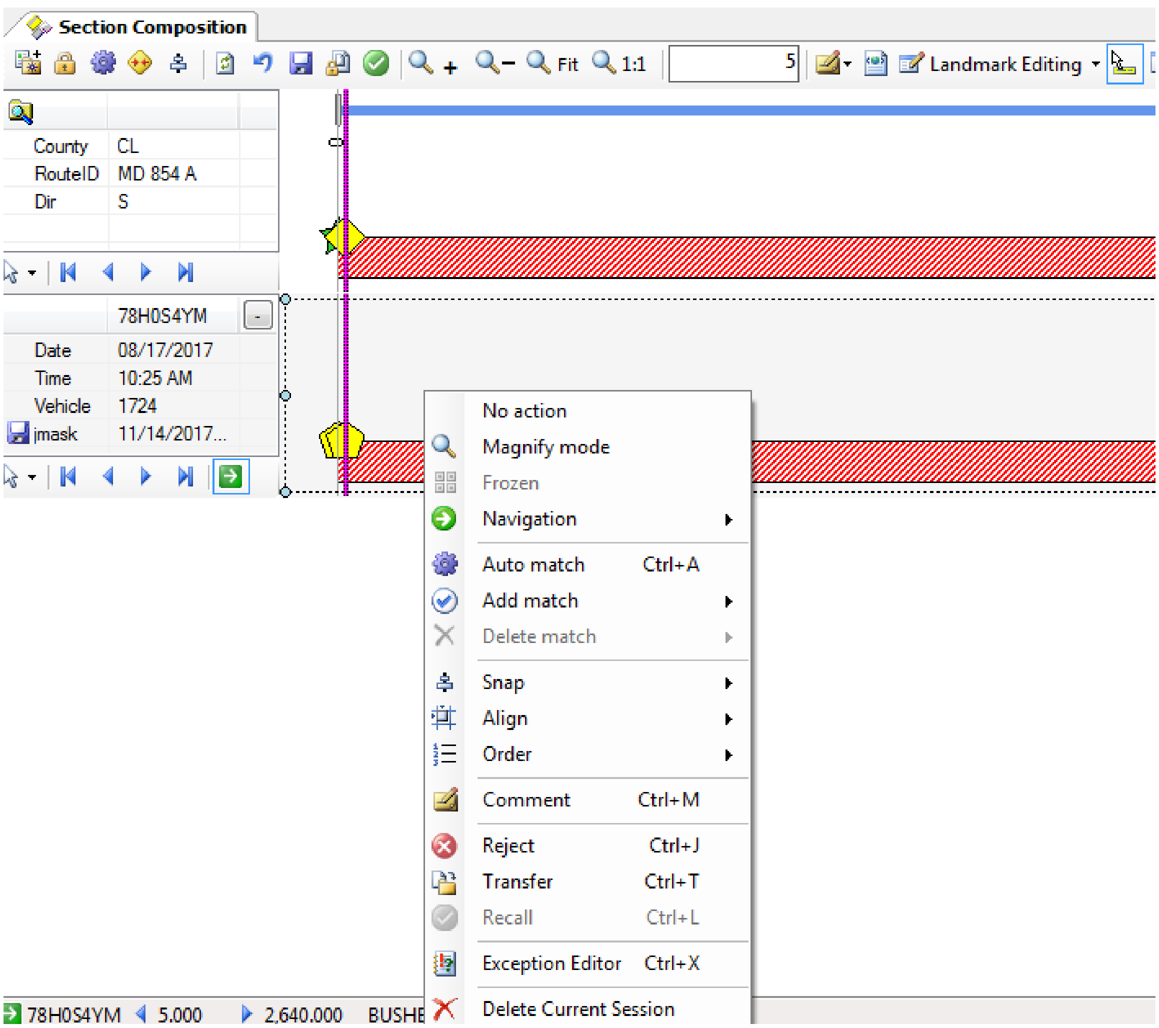


Step 55. The “Insert Landmark” window will appear. Enter the correct chainage into the “Chainage” box (see below image).



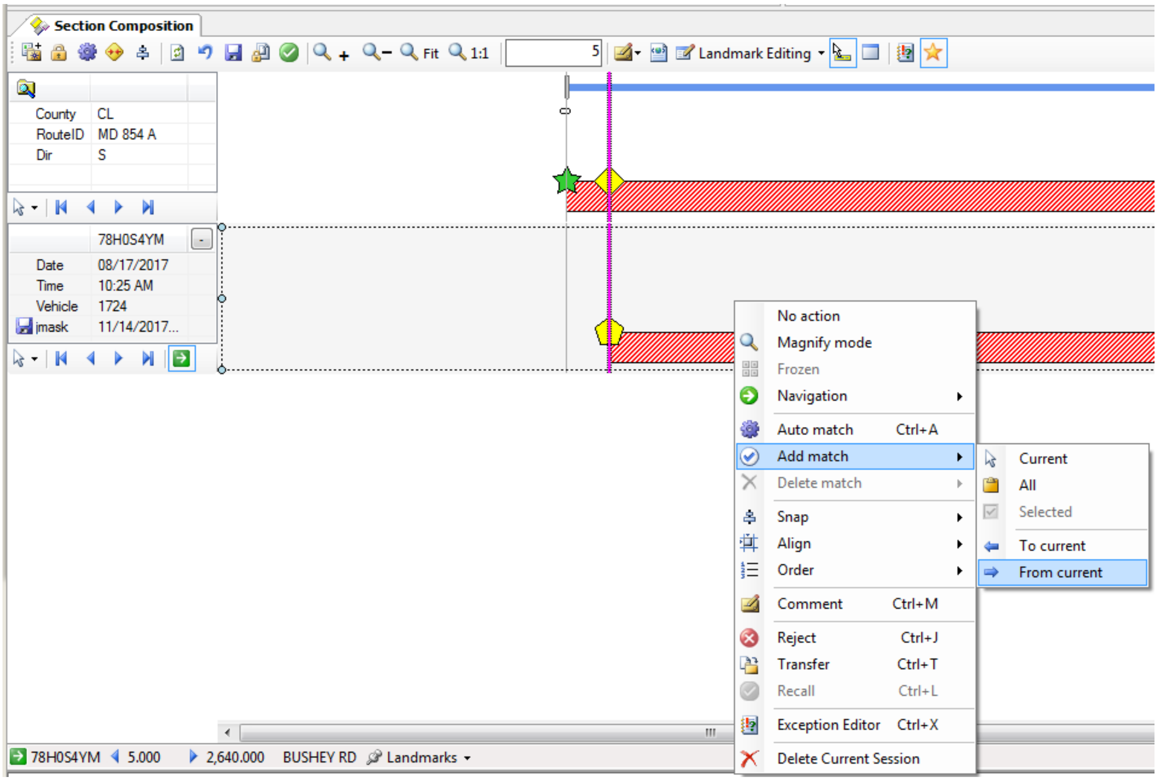
Step 56. Click “OK” and the sensor bar should move to the specified location.

Step 57. Right-click inside the dotted box which contains the sensor bar for the route in the “Section Composition” window (see below image).

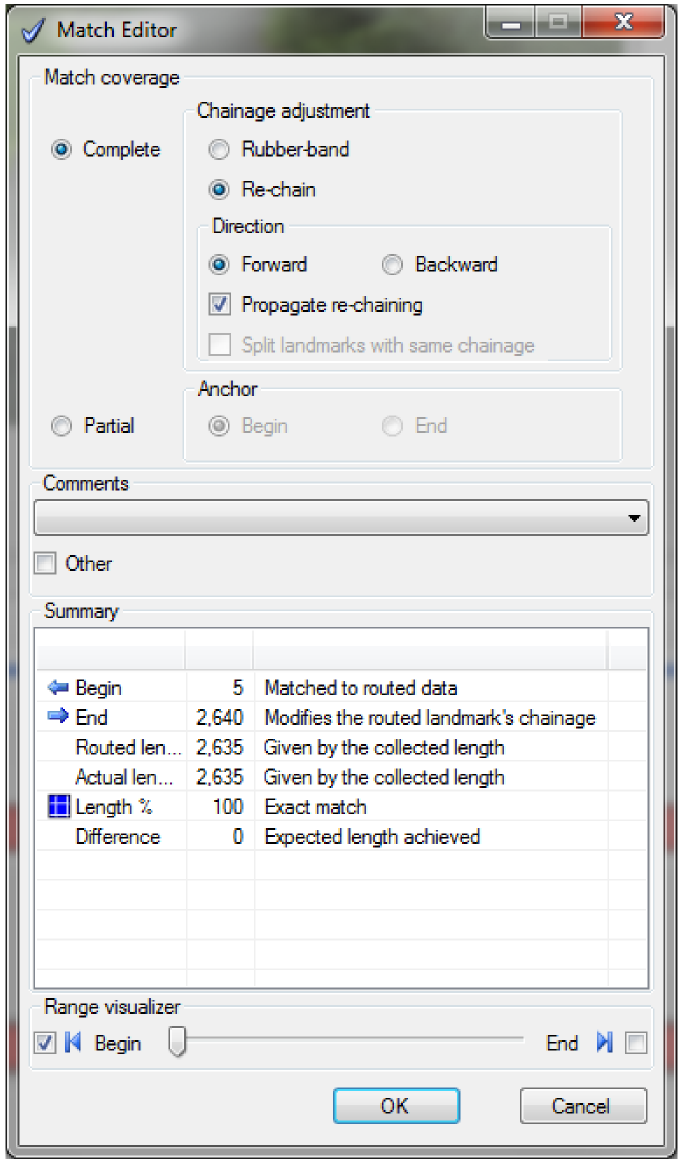


Step 58. Select “Align”, then “Shift Begin.” This will move the start of the file to the location of the sensor bar.

Step 59. Right-click inside the dotted box which contains the sensor bar for the route in the "Section Composition" window. Select "Add Match", then "From current" (see below image). This will match from the location of the sensor bar to the end.

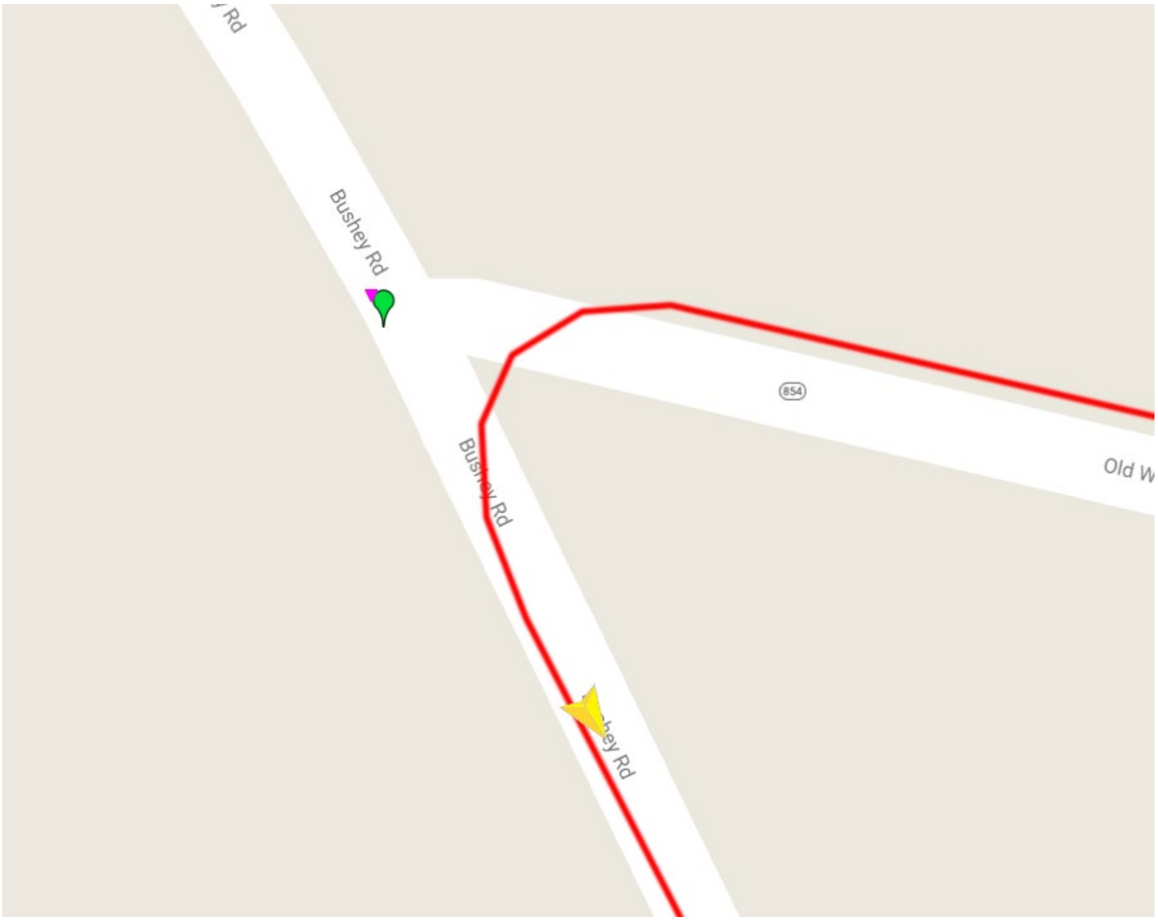


Step 60. The "Match Editor" window will open. Change "Rubber-band" to "Re-chain" and click "OK" (see below image).



Step 61. Navigate to the end of the run (there should be a yellow triangle near the end). Place the sensor bar close to the yellow triangle.

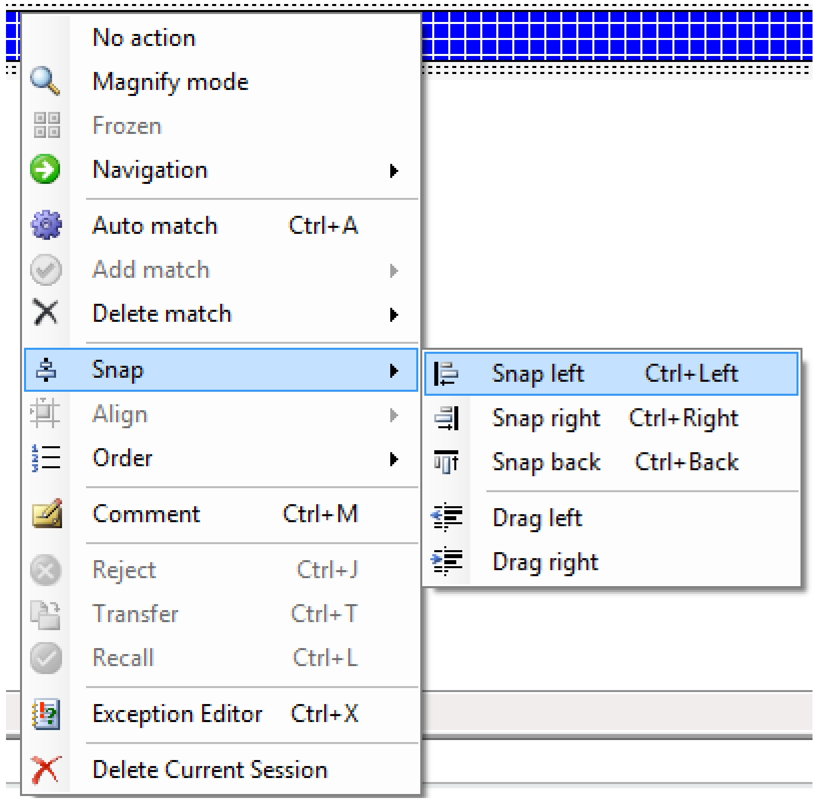
Step 62. Look at the “Map” window. Move the sensor bar in the “Section Composition” window and the yellow vehicle position in the “Map” window to a location close to the green balloon using the navigation controls (see below image).



Step 63. Check the distance between the yellow vehicle position marker and the ending marker (green balloon) using the measurement method as described in Step 51.

i. If the ending marker is greater than 4.2 mmi (approximately 22.176 feet) from the vehicle position, place a gap at the end of the run.

ii. Otherwise, right-click inside the dotted box which contains the sensor bar for the route in the "Section Composition" window. Select "Snap", then "Snap Left" (see below image). This will move the ending point to the correct spot and the triangle on the sensor bar should turn green.



Step 64. With the starting location still selected, check the "ROW Image" and "Left Image" to confirm that there are images present.

i. If there is no image present for one or both of the image windows, investigate missing image issue and resolve before continuing (may require reimporting of image files).

ii. Otherwise, proceed to Step 65.

Step 65. Check the stopping point of the file. Click the sensor bar in the "Section Composition" window somewhere close to the ending landmark (green star before blue bar).

Step 66. In the "Map" window, zoom in to at least 16 feet. Make sure the vehicle position (yellow triangle) is close enough to the ending marker (green balloon). Since the sensor bar is only placing the vehicle position close to the end of the route, it may be necessary to use the arrow keys to move the vehicle to the exact end of the route. Use the measuring tool in the "Map" window if the distance cannot be determined visually.

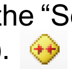
i. If the ending marker is greater than 4.2 mmi (approximately 22.176 feet) from the vehicle position, repeat Step 51 to Step 63 for placing a "gap" in the Section Composition.

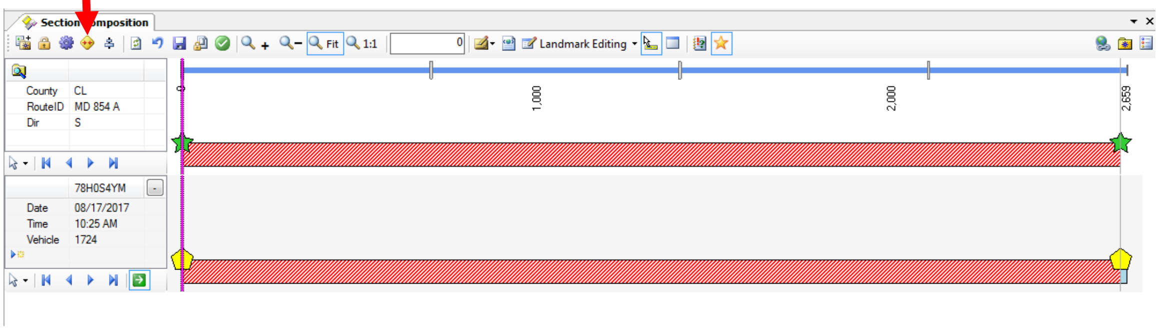
ii. Otherwise, proceed to Step 67.

Step 67. With the ending location still selected, check the "ROW Image" and "Left Image" to confirm that there are images present.

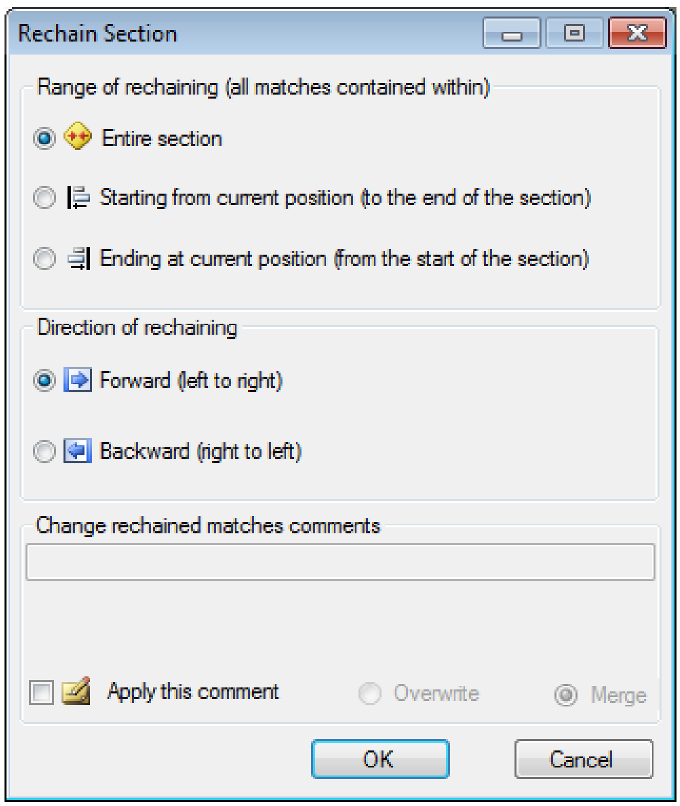
i. If there is no image present for one or both of the image windows, investigate missing image issue and resolve before continuing (may require reimporting of image files).

ii. Otherwise, proceed to Step 68.

Step 68. Using the “Section Composition” window, click the “Rechain” button (see below image). 



Step 69. Click “OK” in the “Rechain Section” window (see below image).



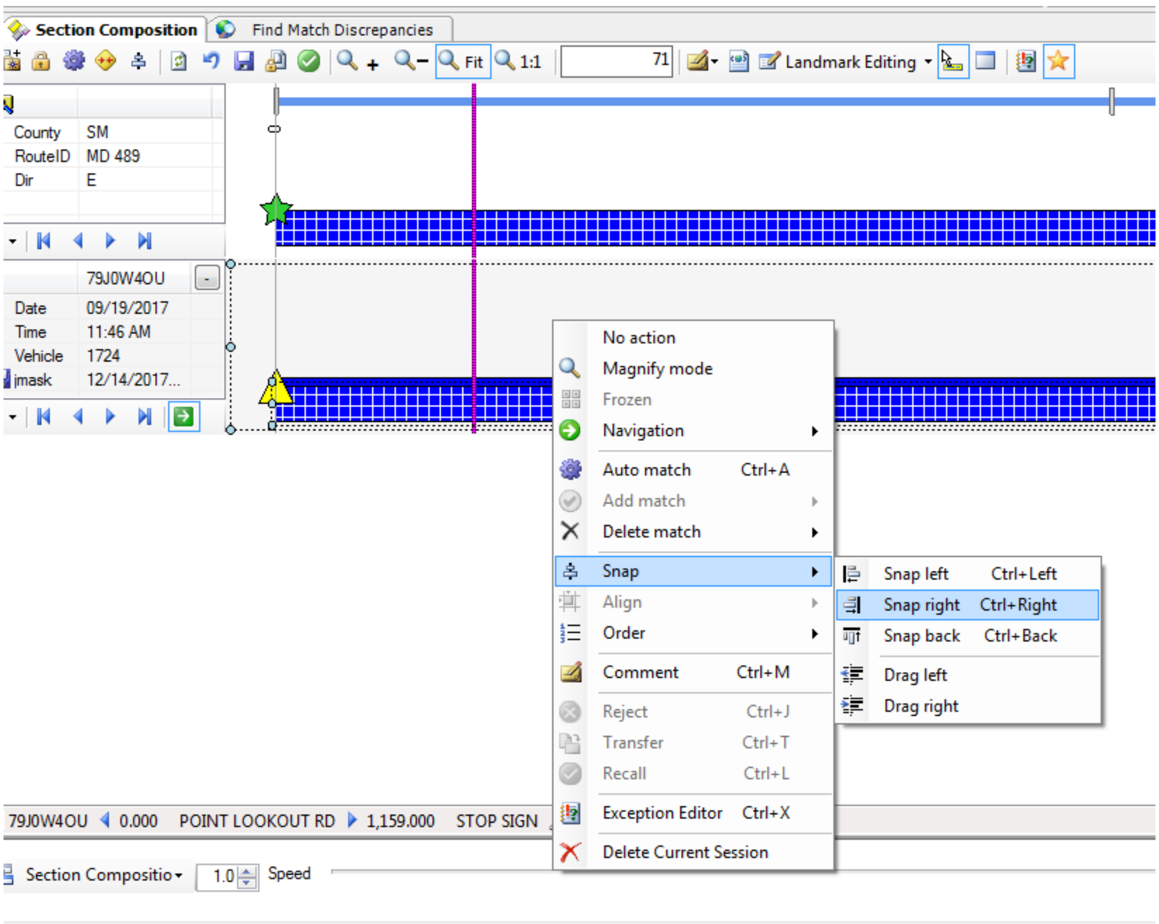
The blue bar for the route will now show a grid of white lines.

Step 70. Check that the starting and ending markers are green.

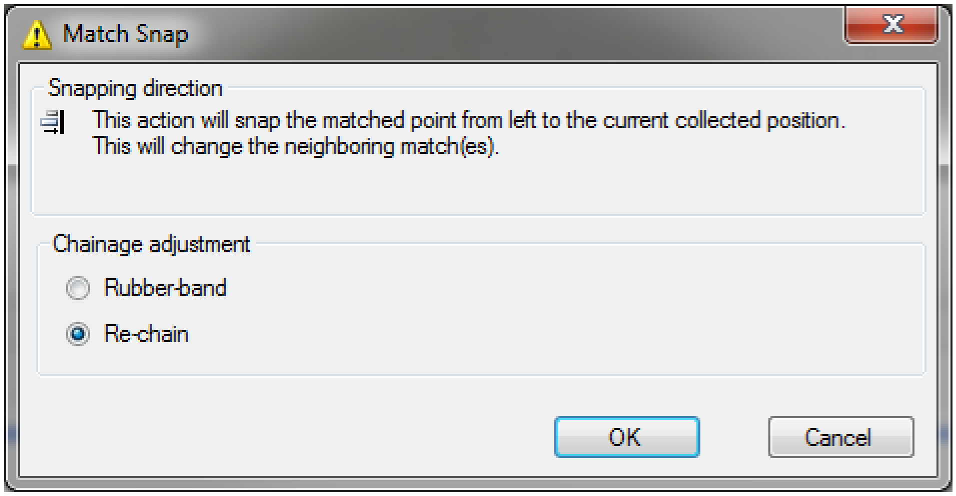
i. If markers remain yellow, proceed to Step 71.

ii. Otherwise, skip to Step 74.

Step 71. If one or both of the markers remain yellow, snapping must occur to move the markers to the proper location. Move the cursor close to the correct location in the "Section Composition" window. Right-click and select "Snap", then "Snap left" or "Snap right", depending on which direction the marker needs to move (see below image).



Step 72. In the "Match Snap" window, select "Re-chain" and click "OK" (see below image).



Step 73. Repeat Step 71 and Step 72 for other markers if necessary.

i. If markers are now both green, proceed to Step 74.

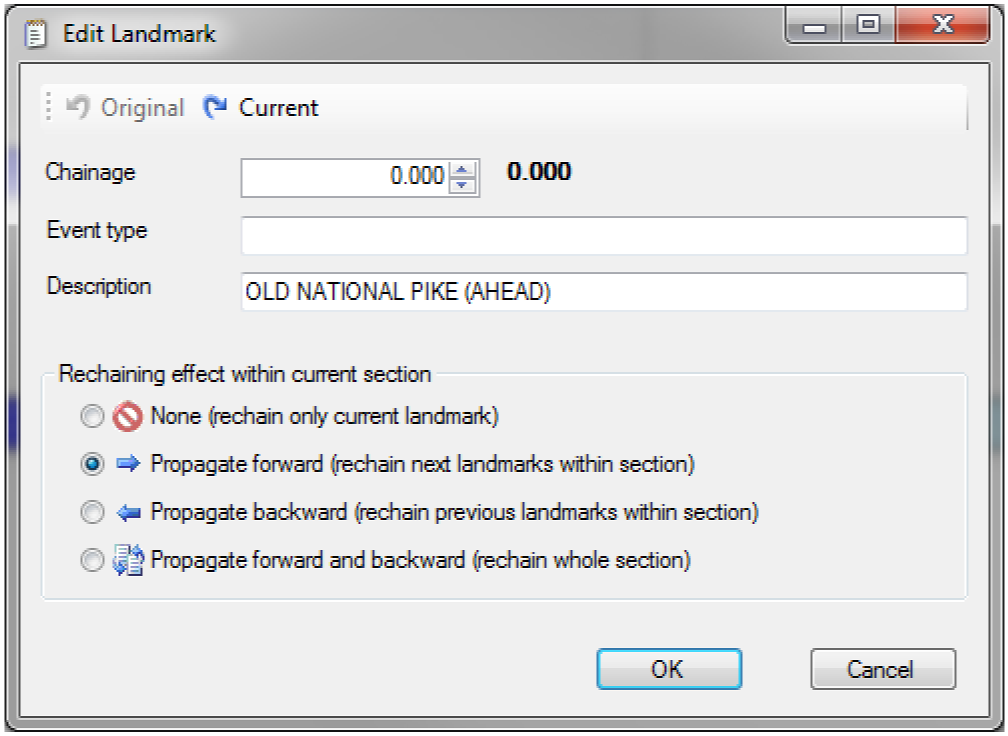
ii. Otherwise, investigate other possible solutions to resolve the issue before continuing.

Step 74. Check that the beginning milepost (BMP) is correct.

i. If the BMP is less than zero or between 0.0 and 0.1, it is incorrect and needs to be updated. Proceed to Step 75.

ii. If the BMP is 0.0 or greater than 0.1, no changes are required. Proceed to Step 76.

Step 75. Click on the starting marker in the “Section Composition” window, click “Landmark Editing”, and then “Edit Landmark.” Enter the correct BMP in the “Chainage” box and click “OK” (see below image). Correct BMP can be looked up in the routing inventory in the “Section Explorer” window.

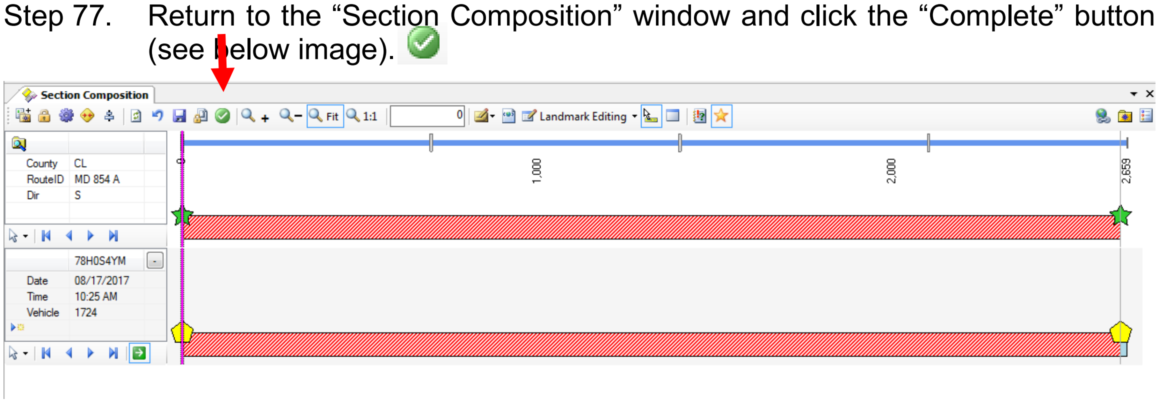


Step 76. Check if multiple routes exist in same file.

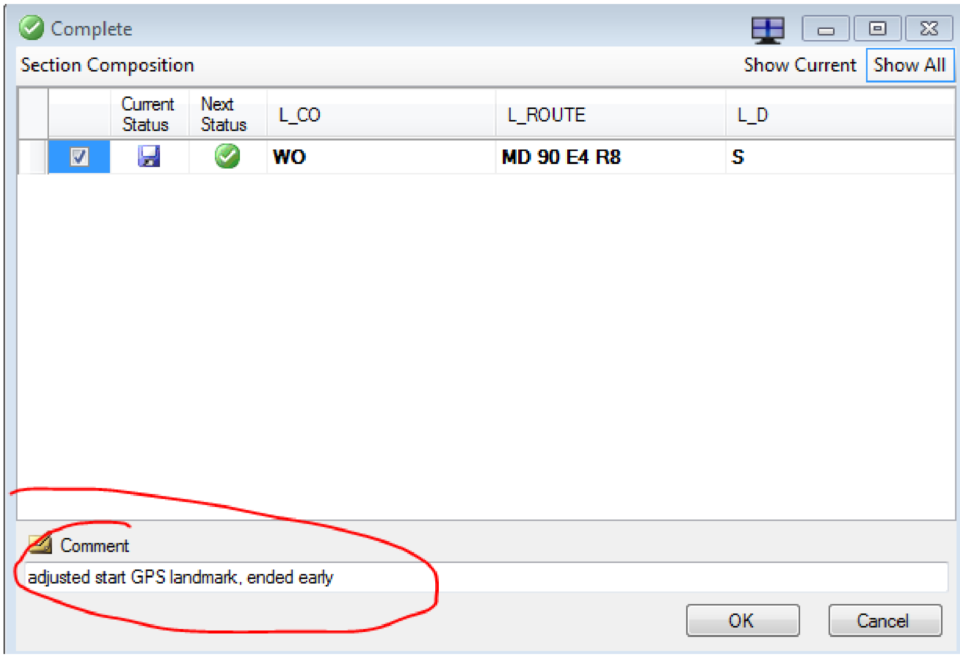
i. If multiple routes exist, refer to Accessing Electronic ARAN Logs for accessing electronic ARAN logs.

ii. If multiple routes do not exist, proceed to Step 77.

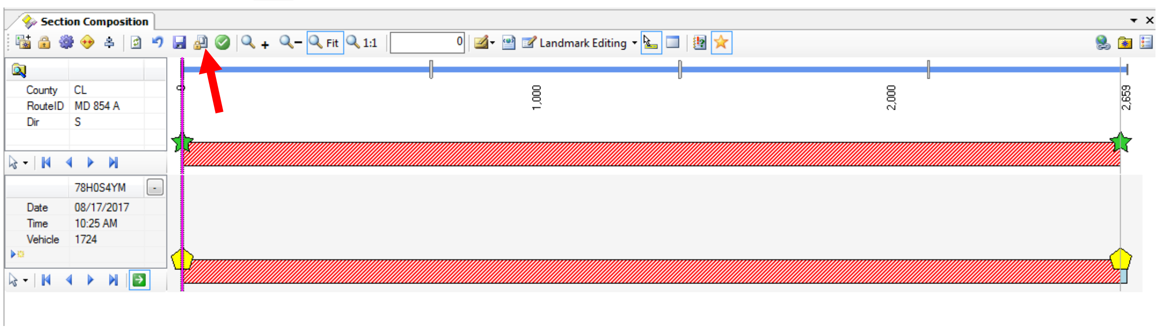
Step 77. Return to the “Section Composition” window and click the “Complete” button (see below image).



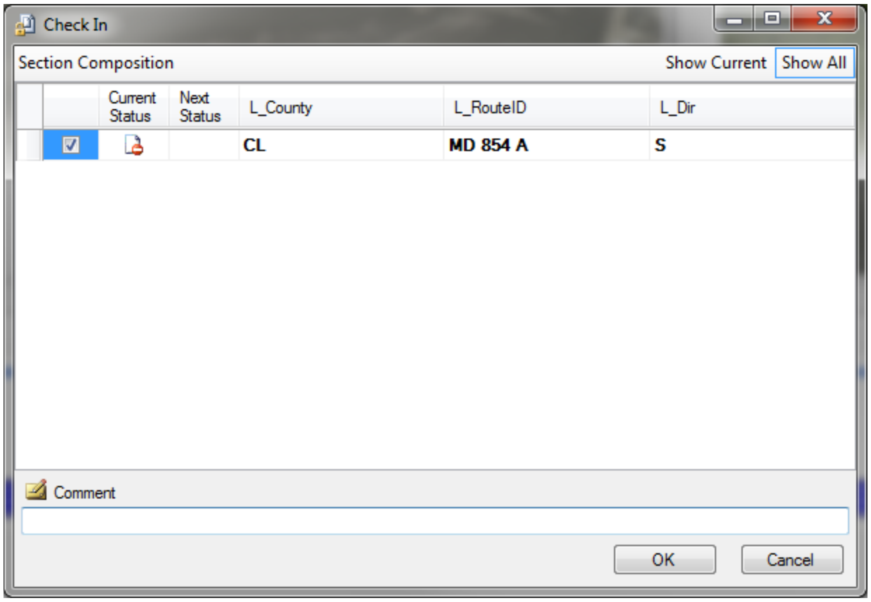
Step 78. Click the “OK” button on the dialogue box that appears (see below image). Place any pertinent notes in the “Comment” field. Comments may include: adjusted GPS landmarks, stopped 100’ early, started 100’ late, adjusted mile points, or gap due to road closure.



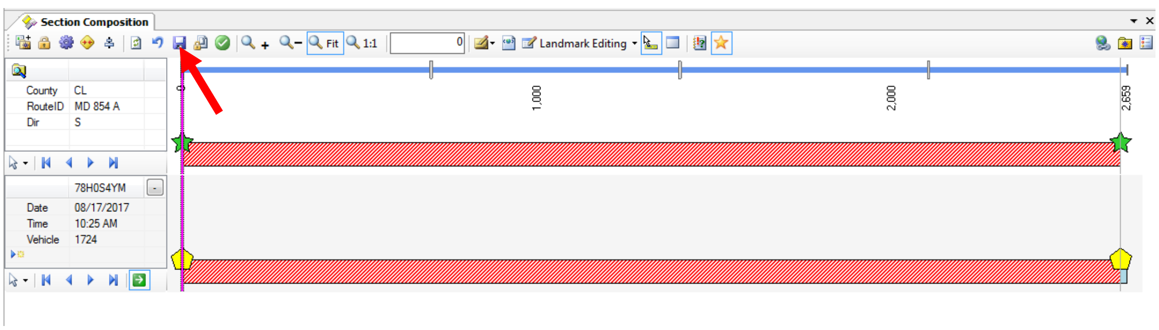
Step 79. In the "Section Composition" window, click the "Check In" button (see below image). 



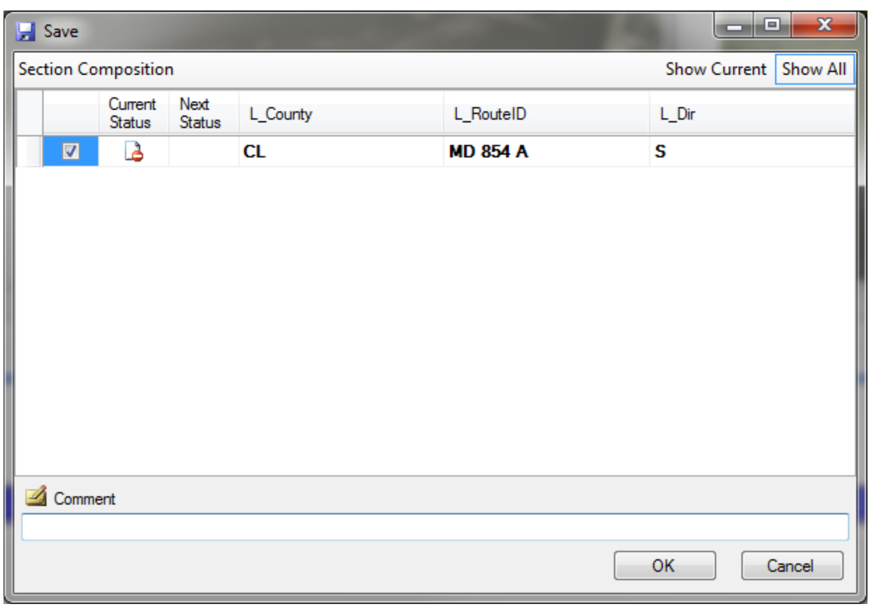
Step 80. Click the "OK" button on the dialogue box that appears (see below image).



Step 81. In the "Section Composition" window, click the "Save" button (see below image).



Step 82. Click the "OK" button on the dialogue box that appears (see below image).

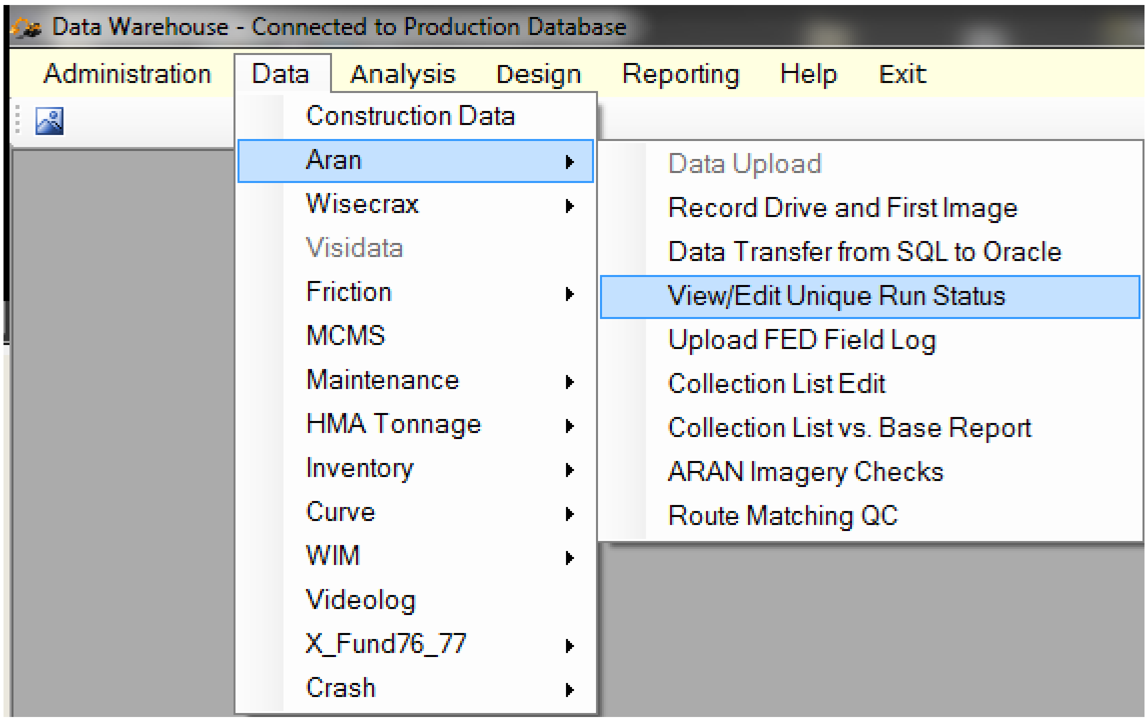


3- Updating Table in the EDW – *performed by EDW user*

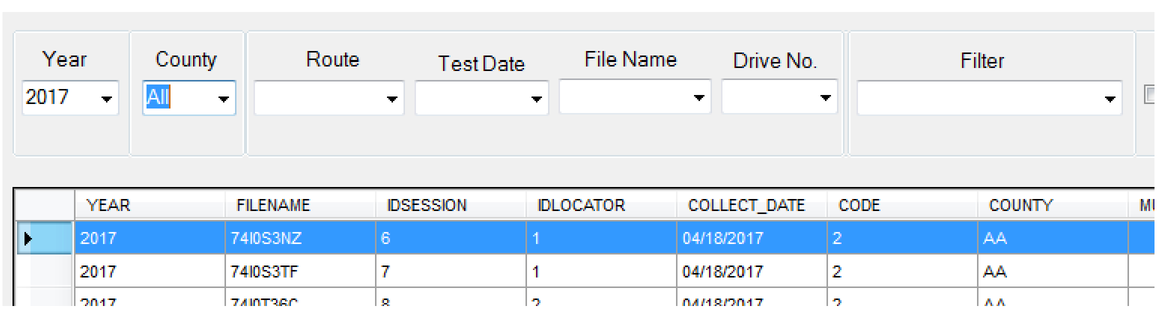
Summary: This task updates the “View/Edit Unique Run Status” table in the EDW with the matched route and includes any notes for the run.

Step 83. Open the EDW application.

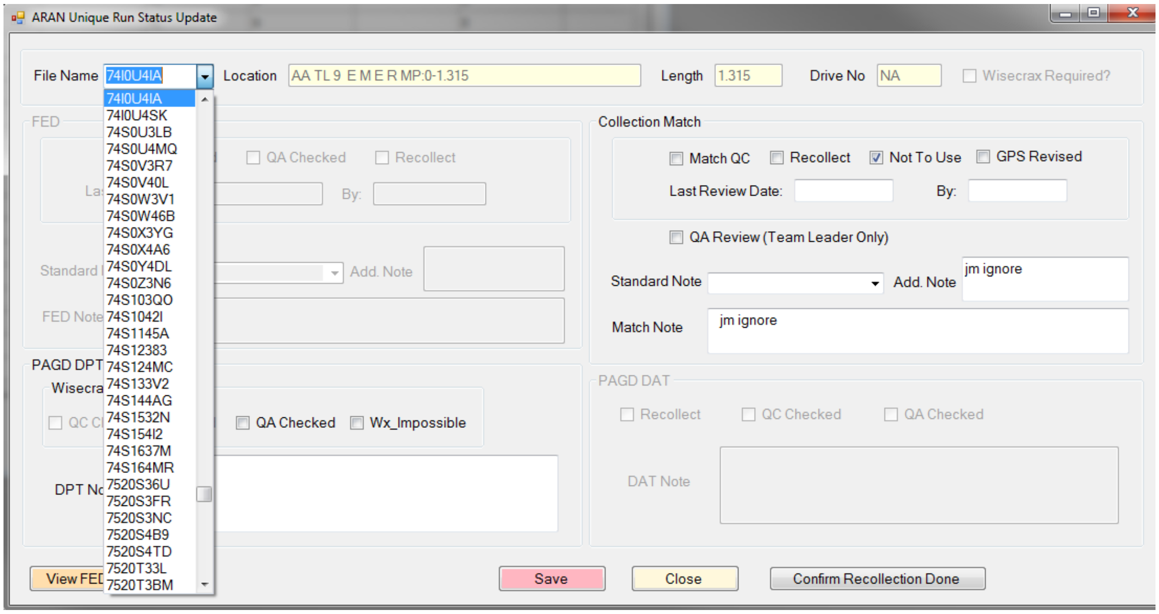
Step 84. Select “Data” and then click “ARAN” and “View/Edit Unique Run Status” from the drop-down menu (see below image).



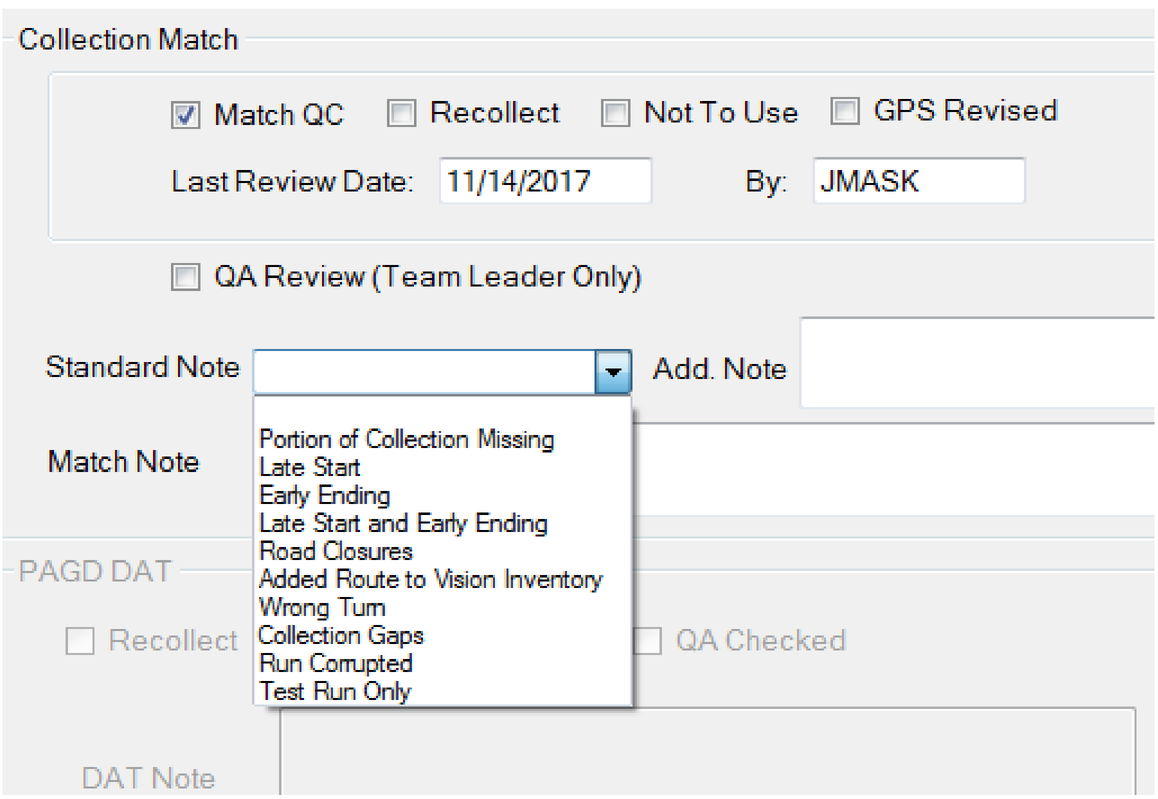
Step 85. In the table that opens, select the current year and “All” in the “County” field. The table will populate based on the above query (see below image).



Step 86. Double click one of the records in the table. It does not matter which record is selected. In the window that opens, click the arrow next to the “File Name” drop-down list and select the file name that was just matched (see below image).



Step 87. Check the box next to "Match QC" once the correct file is selected. The program will add the user name and date. If any notes need to be added, select a common note from the "Standard Note" drop-down menu or type a manual note in the "Add. Note" field (see below image).



Step 88. Add text in the "Match Note" field, which should include user initials, date, and any notes from Step 78.

Step 89. Click the "Save" button.

Step 90. If closing out a District, complete the status table and submit to the DPT TL via email (see below image).

Step	Reviewed	Complete?	worksheet archived?
1			
2			
3			
4			
5			
6			
7			

4- Performing QC of Matched Routes – *performed by Vision and EDW user*

Summary: This task performs route and systemic level reviews of matched routes to check for accuracy and completeness. Vision and EDW application tools are utilized to determine if data is ready for production to further processing routines can occur.

Step 91. Perform route level QC inspection by opening a matched route in Vision. Check for the following key items:

i. Check that all sections in the run are matched, including ramps. Match any remaining sections, if necessary. Use Vision Map, Layers, Routed Nodes feature to assist in process (see image below).

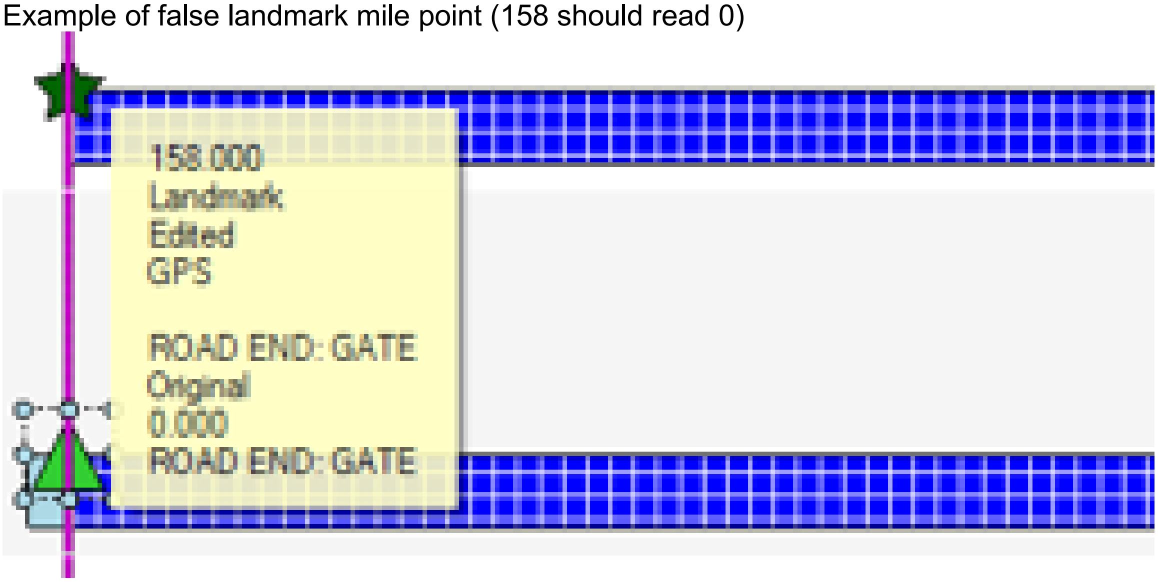
Matched as collected (1), but now needs the ramp match (2)

ii. Check landmark accuracy. If landmark needs adjustment, update the year's inventory spreadsheet with new GPS and load into Vision. Maintain spreadsheet for reference by others.

Example of a bad landmark that requires adjustment

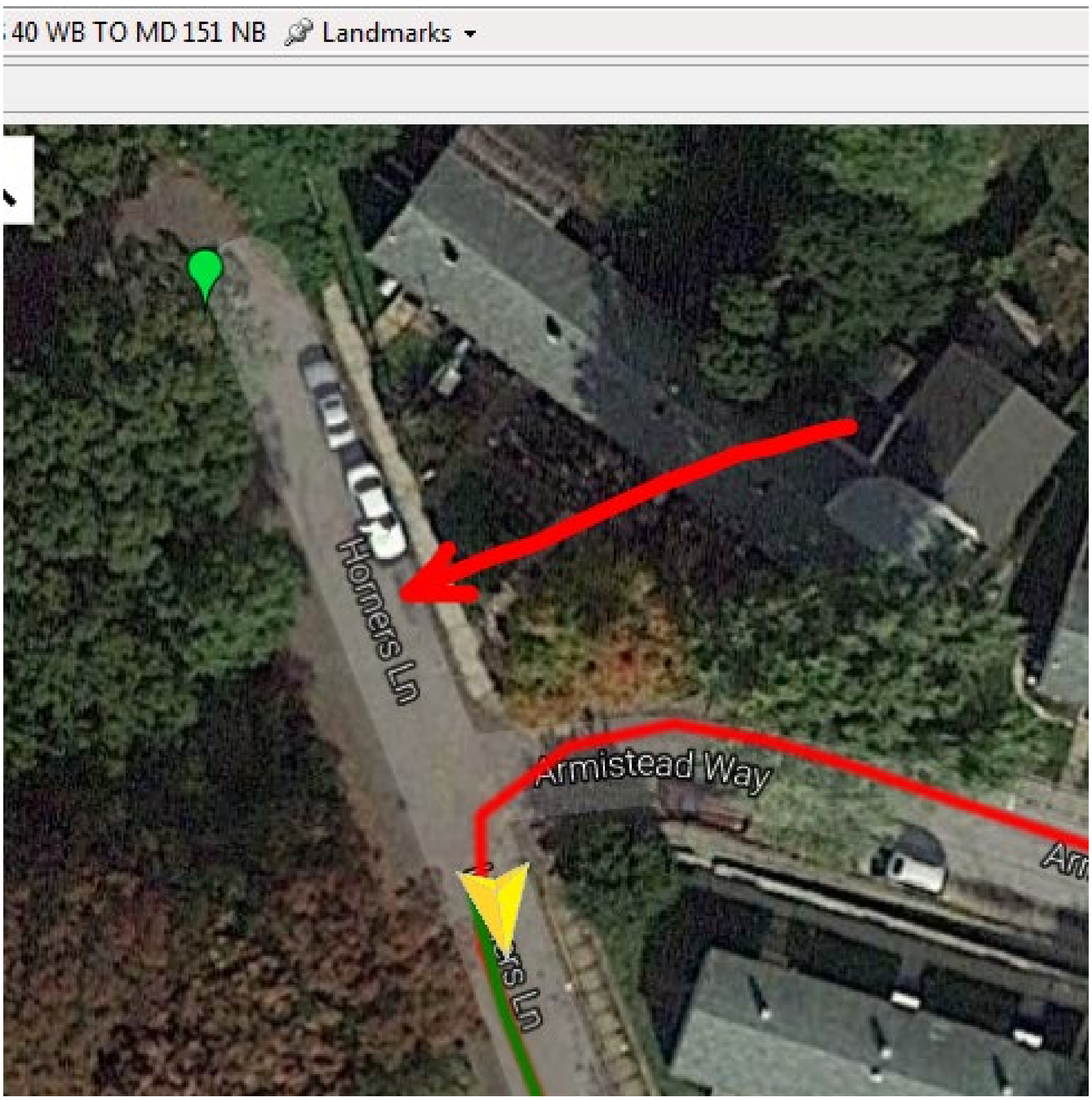
iii. Check the section beginning and ending landmark mileage. Correct if necessary.

Example of false landmark mile point (158 should read 0)

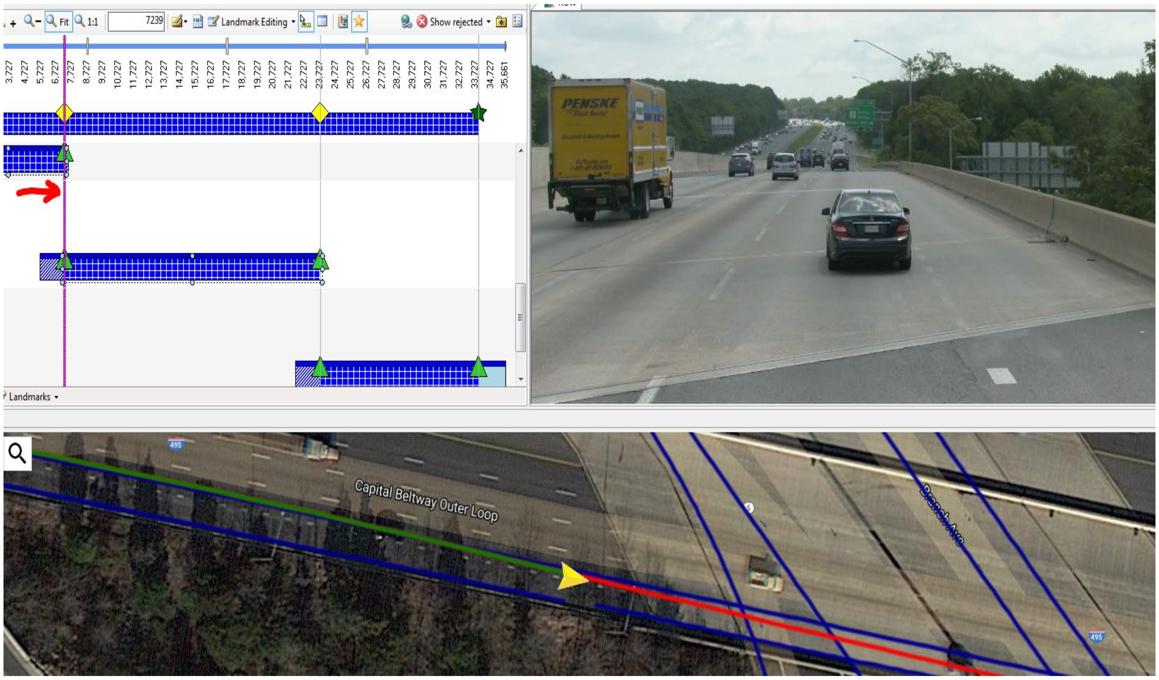


iv. Accommodate gaps in collection (missing collection, late start, early end, road closures, etc.). Determine if a gap (or gaps) exists. Accommodate in the matching process where necessary and place a note in the Vision run upon check out as well as in the EDW for others' reference.

Example of collection missing (and match accommodated) at the start of a route

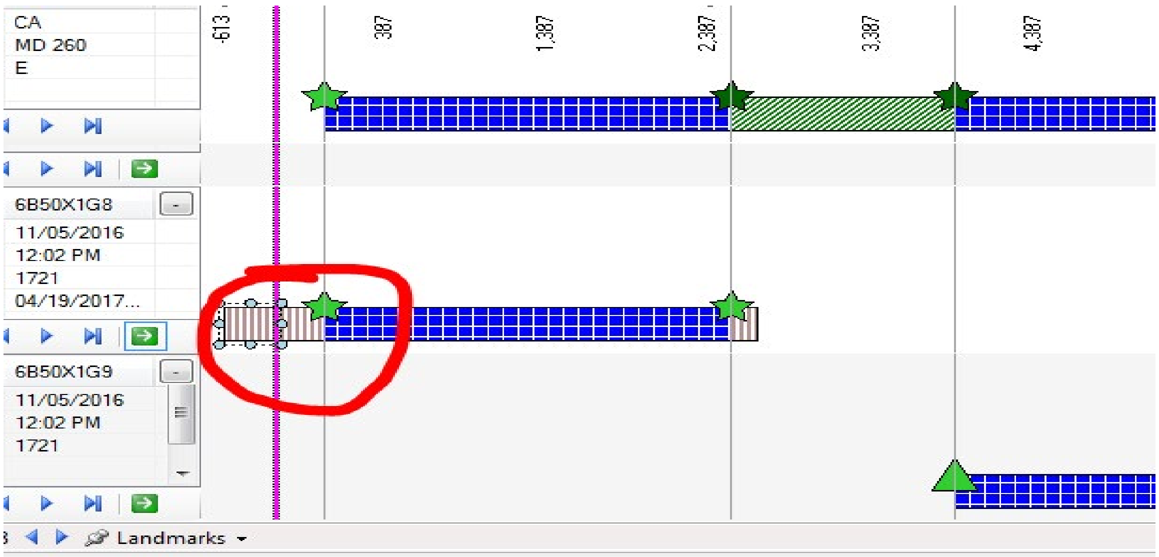


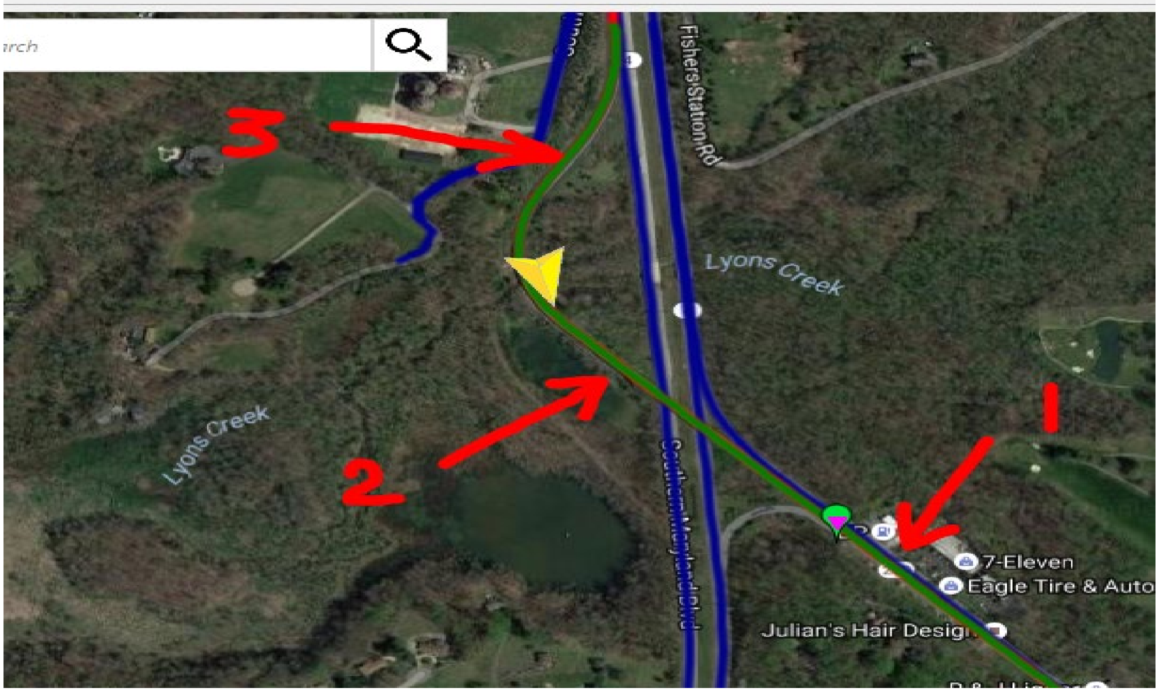
v. Verify collection run joins. Revisit start and end of each run to verify the joins are correct. Use keyboard left or right buttons to navigate to beginning or end of a run after it has been tagged.



vi. Determine if transfers are required and complete transfers where necessary. Use Vision Map, Layers, Routed Nodes feature to help identify routes needing transfer.

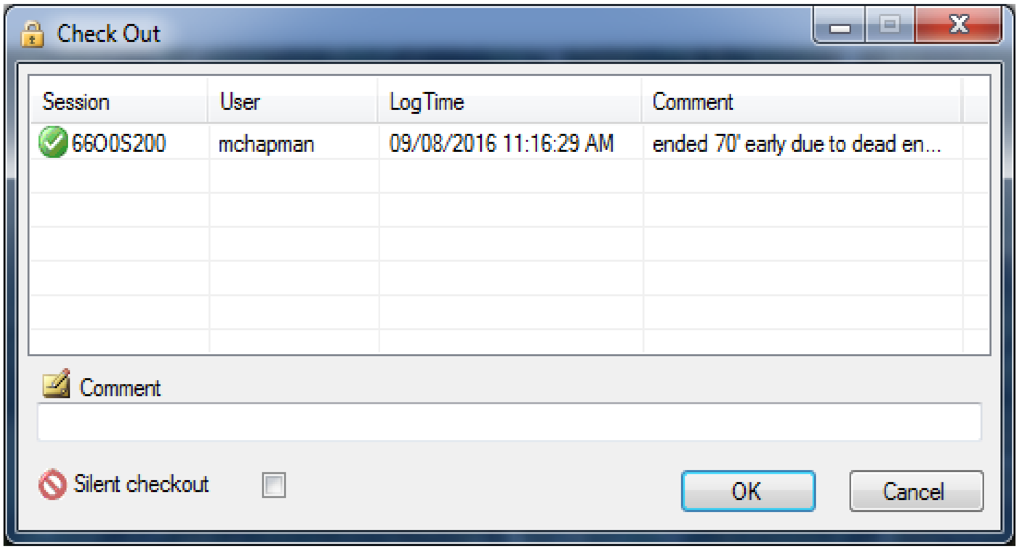
Example: Section 1 was the original collection and Sections 2 and 3 require transfer to their respective ramps.





vii. Check that all collection runs are either matched, transferred, or rejected. Determine if all sections within a collection session are identified and match, transfer, or reject accordingly. Rejecting routes should only be utilized when a collection run has been determined to be unsalvageable due to data or imagery issues (recollection is needed) or a substantial portion of a run is not useful (except where it can be matched to another route).

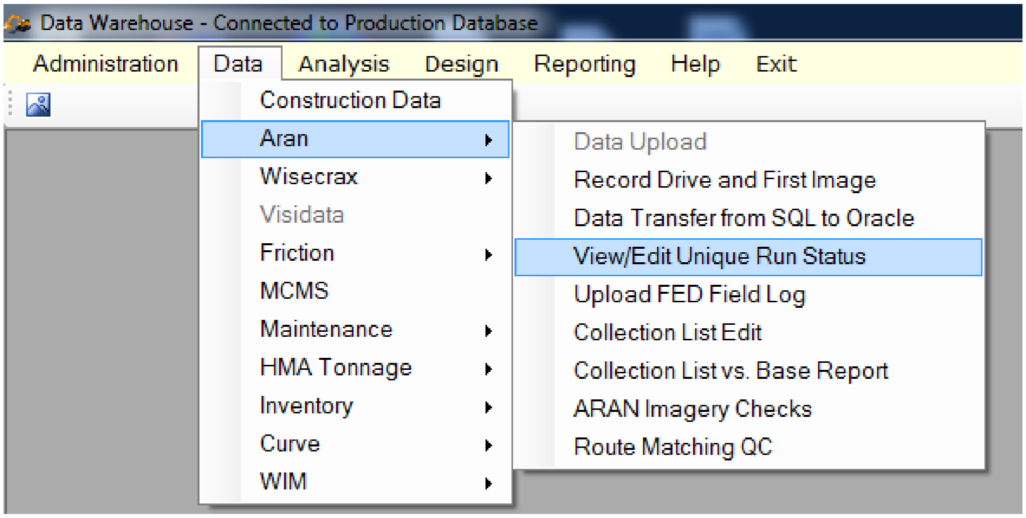
viii. Enter and apply pertinent notes (QC and review notes) for each collection run in Vision. Notes should be entered after selecting the “Complete” button (see below images).

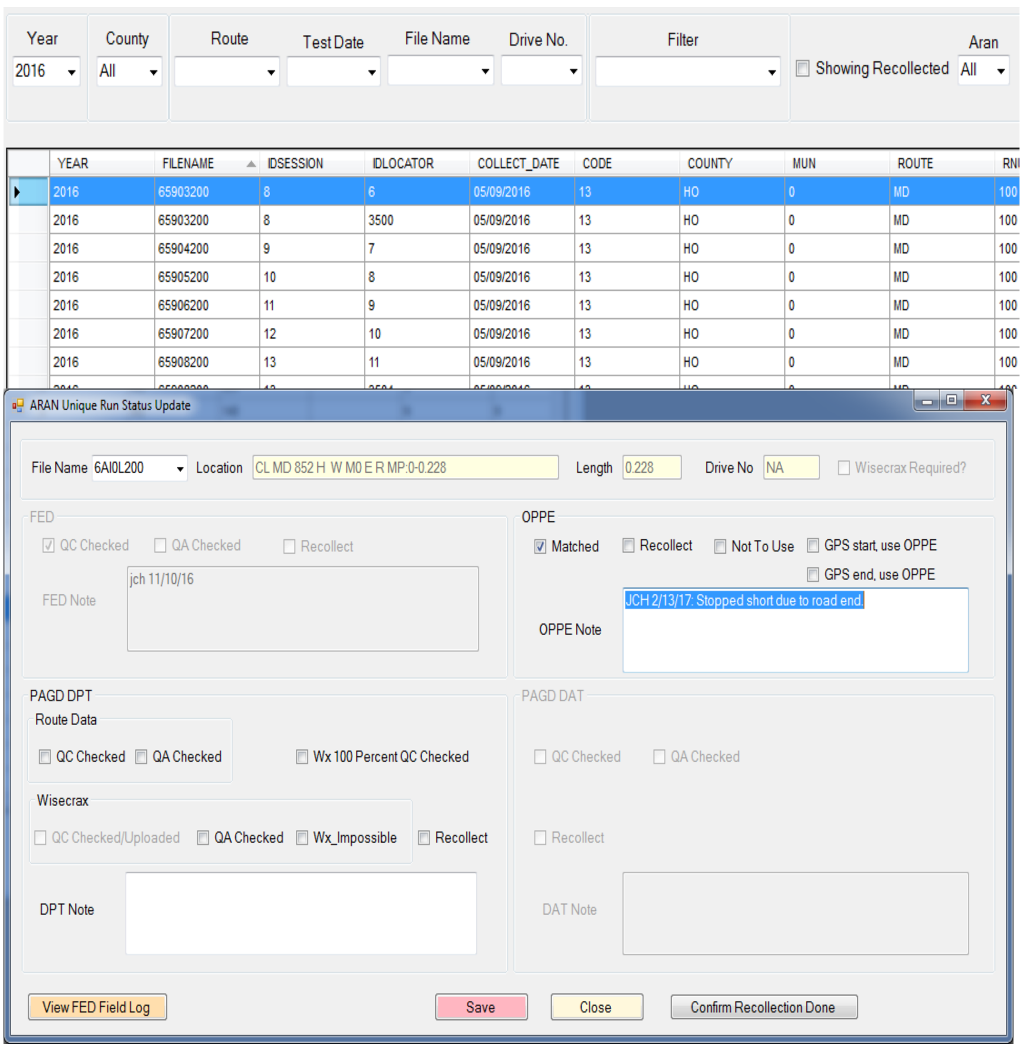


Note examples include:

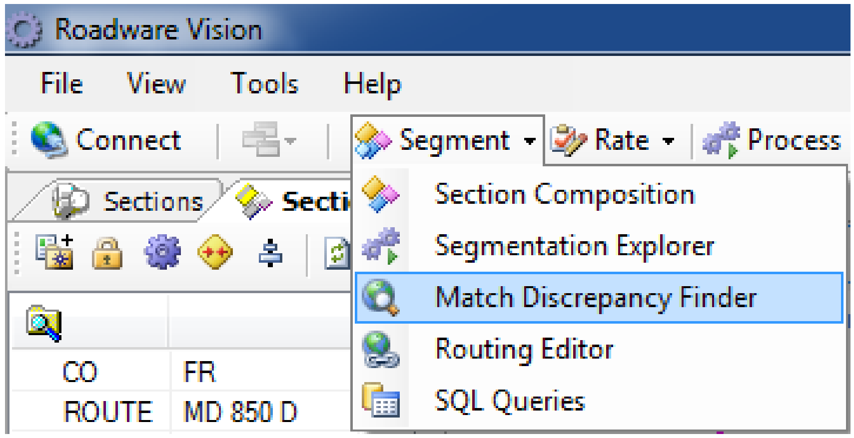
0.15 mi gap due to bridge closure @ MP 0.09
977' short due to early ending (salvaged part of IS 83 south collection)
added route to Vision inventory
adjusted GPS landmarks
adjusted GPS landmarks, ended 410' early due to wrong turn
ended 175' early due to dead end and parked vehicles
ended early due to dead end
started 0.05 mi late due to blocked roadway (farm equip storage)
started 21' late and ended 0.04 mi early due to impassable road - overgrowth
started 25' late due to dead end, gap between 0.32 - 0.44 due to road detour.
started 52' late due to dead end

ix. Enter and apply pertinent notes (QC and review notes) for each collection run in the EDW application (see below images).

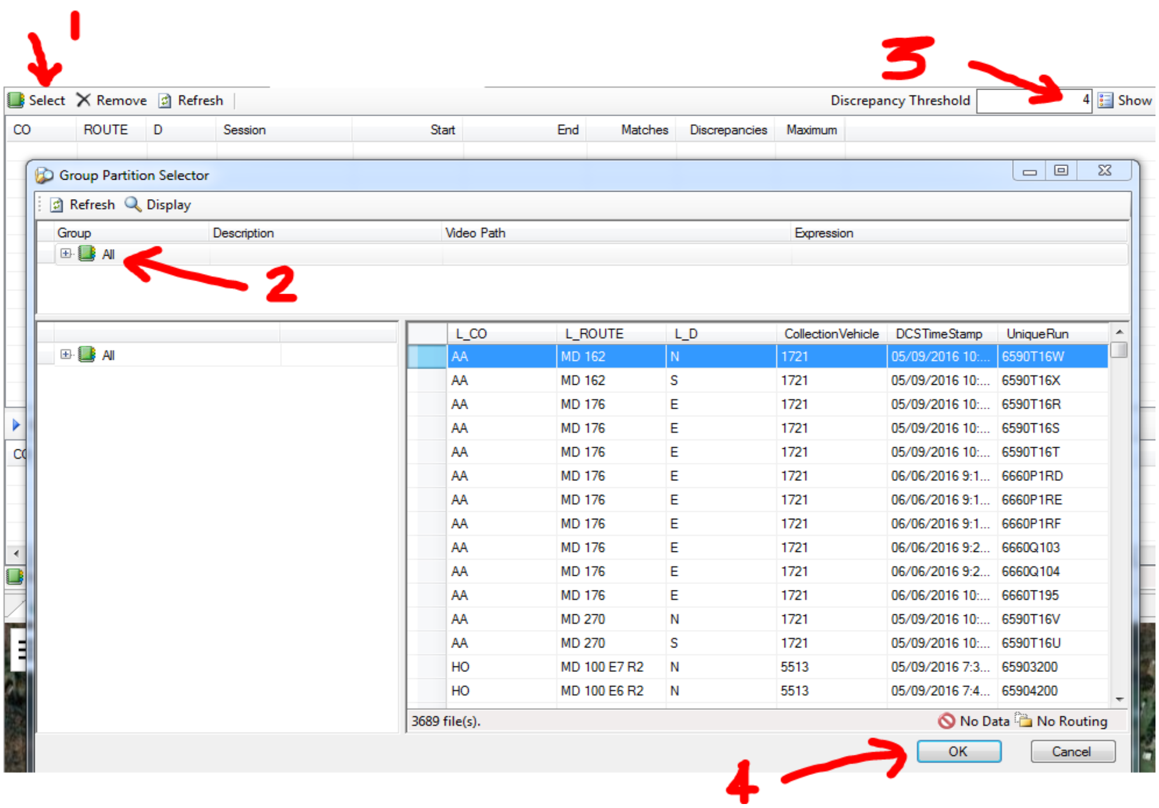

Data Warehouse - Connected to Production Database
Administration
Data
Analysis
Design
Reporting
Help
Exit
Construction Data
Aran
Wisecrax
Visidata
Friction
MCMS
Maintenance
HMA Tonnage
Inventory
Curve
WIM
Data Upload
Record Drive and First Image
Data Transfer from SQL to Oracle
View/Edit Unique Run Status
Upload FED Field Log
Collection List Edit
Collection List vs. Base Report
ARAN Imagery Checks
Route Matching QC


Year
2016
County
All
Route
Test Date
File Name
Drive No.
Filter
Showing Recollected
Aran
All
YEAR
FILENAME
IDSESSION
IDLOCATOR
COLLECT_DATE
CODE
COUNTY
MUN
ROUTE
2016 65903200 8 6 05/09/2016 13 HO 0 MD 100
2016 65903200 8 3500 05/09/2016 13 HO 0 MD 100
2016 65904200 9 7 05/09/2016 13 HO 0 MD 100
2016 65905200 10 8 05/09/2016 13 HO 0 MD 100
2016 65906200 11 9 05/09/2016 13 HO 0 MD 100
2016 65907200 12 10 05/09/2016 13 HO 0 MD 100
2016 65908200 13 11 05/09/2016 13 HO 0 MD 100
ARAN Unique Run Status Update
File Name
6AI0L200
Location
CL MD 852 H W M0 E R MP:0-0.228
Length
0.228
Drive No
NA
Wisecrax Required?
FED
QC Checked
QA Checked
Recollect
FED Note
jch 11/10/16
OPPE
Matched
Recollect
Not To Use
GPS start, use OPPE
GPS end, use OPPE
OPPE Note
JCH 2/13/17: Stopped short due to road end.
PAGD DPT
Route Data
QC Checked
QA Checked
Wx 100 Percent QC Checked
Wisecrax
QC Checked/Uploaded
QA Checked
Wx_Impossible
Recollect
DPT Note
PAGD DAT
QC Checked
QA Checked
Recollect
DAT Note
View FED Field Log
Save
Close
Confirm Recollection Done

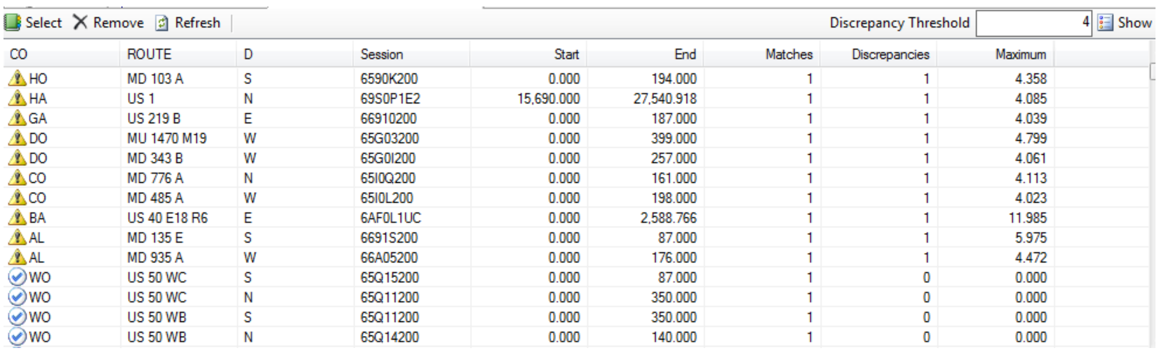
Step 92. Perform systemic level QC inspection by opening Vision once per week. Click “Segment” and select “Match Discrepancy Finder” from the drop-down menu (see below image).



i. In the “Group Partition Selector”, select “All”, enter “4” in the “Discrepancy Threshold” box, and click “OK” (see below image).



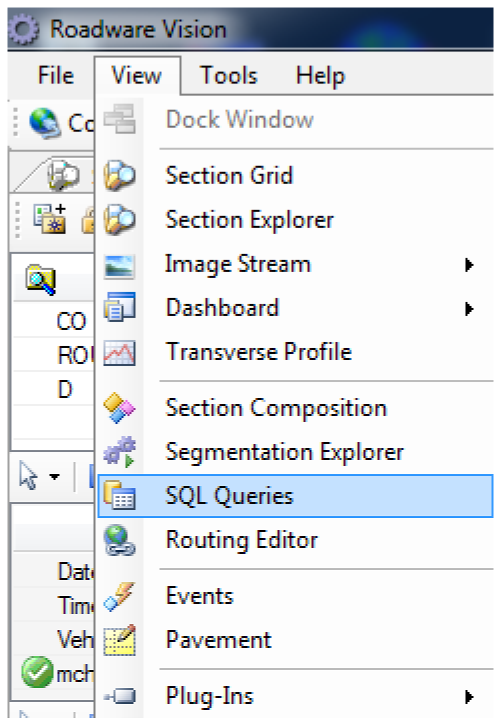
ii. Review results. A yellow triangle in the “CO” column indicates a failed QC (requires review), while a blue check mark indicates a passed QC (see below image). Review each failed QC and determine if discrepancy is reasonable and that QC notes exist within Vision and the EDW. Address the issue by populating notes where needed and making appropriate correct actions.

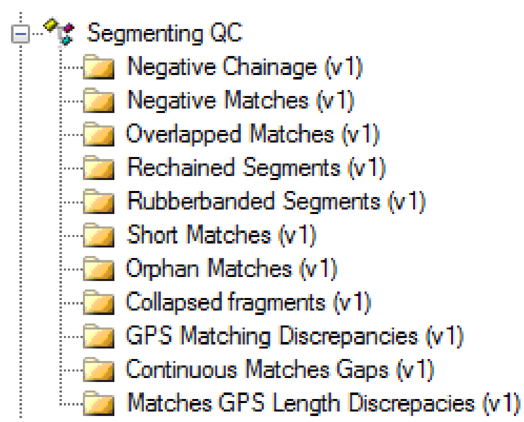


Select | Remove | Refresh | Discrepancy Threshold 4 | Show

CO	ROUTE	D	Session	Start	End	Matches	Discrepancies	Maximum
HO	MD 103 A	S	6590K200	0.000	194.000	1	1	4.358
HA	US 1	N	69S0P1E2	15,690.000	27,540.918	1	1	4.085
GA	US 219 B	E	66910200	0.000	187.000	1	1	4.039
DO	MU 1470 M19	W	65G03200	0.000	399.000	1	1	4.799
DO	MD 343 B	W	65G0I200	0.000	257.000	1	1	4.061
CO	MD 776 A	N	65I0Q200	0.000	161.000	1	1	4.113
CO	MD 485 A	W	65I0L200	0.000	198.000	1	1	4.023
BA	US 40 E18 R6	E	6AF0L1UC	0.000	2,588.766	1	1	11.985
AL	MD 135 E	S	6691S200	0.000	87.000	1	1	5.975
AL	MD 935 A	W	66A05200	0.000	176.000	1	1	4.472
WO	US 50 WC	S	65Q15200	0.000	87.000	1	0	0.000
WO	US 50 WC	N	65Q11200	0.000	350.000	1	0	0.000
WO	US 50 WB	S	65Q11200	0.000	350.000	1	0	0.000
WO	US 50 WB	N	65Q14200	0.000	140.000	1	0	0.000

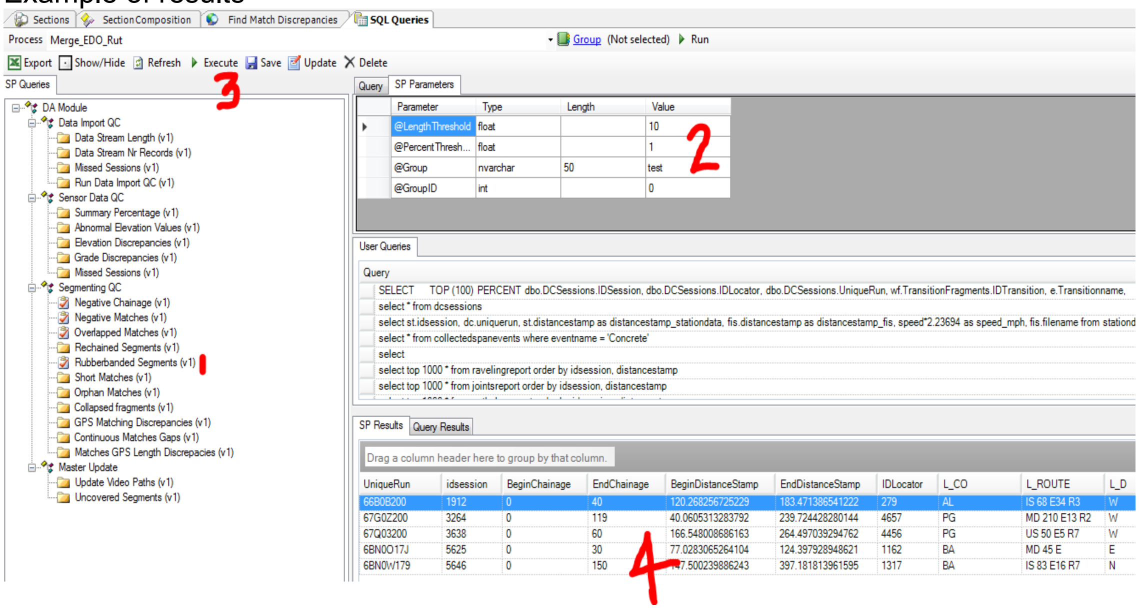
iii. Click “View” and select “SQL Queries”, then “Segmenting QC” to determine what routes require further review of accuracy and completeness (see below image). Take corrective actions where necessary.





For each of the above items, run the SQL procedure to attain collection run(s) with issues that require review to determine accuracy and completeness. Evaluate and address any issues and make sure QC notes are placed in the EDW Unique Run status program for each run. Before selecting “Execute,” Short Matches requires “4” value entry, GPS Matching Discrepancies require “4” value entry, and Continuous Match Gaps requires “0.1” value entry where Values are null.

Example of results



Step 93. Communicate results of QC review to DPT TL and discuss any lingering issues that may need to be resolved.

5- **Performing QA of Overall Process** – *performed by Supervisor*

Summary: This task performs QA checks on route matching process.

Step 94. See existing QA guide.

5.07 PERFORMING 100% DRIVE THROUGH

5.07.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to perform quality control (QC) and quality assurance (QA) checks of the Laser Crack Measurement System (LCMS) pavement image output using data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff. This SOP is performed after completion of route matching (see Route Matching).

5.07.02 *Frequency*

The 100% drive through of pavement images is performed every time a batch of ARAN collected data is received by the DPT. Each ARAN data batch is typically delivered to the DPT every 4 to 5 days. Assuming an average of 60 miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data. The actual frequency varies according to the proximity of the routes on which data were collected for the data batch to the Office of Materials Technology (OMT) office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring data recollection. The annual ARAN data collection season typically lasts from March to Mid-December.

5.07.03 *Purpose*

The purpose of this SOP is to perform a thorough check of the LCMS pavement image output, correct any errors in crack or joint detection, and perform QC and QA checks.

5.07.04 *Resource Requirements*

Performing the 100% drive through involves three people: (1) a user knowledgeable in Vision software to perform QC on the pavement images, (2) a user knowledgeable in Vision software to perform QA on the analyzed images, and (3) a supervisor who, as required, provides guidance and decision-making and performs QA. The estimated effort levels in the table below represent the total time, in man-hours, to complete the drive through QC/QA. These time estimates assume average batch quantities and no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision user and QC	1	336.0
DPT Staff	QA	1	25.0
DPT TL	Supervisor and QA	1	AR[06/12/2019]

5.07.05 *Procedure*

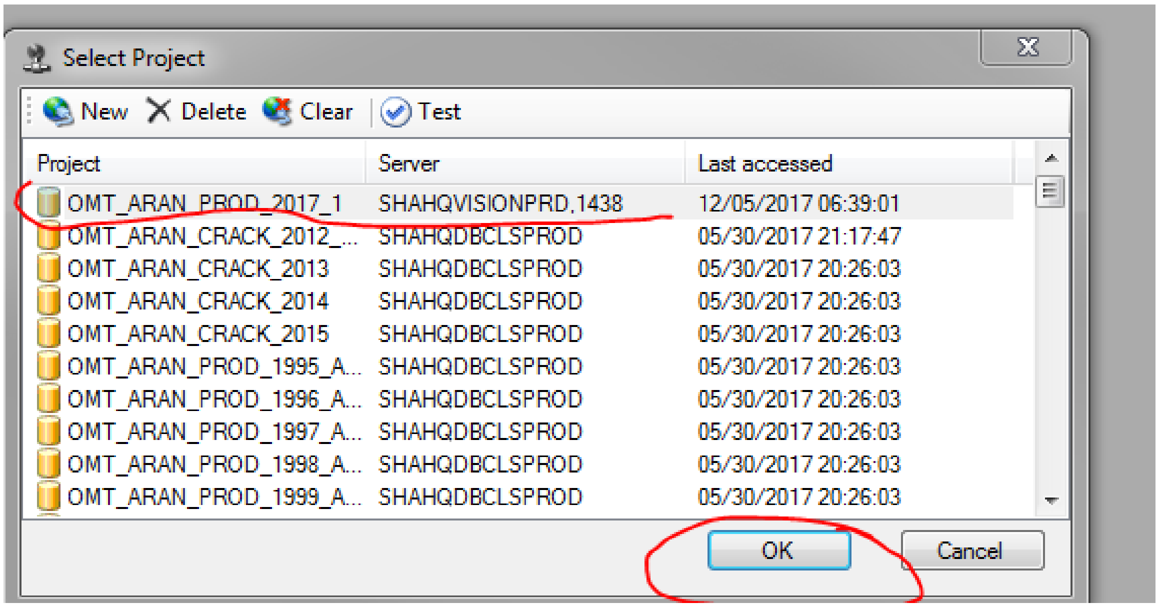
The procedure to perform the 100% drive through and perform QC/QA is comprised of the following three tasks:

(1) performing 100% drive through QC,
(2) performing QA of the analyzed images, and
(3) performing overall QA of the process.

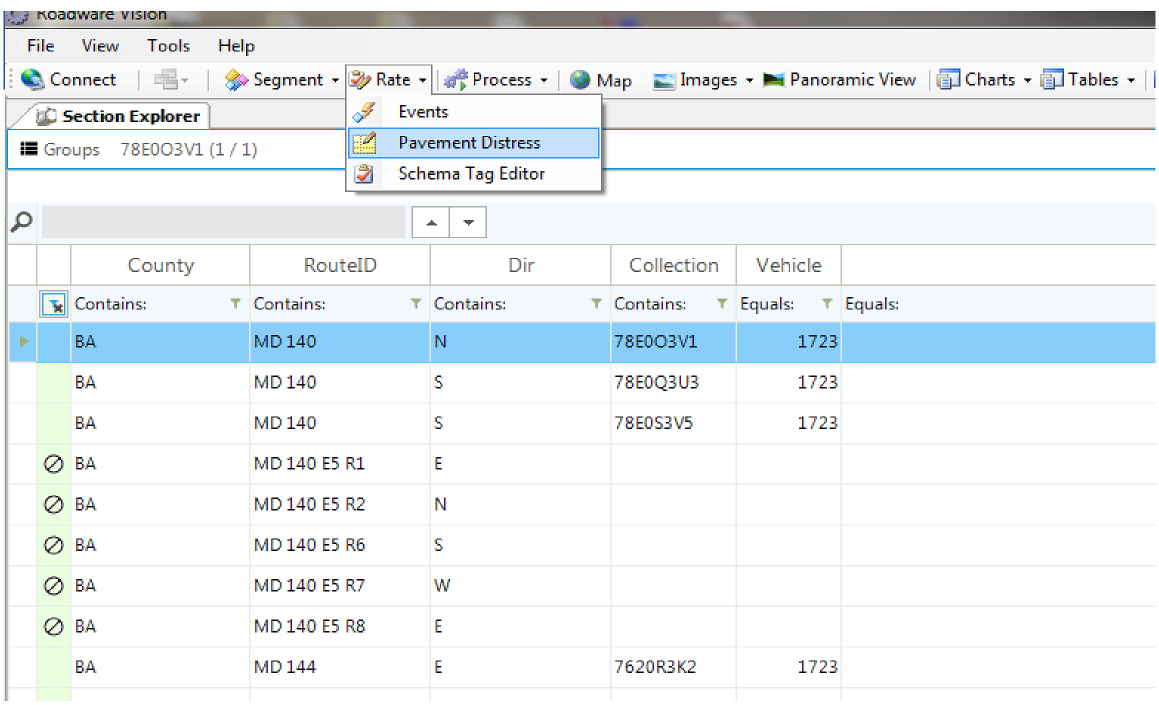
1- Performing 100% Drive Through QC – *performed by Vision user*

Summary: This task uses Vision software to analyze the LCMS output, correct errors in crack or joint detection, and mark events.

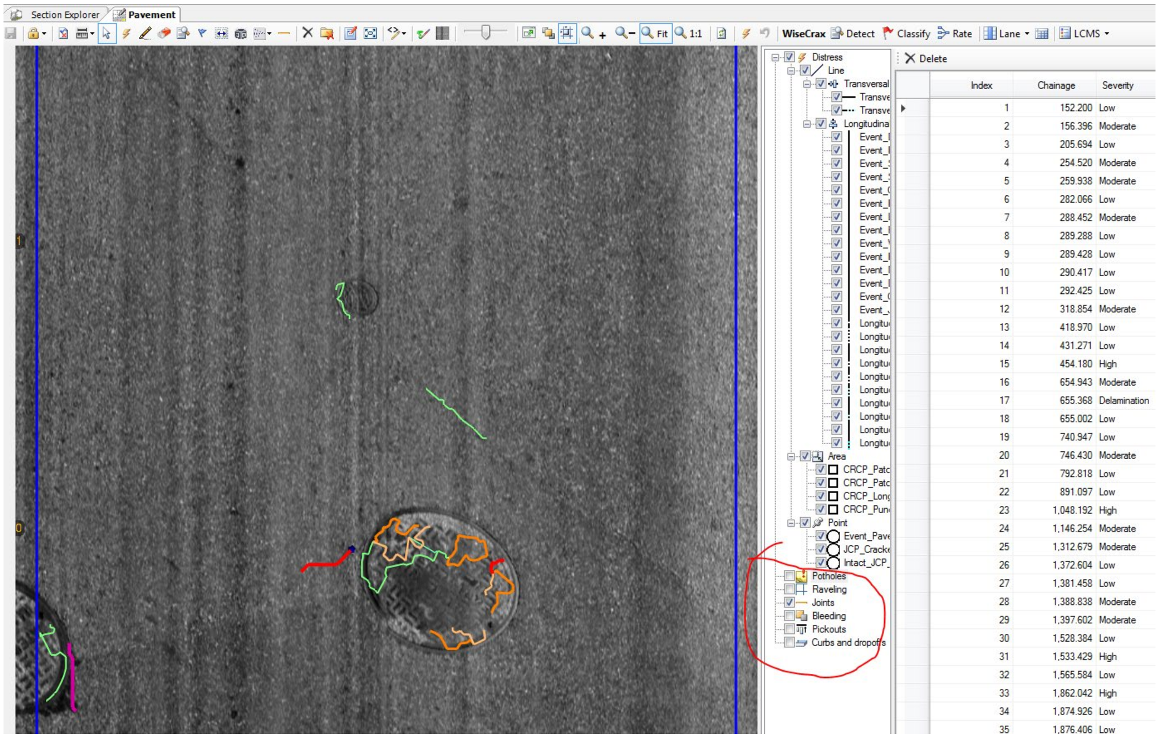
Step 1. Open Vision software. Select the target database and click "OK" (see below image)



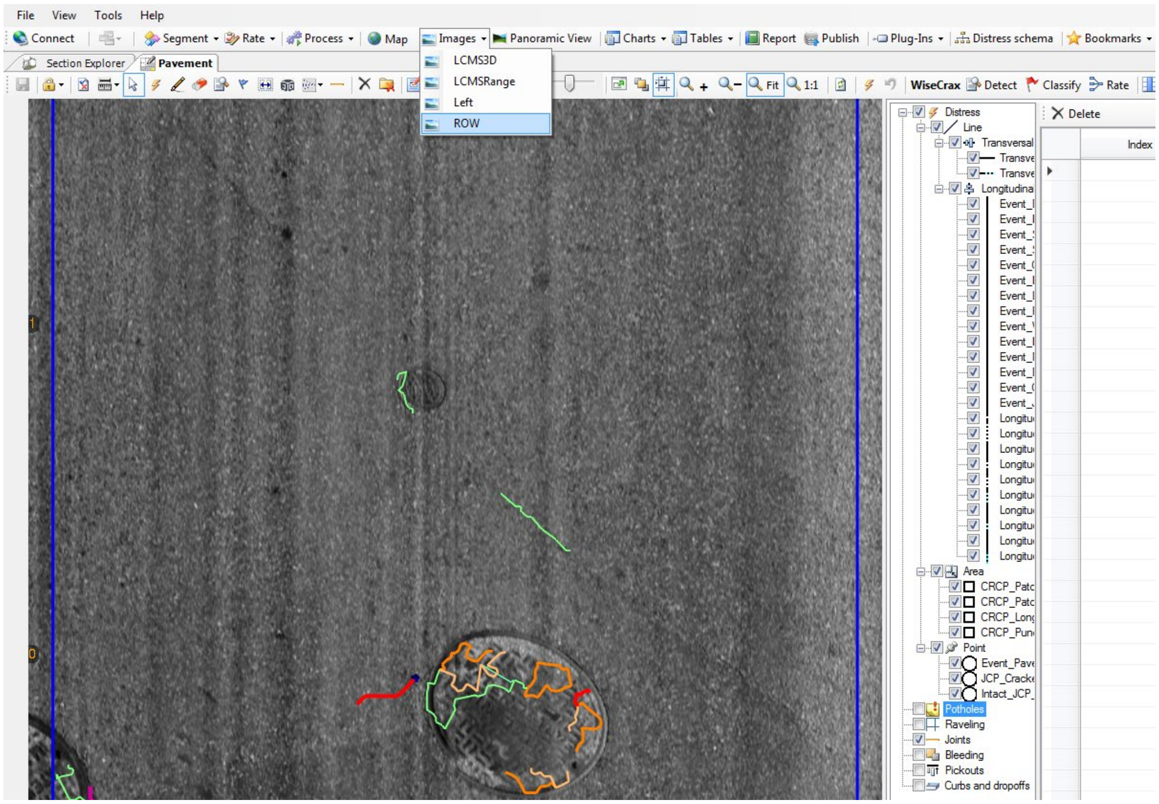
Step 2. Click on "Rate" and select "Pavement Distress" from the drop-down menu (see below image).



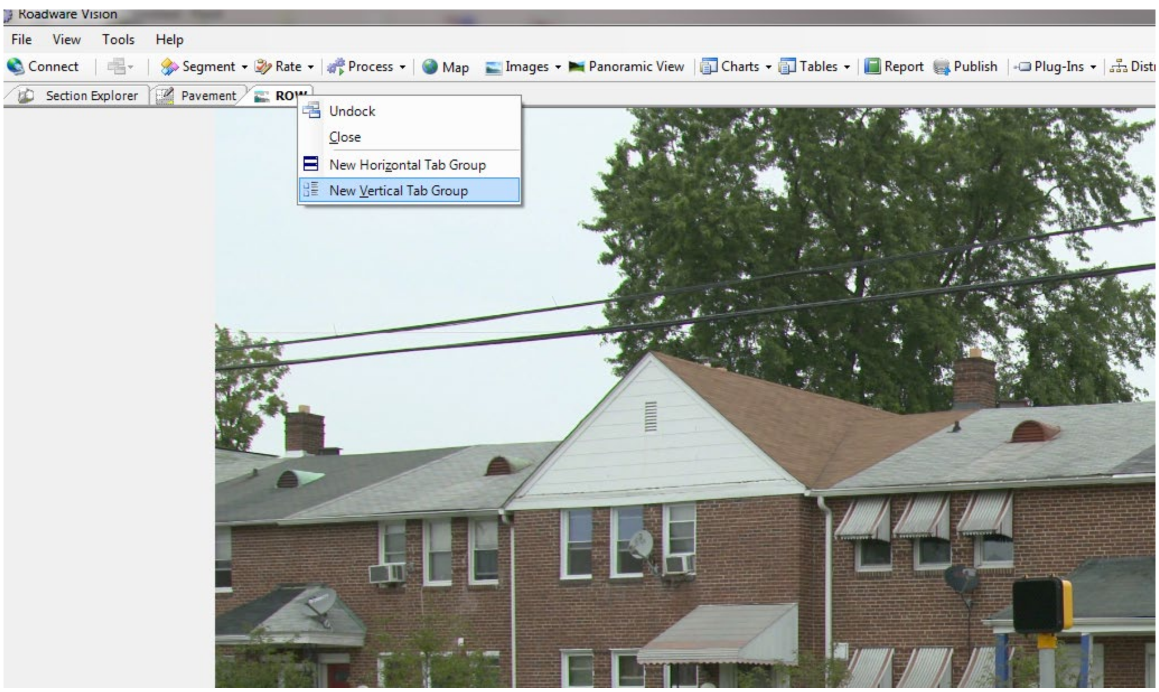
Step 3. From the menu on the right side of the window, deselect: **Potholes, Raveling, Bleeding, Pickouts, and Curbs & Drop-offs** (see below image).



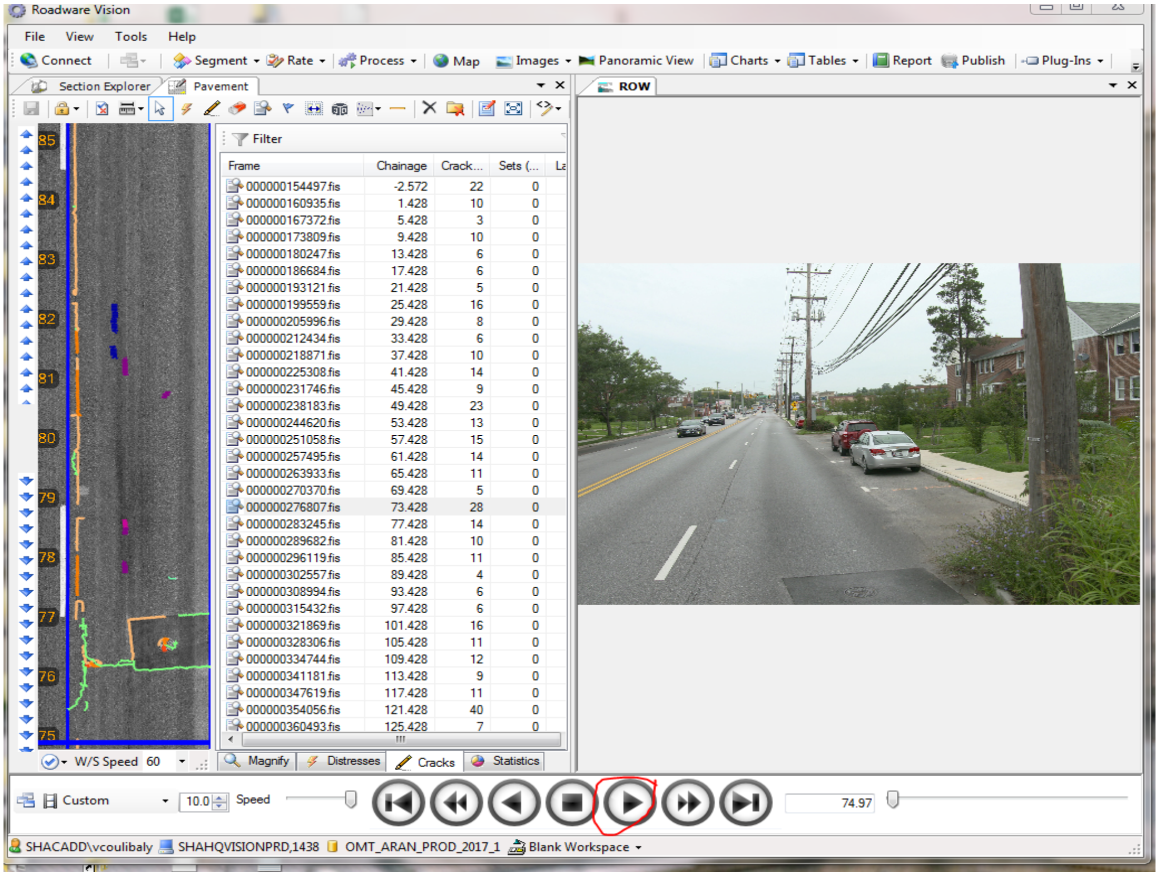
Step 4. Click on “Images” and select “ROW” from the drop-down menu (see below image).



Step 5. Adjust the "ROW" window by clicking on the "ROW" tab and selecting "New Vertical Tab Group" (see below image).



Step 6. Start driving through using the "Play button (see below image).



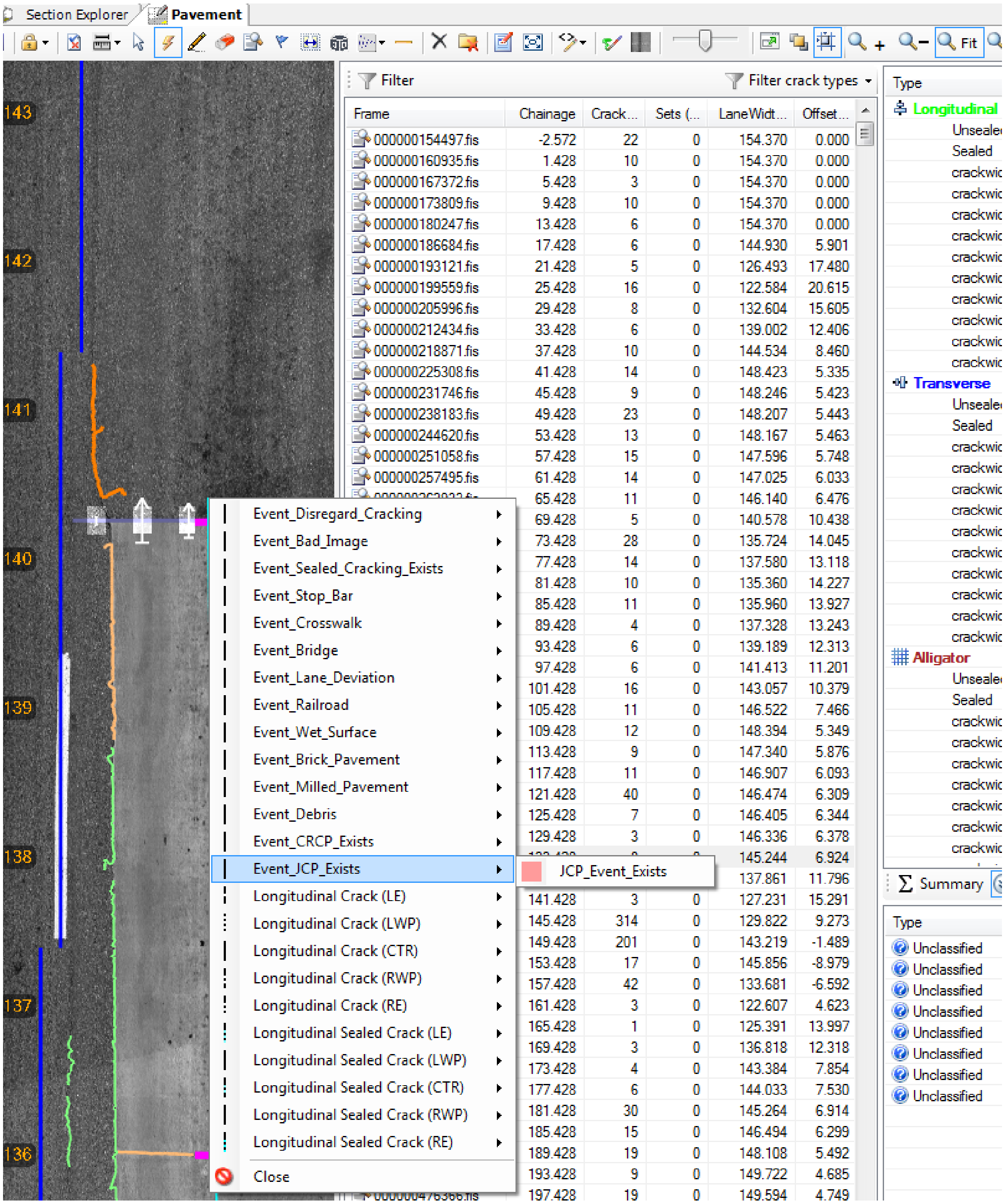
Step 7. Identify pavement type.

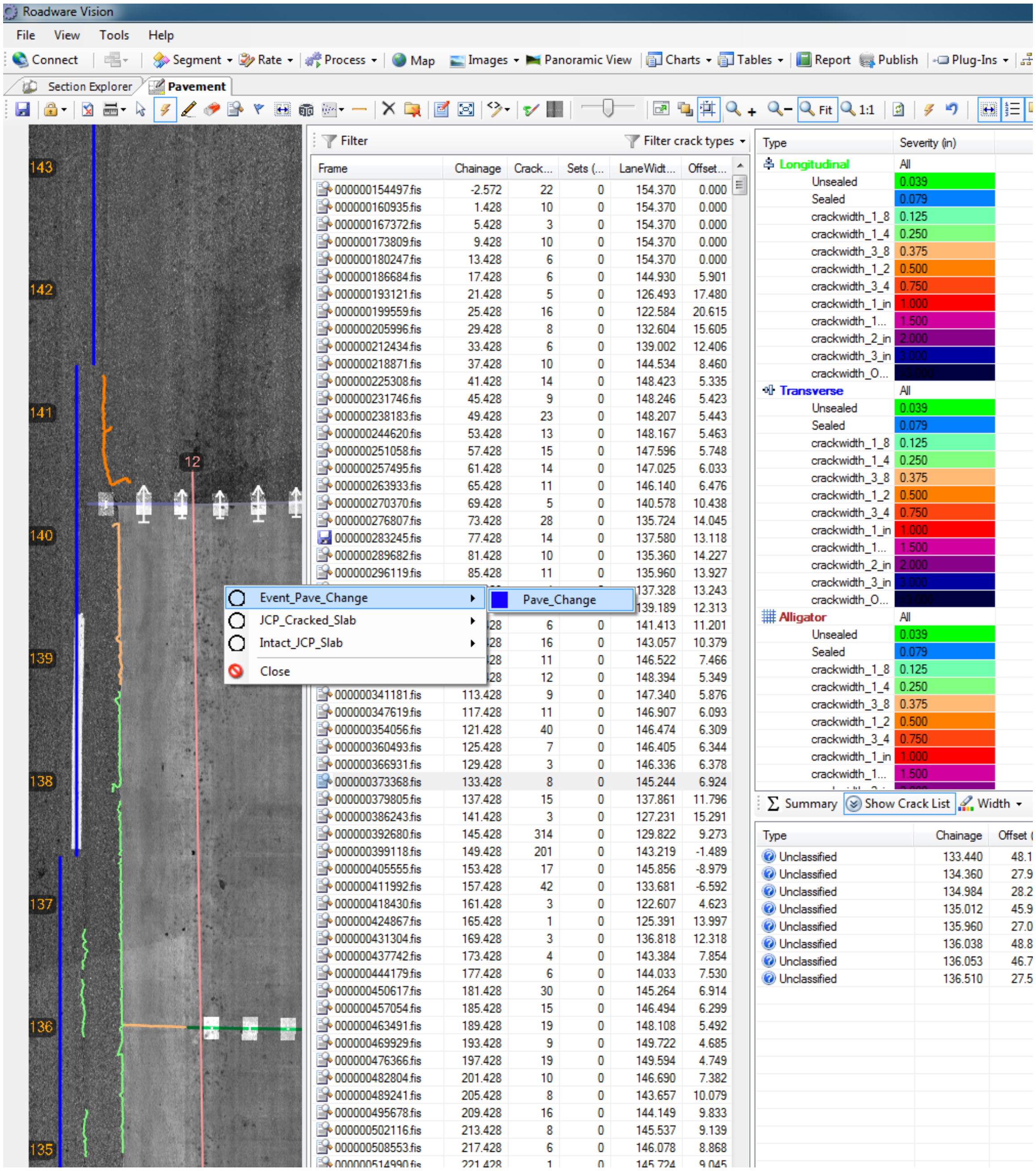
i. If the section is Jointed Concrete Pavement (JCP), proceed to Step 8.

ii. If the section is Continuously Reinforced Concrete Pavement (CRCP), proceed to Step 10.

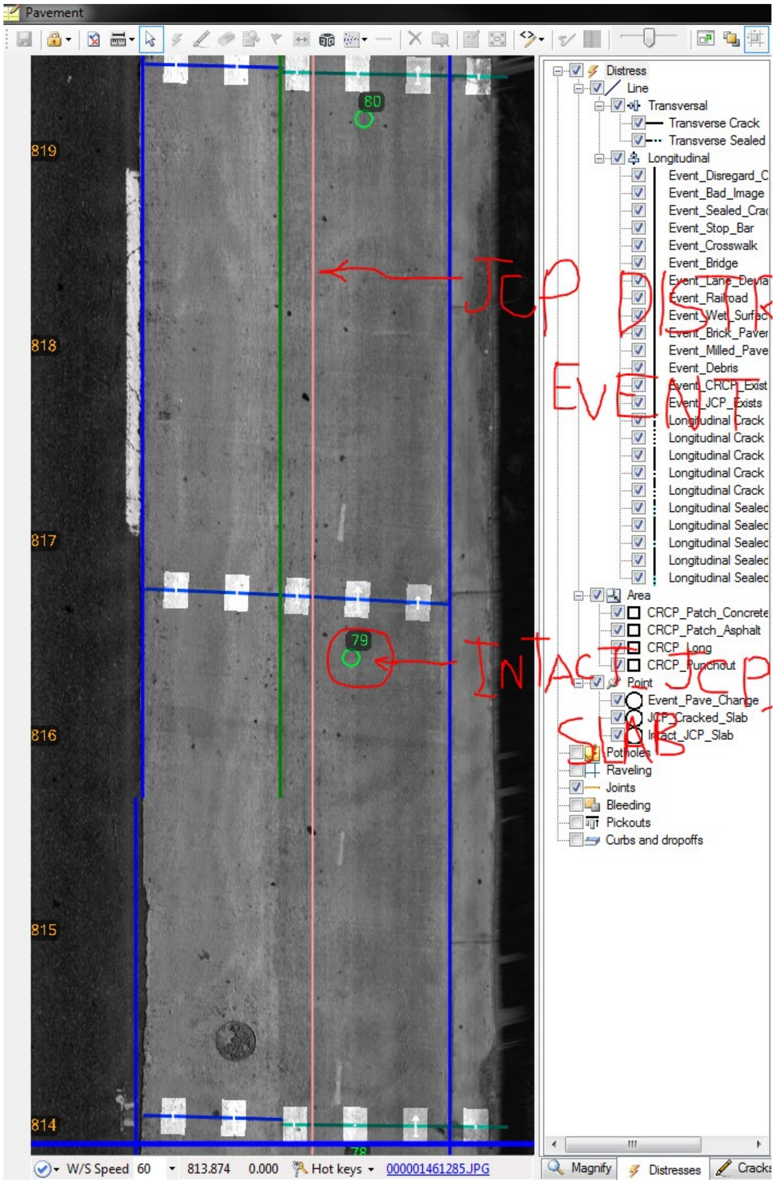
iii. If the section is Flexible (Asphalt) Pavement, proceed to Step 12.

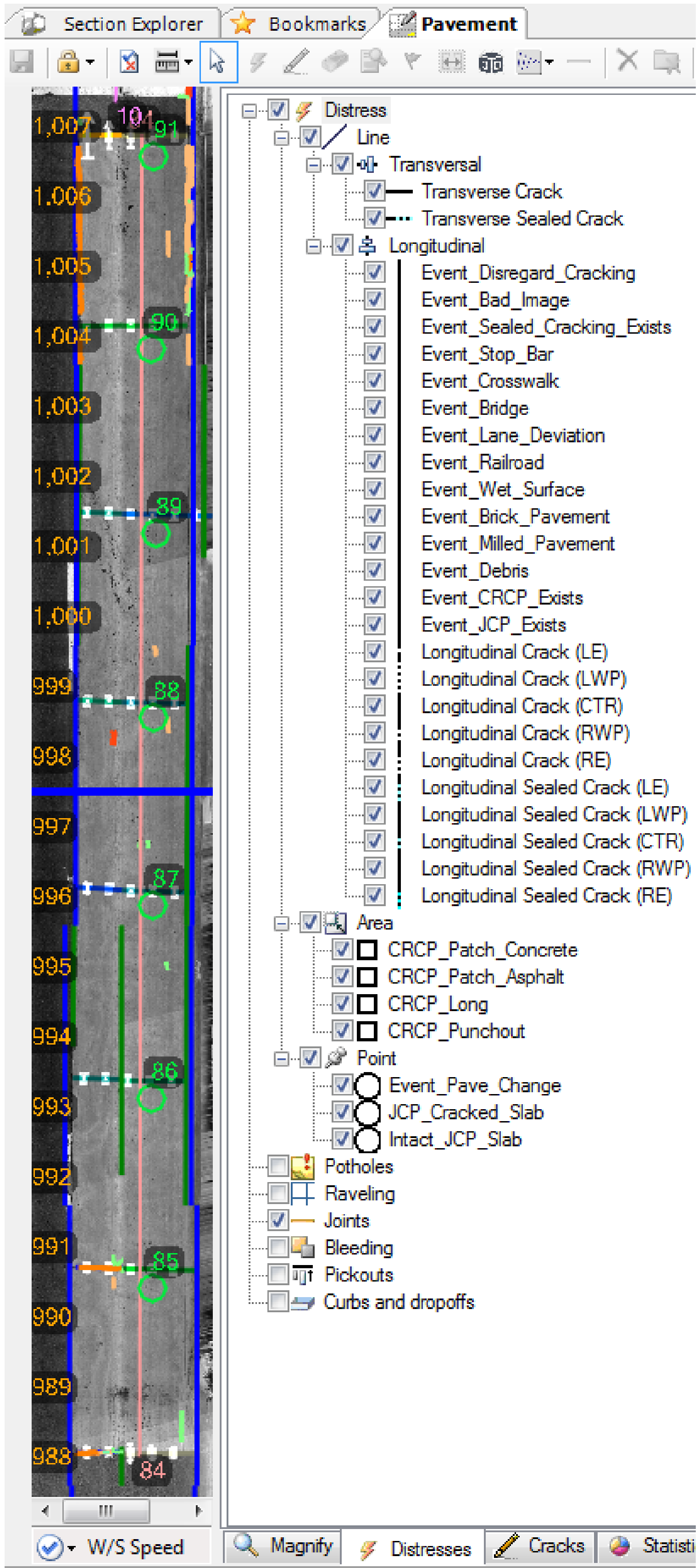
Step 8. Navigate to beginning of section. Draw a “JCP Distress Event” line from the beginning to the end of the JCP concrete section (see below images).



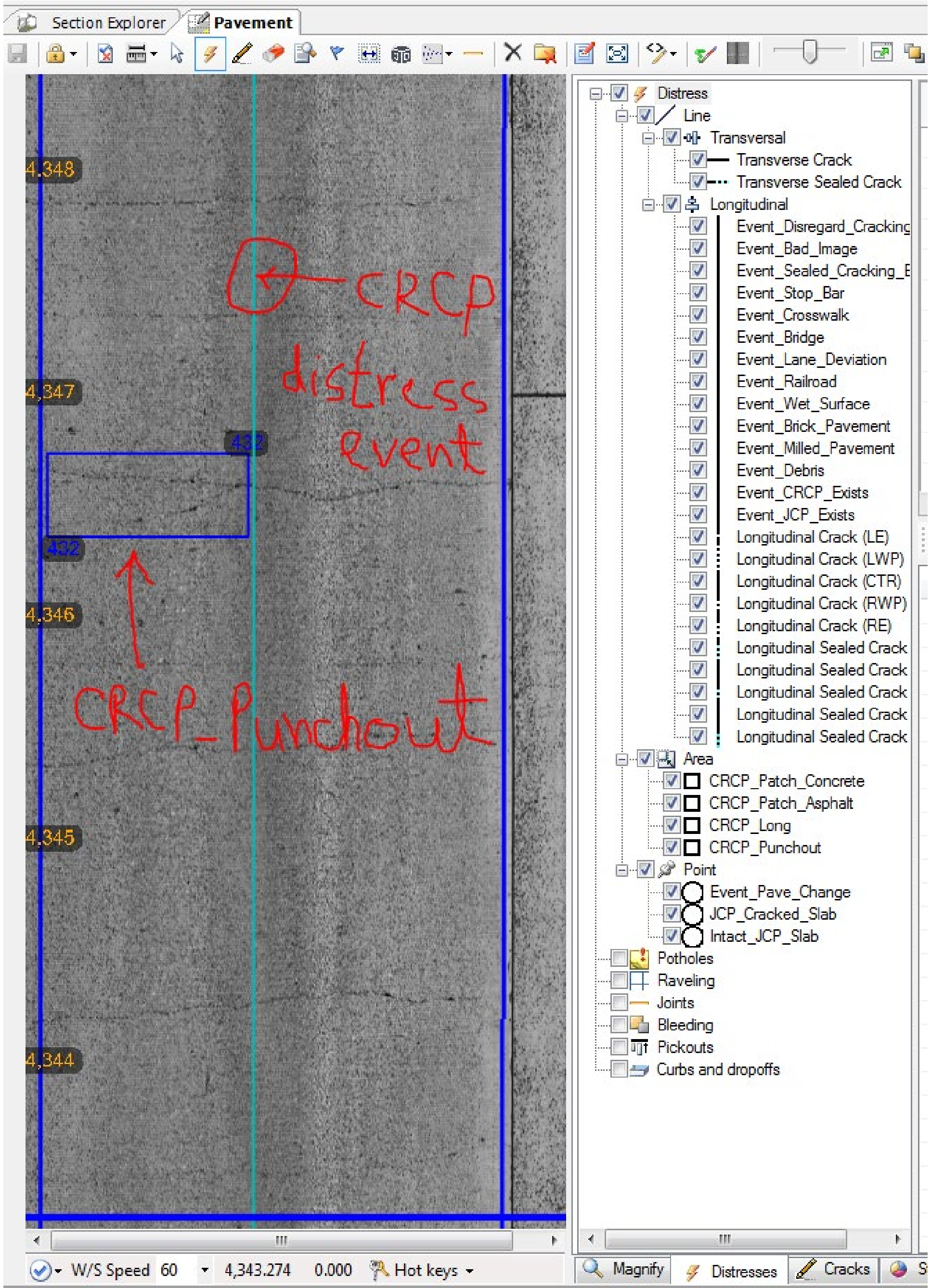


Step 9. Analyze first slab. Examine slab for cracking. If a crack (or cracks) exists, draw a point distress labeled “JCP_Cracked_Slab” in the middle of the slab. Otherwise, draw a point distress labeled “Intact_JCP_Slab” in the middle of the slab. Ensure the slab joint was detected (as indicated by a horizontal blue line at the joint). If it was not detected, draw the joint line in manually. To identify a slab as cracked or intact, select the “Distress” button, double-click on the slab, and select the event. Repeat slab analysis for all slabs in section (see below images).


Pavement
JCP DISTR
EVENT
INTACT JCP
SLAB
Distress
Line
Transversal
Transverse Crack
Transverse Sealed
Longitudinal
Event_Bad_Image
Event_Stop_Bar
Event_Crosswalk
Event_Bridge
Event_Debris
Event_JCP_Exists
Area
CRCP_Patch_Concrete
CRCP_Patch_Asphalt
Point
Event_Pave_Change
JCP_Cracked_Slab
Intact_JCP_Slab
Potholes
Raveling
Joints
Bleeding
Pickouts
Curbs and dropoffs
W/S Speed 60
813.874
0.000
Hot keys
000001461285.JPG
Magnify
Distresses
Cracks

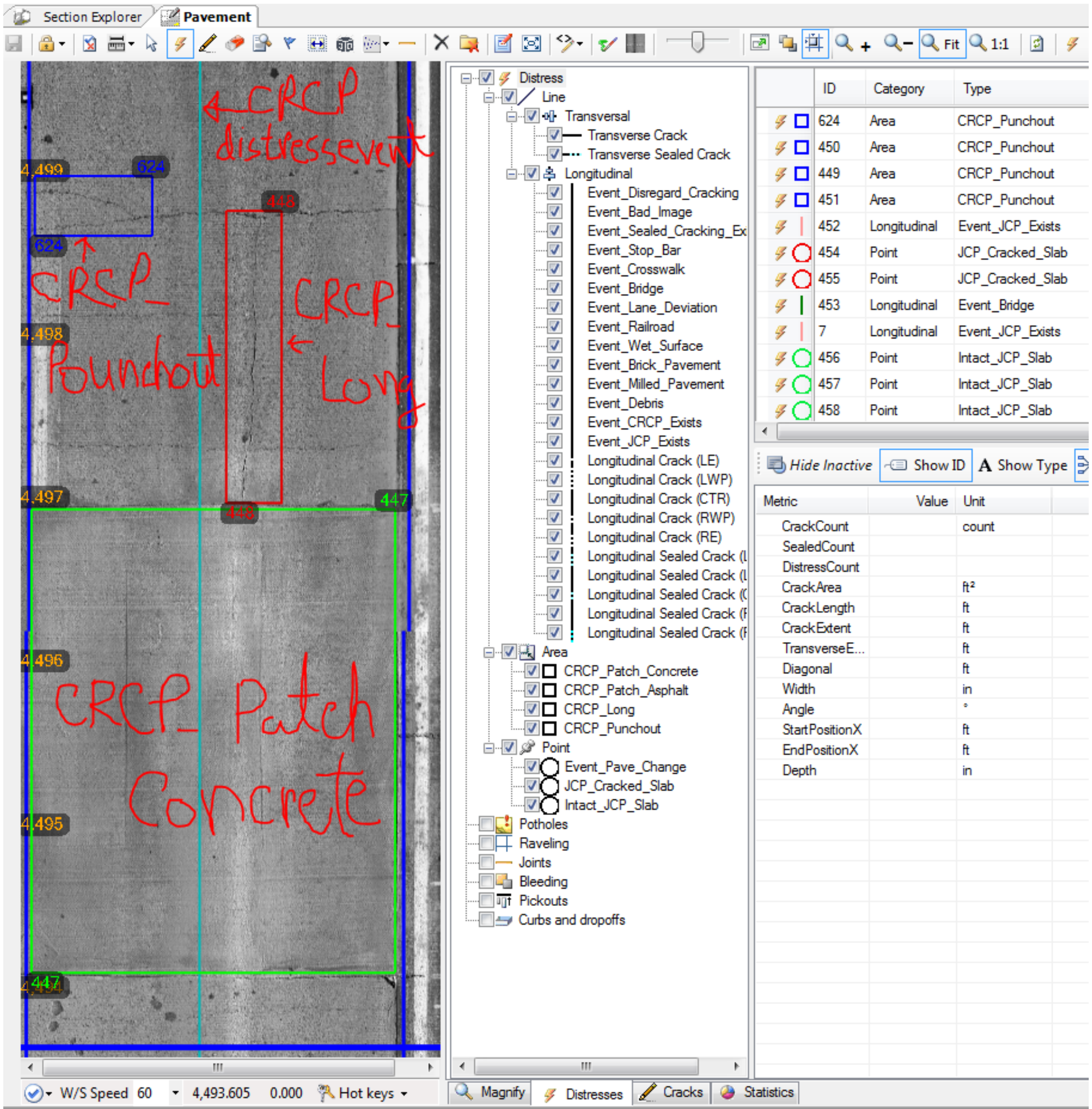

Section Explorer
Bookmarks
Pavement
Distress
Line
Transversal
Transverse Crack
Transverse Sealed Crack
Longitudinal
Event_Disregard_Cracking
Event_Bad_Image
Event_Sealed_Cracking_Exists
Event_Stop_Bar
Event_Crosswalk
Event_Bridge
Event_Lane_Deviation
Event_Railroad
Event_Wet_Surface
Event_Brick_Pavement
Event_Milled_Pavement
Event_Debris
Event_CRCP_Exists
Event_JCP_Exists
Longitudinal Crack (LE)
Longitudinal Crack (LWP)
Longitudinal Crack (CTR)
Longitudinal Crack (RWP)
Longitudinal Crack (RE)
Longitudinal Sealed Crack (LE)
Longitudinal Sealed Crack (LWP)
Longitudinal Sealed Crack (CTR)
Longitudinal Sealed Crack (RWP)
Longitudinal Sealed Crack (RE)
Area
CRCP_Patch_Concrete
CRCP_Patch_Asphalt
CRCP_Long
CRCP_Punchout
Point
Event_Pave_Change
JCP_Cracked_Slab
Intact_JCP_Slab
Potholes
Raveling
Joints
Bleeding
Pickouts
Curbs and dropoffs
W/S Speed
Magnify
Distresses
Cracks
Statisti

Step 10. Navigate to beginning of section. Draw a “CRCP Distress Event” line from the beginning to the end of the CRCP section (see below image).



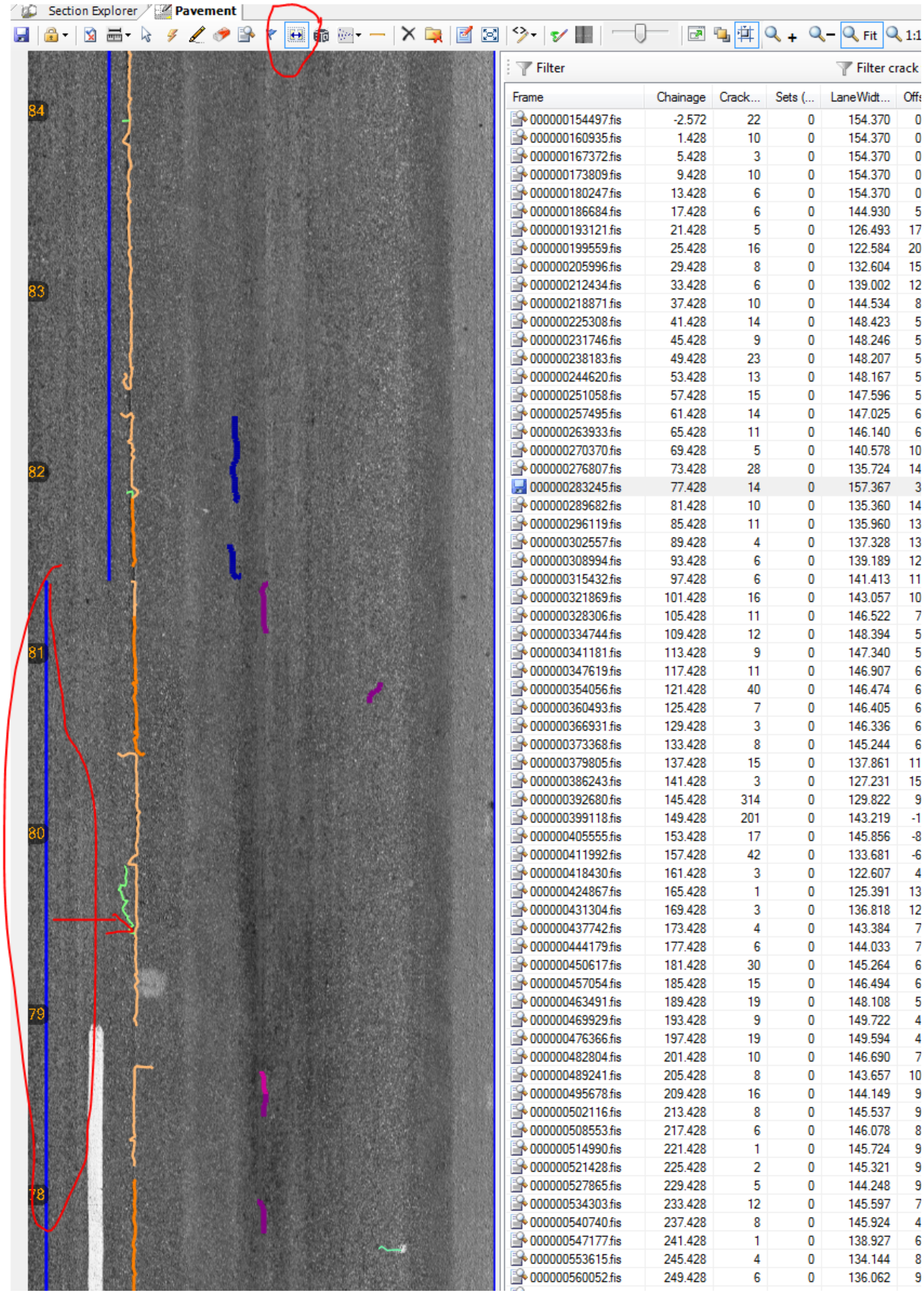
Step 11. Analyze the pavement, moving from beginning to end of the section. Adjust blue line with the “Lane Mark” tool if pavement lane is not lined up properly. Draw area distress markers over top of any observed distresses in the images: “CRCP_Punchout” for punchouts, “CRCP_Long” for longitudinal cracks, “CRCP_Patch_Asphalt” for asphalt patches, or “CRCP_Patch_Concrete” for concrete patches. Follow the HPMS Field Manual (FHWA, December 2016)

for drawing distress areas. To add a distress, select the “Distress” button, double-click on the pavement, and select the event. Continue to end of pavement section (see below image).



Step 12. Navigate to beginning of section. Virtually drive the pavement section. Make the following adjustments where necessary:

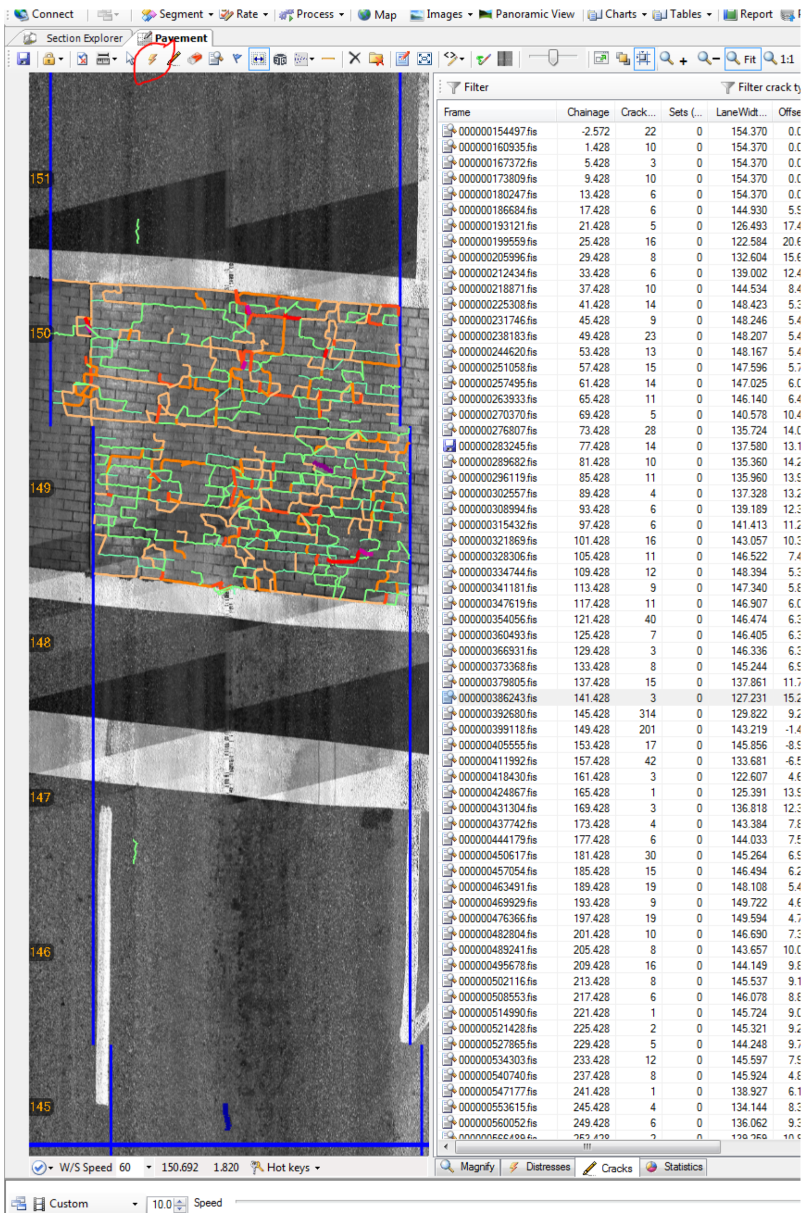
i. If the blue line is not aligned with the marked line (either inside or outside), then adjust it manually (see below image).

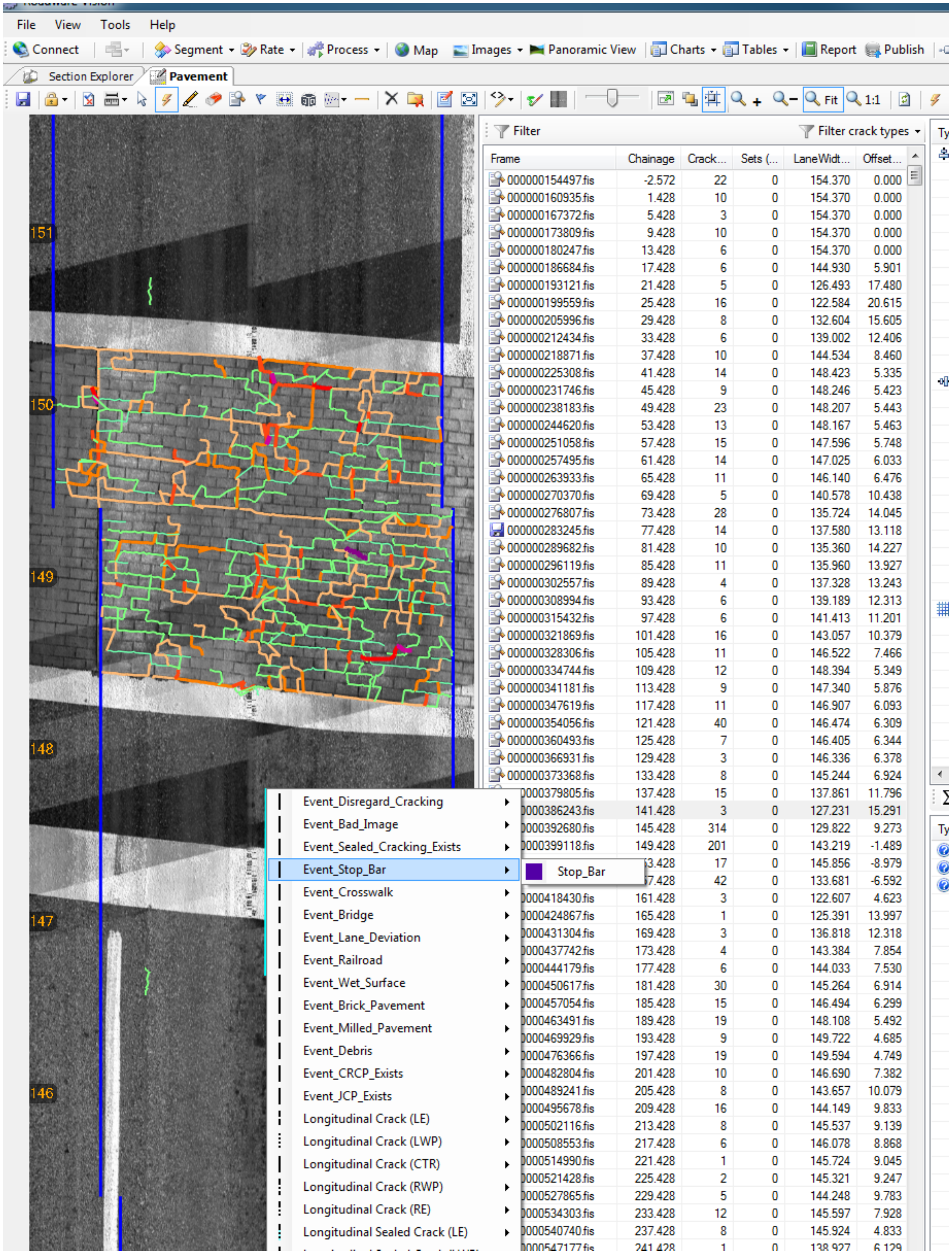


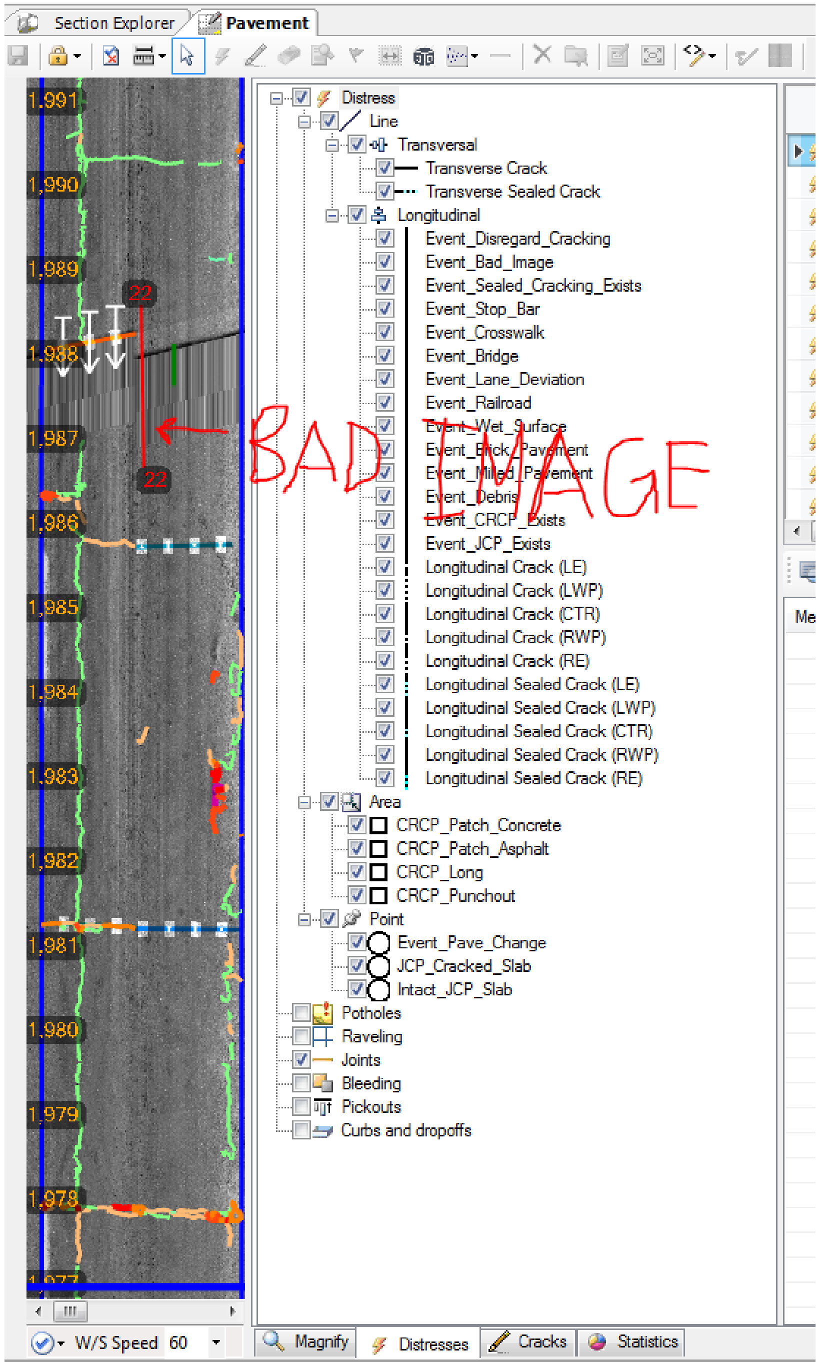
Frame	Chainage	Crack...	Sets (...	LaneWidt...	Offs
000000154497.fis	-2.572	22	0	154.370	0
000000160935.fis	1.428	10	0	154.370	0
000000167372.fis	5.428	3	0	154.370	0
000000173809.fis	9.428	10	0	154.370	0
000000180247.fis	13.428	6	0	154.370	0
000000186684.fis	17.428	6	0	144.930	5
000000193121.fis	21.428	5	0	126.493	17
000000199559.fis	25.428	16	0	122.584	20
000000205996.fis	29.428	8	0	132.604	15
000000212434.fis	33.428	6	0	139.002	12
000000218871.fis	37.428	10	0	144.534	8
000000225308.fis	41.428	14	0	148.423	5
000000231746.fis	45.428	9	0	148.246	5
000000238183.fis	49.428	23	0	148.207	5
000000244620.fis	53.428	13	0	148.167	5
000000251058.fis	57.428	15	0	147.596	5
000000257495.fis	61.428	14	0	147.025	6
000000263933.fis	65.428	11	0	146.140	6
000000270370.fis	69.428	5	0	140.578	10
000000276807.fis	73.428	28	0	135.724	14
000000283245.fis	77.428	14	0	157.367	3
000000289682.fis	81.428	10	0	135.360	14
000000296119.fis	85.428	11	0	135.960	13
000000302557.fis	89.428	4	0	137.328	13
000000308994.fis	93.428	6	0	139.189	12
000000315432.fis	97.428	6	0	141.413	11
000000321869.fis	101.428	16	0	143.057	10
000000328306.fis	105.428	11	0	146.522	7
000000334744.fis	109.428	12	0	148.394	5
000000341181.fis	113.428	9	0	147.340	5
000000347619.fis	117.428	11	0	146.907	6
000000354056.fis	121.428	40	0	146.474	6
000000360493.fis	125.428	7	0	146.405	6
000000366931.fis	129.428	3	0	146.336	6
000000373368.fis	133.428	8	0	145.244	6
000000379805.fis	137.428	15	0	137.861	11
000000386243.fis	141.428	3	0	127.231	15
000000392680.fis	145.428	314	0	129.822	9
000000399118.fis	149.428	201	0	143.219	-1
000000405555.fis	153.428	17	0	145.856	-8
000000411992.fis	157.428	42	0	133.681	-6
000000418430.fis	161.428	3	0	122.607	4
000000424867.fis	165.428	1	0	125.391	13
000000431304.fis	169.428	3	0	136.818	12
000000437742.fis	173.428	4	0	143.384	7
000000444179.fis	177.428	6	0	144.033	7
000000450617.fis	181.428	30	0	145.264	6
000000457054.fis	185.428	15	0	146.494	6
000000463491.fis	189.428	19	0	148.108	5
000000469929.fis	193.428	9	0	149.722	4
000000476366.fis	197.428	19	0	149.594	4
000000482804.fis	201.428	10	0	146.690	7
000000489241.fis	205.428	8	0	143.657	10
000000495678.fis	209.428	16	0	144.149	9
000000502116.fis	213.428	8	0	145.537	9
000000508553.fis	217.428	6	0	146.078	8
000000514990.fis	221.428	1	0	145.724	9
000000521428.fis	225.428	2	0	145.321	9
000000527865.fis	229.428	5	0	144.248	9
000000534303.fis	233.428	12	0	145.597	7
000000540740.fis	237.428	8	0	145.924	4
000000547177.fis	241.428	1	0	138.927	6
000000553615.fis	245.428	4	0	134.144	8
000000560052.fis	249.428	6	0	136.062	9

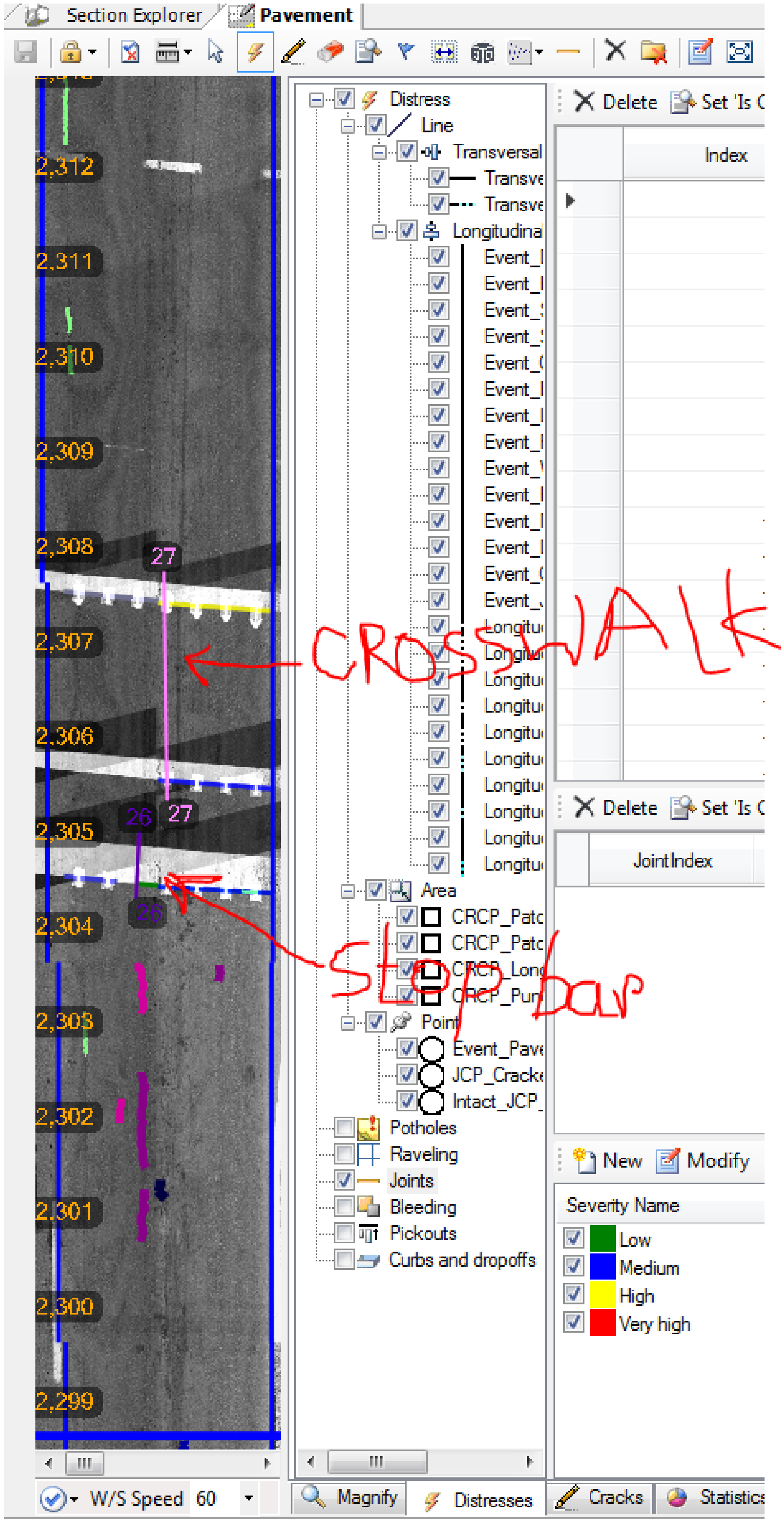
ii. Delete false positive crack detections (can be due to manhole covers, inlets, gutter pans, rumble strips, etc.).

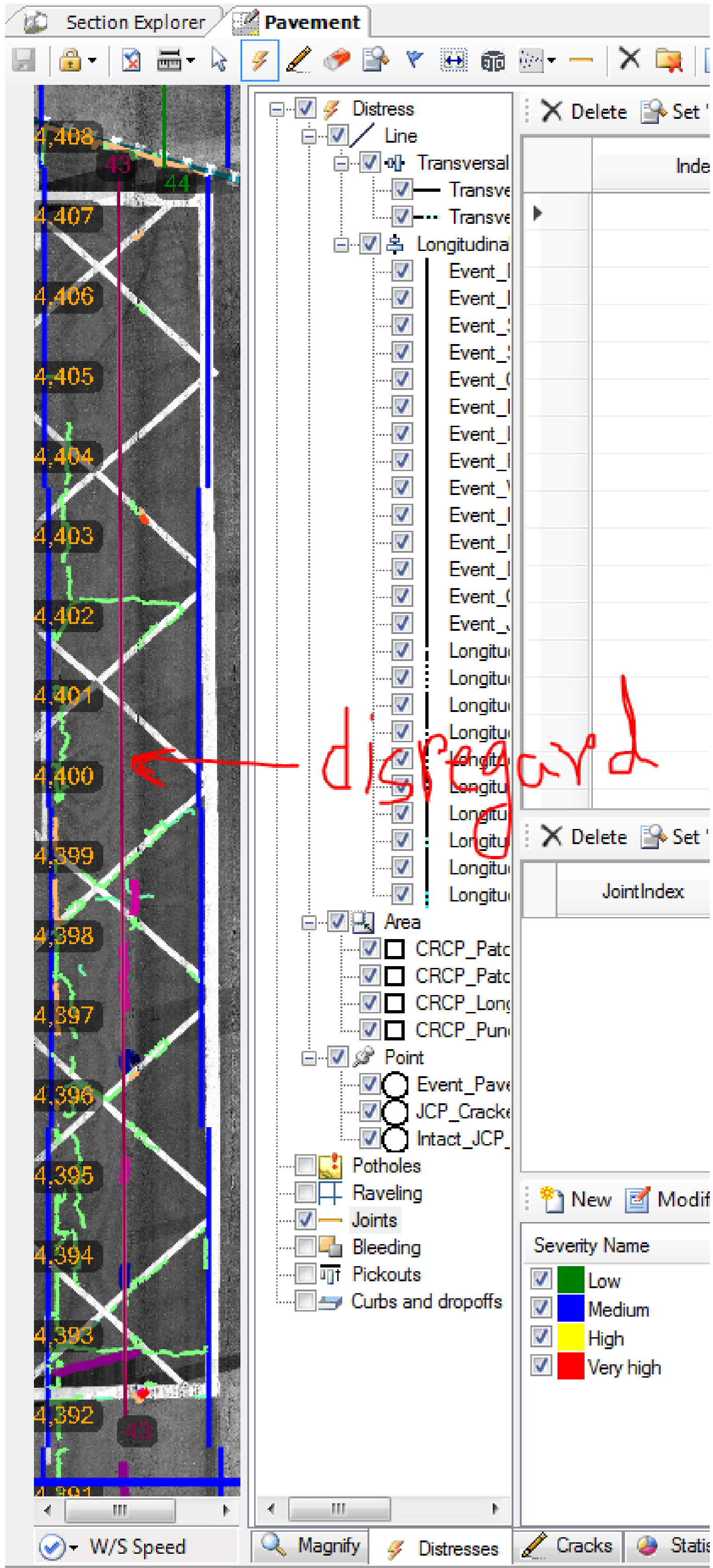
iii. Draw distress event lines for noted items, including bridges, railroads, crosswalks, stop bars, bad images, disregarded cracks, wet pavement, lane deviations, debris, brick pavement, crack seals, etc. Draw a point event for any pavement change. To draw a distress event, click on the "Distress" button and right-click at the start of the event, right-click where the event should end, and choose the event. Continue to end of pavement section (see below images).




File
View
Tools
Help
Connect
Segment
Rate
Process
Map
Images
Panoramic View
Charts
Tables
Report
Publish
Section Explorer
Pavement
Filter
Filter crack types
Frame
Chainage
Crack...
Sets (...
LaneWidt...
Offset...
Event_Disregard_Cracking
Event_Bad_Image
Event_Sealed_Cracking_Exists
Event_Stop_Bar
Stop_Bar
Event_Crosswalk
Event_Bridge
Event_Lane_Deviation
Event_Railroad
Event_Wet_Surface
Event_Brick_Pavement
Event_Milled_Pavement
Event_Debris
Event_CRCP_Exists
Event_JCP_Exists
Longitudinal Crack (LE)
Longitudinal Crack (LWP)
Longitudinal Crack (CTR)
Longitudinal Crack (RWP)
Longitudinal Crack (RE)
Longitudinal Sealed Crack (LE)


Section Explorer
Pavement
1,991
1,990
1,989
1,988
1,987
1,986
1,985
1,984
1,983
1,982
1,981
1,980
1,979
1,978
22
22
BAD IMAGE
Distress
Line
Transversal
Transverse Crack
Transverse Sealed Crack
Longitudinal
Event_Disregard_Cracking
Event_Bad_Image
Event_Sealed_Cracking_Exists
Event_Stop_Bar
Event_Crosswalk
Event_Bridge
Event_Lane_Deviation
Event_Railroad
Event_Wet_Surface
Event_Brick_Pavement
Event_Milled_Pavement
Event_Debris
Event_CRCP_Exists
Event_JCP_Exists
Longitudinal Crack (LE)
Longitudinal Crack (LWP)
Longitudinal Crack (CTR)
Longitudinal Crack (RWP)
Longitudinal Crack (RE)
Longitudinal Sealed Crack (LE)
Longitudinal Sealed Crack (LWP)
Longitudinal Sealed Crack (CTR)
Longitudinal Sealed Crack (RWP)
Longitudinal Sealed Crack (RE)
Area
CRCP_Patch_Concrete
CRCP_Patch_Asphalt
CRCP_Long
CRCP_Punchout
Point
Event_Pave_Change
JCP_Cracked_Slab
Intact_JCP_Slab
Potholes
Raveling
Joints
Bleeding
Pickouts
Curbs and dropoffs
W/S Speed 60
Magnify
Distresses
Cracks
Statistics


Section Explorer
Pavement
2,312
2,311
2,310
2,309
2,308
2,307
2,306
2,305
2,304
2,303
2,302
2,301
2,300
2,299
27
26
Distress
Line
Transversal
Longitudina
Area
Point
Potholes
Raveling
Joints
Bleeding
Pickouts
Curbs and dropoffs
Delete
Index
JointIndex
New
Modify
Severity Name
Low
Medium
High
Very high
W/S Speed 60
Magnify
Distresses
Cracks
Statistics
CROSSWALK
stop bar


Section Explorer
Pavement
Distress
Line
Transversal
Longitudina
Area
Point
Potholes
Raveling
Joints
Bleeding
Pickouts
Curbs and dropoffs
Delete
JointIndex
New
Severity Name
Low
Medium
High
Very high
W/S Speed
Magnify
Distresses
Cracks
disregard

2- Performing QA of Analyzed Images – *performed by Vision user*

Summary: This task checks the QC'ed pavement images through a visual inspection.

Step 13. Open Vision.

Step 14. Complete Step 2 through Step 12 for two random files for each drive through operator. Ensure that protocol has been followed. Correct any errors and resolve any issues before continuing.

Step 15. Report findings to supervisor.

3- Performing QA of Overall Process – *performed by Supervisor*

Summary: This task performs QA checks on the drive through process.

Step 16. Perform weekly data QA routines.

Step 17. TL review of QC staff notification of recollection and QA staff weekly data review.

Step 18. Review of production status – receive weekly update from QA staff (last ARAN collection date and lane miles fully processed).

5.08 RUNNING RUT PROCESSOR

5.08.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to run the Rut Processor in the Roadware Vision software using data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff. The Rut Processor is run in batches throughout the annual data collection season. This SOP applies to the processing of an ARAN data batch (or batches). The Rut Processor is run after completion of the ARAN data drive-through (see Performing 100% Drive Through). This process results in the generation of ARAN pavement transverse profile (rutting) data.

5.08.02 *Frequency*

The Rut Processor is run on batches of ARAN collected data as they are received by the DPT. The frequency and timing varies according to schedule, available resources, and quantity of data received. The batches are processed in a continuous flow throughout the data collection season.

Each ARAN data batch is typically delivered to the DPT every 4 to 5 days. Assuming an average of 60 miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data. The actual frequency varies according to the proximity of the routes on which data were collected for the data batch to the Office of Materials Technology (OMT) office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring data recollection. The annual ARAN data collection season typically lasts from March to Mid-December.

5.08.03 *Purpose*

The purpose of this SOP is to run the Rut Processor for collected ARAN data and perform quality control (QC) and quality assurance (QA) checks.

5.08.04 *Resource Requirements*

The running of the Rut Processor involves two people: (1) a user knowledgeable in Roadware Vision software to run the processors and perform QC, and (2) a supervisor who, as required, provides guidance and decision-making and performs QA. The estimated effort levels in the table below represent the total time, in man-hours, to complete the processing and QC/QA checks. These time estimates assume average batch quantities and no issues encountered during processing.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision user and QC	1	3.0
DPT TL	Supervisor and QA	1	AR[06/12/2019]

5.08.05 *Procedure*

The procedure to run the Rut Processor and perform QC/QA is comprised of the following three tasks:

(1) running Rut Processor in Vision,

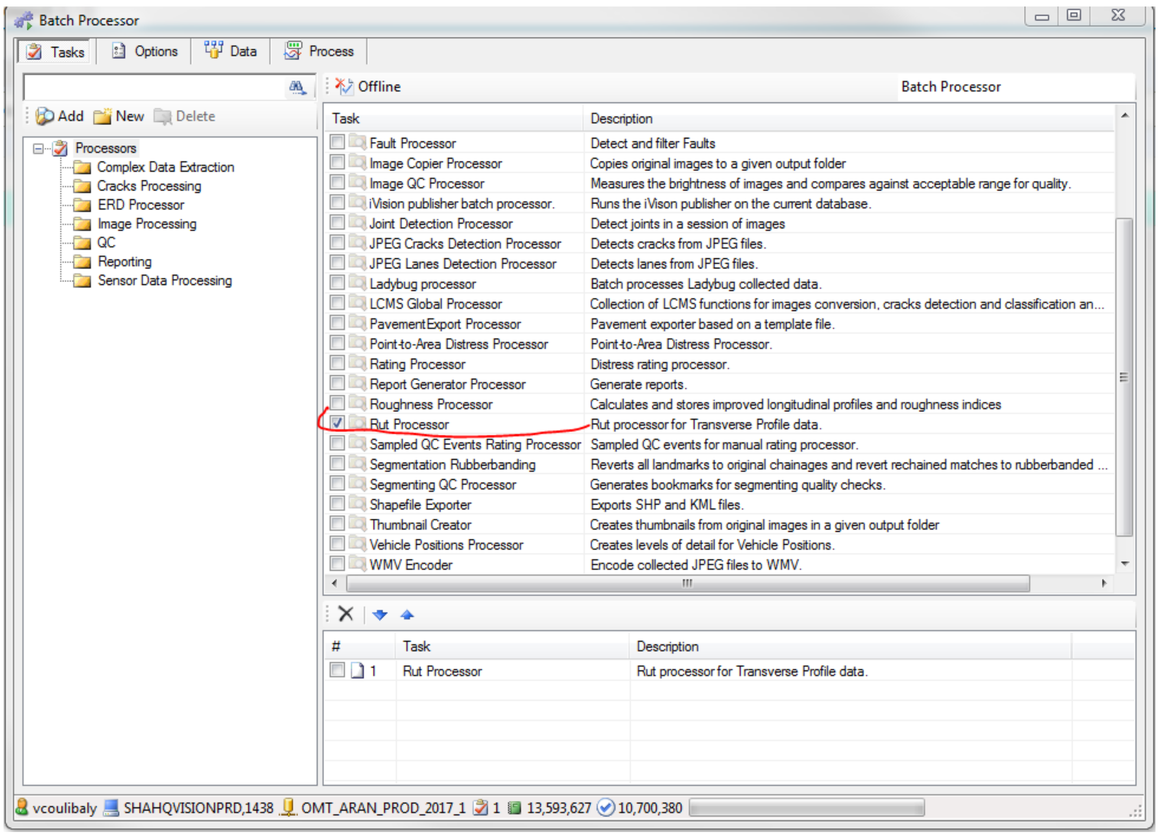
(2) performing QC of the processed rut data, and
(3) performing QA of the processed rut data

1- Running Rut Processor in Vision – *performed by Vision user*

Summary: This task uses Vision software to process rut data from the ARAN data submittal.

Step 1. Open Vision.

Step 2. Click the "Process" drop-down menu. Select "New Batch Processor." The "Batch Processor" window will open (see below image).



Step 3. Click the box next to "Rut Processor" in the window on the right.

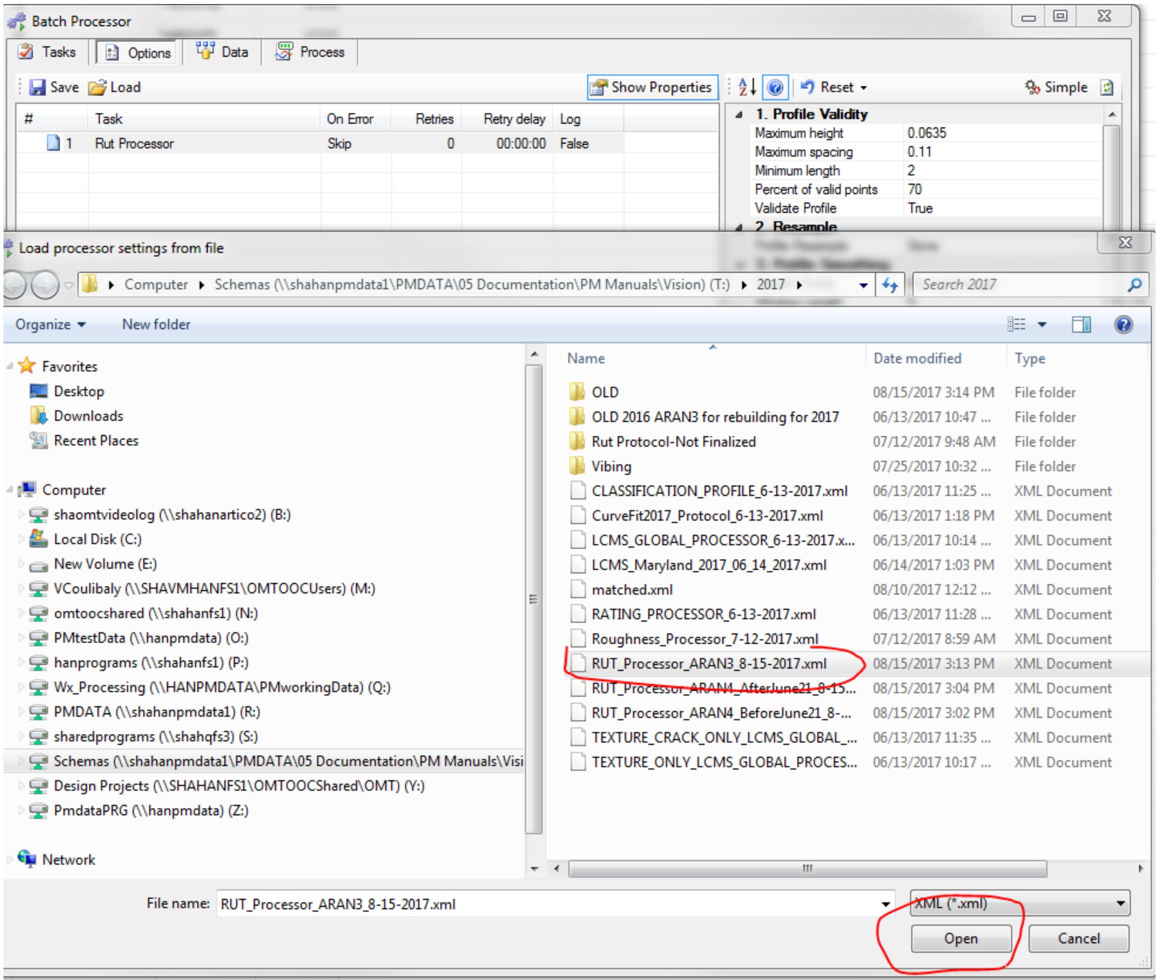
Step 4. Click the "Options" tab. Instead of changing settings manually, search for preset schemas. Click the "Load" button. Navigate to the folder where schema files are stored[06/12/2019]. In this folder, look for the one of three rut XML files for the ARAN data to be processed (see below image).

i. "RUT_Processor_ARAN3_[MOST RECENTDATE]" for all ARAN 3 data.

ii. "RUT_Processor_ARAN4_AfterJune21_[MOST RECENTDATE]" for all ARAN 4 data collected after June 21, 2017.

iii. "RUT_Processor_ARAN4_BeforeJune21_[MOST RECENTDATE]" for all ARAN 4 data collected before June 21, 2017.

Select the XML file for the ARAN 3 and click "Open."

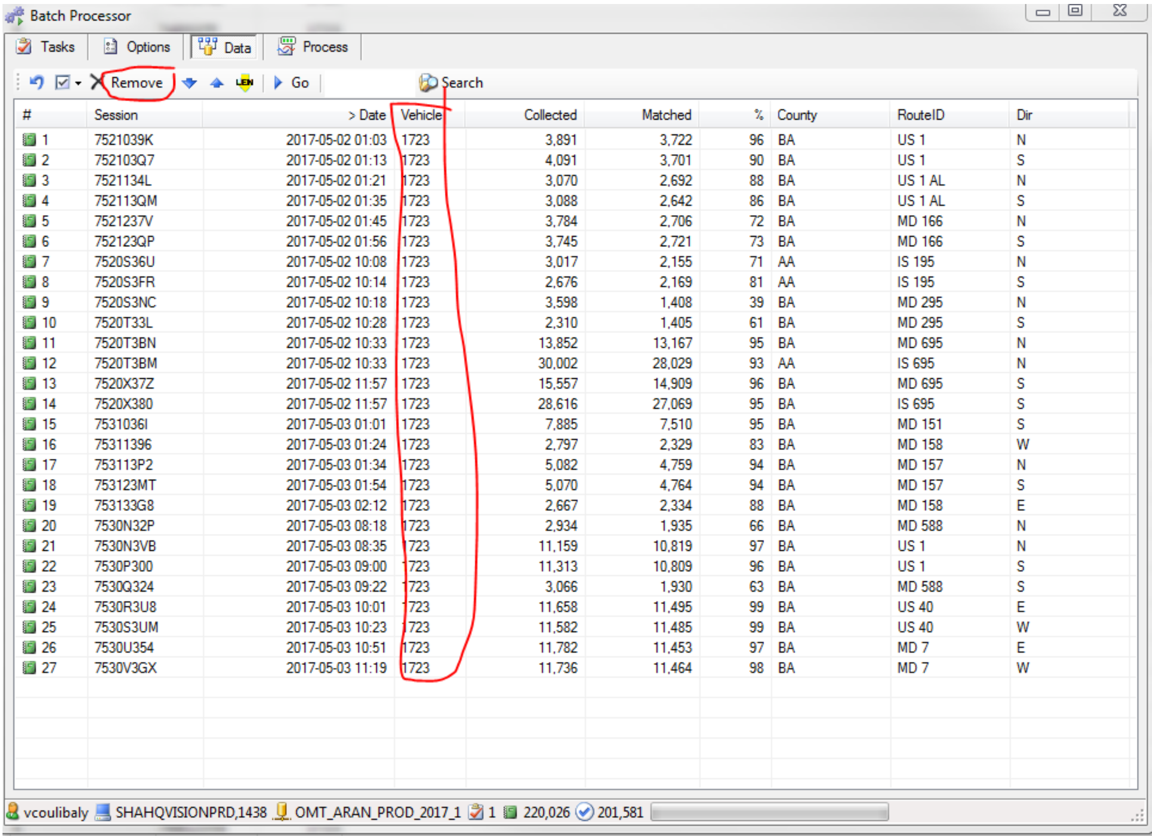


Step 5. Click "Data" from the top menu bar. Every file in the database will appear in the window. The list must be filtered to only include the sections from the current batch and appropriate ARAN vehicle. Under the "Vehicle" column, "1723" is for the ARAN 3 and "1724" is for the ARAN 4. Filtering the list can be accomplished through two different methods:

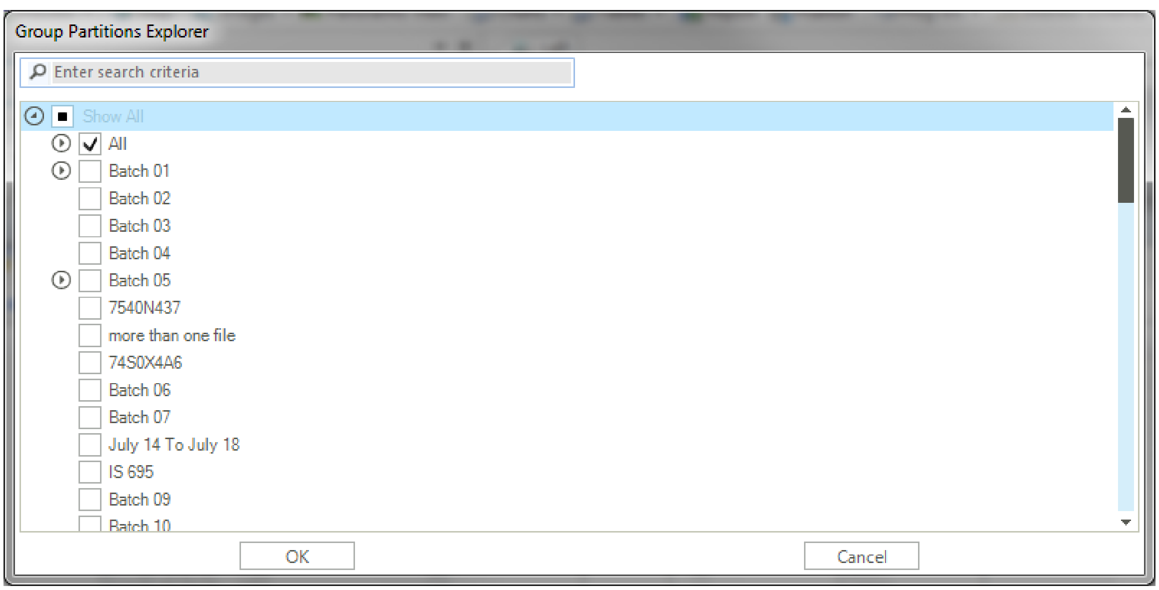
i. Removing unwanted files, or

ii. Removing all files and selecting a batch to re-add.

Step 6. Choose removal method. If removing all files and selecting a batch to re-add is preferred, skip to Step 7. Otherwise, use a combination of the Shift and Ctrl keys to highlight all unwanted files in the window. Click "Remove." Proceed to Step 8 (see below image).

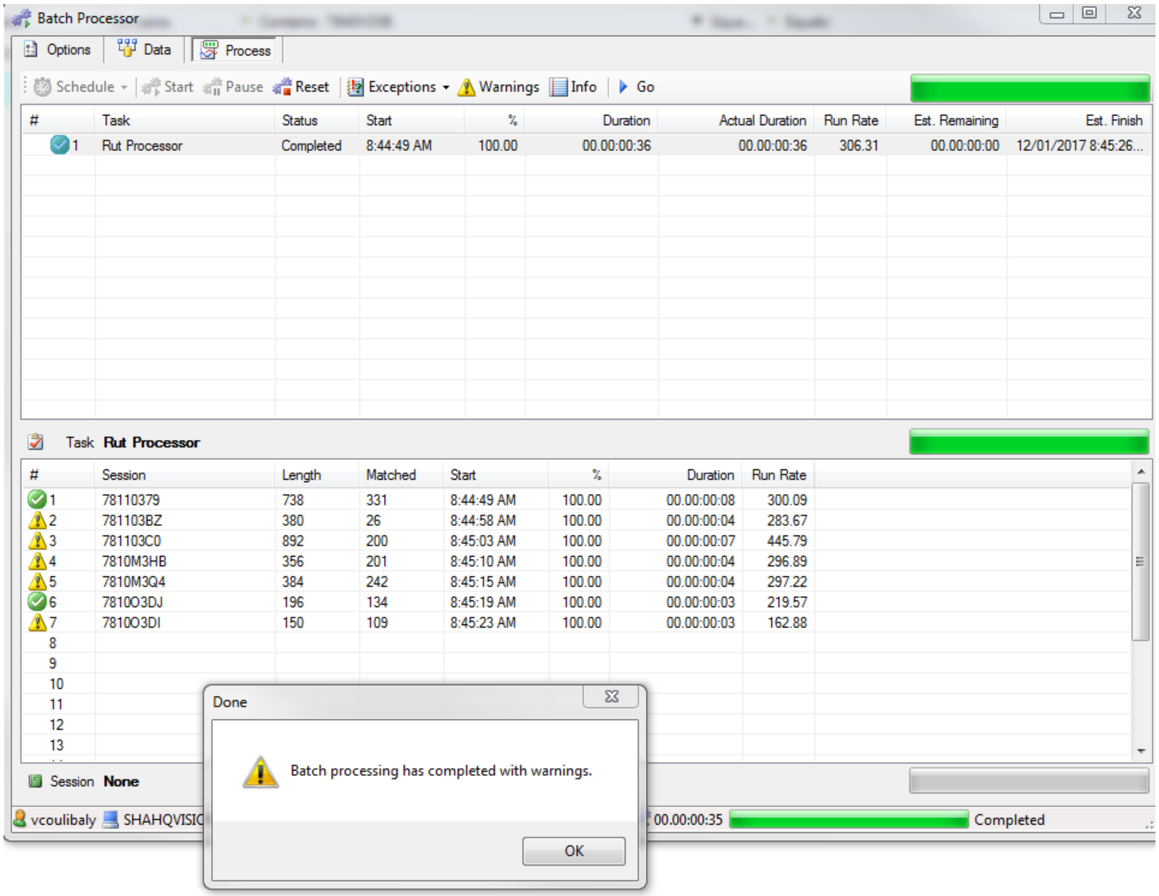


Step 7. To remove all files, click the “Check” drop-down menu and select “All.” Click “Remove.” Then, click the “Reload” (first blue arrow) button. The “Group Partitions” window will open (see below image).



Select the current batch by clicking the checkbox next to the appropriate batch name. Click the “OK.”

Step 8. Once only the desired files appear in the "Batch Processor" window, they may be processed. Click "Process", then "Start." The files will begin to appear under the session window (see below image).



2- **Performing QC of Processed Rut Data** – *performed by Vision user*

Summary: This task checks the quality of processed rut data through an inspection of errors reported by Vision during processing and a visual inspection of the rut depth graph.

Step 9. A dialogue box will appear when processing is complete.

i. If the box says "Batch processing has completed", proceed to Step 11.

ii. If the box says "Batch processing has completed with errors", proceed to Step 10.

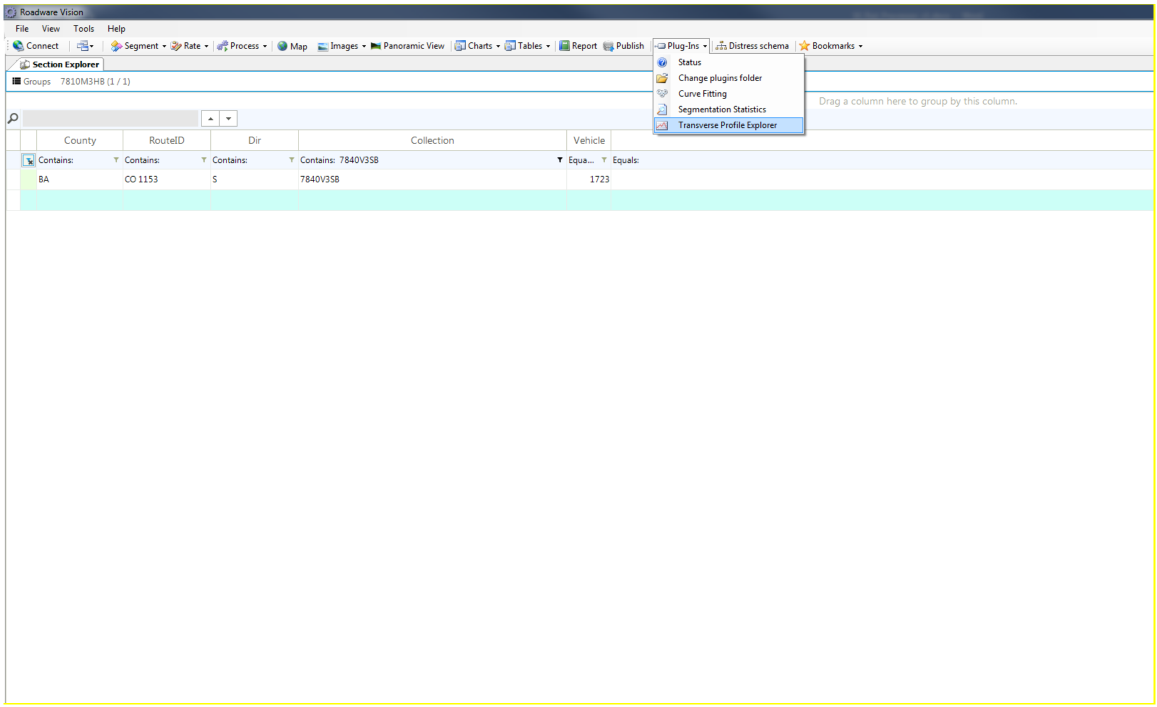
Step 10. View the errors. Click the "*Exceptions*" drop-down menu and select "*View Exceptions*."

i. If the error is "Missing Images", this is acceptable. Proceed to Step 11.

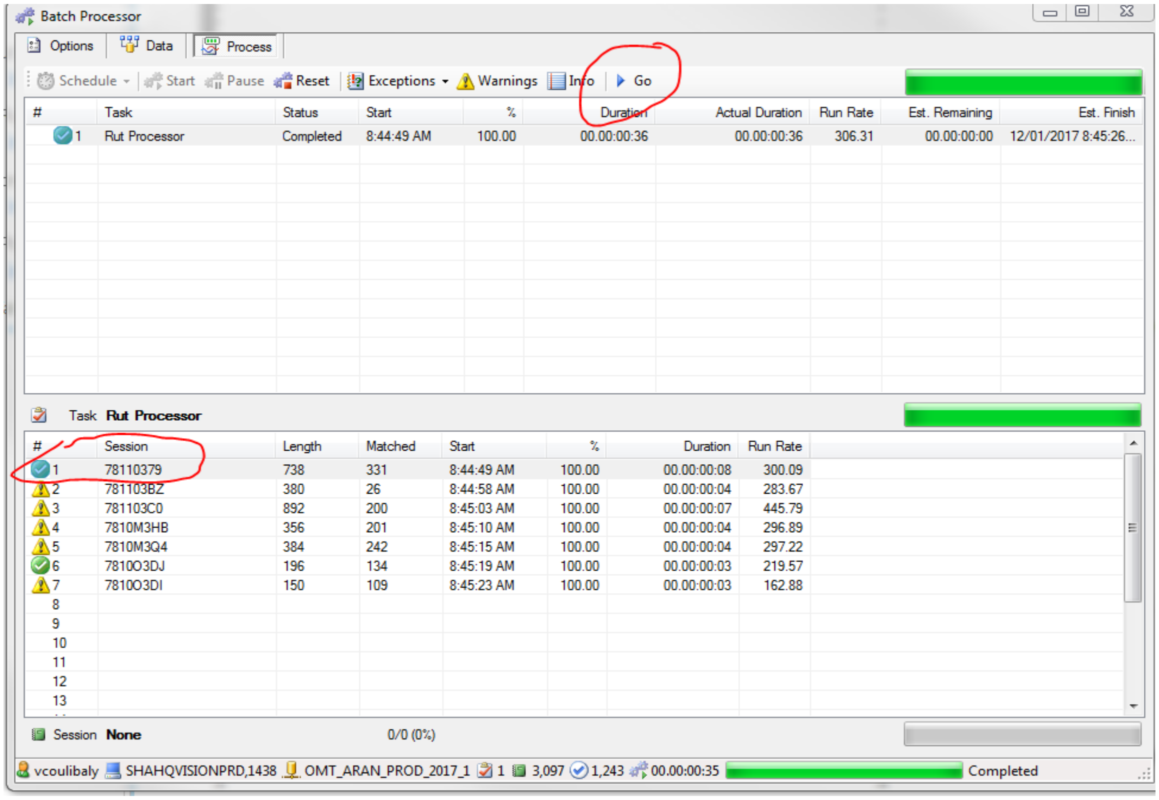
ii. If any other errors are present, reprocessing is required. Click the "Exceptions" drop-down menu and select "Reprocess Exceptions." This will remove all the files from the data screen except for the files that had exceptions. Next, click the "Start" button to reprocess.

Step 11. Check the "Batch Processor" window for runs that did not process. The software occasionally skips runs. In the window showing processed results, check the "Run Rate" column. Any runs that have blanks in this column will need to be reprocessed. Select those runs, removing runs already processed, and change the output location to a new temporary folder. Click "Reset."

Step 12. Click on "Plug-Ins" tab and select "Transverse Profile Explorer" tab (see below image)



Select a session and click on the "Go" button to open the profile of the run (see below image).



The transverse profile and the Rut Depth should be showing a graph similar to the graph below (see below image).

i. If either the “Transverse Profile” or “Rut Depth” graph is blank, the processor will need to be run again by returning to Step 2.

ii. Otherwise, proceed to Step 13.

Step 13. Return to Step 2 and repeat the process for both types of ARAN 4 data, selecting the appropriate XML file each time[06/12/2019].

3- Performing QA of Processed Rut Data – *performed by Supervisor*

Summary: This task performs QA checks on the processed rut data.

Step 14. TL review of QC staff notification of recollection.

Step 15. Review of production status – receive weekly update from QC staff (last ARAN collection data fully processed).

5.09 RUNNING CLASSIFICATION AND RATING PROCESSORS

5.09.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to run the Classification and Rating Processors in the Roadware Vision software using data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff. The Classification and Rating Processors are run in batches throughout the annual data collection season. This SOP applies to the processing of an ARAN data batch (or batches). The Classification and Rating Processors are run after completion of the ARAN data drive-through (see Performing 100% Drive Through). This process results in the generation of ARAN cracking data.

5.09.02 *Frequency*

The Classification and Rating Processors are run on batches of ARAN collected data as they are received by the DPT. The frequency and timing varies according to schedule, available resources, and quantity of data received. The batches are processed in a continuous flow throughout the data collection season.

Each ARAN data batch is typically delivered to the DPT every 4 to 5 days. Assuming an average of 60 miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data. The actual frequency varies according to the proximity of the routes on which data were collected for the data batch to the Office of Materials Technology (OMT) office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring data recollection. The annual ARAN data collection season typically lasts from March to Mid-December.

5.09.03 *Purpose*

The purpose of this SOP is to run the Classification and Rating Processors for collected ARAN data and perform quality control (QC) and quality assurance (QA) checks.

5.09.04 *Resource Requirements*

The running of the Classification and Rating Processors involves two people: (1) a user knowledgeable in Roadware Vision software to run the processors and perform QC, and (2) a supervisor who, as required, provides guidance and decision-making and performs QA. The estimated effort levels in the table below represent the total time, in man-hours, to complete the processing and QC/QA checks. These time estimates assume average batch quantities and no issues encountered during processing.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision user and QC	1	3.0
DPT TL	Supervisor and QA	1	AR[06/12/2019]

5.09.05 *Procedure*

The procedure to run the Classification and Rating Processors and perform QC/QA is comprised of the following three tasks:

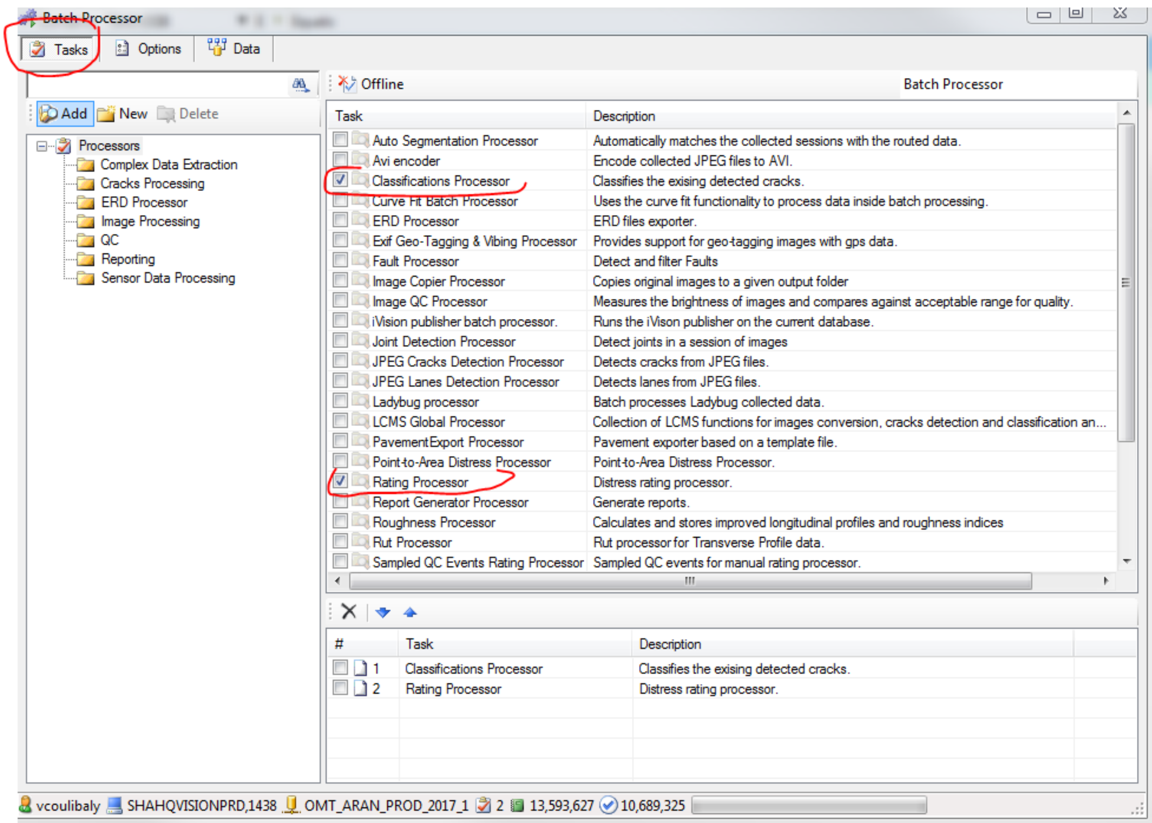
(1) running Classification and Rating Processors in Vision,
(2) performing QC of the processed data, and
(3) performing QA of the processed data.

1- Running Classification & Rating Processors in Vision – *performed by Vision User*

Summary: This task uses Vision software to process cracking data from the ARAN data submittal.

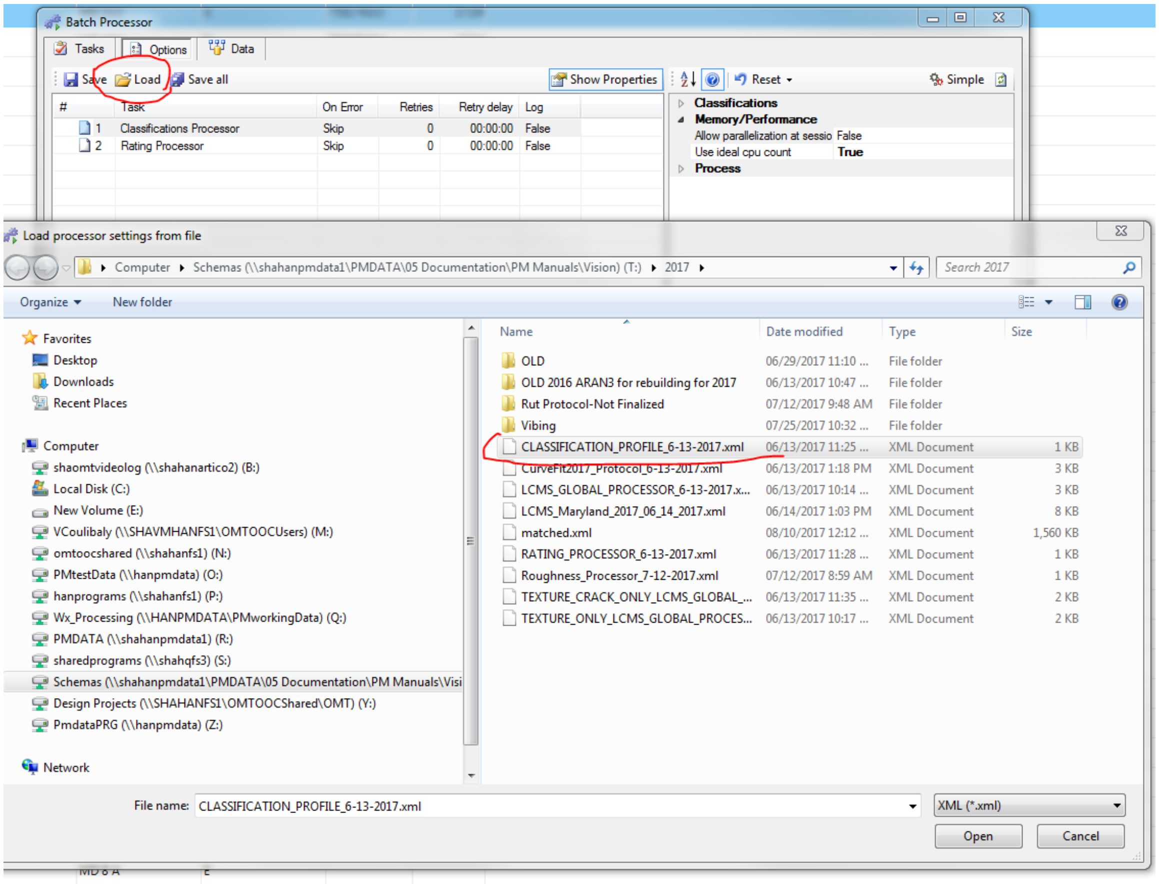
Step 1. Open Vision.

Step 2. Click the "Process" drop-down menu. Select "New Batch Processor." The "Batch Processor" window will open (see below image).

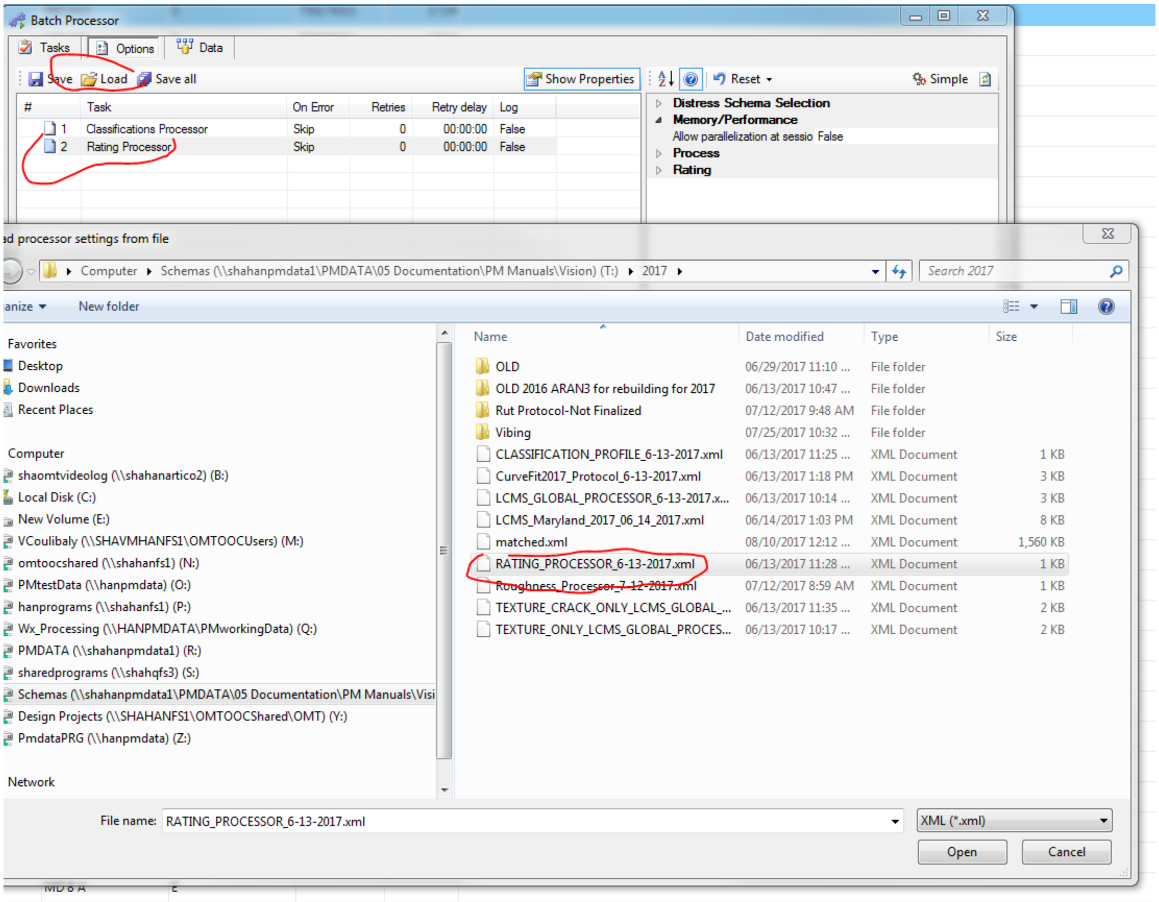


Step 3. Click the box next to "Classification Processor" and "Rating Processor" in the window on the right.

Step 4. Click the "Options" tab with the "Classification Processor" highlighted. Instead of changing settings manually, search for preset schemas. Click the "Load" button. Navigate to the folder where schema files are stored[06/12/2019]. In this folder, look for an XML file named "CLASSIFICATION_PROFILE_[MOST RECENTDATE]." Select the file and click "Open" (see below image).



Step 5. Click the "Options" tab with the "Rating Processor" highlighted. Instead of changing settings manually, search for preset schemas. Click the "Load" button. Navigate to the folder where schema files are stored[06/12/2019]. In this folder, look for an XML file named "RATING_PROCESSOR_[MOST RECENTDATE]." Select the file and click "Open" (see below image).

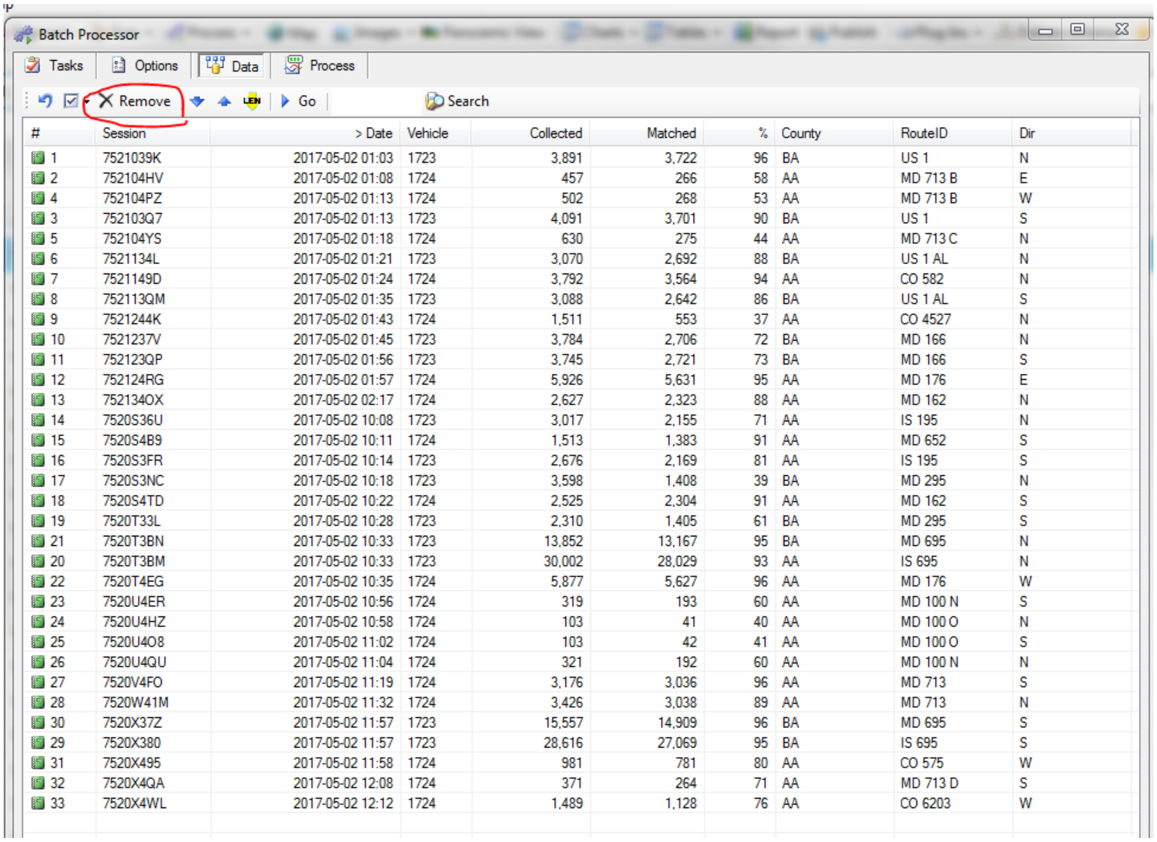


Step 6. Click “Data” from the top menu bar. Every file in the database will appear in the window. The list must be filtered to only include the sections from the current batch. This can be accomplished through two different methods:

i. Removing unwanted files, or

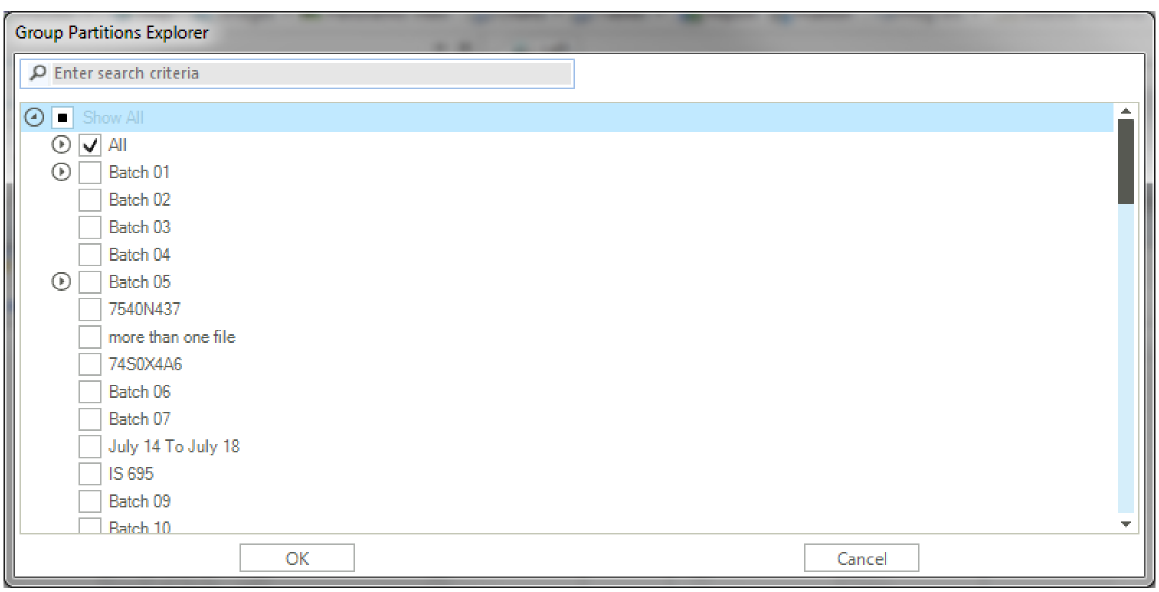
ii. Removing all files and selecting a batch to re-add.

Step 7. Choose removal method. If removing all files and selecting a batch to re-add is preferred, skip to Step 7. Otherwise, use a combination of the Shift and Ctrl keys to highlight all unwanted files in the window. Click “Remove.” Proceed to Step 8 (see below image).



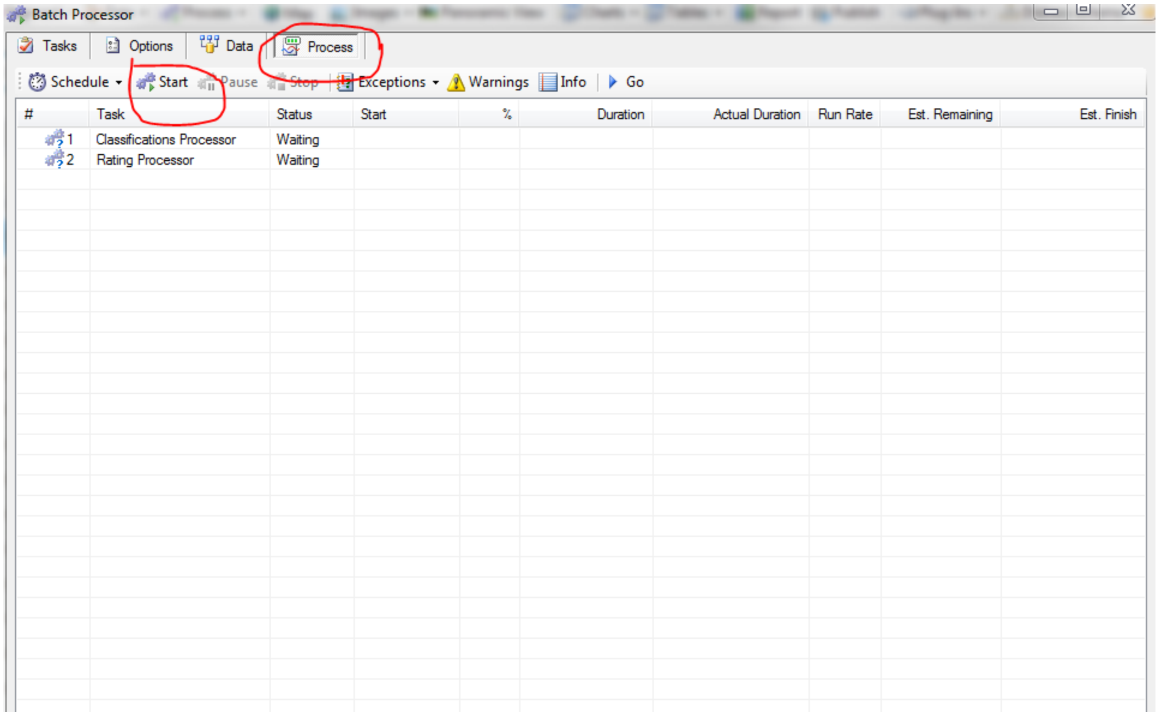
#	Session	> Date	Vehicle	Collected	Matched	%	County	RouteID	Dir
1	7521039K	2017-05-02 01:03	1723	3,891	3,722	96	BA	US 1	N
2	752104HV	2017-05-02 01:08	1724	457	266	58	AA	MD 713 B	E
4	752104PZ	2017-05-02 01:13	1724	502	268	53	AA	MD 713 B	W
3	752103Q7	2017-05-02 01:13	1723	4,091	3,701	90	BA	US 1	S
5	752104YS	2017-05-02 01:18	1724	630	275	44	AA	MD 713 C	N
6	7521134L	2017-05-02 01:21	1723	3,070	2,692	88	BA	US 1 AL	N
7	7521149D	2017-05-02 01:24	1724	3,792	3,564	94	AA	CO 582	N
8	752113QM	2017-05-02 01:35	1723	3,088	2,642	86	BA	US 1 AL	S
9	7521244K	2017-05-02 01:43	1724	1,511	553	37	AA	CO 4527	N
10	7521237V	2017-05-02 01:45	1723	3,784	2,706	72	BA	MD 166	N
11	752123QP	2017-05-02 01:56	1723	3,745	2,721	73	BA	MD 166	S
12	752124RG	2017-05-02 01:57	1724	5,926	5,631	95	AA	MD 176	E
13	752134OX	2017-05-02 02:17	1724	2,627	2,323	88	AA	MD 162	N
14	7520S36U	2017-05-02 10:08	1723	3,017	2,155	71	AA	IS 195	N
15	7520S4B9	2017-05-02 10:11	1724	1,513	1,383	91	AA	MD 652	S
16	7520S3FR	2017-05-02 10:14	1723	2,676	2,169	81	AA	IS 195	S
17	7520S3NC	2017-05-02 10:18	1723	3,598	1,408	39	BA	MD 295	N
18	7520S4TD	2017-05-02 10:22	1724	2,525	2,304	91	AA	MD 162	S
19	7520T33L	2017-05-02 10:28	1723	2,310	1,405	61	BA	MD 295	S
21	7520T3BN	2017-05-02 10:33	1723	13,852	13,167	95	BA	MD 695	N
20	7520T3BM	2017-05-02 10:33	1723	30,002	28,029	93	AA	IS 695	N
22	7520T4EG	2017-05-02 10:35	1724	5,877	5,627	96	AA	MD 176	W
23	7520U4ER	2017-05-02 10:56	1724	319	193	60	AA	MD 100 N	S
24	7520U4HZ	2017-05-02 10:58	1724	103	41	40	AA	MD 100 O	N
25	7520U4O8	2017-05-02 11:02	1724	103	42	41	AA	MD 100 O	S
26	7520U4QU	2017-05-02 11:04	1724	321	192	60	AA	MD 100 N	N
27	7520V4FO	2017-05-02 11:19	1724	3,176	3,036	96	AA	MD 713	S
28	7520W41M	2017-05-02 11:32	1724	3,426	3,038	89	AA	MD 713	N
30	7520X37Z	2017-05-02 11:57	1723	15,557	14,909	96	BA	MD 695	S
29	7520X380	2017-05-02 11:57	1723	28,616	27,069	95	BA	IS 695	S
31	7520X495	2017-05-02 11:58	1724	981	781	80	AA	CO 575	W
32	7520X4QA	2017-05-02 12:08	1724	371	264	71	AA	MD 713 D	S
33	7520X4WL	2017-05-02 12:12	1724	1,489	1,128	76	AA	CO 6203	W

Step 8. To remove all files, click the “Check” drop-down menu and select “All.” Click “Remove.” Then, click the “Reload” (first blue arrow) button. The “Group Partitions” window will open (see below image).



Select the current batch by clicking the checkbox next to the appropriate batch name. Click the “OK.”

Step 9. Once only the desired files appear in the "Batch Processor" window, they may be processed. Click "Process", then "Start." The files will begin to appear under the session window (see below image).



2- Performing QC of Processed Data – *performed by Vision user*

Summary: This task checks the quality of processed cracking data through an inspection of errors reported by Vision during processing.

Step 10. A dialogue box will appear when processing is complete.

i. If the box says "Batch processing has completed", proceed to Step 12.

ii. If the box says "Batch processing has completed with errors", proceed to Step 10.

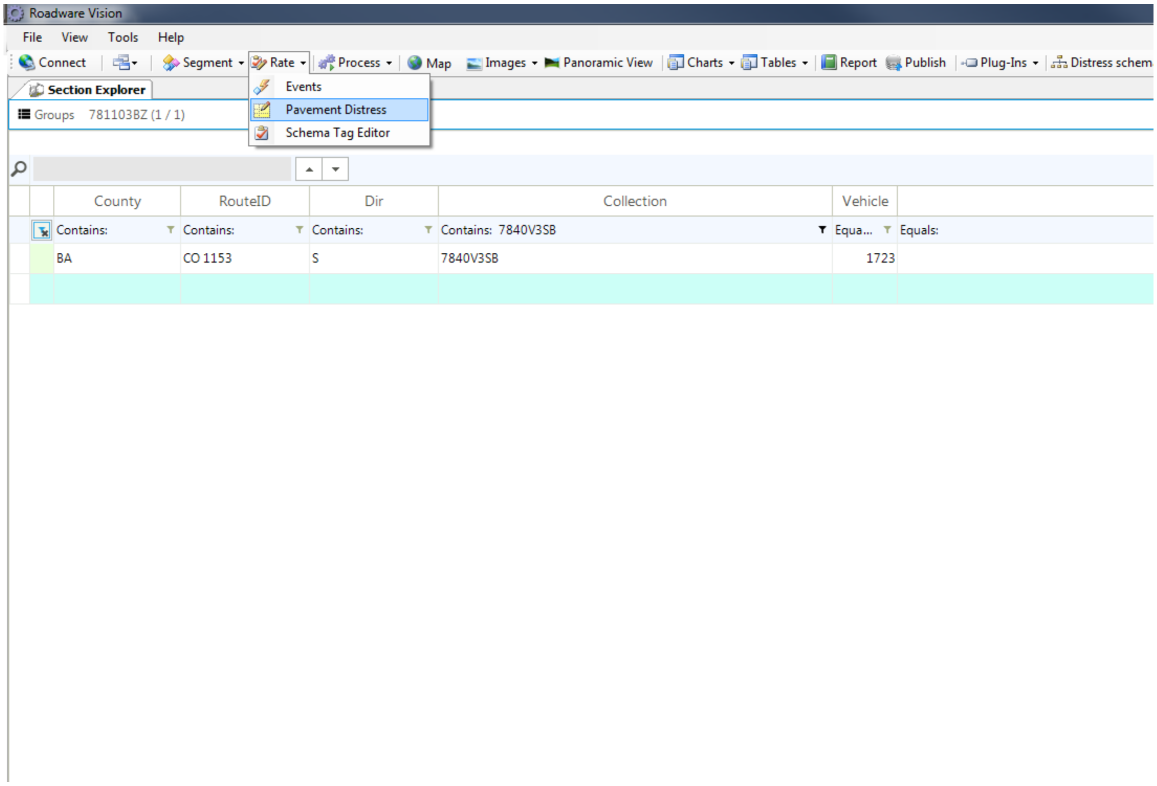
Step 11. View the errors. Click the "Exceptions" drop-down menu and select "View Exceptions."

i. If the error is "Missing Images", this is acceptable. Proceed to Step 12.

ii. If any other errors are present, reprocessing is required. Click the "Exceptions" drop-down menu and select "Reprocess Exceptions." This will remove all the files from the data screen except for the files that had exceptions. Next, click the "Start" button to reprocess.

Step 12. Check the "Batch Processor" window for runs that did not process. The software occasionally skips runs. In the window showing processed results, check the "Run Rate" column. Any runs that have blanks in this column will need to be reprocessed. Select those runs, removing runs already processed, and change the output location to a new temporary folder. Click "Reset."

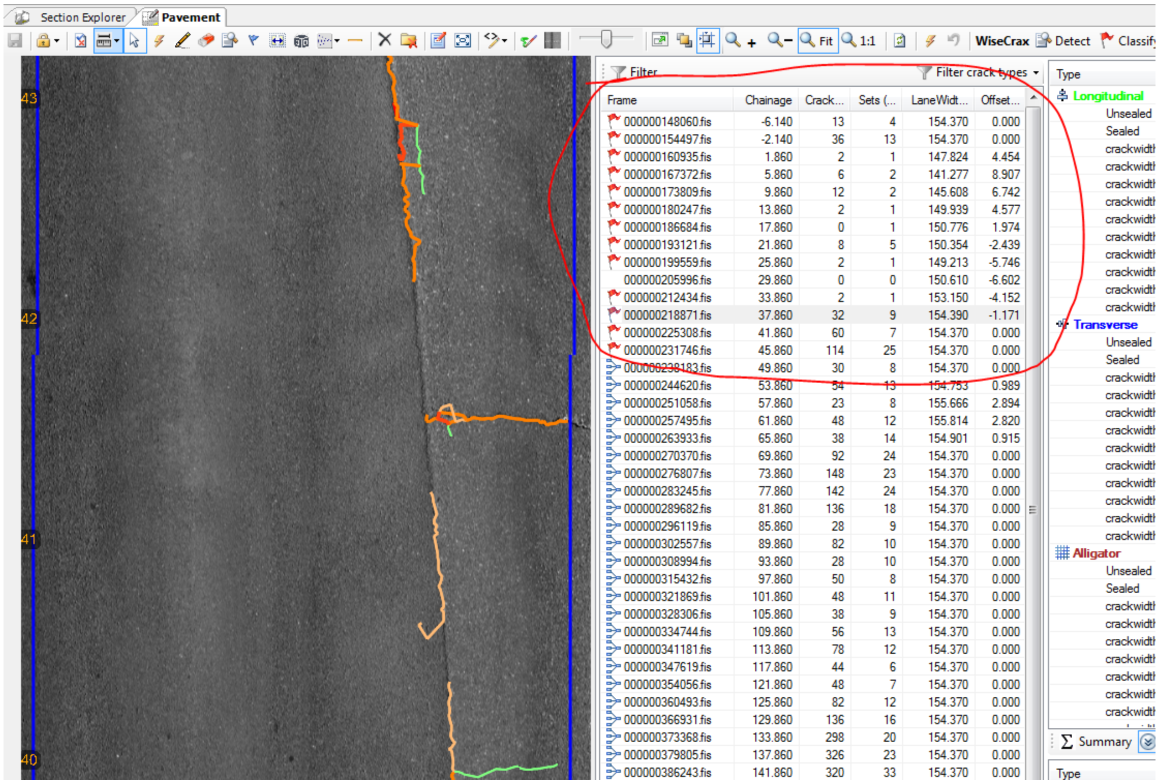
Step 13. Click on the "Rate" tab and select "Pavement Distress" from the drop-down menu (see below image).



The downward image list will open in the "Pavement" tab. Make sure that all the frames have been classified and rated by observing that the rating sign is in front of all frames. There should also be boxes around all the cracks.

i. If all rows have the rating sign and the cracks have boxes around them, proceed to Step 11.

ii. If there are red flags or blank spaces where the rating sign should be, or if there are cracks not surrounded by boxes, those files will need to be re-classified and rated (see below image). Return to Step 2.



3- Performing QA of Processed Rut Data – *performed by Supervisor*

Summary: This task performs QA checks on the processed data.

Step 14. TL review of QC staff notification of recollection.

Step 15. Review of production status – receive weekly update from QC staff (last ARAN collection data fully processed).

5.10 RUNNING VIBING PROCESSOR

5.10.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to perform vibing routines in the Roadware Vision software using data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff. Vibing is the process of adding a status bar and logo to the "Left" and "ROW" images collected with the ARAN van.

The Vibing Processor is run in batches throughout the annual data collection season. The actual name of the processor in Vision is "Exif Geo-Tagging and Vibing Processor," but is commonly referred to as "vibing." This SOP applies to the processing of an ARAN data batch (or batches). The Vibing Processor is run after running the Classification and Rating Processors (see Running Classification and Rating Processors). This process results in the generation of a status bar at the top of the "Left" and "ROW" images and adds latitude/longitude data to the image properties.

5.10.02 *Frequency*

The Vibing Processor is run on batches of ARAN collected data as they are received by the DPT. Vibing can be performed on the same data multiple times. If changes in route mileage occur, the vibing processor will need to be rerun. Performing the rerun on the entire data set will not harm the data output. The frequency and timing varies according to schedule, available resources, and quantity of data received. The batches are processed in a continuous flow throughout the data collection season.

Each ARAN data batch is typically delivered to the DPT every 4 to 5 days. Assuming an average of 60 miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data. The actual frequency varies according to the proximity of the routes on which data were collected for the data batch to the Office of Materials Technology (OMT) office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring data recollection. The annual ARAN data collection season typically lasts from March to Mid-December.

5.10.03 *Purpose*

The purpose of this SOP is to run the Vibing Processor for collected ARAN data and perform quality control (QC) and quality assurance (QA) checks.

5.10.04 *Resource Requirements*

The running of the Vibing Processor involves two people: (1) a user knowledgeable in Roadware Vision software to run the processor and perform QC, and (2) a supervisor who, as required, provides guidance and decision-making and performs QA. The estimated effort levels in the table below represent the total time, in man-hours, to complete the processing and QC/QA checks. These time estimates assume average batch quantities and no issues encountered during processing.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision user and QC	1	40.0
DPT TL	Supervisor and QA	1	AR[06/12/2019]

5.10.05 *Procedure*

The procedure to run the Vibing Processor and perform QC/QA is comprised of the following five tasks:

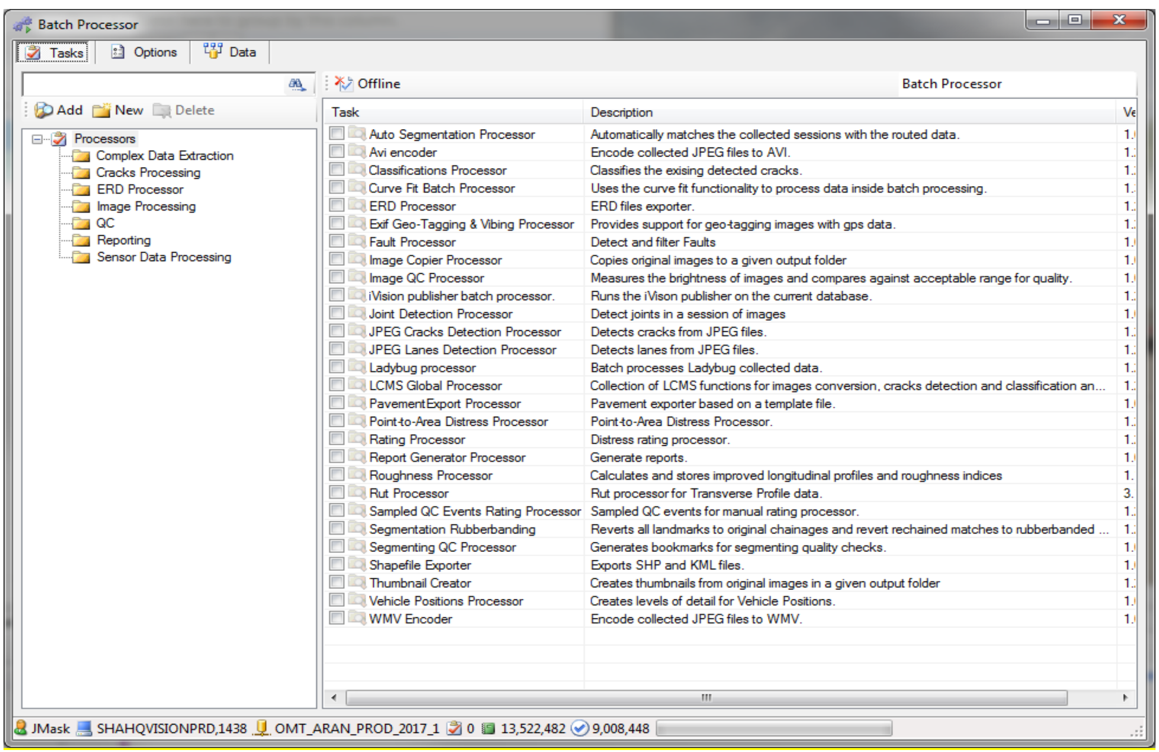
(1) running the Vibing Processor in Vision for "Left" images,
(2) performing QC of processed "Left" images,
(3) running the Vibing Processor in Vision for "ROW" images,
(4) performing QC of processed "ROW" images, and
(5) performing QA of the processed data.

1- Running Vibing Processor for "Left" Images – *performed by Vision user*

Summary: This task uses Vision software to generate a banner and logo on the "Left" image files from the ARAN data submittal. This task also adds latitude/longitude data to the "Left" image properties.

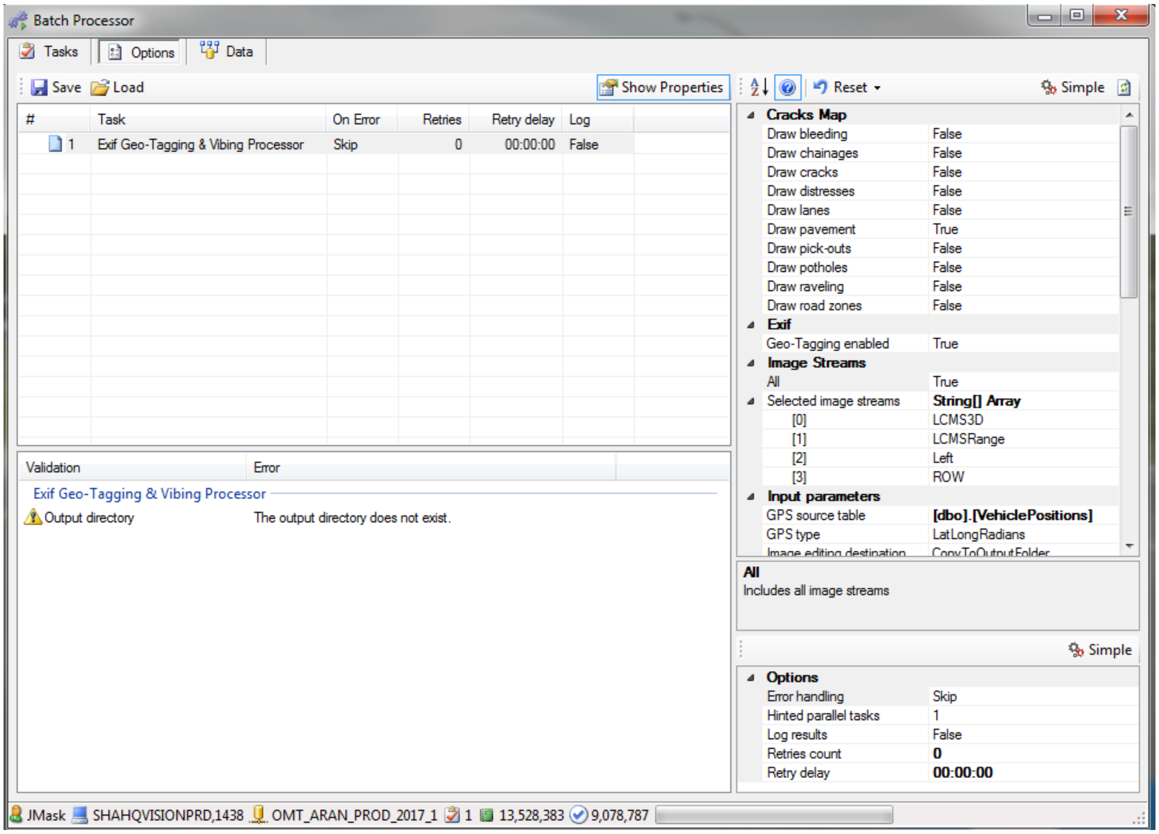
Step 1. Open Vision.

Step 2. Click the "Process" drop-down menu. Select "New Batch Processor." The "Batch Processor" window will open (see below image).



Step 3. Click the box next to "Exif Geo-Tagging and Vibing Processor" in the window on the right.

Step 4. Click the "Options" tab[06/12/2019]. Instead of changing settings manually, search for preset schemas. Click the "Load" button. Navigate to the folder where schema files are stored[06/12/2019]. In this folder, look for an XML file named "Left." Select the file and click "Open" (see below image).

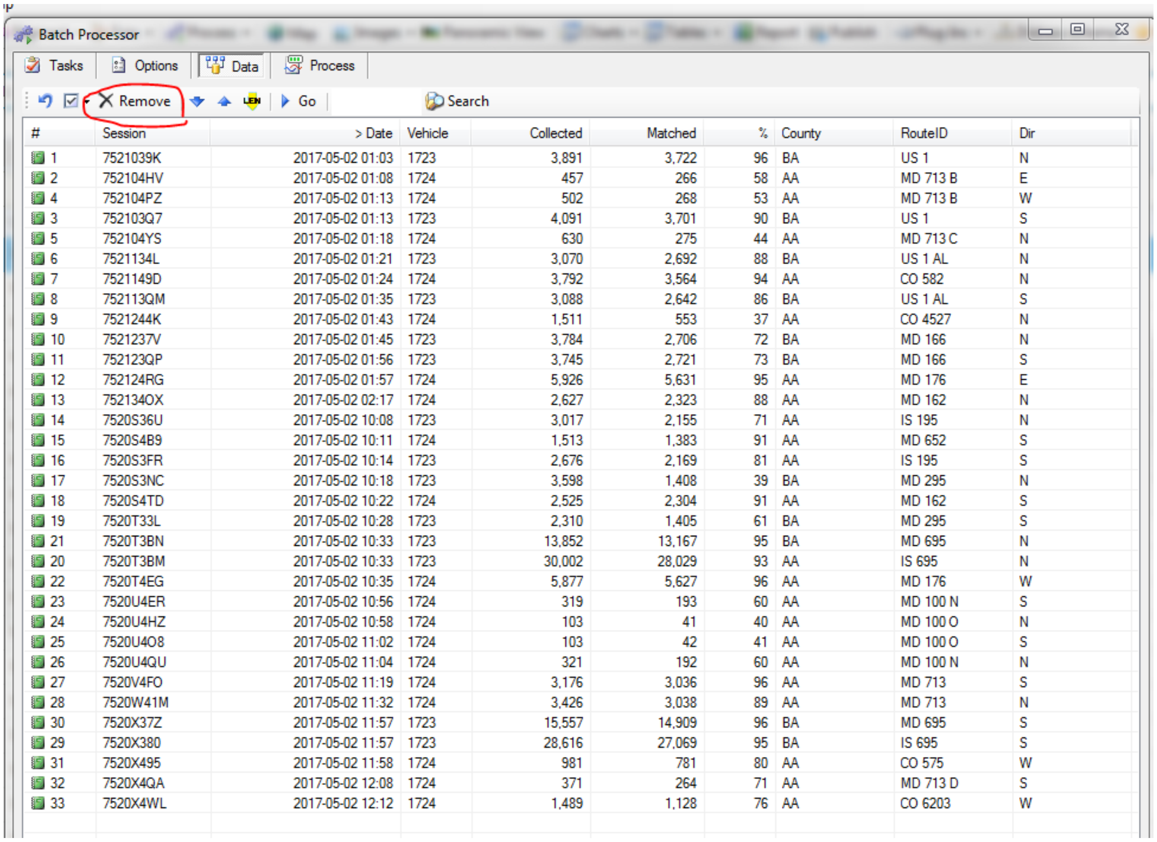


Step 5. Click "Data" from the top menu bar. Every file in the database will appear in the window. The list must be filtered to only include the sections from the current batch. This can be accomplished through two different methods:

i. Removing unwanted files, or

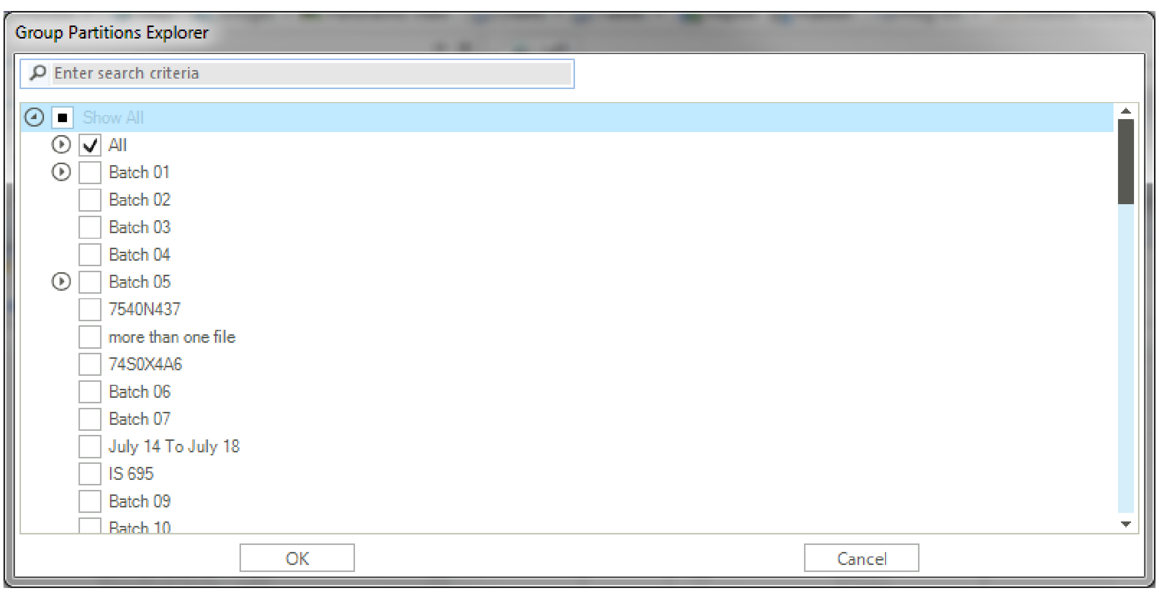
ii. Removing all files and selecting a batch to re-add.

Step 6. Choose removal method. If removing all files and selecting a batch to re-add is preferred, skip to Step 7. Otherwise, use a combination of the Shift and Ctrl keys to highlight all unwanted files in the window. Click "Remove." Proceed to Step 8 (see below image).



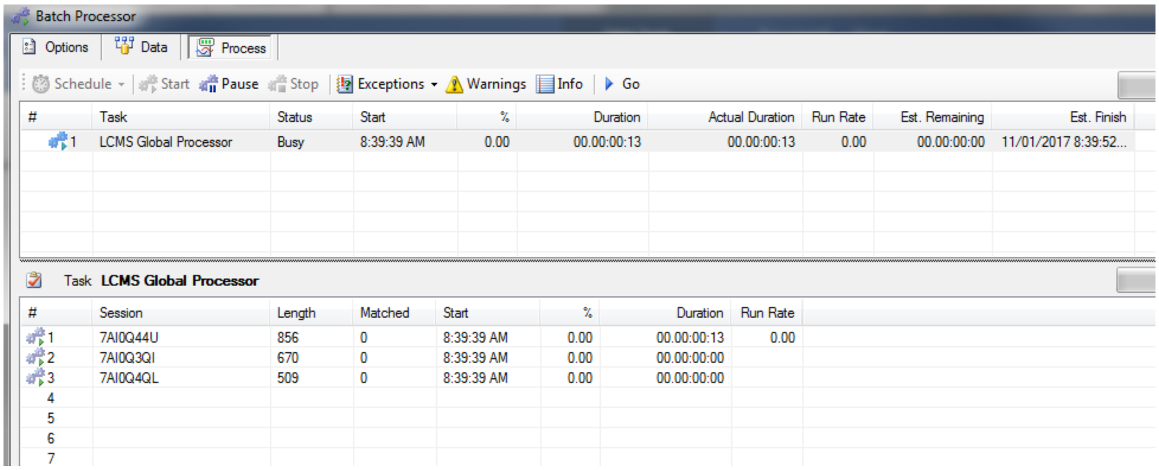
#	Session	> Date	Vehicle	Collected	Matched	%	County	RouteID	Dir
1	7521039K	2017-05-02 01:03	1723	3,891	3,722	96	BA	US 1	N
2	752104HV	2017-05-02 01:08	1724	457	266	58	AA	MD 713 B	E
4	752104PZ	2017-05-02 01:13	1724	502	268	53	AA	MD 713 B	W
3	752103Q7	2017-05-02 01:13	1723	4,091	3,701	90	BA	US 1	S
5	752104YS	2017-05-02 01:18	1724	630	275	44	AA	MD 713 C	N
6	7521134L	2017-05-02 01:21	1723	3,070	2,692	88	BA	US 1 AL	N
7	7521149D	2017-05-02 01:24	1724	3,792	3,564	94	AA	CO 582	N
8	752113QM	2017-05-02 01:35	1723	3,088	2,642	86	BA	US 1 AL	S
9	7521244K	2017-05-02 01:43	1724	1,511	553	37	AA	CO 4527	N
10	7521237V	2017-05-02 01:45	1723	3,784	2,706	72	BA	MD 166	N
11	752123QP	2017-05-02 01:56	1723	3,745	2,721	73	BA	MD 166	S
12	752124RG	2017-05-02 01:57	1724	5,926	5,631	95	AA	MD 176	E
13	752134OX	2017-05-02 02:17	1724	2,627	2,323	88	AA	MD 162	N
14	7520S36U	2017-05-02 10:08	1723	3,017	2,155	71	AA	IS 195	N
15	7520S4B9	2017-05-02 10:11	1724	1,513	1,383	91	AA	MD 652	S
16	7520S3FR	2017-05-02 10:14	1723	2,676	2,169	81	AA	IS 195	S
17	7520S3NC	2017-05-02 10:18	1723	3,598	1,408	39	BA	MD 295	N
18	7520S4TD	2017-05-02 10:22	1724	2,525	2,304	91	AA	MD 162	S
19	7520T33L	2017-05-02 10:28	1723	2,310	1,405	61	BA	MD 295	S
21	7520T3BN	2017-05-02 10:33	1723	13,852	13,167	95	BA	MD 695	N
20	7520T3BM	2017-05-02 10:33	1723	30,002	28,029	93	AA	IS 695	N
22	7520T4EG	2017-05-02 10:35	1724	5,877	5,627	96	AA	MD 176	W
23	7520U4ER	2017-05-02 10:56	1724	319	193	60	AA	MD 100 N	S
24	7520U4HZ	2017-05-02 10:58	1724	103	41	40	AA	MD 100 O	N
25	7520U4O8	2017-05-02 11:02	1724	103	42	41	AA	MD 100 O	S
26	7520U4QU	2017-05-02 11:04	1724	321	192	60	AA	MD 100 N	N
27	7520V4FO	2017-05-02 11:19	1724	3,176	3,036	96	AA	MD 713	S
28	7520W41M	2017-05-02 11:32	1724	3,426	3,038	89	AA	MD 713	N
30	7520X37Z	2017-05-02 11:57	1723	15,557	14,909	96	BA	MD 695	S
29	7520X380	2017-05-02 11:57	1723	28,616	27,069	95	BA	IS 695	S
31	7520X495	2017-05-02 11:58	1724	981	781	80	AA	CO 575	W
32	7520X4QA	2017-05-02 12:08	1724	371	264	71	AA	MD 713 D	S
33	7520X4WL	2017-05-02 12:12	1724	1,489	1,128	76	AA	CO 6203	W

Step 7. To remove all files, click the “Check” drop-down menu and select “All.” Click “Remove.” Then, click the “Reload” (first blue arrow) button. The “Group Partitions” window will open (see below image).



Select the current batch by clicking the checkbox next to the appropriate batch name. Click the “OK.”

Step 8. Once only the desired files appear in the "Batch Processor" window, they may be processed. Click "Process", then "Start." The files will begin to appear under the session window (see below image). The Vibing Processor will take anywhere from 1-3 hours to run. It will depend on the number of lane miles, the number of files, the number of cores in the computer, and database traffic. Other batch processors can process multiple files at one time, however, this processor only processes one file at a time



Step 9. A dialogue box will appear when processing is complete.

i. If the box says "Batch processing has completed", proceed to Step 11.

ii. If the box says "Batch processing has completed with errors", proceed to Step 10.

Step 10. View the errors. Click the "Exceptions" drop-down menu and select "View Exceptions."

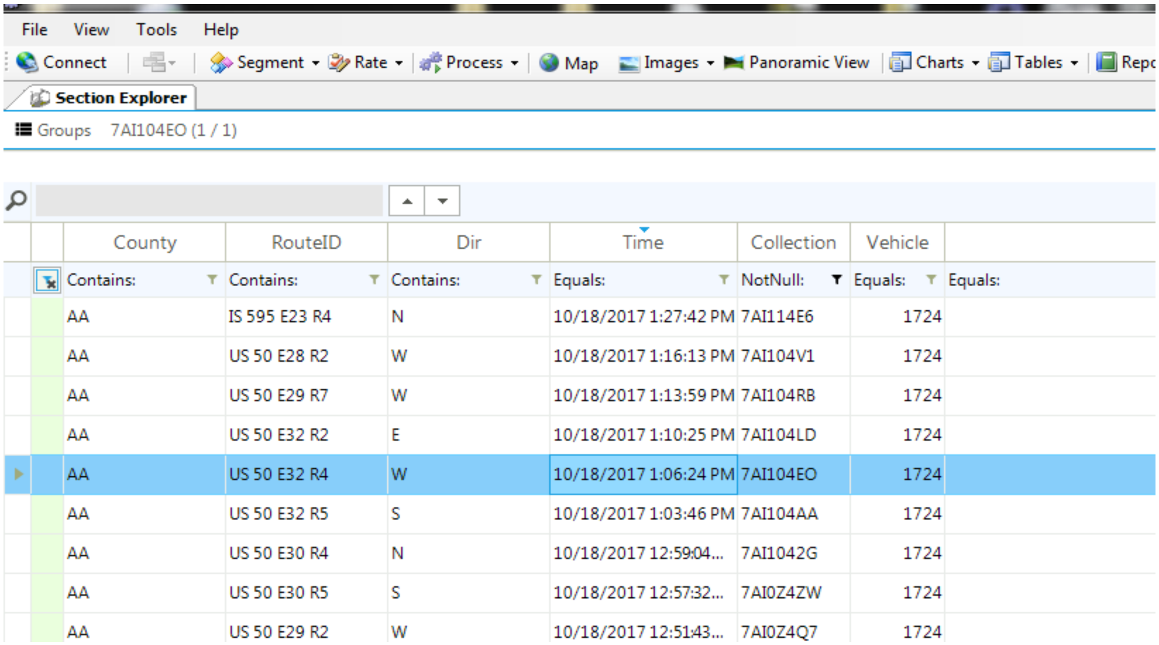
i. If the error is "Missing Images", this is acceptable. Proceed to Step 11.

ii. If any other errors are present, reprocessing is required. Click the "Exceptions" drop-down menu and select "Reprocess Exceptions." This will remove all the files from the data screen except for the files that had exceptions. Next, click the "Start" button to reprocess.

2- Performing QC of Processed "Left" Images – *performed by Vision user*

Summary: This task checks that the banner and logo were added to the "Left" processed images through visual inspection.

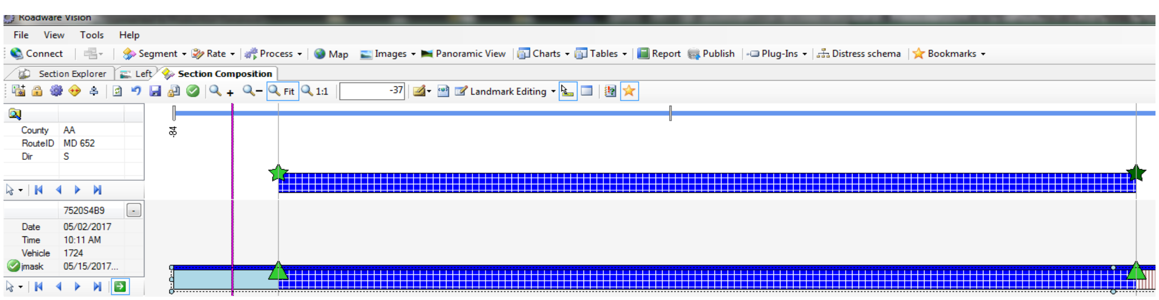
Step 11. Close the processor and restart Vision. In the "Section Explorer" window, select a file that was run in the processor (see below image).



Step 12. Click the “Images” drop-down menu and select “Left.” The first image that appears may not display the banner and logo generated during processing. This is normal. Only the area that is “matched” will display the banner and logo. There are two methods of locating the matched area (choose one and proceed):

i. Click the “Play” button at the bottom of the window and wait until the matched area appears (see below image).

ii. Click the “Segment” drop-down menu and select “Section Comparison.” The area in the checkered blue is matched. Click somewhere in the checkered section and Vision will move to that location (see below image).



Step 13. The “Left” image now should display the blue banner and logo.

i. If you do see the banner and logo after checking the first and last image, proceed to Step 14.

ii. If you do not see the banner and logo, first check that the image is fit on the screen. Move the mouse to the top of the image so that a control bar appears. Click the “Fit” button. If the banner and logo are now displayed, proceed to Step 14.

iii. If the banner and logo are still not displayed, the affected files will need to be reprocessed. Return to Step 2 and perform processing for all affected files. Occasionally, the batch processor will skip files. If a file is found in the QC process which does not have the banner and logo, it will be necessary to check all files for correctness and rerun the processor on all affected files.

3- Running Vibing Processor for “ROW” Images – *performed by Vision user*

Summary: This task uses Vision software to generate a banner and logo on the “ROW” image files from the ARAN data submittal. This task also adds latitude/longitude data to the “ROW” image properties.

Step 14. Run the same processor for the “ROW” images by repeating Step 2 to Step 10. However, this time in Step 4, select the XML file named “ROW.”

4- Performing QC of Processed “ROW” Images – *performed by Vision user*

Summary: This task checks that the banner and logo were added to the “ROW” processed images through visual inspection.

Step 15. Perform the same QC steps for the “ROW” images by repeating Step 11 to Step 13. However, this time in Step 12 select “ROW.”

5- Performing QA of Processed Data – *performed by Supervisor*

Summary: This task performs QA checks on the processed vibing data.

Step 16. TL review of QC staff notification of recollection.

Step 17. Review of production status – receive weekly update from QC staff (last ARAN collection date).

Step 18. Review Vision app’s ROW imagery display and check for banner.

5.11 RUNNING THUMBNAIL CREATOR

5.11.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to run the Thumbnail Creator in the Roadware Vision software using data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff. The Thumbnail Creator is run in batches throughout the annual data collection season. This SOP applies to the processing of an ARAN data batch (or batches). The Thumbnail Creator is run after running the Vibing Processor (see Running Vibing Processor). This process results in the generation of reduced file sizes for the "Left", "ROW", and "Pavement" collected images.

5.11.02 *Frequency*

The Thumbnail Creator is run on batches of ARAN collected data as they are received by the DPT. The frequency and timing varies according to schedule, available resources, and quantity of data received. The batches are processed in a continuous flow throughout the data collection season.

Each ARAN data batch is typically delivered to the DPT every 4 to 5 days. Assuming an average of 60 miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data. The actual frequency varies according to the proximity of the routes on which data were collected for the data batch to the Office of Materials Technology (OMT) office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring data recollection. The annual ARAN data collection season typically lasts from March to Mid-December.

5.11.03 *Purpose*

The purpose of this SOP is to run the Thumbnail Creator for collected ARAN data and perform quality control (QC) and quality assurance (QA) checks.

5.11.04 *Resource Requirements*

The running of the Thumbnail Creator involves two people: (1) a user knowledgeable in Roadware Vision software to run the processor and perform QC, and (2) a supervisor who, as required, provides guidance and decision-making and performs QA. The estimated effort levels in the table below represent the total time, in man-hours, to complete the processing and QC/QA checks. These time estimates assume average batch quantities and no issues encountered during processing.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision user and QC	1	40.0
DPT TL	Supervisor and QA	1	AR[06/12/2019]

5.11.05 *Procedure*

The procedure to run the Thumbnail Creator and perform QC/QA is comprised of the following three tasks:

(1) running the Thumbnail Creator in Vision,

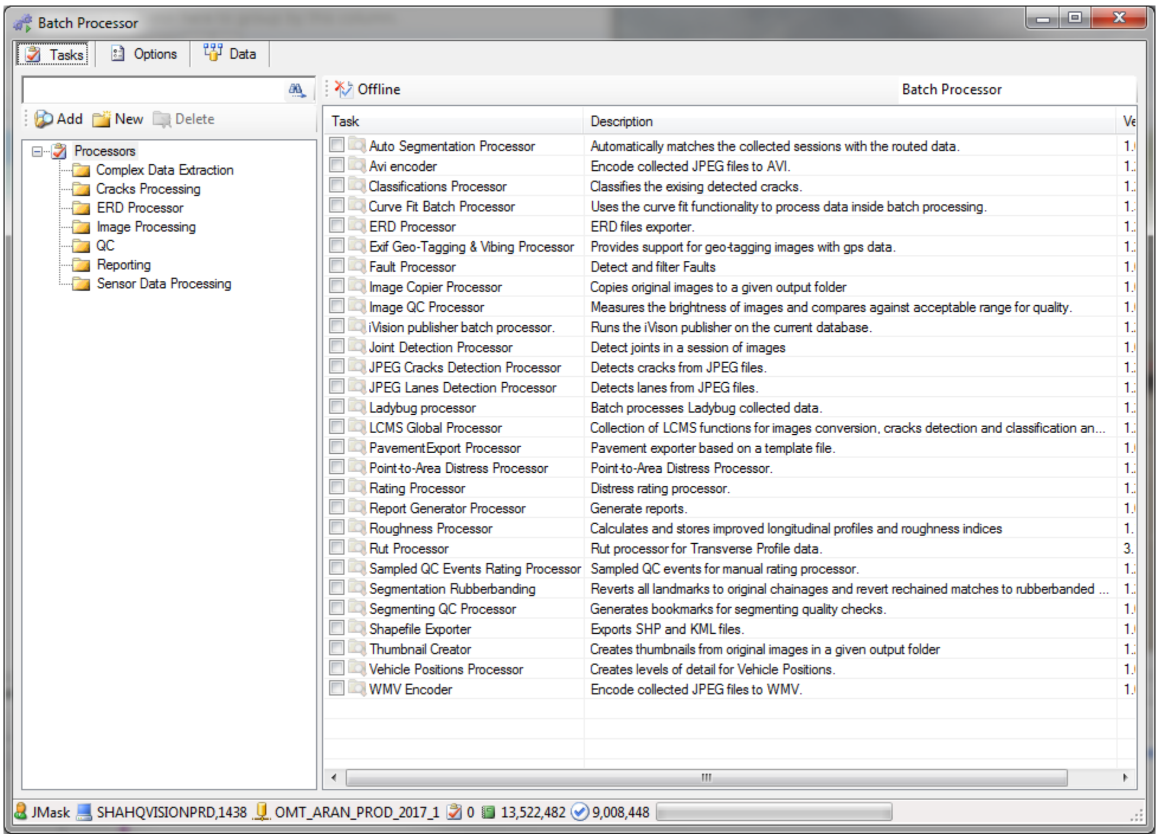
(2) performing QC of the processed data, and
(3) performing QA of the processed data.

1- Running Thumbnail Creator in Vision and QC – *performed by Vision user*

Summary: This task uses Vision software to reduce the file sizes of the “Left”, “ROW”, and “Pavement” image files from the ARAN data submittal.

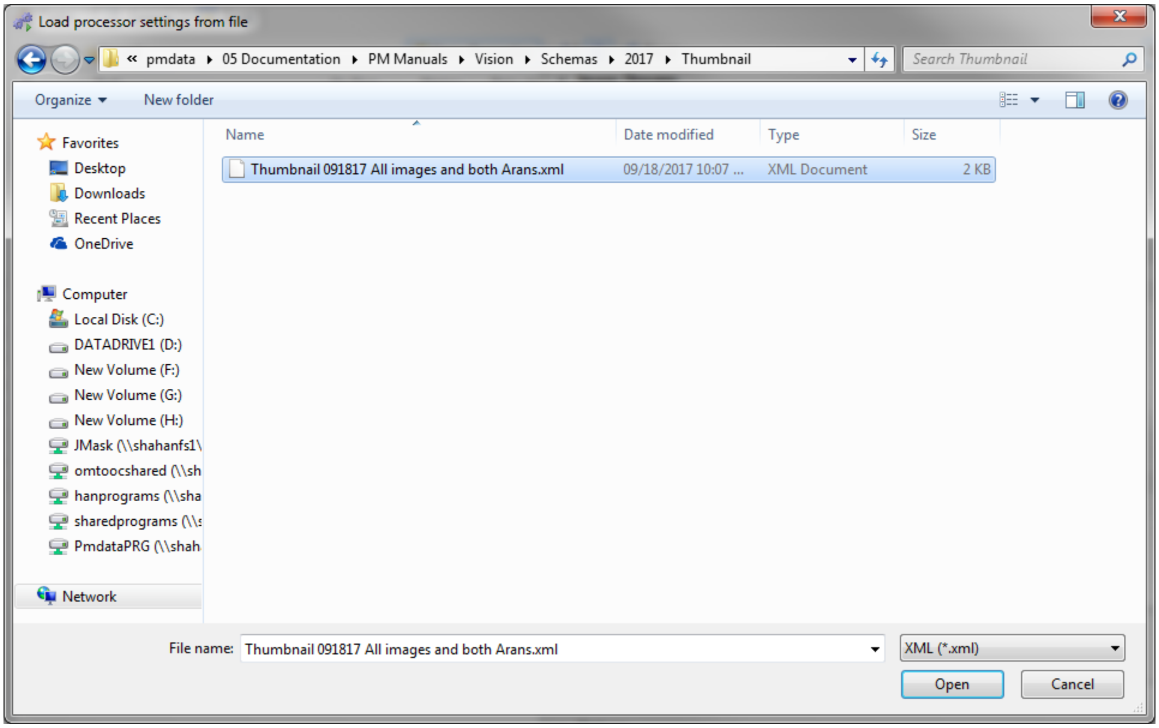
Step 1. Open Vision.

Step 2. Click the “Process” drop-down menu. Select “New Batch Processor.” The “Batch Processor” window will open (see below image).

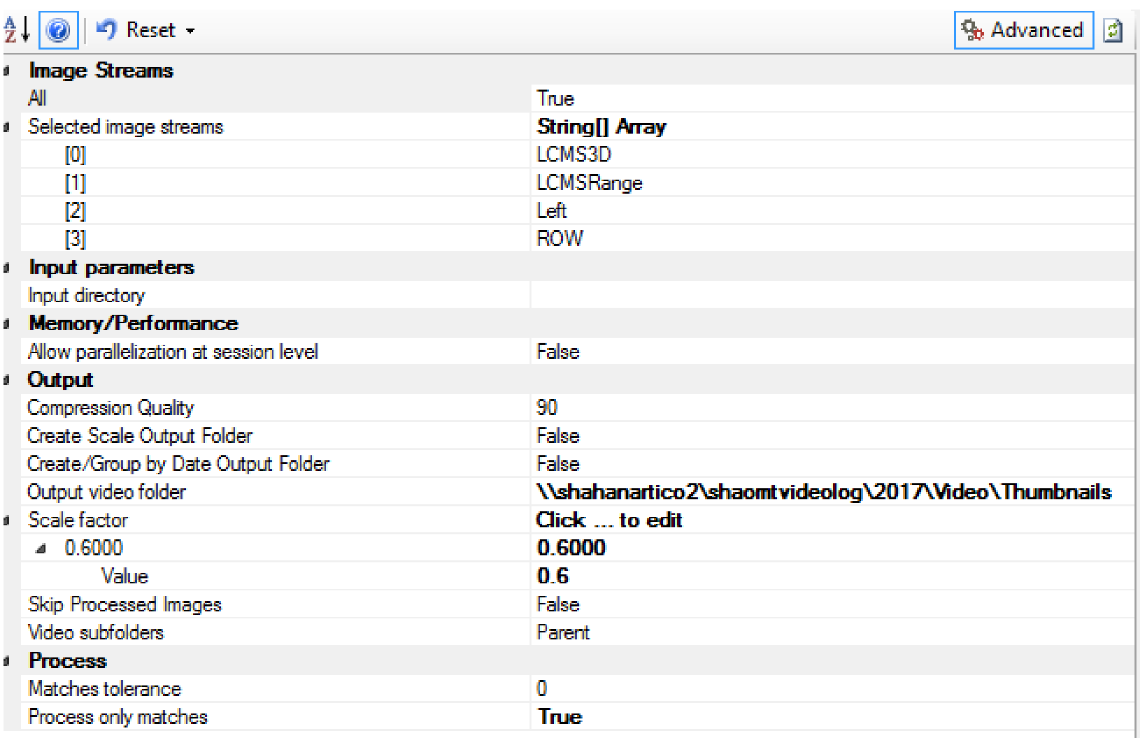


Step 3. Click the box next to “Thumbnail Creator” in the window on the right.

Step 4. Click the “Options” tab[06/12/2019]. Instead of changing settings manually, search for preset schemas. Click the “Load” button. Navigate to the folder where schema files are stored[06/12/2019]. In this folder, look for an XML file named “Thumbnail [MOST RECENT DATE] All images and both Arans.” Select the file and click “Open” (see below image).



Make sure the output folder is pointing to the correct location in the window to the right (see below image).

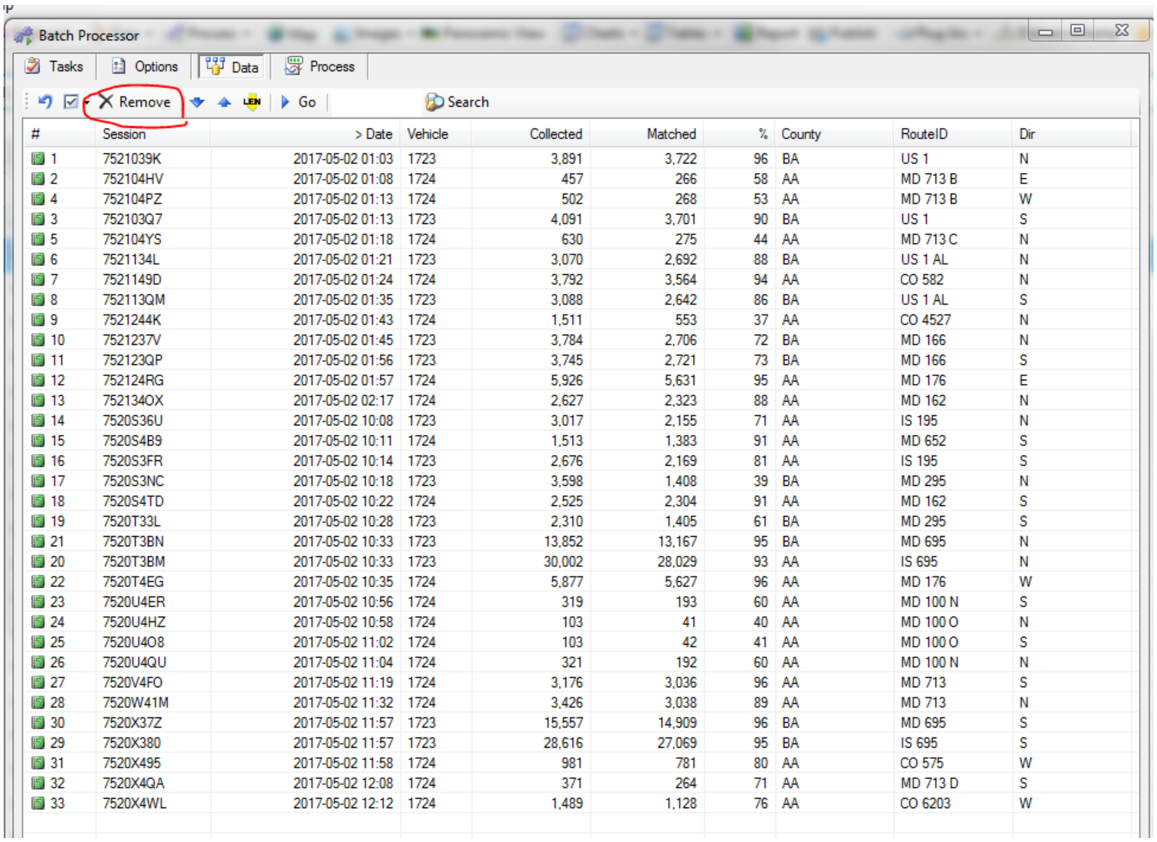


Step 5. Click “Data” from the top menu bar. Every file in the database will appear in the window. The list must be filtered to only include the sections from the current batch. This can be accomplished through two different methods:

i. Removing unwanted files, or

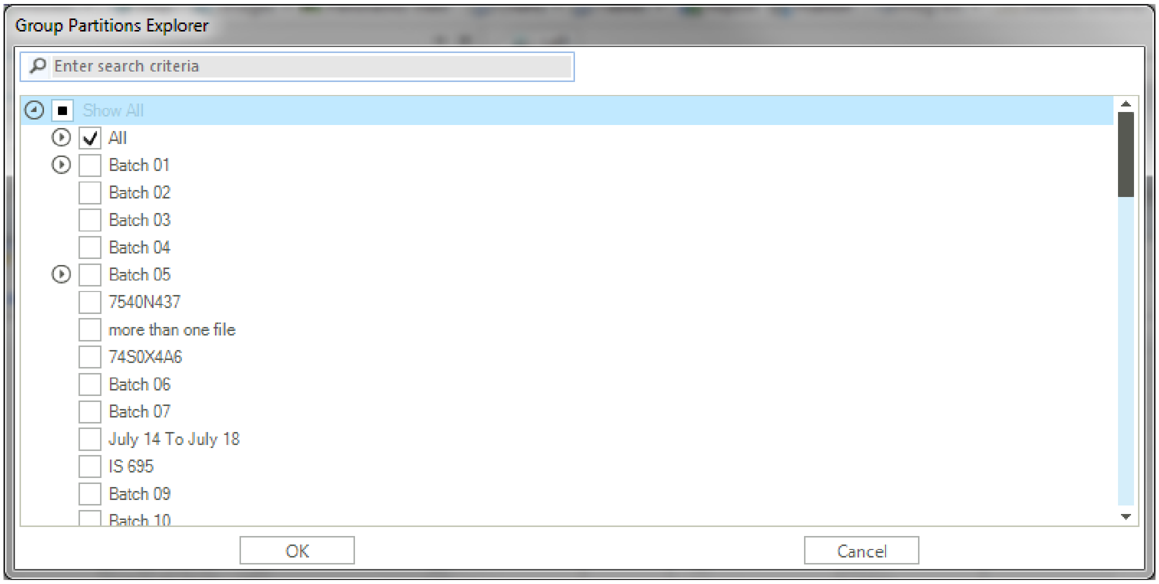
ii. Removing all files and selecting a batch to re-add.

Step 6. Choose removal method. If removing all files and selecting a batch to re-add is preferred, skip to Step 7. Otherwise, use a combination of the Shift and Ctrl keys to highlight all unwanted files in the window. Click “Remove.” Proceed to Step 8 (see below image).



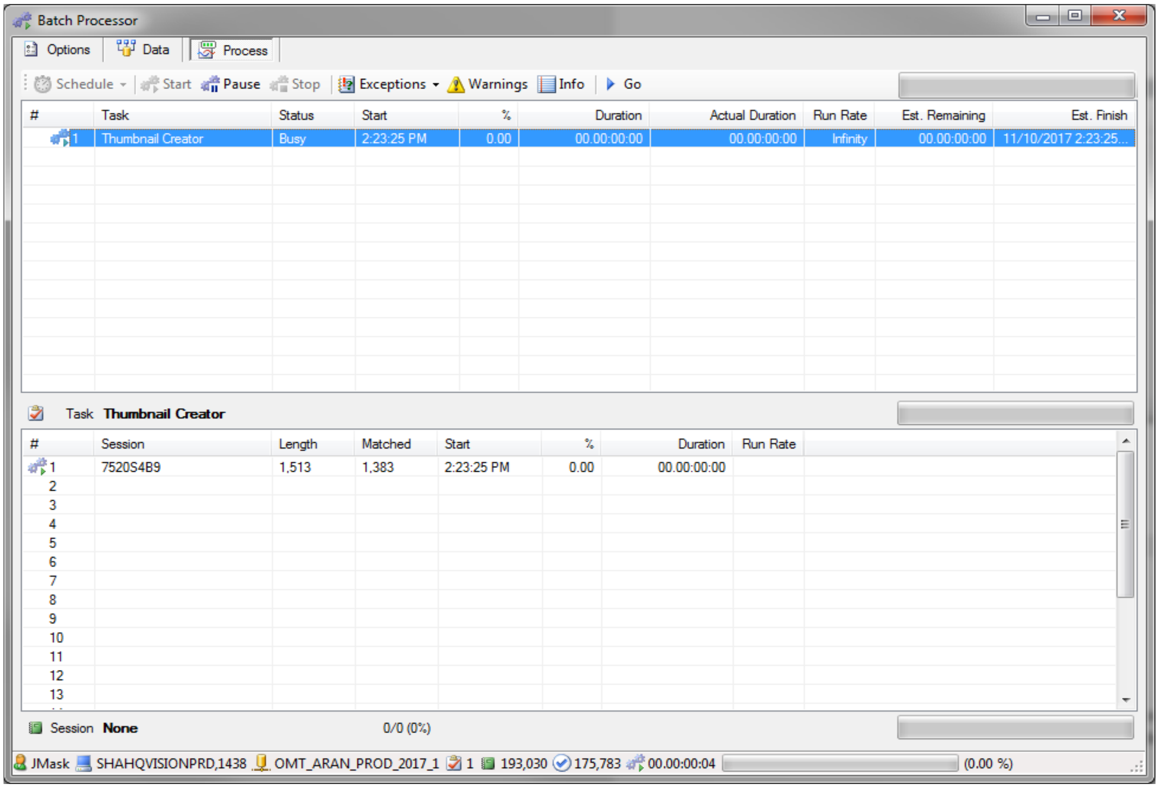
#	Session	> Date	Vehicle	Collected	Matched	%	County	RouteID	Dir
1	7521039K	2017-05-02 01:03	1723	3,891	3,722	96	BA	US 1	N
2	752104HV	2017-05-02 01:08	1724	457	266	58	AA	MD 713 B	E
4	752104PZ	2017-05-02 01:13	1724	502	268	53	AA	MD 713 B	W
3	752103Q7	2017-05-02 01:13	1723	4,091	3,701	90	BA	US 1	S
5	752104YS	2017-05-02 01:18	1724	630	275	44	AA	MD 713 C	N
6	7521134L	2017-05-02 01:21	1723	3,070	2,692	88	BA	US 1 AL	N
7	7521149D	2017-05-02 01:24	1724	3,792	3,564	94	AA	CO 582	N
8	752113QM	2017-05-02 01:35	1723	3,088	2,642	86	BA	US 1 AL	S
9	7521244K	2017-05-02 01:43	1724	1,511	553	37	AA	CO 4527	N
10	7521237V	2017-05-02 01:45	1723	3,784	2,706	72	BA	MD 166	N
11	752123QP	2017-05-02 01:56	1723	3,745	2,721	73	BA	MD 166	S
12	752124RG	2017-05-02 01:57	1724	5,926	5,631	95	AA	MD 176	E
13	752134OX	2017-05-02 02:17	1724	2,627	2,323	88	AA	MD 162	N
14	7520S36U	2017-05-02 10:08	1723	3,017	2,155	71	AA	IS 195	N
15	7520S4B9	2017-05-02 10:11	1724	1,513	1,383	91	AA	MD 652	S
16	7520S3FR	2017-05-02 10:14	1723	2,676	2,169	81	AA	IS 195	S
17	7520S3NC	2017-05-02 10:18	1723	3,598	1,408	39	BA	MD 295	N
18	7520S4TD	2017-05-02 10:22	1724	2,525	2,304	91	AA	MD 162	S
19	7520T33L	2017-05-02 10:28	1723	2,310	1,405	61	BA	MD 295	S
21	7520T3BN	2017-05-02 10:33	1723	13,852	13,167	95	BA	MD 695	N
20	7520T3BM	2017-05-02 10:33	1723	30,002	28,029	93	AA	IS 695	N
22	7520T4EG	2017-05-02 10:35	1724	5,877	5,627	96	AA	MD 176	W
23	7520U4ER	2017-05-02 10:56	1724	319	193	60	AA	MD 100 N	S
24	7520U4HZ	2017-05-02 10:58	1724	103	41	40	AA	MD 100 O	N
25	7520U4O8	2017-05-02 11:02	1724	103	42	41	AA	MD 100 O	S
26	7520U4QU	2017-05-02 11:04	1724	321	192	60	AA	MD 100 N	N
27	7520V4FO	2017-05-02 11:19	1724	3,176	3,036	96	AA	MD 713	S
28	7520W41M	2017-05-02 11:32	1724	3,426	3,038	89	AA	MD 713	N
30	7520X37Z	2017-05-02 11:57	1723	15,557	14,909	96	BA	MD 695	S
29	7520X380	2017-05-02 11:57	1723	28,616	27,069	95	BA	IS 695	S
31	7520X495	2017-05-02 11:58	1724	981	781	80	AA	CO 575	W
32	7520X4QA	2017-05-02 12:08	1724	371	264	71	AA	MD 713 D	S
33	7520X4WL	2017-05-02 12:12	1724	1,489	1,128	76	AA	CO 6203	W

Step 7. To remove all files, click the “Check” drop-down menu and select “All.” Click “Remove.” Then, click the “Reload” (first blue arrow) button. The “Group Partitions” window will open (see below image).



Select the current batch by clicking the checkbox next to the appropriate batch name. Click the “OK.”

Step 8. Once only the desired files appear in the “Batch Processor” window, they may be processed. Click “Process”, then “Start.” The files will begin to appear under the session window (see below image). The Thumbnail Creator will take anywhere from 1-3 hours to run. It will depend on the number of lane miles, the number of files, the number of cores in the computer, and database traffic. Other batch processors can process multiple files at one time, however, this processor only processes one file at a time



Step 9. A dialogue box will appear when processing is complete.

i. If the box says “Batch processing has completed”, proceed to Step 11.

ii. If the box says “Batch processing has completed with errors”, proceed to Step 10.

Step 10. View the errors. Click the “Exceptions” drop-down menu and select “View Exceptions.”

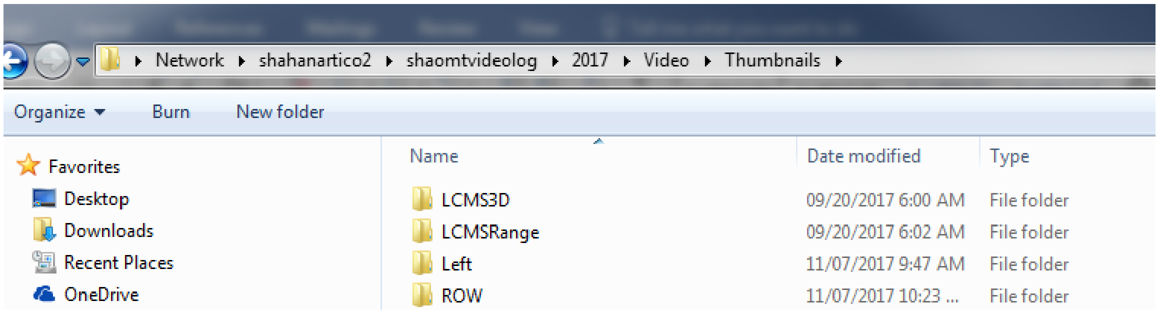
i. If the error is “Missing Images”, this is acceptable. Proceed to Step 11.

ii. If any other errors are present, reprocessing is required. Click the “Exceptions” drop-down menu and select “Reprocess Exceptions.” This will remove all the files from the data screen except for the files that had exceptions. Next, click the “Start” button to reprocess.

2- Performing QC of Processed Data – *performed by Vision user*

Summary: This task checks that the folders contain the correct number of processed images and performs visual inspection of a sample of images to look for abnormalities.

Step 11. Navigate to the output folder (see below image).



Step 12. Check the number of files in each folder. There should be the same number of files in each folder type ("Left", "ROW", "LCMSRange", and "LCMS3D").

i. If the number of files match in each folder, proceed to Step 13.

ii. If there are discrepancies, isolate the files that are missing from certain folders and reprocess those files by returning to Step 2 and repeating the procedure only for the files in question. Proceed to Step 13.

Step 13. Spot check a few of the images in "Windows Explorer."

i. If the images look acceptable, process is complete. However, if there are changes in mileage that cause the Vibing Processor to be rerun, those files will also need to be reprocessed in the Thumbnail Creator.

ii. If there are issues with the processed images, isolate the files that are missing or incorrect and reprocess those files by returning to Step 2 and repeating the procedure only for the files in question.

3- Performing QA of Processed Data – *performed by Supervisor*

Summary: This task performs QA checks on the processed images.

Step 14. TL review of QC staff notification of recollection.

Step 15. Review of production status – receive weekly update from QC staff (last ARAN collection date).

Step 16. Review Videlog server to make sure imagery is posted and available.

5.12 RUNNING CURVE FIT BATCH PROCESSOR

5.12.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to run the Curve Fit Batch Processor in the Roadware Vision software using data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff. The Curve Fit Batch Processor is run in batches throughout the annual data collection season. This SOP applies to the processing of an ARAN data batch (or batches). The Curve Fit Batch Processor is run after completion of the ARAN data route matching (see Route Matching). This process results in the generation of ARAN vertical and horizontal roadway (geometric) data.

5.12.02 *Frequency*

The Curve Fit Batch Processor is run on batches of ARAN collected data as they are received by the DPT. The frequency and timing varies according to schedule, available resources, and quantity of data received. The batches are processed in a continuous flow throughout the data collection season.

Each ARAN data batch is typically delivered to the DPT every 4 to 5 days. Assuming an average of 60 miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data. The actual frequency varies according to the proximity of the routes on which data were collected for the data batch to the Office of Materials Technology (OMT) office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring data recollection. The annual ARAN data collection season typically lasts from March to Mid-December.

5.12.03 *Purpose*

The purpose of this SOP is to run the Curve Fit Batch Processor for collected ARAN data and perform quality control (QC) and quality assurance (QA) checks.

5.12.04 *Resource Requirements*

The running of the Curve Fit Batch Processor involves two people: (1) a user knowledgeable in Roadware Vision software to run the Curve Fit Batch Processor and perform QC, and (2) a supervisor who, as required, provides guidance and decision-making and performs QA. The estimated effort levels in the table below represent the total time, in man-hours, to complete the processing and QC/QA checks. These time estimates assume average batch quantities and no issues encountered during processing.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision user and QC	1	3.0
DPT TL	Supervisor and QA	1	AR[06/12/2019]

5.12.05 *Procedure*

The procedure to run the Curve Fit Batch Processor and perform QC/QA is comprised of the following three tasks:

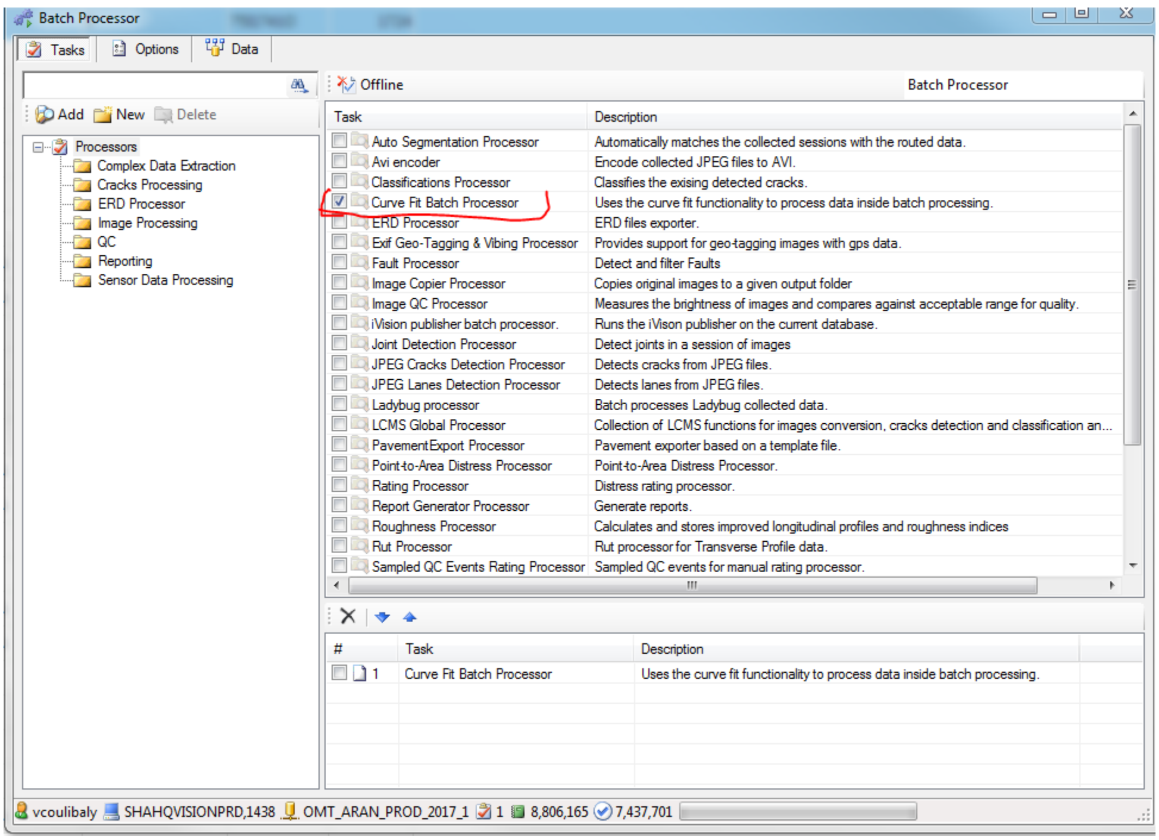
(1) running Curve Fit Batch Processor in Vision,
(2) performing QC of the processed curve fit data, and
(3) performing QA of the processed curve fit data.

1- Running Curve Fit Batch Processor in Vision – *performed by Vision User*

Summary: This task uses Vision software to process curve fit data from the ARAN data submittal.

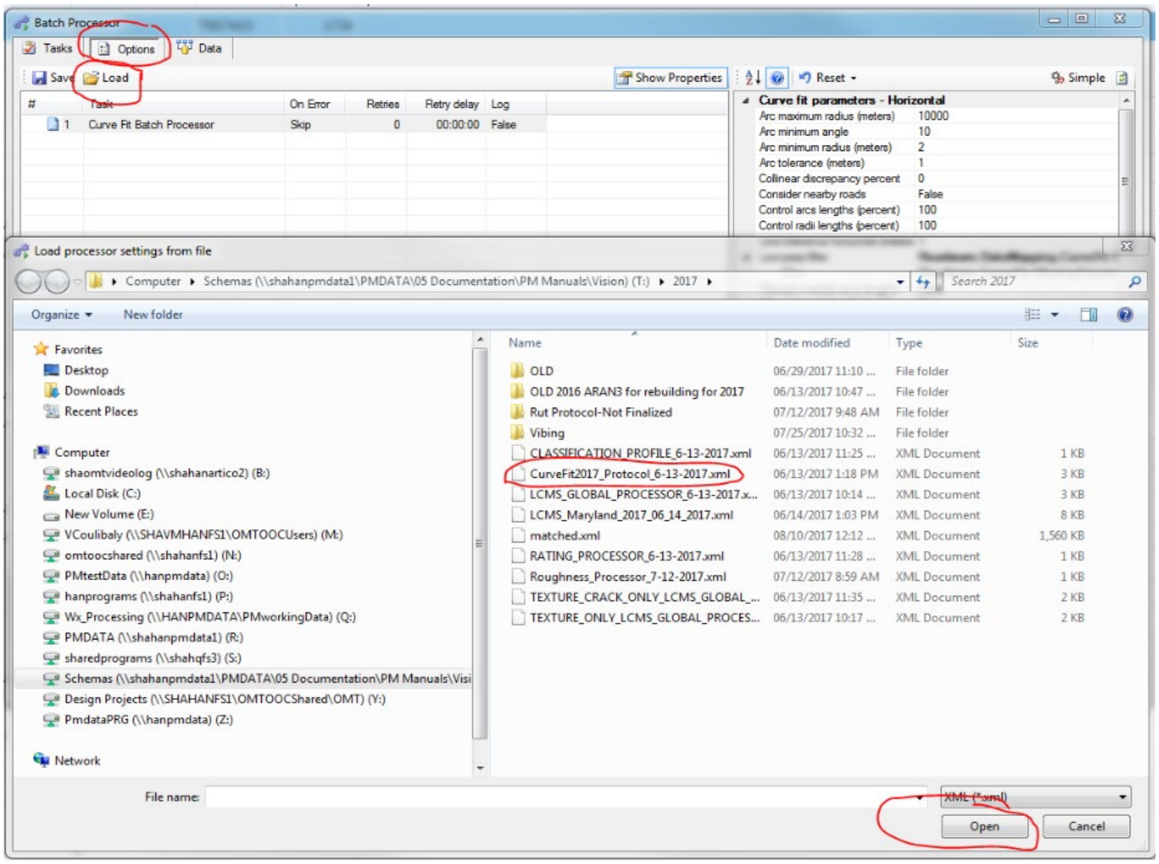
Step 1. Open Vision.

Step 2. Click the "Process" drop-down menu. Select "New Batch Processor." The "Batch Processor" window will open (see below image).

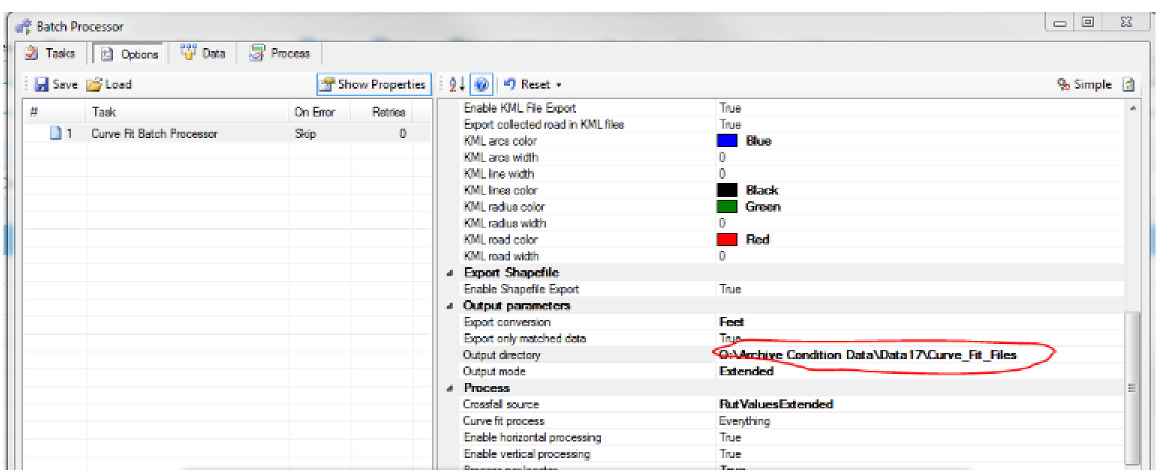


Step 3. Click the box next to "Curve Fit Batch Processor" in the window on the right. Then click the "Options" tab (see above image).

Step 4. Instead of changing settings manually, search for preset schemas. Click the "Load" button. Navigate to the folder where schemas are stored[06/12/2019]. In this folder, look for an XML file named "CurveFit2017_Protocol_[MOST RECENTDATE]." Select the file and click "Open" (see below image).



Step 5. Set the output location to the following: \\shahanpmdata1\PMtestData\Archive Condition Data\Data17\Curve_Fit_Files (see below image).



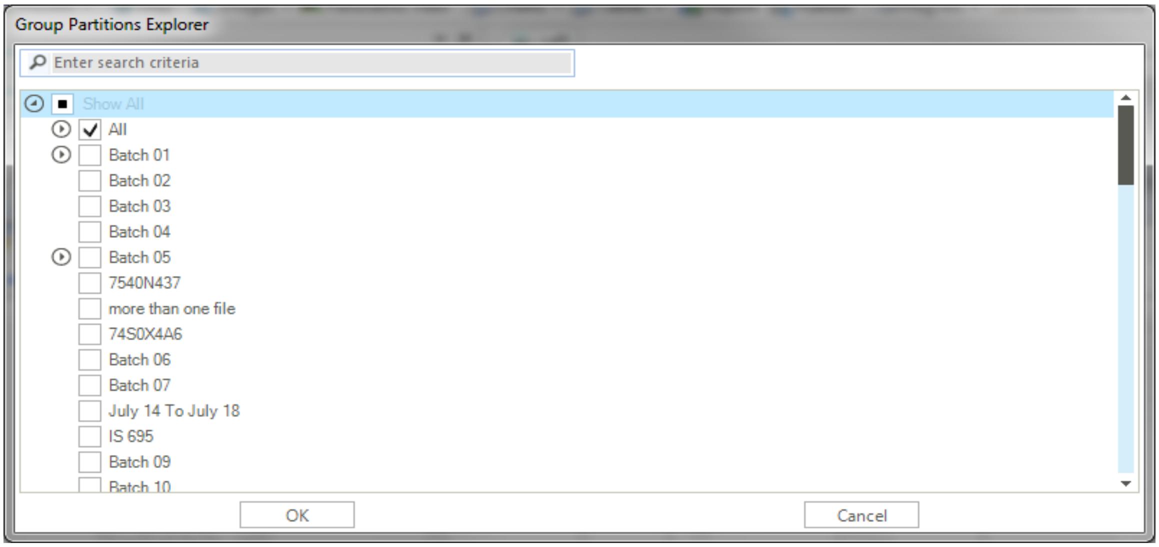
Step 6. Click “Data” from the top menu bar. Every file in the database will appear in the window. The list must be filtered to only include the sections from the current batch. This can be accomplished through two different methods:

i. Removing unwanted files, or

ii. Removing all files and selecting a batch to re-add.

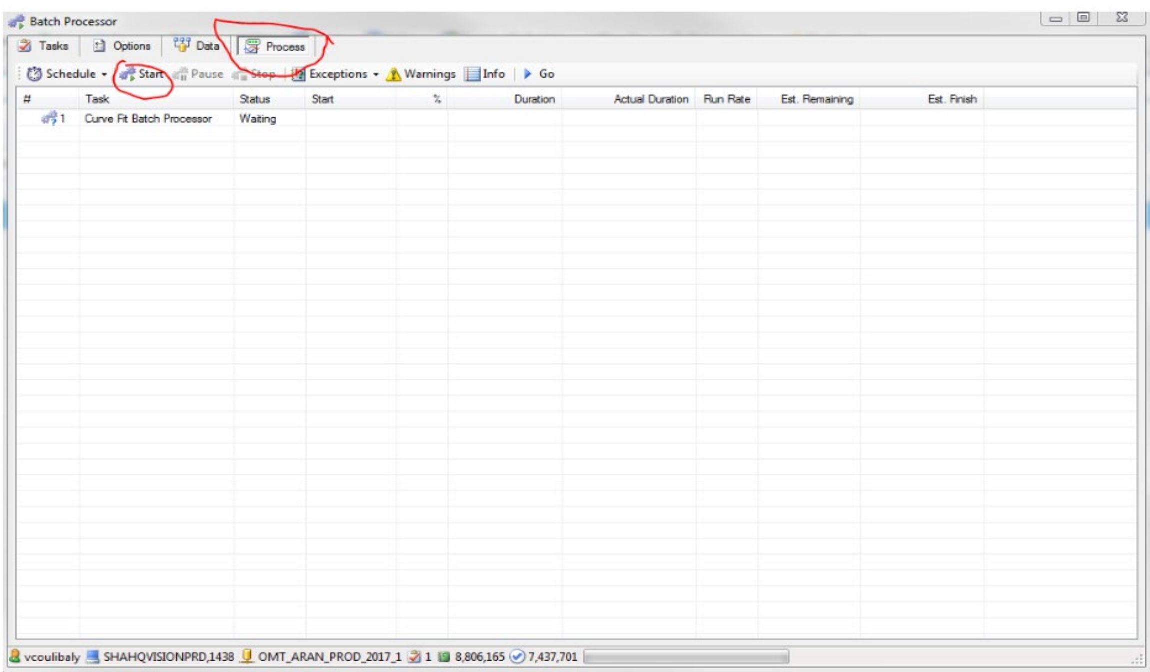
Step 7. Choose removal method. If removing all files and selecting a batch to re-add is preferred, skip to Step 7. Otherwise, use a combination of the Shift and Ctrl keys to highlight all unwanted files in the window. Click "Remove." Proceed to Step 8.

Step 8. To remove all files, click the "Check" drop-down menu and select "All." Click "Remove." Then, click the "Reload" (first blue arrow) button. The "Group Partitions" window will open (see below image).



Select the current batch by clicking the checkbox next to the appropriate batch name. Click the "OK."

Step 9. Once only the desired files appear in the "Batch Processor" window, they may be processed. Click "Process", then "Start." The files will begin to appear under the session window (see below image).



2- Performing QC of Processed Data – *performed by Vision user*

Summary: This task checks the quality of processed curve fit data through an inspection of errors reported by Vision during processing.

Step 10. A dialogue box will appear when processing is complete.

i. If the box says, "Batch processing has completed", proceed to Step 12.

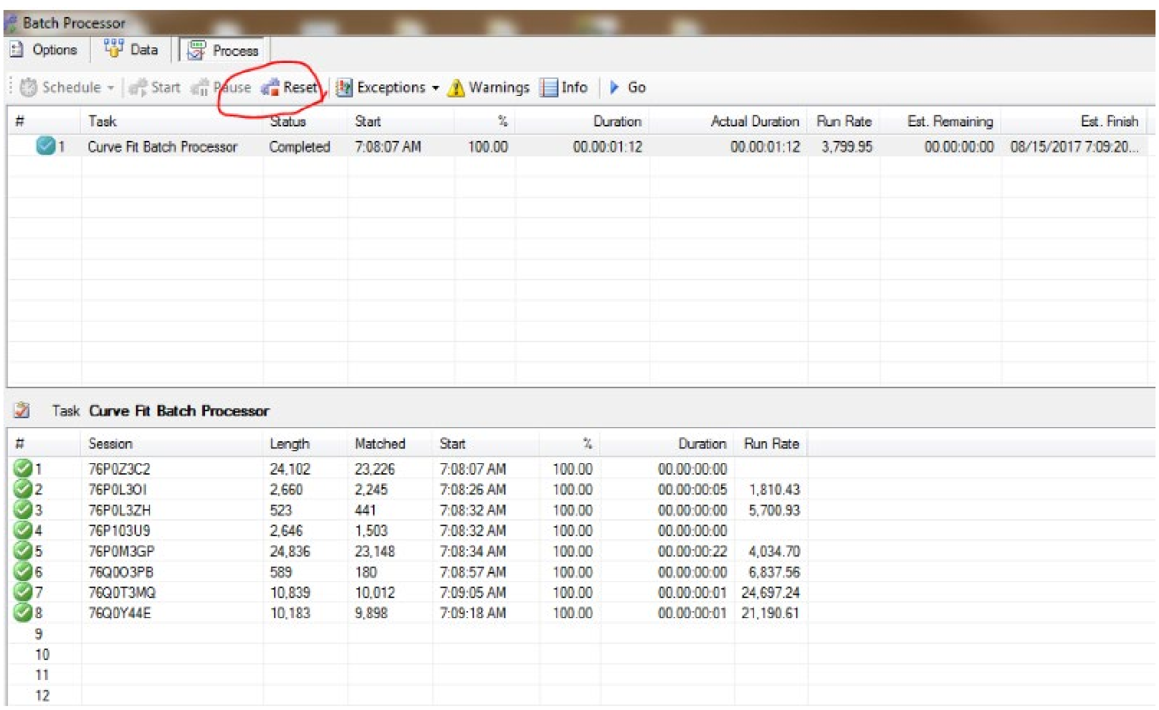
ii. If the box says, "Batch processing has completed with errors", proceed to Step 10.

Step 11. View the errors. Click the "*Exceptions"* drop-down menu and select "*View Exceptions*."

i. If the error is "Missing Images", this is acceptable. Proceed to Step 12.

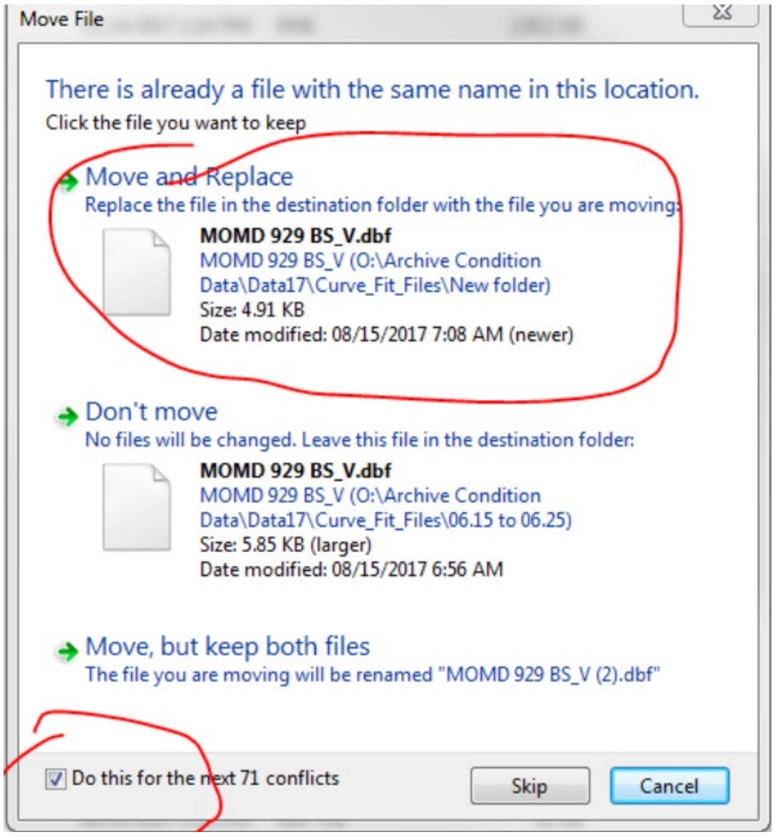
ii. If any other errors are present, reprocessing is required. Click the "Exceptions" drop-down menu and select "Reprocess Exceptions." This will remove all the files from the data screen except for the files that had exceptions. Next, click the "Start" button to reprocess.

Step 12. Check the "Batch Processor" window for runs that did not process. The software occasionally skips runs. In the window showing processed results, check the "Run Rate" column. Any runs that have blanks in this column will need to be reprocessed. Select those runs, removing runs already processed, and change the output location to a new temporary folder. Click "Reset" (see below image).



Step 13. Once reprocessing is complete, navigate to the temporary folder that was created for the reprocessed results. Move all files and move to the main folder

that contains the original processed files. Select “Move and Replace” if there are any duplicate files (see below image).



3- Performing QA of Processed Rut Data – *performed by Supervisor*

Summary: This task performs QA checks on the processed curve fit data.

Step 14. TL review of QC staff notification of recollection.

Step 15. Review of production status – receive weekly update from QC staff (last ARAN collection data fully processed).

5.13 REPORTING AND UPLOADING DATA TO ORACLE

5.13.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to upload data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff and processed by DPT staff in Roadware Vision software to Oracle using the Engineering Data Warehouse (EDW). This SOP is performed once all other data processing is completed for a specific batch of data. A list of columns required for running the report generator in Vision is included as an appendix (see Base Report. In addition, the methodology behind the International Roughness Index (IRI) speed adjustment is also included as an appendix (see IRI Speed Adjustment).

5.13.02 *Frequency*

The report generation and Oracle upload is performed on batches of ARAN collected data as they are received by the DPT. The frequency and timing varies according to schedule, available resources, and quantity of data received. The batches are processed in a continuous flow throughout the data collection season. Each ARAN data batch is typically delivered to the DPT every 4 to 5 days. Assuming an average of 60 miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data. The actual frequency varies according to the proximity of the routes on which data were collected for the data batch to the Office of Materials Technology (OMT) office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring data recollection. The annual ARAN data collection season typically lasts from March to Mid-December.

5.13.03 *Purpose*

The purpose of this SOP is to run the report generator in Vision and then upload the processed data from Vision to Oracle using the EDW. The operations performed in the EDW utilize SQL Developer packages to populate the output tables and perform a speed adjustment for the IRI data. The UPD_VISION_TABLE package populates the Base tables, while the CONDITION_PKG creates new fields in the output tables (LEFTIRI_ADJ and RIGHTIRI_ADJ) and populates them with IRI data adjusted for speed. The output tables will serve as the basis for developing the Business Plan Tables.

5.13.04 *Resource Requirements*

Running the report generator and uploading data to Oracle involves four people: (1) a user knowledgeable in Vision and the EDW to run the report generator and upload the data, (2) a database management expert to perform QA in Oracle, (3) a database management expert who, as required, performs code repair and troubleshooting, and (4) a supervisor who, as required, provides guidance and decision-making and performs QA. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume average batch quantities and no issues encountered during uploading.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision/EDW user	1	120.0
DWT Staff	QA	2	0.5
DWT Staff	Code Repair	1	AR[06/12/2019]
DPT TL	Supervisor and QA	1	

5.13.05 *Procedure*

The procedure to generate the reports and upload data to Oracle is comprised of the following four tasks:

(1) defining a new report,
(2) running the report generator,
(3) uploading data from Vision to Oracle, and
(4) performing QA of uploaded data.

1- Defining a New Report – *performed by Vision user*

Summary: This task uses Vision software to define a new report to be used in the generation of ARAN data reports. If the report has been previously defined and created in Vision, the user may proceed to the next component (Step 8).

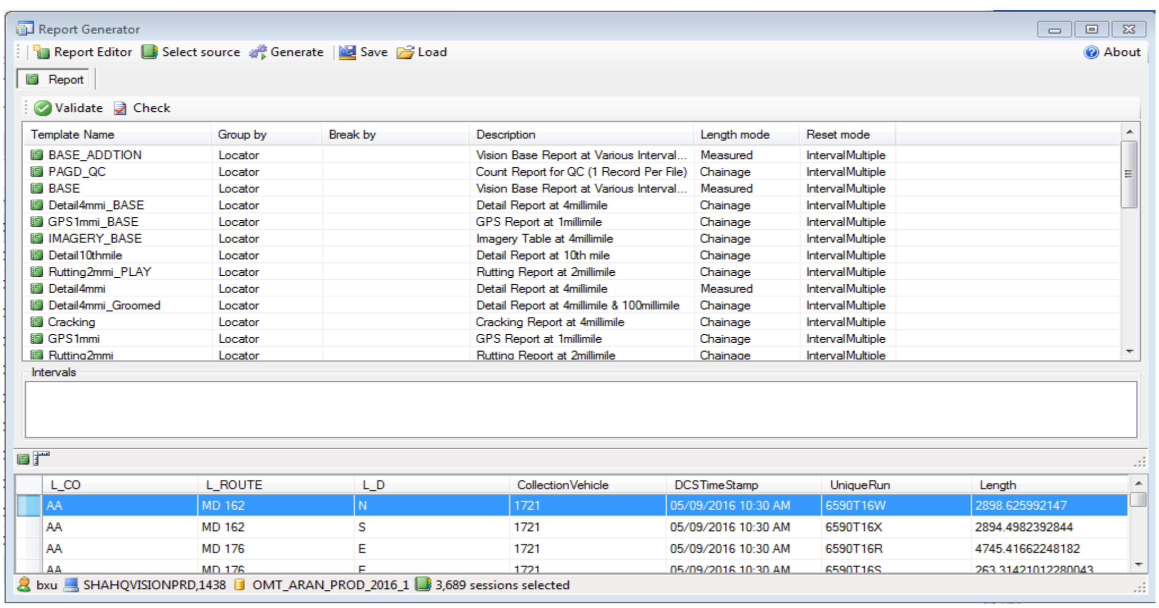
Step 1. Determine if the desired report has already been defined and created in Vision.

i. If the report has been previously defined and created, proceed to the next component by skipping to Step 8.

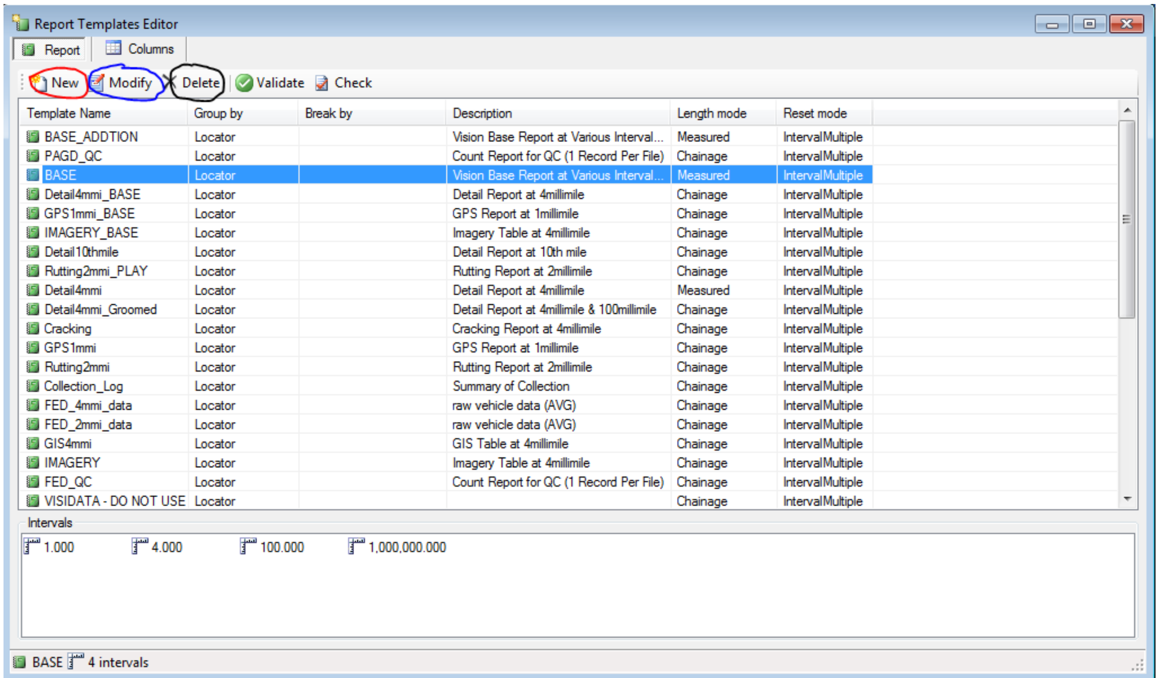
ii. If the report has not been previously defined and created, proceed to Step 2.

Step 2. Open Vision and connect to the proper database.

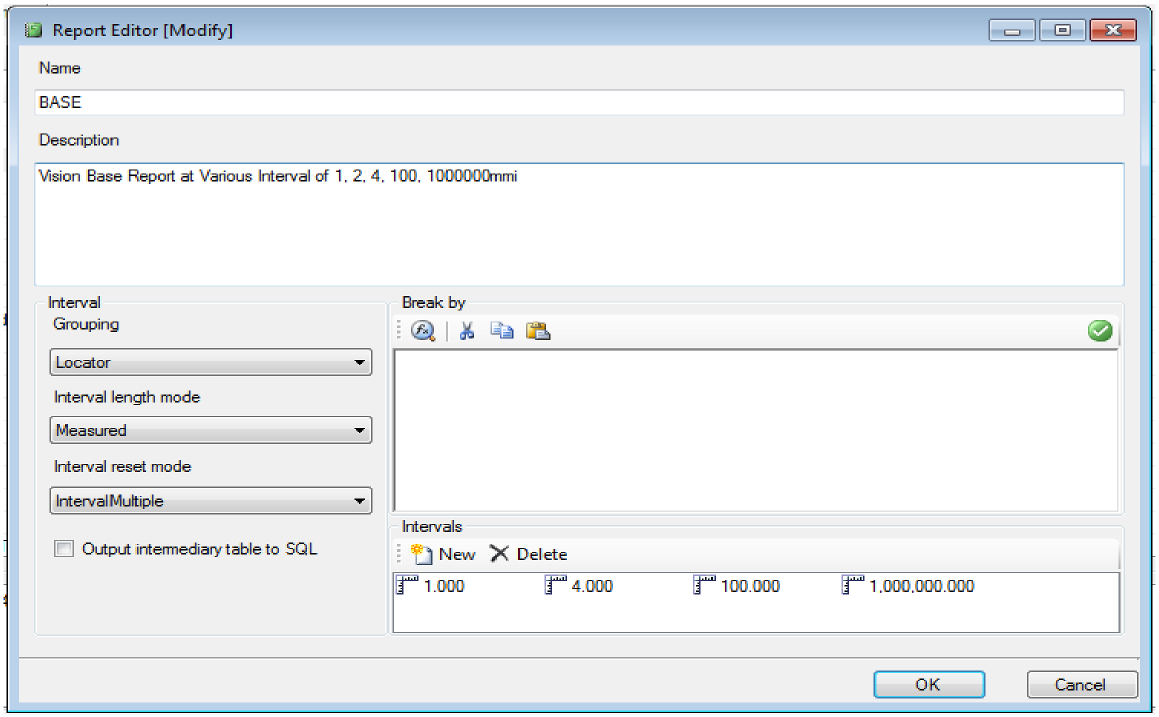
Step 3. Click the "Report" drop-down menu and select "Report Generator." The "Report Generator" window will open with all the reports that have been previously defined (see below image).



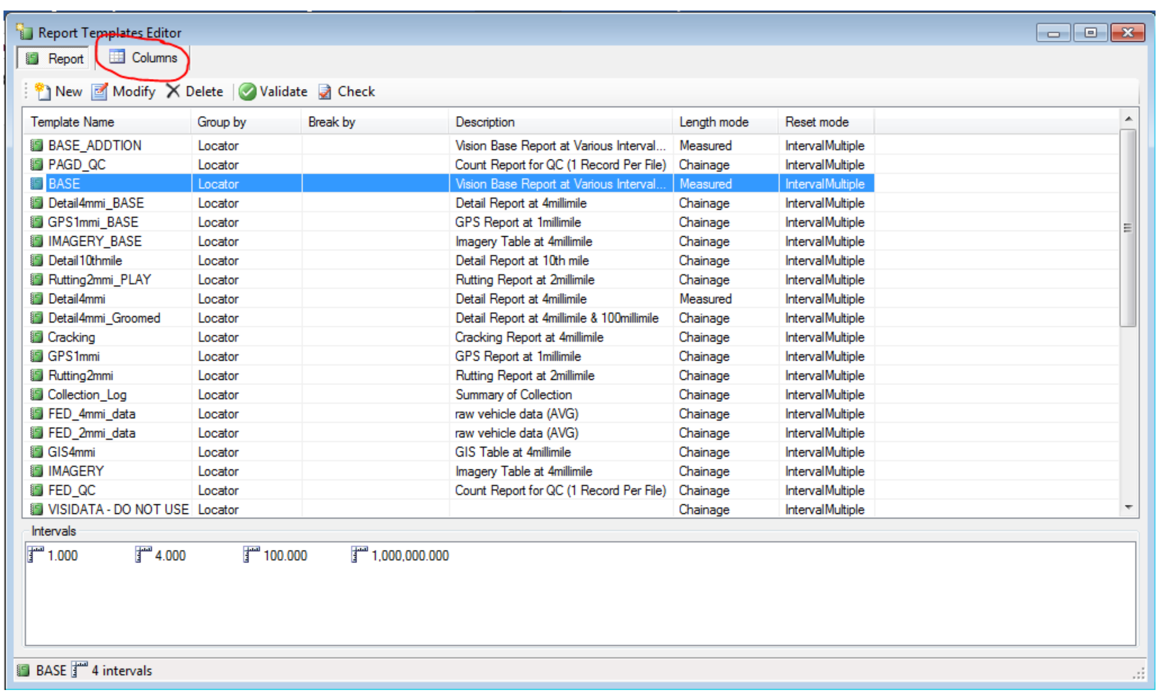
Step 4. Click "Report Editor" and the "Report Template Editor" will appear. Click the "New" button, as highlighted in red, to create a new report, click the "Modify" button, as highlighted in blue, to modify an existing report, or click the "Delete" button, as highlighted in black, to delete an existing report.



Step 5. Click the "New" button and enter the information for: "Name", "Description", "Grouping", "Interval length mode", "Interval reset mode", "Break by", and "Intervals" as shown in the image below. Click "OK." A new report named "Base" will be created in Vision (see below image).

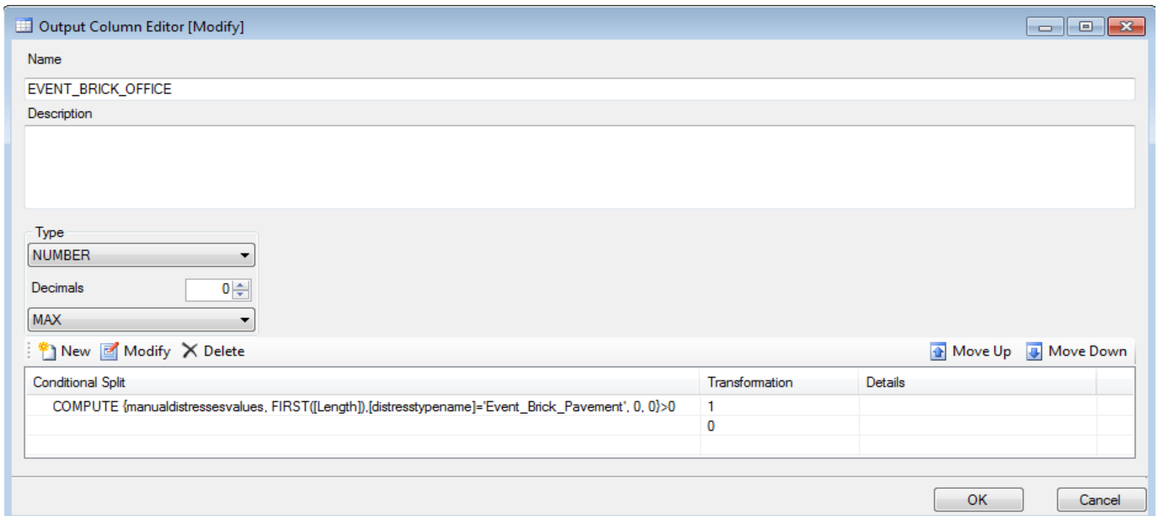


Step 6. After the new “Base” report is created, click the “Columns” tab in the “Report Templates Editor” window to define all columns needed in the new report, one column at a time. Again, click the “New” button to add a new column, click the “Modify” button to modify an existing button, or click the “Delete” button to delete an existing column (see below image).



Step 7. Click the “New” button and enter the information for: “Name”, “Description”, “Type” (data type such as TEXT or NUMBER, decimals, aggregation type such

as MAX, MIN, FIRST…), "Conditional Split" and "Transformation" for each column that is needed. The below image gives an example for defining a column named "EVENT_BRICK_OFFICE." The details of each column of the "Base" report can be found in the appendix Base Report. Once all columns are defined, the new report will be ready to be ran by the Report Generator in Vision (see below image).

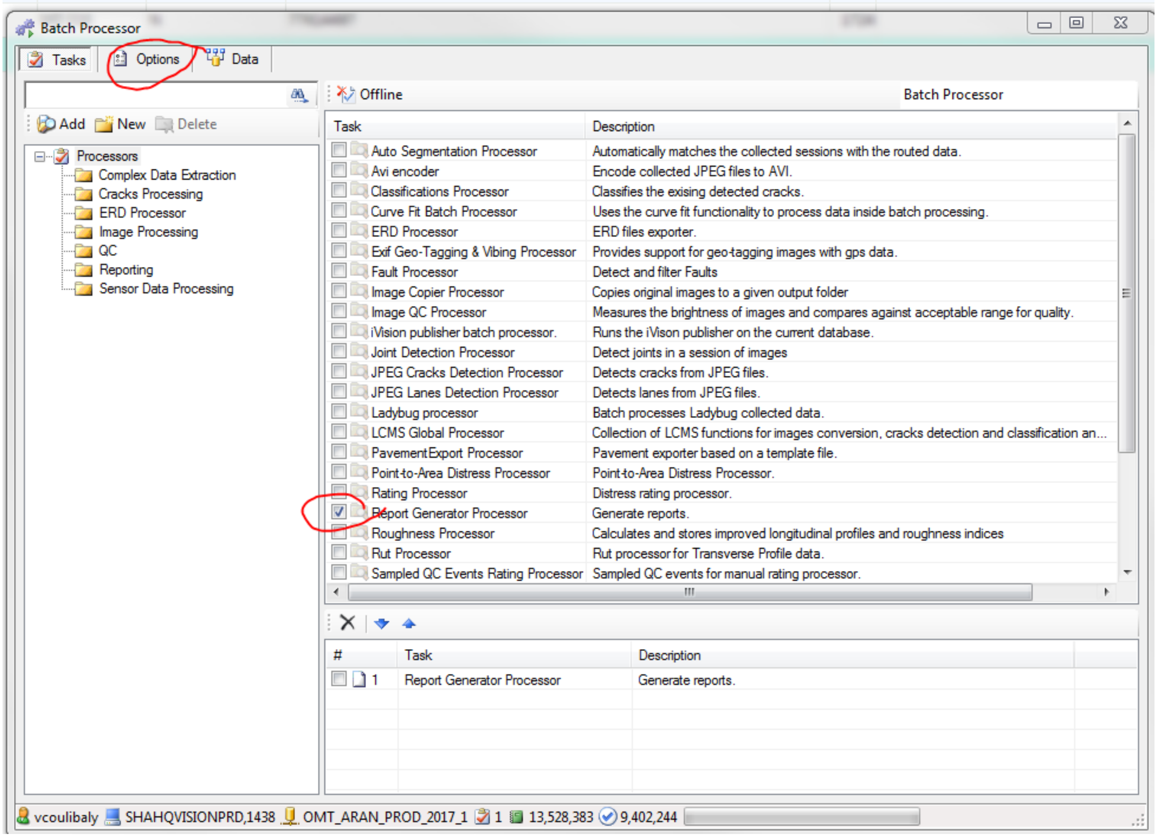


2- Running Report Generator – *performed by Vision user*

Summary: This task uses Vision software to process report data from the ARAN data submittal.

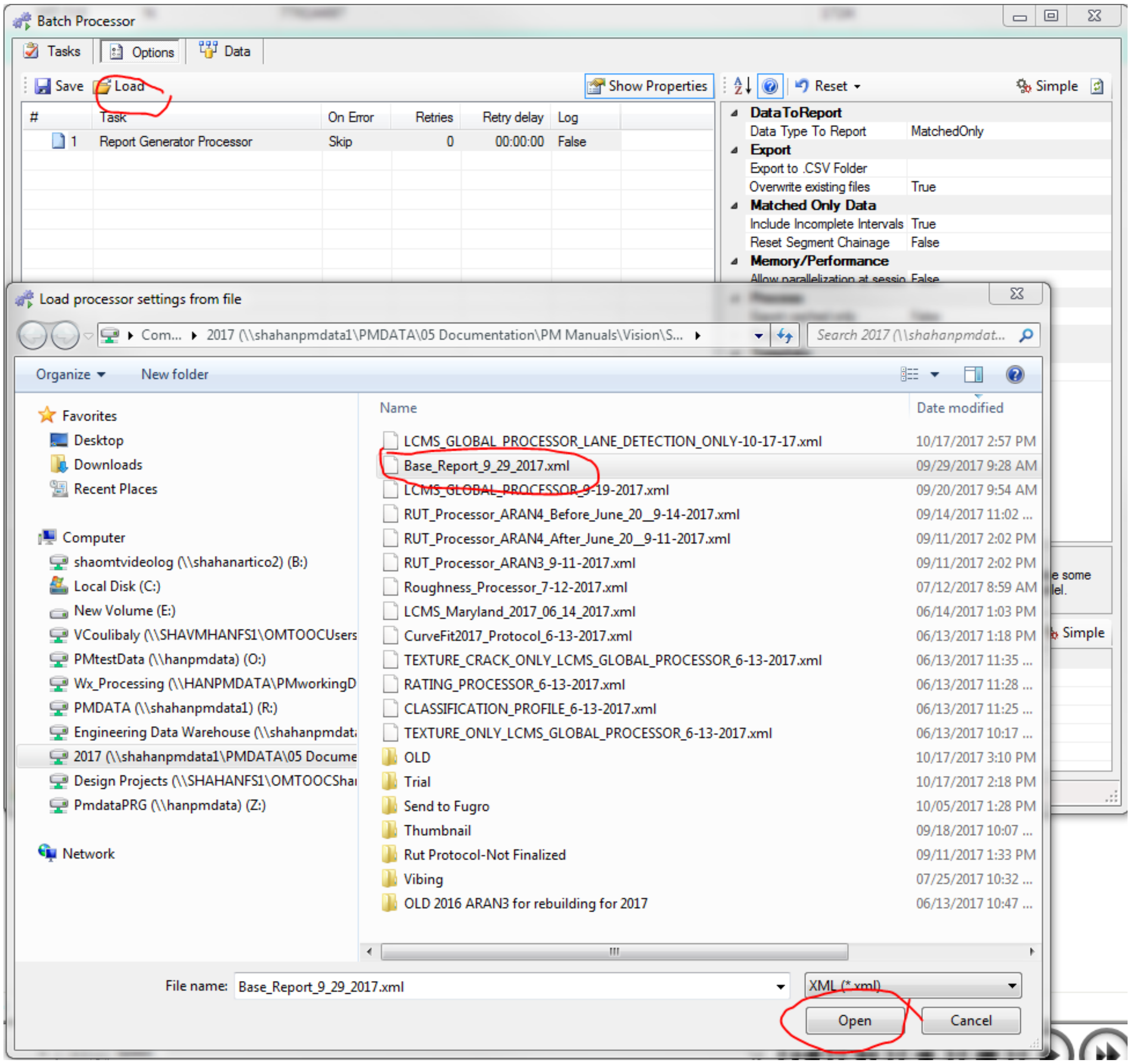
Step 8. Open Vision.

Step 9. Click the "Process" drop-down menu. Select "New Batch Processor." The "Batch Processor" window will open (see below image).



Step 10. Click the box next to “Report Generator Processor” in the window on the right.

Step 11. Click the “Options” tab. Instead of changing settings manually, search for preset schemas. Click the “Load” button. Navigate to the folder where schema files are stored[06/12/2019]. In this folder, look for an XML file named “Base_Report_[MOST RECENTDATE].” Select the file and click “Open” (see below image).

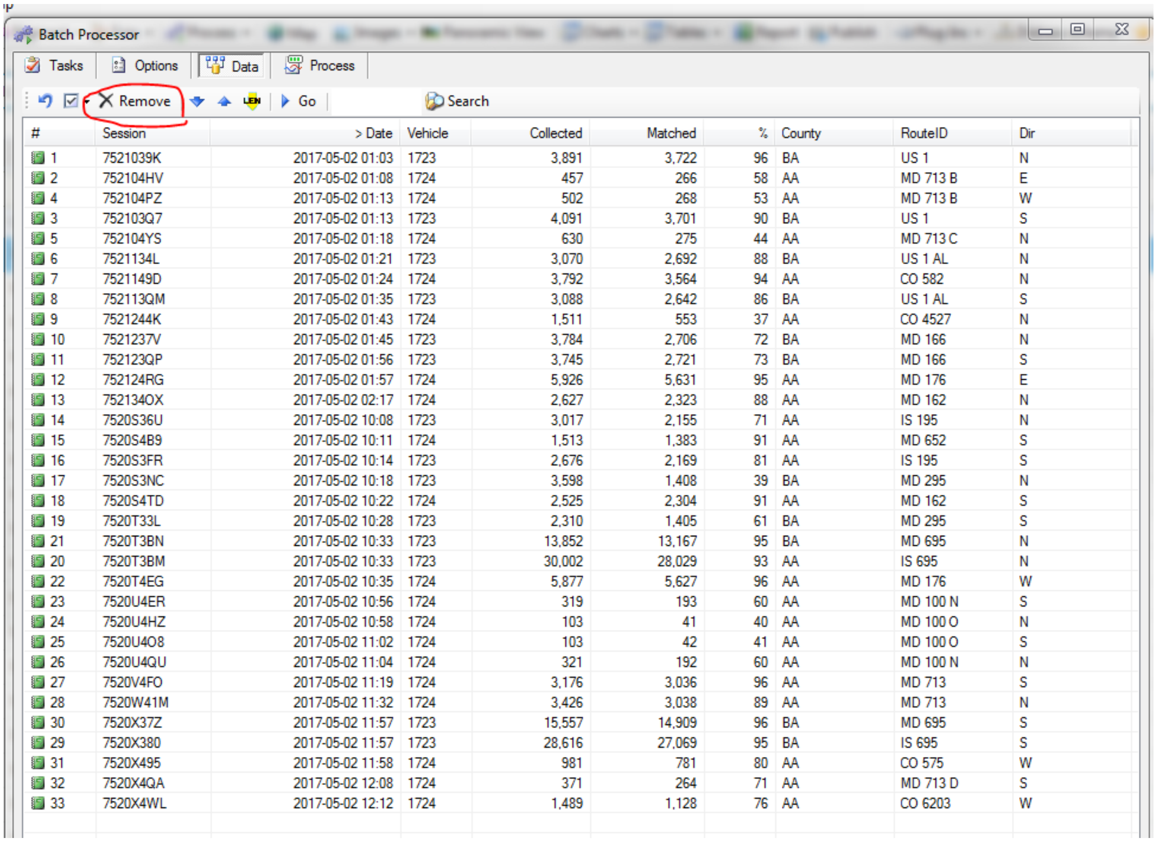


Step 12. Click "Data" from the top menu bar. Every file in the database will appear in the window. The list must be filtered to only include the sections from the current batch. This can be accomplished through two different methods:

i. Removing unwanted files, or

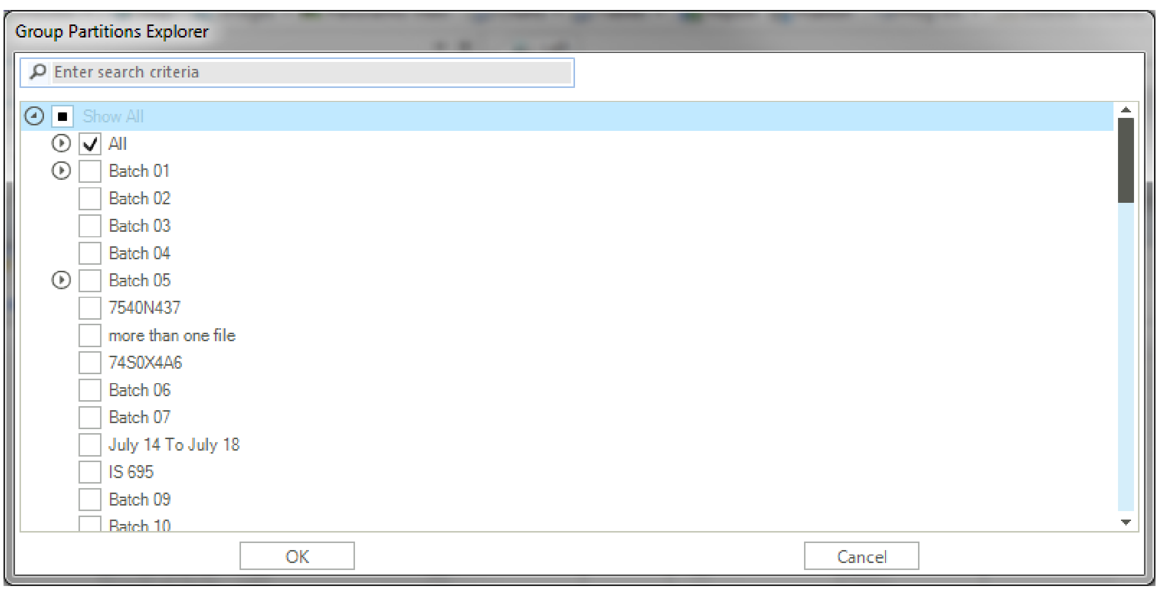
ii. Removing all files and selecting a batch to re-add.

Step 13. Choose removal method. If removing all files and selecting a batch to re-add is preferred, skip to Step 7. Otherwise, use a combination of the Shift and Ctrl keys to highlight all unwanted files in the window. Click "Remove." Proceed to Step 8 (see below image).



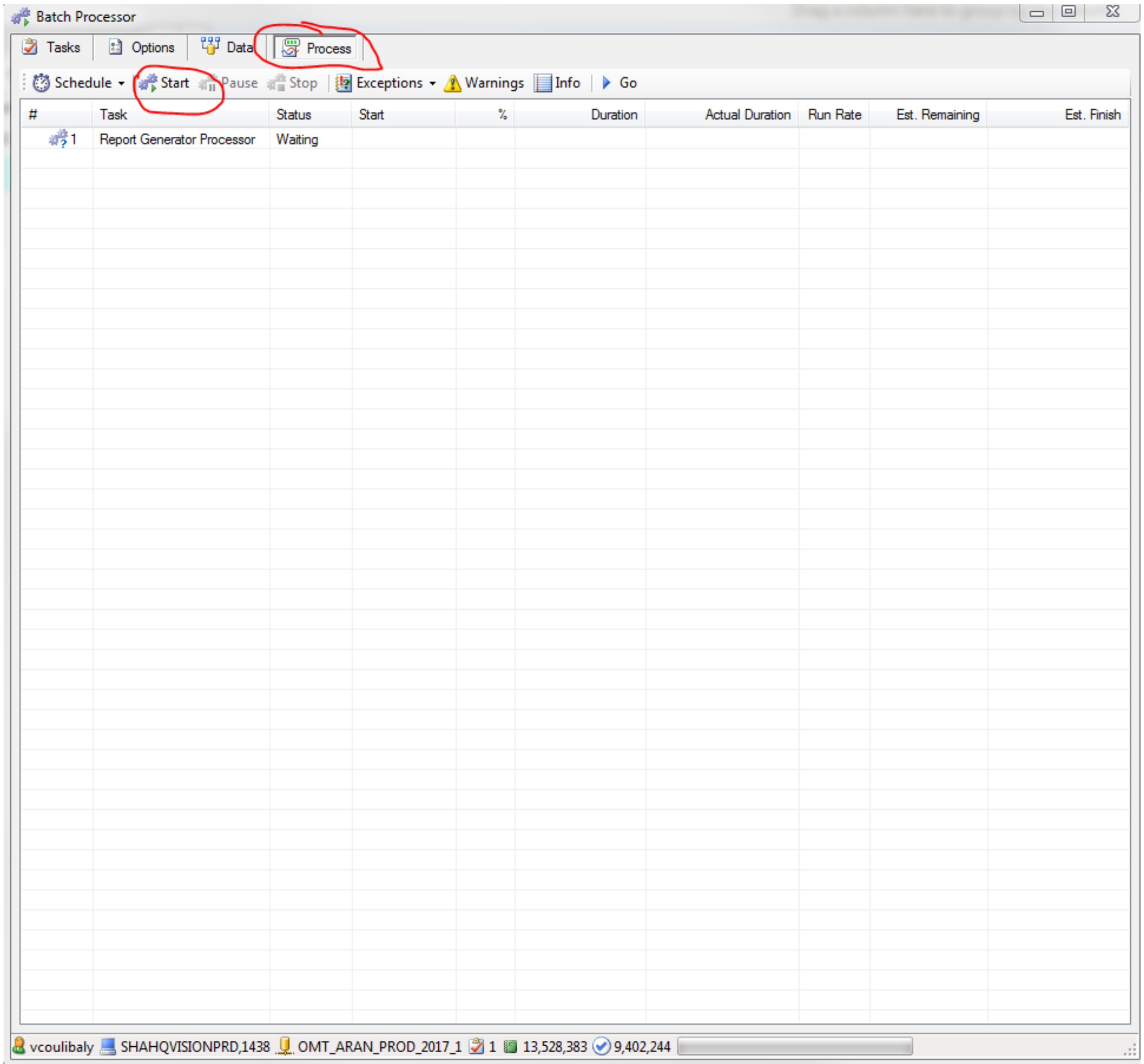
#	Session	> Date	Vehicle	Collected	Matched	%	County	RouteID	Dir
1	7521039K	2017-05-02 01:03	1723	3,891	3,722	96	BA	US 1	N
2	752104HV	2017-05-02 01:08	1724	457	266	58	AA	MD 713 B	E
4	752104PZ	2017-05-02 01:13	1724	502	268	53	AA	MD 713 B	W
3	752103Q7	2017-05-02 01:13	1723	4,091	3,701	90	BA	US 1	S
5	752104YS	2017-05-02 01:18	1724	630	275	44	AA	MD 713 C	N
6	7521134L	2017-05-02 01:21	1723	3,070	2,692	88	BA	US 1 AL	N
7	7521149D	2017-05-02 01:24	1724	3,792	3,564	94	AA	CO 582	N
8	752113QM	2017-05-02 01:35	1723	3,088	2,642	86	BA	US 1 AL	S
9	7521244K	2017-05-02 01:43	1724	1,511	553	37	AA	CO 4527	N
10	7521237V	2017-05-02 01:45	1723	3,784	2,706	72	BA	MD 166	N
11	752123QP	2017-05-02 01:56	1723	3,745	2,721	73	BA	MD 166	S
12	752124RG	2017-05-02 01:57	1724	5,926	5,631	95	AA	MD 176	E
13	752134OX	2017-05-02 02:17	1724	2,627	2,323	88	AA	MD 162	N
14	7520S36U	2017-05-02 10:08	1723	3,017	2,155	71	AA	IS 195	N
15	7520S4B9	2017-05-02 10:11	1724	1,513	1,383	91	AA	MD 652	S
16	7520S3FR	2017-05-02 10:14	1723	2,676	2,169	81	AA	IS 195	S
17	7520S3NC	2017-05-02 10:18	1723	3,598	1,408	39	BA	MD 295	N
18	7520S4TD	2017-05-02 10:22	1724	2,525	2,304	91	AA	MD 162	S
19	7520T33L	2017-05-02 10:28	1723	2,310	1,405	61	BA	MD 295	S
21	7520T3BN	2017-05-02 10:33	1723	13,852	13,167	95	BA	MD 695	N
20	7520T3BM	2017-05-02 10:33	1723	30,002	28,029	93	AA	IS 695	N
22	7520T4EG	2017-05-02 10:35	1724	5,877	5,627	96	AA	MD 176	W
23	7520U4ER	2017-05-02 10:56	1724	319	193	60	AA	MD 100 N	S
24	7520U4HZ	2017-05-02 10:58	1724	103	41	40	AA	MD 100 O	N
25	7520U4O8	2017-05-02 11:02	1724	103	42	41	AA	MD 100 O	S
26	7520U4QU	2017-05-02 11:04	1724	321	192	60	AA	MD 100 N	N
27	7520V4FO	2017-05-02 11:19	1724	3,176	3,036	96	AA	MD 713	S
28	7520W41M	2017-05-02 11:32	1724	3,426	3,038	89	AA	MD 713	N
30	7520X37Z	2017-05-02 11:57	1723	15,557	14,909	96	BA	MD 695	S
29	7520X380	2017-05-02 11:57	1723	28,616	27,069	95	BA	IS 695	S
31	7520X495	2017-05-02 11:58	1724	981	781	80	AA	CO 575	W
32	7520X4QA	2017-05-02 12:08	1724	371	264	71	AA	MD 713 D	S
33	7520X4WL	2017-05-02 12:12	1724	1,489	1,128	76	AA	CO 6203	W

Step 14. To remove all files, click the "Check" drop-down menu and select "All." Click "Remove." Then, click the "Reload" (first blue arrow) button. The "Group Partitions" window will open (see below image).



Select the current batch by clicking the checkbox next to the appropriate batch name. Click the "OK."

Step 15. Once only the desired files appear in the "Batch Processor" window, they may be processed. Click "Process", then "Start." The files will begin to appear under the session window (see below image).



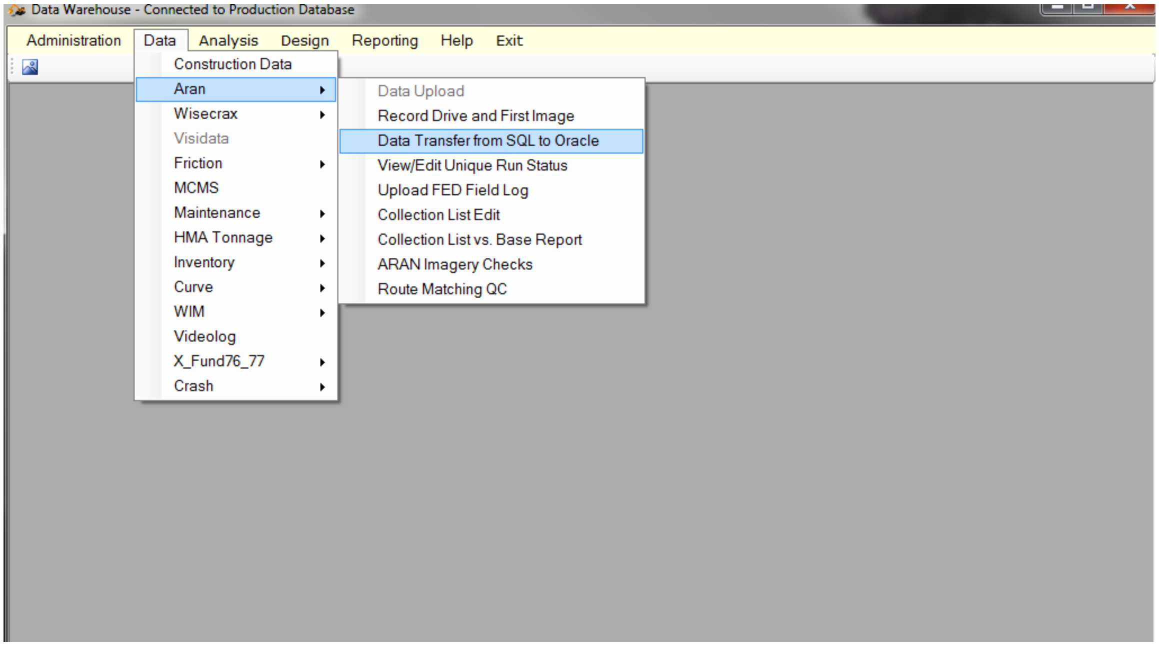
A dialogue box will appear when processing is complete.

3- Uploading Data from Vision to Oracle – *performed by EDW user*

Summary: This task uses the EDW to migrate processed data from Vision to Oracle in the form of "Base_#" tables.

Step 16. Open the Engineering Data Warehouse application.

Step 17. Click the "Data" drop-down menu and select "Aran", then "Data Transfer from SQL to Oracle" (see below image).



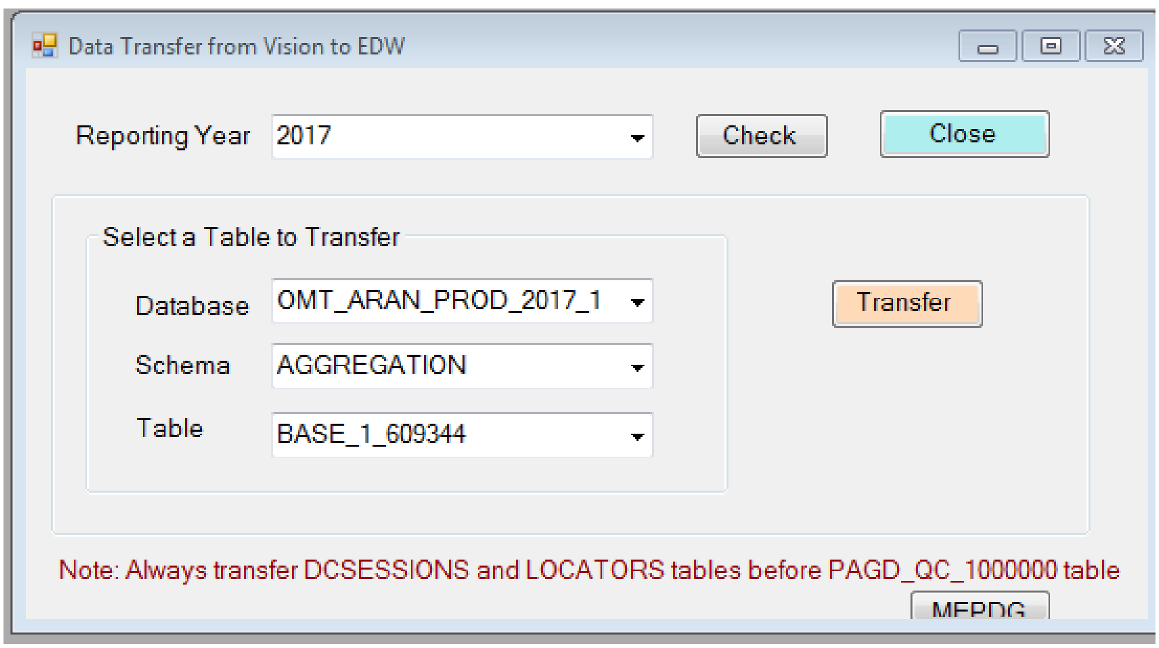
Step 18. The "Data Transfer from Vision to EDW" window will appear. Ensure the following items are selected then click "Transfer" (see below image):

i. Reporting Year – "[Current Year]"

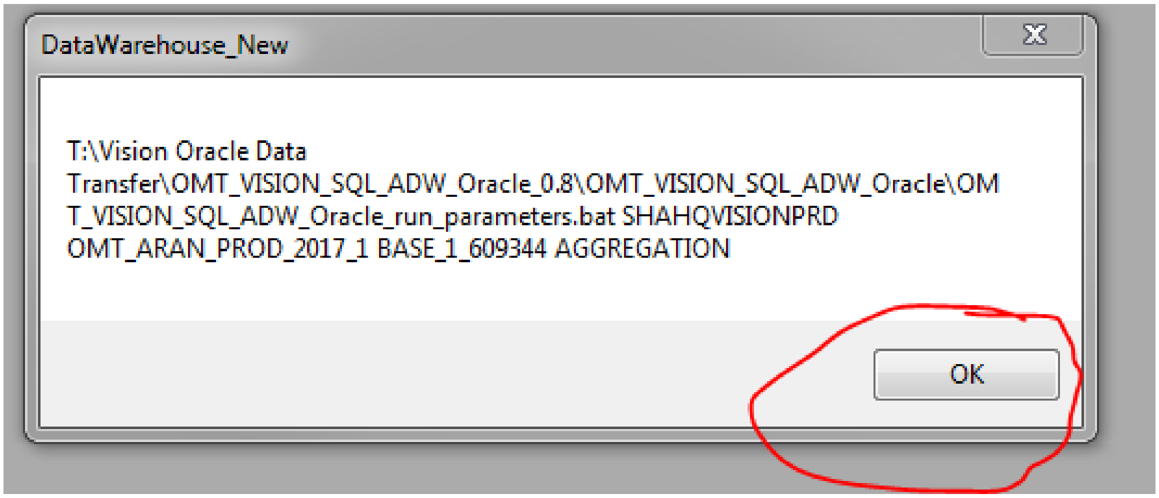
ii. Database – "OMT_ARAN_PROD_[CURRENTYEAR]_1"

iii. Schema – "AGGREGATION"

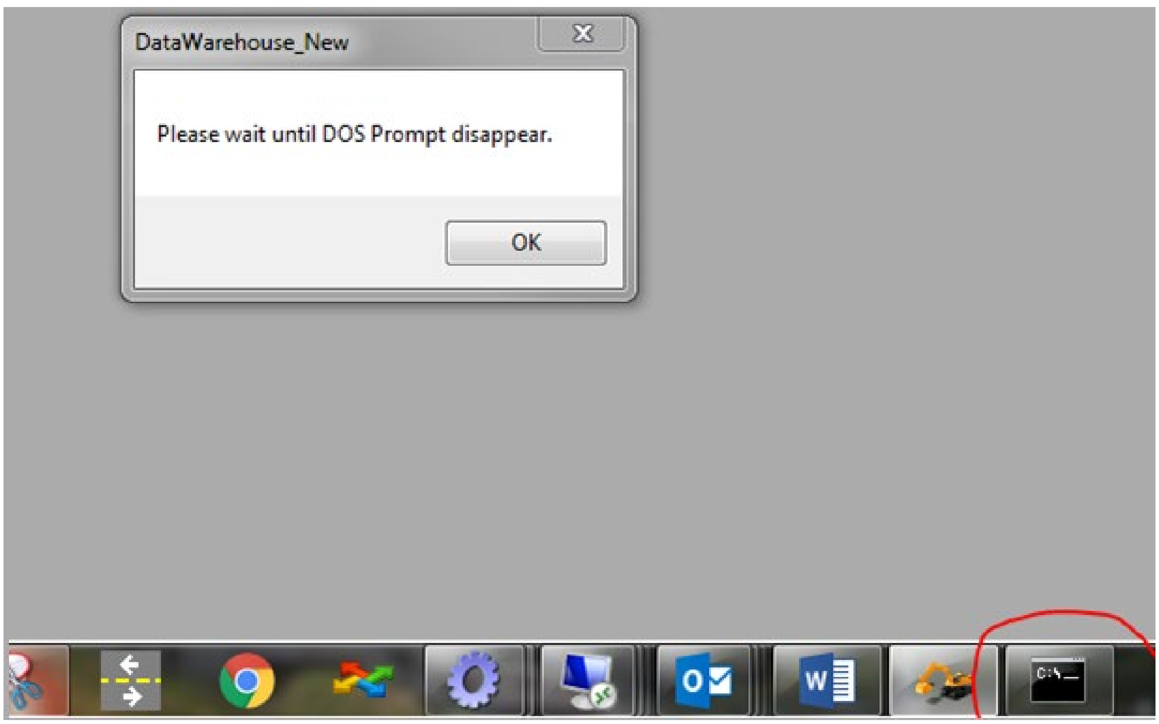
iv. Table – "BASE_1_609344"



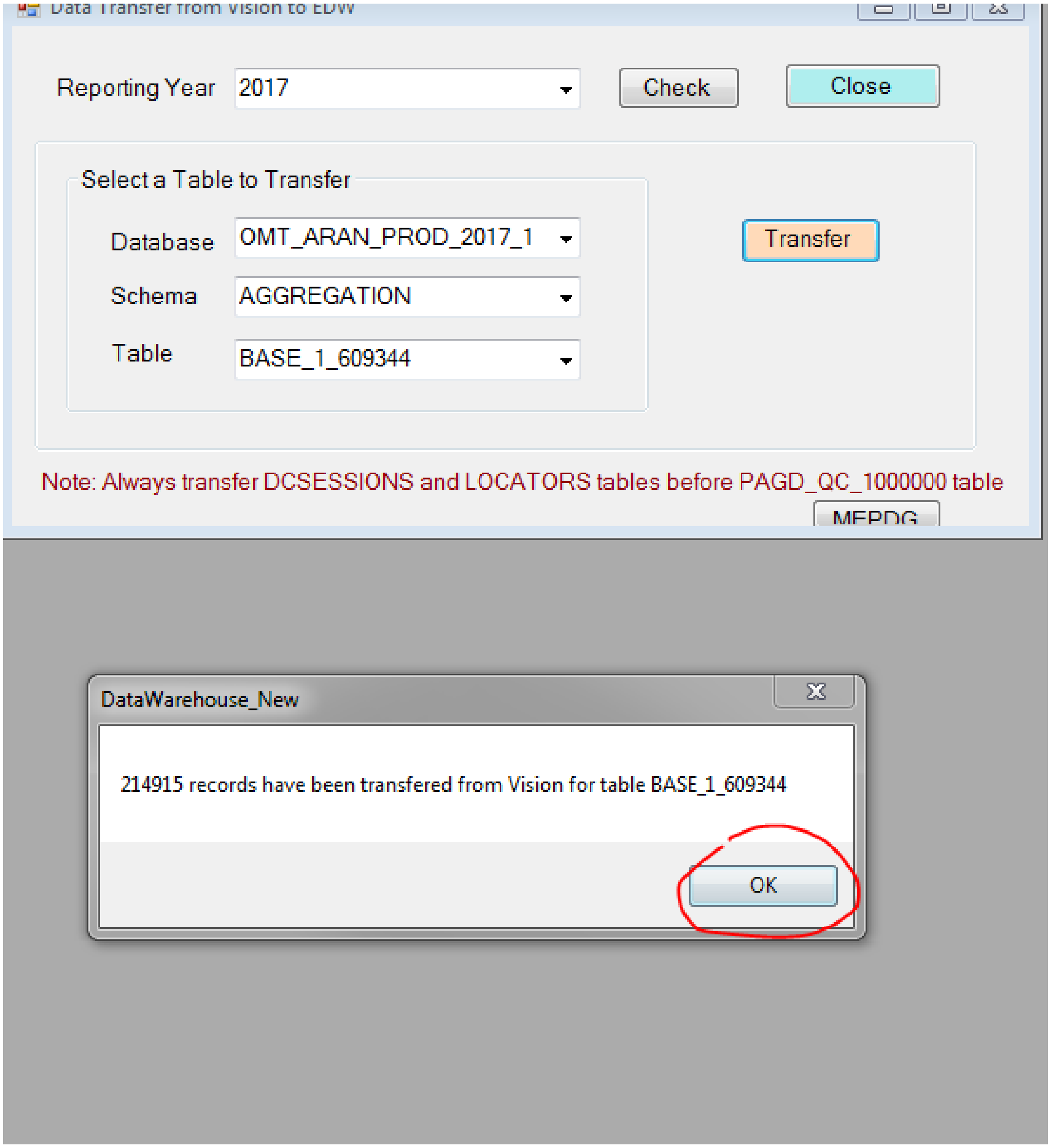
Step 19. Click "OK" on the following prompt (see below image).



Step 20. Click "OK" after the DOS prompt disappears (see below image).



Step 21. A window will appear indicating that the records have been transferred. Click "OK" (see below image).



Step 22. Repeat Step 18 to Step 21 three times, changing the “Table” drop-down option in Step 18 to “BASE_4_437376”, then “BASE_100_934”, and finally “BASE_1000000” in that order. Please note that the EDW program first calls the “TALENT” tool to transfer a base table such as “BASE_1_609344” in Vision to a stage table named “VISION_ BASE_1_609344” in Oracle, then a stored procedure named “UPD_VISION_TABLE” in Oracle production database will be called by EDW to move the data from this stage table into the final base table “EDW17_BASE_1” in Oracle using 2017 data collection as example.

4- Performing QA of Uploaded Data – *performed by Supervisor*

Summary: This task performs QA checks on the uploaded data tables.

The completeness check is needed to make sure a) the base tables in Oracle do not contain any invalid runs or “not to use” runs marked in EDIT_CUR_YR table, and b) the base tables in Oracle contain all the valid runs in EDIT_CUR_YR table. This completeness check is currently done by running a SQL query. The base tables after the clean-up will serve as the basis for populating the business plan tables. Then, the speed adjustment fields are checked to ensure they were created and populated correctly. Finally, the data in the tables are checked for reasonableness.

5.14 REFORMATTING ARAN HARD DRIVES

5.14.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to consolidate and reformat the hard drives which contain data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff. Consolidation and re-formatting may occur any time after the ARAN data has been loaded into the Vision database, as outlined in Loading of ARAN Data into Vision.

5.14.02 *Frequency*

Consolidation and reformatting of ARAN hard drives occurs sporadically, whenever external hard drive space is low (available hard drives are all full or in use).

5.14.03 *Purpose*

The purpose of this SOP is to free up space on the ARAN hard drives so that more data can be collected. The drives are consolidated to save space and then reformatted so that they may be used again.

5.14.04 *Resource Requirements*

Consolidation and reformatting of ARAN hard drives involves two people: (1) a user familiar with computer data storage to consolidate and reformat the drives, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the consolidation and re-formatting. These time estimates assume no issues are encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Operator	1	4.0
DPT TL	Supervisor	1	AR[06/12/2019]

5.14.05 *Procedure*

The procedure to consolidate and reformat ARAN hard drives is comprised of a single task:

(1) consolidating and reformatting ARAN hard drive.

1- Consolidating and Reformatting ARAN Hard Drive – *performed by operator*

Summary: This task consolidates and reformats an ARAN hard drive.

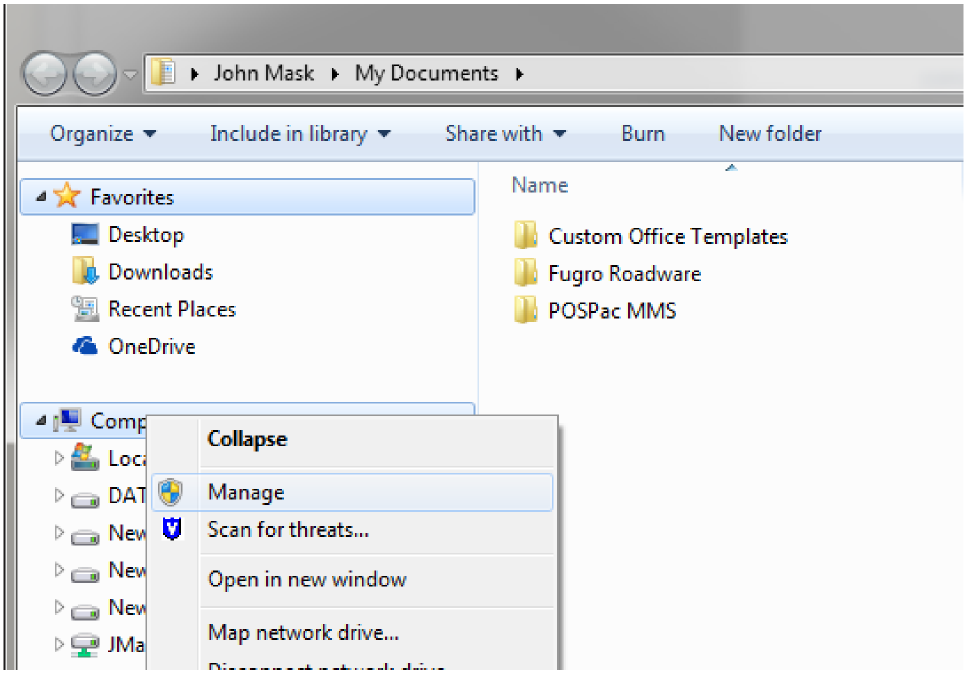
Step 1. Prior to consolidation, copy all data from the hard drive to another drive and re-record the drive data.

Step 2. Place the drive that has been backed up as part of Step 1 into the offline computer. "Admin" rights are needed to reformat drives.

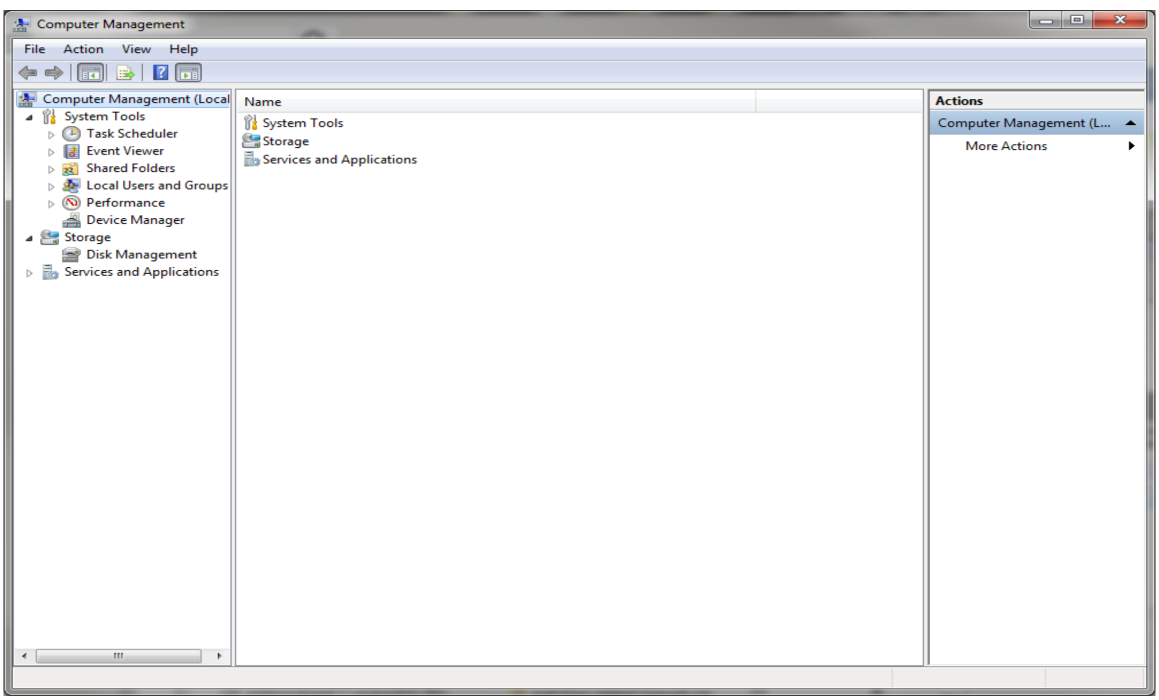
Step 3. Turn the computer on and log-in using proper credentials.

Step 4. Once the computer has initialized and user is logged in, press the "Windows Key" and "E" on the keyboard.

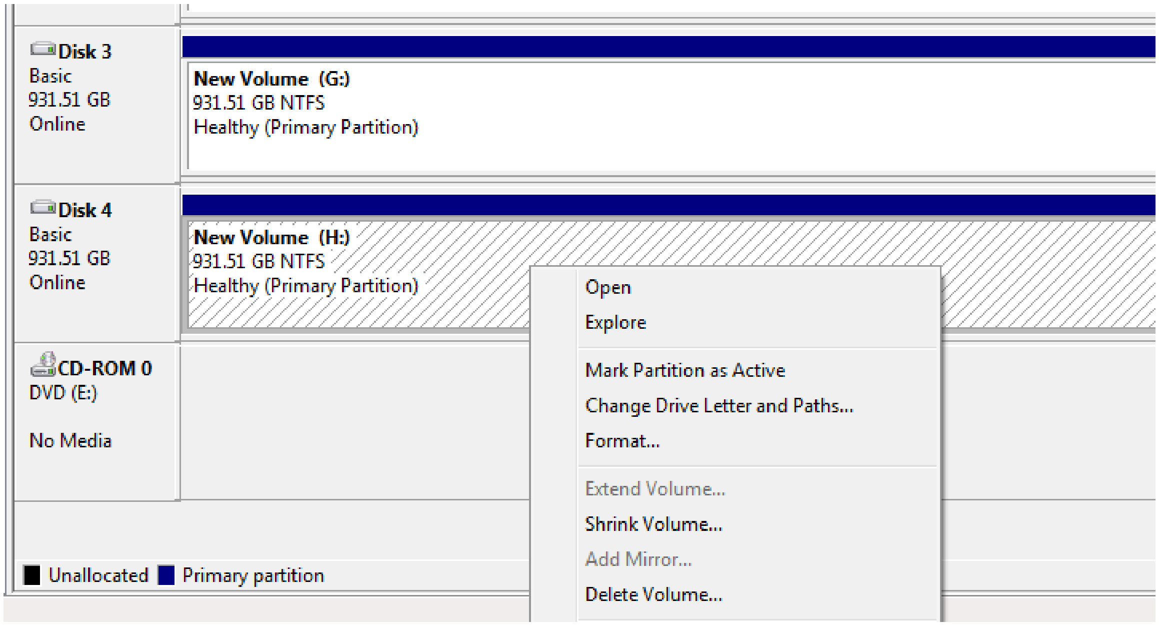
Step 5. The "My Computer" window will open. Right click on "Computers" on the left side of the menu. Select "Manage" (see below image).



Step 6. The "Computer Management" window will open. Find "Storage" on the left side of the menu and select the sub-item "Disk Management" (see below image). The computer may take a few moments to load the disk configuration information.



Step 7. Right-click on the drive to be reformatted. Select "Format" (see below image).



Step 8. On the next window, click "OK." Reformatting will begin.

Step 9. Once the reformatting has completed, click "OK."

Step 10. Place the reformatted drive in a separate location and alert the FED of its location.

5.15 CREATING PAGDQC REPORT

5.15.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to create the "Pavement and Geotechnical Division Quality Control" (PAGDQC) report and upload it to the Engineering Data Warehouse (EDW). The report details the Automatic Road Analyzer (ARAN) data collected in the field by Field Explorations Division (FED) staff. The report is utilized within several other post-processing activities by the DPT.

5.15.02 *Frequency*

Creating and importing the PAGDQC Report is conducted in-part with other post-processing SOPs utilized by the DPT. The DPT processes ARAN collected data in batches upon receipt from the FED. Each ARAN data batch is typically delivered to the DPT every 4 to 5 days. Assuming an average of 60 miles collected per day, each batch contains, on average, between 240 and 300 miles of ARAN data. The actual frequency varies according to the proximity of the routes on which data were collected for the data batch to the Office of Materials Technology (OMT) office and it ranges from 1 day (when collected near the OMT office) to 2 weeks (when collected far from the OMT office). Shorter turn-around periods are preferred to minimize the amount of mileage requiring data recollection. The annual ARAN data collection season typically lasts from March to Mid-December.

5.15.03 *Purpose*

The purpose of this SOP is to create the PAGD QC Report and upload it to the EDW.

5.15.04 *Resource Requirements*

The creation and import of the PAGDQC Report involves two people: (1) a user knowledgeable in Roadware Vision software to create the PAGDQC Report and upload it to the EDW and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the report generation and upload. These time estimates assume average batch quantities and that no issues are to be addressed.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision User	1	1.0
DPT Team Leader (TL)	Supervisor	1	AR[06/12/2019]

5.15.05 *Procedure*

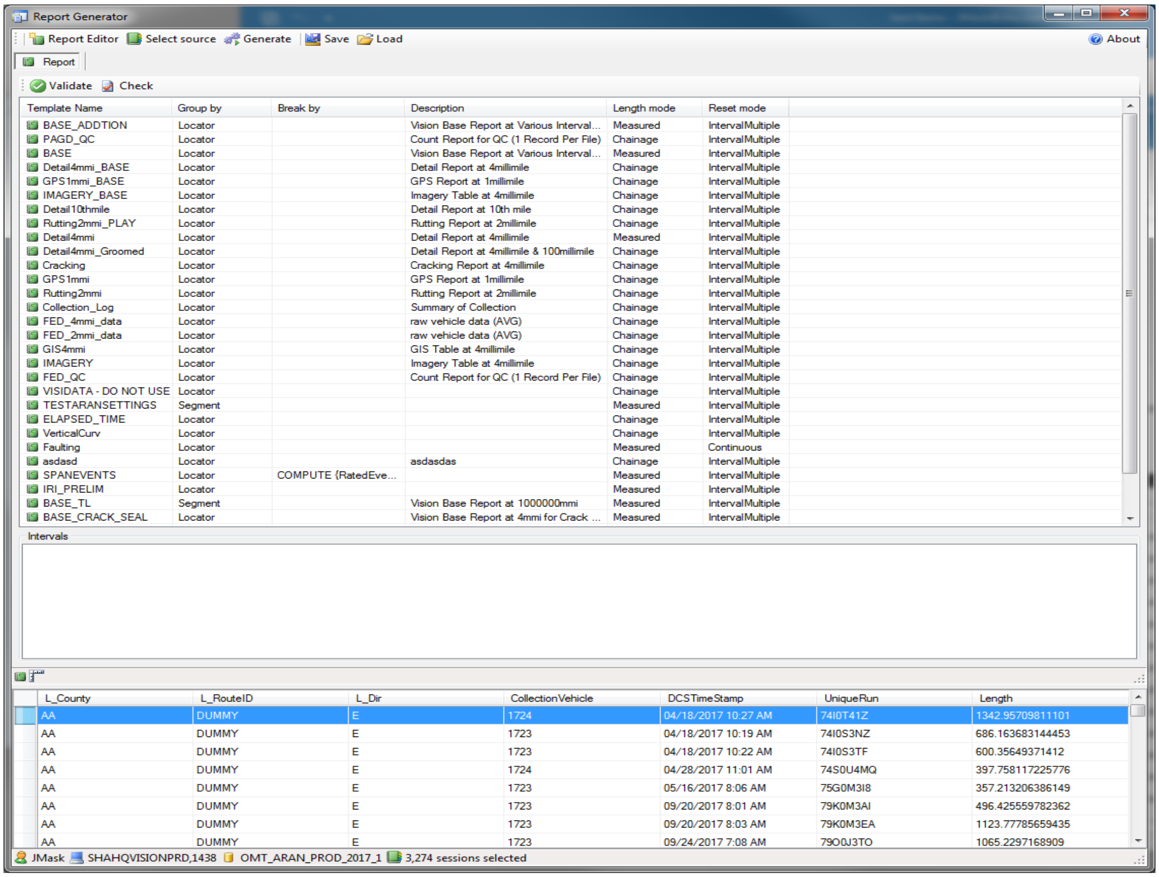
The procedure followed by the DPT staff for creation and import of the PAGDQC Report is comprised of a single task:

(1) creating and importing PAGDQC Report.

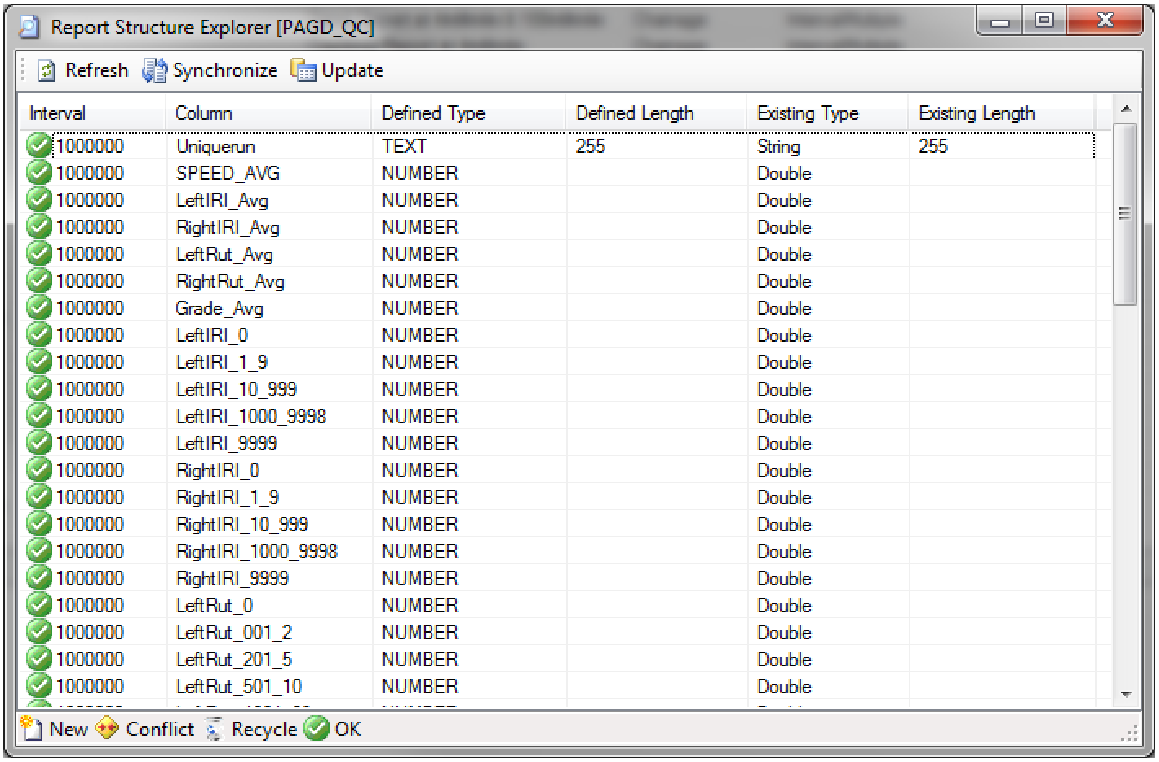
1- Creating and Importing PAGDQC Report – *to be completed by DPT Staff*

Summary: This task creates and populates a PAGD_QC_CSV file for all collection runs imported into the Vision database for each FED submission. The file is then imported into the EDW to update the Edit/View Unique Run Status program to allow tracking, status, and notes of each collection run (FED QC/QA, Route Matching QC/QA, etc.).

Step 1. Open Roadware Vision program. Click the "Report" drop-down menu and select "Report Generator" and the "Report Generator" window will appear (see below image).



Step 2. Select "PAGD_QC" from the list of reports. Click "Check." The "Report Structure Explorer" window will open (see below image).


Report Structure Explorer [PAGD_QC]

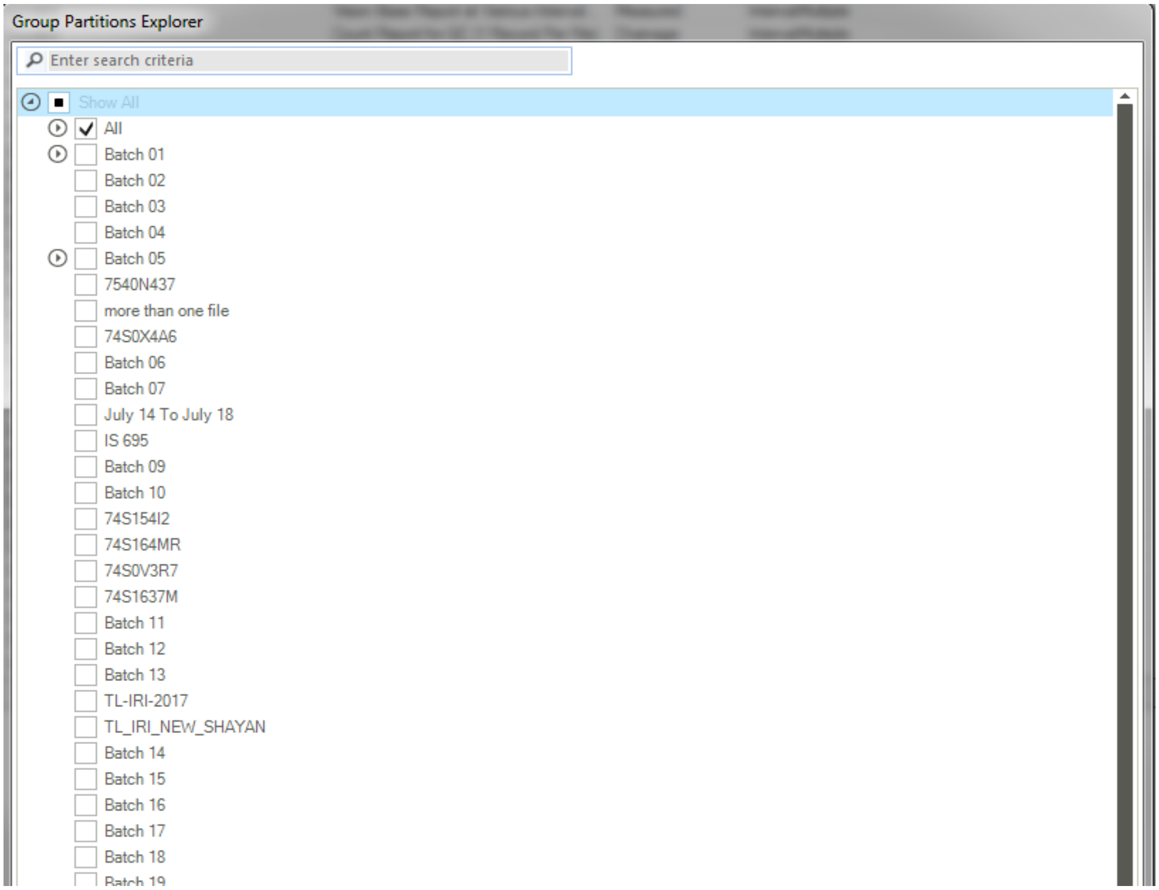
Refresh Synchronize Update

Interval	Column	Defined Type	Defined Length	Existing Type	Existing Length
1000000	Uniquerun	TEXT	255	String	255
1000000	SPEED_AVG	NUMBER		Double	
1000000	LeftIRI_Avg	NUMBER		Double	
1000000	RightIRI_Avg	NUMBER		Double	
1000000	LeftRut_Avg	NUMBER		Double	
1000000	RightRut_Avg	NUMBER		Double	
1000000	Grade_Avg	NUMBER		Double	
1000000	LeftIRI_0	NUMBER		Double	
1000000	LeftIRI_1_9	NUMBER		Double	
1000000	LeftIRI_10_999	NUMBER		Double	
1000000	LeftIRI_1000_9998	NUMBER		Double	
1000000	LeftIRI_9999	NUMBER		Double	
1000000	RightIRI_0	NUMBER		Double	
1000000	RightIRI_1_9	NUMBER		Double	
1000000	RightIRI_10_999	NUMBER		Double	
1000000	RightIRI_1000_9998	NUMBER		Double	
1000000	RightIRI_9999	NUMBER		Double	
1000000	LeftRut_0	NUMBER		Double	
1000000	LeftRut_001_2	NUMBER		Double	
1000000	LeftRut_201_5	NUMBER		Double	
1000000	LeftRut_501_10	NUMBER		Double	

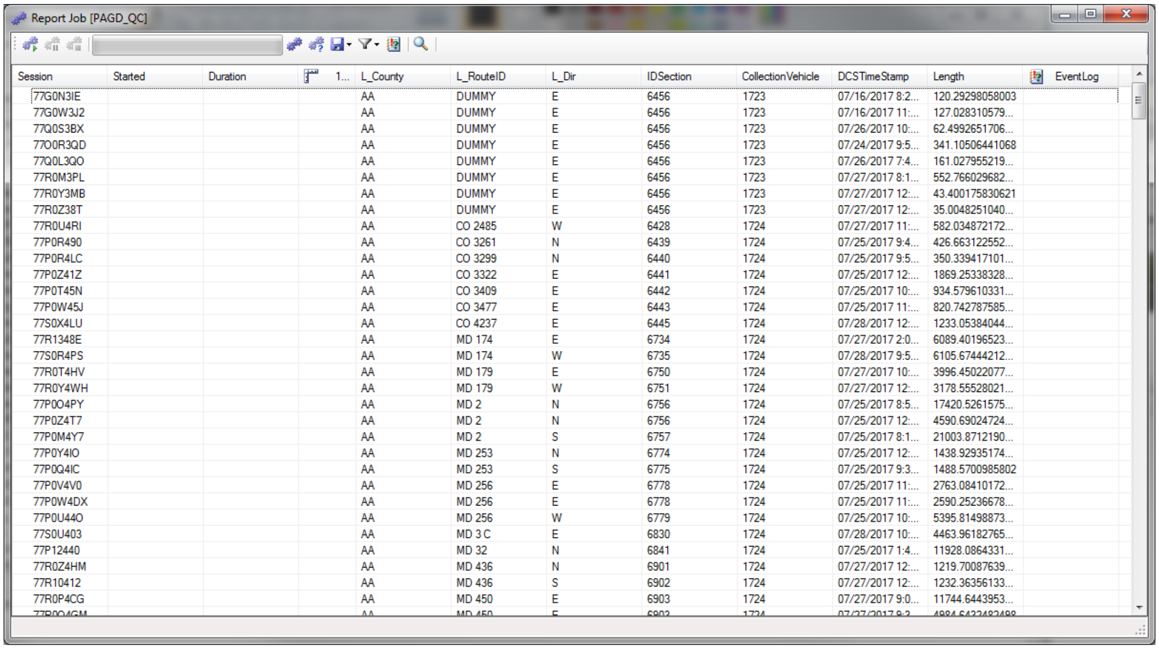
New Conflict Recycle OK

Step 3. Click the "Synchronize" button (see above image). When the button un-highlights itself, the process is complete. Now, click "Update" and wait for the button to un-highlight itself as well. Performing these two actions clears the PAGD_QC table in Vision$^{06/12/2019}$. Close the "Report Structure Explorer" window.

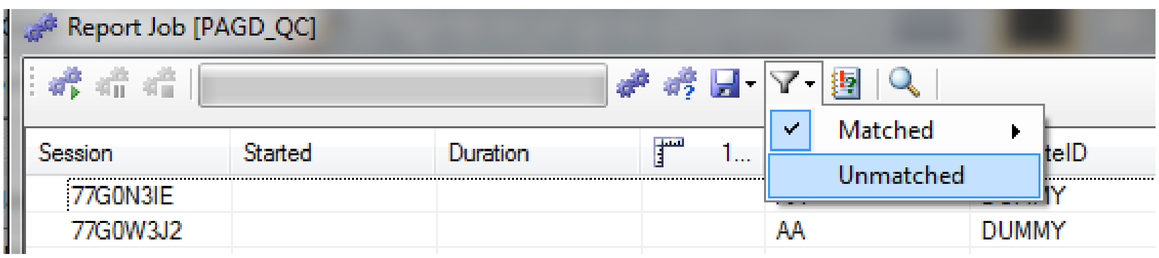
Step 4. Click the "Select Source" button. The "Group Partitions Explorer" will open (see below image). Choose the batch of data to be reported (or create a batch to select the correct data). Click "OK."



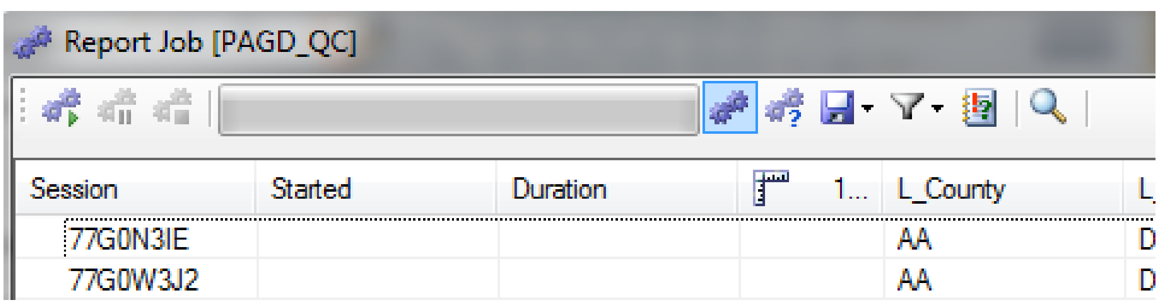
Step 5. The selected files will be shown in the bottom of the “Report Generator” window. Confirm they are correct. If they are incorrect, return to Step 4. Otherwise, click “Generate.” The “Report Job” window will open (see below image).



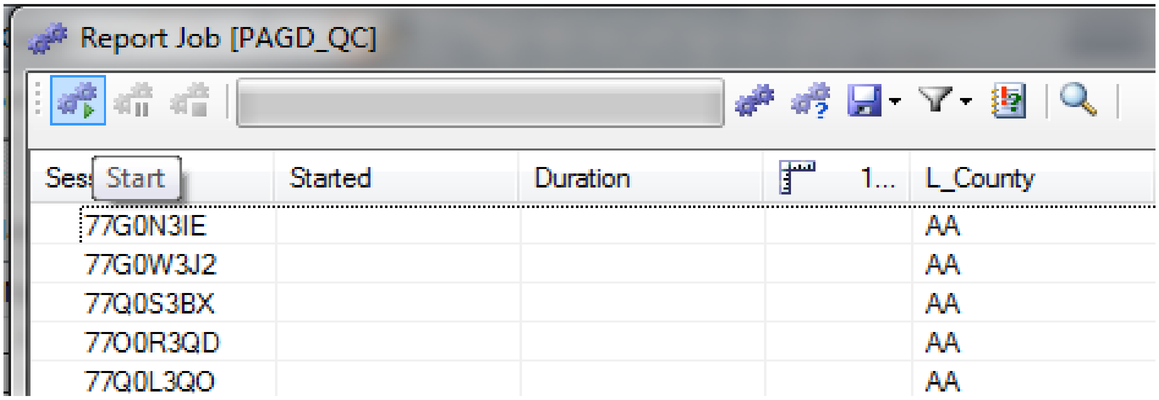
Step 6. Update settings. Click the "Filter "button and select "Unmatched." This will run the report on both Matched and Unmatched files (see below image).



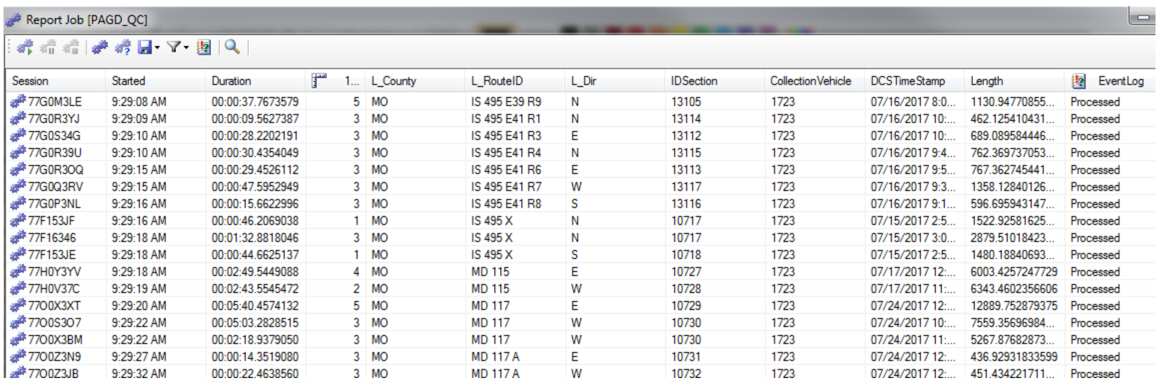
Click the "Regenerate" button (see below image, button is highlighted in blue).



Click the "Start" button (see below image, button is highlighted in blue).

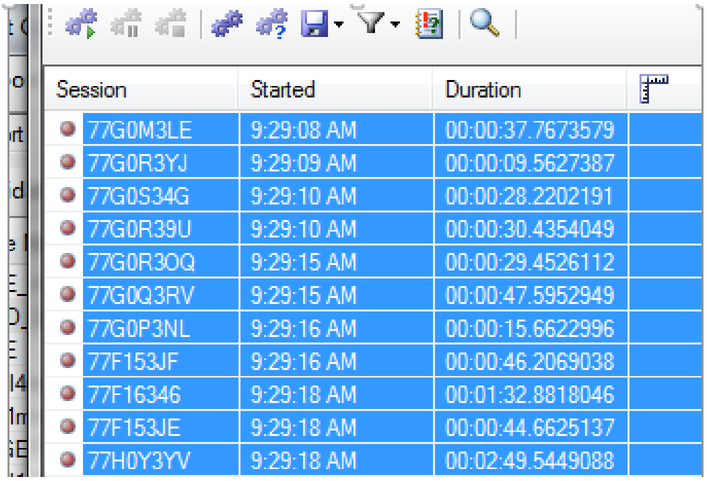


Step 7. Files will begin processing. The “Eventlog” column will indicate the status of the processing. A progress bar will also estimate the overall status. When the program is complete, the progress bar will disappear and the “Eventlog” column will say “Processed” for each file (see below image).



Step 8. If the PAGD_QC is being run on a submission, it must be exported. Otherwise, proceed to Step 9.

To export, click the drop-down arrow next to the “Save” button and select “Export all” (see below image). Browse for the appropriate folder location and click “OK.” Click “Yes” to overwrite existing files. As the program writes the export, a red circle will appear beside each file (see below image). A dialogue box will appear when the export is finished. Click “OK.”

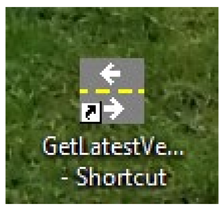


To confirm the export, navigate to the folder where the export was saved. The file should be called “PAGD_QC_1000000.csv”. Open the file and ensure there are no gaps in the data. Below is a table of column headers and a note on whether they should contain data.

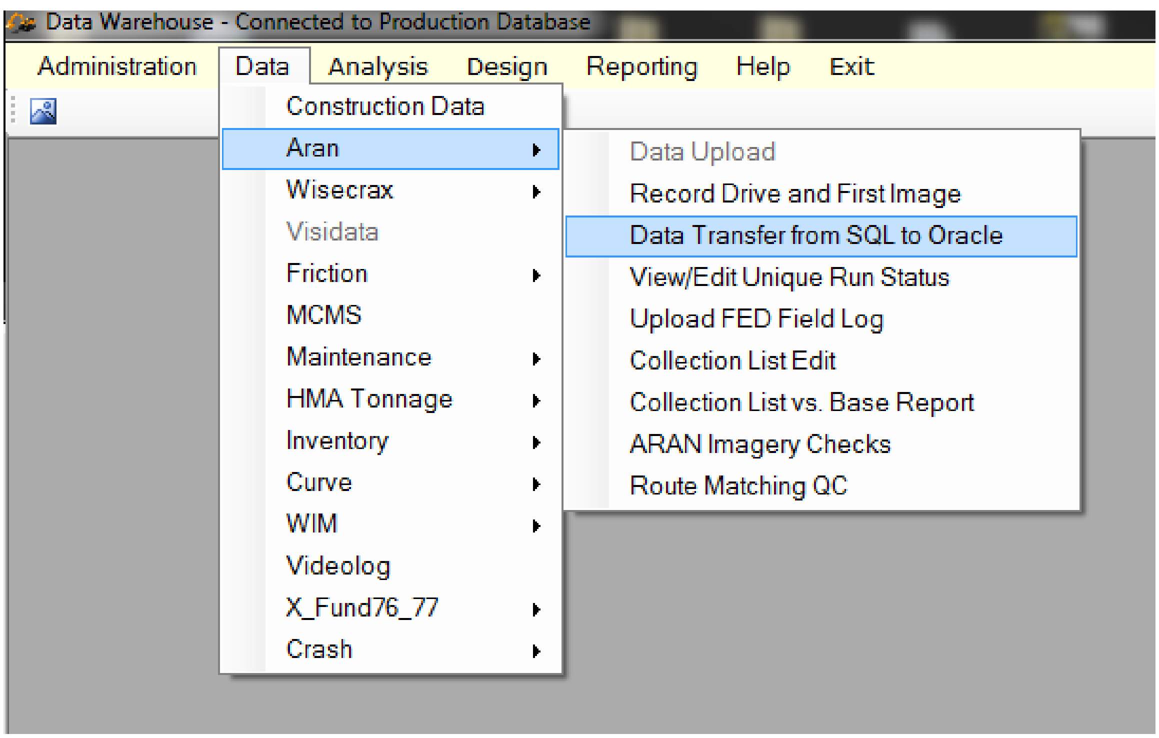
Field	Data?	Field	Data?
IDLocator	Data	RightRut_501_10	Blank
L_County	Data	RightRut_1001_99	Blank
L_RouteID	Data	Grade_N_99_1001	Blank
L_Dir	Data	Grade_N_10_501	Blank
UniqueRun	Data	Grade_N_5_001	Blank
CollectionVehicle	Data	Grade_0	Blank
DCSTimeStamp	Data	Grade_001_5	Blank
IDSession	Data	Grade_501_10	Blank
BeginDistanceStamp	Data	Grade_10_99	Blank
EndDistanceStamp	Data	LeftIRI_TotalRecords	Data
BeginChainage	Data	RightIRI_TotalRecords	Data
EndChainage	Data	LeftRut_TotalRecords	Blank
Status	Data	RightRut_TotalRecords	Blank
Uniquerun1	Data	Grade_TotalRecords	Blank
SPEED_AVG	Data	GPSTime_MAX	Data
LeftIRI_Avg	Data	GPSTime_MIN	Data
RightIRI_Avg	Data	GPSTime_COUNT	Data
LeftRut_Avg	Blank	Hertz_Actual	Blank
RightRut_Avg	Blank	SPEED_STDEV	Data
Grade_Avg	Blank	SPEED_CV	Blank
LeftIRI_0	Blank	L_RUT_STDEV	Blank
LeftIRI_1_9	Blank	L_RUT_CV	Blank
LeftIRI_10_999	Data	R_RUT_STDEV	Blank
LeftIRI_1000_9998	Varies	R_RUT_CV	Blank
LeftIRI_9999	Blank	L_IRI_STDEV	Data
RightIRI_0	Blank	L_IRI_CV	Blank

Field	Data?	Field	Data?
RightIRI_1_9	Blank	R_IRI_STDEV	Data
RightIRI_10_999	Data	R_IRI_CV	Blank
RightIRI_1000_9998	Varies	GRADE_ABS_AVG	Blank
RightIRI_9999	Blank	GRADE_ABS_STDEV	Blank
LeftRut_0	Blank	GRADE_ABS_CV	Blank
LeftRut_001_2	Blank	XFALL_ABS_AVG	Blank
LeftRut_201_5	Blank	XFALL_ABS_STDEV	Blank
LeftRut_501_10	Blank	XFALL_ABS_CV	Blank
LeftRut_1001_99	Blank	COLL_CATEGORY	Data
RightRut_0	Blank	PRIORITY	Data
RightRut_001_2	Blank	RSECTION_COPY	Data
RightRut_201_5	Blank		

Step 9. Import PAGD_QC into the EDW. Open the program icon to the **left below** ("GetLatestVe…"), not the one to the right (see below images).



Step 10. When the program opens, navigate to "Data\ARAN\Data Transfer from SQL to Oracle" (see below image).



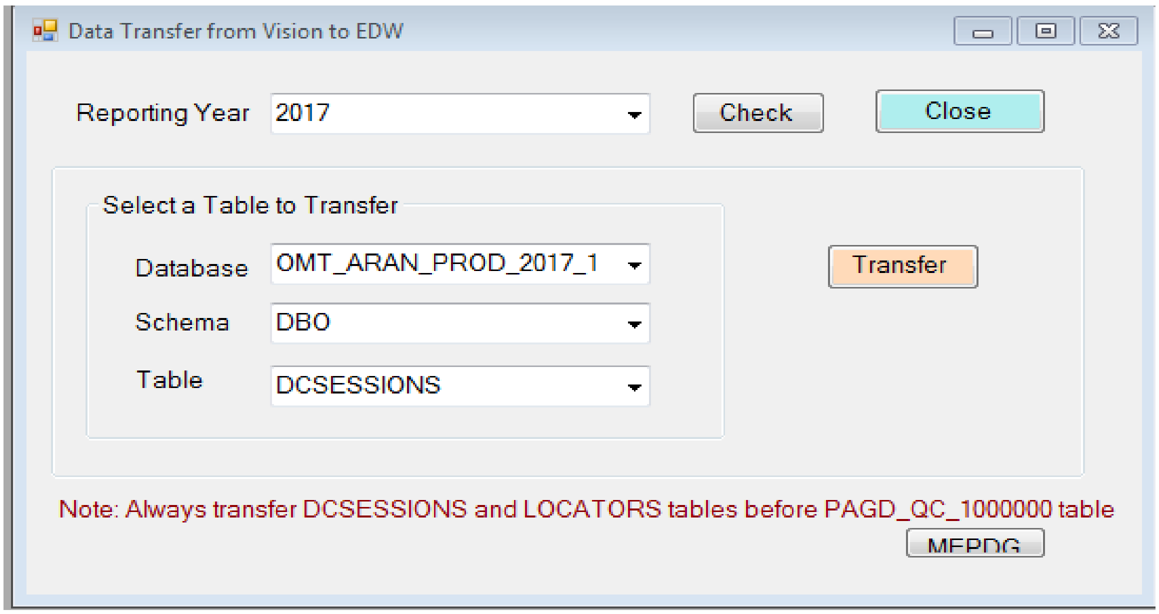
Step 11. The window below will open. Make the following changes to the window (see below image).

i. Change the “Reporting Year” to the correct year using the drop-down menu.

ii. Select database “OMT_ARAN_PROD_2017_1” using the drop-down menu.

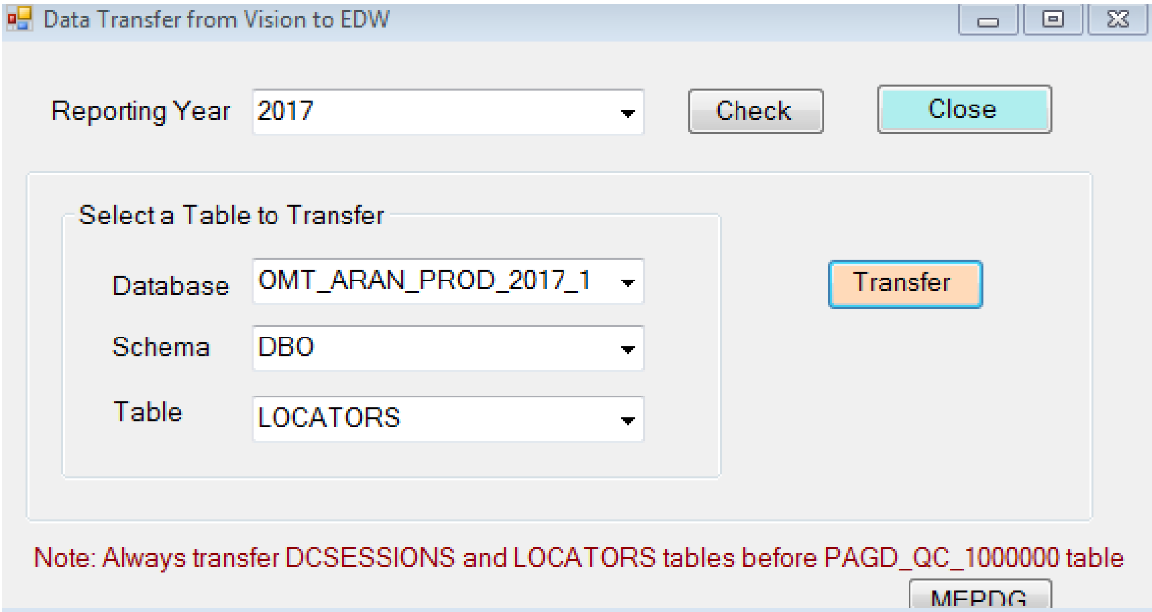
iii. Select DB Schema “DBO” using the drop-down menu.

iv. Select Table “DCSESSIONS” using the drop-down menu.

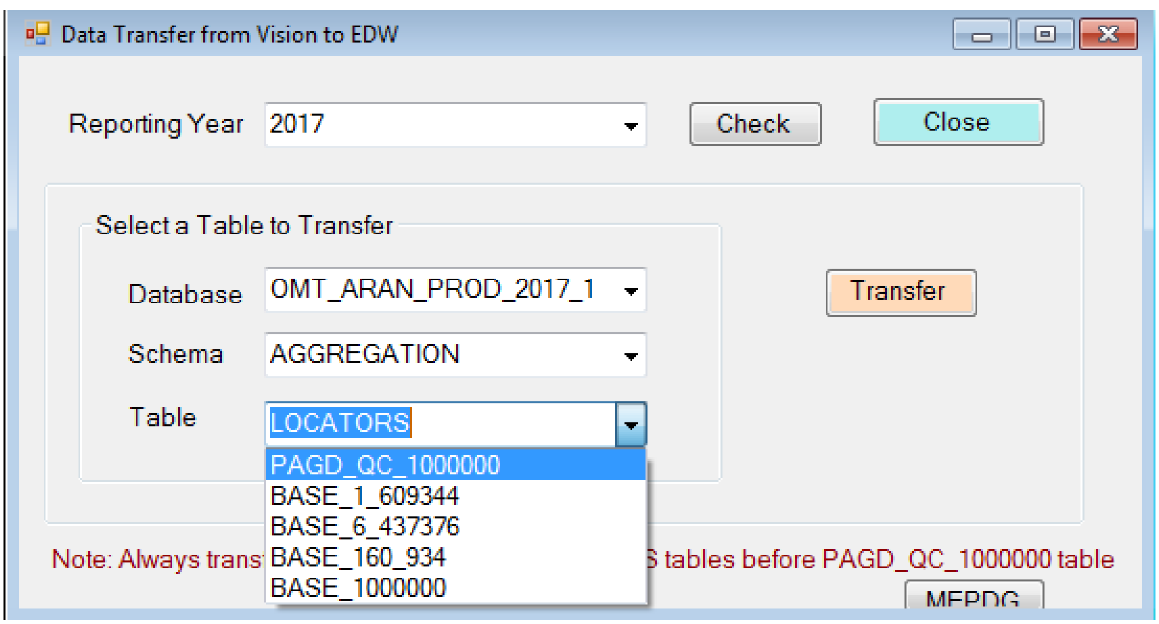


Click “Transfer” (see above image). Click “OK” when the next dialogue box opens. The next dialogue box to appear will say “Please wait until DOS Prompt disappear”. Click “OK” after the DOS window closes. Click “OK” to return to the “Data Transfer” window.

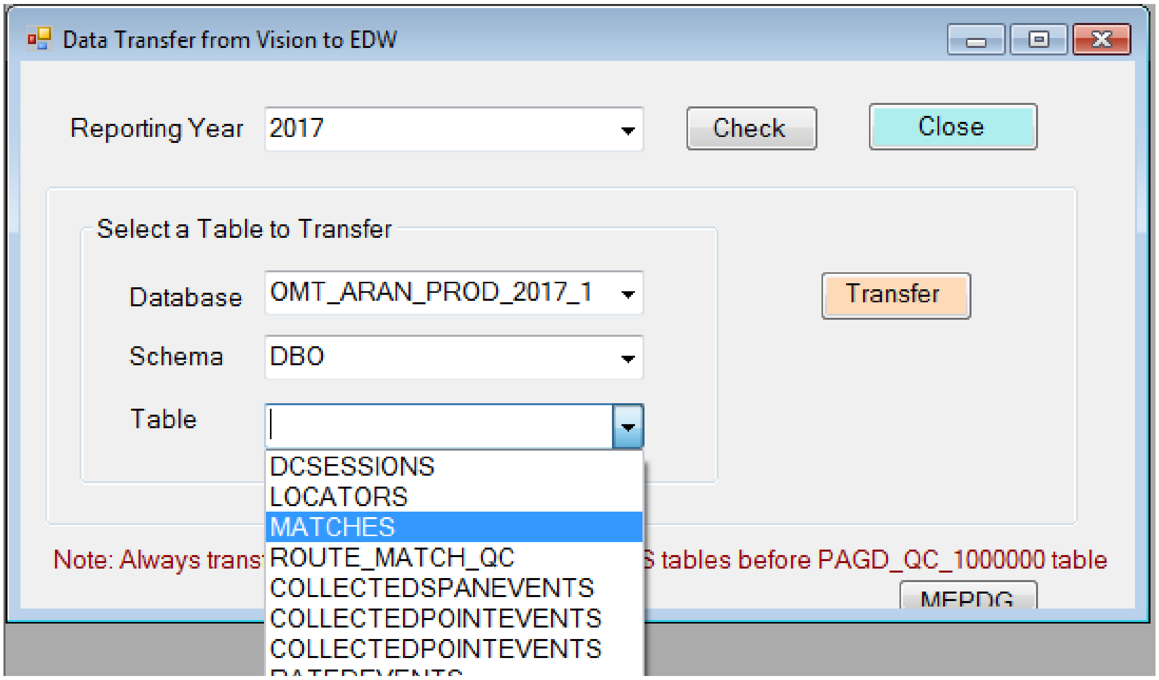
Step 12. Change the Table to “LOCATORS” and click the “Transfer” button again (see below image). Click “OK” when the next dialogue box opens. The next dialogue box to appear will say “Please wait until DOS Prompt disappear”. Click “OK” after the DOS window closes. Click “OK” to return to the “Data Transfer” window.



Step 13. Change the Schema to "AGGREGATION" and the Table to "PAGD_QC_1000000" and click the "Transfer" button again (see below image). Click OK when the next dialogue box opens. The next dialogue box to appear will say "Please wait until DOS Prompt disappear". Click "OK" after the DOS window closes. Click "OK" to return to the "Data Transfer" window.



Step 14. Change the "Schema" to "DBO", then select the "MATCHES" table and click the "Transfer" button (see below image).



Step 15. Check the EDW's "View/Modify Unique Run Status" table to make sure the data was imported. The EDW's "View/Modify Unique Run Status" table needs to be updated once a week to show which files have been matched.

5.16 RUNNING ROUTING IMPORTER

5.16.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to run the Routing Importer in the Roadware Data Control Software (DCS) using the Automatic Road Analyzer (ARAN) Collection List produced in the planning stage of the ARAN data collection process (see Production of ARAN Collection List). This SOP is performed once the ARAN Collection List for the year has been created and quality assurance (QA) has been performed.

5.16.02 *Frequency*

The Routing Importer is run once per year, prior to the start of the annual data collection season, and then rerun as-needed, in the event any routes change throughout the year.

5.16.03 *Purpose*

The purpose of this SOP is to import all routing data into the Vision Database using the Roadware DCS Routing Importer. It is also used to update existing routing data as-needed.

5.16.04 *Resource Requirements*

The running of the Routing Importer involves two people: (1) a user knowledgeable in Roadware DCS software to run the importer, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the import. These time estimates assume no issues encountered during importing.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	DCS user and QC	1	0.5
DPT TL	Supervisor	1	AR[06/12/2019]

5.16.05 *Procedure*

The procedure to run the Routing Importer is comprised of a single task:

(1) running Routing Importer.

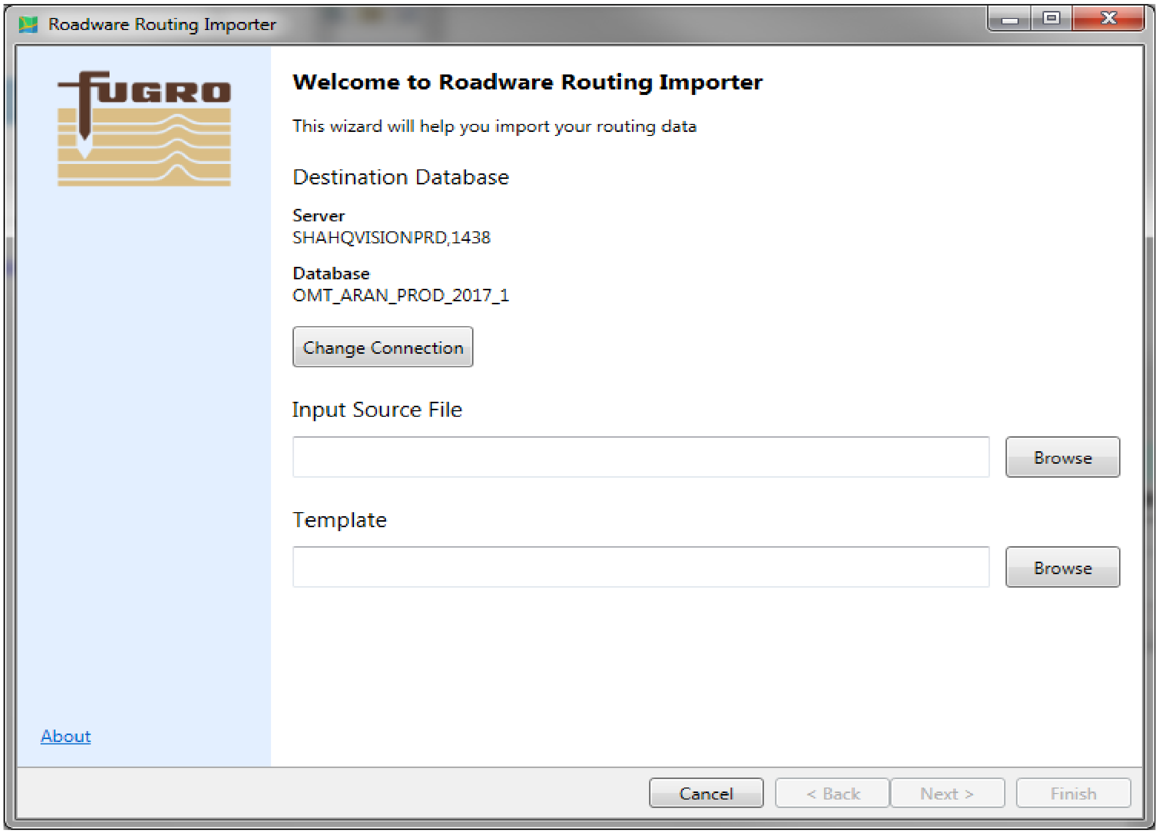
1- Running Routing Importer – *performed by Roadware DCS user*

Summary: This task uses Roadware DCS to import or update routing files into the Vision Database for ARAN data collection.

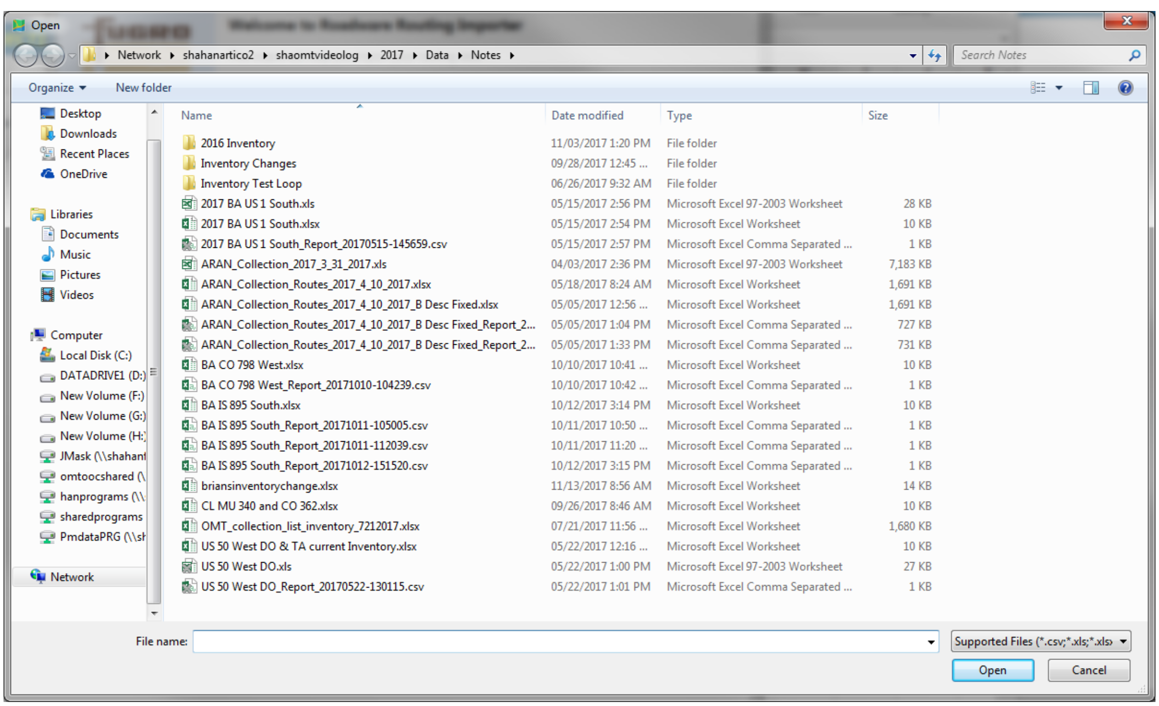
Step 1. Open Roadware DCS.

Step 2. Click the "Tools" drop-down menu and select "Routing Importer", then select the current database[06/12/2019].

Step 3. Make sure the correct database is displayed in the "Roadware Routing Importer" window. If not, return to Step 2 and select correct database. Once the database is correct, click “Browse” next to “Input Source File” (see below image).



Step 4. Select Inventory file[06/12/2019] (see below image). Click “Open.”

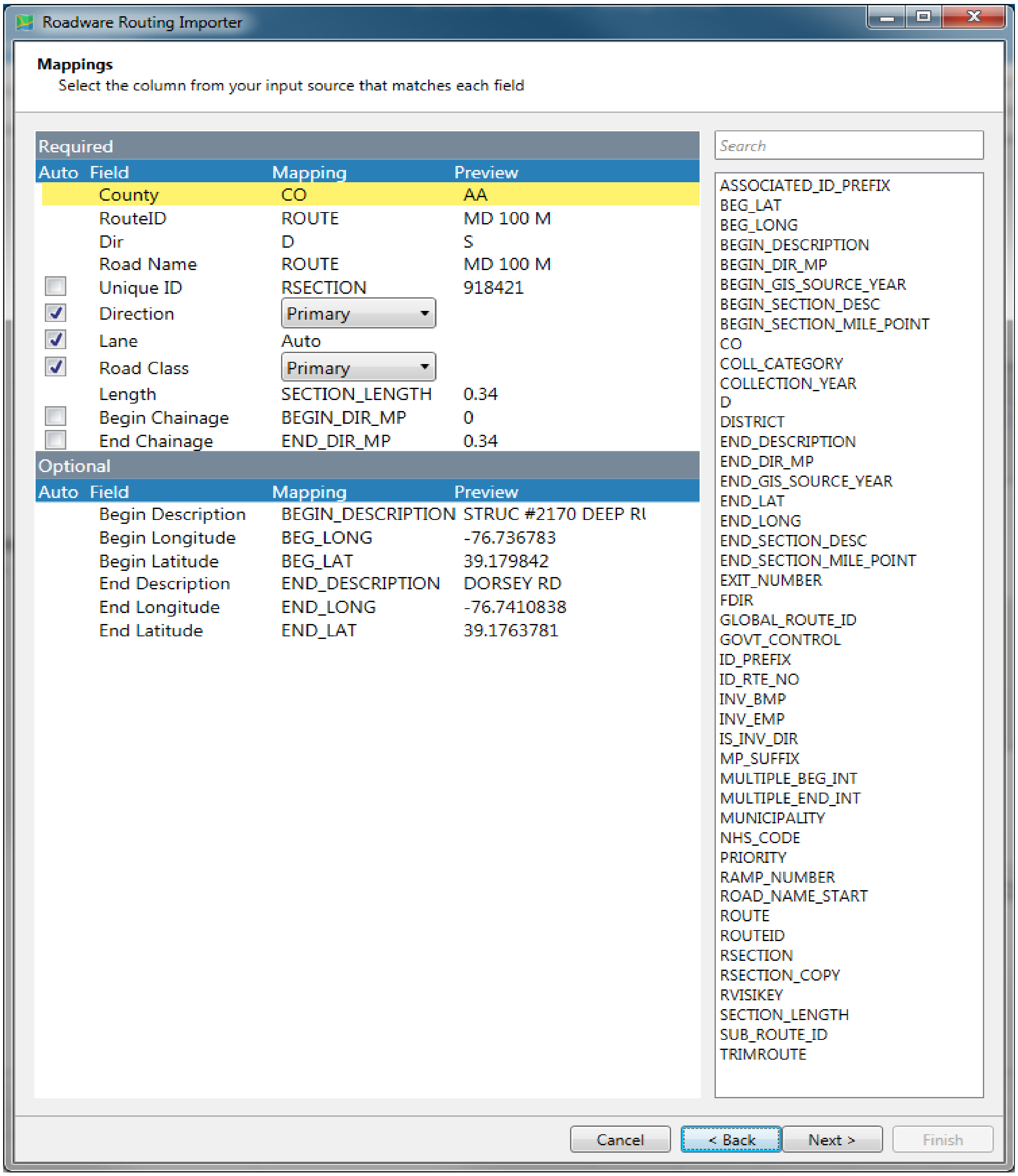


Step 5. Select preferred template. There are two options:

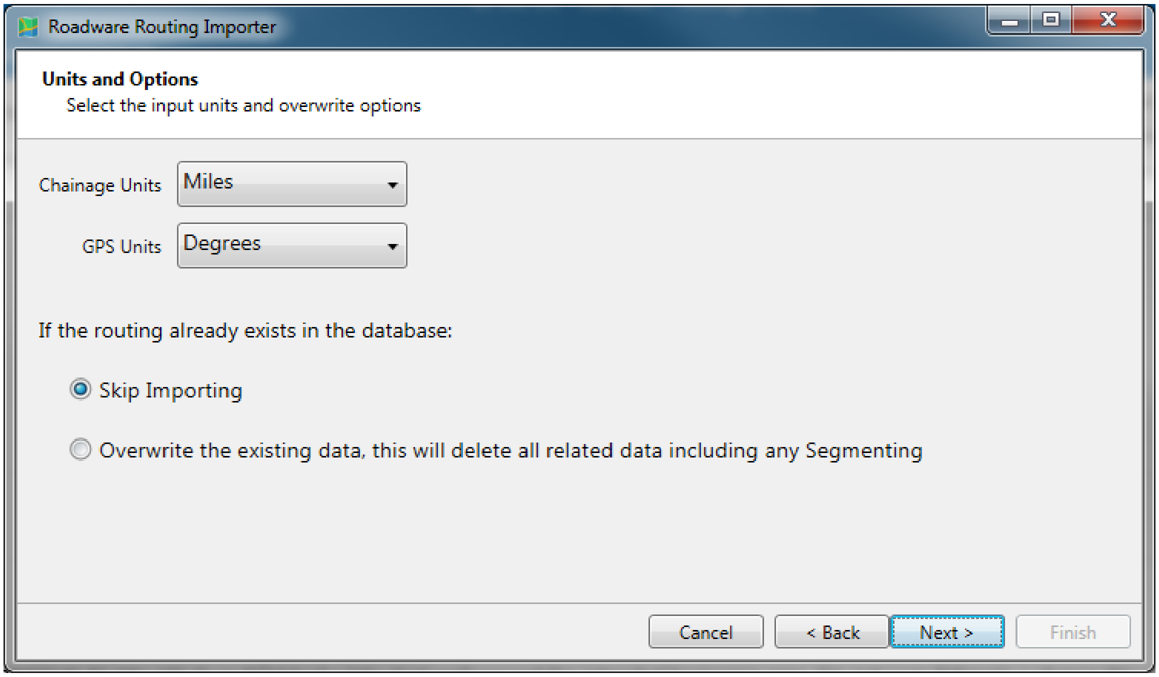
i. Open an existing template. Click “Browse” next to “Template”. Select the proper template (XML file) from the same folder as the inventory file. Click “Open” and then “Next” and proceed to Step 8.

ii. Create a new template. Instead of browsing for a file, click “Next” with the template blank and proceed to Step 6.

Step 6. “Mappings” window will open. Change settings to the preferred configuration. Click “Next” (see below image).



Step 7. “Units and Options” window will open. Ensure the “Chainage Units” are in “Miles” and the “GPS Units” are in “Degrees.” In addition, make sure the box next to “Skip importing” is checked for new inventory or “Overwrite” for updated inventory. Click “Next” (see below image).

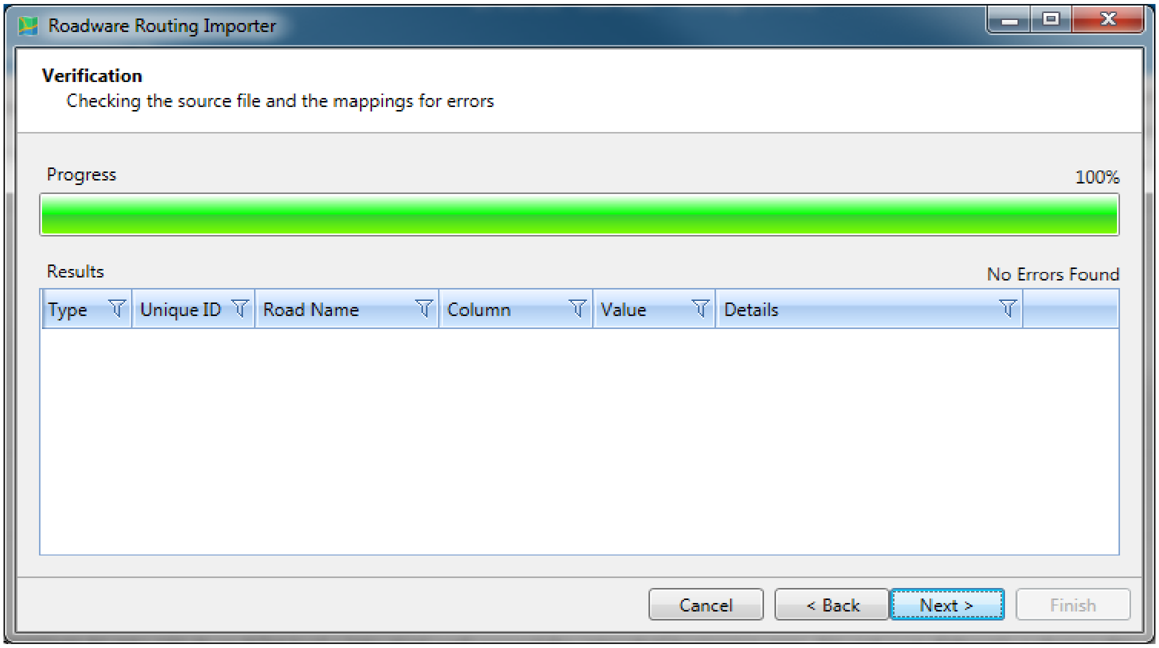


Step 8. “Verification” window will appear.

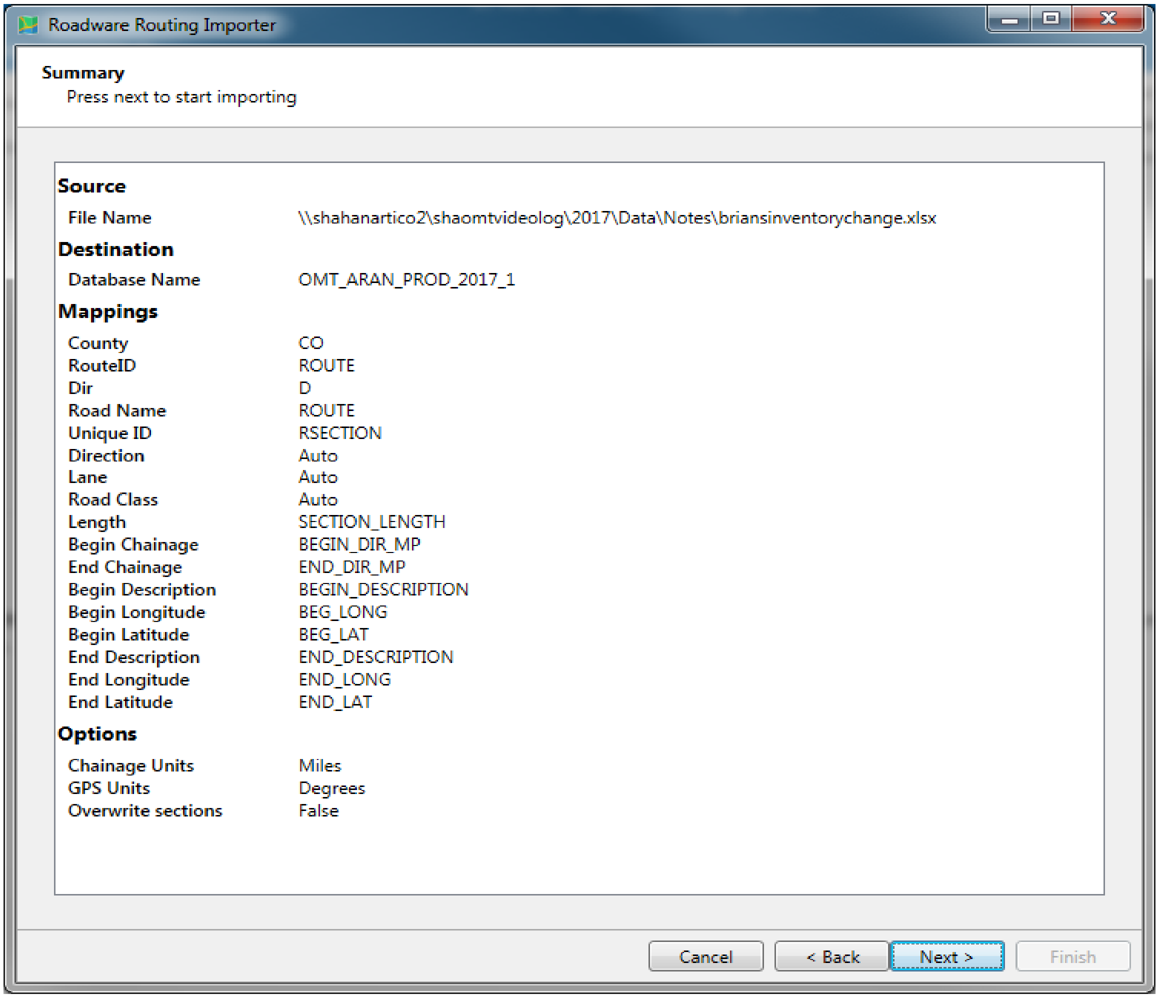
i. If an existing template was selected in Step 5 and the inventory is new, click “Next.”

ii. If an existing template was selected in Step 5 and the inventory is updated, click “Back” to return to the “Units and Options” window and make sure “Overwrite” is selected. Then, click “Next” and “Next” again.

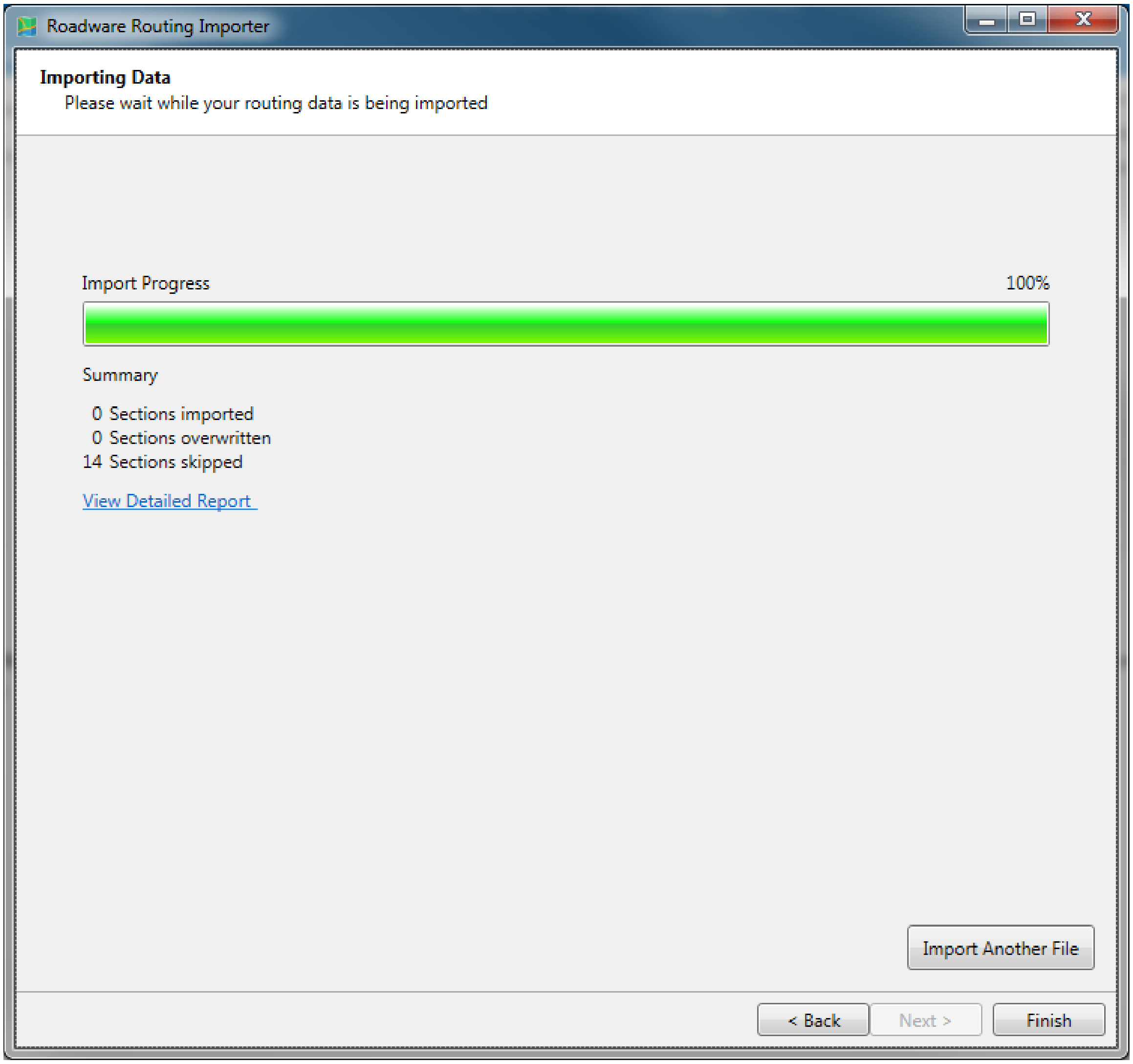
iii. If a new template was created in Step 5 click “Next.”



Step 9. "Summary" window will appear. Click "Next" (see below image).



Step 10. Import progress will be displayed. When the progress bar reaches 100%, import is complete. A summary below the progress bar will list the number of sections imported, overwritten, or skipped. When finished, click “Finish” and the program will close (see below image).


Roadware Routing Importer
Importing Data
Please wait while your routing data is being imported
Import Progress
100%
Summary
0 Sections imported
0 Sections overwritten
14 Sections skipped
View Detailed Report
Import Another File
< Back
Next >
Finish

5.17 CHANGING LATITUDE/LONGITUDE

5.17.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to resolve incorrect route GPS information by changing the latitude and longitude of the beginning or ending point along a route. This SOP is used during route matching (Route Matching) to correct discrepancies between the inventory beginning/ending points and the collected route. Examples of situations where the latitude and longitude should be changed have been included as an appendix (see Examples for Changing Latitude/Longitude).

5.17.02 *Frequency*

Changing the latitude and longitude of the beginning or ending point of a route occurs on an as-needed basis whenever incorrect locations are displayed on the map during route matching.

5.17.03 *Purpose*

The purpose of this SOP is to resolve incorrect route GPS information by changing the latitude and longitude of the beginning or ending points along the route.

5.17.04 *Resource Requirements*

Changing the latitude and longitude of the beginning or ending point of a route is performed by a member of the DPT during route matching to resolve incorrect route GPS information. The estimated effort levels in the table below represent the total time, in man-hours, to complete the attribute changes. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision user	1	0.5

5.17.05 *Procedure*

The procedure to change the latitude and longitude of the beginning or ending point of a route is comprised a single task:

(1) changing the latitude and longitude of route beginning or ending point.

1- Changing the Latitude and Longitude of Route Beginning or Ending Point – *performed by Vision user*

Summary: This task identifies incorrect GPS information in the Vision database and resolves it by changing the latitude and longitude of the beginning or ending point of a route. This is a supplemental, corrective task that occurs during route matching (see Route Matching), so the Vision program will already be open, and the user will have decided that a beginning or ending location on the map is incorrect and needs to be updated.

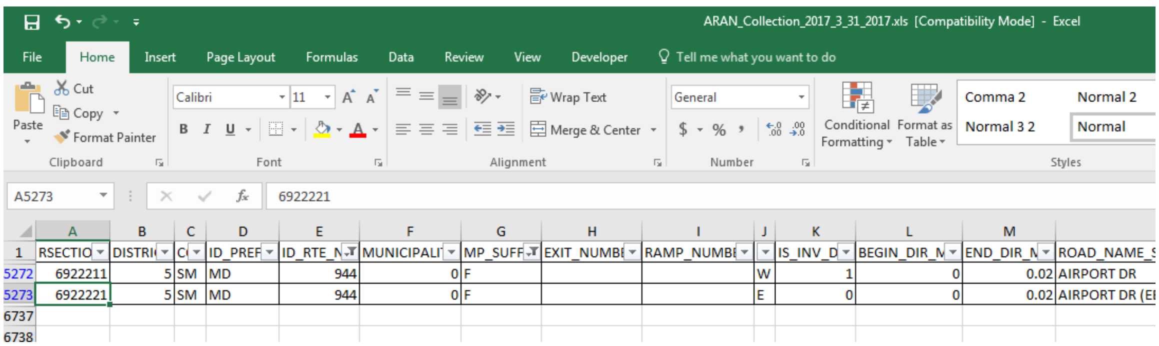
Step 1. In the “Map” window, click on the “Options” icon (three horizontal lines in the upper left-hand corner of the screen).

Step 2. Select “Base Maps”, then “Google”, then “GoogleSatelliteMap” to turn on the satellite view so that the lane configuration of the route in question can be seen.

Step 3. Before continuing, check the same route in the other direction and confirm the location of the corresponding beginning or ending point (green balloon icon on map).

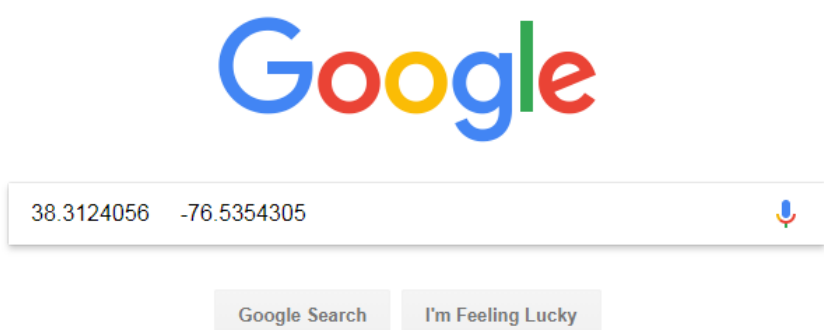
Step 4. Open the inventory Excel file for the current year. It will be stored at: \\shahanartico2\shaomtvideolog\(YEAR)\Data\Notes. The name of the file will have the format “ARAN_Collection_Routes_(MostCurrentDate).”

Step 5. Use the filter button (under “Data,” then “Filter”) to find the route in question. Filter by Column E, “ID_RTE_N.” Make sure both directions of the route are displayed (see below image).

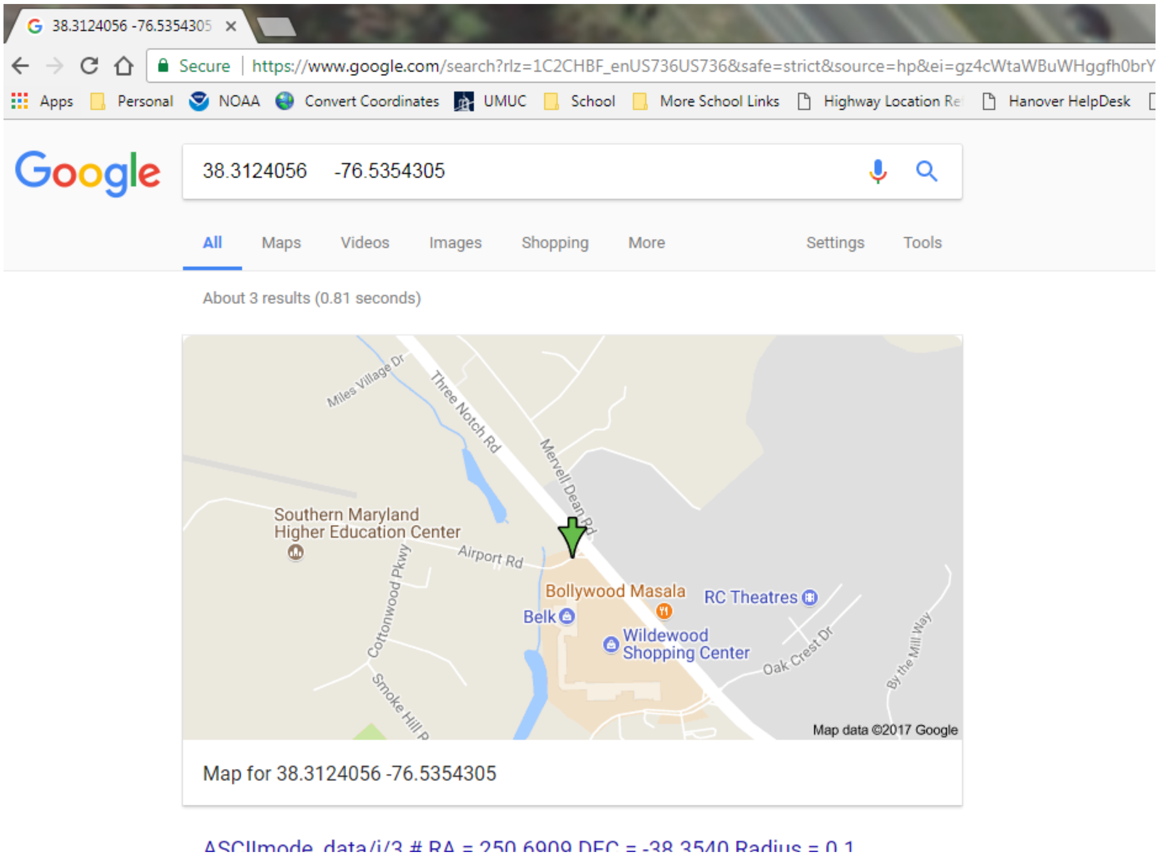


Step 6. Copy the header row (Row 1) and the route rows and paste them into a blank Excel file.

Step 7. Copy the beginning latitude (Column X, “BEG_LAT”) and longitude (Column Y, “BEG_LONG”) for the first route direction into a Google search engine web page (see below image).



Step 8. Hit the Enter key. The results of the Google search will appear (see below image).

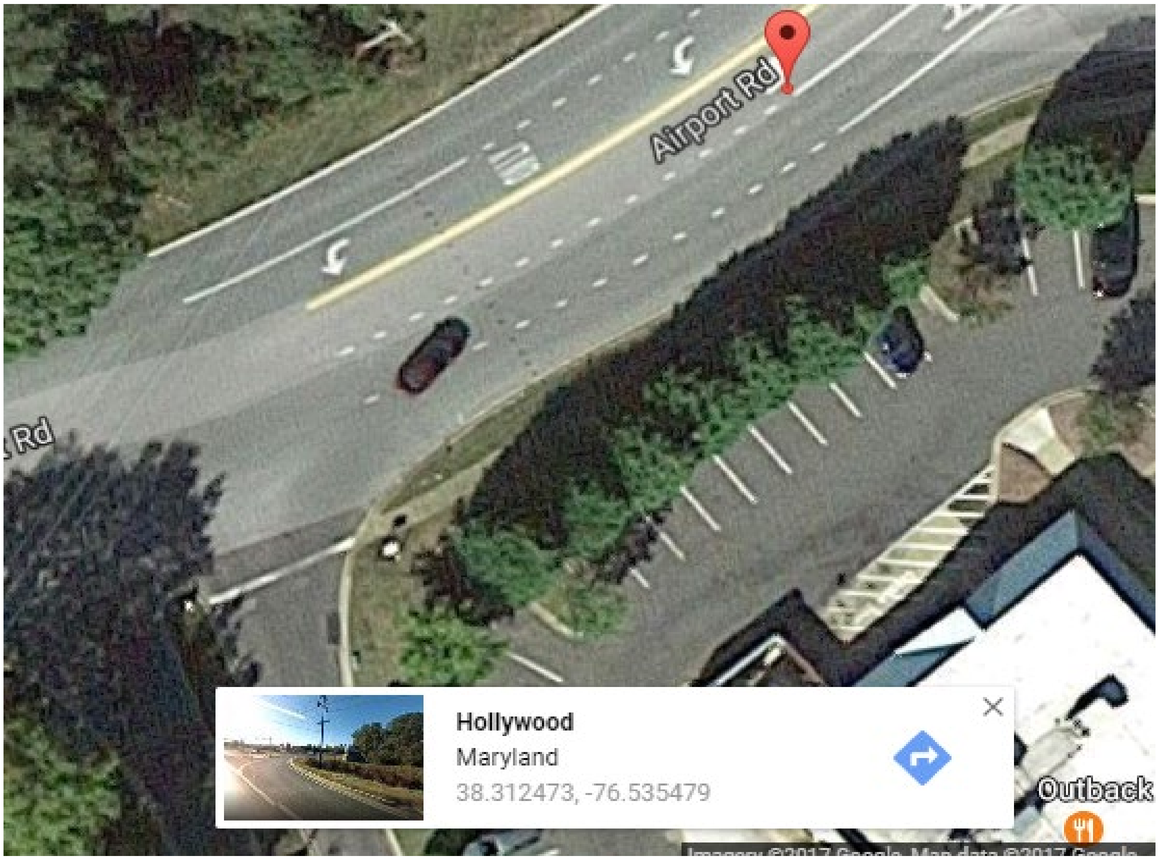


Step 9. Click on the map in the search results window to open Google Maps. Zoom in to the red balloon marker. Check that the red balloon is in the identical location as the green balloon in the Vision “Map” window.

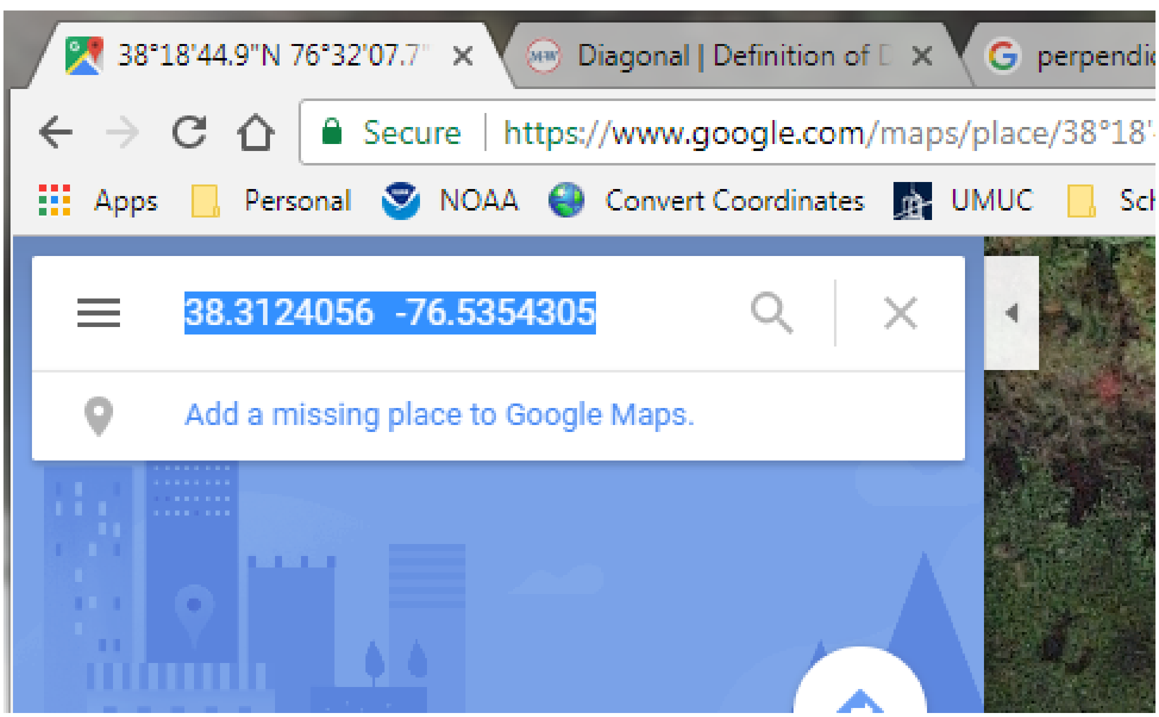
i. If the two balloons are in the same location, proceed to Step 10.

ii. Otherwise, the wrong latitude and longitude have been copied. Check that the route number is correct and that the correct coordinates have been copied into the browser. Resolve before continuing.

Step 10. In Google Maps, click the location on the map of the corrected beginning location. A dialogue box will open at the bottom of the screen. Click on the coordinates listed (see below image).



Step 11. The search box will change and the red balloon will move to the new location. Repeat if the new location is not satisfactory. Otherwise, copy the coordinates that are now displayed in the search box (see below image).



Step 12. Paste the coordinates back into the new Excel file in the appropriate fields. Highlight the updated cells in yellow.

Step 13. If multiple beginning or ending points require an update, repeat Step 7 to Step 12 for the other locations. When all points have been updated, proceed to Step 14.

Step 14. Save the Excel file. The name of the file can either be (1) the route name or (2) InventoryChanges(MMDDYY) if more than one route is being updated at once.

Step 15. Email the Excel file with the updated data to the DPT TL and the database developer.

Step 16. Import the updated routing information (see Running Routing Importer) before continuing with the matching of that route.

5.18 ACCESSING ELECTRONIC ARAN LOGS

5.18.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to access the electronic Automatic Road Analyzer (ARAN) logs in order to review data collection information. The electronic logs are created on the ARAN computer by field crew members of the Field Explorations Division (FED). The operator manually adds comments to the electronic log. The log is then added to the Engineering Data Warehouse (EDW) when the drives are recorded. This SOP is used during route matching (Route Matching) to check if multiple routes were collected in a single file.

5.18.02 *Frequency*

Accessing electronic ARAN logs occurs on an as-needed basis whenever it is suspected that multiple routes may have been collected in a single file during route matching (see Route Matching).

5.18.03 *Purpose*

The purpose of this SOP is to access information in the electronic ARAN logs to determine if multiple routes were collected in a single file.

5.18.04 *Resource Requirements*

Accessing electronic ARAN logs is performed by a member of the DPT during route matching (see Route Matching) to determine if multiple routes were collected in a single file using the EDW application. The estimated effort levels in the table below represent the total time, in man-hours, to complete electronic log export and investigation. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	EDW user	1	0.5

5.18.05 *Procedure*

The procedure to access electronic ARAN logs is comprised a single task:

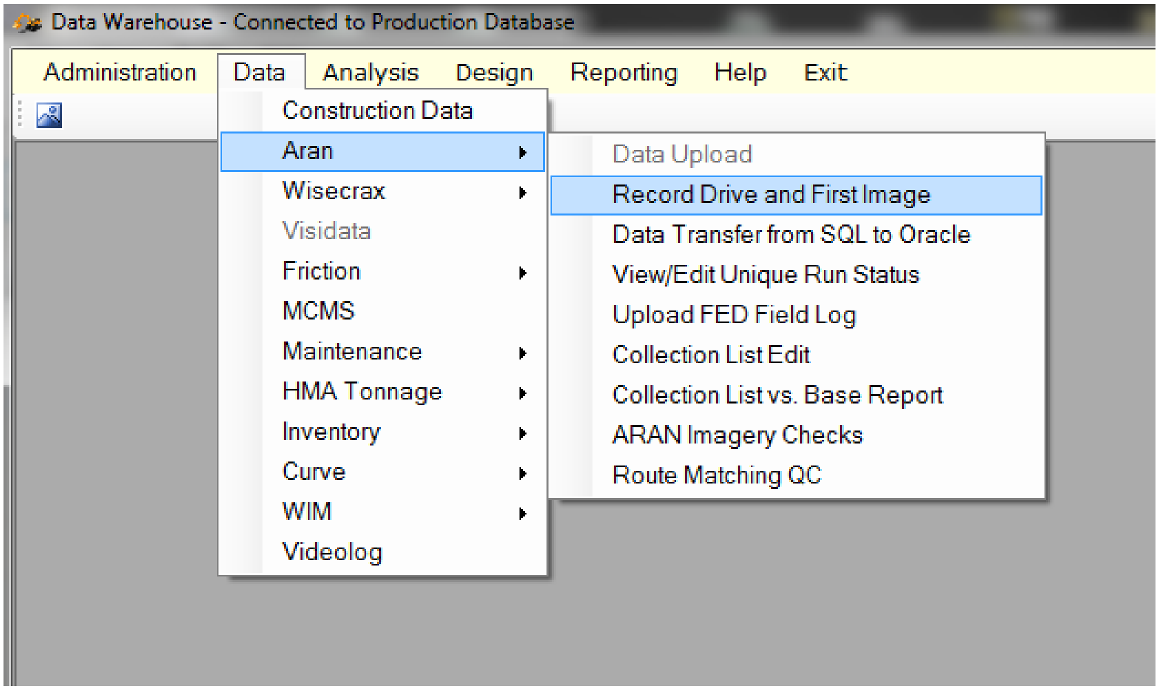
(1) accessing electronic ARAN logs.

1- Accessing Electronic ARAN Logs – *performed by EDW user*

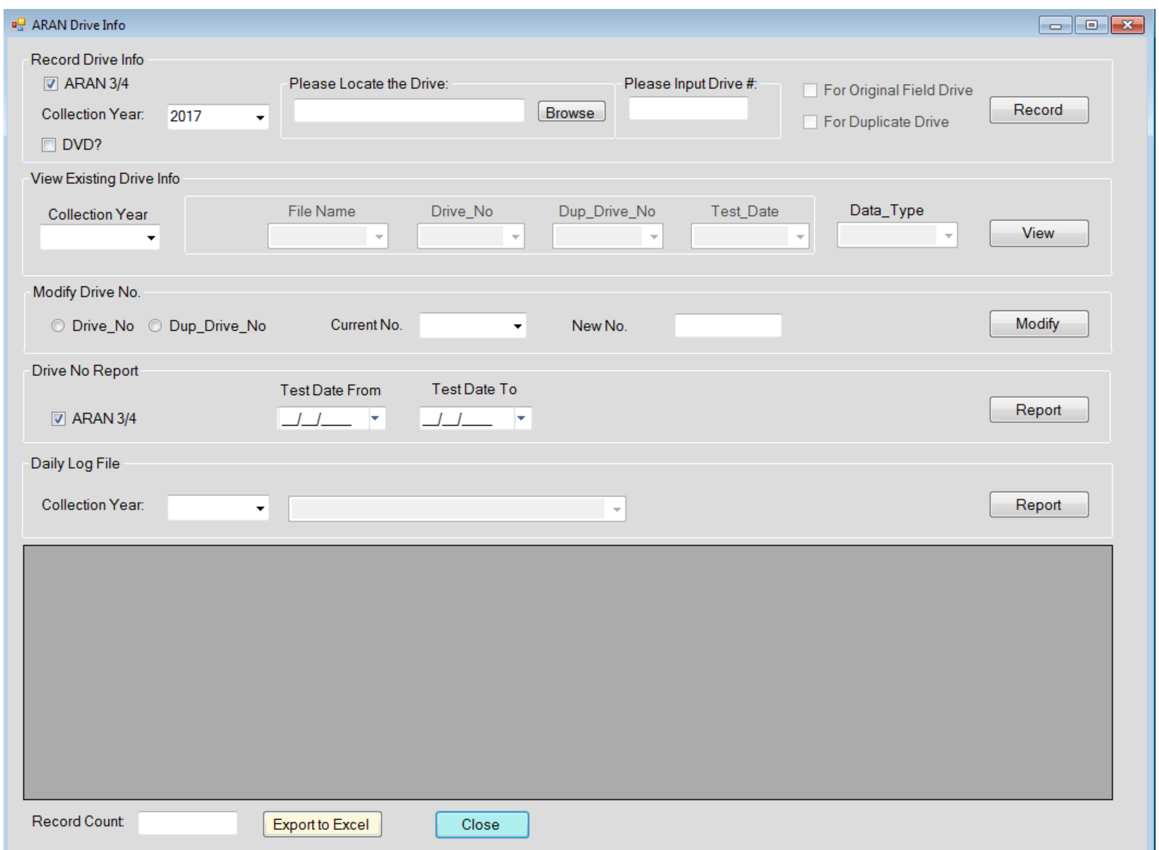
Summary: This task accesses information in the electronic ARAN logs to determine if multiple routes were collected in a single file using the EDW.

Step 1. Open the EDW application.

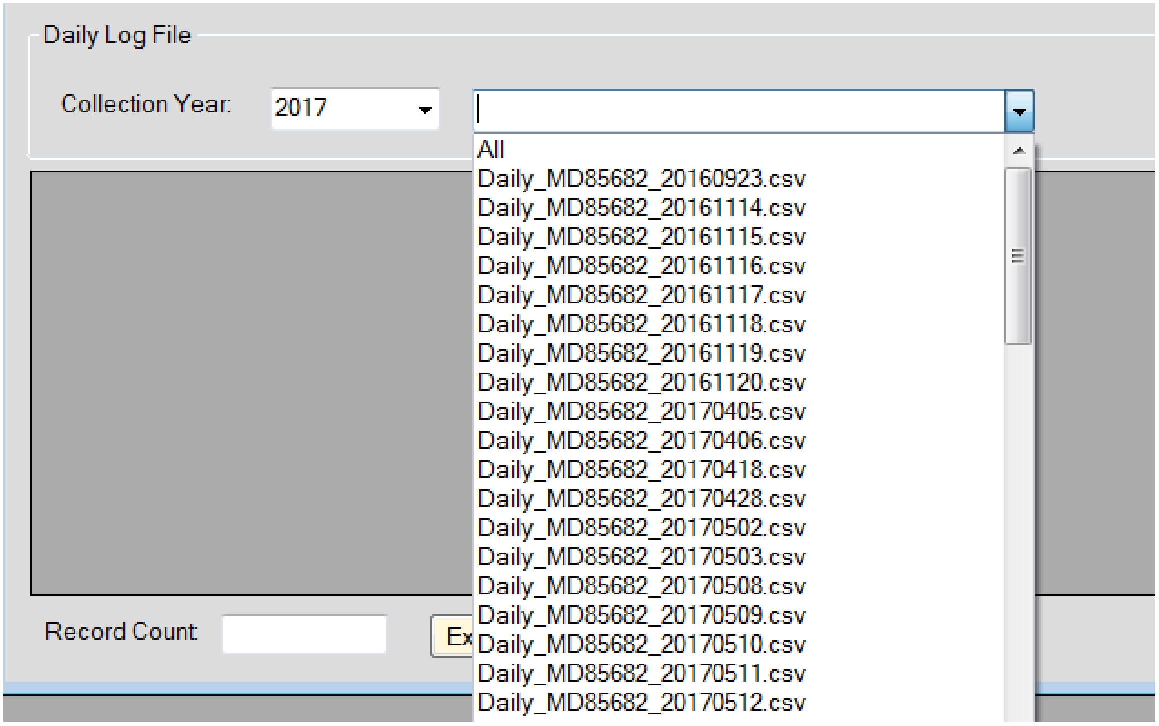
Step 2. Click "Data" and select "ARAN", then "Record Drive and First Image" from the drop-down menus (see below image).



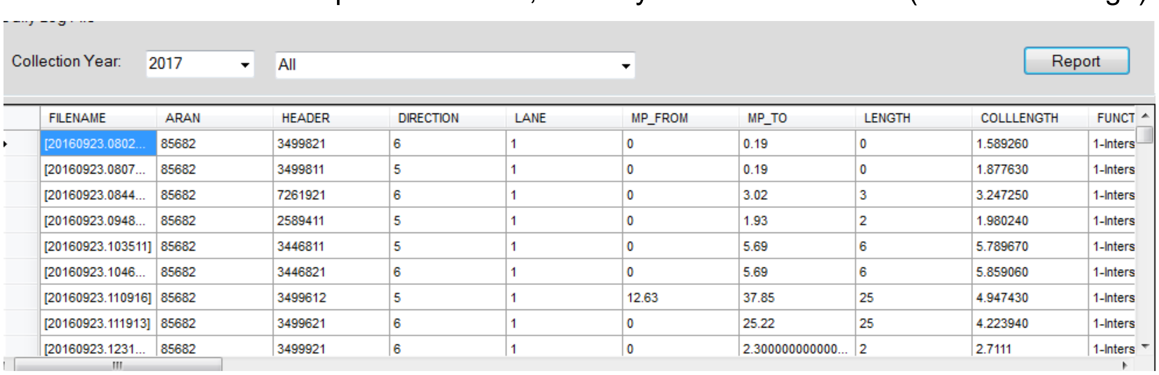
Step 3. The "ARAN Drive Info" window will appear. Select the correct "Collection Year" from the drop-down menu under "Daily Log File" (see below image).



Step 4. In the box next to “Collection Year”, select the correct log or choose “All.” It is easier to select “All”, but the export will take longer (see below image).

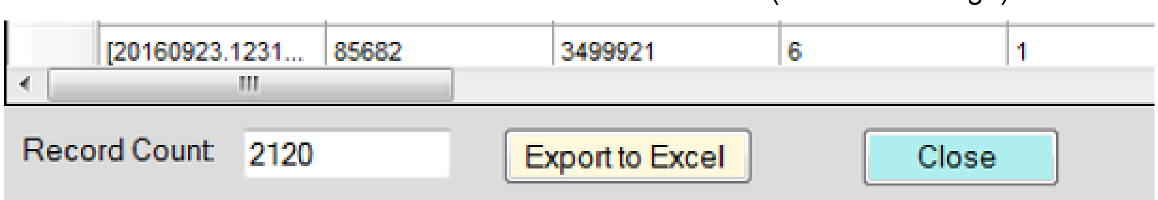


Step 5. Click “Report.” The table that populates can be used to view routes and look at the ARAN operator’s notes, but they are not searchable (see below image).



Step 6. Click “Export to Excel” and choose a name and location to save the file. Click “Save” and wait for export to complete (if “All” was selected it may take a few minutes). Do not interrupt export by clicking the Excel icon on the taskbar.

Step 7. When the export is complete, open the Excel file and compare the number of rows to the “Record Count” in the EDW window (see below image).



Step 8. Examine the Excel spreadsheet. Find the file name in question using the “FILENAME” field, which displays the date and time of the collected route. The file names in Vision will not exactly match the file names from the electronic ARAN log (the time in Vision is in 12-hour format while the time in the log is in 24-hour format). The “HEADER” column will display the name of the route that was collected. Find the route in question and look at the “COMMENTS” column (see below image). If a file contains more than one route, it will be specified in this column (look for a “+” or “and” in the text). Please note that the “HEADER” and “COMMENTS” fields are entered manually in the field and the chance for human error exists.

	A	B	C	D	E	F	G	H	I	J	K	L
1	FILENAME	ARAN	HEADER	DIRECTION	LANE	MP_FROM	MP_TO	LENGTH	COLLLENGTH	FUNCTIONALCLASS	COMMENTS	INITIAL
2	[20170910.090409]	8[illegible]6	923311	5	1	0	0.42	0	0.950210	2-Primary	M408 A+M408 A EB+M408 B NB+SB	
3	[20170614.143458]	85686	3445621	6	1	0	9.982	10	10.551040	2-Primary	I270	
4	[20170614.144736]	85686	3445611	5	1	0	10.09	10	10.320640	2-Primary	I270	
5												
6												

5.19 USING EGIS

5.19.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to search for route identifier information using the Maryland Department of Transportation's (MDOT) eGIS system. This SOP is used during route matching (Route Matching) when discrepancies exist which involve checking route information. For further information regarding eGIS, refer to the Vision Matching 2015 guide.

5.19.02 *Frequency*

Using the MDOT eGIS system occurs on an as-needed basis whenever route information must be checked during route matching.

5.19.03 *Purpose*

The purpose of this SOP is to reference routing information using the MDOT eGIS system.

5.19.04 *Resource Requirements*

Using the MDOT eGIS system is performed by a member of the DPT during route matching (see Route Matching) to resolve discrepancies in routing information. The estimated effort levels in the table below represent the total time, in man-hours, to complete the identification of a single route. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision user	1	0.5

5.19.05 *Procedure*

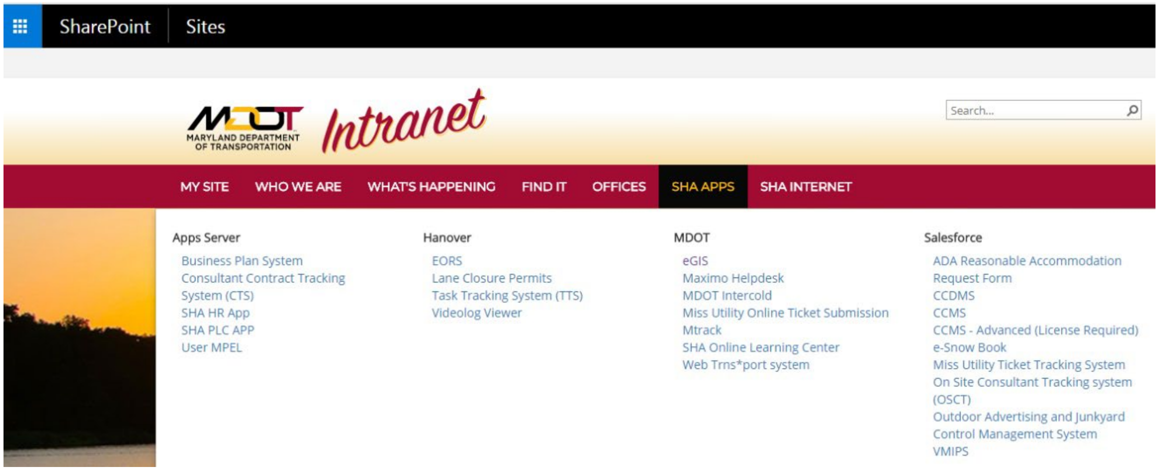
The procedure to identify a route using the MDOT eGIS system is comprised a single task:

(1) identifying a route using eGIS.

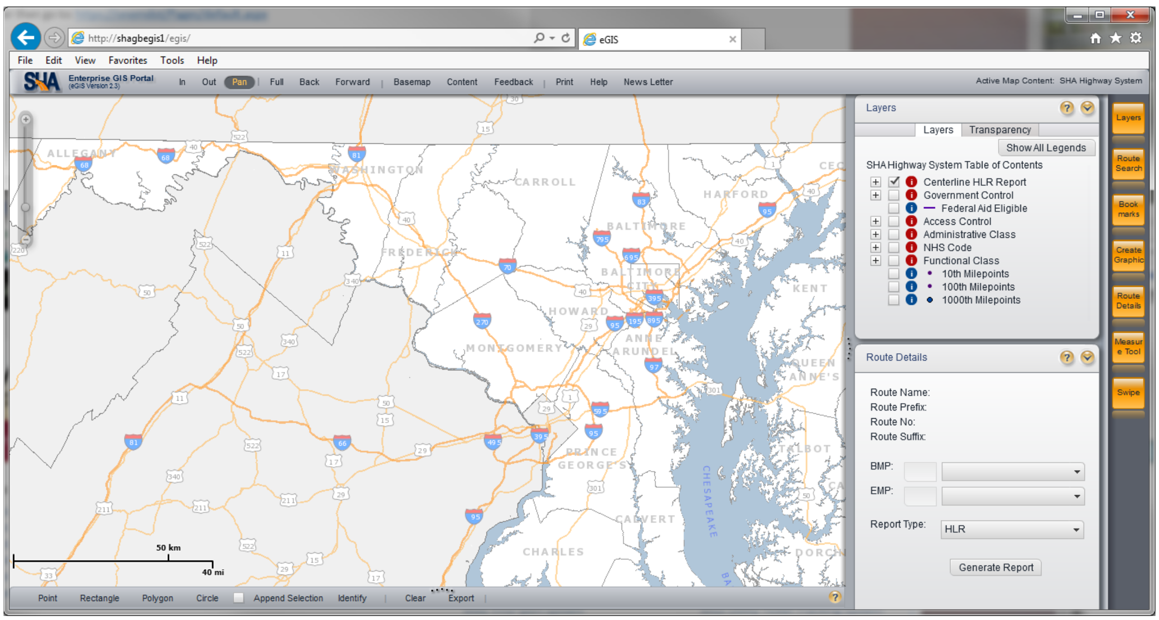
1- Identifying a Route Using eGIS – *performed by Vision user*

Summary: This task uses the MDOT eGIS system to identify a route.

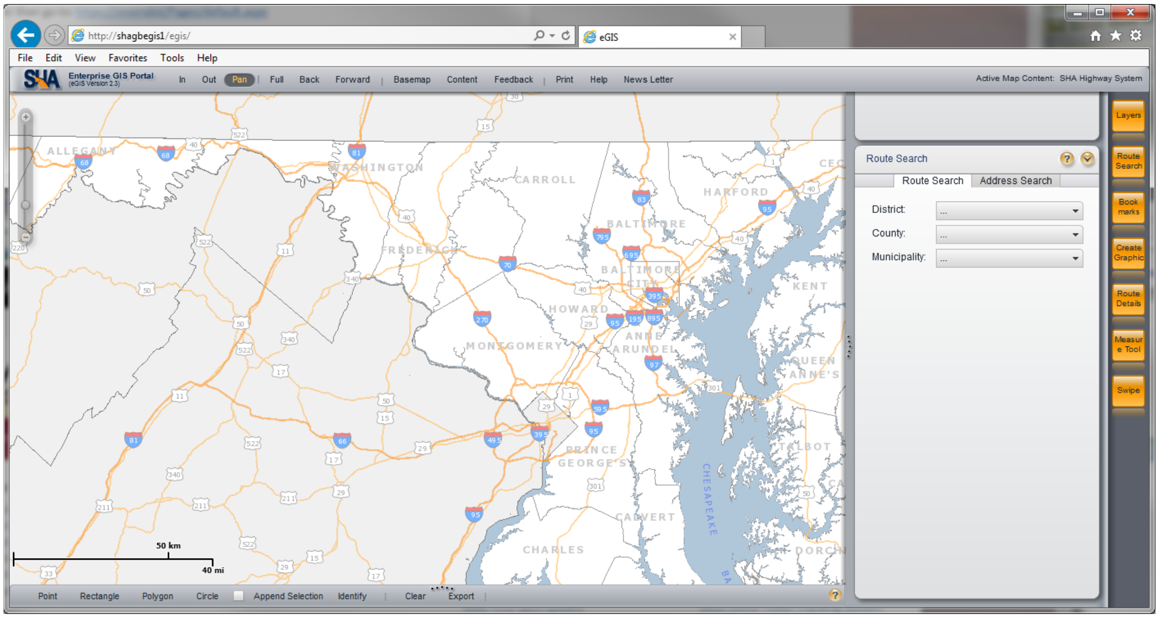
Step 1. Open a web browser and navigate to: https://onemdot/Pages/default.aspx. The MDOT intranet page will open (see below image).



Step 2. Click on “SHA APPS” and then select “eGIS.” The eGIS page will open (see below image).



Step 3. Uncheck the box beside “Centerline HLR Report” on the right side of the screen, then click the “Route Search” button (see below image).



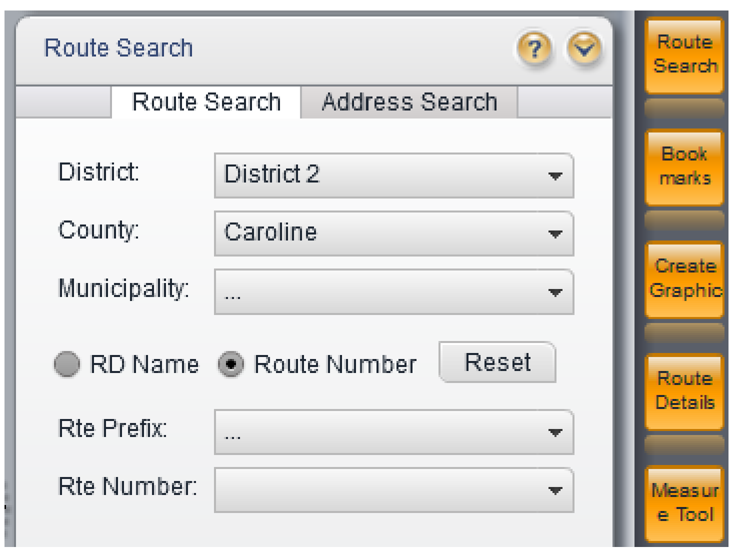
Step 4. Use the drop arrows to select the correct District for the route in question (if the route is in Baltimore City, do not select a District).

Step 5. Select the correct County (Baltimore City will be an option at the bottom of the list if no District was selected).

Step 6. Select the correct Municipality if the route is in a city.

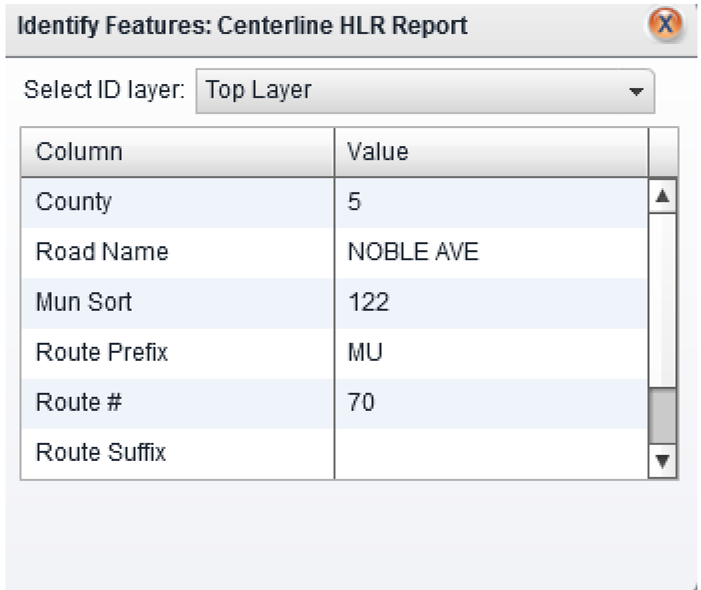
Step 7. Check the circle next to “Route Number.”

Step 8. In the drop-down menus, select the “Route Prefix” and “Route Number” (see below image). If the Route Number is not known, select a known Route Number that is close to the desired route.

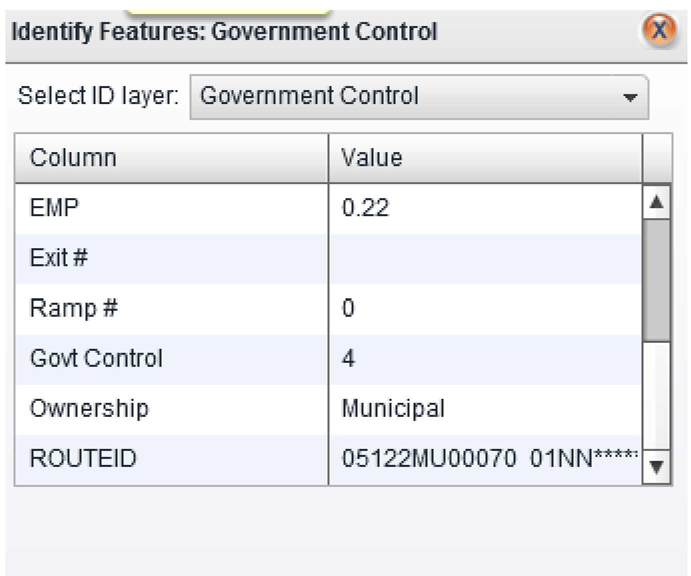


Step 9. The map will populate with the route starting and ending points, as well as intermediate points along the route. The map can be moved by clicking and dragging or zoomed by using the mouse wheel. If the desired route number

was not known, zoom in to its location. Click the “Identify” button at the bottom of the map screen and then click on the route on the map. The “Identify Features” window will populate with the correct route number and other information (see below image).



If the primary direction is required, change the “Select ID layer” to “Government Control” and view the “ROUTEID” field at the bottom of the window (see below image).



5.20 CHANGING IMAGE BANNER OR LOGO

5.20.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Processing Team (DPT) to change the banner or logo on "Left" and "Row" images in the Roadware Vision software using data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff. This SOP is used during the running of the Vibing Processor (see Running Vibing Processor) in the event that the banner or logo associated with the schema needs to be updated[06/12/2019].

5.20.02 *Frequency*

The changing of the banner or logo for "Left" and "ROW" images is performed as-needed when an alteration to the current format is requested. This is preferably performed prior to the beginning of the ARAN data collection season to ensure continuity in the output image format. The annual ARAN data collection season typically lasts from March to Mid-December.

5.20.03 *Purpose*

The purpose of this SOP is to change the image banner or logo applied to ARAN collected "Left" and "ROW" images.

5.20.04 *Resource Requirements*

Changing the image banner or logo involves two people: (1) a user knowledgeable in Roadware Vision software to update the image format prior to running the Vibing Processor, and (2) a supervisor who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the format changes. These time estimates assume no issues were encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision user and QC	1	0.5
DPT TL	Supervisor	1	AR[06/12/2019]

5.20.05 *Procedure*

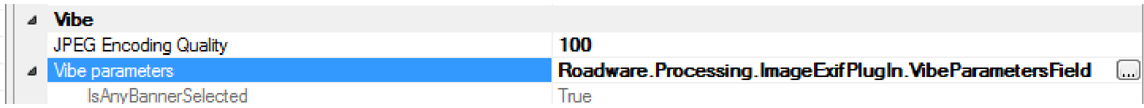
The procedure to change the image banner or logo for "Left" and "ROW" ARAN images is comprised of a single task:

(1) changing the image banner or logo in Vision

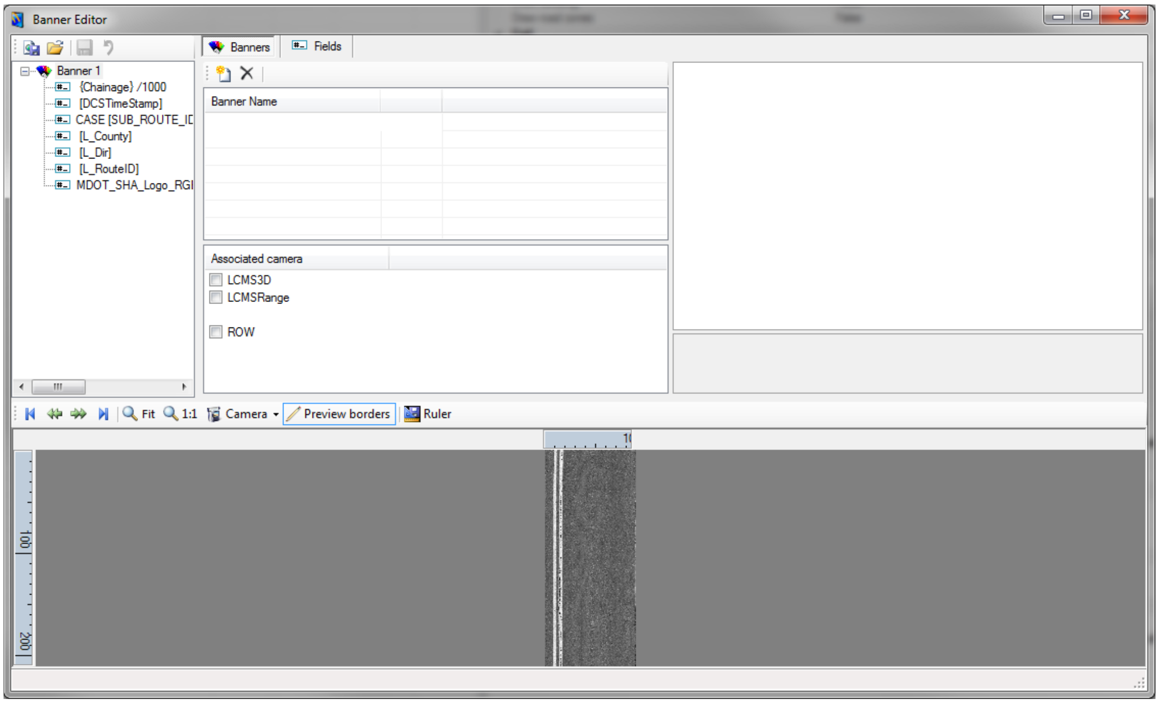
1- Changing the Image Banner or Logo in Vision – *performed by Vision user*

Summary: This task uses Vision software to change the image banner or logo that is applied to ARAN collected "Left" and "ROW" images.

Step 1. While on the "Options" tab select "Vibe Parameters" and then click the "…" button on the right side of the screen (see below image).



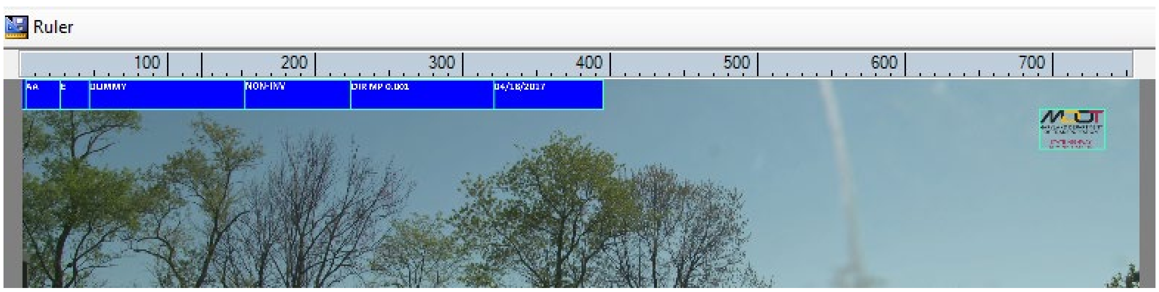
Step 2. The “Banner Editor” window will appear. Change the image to either “Left” or “ROW” depending on which banner is to be edited by click the “Camera” drop-down menu and selecting “Left” or “ROW” (see below image).



Step 3. Click the “Fields” tab and the “Expression” window will populate. To make a change, click on one of the expressions. Edit the necessary information in the table to the right (see below image). Make sure the “FieldFont” and “FontColor” fields are the same for each field name.

Metadata	
Field name	MP
Field result	MP DIR MP 0.001
Field type	PaintOnBanner
Misc	
AbsoluteCoords	1130, 3
EvaluatedMaxSize	18
EvaluatedMaxValue	63.934043249130100
EvaluatedText	DIR MP 0.001
EvaluatorException	
Expression	{Chainage} /1000
FieldFont	Calibri, 36pt, style=Bold
FontColor	White
FontOpacityPercent	100
Format	DIR MP 0.000
FormatException	
Parent	Roadware.Processing.ImageExifPlugIn.Banner
PercentageLeft	56.5656548
PercentageTop	2.43902421
Table	Locators
TextAlignment	LeftToRight

To move the banner to a different location on the image, click and hold on the desired part of the banner and move to new location (see below image).



Step 4. To change the logo, click on the expression "MD_SHA_Logo_RGB_SM.p…" Click the "FilePath" table to the right and select the "…" button. Browse to the location of the new logo and select it (see below image).

Misc	
AbsoluteCoords	3496, 105
FilePath	\\shahanpmdata1\pmdata\05 Documentation\PM Manuals\Vision\Schemas\2017\Vibin(...
LogoException	

Step 5. When all changes have been made, click the "Save" button on the "Banner Editor" toolbar. Click the "X" to close the "Banner Editor."

Step 6. Click the "Save" button on the options screen. Change the filename to match its previous name but with the current date at the end.

5.21 YEAR-END ARAN DATA CLOSEOUT

5.21.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Processing Team (DPT) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to perform the year-end data closeout. The closeout entails copying data from the Vision program and from the Engineering Data Warehouse (EDW) into a Microsoft Excel spreadsheet, then running queries on the spreadsheet to identify missing or incomplete data, and where possible addressing those data issues. The year-end data closeout is performed at the district level – each district will have its own year-end data closeout spreadsheet.

5.21.02 *Frequency*

The year-end data closeout is performed once per year by MDOT-SHA DPT staff, after all routes have been matched (see Route Matching) and the required drive-through checks have been completed (see Performing 100% Drive Through).

5.21.03 *Purpose*

The purpose of this SOP is to complete the data processing activities for the year by identifying missing routes, performing quality control (QC) checks of matched data, and filling in gaps identified in the data set.

5.21.04 *Resource Requirements*

Performing the year-end data closeout involves the following two MDOT-SHA staff members: (1) a DPT staff member knowledgeable in Roadware Vision software and the Engineering Data Warehouse (EDW) to identify missing routes, fill gaps in the data, and perform QC checks, and (2) a supervisor – typically a DPT Team Leader (TL) – who, as required, provides guidance and decision-making and performs quality assurance (QA). The estimated effort levels shown in the table below represent the total time, in man-hours, to complete the closeout and QC/QA checks. These time estimates assume no issues encountered during processing.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff Member	Vision/EDW user and QC	1	20.0
DPT TL	Supervisor and QA	1	As Required[06/12/2019]

5.21.05 *Procedure*

The procedure to perform the MDOT-SHA year-end data closeout is comprised of the following two tasks:

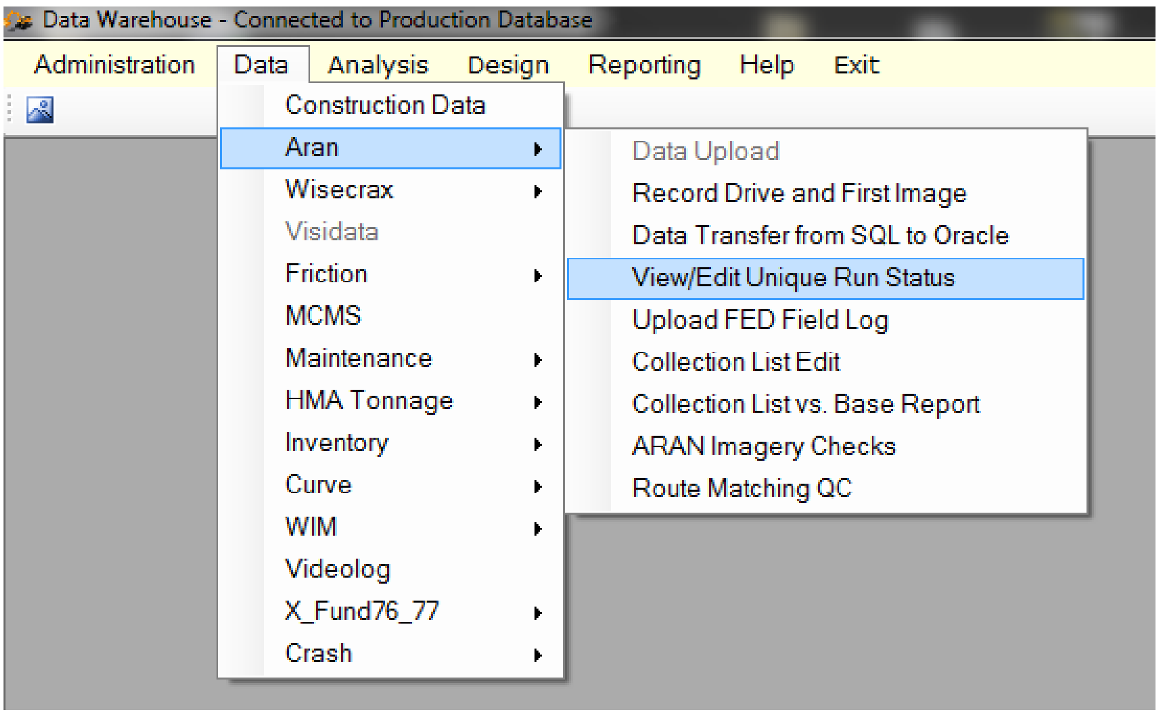
(1) completion of year-end data closeout spreadsheet, and
(2) QA of year-end data closeout spreadsheet.

1- Completion of Year-End Data Closeout Spreadsheet – *performed by DPT staff member knowledgeable in Vision software and EDW*

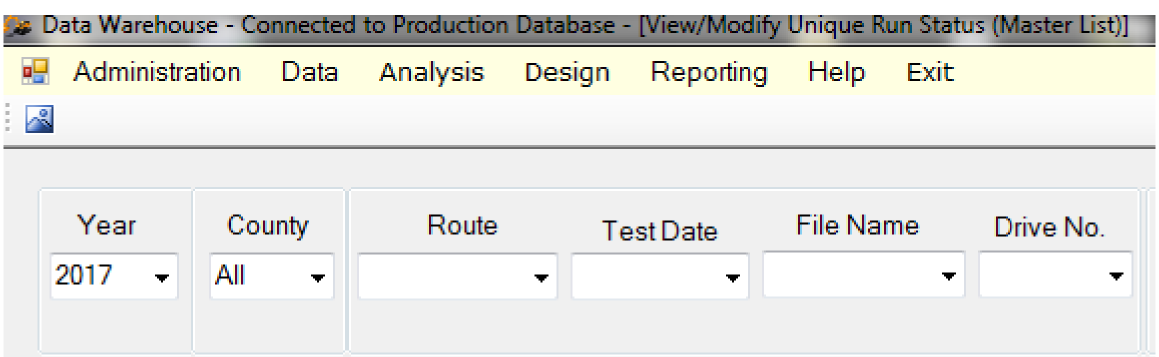
Summary: Under this task, missing routes are identified, data gaps are filled, and QC checks are performed by first building a district-level Microsoft Excel spreadsheet using data from Vision and the EDW.

Step 1. Follow the steps in Creating PAGDQC Report for the creation of the PAGDQC Report in Vision and then updating the PAGDQC Report in the EDW.

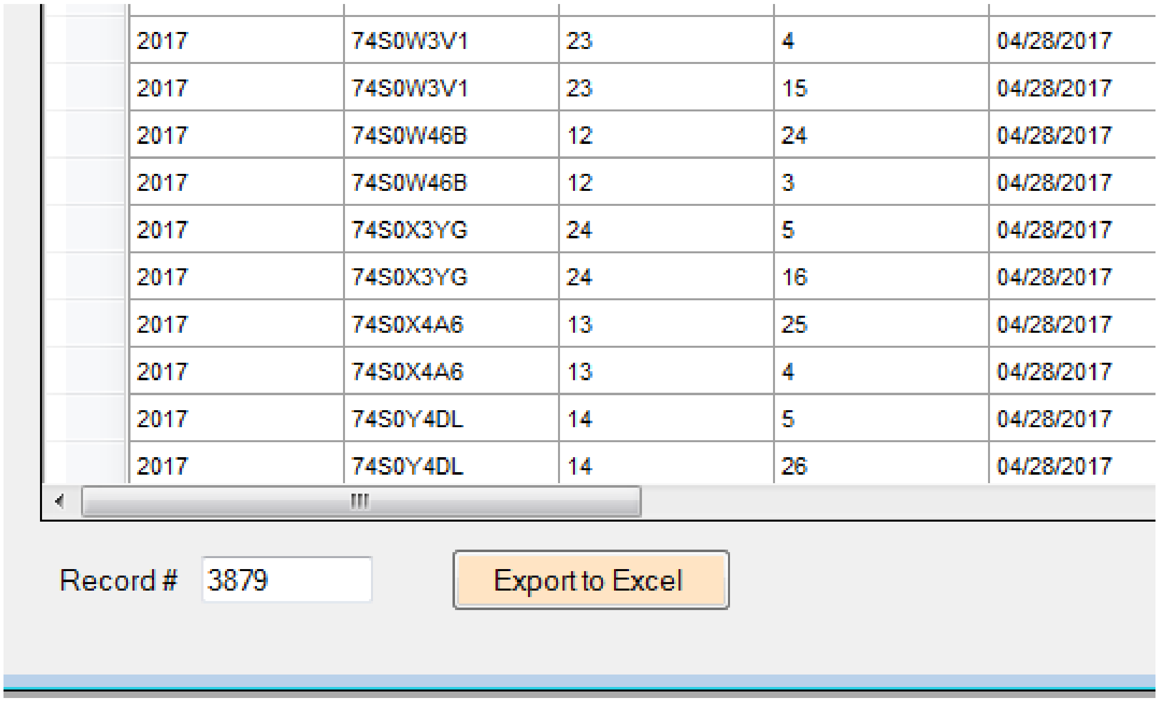
Step 2. In the EDW, navigate to and select "View/Modify Unique Run Status" (see below image).



Step 3. Using the drop-down menu, select the appropriate "Year" and set the "County" field to "All" (see below image).

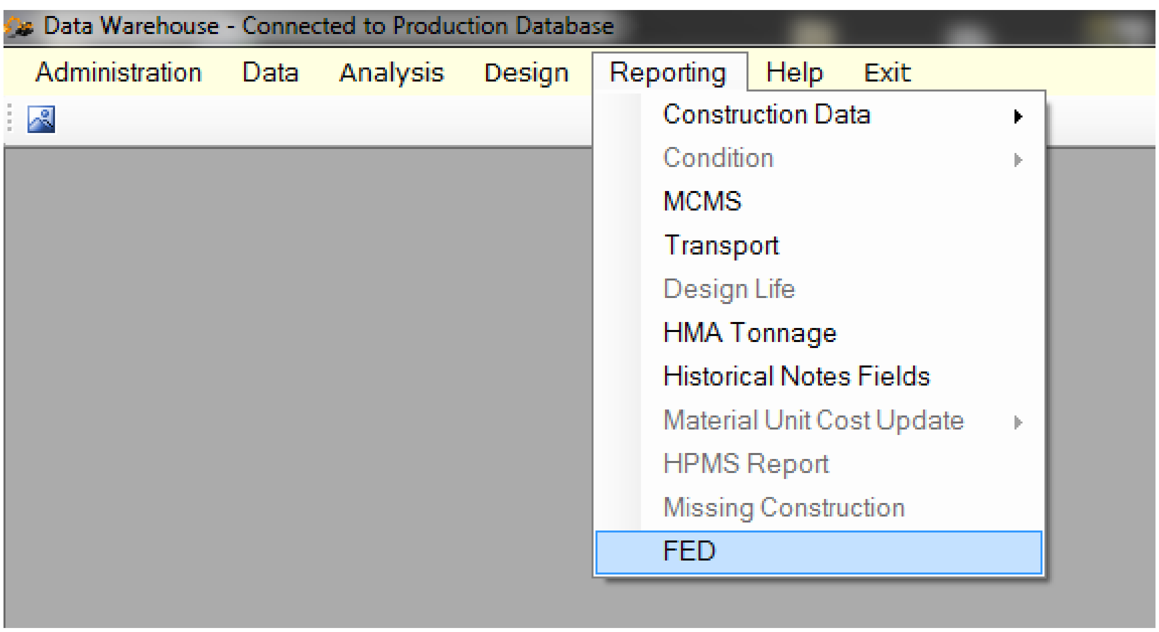


Step 4. After the table populates with the corresponding records, select the “Export to Excel” button beneath the table (see below image) and save the Excel file as “AllEditTable.xlsx.”

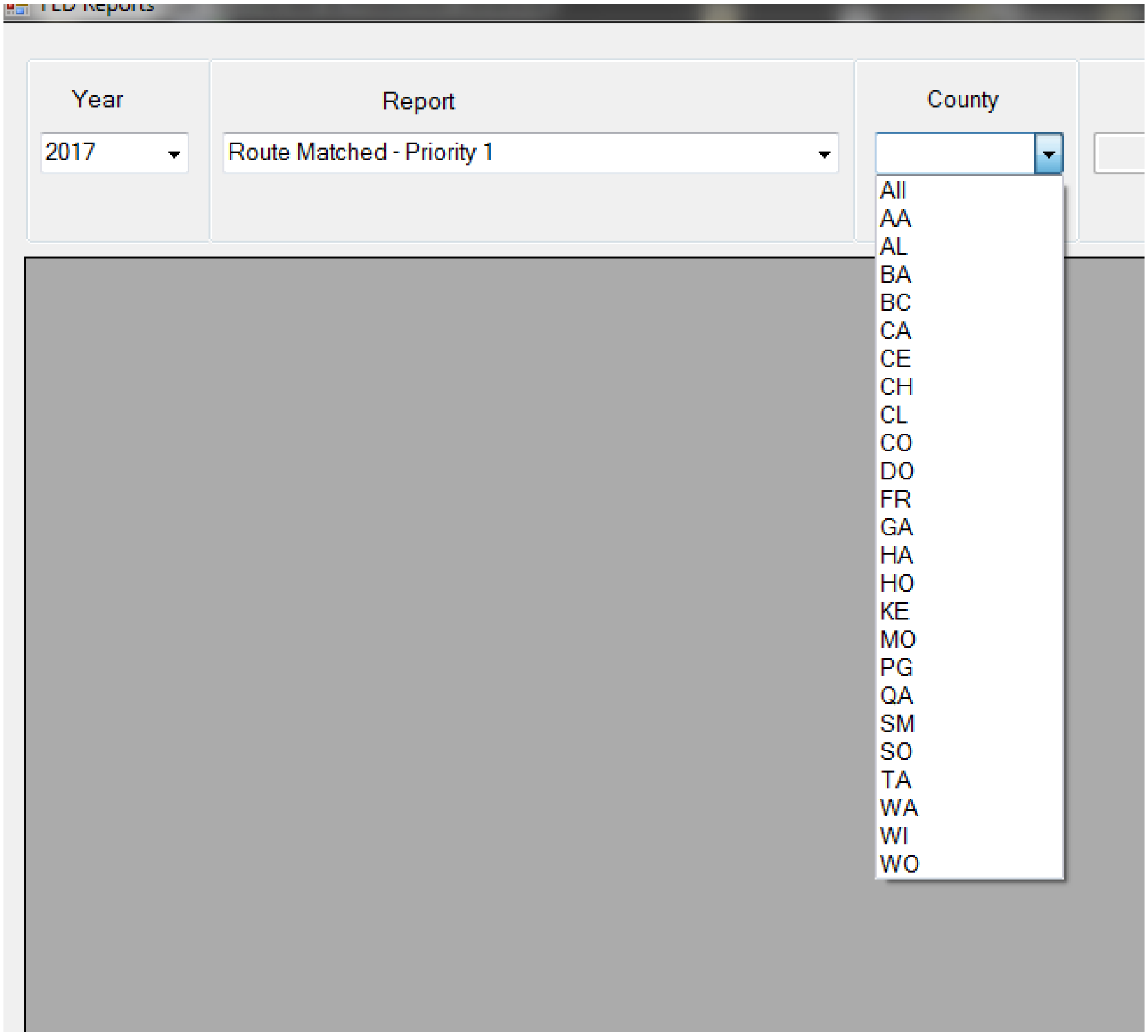


2017	74S0W3V1	23	4	04/28/2017
2017	74S0W3V1	23	15	04/28/2017
2017	74S0W46B	12	24	04/28/2017
2017	74S0W46B	12	3	04/28/2017
2017	74S0X3YG	24	5	04/28/2017
2017	74S0X3YG	24	16	04/28/2017
2017	74S0X4A6	13	25	04/28/2017
2017	74S0X4A6	13	4	04/28/2017
2017	74S0Y4DL	14	5	04/28/2017
2017	74S0Y4DL	14	26	04/28/2017

Step 5. In the EDW, navigate to and select “FED” under the “Reporting” tab (see below image).



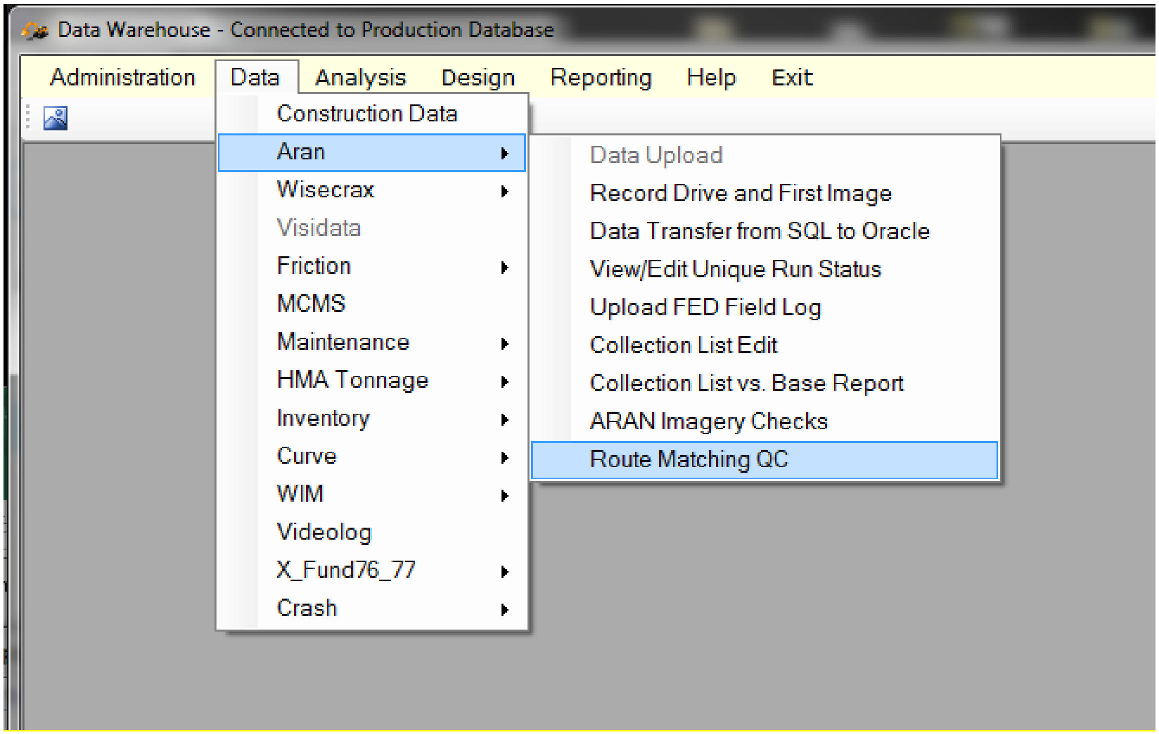
Step 6. Using the drop-down tabs, select the appropriate “Year,” then select “Pre-Route Matched - Priority 1” under “Report,” and then select “All” for “County” (see below image).



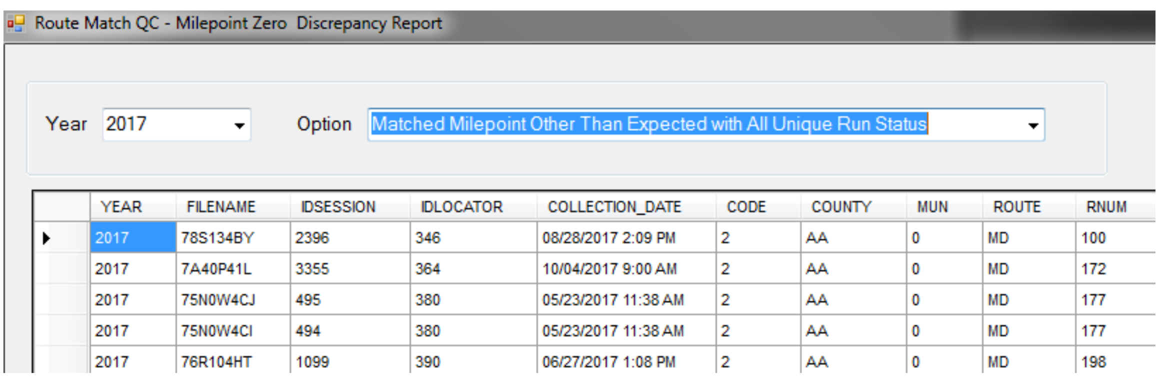
Step 7. After the table populates with the corresponding records, select the “Export to Excel” button beneath the table and save the Excel file as “Route Matched Priority 1.xlsx.”

Step 8. Repeat Step 5 through Step 7, except select “Route Matched - Priority 2” under “Reports” and save the Excel file as “Route Matched Priority 2.xlsx.”

Step 9. In the EDW, navigate to and select “Route Matching QC” (see below image).



Step 10. Using the drop-down tabs, select the appropriate “Year” and select “Matched Milepoint Other Than Expected with All Unique Run Status” under “Option” (see below image).



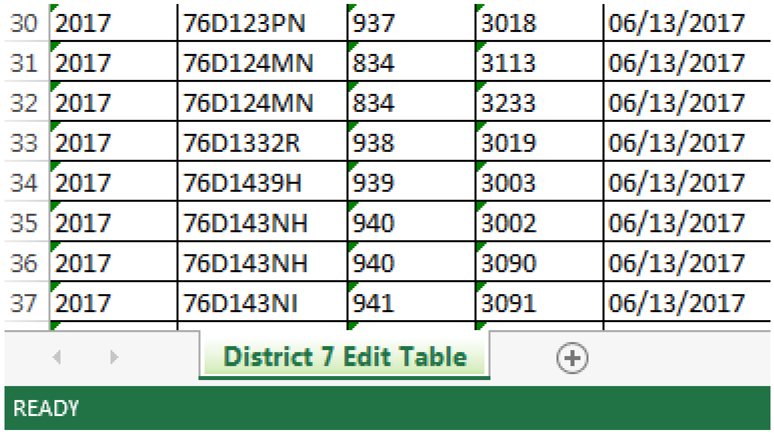
Step 11. After the table populates with the corresponding records, select the “Export to Excel” beneath the table and save the Excel file as “Matched Milepoint Other Than Expected.xlsx.”

Step 12. Save all exported Microsoft Excel files to a local drive.

Step 13. Rename the “View/Modify Unique Run Status” Microsoft Excel workbook to the name of the district for which the year-end data closeout is being performed.

Step 14. Open “View/Modify Unique Run Status” Microsoft Excel sheet. Use a filter on the “County” column of the sheet to select and delete all records that are not associated with the district for which the year-end data close-out is being performed.

Step 15. Rename the sheet tab of the open Microsoft Excel file to the name of the district for which the year-end data close-out is being performed (see below image).



30	2017	76D123PN	937	3018	06/13/2017
31	2017	76D124MN	834	3113	06/13/2017
32	2017	76D124MN	834	3233	06/13/2017
33	2017	76D1332R	938	3019	06/13/2017
34	2017	76D1439H	939	3003	06/13/2017
35	2017	76D143NH	940	3002	06/13/2017
36	2017	76D143NH	940	3090	06/13/2017
37	2017	76D143NI	941	3091	06/13/2017

Step 16. Create seven new sheets in the Microsoft Excel file by clicking on the "+" icon next to the existing sheet names. Name the new sheets as follows:

i. Matched priority 1 Diff >-5

ii. Matched priority 1&2 >.10mi

iii. Milepoints other than expected

iv. Match discrepancies

v. Rechain

vi. Step 6

vii. Step 7

Step 17. Copy the data from the saved (in Step 12) Microsoft Excel files from the EDW into the corresponding new sheets as follows:

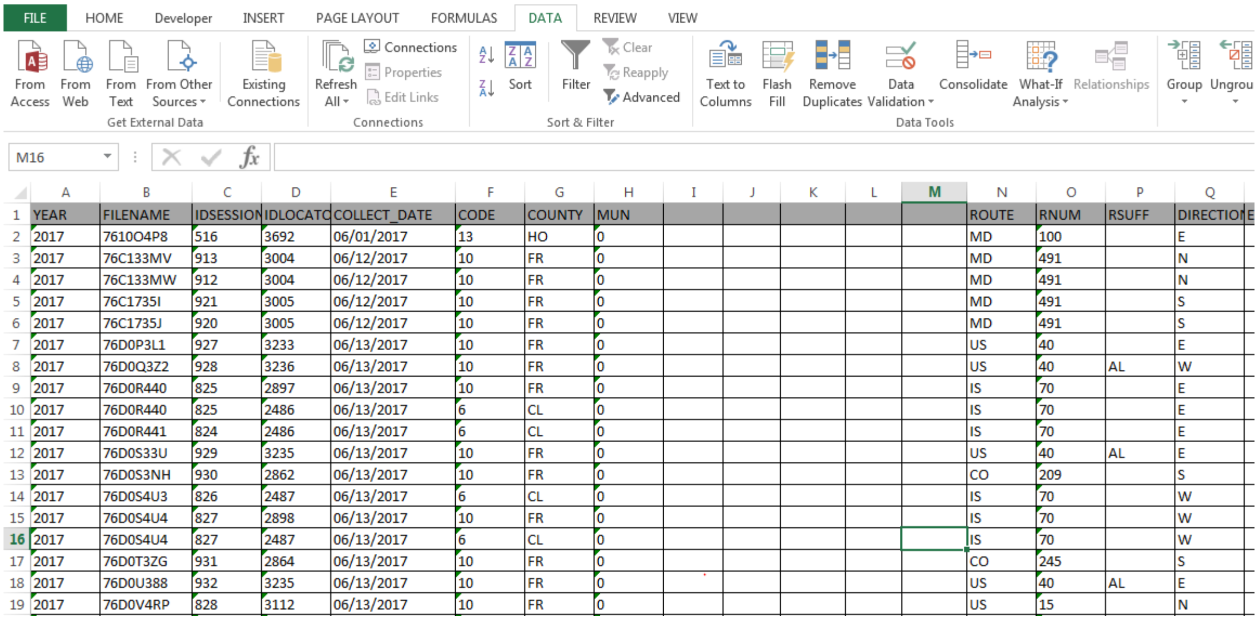
i. Copy "Route Matched - Priority 1" to "Matched priority 1 Diff >-5" sheet

ii. Copy "Route Matched - Priority 1" and "Route Matched – Priority 2" to "Matched priority 1&2 >.10mi" sheet (Note: do not copy routes listed in the "Route Matched – Priority 2" file that have a "DIFF_PERC" and "COLLECTED LENGTH" of zero; they are routes that do not need to be collected).

iii. Copy "Route Matching QC" to "Milepoints other than expected"

Step 18. In the three new sheets where data have been copied to, use a filter on the "County" columns to select and delete all records that are not associated with the district for which the year-end data close-out is being performed.

Step 19. In the main "District" sheet, move the "Route" column and all columns to the right of the "Route" column to Column N. This will leave Column I through M blank (see below image).



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	YEAR	FILENAME	IDSESSION	IDLOCATC	COLLECT_DATE	CODE	COUNTY	MUN						ROUTE	RNUM	RSUFF	DIRECTIO
2	2017	761004P8	516	3692	06/01/2017	13	HO	0						MD	100		E
3	2017	76C133MV	913	3004	06/12/2017	10	FR	0						MD	491		N
4	2017	76C133MW	912	3004	06/12/2017	10	FR	0						MD	491		N
5	2017	76C1735I	921	3005	06/12/2017	10	FR	0						MD	491		S
6	2017	76C1735J	920	3005	06/12/2017	10	FR	0						MD	491		S
7	2017	76D0P3L1	927	3233	06/13/2017	10	FR	0						US	40		E
8	2017	76D0Q3Z2	928	3236	06/13/2017	10	FR	0						US	40	AL	W
9	2017	76D0R440	825	2897	06/13/2017	10	FR	0						IS	70		E
10	2017	76D0R440	825	2486	06/13/2017	6	CL	0						IS	70		E
11	2017	76D0R441	824	2486	06/13/2017	6	CL	0						IS	70		E
12	2017	76D0S33U	929	3235	06/13/2017	10	FR	0						US	40	AL	E
13	2017	76D0S3NH	930	2862	06/13/2017	10	FR	0						CO	209		S
14	2017	76D0S4U3	826	2487	06/13/2017	6	CL	0						IS	70		W
15	2017	76D0S4U4	827	2898	06/13/2017	10	FR	0						IS	70		W
16	2017	76D0S4U4	827	2487	06/13/2017	6	CL	0						IS	70		W
17	2017	76D0T3ZG	931	2864	06/13/2017	10	FR	0						CO	245		S
18	2017	76D0U388	932	3235	06/13/2017	10	FR	0						US	40	AL	E
19	2017	76D0V4RP	828	3112	06/13/2017	10	FR	0						US	15		N

Step 20. Rename the blank columns as follows:

Column	Name
I	Dir+CO+Route
J	Milesage Diff >0.10
K	'Milesage Diff >0.10 Notes
L	differences >-5
M	'differences >-5 notes

Step 21. In the “Matched priority 1 Diff >-5” sheet, move the “ROUTE” column and all columns to the right of the “ROUTE” column one column to the right. The resulting columns will be as follows (Column B, J, and K will need to be added manually):

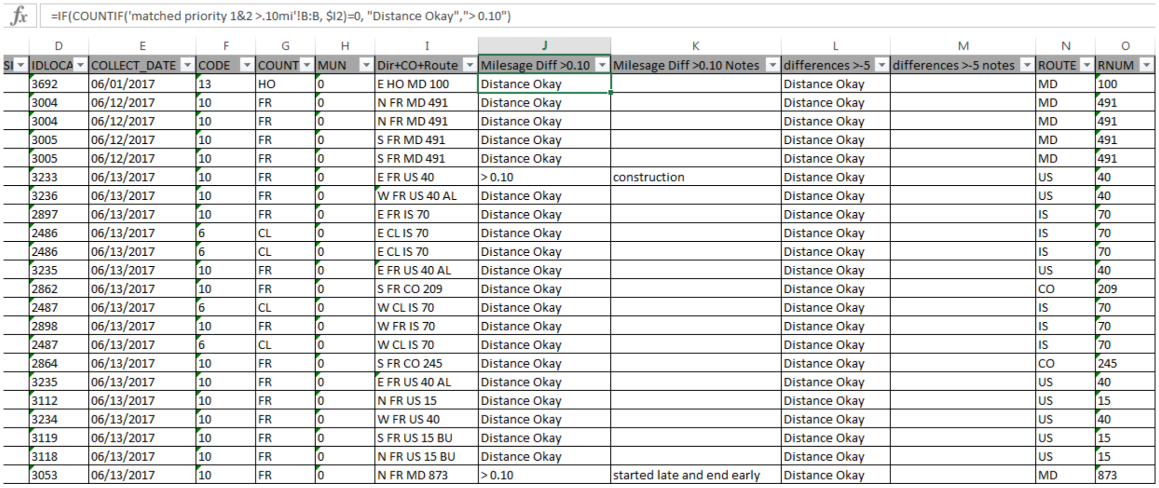
Column	Name
A	COUNTY
B	Dir+CO+Route
C	ROUTE
D	DIRECTION
E	PRIORITY
F	SECTION_LENGTH
G	COLLECTED_LENGTH
H	DIFF_LENGTH
I	DIFF_PERC
J	Collected?
K	Checked

Step 22. In the “Matched priority 1&2 >.10mi” sheet, move the “ROUTE” column and all columns to the right of the “ROUTE” column one column to the right. The resulting columns will be as follows (Column B, J, and K will need to be added manually):

Column	Name
A	COUNTY
B	Dir+CO+Route
C	ROUTE
D	DIRECTION
E	PRIORITY
F	SECTION_LENGTH
G	COLLECTED_LENGTH
H	DIFF_LENGTH
I	DIFF_PERC
J	Collected?
K	Checked

Step 23. Enter appropriate formulas into the newly created columns for the three sheets addressed in Step 19 through Step 22. The table below summarizes the appropriate formula to be entered for each new column in the three sheets (see image after table).

Sheet	Column	Formula	Notes
District	Dir+CO+Route	=Q2&" "&G2&" "&N2&" "&O2&""	This is for routes where the “RSUFF” column is blank.
District	Dir+CO+Route (part II)	=Q3&" "&G3&" "&N3&" "&O3&" "&P3&""	Filter the “RSUFF” column hide blank cells, then paste the formula to the remaining records.
District	Milesage Diff >0.10	=IF(COUNTIF('matched priority 1&2 >.10mi'!B:B, $I2)=0, "Distance Okay",">0.10")	If there are any matching Dir+CO+Route records in the Milesage Diff >0.10 sheet, then the formula will return >0.10. Until you start removing records all the routes listed will show >0.10.
District	differences >-5	=IF(COUNTIF('matched priority 1 Diff >-5'!B:B, $I2)=0, "Distance Okay"," >-5")	If there are any matching Dir+CO+Route records in the Milesage Diff >-5 sheet, then the formula will return >-5. Until you start removing records all the routes listed will show >-5.
Matched priority 1 Diff >-5	Dir+CO+Route	=D2&" "&A2&" "&C2	
Matched priority 1&2 >.10mi	Dir+CO+Route	=D2&" "&A2&" "&C2	



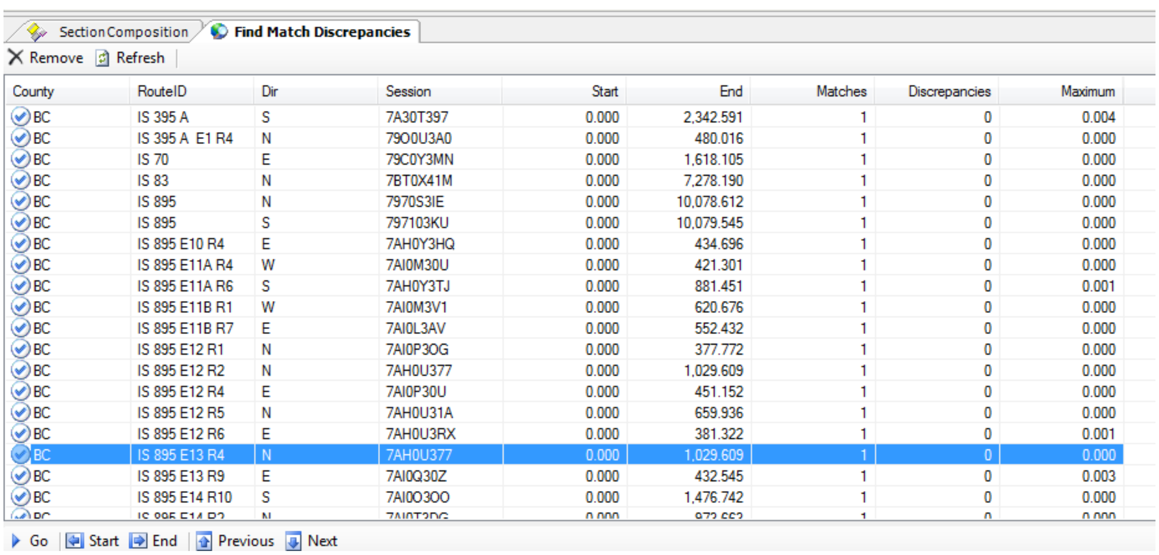
=IF(COUNTIF('matched priority 1&2 >.10mi'!B:B, $I2)=0, "Distance Okay","> 0.10")

SI	IDLOCA	COLLECT_DATE	CODE	COUNT	MUN	Dir+CO+Route	Milesage Diff >0.10	Milesage Diff >0.10 Notes	differences >-5	differences >-5 notes	ROUTE	RNUM
	3692	06/01/2017	13	HO	0	E HO MD 100	Distance Okay		Distance Okay		MD	100
	3004	06/12/2017	10	FR	0	N FR MD 491	Distance Okay		Distance Okay		MD	491
	3004	06/12/2017	10	FR	0	N FR MD 491	Distance Okay		Distance Okay		MD	491
	3005	06/12/2017	10	FR	0	S FR MD 491	Distance Okay		Distance Okay		MD	491
	3005	06/12/2017	10	FR	0	S FR MD 491	Distance Okay		Distance Okay		MD	491
	3233	06/13/2017	10	FR	0	E FR US 40	> 0.10	construction	Distance Okay		US	40
	3236	06/13/2017	10	FR	0	W FR US 40 AL	Distance Okay		Distance Okay		US	40
	2897	06/13/2017	10	FR	0	E FR IS 70	Distance Okay		Distance Okay		IS	70
	2486	06/13/2017	6	CL	0	E CL IS 70	Distance Okay		Distance Okay		IS	70
	2486	06/13/2017	6	CL	0	E CL IS 70	Distance Okay		Distance Okay		IS	70
	3235	06/13/2017	10	FR	0	E FR US 40 AL	Distance Okay		Distance Okay		US	40
	2862	06/13/2017	10	FR	0	S FR CO 209	Distance Okay		Distance Okay		CO	209
	2487	06/13/2017	6	CL	0	W CL IS 70	Distance Okay		Distance Okay		IS	70
	2898	06/13/2017	10	FR	0	W FR IS 70	Distance Okay		Distance Okay		IS	70
	2487	06/13/2017	6	CL	0	W CL IS 70	Distance Okay		Distance Okay		IS	70
	2864	06/13/2017	10	FR	0	S FR CO 245	Distance Okay		Distance Okay		CO	245
	3235	06/13/2017	10	FR	0	E FR US 40 AL	Distance Okay		Distance Okay		US	40
	3112	06/13/2017	10	FR	0	N FR US 15	Distance Okay		Distance Okay		US	15
	3234	06/13/2017	10	FR	0	W FR US 40	Distance Okay		Distance Okay		US	40
	3119	06/13/2017	10	FR	0	S FR US 15 BU	Distance Okay		Distance Okay		US	15
	3118	06/13/2017	10	FR	0	N FR US 15 BU	Distance Okay		Distance Okay		US	15
	3053	06/13/2017	10	FR	0	N FR MD 873	> 0.10	started late and end early	Distance Okay		MD	873

Step 24. Using the Filter tool in Excel, isolate the following data and delete the records.

Sheet	Data	Notes
Matched priority 1 Diff >-5	DIFF_PERC	Remove any record that has a DIFF_PERC of -4 to 100.
Matched priority 1 Diff >-5	DIFF_LENGTH	Remove any record that has a DIFF_LENGTH -0.01 to inf.
Matched priority 1&2 >.10mi	DIFF_LENGTH	Remove any record that has a DIFF_LENGTH -0.1 to inf.

Step 25. Open Vision. Click the "Segment" drop-down menu and select "Match Discrepancy Finder." The "Find Match Discrepancies" window will appear (see below image).



Section Composition | Find Match Discrepancies
Remove | Refresh

County	RouteID	Dir	Session	Start	End	Matches	Discrepancies	Maximum
BC	IS 395 A	S	7A30T397	0.000	2,342.591	1	0	0.004
BC	IS 395 A E1 R4	N	79O0U3A0	0.000	480.016	1	0	0.000
BC	IS 70	E	79C0Y3MN	0.000	1,618.105	1	0	0.000
BC	IS 83	N	7BT0X41M	0.000	7,278.190	1	0	0.000
BC	IS 895	N	7970S3IE	0.000	10,078.612	1	0	0.000
BC	IS 895	S	797103KU	0.000	10,079.545	1	0	0.000
BC	IS 895 E10 R4	E	7AH0Y3HQ	0.000	434.696	1	0	0.000
BC	IS 895 E11A R4	W	7AI0M30U	0.000	421.301	1	0	0.000
BC	IS 895 E11A R6	S	7AH0Y3TJ	0.000	881.451	1	0	0.001
BC	IS 895 E11B R1	W	7AI0M3V1	0.000	620.676	1	0	0.000
BC	IS 895 E11B R7	E	7AI0L3AV	0.000	552.432	1	0	0.000
BC	IS 895 E12 R1	N	7AI0P3OG	0.000	377.772	1	0	0.000
BC	IS 895 E12 R2	N	7AH0U377	0.000	1,029.609	1	0	0.000
BC	IS 895 E12 R4	E	7AI0P30U	0.000	451.152	1	0	0.000
BC	IS 895 E12 R5	N	7AH0U31A	0.000	659.936	1	0	0.000
BC	IS 895 E12 R6	E	7AH0U3RX	0.000	381.322	1	0	0.001
BC	IS 895 E13 R4	N	7AH0U377	0.000	1,029.609	1	0	0.000
BC	IS 895 E13 R9	E	7AI0Q30Z	0.000	432.545	1	0	0.003
BC	IS 895 E14 R10	S	7AI0O3OO	0.000	1,476.742	1	0	0.000

Go | Start | End | Previous | Next

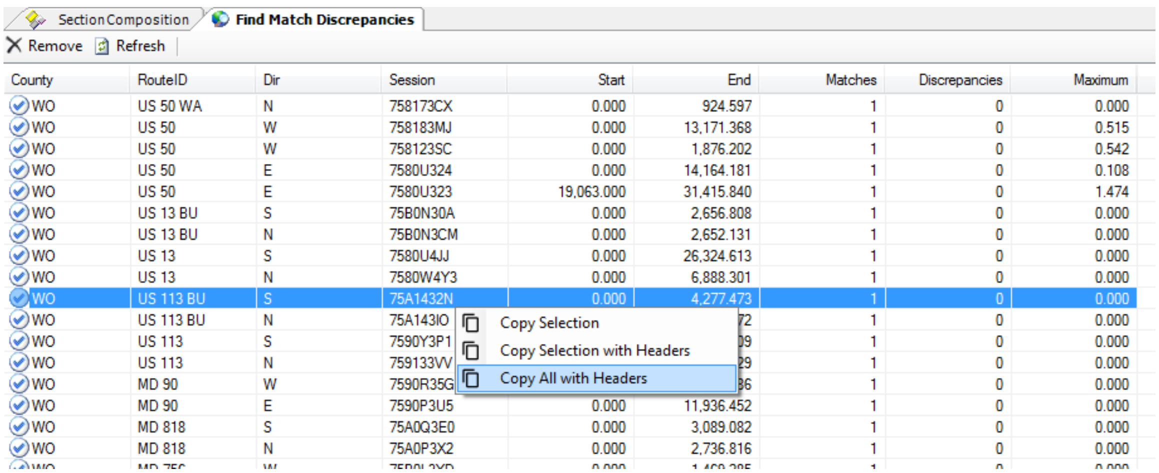
Step 26. Click on the heading of the "Discrepancies" column so that the records (i.e., rows) on the table are sorted such that those records with data discrepancies are listed at the top of the table.

Step 27. Double-click on each file with a discrepancy and Vision will navigate to that file. Open the “Section Composition” window to edit the file. Follow the steps in Route Matching [Route Matching](#) to correct match discrepancies.

Step 28. Click the “Refresh” button at the top of the “Find Match Discrepancies” window so that changes made in the “Section Composition” window are reflected in the “Find Match Discrepancies” table.

Step 29. Repeat Step 27 and Step 28 until no more discrepancies exist.

Step 30. Right click on the “Find Match Discrepancies” window and select “Copy All with Headers” (see below image).



County	RouteID	Dir	Session	Start	End	Matches	Discrepancies	Maximum
WO	US 50 WA	N	758173CX	0.000	924.597	1	0	0.000
WO	US 50	W	758183MJ	0.000	13,171.368	1	0	0.515
WO	US 50	W	758123SC	0.000	1,876.202	1	0	0.542
WO	US 50	E	7580U324	0.000	14,164.181	1	0	0.108
WO	US 50	E	7580U323	19,063.000	31,415.840	1	0	1.474
WO	US 13 BU	S	75B0N30A	0.000	2,656.808	1	0	0.000
WO	US 13 BU	N	75B0N3CM	0.000	2,652.131	1	0	0.000
WO	US 13	S	7580U4JJ	0.000	26,324.613	1	0	0.000
WO	US 13	N	7580W4Y3	0.000	6,888.301	1	0	0.000
WO	US 113 BU	S	75A1432N	0.000	4,277.473	1	0	0.000
WO	US 113 BU	N	75A143IO	[illegible]	[illegible]72	1	0	0.000
WO	US 113	S	7590Y3P1	[illegible]	[illegible]09	1	0	0.000
WO	US 113	N	759133VV	[illegible]	[illegible]29	1	0	0.000
WO	MD 90	W	7590R35G	[illegible]	[illegible]36	1	0	0.000
WO	MD 90	E	7590P3U5	0.000	11,936.452	1	0	0.000
WO	MD 818	S	75A0Q3E0	0.000	3,089.082	1	0	0.000
WO	MD 818	N	75A0P3X2	0.000	2,736.816	1	0	0.000

Step 31. Paste the records that were copied into the “Match Discrepancies” sheet created in the Microsoft Excel file.

Step 32. Run the rechain query in Vision (see query at the end of this SOP).

i. If all files have been rechained, paste a screenshot of the query results in the “Rechain” sheet created in the Microsoft Excel file.

ii. If there are files that have not been rechained, follow the steps in Route Matching [Route Matching](#) to rechain. Then, rerun the query and paste a screenshot of the query results in the “Rechain” sheet created in the Microsoft Excel file.

Step 33. In the “District” sheet, check every route that has a “>0.10” in Column J or a “>-5” in Column L.

i. If the matching is correct, enter “Acceptable” in Column K (for notes pertaining to Column J) or Column M (for notes pertaining to Column L).

ii. If the matching is incorrect, correct it in Vision and enter “Fixed” in Column K (for notes pertaining to Column J) or Column M (for notes pertaining to Column L). If a file is new or re-matching uncovers a previously non-drive through section, add the filename to the “Step 6” sheet in the Microsoft Excel workbook. If a file only requires re-importing, add file name to the “Step 7” sheet in the Microsoft Excel workbook.

Step 34. In the “Matched priority 1 Diff >-5” sheet, check all routes that have a “-100” in the “DIFF_PERC” column. Enter “Collected” or “No Collected” in Column J.

All other routes listed in this sheet should be accounted for on the "District" sheet.

Step 35. In the "Matched priority 1&2 >.10mi" sheet, check all routes that have a "-100" in the "DIFF_PERC" column. Enter "Collected" or "No Collected" in Column J. Compare the filtered list to the one from the "Matched priority 1 Diff >-5" sheet. All other routes listed in this sheet should be accounted for on the "District" sheet.

Step 36. Email the completed Microsoft Excel file to the DPT TL for review.

2- QA of Year-End Data Closeout Spreadsheet – *performed by TL*

Summary: This task performs QA checks on the year-end district-level closeout spreadsheet.

Step 37. Review the transmitted Excel file and discuss any issues with DPT Staff for resolution.

Rechain Query

This query is run to rechain discrepancies that have results from route matching.

```
select

c.uniquerun,
c.idlocator,
c.l_county,
c.l_routeid,
c.l_dir,
c.routedlength,
c.beginchainage,
c.endchainage,
c.dmi_distance,
c.matched_distance,
c.distance_diff

from
(select

b.uniquerun,
b.idlocator,
b.l_county,
b.l_routeid,
b.l_dir,
b.routedlength,
b.beginchainage,
b.endchainage,
b.dmi_distance,
b.matched_distance,
(abs(b.dmi_distance) - abs(b.matched_distance)) distance_diff

from

(select a.uniquerun,
a.idsession,
a.idlocator,
a.l_county,
a.l_routeid,
a.l_dir,
a.routedlength,
a.beginchainage,
a.endchainage,
(a.EndDistanceStamp_MMI - a.BeginDistanceStamp_MMI) DMI_Distance,
(a.EndChainage - a.BeginChainage) Matched_Distance,
a.matchcomment

from

(SELECT DCSessions.Uniquerun,
Matches.IDSession,
Matches.BeginChainage,
Matches.EndChainage,
Matches.BeginDistanceStamp *  0.621371192237334 BeginDistanceStamp_MMI,
Matches.EndDistanceStamp  *  0.621371192237334 EndDistanceStamp_MMI,
```

```
Locators.IDLocator,
Locators.L_County,
Locators.L_RouteID,
Locators.L_Dir,
Matches.MatchComment,
abs(Matches.EndChainage - Matches.BeginChainage)  RoutedLength
FROM dbo.Matches,
dbo.DCSessions,
dbo.Locators
where DCSessions.IDSession = Matches.IDSession
and DCSessions.IDLocator = Locators.IDLocator
and Locators.L_Routeid not like 'TL%'
and UPPER(Locators.L_Routeid) not like 'DUMMY'
) a
) b
) c
where distance_diff > 1
or distance_diff <-1
```

5.22 ROUTE MATCHING - TRANSFERS

5.22.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Processing Team (DPT) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to transfer data collected by the Automatic Road Analyzer (ARAN) survey vans to the appropriate route or section using the vendor supplied Vision post-processing software. Data collection may occur on one or more routes under the same run/file route header to maximize efficiency (e.g., collection on interchange ramps). It is also possible that errors may occur (e.g., route keyed in incorrectly or extra collection on adjacent routes). To accommodate this issue, the ARAN Vision software contains features that enable the user to transfer and re-assign a portion(s) or entire collection run to the appropriate route(s) or sections(s).

5.22.02 *Frequency*

Route matching transfers are a routine part of the MDOT-SHA Route Matching process (Route Matching), which occur upon arrival of the Field Explorations Division's (FED's) ARAN QC/QA'd deliverables. These FED deliverables typically arrive during the April through early October timeframe, but they can also arrive at other times of the year.

5.22.03 *Purpose*

The purpose of this SOP is to document the MDOT-SHA routines and procedures associated with the route matching transfer process. The latest version of the ARAN "Vision Training Guide" should be referenced when addressing issues not covered by this SOP.

5.22.04 *Resource Requirements*

The route matching transfer routine involves the following two MDOT-SHA staff members: (1) a DPT staff member who is knowledgeable in the Vision software and the Engineering Data Warehouse (EDW) application to perform the route matching transfers, and (2) the DPT Team Leader (TL) to perform quality assurance (QA) functions and who, as required, provides guidance and decision-making. The Quality Control (QC) and Quality Assurance (QA) routines are incorporated into the Route Matching process (Route Matching). Any issues (and associated recommendations) are discussed with the DPT TL for guidance and decision-making. The estimated effort levels shown in the table below represent the total time, in man-hours, to complete route matching transfers for each FED deliverable. These time estimates assume average batch quantities and that no major issues are encountered during the transfer process.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	Vision/EDW user and QC	1	1.5
DPT Team Leader (TL)	Supervisor and QA	1	0.15

5.22.05 *Procedure*

The procedure for transferring a portion(s) or entire ARAN data collection run to the appropriate route(s) or sections(s) is performed, as needed, during the Route Matching process (Route Matching). Once a route or section is identified for transfer, the following three tasks are performed:

(1) determine the target route or section,
(2) perform the transfer routine and QC, and
(3) perform QA.

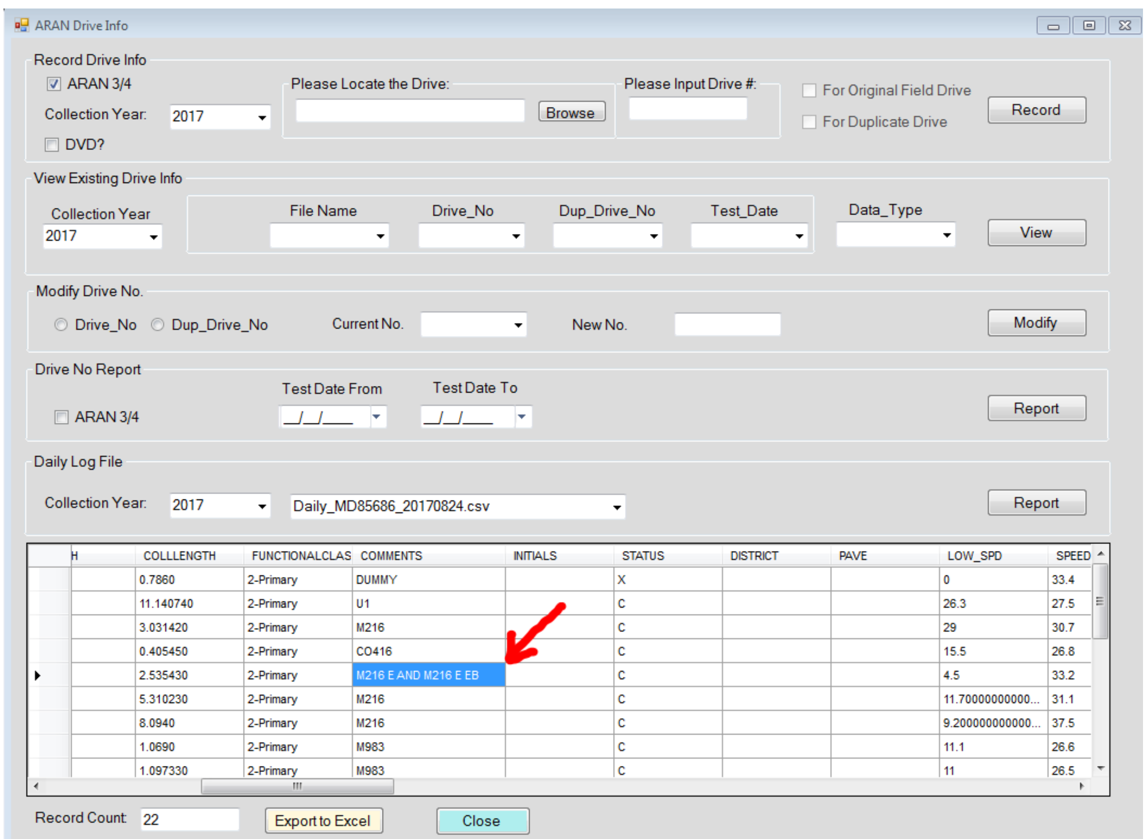
There are 15 steps associated with these three tasks and the table below summarizes the specific steps associated with each task.

Task	Steps
1	1 - 2
2	3 - 14
3	15

1- Determine the Target Route or Section – *performed by Vision and EDW user*

Summary: This task identifies the collection run's destination route or section.

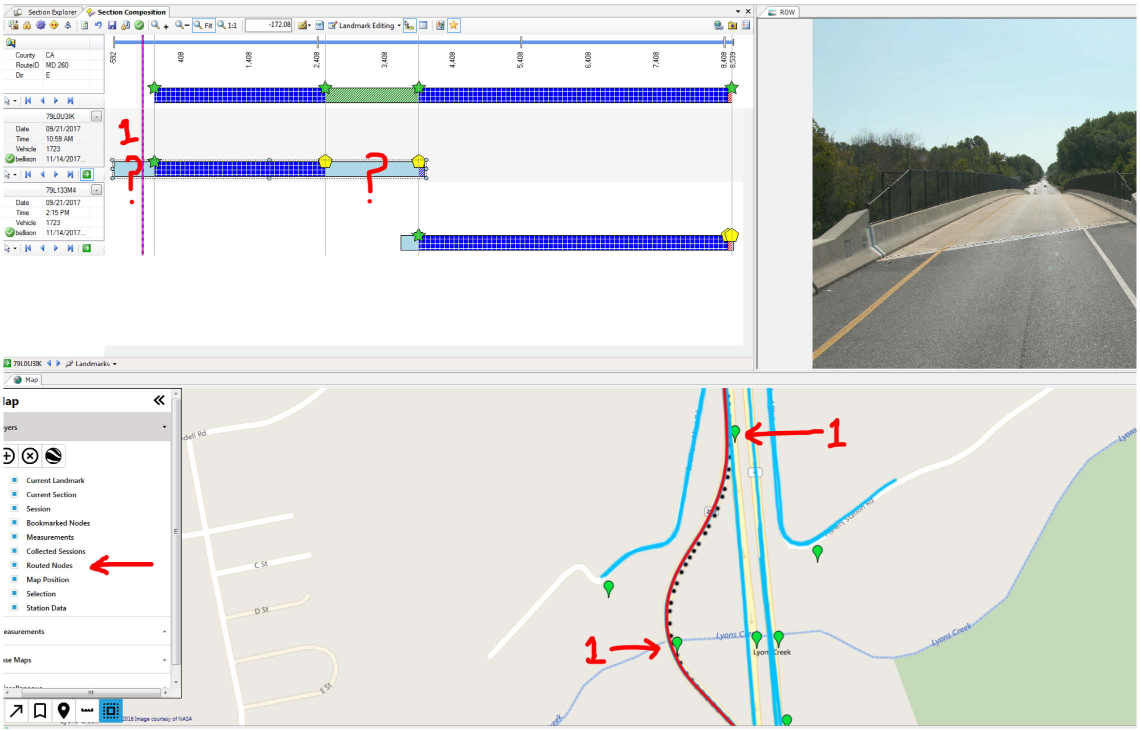
Step 1. Using the EDW's FED ARAN Electronic Daily logs feature (see Accessing Electronic ARAN Logs), review the collection run(s) to determine if the field crew identified additional routes to be assigned to the collection run. Use the "COMMENTS" field to identify comments, as illustrated in the image below.



Step 2. If a matched collection run contains an abnormally high (>0.10 mile) lead-in and lead-out, investigate the collection run to determine if the lead-in and lead-out could potentially be on another route that can also be matched. To help identify such cases, use the Vision Map's "Routed Nodes" feature, HLR Guide,

and eGIS's SHA Highway System content feature tools illustrated and described in the following images.

Vision Routes Nodes feature:



HLR Guide:

http://www.roads.maryland.gov/index.aspx?PageId=832

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
DATA SERVICES DIVISION

HIGHWAY LOCATION REFERENCE

PAGE: 29

COUNTY: ALLEGANY
DISTRICT: 6
DATE: 12/31/16

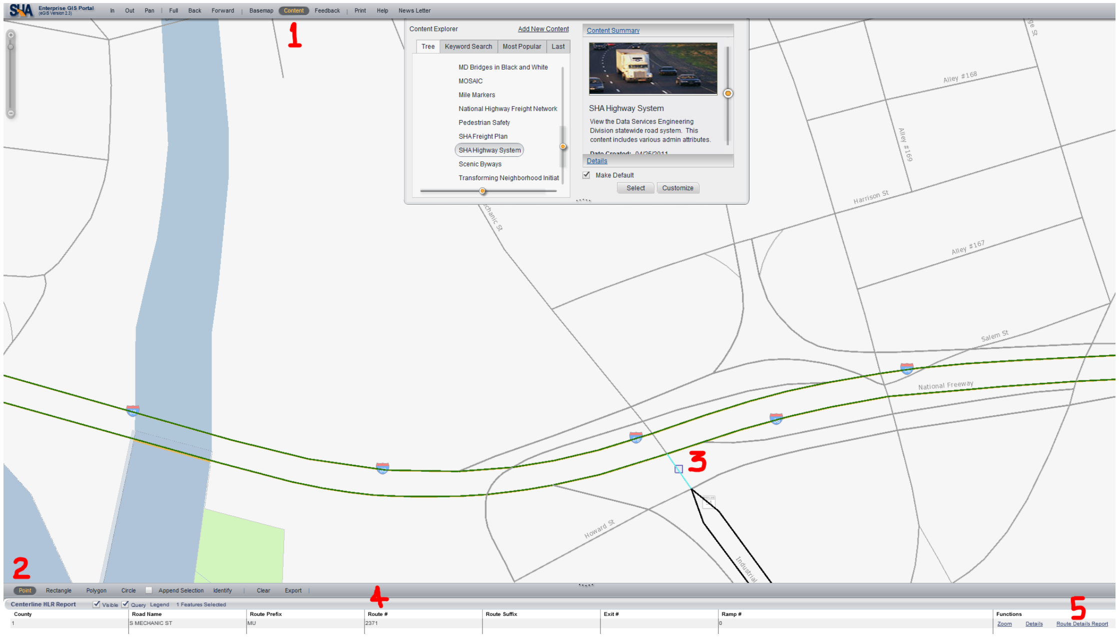
ROUTE NUMBER: MD 51 CONTINUED
INVENTORY DIRECTION: EAST
ROUTE NAME: INDUSTRIAL BLVD

STATE SYSTEM	FUNCTIONAL CLASS	MEDIAN TYPE	ACCESS CONTROL	NHS	MILEPOINT	MILEPOINT DESCRIPTION	MARKED LANES	SURFACE WIDTH/TYPE*	AADT
STATE SECONDARY	URB OPA	CURBED	NONE	NOT NHS	00.000 MU1780	HOWARD ST	3	36I	14,910
					00.000 MU2371	S MECHANIC ST (BACK)			
					00.040		4	48I	
					00.040	CROSSOVER			
					00.050	TRAFFIC SIGNAL			
					00.050 MU3935	WINSTON ST			
					00.060		5	58I	
					00.060	SPUR FR WINSTON ST			

eGIS's SHA Highway System content feature:

http://shagbegis1/egis/

Using eGIS's Street Map or Imagery Basemap feature, zoom in to the required area.



1. Select SHA Highway System
2. Left click “Point”
3. Hover pointer over required portion of route and then left click.
4. Route number will now be displayed.
5. If additional route details are required, see below example display.

1 of 2 | 100% | Find | Next

eGIS

Maryland State Highway Administration
Highway Location Reference Report

Page 1 of 2
Generated: 4/30/2018

ROUTE NUMBER	DIRECTION	ROAD NAME	DISTRICT	CO NAME	BEG MILEPOINT	END MILEPOINT	IS INVENTORY
MU-2371	E	S MECHANIC ST / S MECHANIC ST	6	ALLEGANY	0	0.19	Y

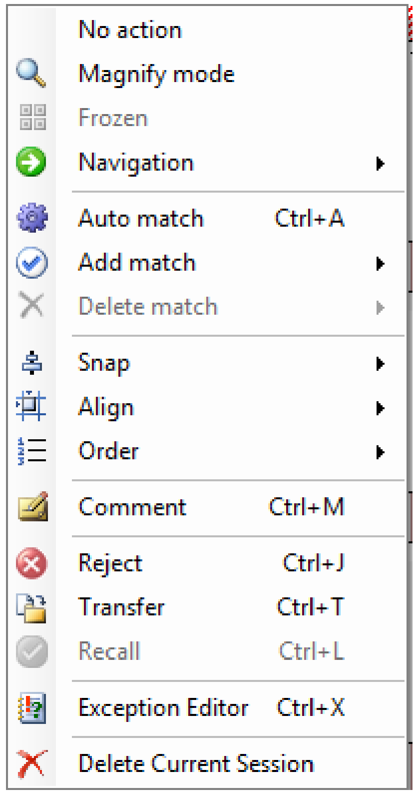
ROUTE NUMBER	DIRECTION	ROAD NAME	DISTRICT	CO NAME	BEG MILEPOINT	END MILEPOINT	IS INVENTORY
MU-2371	E	S MECHANIC ST	6	ALLEGANY	0	0.19	Y

BEG MILEPT	BEGSEGID	INT RTES	ADDITIONAL DESC	CLASSIFICATION	FSYSTEM	MEDIAN	MAINT SHOP	NHS	AADT	MARKED LANES	SURFACE TYPE	SURFACE WIDTH
0	923237	MU 250	BALTIMORE ST	EVERYTHING ELSE	PRINCIPAL ARTERIAL – OTHER	NONE (UNDIV)	N/A	NOT NHS	9370	2	PAVED	26
0	923237	MU 2370	N MECHANIC ST (BACK)									
0.05	923287	MU 2770	PERSHING ST									
0.12	923357	MU 1640	HARRISON ST									
0.12	923357		TRAFFIC SIGNAL									

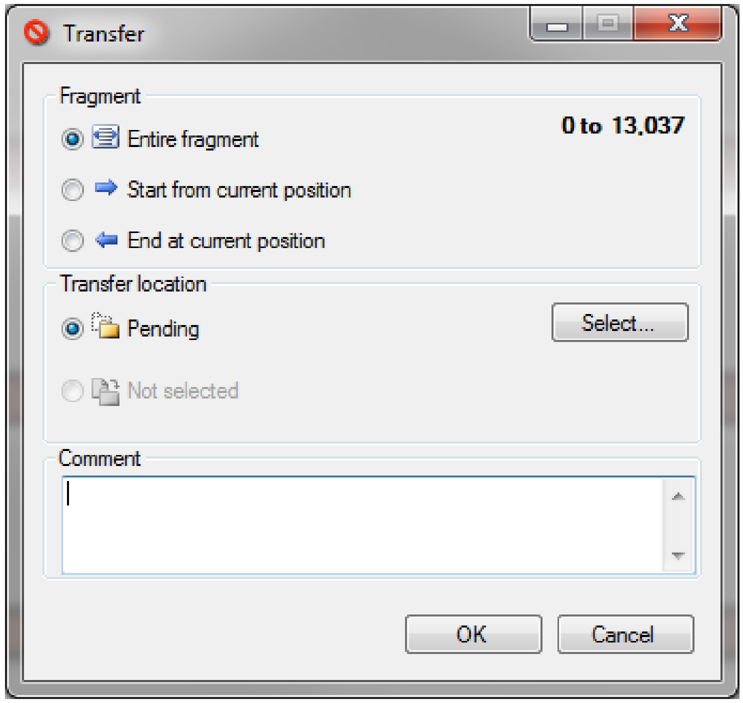
2- Perform the Transfer Routine and QC – *performed by Vision user*

Summary: This task allows the user to transfer and re-assign a portion or entire collection run to the appropriate route(s) or sections(s). QC is then performed.

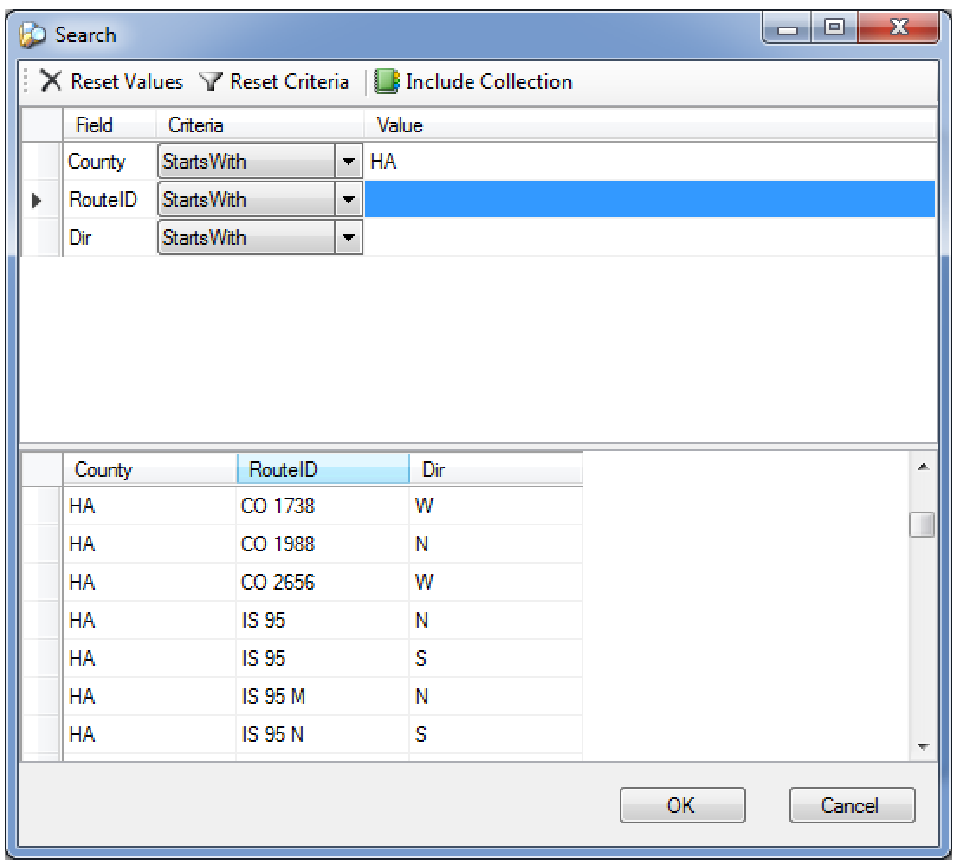
Step 3. Open the "Section Composition" window, then right click on the collection run/file. The below window will now appear.



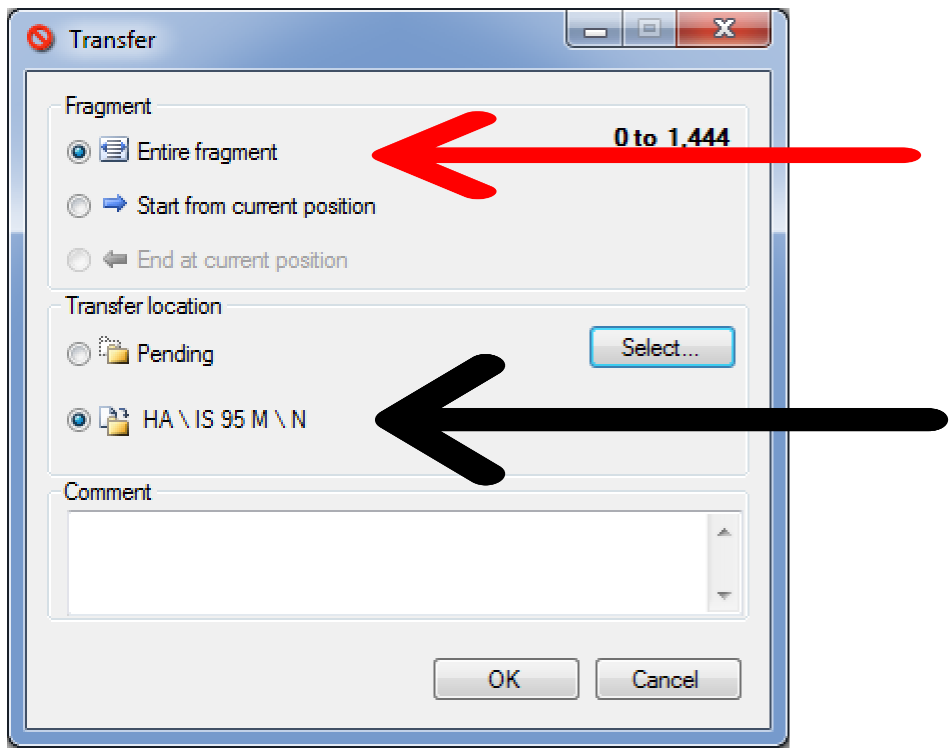
Step 4. Select "Transfer" from the displayed menu. The window below will appear.



Step 5. Left click on the “Select” button. The window below will appear.



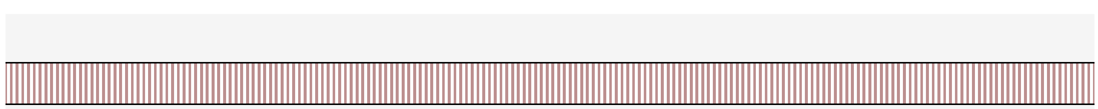
Step 6. Locate the route to be assigned by using the route search (AL, BA, etc.), then route prefix (CO, IS, MD, etc.), and then select the appropriate route/direction. Select "OK". The search window will close, and the "Transfer" window illustrated in the image below will be displayed.



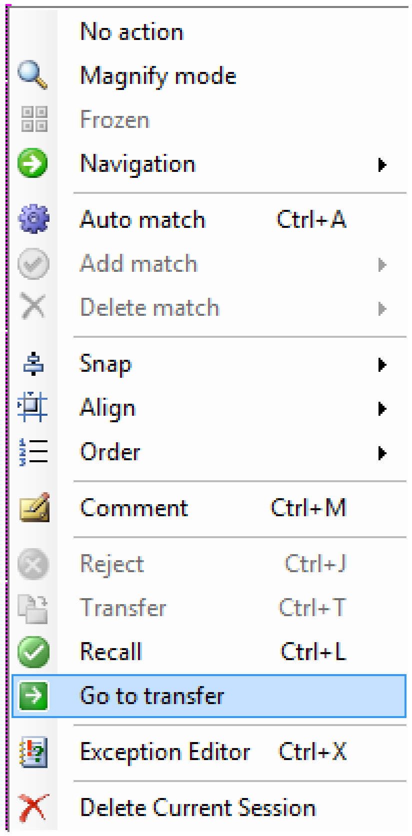
Step 7. Confirm the destination of the transfer. If not correct, left click on the "Select" button again and search for the correct route.

Step 8. If an entire collection run requires transfer to a single route, select "Entire fragment" (see red arrow in above image). If transferring only a portion of the collection run/file, use the "Start from current position" or "End at current position" (see black arrow in above image). *Note: If file contains two or more routes, user will need to start the transfer from the end – working backwards.*

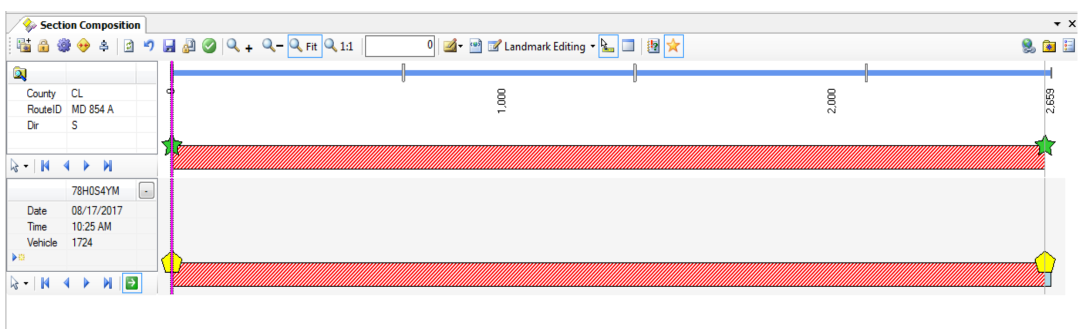
Step 9. Left click on the "OK" button. The collection run's background will appear as shown in the below image.

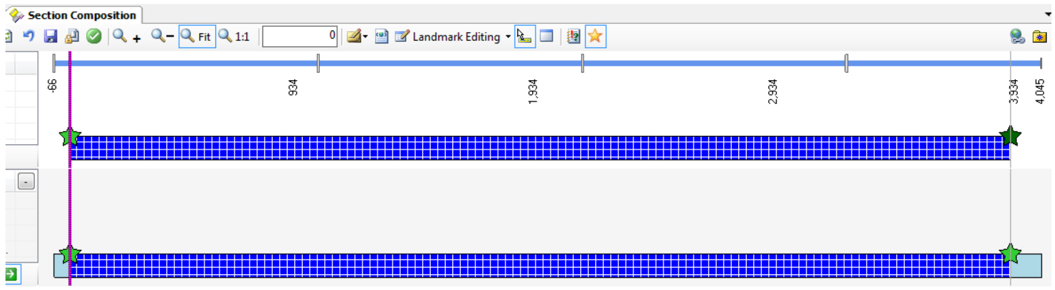


Step 10. While hovering over the collection run, right click and select the "Go to transfer" button, which is shown in the below image. If there is an inadvertent transfer to the incorrect route, select the "Recall" button, which is also shown in the below image.



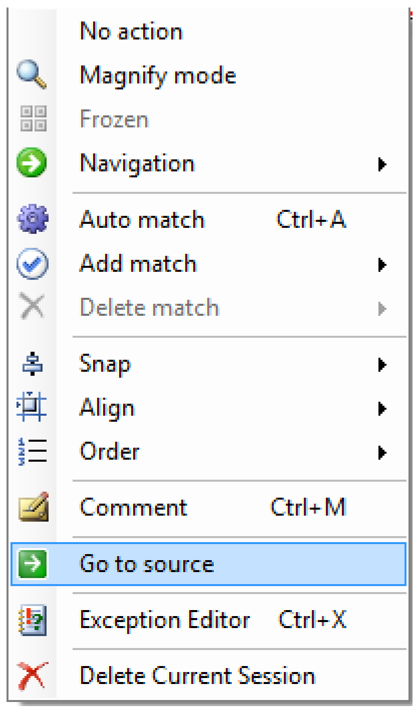
Step 11. The “Section Composition” window will open for the transfer’s destination(s) as in the images below. Using Route Matching - Transfers Task 2 (Developing a Route Match Candidate and QC), review and verify the transfer’s route destination and that the transferred run is located between the destination’s route expected begin and end anchor landmarks.





Step 12. Complete the transferred run's route match by completing Route Matching - Transfers Tasks 2 and 3.

Step 13. Once the match is complete, select "Go to source" as shown in the below image to go back to the original route.



Step 14. Communicate processing and/or QC issues (including recommendations) to DPT TL so they can be resolved.

3- Perform QA – *performed by DPT Team Leader*

Summary: This task performs QA checks on route transfer process.

Step 15. The procedure for completing this step is incorporated in Route Matching - Transfers Task 5 (Performing Quality Assurance (QA), which is performed on a weekly basis.

5.23 LOADING PAVEMENT SURFACE FRICTION DATA

5.23.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA) Data Processing Team (DPT) to load pavement surface friction data collected by the Field Explorations Division (FED) into the Engineering Data Warehouse (EDW). During this process, the pavement surface friction data are converted to a format consistent with the other MDOT-SHA pavement condition measures.

5.23.02 *Frequency*

The loading of pavement surface friction data into the EDW is completed every time a delivery of such data is received by the DPT. The actual frequency varies according to the proximity of the routes on which data were collected for the delivery. The data collection season typically lasts from April to October, but deliveries may occur year-round.

5.23.03 *Purpose*

The purpose of this SOP is to document the procedure for (1) loading raw pavement surface friction data into the EDW and (2) converting the format of those data to one consistent with that for other pavement condition measures, in preparation for the 4-Phase Study (see Outlier Review), further analysis, and reporting.

5.23.04 *Resource Requirements*

The loading of pavement surface friction data involves two people: (1) a DPT staff member that is knowledgeable of the EDW application for loading the raw friction data and for reassigning route identifiers for invalid records, and (2) the DPT Team Leader (TL) to perform quality assurance (QA) functions and who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues are encountered during loading.

Position	Function	Resources	Effort Level (man-hrs)
DPT Staff	EDW user	1	20.0
DPT TL	Supervisor and QA	1	AR[06/12/2019]

5.23.05 *Procedure*

The procedure required to load the pavement surface friction data into the EDW and to make the needed format changes to those data is comprised of the following two tasks:

(1) load and validate pavement surface friction data into the EDW, and
(2) convert validated pavement surface friction data from point values to ranges.

1- Load and Validate Pavement Surface Friction Data into the EDW – *performed by EDW user*

Summary: Under this task, the pavement surface friction data files, as delivered by the FED, are first loaded into the EDW and then route identifiers for invalid records are reassigned.

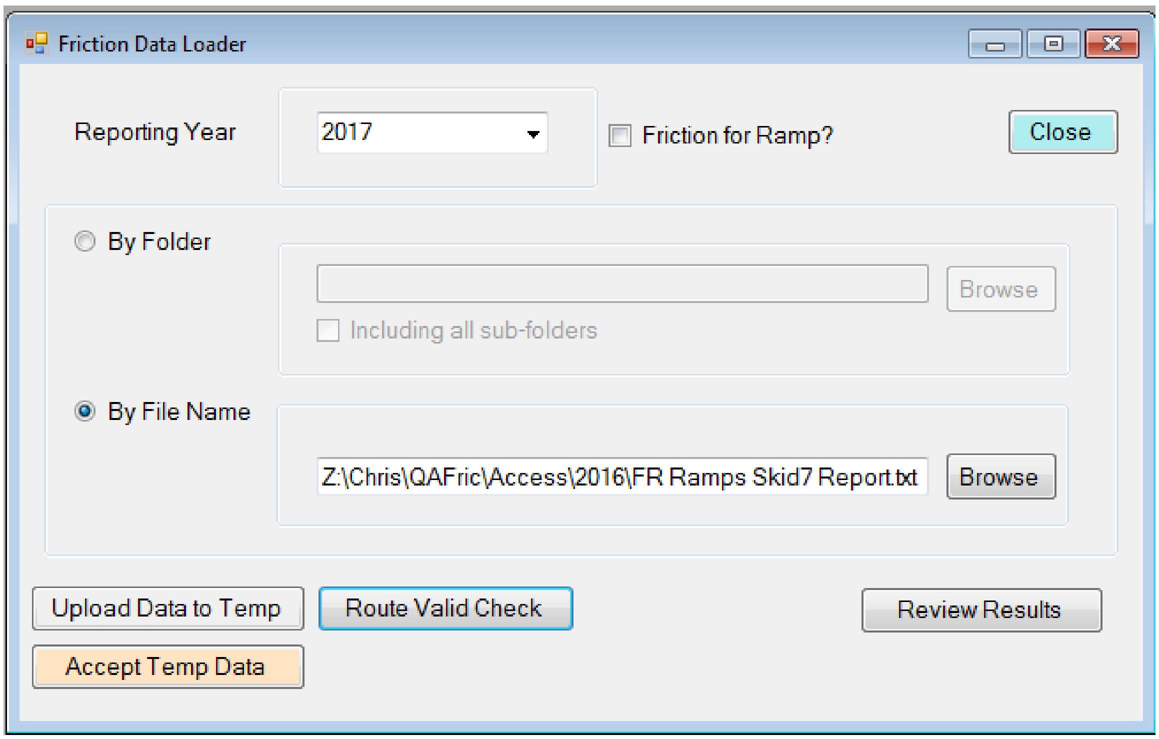
Step 1. Launch EDW and open the "Friction Data Loader" by clicking "Data," "Friction," and then selecting "Route Data Upload" from the main EDW interface.

Step 2. In the "Friction Data Loader" window, select a data upload method:

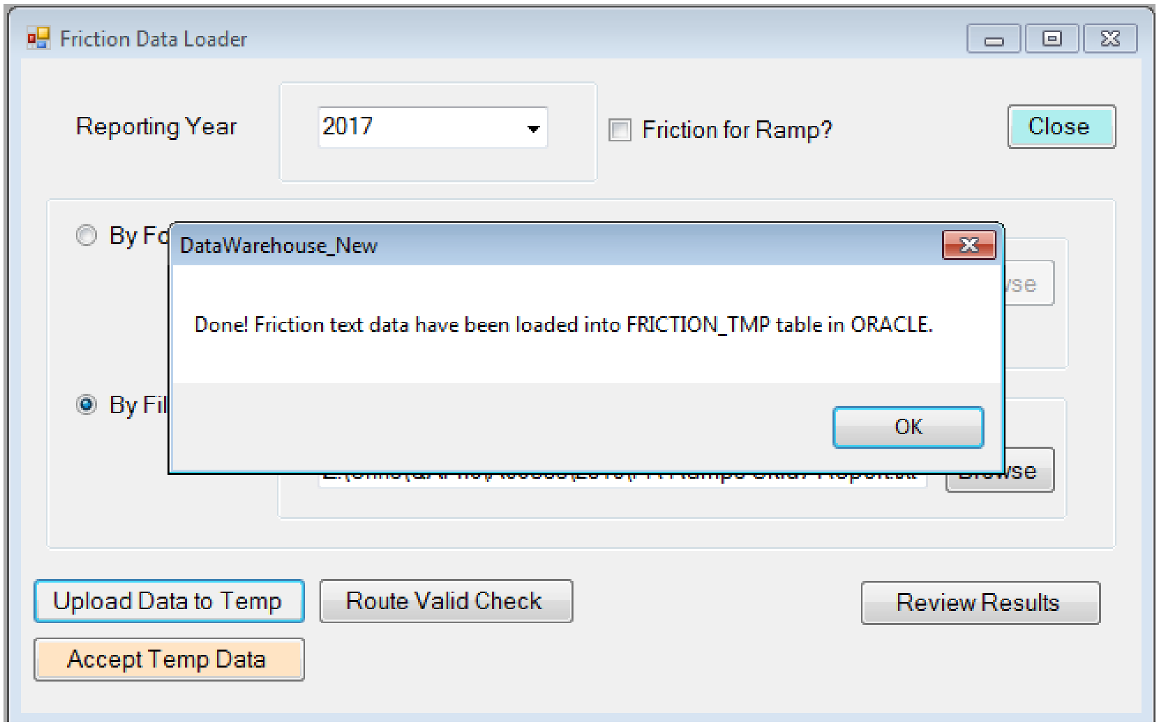
i. "By Folder" – if loading multiple data files at one time, or

ii. "By File Name" – if loading a single data file.

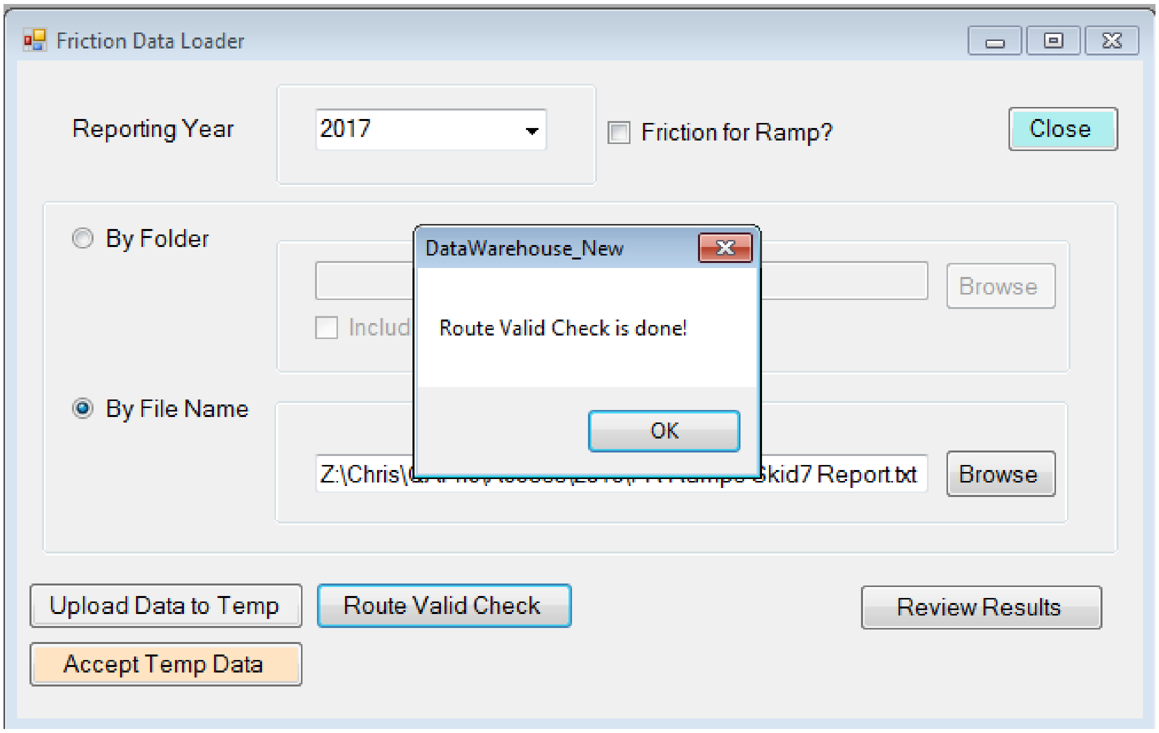
Step 3. Click "Browse" to the right of the selected data upload method and navigate to the location of the friction data file/folder to upload. Friction data files from the FED will be in either text (.txt) or CSV (.csv) format. Use the drop-down menu at the top of the window to select the "Reporting Year" (see image below).



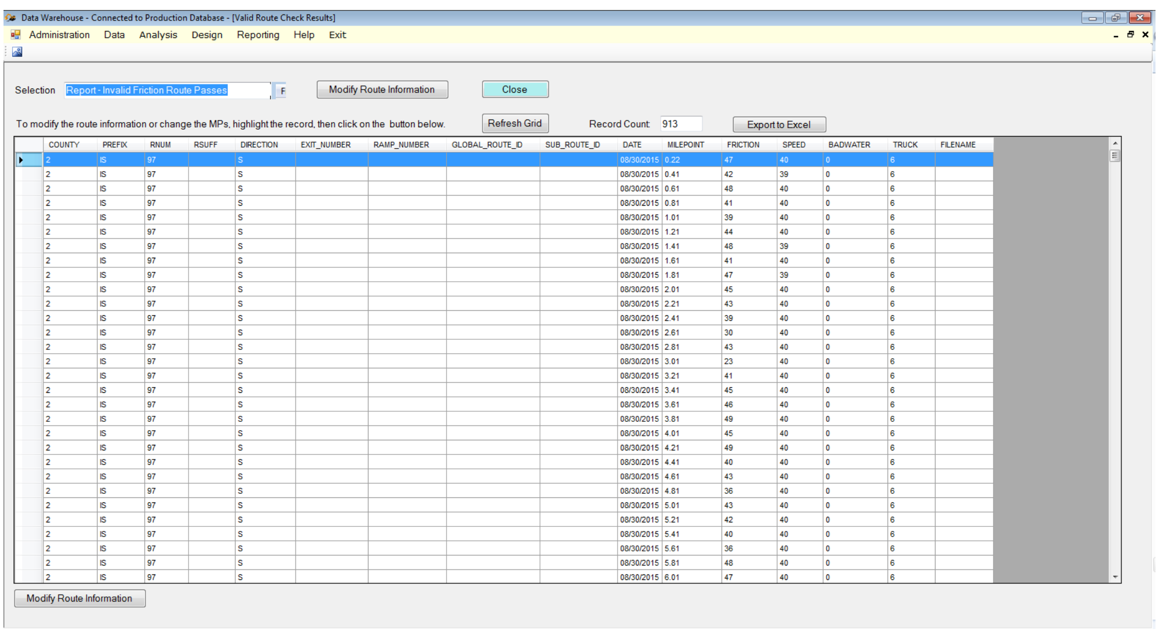
Step 4. Click "Upload Data to Temp" to populate the friction data into the "FRICTION_TMP" table in Oracle. Once the upload is complete, the message in the following image will appear:



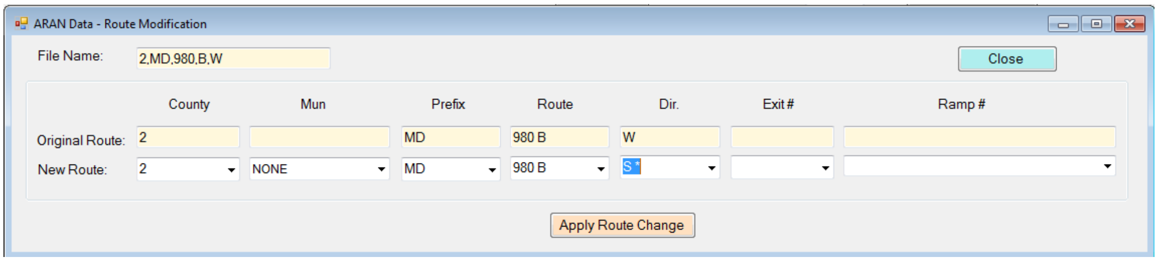
Step 5. In the “Friction Data Loader” window, click on the “Route Valid Check**”** button to check that all routes are valid in the friction data file(s). A route would be invalid if the county code, route number, or direction have been assigned incorrectly. Routes that successfully pass the check will have the data fields “global_route_id” and “sub_route_id” assigned to the associated friction data. The message shown in the following image will appear when the route validation process is complete:



Step 6. Click on the "Review Results" button and the window shown in the image below will appear. Use the "Selection" field at the upper left side of the window to view "Report - Valid Friction Route Passes" or "Report - Invalid Route Passes." The focus of the data review will be on the invalid route records.



Step 7. View the "Report – Invalid Route Passes" and highlight rows in the table by clicking in the left-most column. After rows are highlighted, click on the "Modify Route Information" button at the bottom of the window. The screen shown in the image below will appear:



Step 8. Use the fields to the right of the “New Route” row to re-assign correct route identifiers to the friction data. Click the “Apply Route Change” button to overwrite the original route identifiers with the newly selected ones. The options under “New Route” directly come from the EDW “Global Route Pav” table and therefore are the only valid identifiers. Updated records will also be assigned a “global_route_id” and “sub_route_id.”

Step 9. Repeat Step 7 and Step 8 until there are no more records in the invalid route report table.

Step 10. In the “Friction Data Loader” window (Step 1) click the “Accept Temp Data” button. The friction data in the “FRICTION_TMP” table will then be uploaded to the “FRICTION” table. The “FRICTION” table is the final table designated for storing friction data.

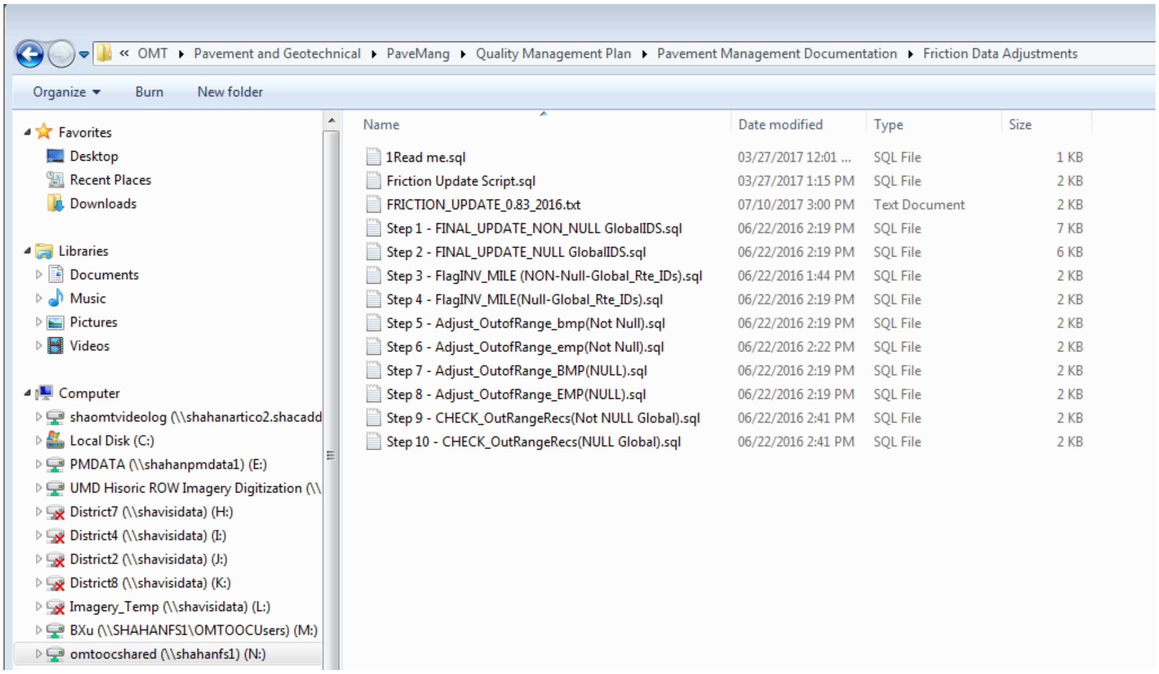
2- Convert Validated Pavement Surface Friction Data from Point Values to Ranges *– performed by EDW user*

Summary: Pavement surface friction is measured at a single point and therefore does not span the full length of a segment or range of pavement segments. To be consistent with other pavement condition measures, this task converts a single mile point to the beginning and ending mile points of every pavement surface friction measurement record.

Step 11. Navigate to the folder located at the following file path:

N:\OMT\Pavement and Geotechnical\PaveMang\Quality Management Plan\Pavement Management Documentation\Friction Data Adjustments/.

The below image shows the contents of the above referenced folder:



Step 12. Click on the SQL script in the folder named “Friction Update Script.sql.” The script will call and execute 10 individual SQL files (Steps 1 through Step 10 in the above image) in sequence to process the friction data. After the script finishes processing, the friction data will be ready for the 4-Phase Study (see Outlier Review) to identify potential outliers in the data. Following the outlier study, the data will be populated into the “BUSINESS_PLAN” tables for reporting and for further analysis).

5.24 SKID SUBMITTAL QC

5.24.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Field Explorations Division (FED) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to perform quality control (QC) checks on skid data collected by the agency.

5.24.02 *Frequency*

This SOP requires that QC checks on skid data collected by the MDOT-SHA be performed in batches as they are received from the FED crews throughout the data collection season [06/12/2019]. The frequency and timing of the QC checks varies according to data collection schedule, available resources, and quantity of data received. Typically, the QC checks are performed once the skid data for an entire county has been completed.

5.24.03 *Purpose*

The purpose of this SOP is to perform QC checks on the skid data collected by the MDOT-SHA FED in order to identify and eliminate unreasonable data points.

5.24.04 *Resource Requirements*

The actions detailed in this SOP are performed by the MDOT-SHA FED Team Leader (TL). The estimated effort level shown in the table below represents the total time, in man-hours, required for completion of the QC checks for a given batch of skid data. These time estimates assume no issues are encountered during the checks.

Position	Function	Resources	Effort Level (man-hrs)
FED TL or Coordinator	QC	1	1.0

5.24.05 *Procedure*

The procedure required to complete the QC checks for a given batch of skid data is comprised of the following two tasks:

(1) running skid report, and
(2) running skid data analyzer.

5- Running Skid Report

Summary: Under this task, the Skid Report 1.3.2.0 software is used to analyze the skid data contained within a given batch by checking for data completeness and for appropriate use of file naming schemes.

Step 1. On the desktop, double-click on the "Skid Report 1.3.2.0" icon.

Step 2. Select "Skid Summary" from the drop-down menu[06/12/2019].

Step 3. Select the desired data set to report.

Step 4. Select "Run Report." This will create a .csvs file for the data.

Step 5. Perform required completeness checks on .csvs file as described below. Highlight any issues and alert the appropriate FED personnel if changes to the data must be made.

i. The file name is displayed correctly.

ii. The collected data is complete when compared to the Skid Collection List.

iii. The section numbers are logical for the specific road being collected (R section).

Step 6. Save .csvs file with QC notes in appropriate location.

6- Running Skid Data Analyzer

Summary: Under this task, the Skid Data Analyzer 1.1 software is used to analyze the skid data contained within a given batch by checking for unreasonable data points in relation to speed, water output, and skid number (SN).

Step 7. On the desktop, double-click on the “Skid Data Analyzer 1.1” icon.

Step 8. Select “Settings” and then “Location Settings.”

Step 9. Under “Save Route Data,” navigate to the appropriate collection list file.

Step 10. Under “Skid Results Data,” navigate to the .csvs file for the data collection.

Step 11. Click “Save.”

Step 12. Click on “Test Criteria Settings.”

Step 13. Accept or adjust thresholds for the various test criteria, including: MPH, Water Average, Lock Friction Value, Slip Friction Value, and Standard Deviation. The current value for each threshold is shown in the table below.

Criteria	Minimum Value	Maximum Value
Speed	22 mph	42 mph
Water Average	60% of speed	80% of speed
Lock Friction Value	10	75
Slip Friction Value	Not used	Not used
Standard Deviation	0	12.5

Step 14. Click “Save Criteria.”

Step 15. Click on “Test Value Ranges.”

Step 16. Accept or adjust thresholds for the various test criteria, including: MPH, Water Average, Lock Friction Value, Slip Friction Value, and Standard Deviation. These ranges differ from the “Test Criteria Settings” in that the software will eliminate data points identified in these ranges, as opposed to simply flagging them. The current values for “Test Value Ranges” are 90% of the minimum value and 110% of the maximum value in “Test Criteria Settings.” The current value for each threshold is shown in the table below.

Criteria	Minimum Value	Maximum Value

Speed	19.8 mph	46.2 mph
Water Average	54% of speed	88% of speed
Lock Friction Value	9	82.5
Slip Friction Value	Not used	Not used
Standard Deviation	0	13.75

Step 17. Click “Save Parameters” and then “Save Ranges.”

Step 18. Make sure “Lock Test” option is selected.

Step 19. Select the appropriate county from the drop-down menu.

Step 20. Click on the “Get Save Data” and “Yes” buttons, and then close the pop-up window that appears.

Step 21. Click on the “Validate Files” and “Yes” buttons, and then close the pop-up window that appears.

Step 22. Click on the “Process Skid Data” and “Yes” Buttons.

Step 23. Click on the “Processed Data” tab. A list of processed files will appear. View plots of the various data runs by double-clicking on a route name. Flagged data points will be identified in both the process data table and the plots.

Step 24. Click “Show in Excel” and then “Save.”

6 DATA MIGRATION

Click to go to Outlier Review
Click to go to Update Final Condition Detail Table
Click to go to Update Rut Detailed Table
Click to go to Update Cracking Detailed Table
Click to go to Update Concrete Detailed Table
Click to go to Migrating to Business Plan Tables

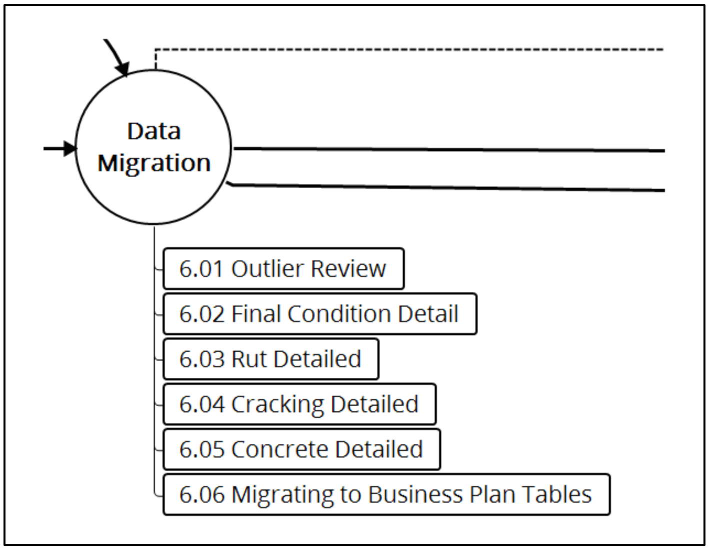


Figure 9: Data Migration SOPs Flowchart

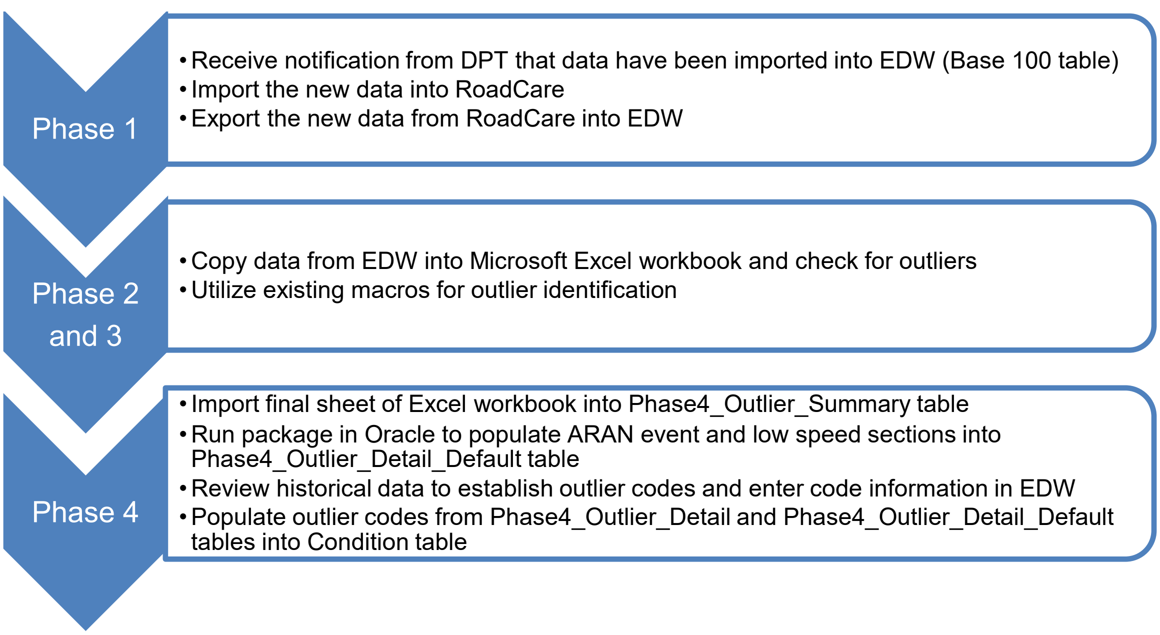
This section describes the set of standard operating procedures (SOP) conducted mainly by staff from the Data Warehouse Team (DWT) of the Maryland Department of Transportation State Highway Administration's (MDOT-SHA) Office of Materials Technology (OMT) to integrate the Base Tables to the Business Plan Tables. This set of SOPs includes six procedures.

The first step in the data migration process is to identify and review outliers in performance measure data (IRI, rut, structural crack density, and functional crack density). This helps the DWT to flag questionable data and investigate the possible causes in order to define remedial actions. Following the outlier review, four intermediate databases are created: the Final Condition Detail Table, the Rut Detailed Table, the Cracking Detailed Table, and the Concrete Detailed Table. These intermediate databases prepare the data for migration to the Business Plan Tables, which includes adjusting location information to address potential errors in GPS data, removing outliers, and formatting the data. The final step in the data migration process consists of the production of the Business Plan Tables through the use of Oracle SQL Developer packages. QC checks of the tables are performed throughout every step of data migration.

6.01 OUTLIER REVIEW

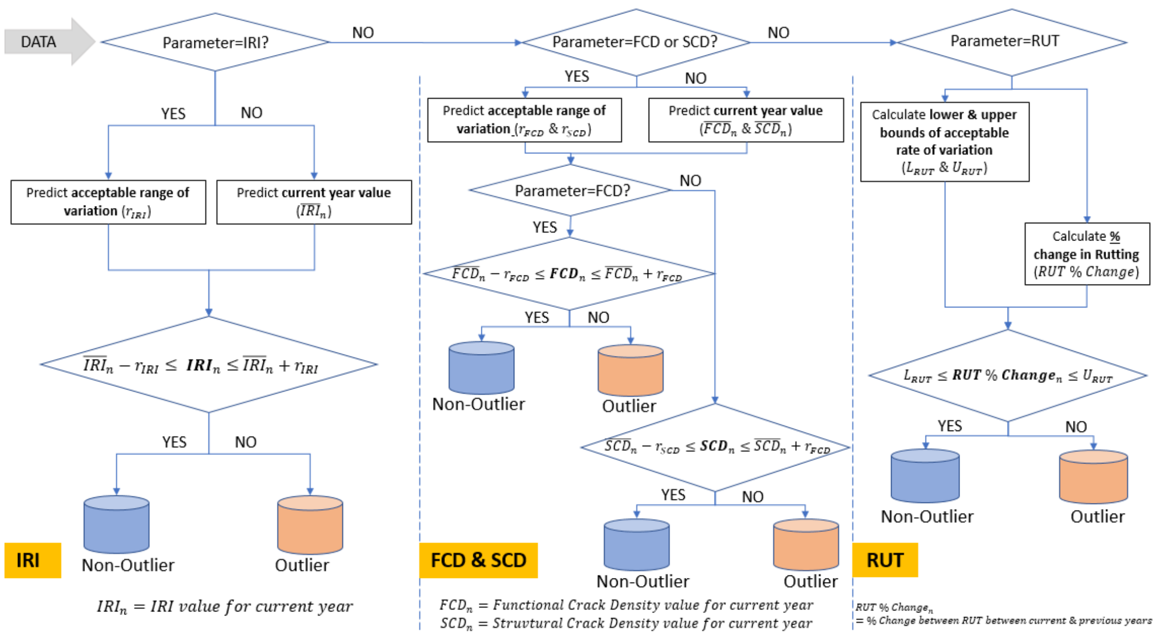
6.01.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Warehouse and Data Analysis Teams (DWT and DAT) to perform the outlier review with data collected by the Automatic Road Analyzer (ARAN) survey vans in the field by Field Explorations Division (FED) staff. This study is performed after the ARAN data have been uploaded from Vision to Oracle and the DWT has been notified by the Data Processing Team (DPT) (see Reporting and Uploading Data to Oracle). The outlier review process identifies data deviating from expected trends and determines possible causes for outlier performance measure values by evaluating historical ARAN data, including speed, construction history, flagged events, pavement imagery, Right-of-Way (ROW) imagery, and comments from the previous year's study. The list of outlier codes is included as an appendix to this SOP (see Outlier Review - Outlier Codes). Outlier identification process identifies and reviews outliers for performance measures such as International Roughness Index (IRI), rut, structural crack density (SC), and functional crack density (FC). The initial study consisted of four phases to identify only IRI outliers and to determine the cause(s) of those anomalies, as illustrated in the figure below.



However, in 2018, a new study was conducted, and the procedures were revised to address the changes and improvements in data collection and processing technologies and to include other performance measures in the process. The new procedure looks at each permornance measure separately and uses unique outlier identification criteria for each measure. Each performance measure requires a unique and customized set of criteria due to the nature of each measure, and different data collection and processing methods and as a result different acceptable ranges of data variation for each measure. The new approach developed for identifying outliers in condition data is referred to as the Hybrid Approach because it combines different outlier identification approaches for

parameters into a unified outlier flagging scheme. With the hybrid approach, a section is only flagged as an outlier if the deviation from the previous year is considered abnormal when previous year's data is valid. The Hybrid approach makes use of parameter trends in the entire network to predict the expected current values and uses data variation in valid test loop sections to define acceptable boundaries for deviation in each parameter. The main assumption with this approach is that the rate of deterioration of a given parameter depends on the current performance level. Deterioration rate versus performance level graghs are developed based on network level data every year and are used for predicting the current year data based on previous year performance levels. Test loop data is carefully monitored and is considered as reliable data which can be used to assess pavement material behavior over time. Data from the test loop were utilized in defining an acceptable window of variation for each parameter. When no maintenance and rehabilitation activity is carried out on a section of test loop over a data collection season, the variation of the collected and processed data in that section can serve as a proxy for acceptable variation of measured pavement condition parameter values.
The following figure is a schematic representation of the Hybrid Approach for flagging outliers for each performance parameter. If a given observation does not fall within the acceptable prediction zone, it is flagged as an outlier. The prediction zone is simply "predicted value ± acceptable range of variation/2".



In the case of rut, it was observed that low rut values are extremely volatile and result in a high percentage of outliers. Thus, based on historic data, a threshold of 0.15" rut in the current year is used for previous year's rut values below 0.07".

6.01.02 *Frequency*

The outlier review is performed multiple times per year, after a set of ARAN data, typically by county or by district, have been uploaded to Oracle and the DWT has been notified by the Data Processing Team (DPT).

6.01.03 *Purpose*

The purpose of this SOP is to identify performance measure outliers and to determine the cause(s) of those anomalies.

6.01.04 *Resource Requirements*

The outlier review involves two or three people: (1) one or two database management experts from the DWT and DAT to perform the outlier identification and review and quality control (QC) checks, and (2) a supervisor who, as required, provides guidance and decision-making and performs quality assurance (QA) checks. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process every time a new set of data is uploaded to Oracle. These time estimates assume no issues are encountered.

Position	Function	Resources	Effort Level (man-hrs)
DWT/DAT Staff	Database Management and QC	2	24.0
DWT TL	Supervisor and QA	1	AR[1]

6.01.05 *Procedure*

The procedure to perform the outlier review is comprised of two tasks:

(1) performing the outlier review and QC,
(2) performing QA on the outlier review results.

1- Performing Outlier Review – *performed by database engineers*

Summary: This task identifies causes for outlier performance measure values using historical ARAN data.

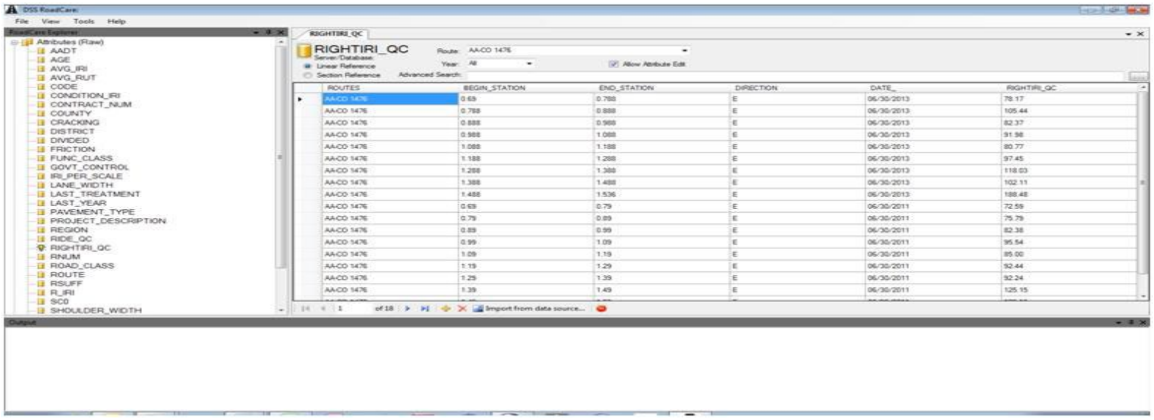
Step 1. Before the start of the outlier review, a new procedure named by current collection year needs to be created and updated in the "EVENTS_DEFAULT" package. For instance, for collection year 2018, the procedure "PHASE4_DEFAULTS_2018" needs to be created by copying the codes from the procedure "PHASE4_DEFAULTS_2017" and updating the table names used in the codes from "EDW17_BASE_4" to "EDW18_BASE_4". The purpose of this procedure is to generate the default outlier codes based on the events identified during DPT's VISION drive through efforts as well as the construction history records entered by the DPT team. Run the procedure to insert the default codes into the "Phase4_Outlier_Detail_Default" table.

Step 2. Open the DCS RoadCare software from the computer desktop and enter the username and password provided by the RoadCare administrator.

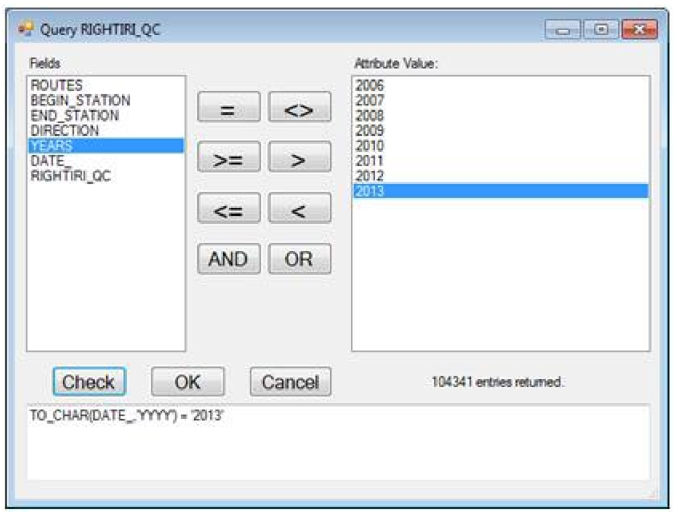
Step 3. In the RoadCare Explorer window, to the left of the screen, click on "Attributes" and then double-click on the intended performance measure QC attribute ("Performance_Measure_QC"). The procedures should be performed on following attributes: "AVG_IRI_QC", "AVG_RUT_QC", "FC_DENSITY_QC", and "SC_DENSITY_QC".

Step 4. Check the box next to "Allow Attribute Edit" at the top of the data window (see below image).

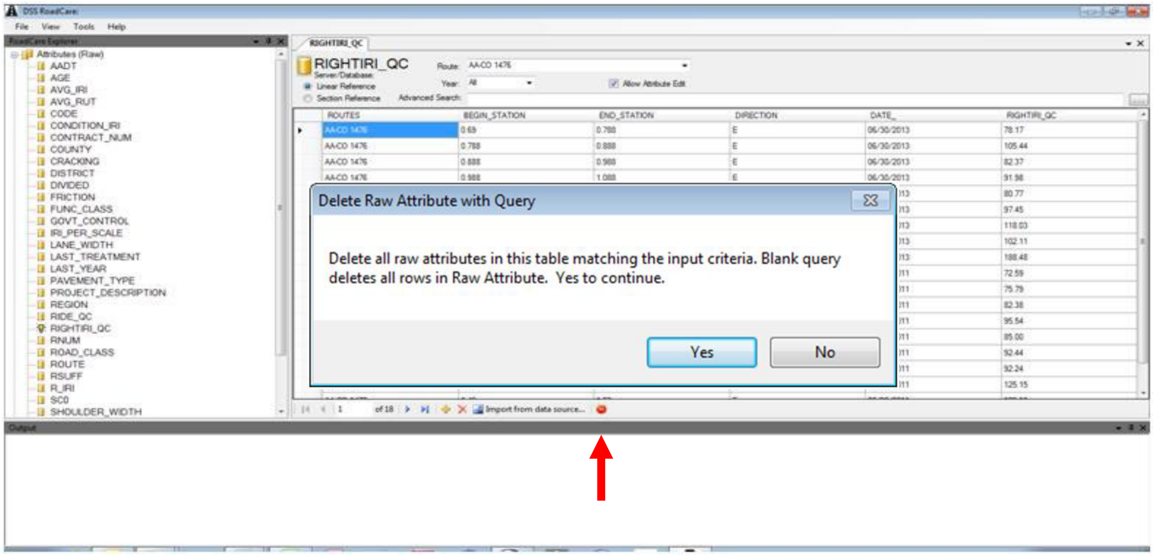
[1] "As Required" – Team Leader may be required for decision-making and troubleshooting.



Step 5. Click the “Advanced Search” button on the far right side of the data window. Next, in the data window shown below, enter the following query: “EXTRACT(YEAR FROM DATE_) = QC YEAR” and then click “OK” (see below image). This step is intended to filter the data that will be replaced with imported data.

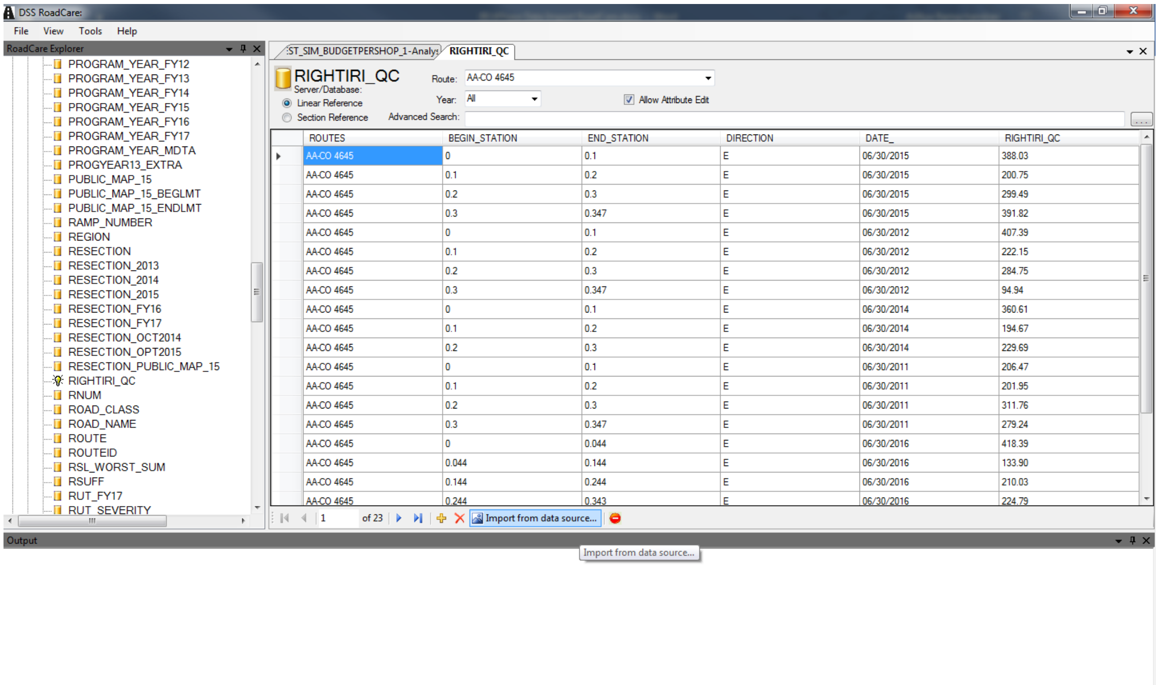


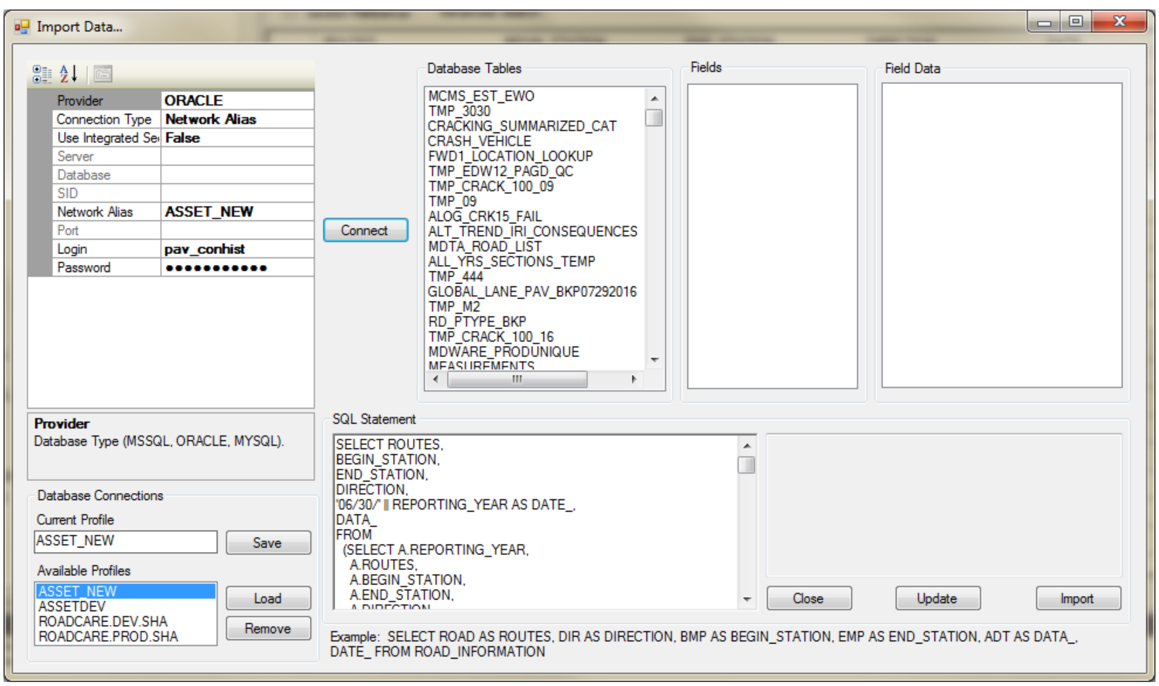
Step 6. Click on the red icon at the bottom of the data window back on the main RoadCare screen, and then click “Yes” on the dialogue box that appears (see below image). This step deletes the filtered data.



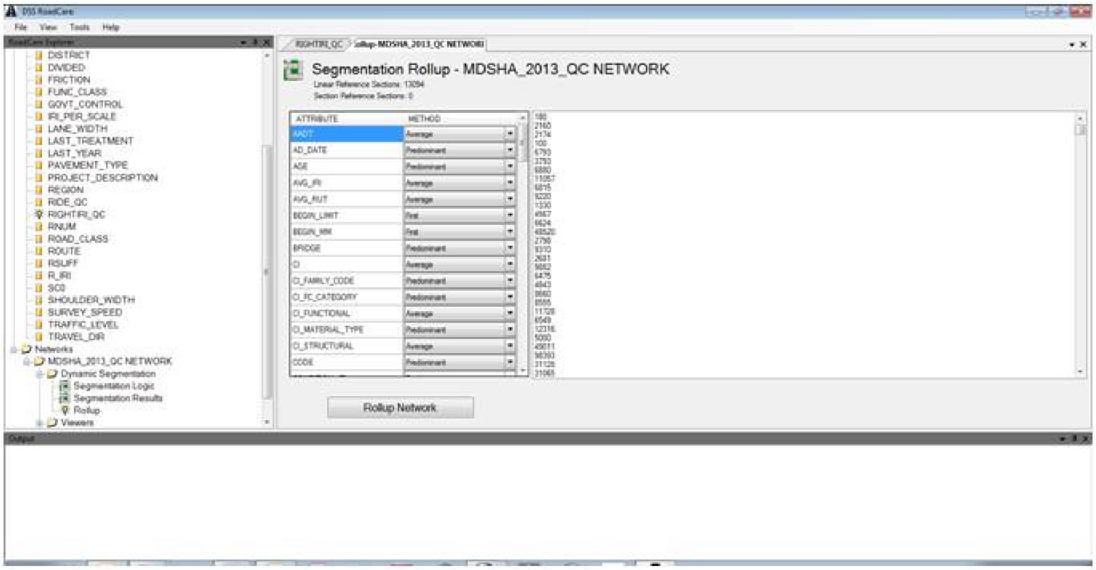
Step 7. After the particular year data is deleted, run the specific attribute query in Oracle SQL Developer from file named: "4Phase Data import queries-QC Year.sql ," which is saved in: \\shahanpmdata1\pmdataprg\Shayan\4 Phase Study. This step is intended for checking the query and query results before importing the data.

Step 8. Double click on the "Import from data source…" button to open the "Data Import" window. Enter the database connection parameters in the left hand top portion of the window and click "Connect" to verify the connection. Paste the SQL statement for the specific QC attribute in the text box and click the "Import" button to import the data. This is the preferred method of data import for large datasets. Alternatively, for smaller datasets, copy and paste the results from the above query by pressing "CTRL+A" in Oracle SQL Developer and "CTRL+C" in RoadCare. Double check that the data is copied by clicking on the year drop-down menu in the main window and selecting that year (see below images).





Step 9. Following importing of the new data, close the "Performance_Measure_QC" window and perform steps 2-7 for the remaining "Performance_Measure_QC" attributes. Once data import is completed double-click on the "Networks" option in the left hand window followed by "MDSHA_'YEAR'_QC Network" followed by "Dynamic Segmentation" followed by "Rollup" (see below image).

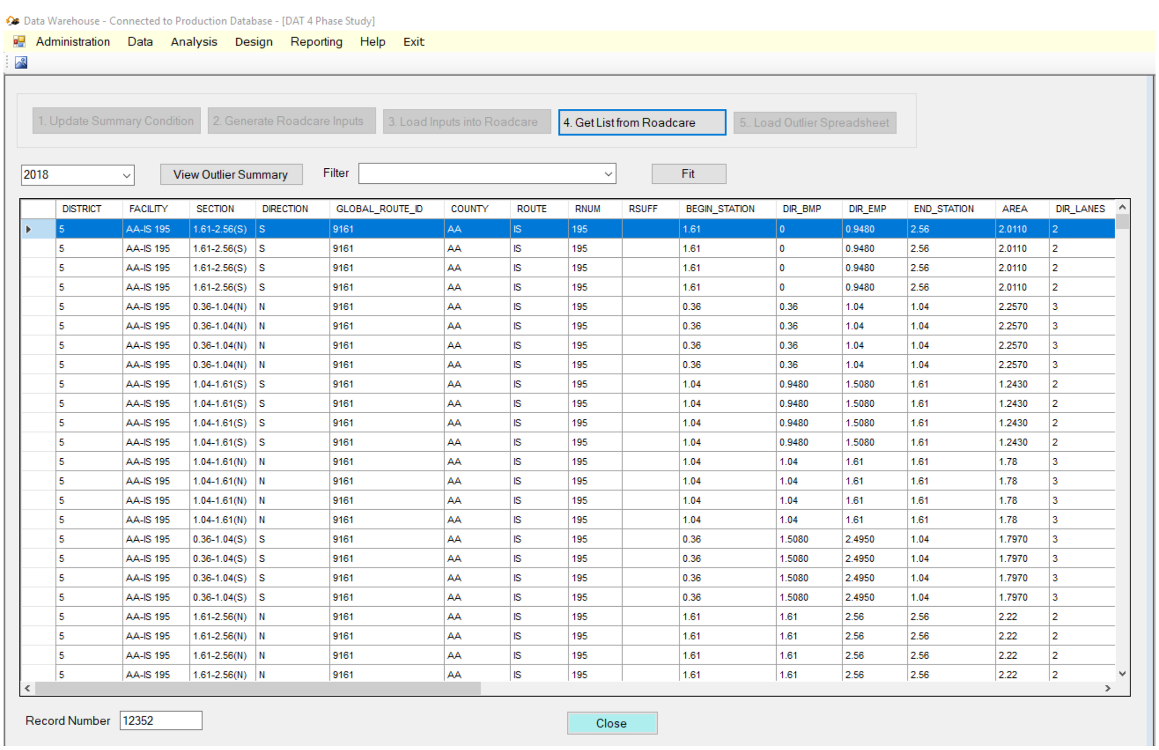


Step 10. Click the “Rollup Network” button.

Step 11. Open Engineering Data Warehouse (EDW) application.

Step 12. Click on “Analysis” and then select “DAT QC/QA”, “ARAN”, and “Outlier Review” from the drop-down menus.

Step 13. Click on “Get List from RoadCare” (see below image). The data will be imported from RoadCare and stored in the “phase4_list_storage” table in Oracle.



Step 14. In Oracle SQL Developer, go to the production database and run the following query: "SELECT * FROM PHASE4_LIST_STORAGE". Export the data from "PHASE4_LIST_STORAGE" table to an excel file and save the file as a backup file with date in the corresponding folder. To export the table simply right click on the data, click on the Export option and save the file as a ".xlsx" file format. Then, copy all the data from "phase4_list_storage" table in Oracle SQL Developer using "CTRL+A."

Step 15. Open the "Outlier_Identifier-Template.xlsm" in Microsoft Excel and paste the copied data in the corresponding columns of the "Data" sheet. The spreadsheet is saved at the following location: \\shahanpmdata1\ pmdataprg\ Shayan\4 Phase Study. Make sure the columns from the Excel output match the Excel template file. After pasting the data make sure the number of records is accurate and "COLLECTION_YEAR" column is populated for all the records.

Step 16. Select the "RUN OUTLIER IDENTIFICATION" button at the top of "Data" sheet and make sure number of copied rows matches the number of outlier calculation rows at the far right of the spreadsheet. If number of rows do not match, then extend or remove the calculation rows to obtain matching number of rows. Then save the file as "Outlier_Identification_RunX_MM-DD-YY.xlsm" in the corresponding year's outlier review folder.

Step 17. Copy the values in columns A-AD from "Data" sheet of the latest "Outlier_Identification_RunX_MM-DD-YY.xlsm" file and paste them in the corresponding columns of the "Load_to_Oracle.xls" file saved in \\shahanpmdata1\ pmdataprg\ Shayan\4 Phase Study. Then, save the file as "Load_to_Oracle_MM-DD-YY.xls" in the corresponding year's outlier review folder.

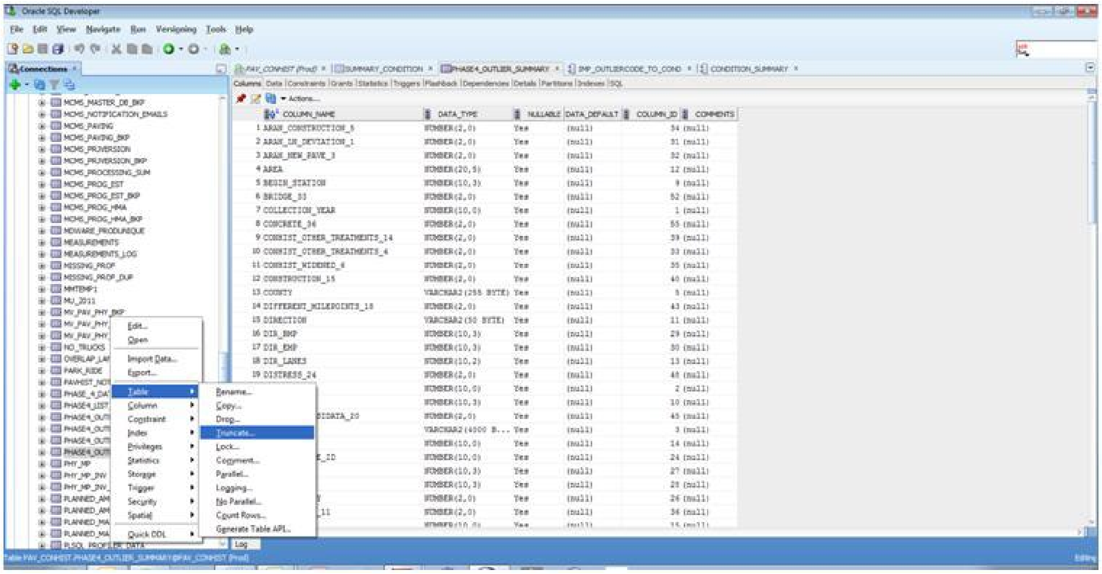
i. If the "Phase4_outcome" is 0, then the section is not an outlier and therefore not selected for further investigation.

ii. If the "Phase4_outcome" is 1, then the section is an outlier and therefore selected for further investigation.

Step 18. In Oracle SQL Developer, right-click on the table titled "Phase4_ Outlier_Summary." Remove previously imported data using one of the following methods.

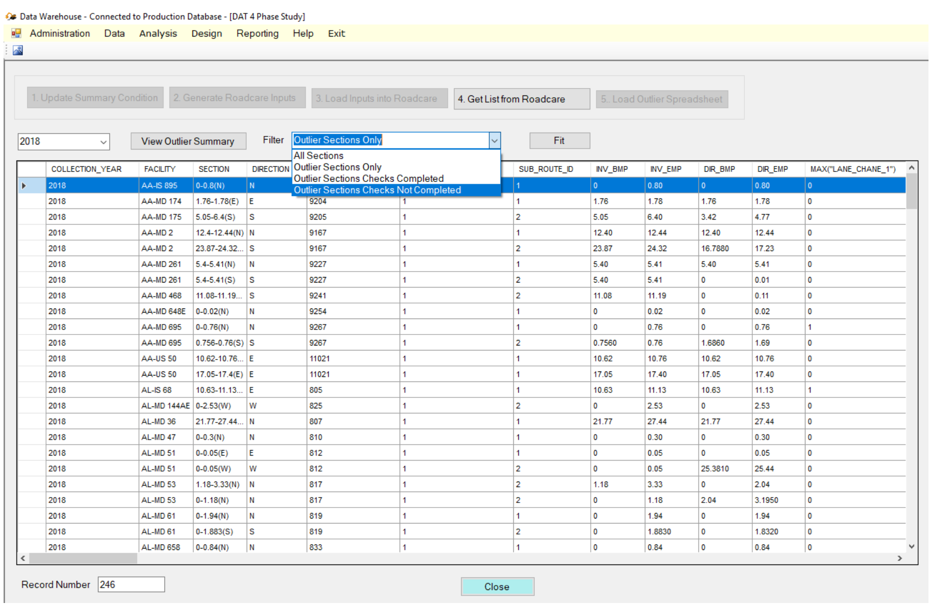
i. In Oracle SQL Developer, use the following command: "DELETE PHASE4_ OUTLIER_SUMMARY WHERE COLLECTION_YEAR = [CURRENT YEAR]." The existing year current data will be deleted and replaced with the updated and current data.

ii. Click on "Table" followed by "Truncate." This will delete all the data from the table without deleting its properties (see below image). Use of this method should be limited to those cases where the table contains current year data only. This method should be avoided if the table contains data from previous years as it will remove all data.



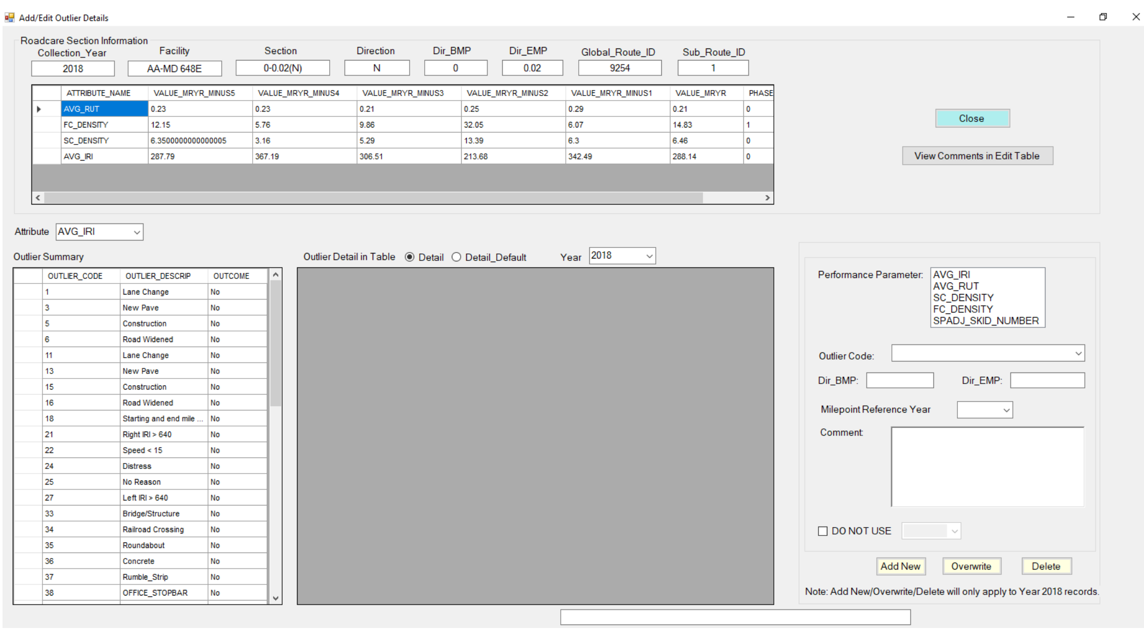
Step 19. Click "Import Data" in the same table. Select the latest "Load_to_Oracle_MM-DD-YY" file. In the step 4 of the data import select the "Position" option in the "Match by" drop-down menu. Since data import is done based on column positions, check the column positions of both tables before data import.

Step 20. In the EDW application "Outlier Review" window (see Step 12 if window has closed), click on the year drop-down menu and select the revew year, then click on the View Outlier Summary Button to import the data from Oracle and populate relevant tables and data fields. Afterward, click on the "Filter" drop-down menu and select "Outlier Sections Checks Not Completed" (see below image).



Step 21. All the outlier sections where the "Outlier_outcome" has been marked as "1" previously will be shown in the window. Click on the "Fit" button to expand the columns.

Step 22. Investigate each section and enter additional data where necessary. Double-click on a section and an additional "Add/Edit Outlier Details" window will appear (see below image). Open the current and previous year Vision database to supplement the investigation. In Vision, check for recent or active construction activities, data collection lane changes, vehicle wander, new distresses or other possible causes for data discrepancy for the section in question. Review the previous year Vision database and historical Vision databases and compare with current year Vision for the same section to determine the reasons for data discrepancy. Use the "Detail_Default" and "Year" drop-down menu to explore data populated from existing data tables including construction history data and pavement event data flagged by DPT technicians as a complementary source of data for the review (Note: the current performance parameters are: IRI, structural crack density, functional crack density, rut, and friction. The section will be an outlier if any of these parameters are flagged as outliers).



i. If there is a difference in the Vision data affecting any of the performance parameters, specify the reason for change of affected parameters (IRI, structural crack density, functional crack density, rut, and friction) by highlighting the affected performance parameters and entering the corresponding outlier code in the "Outlier Code" text box in the EDW window. Outlier codes are included as an appendix (see Outlier Review - Outlier Codes).

ii. If no reasons for the discrepancy can be identified after comparing Vision data, then an investigation will need to be conducted comparing current and historic years' condition databases. This investigation should look for any possible reason including errors in data collection, processing, transfer, storage, and analysis. If no reason can be found, outlier code "25 - No Reason" will be selected and an explanation will be added.

iii. If no explanation for the discrepancy is identified after comparing databases, and data discrepancy is considerable, then the section will go to a recollection list to validate the true value. Currently, outlier review is done gradually along the season on a county by county basis. Once data processing and reporting is complete for a county, outlier identification and review will be performed on the data. If the difference in parameters is not significant and data is marginally outside of the acceptable range, then usually nothing is done about it. However, if the difference is remarkable and such difference is observed in meny sections without any explanation, it is concluded that collected data has issues then source of the issue is investigated and if necessary, recollection is recommended.

Step 23. Investigate all outlier sections until either explanation has been provided for the outliers or the sections have been moved to the recollection list. Once done, the "Outlier Sections Checks Not Completed" list in the EDW should be empty. Once the "Add/Edit Outlier Details" window is completed and closed for a section, the section automatically moves to the "Outlier Sections Checks Completed" list.

Step 24. All the outlier codes identified during the outlier review will be populated into the "Phase4_Outlier_Detail" table. All the events identified earlier by ARAN operators, construction history, video review, and available data such as speed less than 15 mph with corresponding codes will be stored in "Phase4_Outlier_Detail_Default" table. The data from those two tables should be exported into the "Condition" table using the procedure: "Imp_OutlierCode_To_cond" followed by "Imp_Default_Events_To_Cond."

Step 25. After all the outlier codes are populated from the above referenced two tables, run the following SQL query to insert comma at the end of each outlier code: *"Update condition set note=note||',' where note is not null and year = YEAR OF QC;"*

2- Performing QA on Outlier Review Results – *performed by DAT TL*

Summary: This task performs QA checks on the output from the outlier review in order to identify possible causes of and explanations for the outlier data and to enable discussions with appropriate MDOT-SHA teams in order to pursue possible remedial actions.

Step 26. Perform detailed investigation of outlier review output tables "Phase4_Outlier_Detail" and "Phase4_Outlier_Detail_Default." Using SQL Developer, run queries to review location of outliers and investigate possible causes or explanations for higher values (e.g., a group of outliers in the same area could be traced back to a problem with the Distance Measuring Instrument (DMI) calibration). This step specifically intends to identify systematic errors or errors that affect a group of data. If an issue is discovered, discuss remedial actions with the appropriate MDOT-SHA team.

6.02 UPDATE FINAL CONDITION DETAIL TABLE

6.02.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Warehouse Team (DWT) to populate, update and quality control (QC) the annual Final Condition Detail Table. This procedure is performed after the update of the Base 4 Table (see Reporting and Uploading Data to Oracle) and after the completion of the Outlier Review (see Outlier Review). The Final Condition Detail Table is populated and updated with the processed International Roughness Index (IRI) and rut data. The population and updating of this table is one of several intermediate steps performed by the DWT prior to the migration of all intermediate tables to the Business Plan Tables.

6.02.02 *Frequency*

The Final Condition Detail Table is populated and updated once per year.

6.02.03 *Purpose*

The purpose of this SOP is to populate, to update and to QC the Final Condition Detail Table for migration of the processed IRI and rut depth data to the Business Plan Tables. This procedure performs location adjustments to the IRI and rut data to address inconsistencies in GPS data, removes outliers, and organizes the data in preparation for the Business Plan Table migration.

6.02.04 *Resource Requirements*

The updating of the Final Condition Detail table involves two people: (1) a database management expert from the DWT to populate and update the table and perform QC, and (2) a supervisor, typically the DWT Team Leader (TL), who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues are encountered.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Database Management and QC	1	40.0
DWT TL	Supervisor	1	AR[06/12/2019]

6.02.05 *Procedure*

The procedure to update the Final Condition Detail table is comprised of the following three tasks:

(1) manually populating initial table,
(2) applying location adjustments, and
(3) performing QC of updated table.

1- Manually Populating Initial Table – *performed by database engineer*

Summary: This task manually prepares the initial table using the Base 4 table. SQL Developer is utilized to add rows and to update field names in the table for the current year.

Step 1. Using Oracle SQL Developer, initialize the Final Condition Detail Table by adding rows of data for the current year. Rename fields that may have changed from the previous year.

2- Applying Location Adjustments – *performed by database engineer*

Summary: This task creates new fields in the table for location adjustments through the running of a package in Oracle SQL Developer.

Step 2. Run the IRI_CLEAN_UP_PKG package to correct inconsistencies in the GPS data. This package compares ARAN data GPS data to historical DSD GPS data and makes corrections where differences may occur. The package compares location data at an interval of every 4 mmi (milli-miles). Two sets of location fields are maintained. The original locators refer to the data collection year and the adjusted locators refer to the inventory year.

i. If the ARAN location data matches the historical location data at a data point, no adjustments are made.

ii. If the ARAN location data deviates from the inventory year location data at a data point, the ARAN location data is adjusted to match the inventory year location data. All subsequent points along the route are adjusted by this difference.

3- Performing QC of Updated Table – *performed by database engineer*

Summary: This task checks that the updates to the Final Condition Detail Table have been performed correctly.

Step 3. Using Oracle SQL Developer, check that the new rows have been populated and updated in the Final Condition Detail Table.

i. If the table has been updated, proceed to Step 4.

ii. If the table has not been updated, confirm that the process has been completed correctly by returning to Step 1.

Step 4. Using Oracle SQL Developer, check that the location adjustment fields have been created and populated.

i. If the new fields have been created and populated, process is complete.

ii. If the new fields have not been created and/or populated, confirm that the process has been completed correctly by returning to Step 2.

6.03 UPDATE RUT DETAILED TABLE

6.03.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Warehouse Team (DWT) to populate, update and quality control (QC) the annual Rut Detailed Table. This process is performed after the update of the Base 4 Table (see Reporting and Uploading Data to Oracle), after the completion of the Outlier Review (see Outlier Review), and after the update of the Final Condition Detail Table (see Update Final Condition Detail Table). The Rut Detailed Table is populated and updated with the processed rut data. The populating and updating of this table is one of several intermediate steps performed by the DWT prior to the migration of all intermediate tables to the Business Plan Tables.

6.03.02 *Frequency*

The Rut Detailed Table is populated and updated once per year.

6.03.03 *Purpose*

The purpose of this SOP is to populate, to update and to QC the Rut Detailed Table for migration of the processed rut data to the Business Plan Tables. This process performs location adjustments to the rut data to address inconsistencies in GPS data, removes outliers, and organizes the data in preparation for the table migration.

6.03.04 *Resource Requirements*

The updating of the Rut Detailed table involves two people: (1) a database management expert from the DWT to populate and update the table and perform QC, and (2) a supervisor, typically the DWT Team Leader (TL), who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues are encountered.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Database Management and QC	1	16.0
DWT TL	Supervisor	1	AR[06/12/2019]

6.03.05 *Procedure*

The procedure to populate, to update and to QC the Rut Detailed table is comprised of the following three tasks:

(1) manually populating initial table,
(2) running rut package, and
(3) performing QC of updated table.

1- Manually Populating Initial Table – *performed by database engineer*

Summary: This task manually prepares the initial table using the Base 4 table and the results from the location adjustments made in the Final Condition Detailed Table. SQL Developer is utilized to add rows and update field names in the table for the current year.

Step 1. Using Oracle SQL Developer, initialize the Rut Detailed Table by adding rows of data for the current year. Rename fields that may have changed from the previous year.

Step 2. Using Oracle SQL Developer, extract location adjustments from the processed rut data in the Final Condition Detail Table.

2- Running Rut Package – *performed by database engineer*

Summary: This task organizes the processed rut data through the running of a package in Oracle SQL Developer.

Step 3. Run the RUT_DETAILED_PKG package to update the Rut Detailed Table.

3- Performing QC of Updated Table – *performed by database engineer*

Summary: This task checks that the updates to the Rut Detailed Table have been performed correctly.

Step 4. Using Oracle SQL Developer, check that the new rows have been populated and updated in the Rut Detailed Table.

i. If the table has been updated, proceed to Step 4.

ii. If the Table has not been updated, confirm that the process has been completed correctly by returning to Step 1.

Step 5. Using Oracle SQL Developer, check that the location adjustment fields have been created and populated.

i. If the new fields have been created and populated, process is complete.

ii. If the new fields have not been created and/or populated, confirm that the process has been completed correctly by returning to Step 2.

6.04 UPDATE CRACKING DETAILED TABLE

6.04.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Warehouse Team (DWT) to populate, to update and to quality control (QC) the annual Cracking Detailed Table. This process is performed after the update of the Base 4 Table (see Reporting and Uploading Data to Oracle), after the completion of the Outlier Review (see Outlier Review), and after the updates of the Final Condition Detail Table (see Update Final Condition Detail Table) and Rut Detailed Table (see Update Rut Detailed Table). The Cracking Detailed Table is populated with the processed Laser Crack Measurement System (LCMS) data. The populating and updating of this table is one of several intermediate steps performed by the DWT prior to the migration of all intermediate tables to the Business Plan Tables.

6.04.02 *Frequency*

The Cracking Detailed Table is populated and updated once per year.

6.04.03 *Purpose*

The purpose of this SOP is to populate, to update and to QC the Cracking Detailed Table for migration of the processed cracking data to the Business Plan Tables. This process performs location and density adjustments to the cracking data to address inconsistencies in GPS data and cracking quantities, removes outliers and special event locations, and organizes the data in preparation for table migration.

6.04.04 *Resource Requirements*

The updating of the Cracking Detailed table involves two people: (1) a database management expert from the DWT to populate and update the table and perform QC, and (2) a supervisor, typically the DWT Team Leader (TL), who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues are encountered.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Database Management and QC	1	16.0
DWT TL	Supervisor	1	AR[06/12/2019]

6.04.05 *Procedure*

The procedure to populate, to update and to QC the Cracking Detailed Table is comprised of the following three tasks:

(1) manually populating initial table,
(2) applying cracking density adjustments, and
(3) performing QC of updated table.

1- Manually Populating Initial Table – *performed by database engineer*

Summary: This task manually prepares the initial table using the Base 4 table and the results from the location adjustments made in the Final Condition Detailed Table. SQL Developer is utilized to add rows and update field names in the table for the current year and to remove special event locations in the data.

Step 1. Using Oracle SQL Developer, initialize the Cracking Detailed Table by adding rows of data for the current year. Rename fields that may have changed from the previous year.

Step 2. Run the CRACKING_TABLES_MP_CORRECTION package to extract location adjustments from the processed data in the Final Condition Detail Table and apply those adjustments to the processed cracking data.

Step 3. Run the CRACKING_EVENT_LOCATION package to filter out rows marked with a special event. Event markers are placed on images that contain appurtenances, which should be removed from the cracking data, including bridges, railroad crossings, manhole covers, concrete pavement, etc. The placing of these markers is performed as a part of Performing 100% Drive Through.

2- Applying Cracking Density Adjustments – *performed by database engineer*

Summary: This task applies a correction factor for cracking density to the processed cracking data based on manual evaluations performed during data processing.

Step 4. Run the CRACKING_DENSITY_CORRECTION package to apply the required correction factor to the cracking quantities in the Cracking Detailed Table. As a part of the cracking data processing QC, 1% of the network is manually evaluated and the resulting quantities are compared to the automated quantities collected by the ARAN. This comparison results in the development of a correction factor that is applied to the processed data. For sections that did not receive a manual evaluation, an average correction factor is applied based on the county and functional class associated with the specific section. A separate table called CRK_AUTODENSITY_CORR_BINS is created prior to the running of the CRACKING_DENSITY_CORRECTION package, which contains the route-specific correction factors in bins that will be looked up by the density package.

3- Performing QC of Updated Table – *performed by database engineer*

Summary: This task checks that the updates to the Cracking Detailed Table have been performed correctly.

Step 5. Using Oracle SQL Developer, check that the new rows have been populated and updated in the Rut Detailed Table.

i. If the Table has been updated, proceed to Step 4.

ii. If the Table has not been updated, confirm that the process has been completed correctly by returning to Step 1.

Step 6. Using Oracle SQL Developer, check that the location adjustment fields have been created and populated.

i. If the new fields have been created and populated, proceed to Step 7.

ii. If the new fields have not been created and/or populated, confirm that the process has been completed correctly by returning to Step 2.

Step 7. Using Oracle SQL Developer, check that the cracking density adjustment fields have been created and populated.

i. If the new fields have been created and populated, process is complete.

ii. If the new fields have not been created and/or populated, confirm that the process has been completed correctly by returning to Step 4.

6.05 UPDATE CONCRETE DETAILED TABLE

6.05.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Warehouse Team (DWT) to update and quality control (QC) the annual Concrete Detailed Table. This process is performed after the update of the Base 4 Table (see Reporting and Uploading Data to Oracle), after the completion of the 4 Phase Study (see Outlier Review), and after the updates of the Final Condition Detail Table (see Update Final Condition Detail Table), Rut Detailed Table (see Update Rut Detailed Table), and Cracking Detailed Table (see Update Cracking Detailed Table). The Concrete Detailed Table is populated with all processed data for concrete pavements. The updating of this table is one of several intermediate steps performed by the DWT prior to the migration of all intermediate tables to the Business Plan Tables.

6.05.02 *Frequency*

The Concrete Detailed Table is updated once per year.

6.05.03 *Purpose*

The purpose of this SOP is to populate and update the Concrete Detailed Table for migration to the Business Plan Tables. This process organizes the data for concrete sections only in preparation for the table migration.

6.05.04 *Resource Requirements*

The updating of the Concrete Detailed table involves two people: (1) a database management expert from the DWT to populate and update the table and perform QC, and (2) a supervisor, typically the DWT Team Leader (TL), who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues are encountered.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Database Management and QC	1	4.0
DWT TL	Supervisor	1	AR[06/12/2019]

6.05.05 *Procedure*

The procedure to populate, to update and to QC the Concrete Detailed Table is comprised of the following three tasks:

(1) manually populating initial table,
(2) running concrete package, and
(3) performing QC of updated table.

1- Manually Populating Initial Table – *performed by database engineer*

Summary: This task manually prepares the initial table using the Base 4 table. SQL Developer is utilized to add rows and update field names in the table for the current year and to remove special event locations in the data.

Step 1. Using Oracle SQL Developer, initialize the Concrete Detailed Table by adding rows of data for the current year. Rename fields that may have changed from the previous year.

2- Running Concrete Package – *performed by database engineer*

Summary: This task takes the previously processed tables (Final Condition Detail Table, Rut Detailed Table, and Cracking Detailed Table) and extracts the concrete sections into a separate table.

Step 2. Run the CONCRETE_DETAILED_PKG package to populate the Concrete Detailed Table with data from the concrete sections only.

3- Performing QC of Updated Table – *performed by database engineer*

Summary: This task checks that the updates to the Concrete Detailed Table have been performed correctly.

Step 3. Using Oracle SQL Developer, check that the new rows have been populated and updated in the Concrete Detailed Table. If the Table has not been updated, confirm the process has been completed correctly by returning to Step 1.

6.06 MIGRATING TO BUSINESS PLAN TABLES

6.06.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Warehouse Team (DWT) to reformat and to migrate intermediate tables - Final Condition Detail Table (Update Final Condition Detail Table), Rut Detailed Table (Update Rut Detailed Table), Cracking Detailed Table (Update Cracking Detailed Table), and Concrete Detailed Table (Update Concrete Detailed Table) - to the Business Plan Tables and to perform quality control (QC) on the migrated tables. This process is performed after the completion of the intermediate tables.

6.06.02 *Frequency*

Reformatting and migration of the referenced intermediate tables to the Business Plan Tables and QC of the migrated tables is performed once per year.

6.06.03 *Purpose*

The purpose of this SOP is to reformat and to migrate the referenced intermediate tables to the Business Plan Tables and to perform QC checks on the migrated tables.

6.06.04 *Resource Requirements*

Migration to Business Plan Tables involves two people: (1) a database management expert from the DWT to populate and update the tables and perform QC, and (2) a supervisor, typically the DWT Team Leader (TL), who, as required, provides guidance and decision-making. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues are encountered.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Database Management and QC	1	8.0
DWT TL	Supervisor	1	AR[06/12/2019]

6.06.05 *Procedure*

The procedure to reformat and to migrate all intermediate tables to the Business Plan Tables and to perform QC on the migrated tables is comprised of two tasks:

(1) reformatting and migrating intermediate tables to Business Plan Tables, and
(2) performing QC of table migration.

1- Reformatting and Migrating Intermediate Tables to Business Plan Tables – *performed by database engineer*

Summary: This task reformats and migrates all intermediate tables to Business Plan Tables.

Step 1. Discuss possible changes to the Business Plan Tables with TL. Changes could be related to the data structure (new fields added, existing field names changed) or the business plan itself (segmentation changed).

i. If changes have occurred from the previous year, modify the packages accordingly before proceeding to Step 2.

ii. If no changes have occurred, proceed to Step 2.

Step 2. Using Oracle SQL Developer or the link provided in the Engineering Data Warehouse (EDW) program, run BUSINESS_PLAN_PKG package. The package will create the BUSINESS_PLAN_1MILE table using condition data from the intermediate tables. To use the EDW program, click "Analysis", then "Business Plan Update", then "Business Plan 1Mile."

Step 3. Using Oracle SQL Developer or the link provided in the EDW program, run BUSINESS_PLAN_PKG_100MMI package. The package will create the BUSINESS_PLAN_100MMI table using condition data from the intermediate tables. To use the EDW program, click "Analysis", then "Business Plan Update", then "Business Plan 100mmi."

Step 4. Using Oracle SQL Developer or the link provided in the EDW program, run BUSINESS_PLAN_LMY_PKG package in the Production Database (note: this is an exception as all other Oracle SQL packages are run in development, not production database). This package will create the BUSINESS_PLAN_LMY table, the BUSINESS_PLAN_CONHIST table, and the BUSINESS_PLAN_TREATMENTS table. To use the EDW program, click "Analysis", then "Business Plan Update", then "Business Plan LMY."

Step 5. Using Oracle SQL Developer or the link provided in the EDW program, run BUSINESS_PLAN_TREND_PKG package. The package will create the BUSINESS_PLAN_TREND table. The trend table is produced by merging the BUSINESS_PLAN_LMY and BUSINESS_PLAN_ 100MMI tables. To use the EDW program, click "Analysis", then "Business Plan Update", then "Business Plan Trend."

2- Performing QC of Table Migration – *performed by database engineer*

Summary: This task performs QC checks of the migrated tables to identify missing or unreasonable data.

Step 6. Perform QC of BUSINESS_PLAN_1MILE table and BUSINESS_PLAN_100MMI table. Compare each table with the same table from the previous year and investigate data that meet one of the following criteria:

i. Difference in rating category percentage of more than 2 points.

ii. Condition element total average greater than 1%.

iii. Total lane mileage difference of more than 50 miles.

Using SQL Developer, investigate all instances where one or more of the above criteria are met. Look for missing data and double check that issues are not the result of data processing. Check if year-to-year differences could be caused by other external factors, such as increased or decreased construction funding. Discuss with ADC and decide if reprocessing must take place or if the packages should be rerun before continuing.

Step 7. Perform QC of BUSINESS_PLAN_LMY table (intermediate tables Treatments and Con history are not checked). Compare total lane miles of treated sections with the same table from the previous year.

i. If there is an unreasonable difference (no specific tolerance since differences are expected, but only within reason), investigate and resolve data processing issues and rerun package.

ii. Otherwise, proceed to Step 8.

Step 8. Perform QC of BUSINESS_PLAN_TREND table. Compare total lane mileage of treated sections in table with the total lane mileage of treated sections in the LMY table. The total lane mileage should be exactly the same.

i. If there is a difference between lane mileage totals, investigate difference, debug code if necessary, and rerun package.

ii. Otherwise, proceed to Step 9.

Step 9. Notify TL that the Business Plan Tables are ready for QA.

7 FRICTION MANAGEMENT

This section describes the set of standard operating procedures (SOP) to document a systematic approach to addressing pavement friction requirements across the MDOT SHA pavement network. These procedures are conducted mainly by staff from the Data Analysis Team (DAT) and Data Warehouse Team (DWT) to determine site and friction demand categories and corresponding threshold pavement surface friction levels (investigatory and intervention levels), to identify pavement locations that have inadequate friction levels and a higher possibility of wet surface accidents throughout the state. This section is divided into seven SOPs: development/review of friction site and demand categories, network definition and segmentation, site and demand category analysis, data aggregation, section prioritization (under development), report generation, and future improvements to the friction management program. Figure 1 shows the steps of Pavement Friction Management (PFM) program at MDOT SHA for generating annual friction management reports.

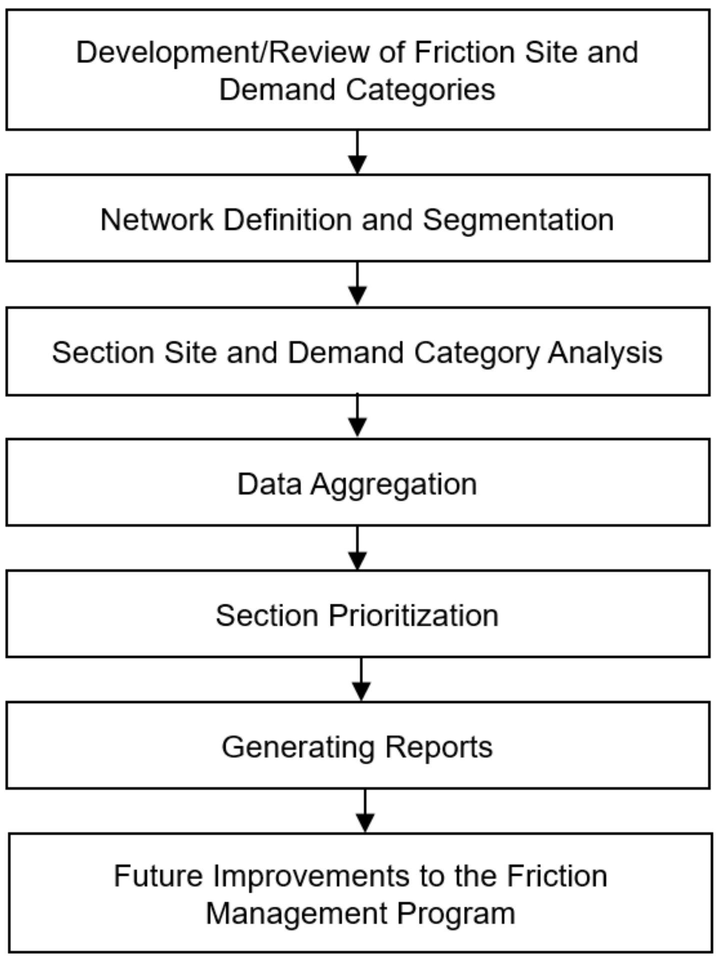


Figure 10: MDOT SHA's Pavement Friction Management (PFM) program

7.01 DEVELOPMENT/REVIEW OF FRICTION SITE AND DEMAND CATEGORIES

7.01.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Analysis Team (DAT) to identify the road features and attributes that play a role in occurrence of wet accidents and to quantify their effect on the road sections' friction demand and investigatory and intervention friction levels. Investigatory and intervention levels are defined, respectively, as levels that prompt the need for a detailed site investigation or the application of a friction restoration treatment. The exact nature of the relationship between pavement friction and wet crashes is site specific, as it is defined not only by pavement friction but by many other factors such as highway alignment, highway features/environment, and highway traffic characteristics. Thus, pavement friction and wet crashes relationships must be developed for the site categories that are typically present in the pavement network. This section describes the steps in development of site and friction demand category criteria that are used to classify network sections based on the effect of various factors on section's friction demand. The goal of this procedure is to manage network friction more efficiently by determining the appropriate level of pavement surface friction for pavement sections within the highway network, based on each section's friction demand. This procedure is intended to ensure the provision of adequate friction levels for a variety of roadway (intersections, approaches to traffic signals, tight curves) and traffic conditions. Pavement sections with measured friction values at or below an assigned investigatory level are subject to a detailed site investigation to determine the need for warning or remedial action, such as erecting warning signs, performing more frequent testing and analysis of friction data and crash data, or applying a short-term restoration treatment. For pavement sections with friction values at or below the intervention level, remedial action may consist of either immediately applying a restoration treatment or programming a treatment into the maintenance or construction work plan and erecting temporary warning signs at the site of interest. Currently, the site categories presented in the following table are being used for assessing the friction adequacy of each section. However, this table might be revised in the future as site category criteria are assessed every year following the steps provided in this SOP.

Site Category	Site Description	Investigatory Skid Number (SN)	Intervention Skid Number (SN)	Demand Category
1	• 0.1 mile within approach to Railroad Crossings, Roundabouts, Traffic Lights, Pedestrian Crossings, Stop and Give Way Controlled Intersections, and the prevailing speed is ≥ 55 mph, **OR** • Curves with radius ≤ 750 ft, all speeds, **OR** • Downhill gradients > 10% and > 0.03 miles long, all speeds, **OR** Freeway/highway off ramps, all speeds.	55	45	High
2	• 0.1 mile within approach to Railroad Crossings, Roundabouts, Traffic Lights, Pedestrian Crossings, Stop and Give Way Controlled Intersections, and the prevailing speed is ≥ 35 mph and < 55 mph, **OR** • 0.1 mile within approach to all other intersections ≥ 35 mph, **OR** • Downhill gradients 5 to 10% and > 0.03 miles long and speed limit is ≥ 35 mph, **OR** • Undivided Highways without other geometric constraints which influence frictional demand, the travelling speed is at least 55 mph and average rutting > ¼", **OR** • Curves with radius > 750 ft and ≤ 1,500 ft and speed limit ≥35 mph.	45	35	Medium
3	All other situations.	40	30	Low

7.01.02 *Frequency*

Development (first year) and review of friction site and demand categories is performed every year, before the end of the data collection season.

7.01.03 *Purpose*

The purpose of this SOP is to identify the effect of factors that contribute to wet weather accidents and to develop and/or review criteria for using the section attributes to identify site and demand categories and investigatory and intervention friction levels for each category. The goal is to manage network friction more efficiently by determining the appropriate level of pavement friction for pavement sections within the highway network, based on each section's friction demand.

7.01.04 *Resource Requirements*

Development (first year) and review of friction site and demand categories involves two persons: a DAT staff member knowledgeable of friction performance of pavements, available road and pavement attribute data, and Oracle data tables and DAT team leader.

The estimated effort level in the table below represents the total time, in man-hours, to complete the development and review of friction demand categories. The time estimate assumes no issues are encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DAT Staff	Analyst	1	40.0 (first year) 16.0 (following years)
DAT TL	Supervisor	1	2

7.01.05 *Procedure*

The procedure required to perform the development/update of friction site and demand categories process is comprised of the following three components:

(1) Identifying influential parameters and their data availability,
(2) defining site and demand category criteria based on the identified parameters,
(3) determining the investigatory and intervention friction levels for each site category.

1- Identifying Influential Parameters with Available Reliable Data – *performed by DAT staff*

Summary: Under this task, all the road features and pavement attributes that can affect the occurrence of wet accidents are listed and those with available reliable data are identified.

Step 1. Prepare a list of factors, road features, and pavement attributes that can affect the occurrence of wet accidents using credible pavement friction and safety documents.

Step 2. Investigate availability and reliability of data identified in step 1.

i. Identify data that are available in data tables and have established quality control procedures.

ii. Identify data that are available in data tables or can be obtained internally by means of modifying the data processing procedures but need to be validated before they can be used and plan to establish data validation procedures.

iii. Identify data that cannot be obtained through internal data collection and processing procedures but can be obtained from reliable outside sources and plan to acquire the data in a timely manner.

Step 3. Prepare a list of available factors, road features, and pavement attributes and their data sources. The following table presents the list of factors and their associated data source currently used in friction management program:

Attribute	Source
ROAD_NAME	HMIS_MASTER_ALL_YEARS
DISTRICT	HMIS_MASTER_ALL_YEARS, EDW_BASE_1
COUNTY	HMIS_MASTER_ALL_YEARS, CURVE_H_ALL_YRS, EDW_BASE_1

Attribute	Source
ROUTE	HMIS_MASTER_ALL_YEARS, CURVE_H_ALL_YRS, EDW_BASE_1
DIRECTION	HMIS_MASTER_ALL_YEARS, CURVE_H_ALL_YRS, EDW_BASE_1
BEGINROWPATH	CURVE_H_ALL_YRS
ENDROWPATH	CURVE_H_ALL_YRS
UNIQUERUN	CURVE_H_ALL_YRS
CURVE_YEAR	CURVE_H_ALL_YRS
CLASS	CURVE_H_ALL_YRS
GLOBAL_ROUTE_ID	HMIS_MASTER_ALL_YEARS, CURVE_H_ALL_YRS, EDW_BASE_1
SUB_ROUTE_ID	HMIS_MASTER_ALL_YEARS, CURVE_H_ALL_YRS, EDW_BASE_1
ROUTEID	CURVE_H_ALL_YRS
INV_BMP	HMIS_MASTER_ALL_YEARS, CURVE_H_ALL_YRS, EDW_BASE_1
INV_EMP	HMIS_MASTER_ALL_YEARS, CURVE_H_ALL_YRS, EDW_BASE_1
BEGINCHAINAGE	CURVE_H_ALL_YRS, EDW_BASE_1
ENDCHAINAGE	CURVE_H_ALL_YRS, EDW_BASE_1
BEGINDISTANCESTAMP	CURVE_H_ALL_YRS, EDW_BASE_1
ENDDISTANCESTAMP	CURVE_H_ALL_YRS, EDW_BASE_1
DIR_BMP	CURVE_H_ALL_YRS, EDW_BASE_1
DIR_EMP	CURVE_H_ALL_YRS, EDW_BASE_1
BEGIN_LAT	\\shahqhisdfs1\GIS_DATA\TRANSPORTATION\MILE_POINTS\CURRENT\1000TH\SHA_MILEPOINTS_1000TH_MD.gdb
BEGIN_LONG	\\shahqhisdfs1\GIS_DATA\TRANSPORTATION\MILE_POINTS\CURRENT\1000TH\SHA_MILEPOINTS_1000TH_MD.gdb
END_LAT	\\shahqhisdfs1\GIS_DATA\TRANSPORTATION\MILE_POINTS\CURRENT\1000TH\SHA_MILEPOINTS_1000TH_MD.gdb
END_LONG	\\shahqhisdfs1\GIS_DATA\TRANSPORTATION\MILE_POINTS\CURRENT\1000TH\SHA_MILEPOINTS_1000TH_MD.gdb
LENGTH	HMIS_MASTER_ALL_YEARS, CURVE_H_ALL_YRS, EDW_BASE_1
BEGINELEVATION	CURVE_H_ALL_YRS
ENDELEVATION	CURVE_H_ALL_YRS
TYPE	CURVE_H_ALL_YRS
RADIUS	CURVE_H_ALL_YRS
ARCANGLE	CURVE_H_ALL_YRS
DEFLECTIONANGLE	CURVE_H_ALL_YRS
CURVATUREDEGREE	CURVE_H_ALL_YRS
BEGINHEAD	CURVE_H_ALL_YRS
ENDHEAD	CURVE_H_ALL_YRS
MEANERR	CURVE_H_ALL_YRS
MAXERR	CURVE_H_ALL_YRS
BEGINERR	CURVE_H_ALL_YRS

Attribute	Source
ENDERR	CURVE_H_ALL_YRS
BEGINX	CURVE_H_ALL_YRS
BEGINY	CURVE_H_ALL_YRS
ENDX	CURVE_H_ALL_YRS
ENDY	CURVE_H_ALL_YRS
CTRX	CURVE_H_ALL_YRS
CTRY	CURVE_H_ALL_YRS
FEATURETYPES	CURVE_H_ALL_YRS
MAXISUPERELEVATION	CURVE_H_ALL_YRS
ANGLEPOINT	CURVE_H_ALL_YRS
STARTSUPERELEVATION	CURVE_H_ALL_YRS
MIDDLESUPERELEVATION	CURVE_H_ALL_YRS
ENDSUPERELEVATION	CURVE_H_ALL_YRS
AVERAGESUPERELEVATION	CURVE_H_ALL_YRS
AVG_LANEWIDTH_FEET	RUT_DETAILED
AVG_PONDING_AREA	RUT_DETAILED
AVG_RUT_DEPTH	RUT_DETAILED
AVG_CROSSFALL_PERCENT	RUT_DETAILED
MIN_CROSSFALL_PERCENT	RUT_DETAILED
MAX_CROSSFALL_PERCENT	RUT_DETAILED
FIRST_CROSSFALLINPERCENT	EDW_BASE_1
LAST_CROSSFALLINPERCENT	EDW_BASE_1
FN_CURRENT	FRICTION
FN_MINUS1	FRICTION
FN_MINUS2	FRICTION
FN_MINUS3	FRICTION
LAST_TREATMENT_YEAR	BUSINESS_PLAN_LMY & LU_TREATMENT
FN_NUMBER	FRICTION, BUSINESS_PLAN_LMY, & LU_TREATMENT
SC_DENSITY	CRACKING_DETAILED
FC_DENSITY	CRACKING_DETAILED
AVG_IRI	EDW18_BASE_4
SURFACE_AGE	BUSINESS_PLAN_LMY & LU_TREATMENT
SURFACE_MATERIAL	BUSINESS_PLAN_TREATMENTS & LU_TREATMENT
SURFACE_TYPE	EDW18_BASE_4 and CONHIST_SURF_TYPE
AVG_GRADE	FINAL_CONDITION_DETAIL
MIN_GRADE	FINAL_CONDITION_DETAIL

Attribute	Source
MAX_GRADE	FINAL_CONDITION_DETAIL
MPD_WP_AVG	FRICTION
FUNC_CL	SECTION_TABLE
SPEED_LIMIT	SECTION_TABLE, HMIS_MASTER_ALL_YEARS
AADT	SECTION_TABLE
ADT	SECTION_TABLE
TRUCK_PERCENTAGE	Traffic Data (MDOT SHA's Traffic Engineering Division)(1)
MEDIAN_TYPE	SECTION_TABLE
WET_CRASH_RATE	Obtained from Office of Traffic and Safety annually
500'_FROM_CROSS	HMIS_MASTER_ALL_YEARS, EDW18_BASE_4, OOT DATABASE
SITE CATEGORY	SITE_CATEGORY_TABLE
INVESTIGATORY_SN	SITE_CATEGORY_TABLE
INTERVENTION_SN	SITE_CATEGORY_TABLE
DEMAND_CATEGORY	SITE_CATEGORY_TABLE
SN_RSL	BUSINESS_PLAN_100MMI
OVERALL_RSL	BUSINESS_PLAN_100MMI
SN_DOMINANT	BUSINESS_PLAN_100MMI

(1): Source: https://www.roads.maryland.gov/Index.aspx?PageId=251

2- Defining Site and Demand Categories Based on the Identified Parameters – *performed by DAT staff*

Summary: Under this task, the effect of identified parameters in step 1 on required friction level of the sections for safe operation of all vehicles will be investigated, and site and demand category criteria (mentioned in Section 7.01.01) will be developed/reviewed accordingly.

Step 1. Use the most recent friction guidance documents published or recommended by transportation agencies and organizations to identify and establish relationships between the identified parameters and required friction levels. Some of the transportation agencies and organizations that have publications related to pavement friction are:

- Federal Highway Administration (FHWA)—Office of Safety, Technical Advisories on skid crash reduction, pavement friction courses, and pavement texturing.
- National Cooperative Highway Research Program (NCHRP)—Syntheses and Reports covering, among other things, safety, friction testing, and surface drainage.
- American Association of State Highway and Transportation Officials (AASHTO)—Guides, Manuals, and Guide Specifications for highway

geometric design, construction, maintenance, and pavement management.
- State Departments of Transportation (DOT)—Friction management guides and plans.
- Pavement industry groups—Bulletins and Manuals on surface mixture selection and texturing.
- International Agencies (e.g., United Kingdom, Australia, Japan)—Various guides, manuals, and reports on friction testing, design, and safety management.

Step 2. Update site and demand category criteria based on the identified relationships using the best available guides and practices.

i. Identify attributes from step 1 (highway alignment, highway features/environment, and highway traffic characteristics factors) that are available in MDOT SHA data tables and have established quality control procedures.

ii. Assess the effect of available attributes on friction demand of network sections using the documents published by organizations listed in step 1 and develop/modify friction site categories accordingly.

iii. Check the site category criteria against criteria developed by other agencies with successful friction management programs and investigate any major discrepancy.

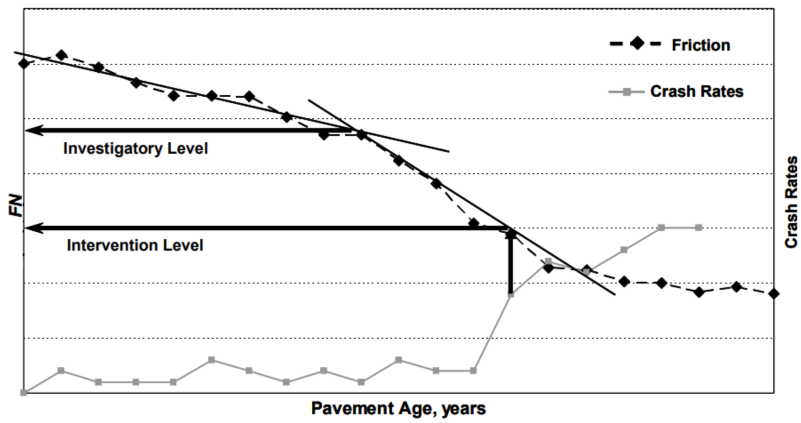
iv. Correlate the latest wet-weather crash data with the road features and pavement attributes data to validate and quantify the effect of selected attributes and modify the demand category criteria if needed.

3- Determining the Investigatory and Intervention Friction Levels for Each Site Category – *performed by DAT staff*

Summary: Under this task, the two distinct threshold levels, investigatory and intervention friction levels, are defined/reviewed for assessment of friction adequacy of pavement sections within each site category.

Step 1. Assess the adequacy of current investigatory and intervention levels by using historical pavement friction data and crash data.

i. Plot friction versus pavement age and friction versus wet crash rates for each friction site category as illustrated in the figure below.



ii. Identify investigatory level as the point corresponding to a large change in friction loss rate.

iii. Set the friction number corresponding to a significant increase in wet crashes as intervention level.

iv. Compare the existing and new investigatory and intervention levels and update the thresholds if necessary.

7.02 NETWORK DEFINITION AND SEGMENTATION

7.02.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Analysis Team (DAT) and Data Warehouse Team (DWT) to define the PFM program network and then divide the network into segments based on factors that influence friction demand. In general, an array of factors comprising the following four broad categories affect the pavement friction demand: highway alignment, highway features/environment, highway traffic characteristics, and driver/vehicle characteristics. The last category, driver/vehicle characteristics, is difficult to assess in terms of friction demand but factors such as location, road geometrics, pavement type, construction history, road and median type, traffic level, road features (intersections, crosswalks, …), and so forth can be assessed. This section describes network segmentation procedure that is vital to preparation of annual friction management reports.

7.02.02 *Frequency*

Network definition and segmentation is performed annually, after friction site and demand categories and network data tables are finalized. Additionally, selected attribute data are deleted and re-imported whenever changes to the source tables occur. Network definition and segmentation should be repeated every time an updated inventory is provided.

7.02.03 *Purpose*

The purpose of this SOP is to define pavement sections with similar friction demand levels within the network using factors known to affect pavement friction demand.

7.02.04 *Resource Requirements*

The network definition and segmentation involve three persons: a DAT staff member knowledgeable of pavement friction performance and pavement management data tables, a DWT staff member knowledgeable of Oracle and source data tables, and and a DAT team leader. The estimated effort level in the table below represents the total time, in man-hours, to complete the network segmentation and data aggregation process. The time estimate assumes no issues are encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DAT Staff	Analyst	1	4.0
DWT Staff	Database Management	1	24.0
DAT TL	Supervisor	1	2

7.02.05 *Procedure*

The procedure required to perform the network definition/segmentation process is comprised of the following three components:

(1) Updating the network,
(2) identifying segmentation factors,
(3) develop/review segmentation logic, and
(4) develop/update segmentation SQL packages based on segmentation logic.

1- Updating the Network – *performed by DWT staff*

Summary: Under this task, the network used for the PFM program will be defined/updated to match the current network.

Step 1. Use the most recent Highway Location Reference (HLR) table as main source to define the network.

Step 2. Perform manual quality control review of the inventory to identify and address missing data or wrong data. This review will include investigating the completeness of network and the accuracy and consistency of data such as direction, road name, and so on.

Step 3. Update the PFM network where needed to embrace recent changes in the network.

2- Identifying Segmentation Factors – *performed by DAT staff*

Summary: Under this task, factors that influence friction demand are identified.

Step 1. Identify the factors that affect friction demand and are accessible within the pavement management databases.

Step 2. Identify the best source table or tables with the most reliable and updated data for each factor.

3- Develop/Review Segmentation Logic – *performed by DAT staff and Team Leader*

Summary: Under this task, the network is divided into sections with similar friction demands along each section using a segmentation logic that takes the factors identified in step 1 into account (demand category table in section 7.01.01). Segmentation logic will be reviewed and, if necessary, updated every year. Any change in the segmentation logic should be reviewed and confirmed by a DAT Team Leader (TL).

Step 1. Apply Category 1 criteria as per the demand category table in section 7.01.01 of this guide. Section length should be at least 0.1 mile for all category 1 sections.

Step 2. Apply site category extension criteria as follows:

Site Category Extension Criteria:

1) If any section with a site category is less than 0.1 mile,
   - For stop events such as traffic signal, stop sign, and so on, extend the section backward starting from end milepoint (EMP),
   - For qualifying curves and downhill gradients, compute the mid-point (mid_mp) of the section, mid_mp = (BMP+EMP)/2 and extend on both sides of the mid-point to achieve 0.1 mile.
2) If encountering a section with equal or higher site category (lower number represents higher site category), terminate BMP and/or EMP at the edge of that higher site category section and proceed to the next steps (consolidation and merge).

3) If Step 2 does not apply, break the mile point at 0.1 mile boundaries and apply the site category to the created 0.1 mile long section (0.1 mile approach to the stop event or between mid_mp - 0.05 and mid_mp + 0.05 in qualifying curves and downhill gradients).
4) Go back to Step 1 and repeat until no more sections less than 0.1 mile encountered.

Step 3. Apply site category consolidation criteria as follows:

Site Category Consolidation Criteria:

Consolidate adjacent sections with the same site category into one section.

Step 4. Apply site category merge criteria as follows:

Site Category Merge Criteria:

1) Check the gap between any two sections with a site category. If the gap length is less than 0.1 mile:
   - If the gap is between two sections with similar site categories apply the site category to the section/sections in the gap.
   - If the gap is between two sections with different site categories apply the higher of the two site category numbers (e.g. between site categories 1 and 3, assign 3 to the section/sections in the gap)
2) If section is <0.1 mile, and the section is the beginning or ending section of a route, then assign the Site Category from the adjacent section to the begin/end section.

Step 5. At this point, the network is segmented as Category 1 or “Not Categorized”. Check whether all Category 1 segments are greater or equal to 0.1 mile in length and proceed to steps 6-9 to determine site category 2 sections.

Step 6. Apply Category 2 criteria based on the demand category table in section 7.01.01 of this guide for the “Not Categorized” sections of the network without any section length limit consideration.

Step 7. Apply site category extension criteria (step 2).

Step 8. Apply site category consolidation criteria (step 3).

Step 9. Apply site category merge criteria (step 4).

Step 10. At this point, the “Not Categorized” network is further segmented to Category 2 or “Not Categorized” sections and All Category 1 and Category 2 segments are at least 0.1 mile long. Proceed with Steps 11-14 using the “Not Categorized” sections of the network to assign site category 3.

Step 11. Apply Category 3 criteria based on the demand category table in section 7.01.01 of this guide for the “Not Categorized” sections of the network without any section length limit consideration.

Step 12. Apply site category extension criteria (step 2).

Step 13. Apply site category consolidation criteria (step 3).

Step 14. Apply site category merge criteria (step 4).

Step 15. At this point, the entire network should be categorized, and every segment should be at least 0.1 mile long.

Step 16. No given section should be downgraded from its assigned site category at any point throughout the segmentation steps. Perform a check on the entire segment to verify the network has been categorized correctly.

Step 17. Add GPS lat and long for each of the segmentation mile markers.

4- Develop/update network segmentation SQL packages – *performed by DWT staff*

Summary: Under this task, the site and demand category criteria and segmentation logics are translated into SQL procedures and packages. Segmentation SQL packages will be reviewed and, if necessary, updated every year.

Step 1. Review the segmentation logic, and

Step 2. Develop/update SQL procedures and packages for segmenting the network based on the segmentation logic.

All the SQL procedures and packages currently used for network segmentation are included in Appendix 11.14.

7.03 SECTION SITE AND DEMAND CATEGORY ANALYSIS

7.03.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Analysis Team (DAT) and Data Warehouse Team (DWT) to check the performance of the developed network segmentation SQL packages and to create a segmented network table with friction site and demand category and investigatory and intervention level information for each section in accordance with the established criteria and logics.

7.03.02 *Frequency*

Demand category analysis is performed annually, after friction demand categories are reviewed, network data tables are finalized, network segmentation logic is established, and network segmentation SQL packages are developed or updated or confirmed. Additionally, if any relevant attribute data is re-imported due to a change to the source tables, or if SQL packages are updated due to a change in the segmentation logic, section site and demand category analysis should be repeated.

7.03.03 *Purpose*

The purpose of this SOP is to segment the network using the established criteria and logic and to identify the friction site and demand category and investigatory and intervention friction levels for each section of the network.

7.03.04 *Resource Requirements*

The section friction site and demand category analysis involves two persons: a DAT staff member knowledgeable of PFM program segmentation demand category criteria and segmentation logics and a DWT staff member knowledgeable of Oracle SQL Developer. The estimated effort level in the table below represents the total time, in man-hours, to complete the site and demand category analysis. The time estimate assumes no issues are encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DAT Staff	Analyst	1	12.0
DWT Staff	Database Management	1	4.0

7.03.05 *Procedure*

The procedure required to perform the site and demand category analysis is comprised of the following two components:

(1) check the performance of the developed SQL packages.
(2) execute the segmentation and demand category SQL packages.

1- Check the performance of the developed SQL packages – *performed by DAT staff*

Summary: Under this task, the performance of the developed segmentation SQL packages will be examined. The performance/accuracy of the package needs to be examined after each package update.

Step 1. Select several sample routes with a variety of features and event affecting the friction demand.

Step 2. Segment the table manually and using the SQL package and compare the results.

Step 3. If manual and automated (SQL package) segmentation results match for all the sample routes then proceed to the next step (package execution), otherwise report the discrepancy to the DWT staff for troubleshooting.

2- Execute the segmentation and demand category SQL package – *performed by DWT staff*

Summary: Under this task, the network is segmented and site and demand category for each section of the network is determined by executing the segmentation and demand category SQL packages.

Step 1. Execute the segmentation and demand category SQL packages annually for the network.

Run the segmentation and demand category SQL packages to segment the network and populate site category, demand category, and investigatory and intervention friction levels for each section of the network. The packages need to be executed at least once every year to account for inventory changes or construction related geometry changes. Moreover, the packages should be executed after every package update.

7.04 DATA AGGREGATION

7.04.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Analysis Team (DAT) and Data Warehouse Team (DWT) to aggregate data needed for performing friction analysis for each section of the network and prioritization of sections with friction deficiency. This section describes data aggregation logics and procedures to prepare the annual friction management table for friction analysis.

7.04.02 *Frequency*

Network data aggregation for friction management table is performed annually, after friction demand categories are reviewed, network data tables are finalized, network segmentation logic is established, and network segmentation SQL packages are developed, examined, and executed. Additionally, selected attribute data are deleted and re-imported whenever changes to the source tables or segmentation table occur.

7.04.03 *Purpose*

The purpose of this SOP is to prepare the friction management table for performing friction analysis for each section of the network and section prioritization.

7.04.04 *Resource Requirements*

The data aggregation involves two persons: a DAT staff knowledgeable of friction table attributes and friction demand categories and a DWT staff member knowledgeable of Oracle and source data tables. The estimated effort level in the table below represents the total time, in man-hours, to complete the data aggregation process. The time estimate assumes no issues are encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DAT Staff	Analyst	1	3.0
DWT Staff	Database Management	1	6.0

7.04.05 *Procedure*

The procedure required to perform the data aggregation process is comprised of the following two components:

(1) identify data aggregation method for each attribute, and
(2) perform data aggregation.

1- Identify Data Aggregation Method – *performed by DAT staff*

Summary: Under this task, the proper data aggregation method for each data field is identified.

Step 1. Identify/review data fields in the PFM table and update, add, or remove data fields if necessary.

Step 2. Identify the use and purpose of each data field in the pavement friction program.

Step 3. Based on the identified purpose of each data field, determine the right aggregation method/methods (minimum, maximum, average, dominant, …).

The following table presents some of the data fields in the pavement friction management program table with their purpose and identified aggregation method:

Attribute	Effect/Purpose	Aggregation Method
CURVE_YEAR	NA	Latest Year Available
TYPE	Curves Have Higher Demand	Dominant
RADIUS	Increases Demand	Maximum
CLASS	A: smooth curve (R>506 m), F: sharp curve (R<61 m)	Minimum
FEATURETYPES	Curve Type	Dominant
MAXISUPERELEVATION	Can Decrease Demand	Maximum
MINISUPERELEVATION	Can Decrease Demand	Minimum
STARTSUPERELEVATION	Can Decrease Demand	Begin
MIDDLESUPERELEVATION	Can Decrease Demand	Middle
ENDSUPERELEVATION	Can Decrease Demand	End
AVERAGESUPERELEVATION	Can Decrease Demand	Weighted Average
AVG_LANEWIDTH_FEET	NA	Weighted Average
PONDING_AREA	Increases Demand	Maximum
AVG_PONDING_AREA	Increases Demand	Weighted Average
RUT_DEPTH	Increases Demand	Maximum
AVG_RUT_DEPTH	Increases Demand	Weighted Average
AVG_CROSSFALL_PERCENT	Can Decrease Demand	Weighted Average
MIN_CROSSFALL_PERCENT	Can Decrease Demand	Minimum
MAX_CROSSFALL_PERCENT	Can Decrease Demand	Maximum
FIRST_CROSSFALLINPERCENT	Can Decrease Demand	First
LAST_CROSSFALLINPERCENT	Can Decrease Demand	Last
SN_CURRENT	SN_NUMBER	Stepped average
SN_MINUS1	SN_NUMBER	NA
SN_MINUS2	SN_NUMBER	NA
SN_MINUS3	SN_NUMBER	NA
LAST_TREATMENT_YEAR	Years Used for Determining SN_NUMBER	Last treatment year
SN_NUMBER	Prioritization and Treatment Decision	Minimum
SC_DENSITY	Treatment Decision	Weighted Average
FC_DENSITY	Treatment Decision	Weighted Average
AVG_IRI	Treatment Decision	Weighted Average

Attribute	Effect/Purpose	Aggregation Method
SURFACE_AGE	Treatment Decision	Dominant
SURFACE_MATERIAL	Treatment Decision	Dominant
AVG_GRADE	Downhill gradient increases demand	Weighted Average
MIN_GRADE	Downhill gradient increases demand	Minimum
MAX_GRADE	Downhill gradient increases demand	Maximum
MPD_WP_AVG	Higher Mean Profile Depth Accelerates Surface Water Drainage	Weighted Average
FUNC_CL	Treatment Decision	Dominant
AADT	Higher Traffic Increases Demand	Maximum
SPEED	Higher Speed Limits Increase Demand	Maximum
ADT	Higher Traffic Increases Demand	Maximum
Truck Percentage	Higher Truck Percentage Increases Demand	Maximum
MEDIAN_TYPE	Undivided Highways have Higher Demand	Dominant
Wet Crash Rate	Demand Category Verification	Maximum
528'_FROM_CROSS	Road Crossing Features Increase Demand	0 or 1
LATITUDE	Mapping	Closest
LONGITUDE	Mapping	Closest

2- Perform Data Aggregation – *performed by DWT staff*

Summary: Under this task, data aggregation for pavement friction management program table data fields is performed.

Step 1. Compile SQL queries or SQL packages for aggregating data into the segmented PFM table using the determined data aggregation methods for each field.

Step 2. Execute the queries or packages to populate data into the segmented PFM table.

The SQL package is currently under development by the DWT staff.

7.05 SECTION PRIORITIZATION

7.05.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Warehouse Team (DWT) to prioritize sections with friction deficiency based on their friction demand, road class, traffic characteristics, and friction level. The current version of PFM only uses site category and friction deficiency for prioritization, but a more comprehensive and robust prioritization procedure will be implemented into the PFM in the future.

7.05.02 *Frequency*

Section prioritization is performed annually, once section site and demand category analysis, and data aggregation are completed. Additionally, if any attribute data is re-imported or network segmentation is updated due to a change to the source tables or a change in the inventory, section prioritization should be repeated.

7.05.03 *Purpose*

The purpose of this SOP is to give higher priority to the sections with higher potential for wet weather accidents within each site category.

7.05.04 *Resource Requirements*

The section prioritization involves one person: a DAT staff member knowledgeable of pavement friction performance and PFM. The estimated effort level in the table below represents the total time, in man-hours, to complete the demand category analysis. The time estimate assumes no issues are encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DAT Staff	Analyst	1	4.0

7.05.05 *Procedure*

The procedure required to prioritize the sections is comprised of the following step:

(1) Give the sections priorities based on site category and friction deficiency,
(2) Compare the results with the most recent wet crash data, and
(3) Update the skid data collection list if needed.

1- Give the Sections Priorities Based on Site Category and Friction Deficiency – *performed by DAT staff*

Summary: Under this task, sections are prioritized based on their site category and friction deficiency.

Step 1. Sort the sections based on site category from smallest to largest. Site category 1 has the highest and site category 3 has the lowest friction demand.

Step 2. Within each site category, order the sections based on friction deficiency by simply sorting them based on friction value from smallest to largest.

Step 3. If multiple sections have similar friction values, sort them based on traffic volume and speed limit from largest to smallest.

2- Compare the results with the most recent wet crash data – *performed by DAT staff*

Summary: Under this task, the most recent wet crash data are obtained and sections with high wet accident rates are further investigated.

Step 1. Obtain the most recent state wet crash list in cooperation with Office of Traffic and Safety (OOTS).

Step 2. Identify sections with high numbers of wet crashes.

Step 3. Investigate the identified sections and update their priority if needed.

3- Update the skid data collection list – *performed by DAT staff*

Summary: Under this task, the skid collection list is updated using the updated site categories.

Step 1. Populate the inventory mileage table based on updated site categories.

Step 2. Work with Field Explorations Division (FED) staff to determine available skid data collection resources and skid data collection limitations.

Step 3. Optimize the "% of miles collected per year" and "data collection interval" for each site category with a high emphasis on collecting more mileage and data points from site categories with a higher demand. The goal would be collecting 100% of roads in site category 1 using minimum possible data collection interval and adjusting the "% of miles collected per year" and "data collection interval" for the rest of the network (site categories 2 and 3) based on available data collection resources and feasible skid data points.

The following table is an example skid data collection list. Note that the actual annual list can change based on feedback from FED and data collection limitations.

					>=1 Mile Roads				< 1 Mile Roads				Total	
Site Category	**Investigatory SN**	**Intervention SN**	**Demand Category**	**Total Mileage - SHA Only**	**Mileage**	**% of miles collected per year**	**Collection Interval (mile)**	**# of tests collected**	**Mileage**	**% of miles collected per year**	**Collection Interval (mile)**	**# of tests collected**	**# Miles Tested**	**# of tests collected**
1	55	45	High	1,730	1,428	100%	0.05	28,560	302	100%	0.05	6,040	1,730	34,600
2	45	35	Medium	3,092	2,847	50%	0.2	7,118	245	50%	0.2	613	1,546	7,730
3	40	30	Low	6,192	5,870	33%	0.5	3,909	322	33%	0.5	536	2,062	4,446
Total				**11,014**	**10,145**								**5,338**	**46,776**
													48%	***0.114***
													% Collected	***Avg Interval***

i. This table is only a suggested skid data collection approach and can change based on feedback from FED and data collection limitations.

ii. For site category descriptions, refer to the site category table in section 7.01.01.

7.06 GENERATING REPORTS

7.06.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Analysis Team (DAT) to generate annual reports and maps for the "Pavement Friction Management Plan". This SOP is performed once the site and demand categories are populated and sections are sorted based on priority.

7.06.02 *Frequency*

The generation of skid reports and maps is performed annually, after the end of the data collection season, and once all data have been processed and migrated into the appropriate tables, network is segmented, data is aggregated into the friction management table, and sections are prioritized. The reports may need to be re-generated if any of the source tables or segmentation change.

7.06.03 *Purpose*

The purpose of this SOP is to generate friction demand category reports and maps to identify sections with friction values below intervention and investigatory levels in each category demand. These reports are complemented with guidance for selecting techniques and treatments that will provide adequate wet pavement friction or lower the chance of wet crash accidents.

7.06.04 *Resource Requirements*

Generating reports and maps involves one person: a DAT staff member familiar with the friction management plan. The estimated effort level shown in the table below represents the total time, in man-hours, to complete the report generation. This time estimate assumes no issues are encountered during the report generation process.

Position	Function	Resources	Effort Level (man-hrs)
DAT Staff	Analyst	1	4.0

7.06.05 *Procedure*

The procedure to generate reports is comprised of the following two tasks:

(1) generate statewide report,
(2) generate district and county reports, and
(3) generate color coded district and couty maps.

1- Generate Statewide Reports – *performed by DAT Staff*

Summary: Under this task, state-wide reports from the site and demand category analysis will be generated for the whole network.

Step 1. Publish state-wide PFM table and friction deficiency table.

i. Open the friction management table

ii. List the sections based on site category and priority level.

iii. Create another list by filtering out the sections that have friction values above investigatory level.

iv. Publish both lists as state-wide pavement friction management (PFM) program table and state-wide sections with friction deficiency.

v. Attach the following statement to the report:

“Design engineers should use the latest Maryland State Highway Administration (MDSHA) Pavement & Geotechnical Design Guide to fulfill the requirements of the identified sections with friction deficiency. Section 2.08 of the Design Guide contains guide tables for identifying proper treatments based on pavement type, daily traffic, and pavement performance measures.

Section 2.09 of the Design Guide provides detailed information for each treatment and shows which treatments are intended to improve skid resistance.

Section 6.06.03.02.03.1 of Design Guide describes the pavement preservation and rehabilitation friction design concepts used by MDOT SHA. This section contains guide tables and equations for determining the initial skid numbers and deterioration rates for treatments such as Dense-Graded HMA, Gap-Graded HMA, Micro-Surfacing, High Friction Surface, Surface Abrasion, and Diamond Grinding.”

2- Generate District and County Reports – *performed by DAT Staff*

Summary: Under this task, district- and county-based reports from the site and demand category analysis will be generated for the whole network.

Step 1. Open the friction management table.

Step 2. Use the state-wide table to create individual district tables.

i. Filter the state-wide table using the district field.

ii. List the sections based on site category and priority level.

iii. Create another list by filtering out the sections that have friction values above investigatory level.

iv. Publish both lists as district friction management program (PFM) table and district sections with friction deficiency for each district.

v. Attach the following statement to each report:

“Design engineers should use the latest Maryland State Highway Administration (MDSHA) Pavement & Geotechnical Design Guide to fulfill the requirements of the identified sections with friction deficiency. Section 2.08 of the Design Guide contains guide tables for identifying proper treatments based on pavement type, daily traffic, and pavement performance measures.

Section 2.09 of the Design Guide provides detailed information for each treatment and shows which treatments are intended to improve skid resistance.

Section 6.06.03.02.03.1 of Design Guide describes the pavement preservation and rehabilitation friction design concepts used by MDSHA. This section contains guide tables and equations for determining the initial skid numbers and deterioration rates for treatments such as Dense-Graded HMA, Gap-Graded HMA, Micro-Surfacing, High Friction Surface, Surface Abrasion, and Diamond Grinding."

Step 3. Use the state-wide table to create individual county tables.

i. Filter the state-wide table using the county field.

ii. List the sections based on site category and priority level.

iii. Create another list by filtering out the sections that have friction values above investigatory level.

iv. Publish both lists as county friction management program (PFM) table and county sections with friction deficiency for each district.

v. Attach the following statement to each report:

"Design engineers should use the latest Maryland State Highway Administration (MDSHA) Pavement & Geotechnical Design Guide to fulfill the requirements of the identified sections with friction deficiency. Section 2.08 of the Design Guide contains guide tables for identifying proper treatments based on pavement type, daily traffic, and pavement performance measures.

Section 2.09 of the Design Guide provides detailed information for each treatment and shows which treatments are intended to improve skid resistance.

Section 6.06.03.02.03.1 of Design Guide describes the pavement preservation and rehabilitation friction design concepts used by MDSHA. This section contains guide tables and equations for determining the initial skid numbers and deterioration rates for treatments such as Dense-Graded HMA, Gap-Graded HMA, Micro-Surfacing, High Friction Surface, Surface Abrasion, and Diamond Grinding."

3- generate color coded district and county maps – *performed by DAT Staff*

Summary: Under this task, district and county reports are used to create color coded skid maps.

Step 1. Map the data for each district and county using the latest geospatial skid data tables.

Step 2. Use the friction number, investigatory and intervention level of each section to color code the map as follows:

- Use red if Skid Number is worse than Intervention Level.
- Use yellow if Skid Number is between Intervention Level and Investigatory Level.
- Use green if Skid Number is higher than Investigatory Level.

7.07 FUTURE IMPROVEMENTS TO THE PFM PROGRAM

7.07.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Analysis Team (DAT) to improve the current procedures of the "Pavement Friction Management Plan". This SOP is performed annually after the publication of PFM reports or once any new relevant type of data with potential for improvement of program becomes available. Implementation of International Friction Index (IFI) into the plan and development of a more robust prioritization procedure for correction of the hazardous skid-prone locations are two expected improvements that MDOT SHA will be undertaking in near future. As more reliable data become available, the PFM procedures may be modified to increase the efficiency of the program.

7.07.02 *Frequency*

The improvement to the PFM is performed annually, after the publication of PFM reports or once new relevant type of data become available.

7.07.03 *Purpose*

The purpose of this SOP is to use the available resources to make the PFM as efficient as possible.

7.07.04 *Resource Requirements*

Improving the PFM involves two persons: a DAT staff member familiar with the friction management plan and DAT team leader. The estimated effort level shown in the table below represents the total time, in man-hours, to complete the report generation. This time estimate assumes no issues are encountered during the report generation process.

Position	Function	Resources	Effort Level (man-hrs)
DAT Staff	Analyst	1	8.0
DAT TL	Supervision	1	2.0

7.07.05 *Procedure*

The procedure to improve the PFM is comprised of the following two tasks:

(1) Identify procedures that can be improved by modifying the steps, and
(2) Investigate if new data sources can be used to improve the procedures.

1- Identify Procedures That Can Be Improved by Modifying the Steps – *performed by DAT Staff*

Summary: Under this task, steps within each procedure are assessed and areas where improvements can be made are identified.

Step 1. Assess the steps within each procedure and look for ways to improve the procedure.

Step 2. Make a list of suggested improvements and share it with DAT team leader.

Step 3. Improve the procedures based on the approved list of suggestions.

2- Investigate if New Data Sources Can Be Used to Improve the Procedures – *performed by DAT Staff*

Summary: Under this task, availability of new data sources and data fields will be investigated, and procedures will be modified accordingly to allow for incorporation of new resources.

Step 1. Assess the availability of new resources such as new data fields.

Step 2. Assess the reliability and accuracy of new data.

Step 3. Make a list of suggested improvements and share it with DAT team leader.

Step 4. Improve the procedures based on the approved list of suggestions.

8 HPMS DATA REPORTING

Click to go to Production of HPMS Sample Table
Click to go to Production of HPMS Full Extent Table
Click to go to QA of HPMS Tables

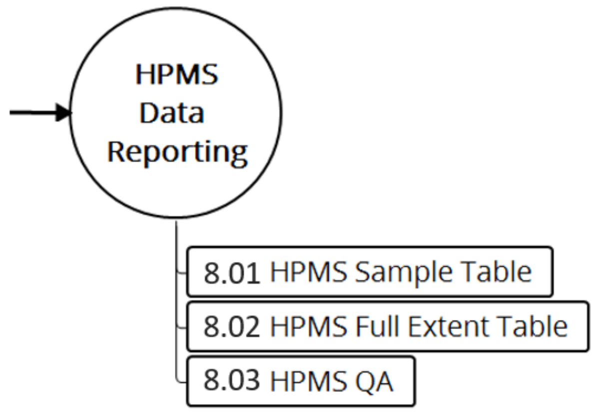


Figure 11: HPMS Data Reporting Flowchart

This section describes the set of standard operating procedures (SOP) conducted mainly by staff from the Data Analysis Team (DAT) of the Maryland Department of Transportation State Highway Administration's (MDOT-SHA) Office of Materials Technology (OMT) to update, format, and deliver the Highway Performance Monitoring System (HPMS) tables to the DSD. This section is divided into three SOPs: updating of the HPMS Sample table, updating of the HPMS Full-Extent table, and QA of the tables. The first two cover the production and QC of the HPMS deliverables whereas the third SOPs covers the QA performed to the HPMS deliverables before they are submitted to the DSD.

8.01 PRODUCTION OF HPMS SAMPLE TABLE

8.01.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Warehouse Team (DWT) and Data Analysis Team (DAT) to produce the Highway Performance Monitoring System (HPMS) Sample Table as required by the Federal Highway Administration (FHWA). The table utilizes the Data Services Division's (DSD) Sample Section table, which is received in Excel format and includes a list of sections for the current year's Sample Table. This process is performed after the completion of Business Plan Tables (BPT) migration, as outlined in Migrating to Business Plan Tables and the production of the HPMS Full Extent table, as outlined in Production of HPMS Full Extent Table.

8.01.02 *Frequency*

The HPMS Sample Table is produced once per year.

8.01.03 *Purpose*

The purpose of this SOP is detailed the procedure required to process the DSD Sample Section Table dataset and to populate the HPMS Sample Table with data for the current year for submission to the FHWA.

8.01.04 *Resource Requirements*

The production of the HPMS Sample Table involves two people: (1) the DAT Team Leader (TL) who produces the table and performs quality control (QC), and (2) a DWT member, who, as requested, provides database management support. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues are encountered.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Database Management Support	1	AR[06/12/2019]
DAT TL	Data Processing and QA	1	50.0

8.01.05 *Procedure*

The procedure to produce the HPMS Sample Table is comprised of four tasks:

(1) processing DSD Sample Section dataset,
(2) sending list of changes to DSD,
(3) producing initial version of HPMS Sample Table, and
(4) performing QC of HPMS Sample Table.

1- Processing DSD Sample Section Dataset – *performed by DAT TL*

Summary: Under this task, HPMS sections that do not have homogenous surface types are split. For instance, if a sample section has a flexible surface type and a concrete surface type, the sample section needs to be split into two distinct sections, one per each surface type. The output is an updated HPMS Sample Section Table with the surface type field populated for all sections. A list of sections that were broken out in this task based on varying surface types will be sent back to the DSD (see below image for an example of the Sample Section Table).

ROUTEID	COUNTY	PREFIX	RTE_NO	SUFFIX	MUN_SORT	BMP	EMP	NEW_BMP	EMP_NEW	BMP_LAT	BMP_LONG	EMP_LAT	EMP_LONG
02000IS00097 01NN**************	2	IS	97		0	11.19	12.1	11.19	12.056	39.11593614	-76.63542651	39.11594939	-76.63543419
02000IS00097 01NN**************	2	IS	97		0	11.19	12.1	12.056	12.1	39.12773572	-76.64106639	39.12774939	-76.64107266
03000US00040 01EE**************	3	US	40		0	21.84	23.06	21.84	22.977	39.38429794	-76.42215534	39.38430811	-76.422142
03000US00040 01EE**************	3	US	40		0	21.84	23.06	22.977	23.06	39.39586443	-76.4069788	39.39587464	-76.40696544
07000MD00213 01NN**************	7	MD	213		0	18.85	19.11	18.85	18.937	39.6079611	-75.83400371	39.60797408	-75.834012
07000MD00213 01NN**************	7	MD	213		0	18.85	19.11	18.937	19.006	39.60910045	-75.83471296	39.60911346	-75.83472122
07000MD00213 01NN**************	7	MD	213		0	18.85	19.11	19.006	19.11	39.60999754	-75.83528331	39.61001048	-75.83529171
08000US00301 01NN**************	8	US	301		0	0	2.08	0	1.905	38.35895819	-77.01840715	38.358946	-77.01840244
08000US00301 01NN**************	8	US	301		0	0	2.08	1.905	2.08	38.36376154	-76.98072178	38.36376384	-76.98070364
08000US00301 01NN**************	8	US	301		0	2.23	3.81	2.23	2.318	38.3644891	-76.97480903	38.36449193	-76.97479089
08000US00301 01NN**************	8	US	301		0	2.23	3.81	2.318	3.81	38.36472564	-76.97321318	38.36472812	-76.97319503
15000MD00187 01NN**************	15	MD	187		0	0.65	0.91	0.65	0.665	38.99063073	-77.10385837	38.99063966	-77.10387303
15000MD00187 01NN**************	15	MD	187		0	0.65	0.91	0.665	0.877	38.99076425	-77.10407855	38.99077316	-77.10409325
15000MD00187 01NN**************	15	MD	187		0	0.65	0.91	0.877	0.897	38.99270694	-77.10715414	38.99271692	-77.10716781
15000MD00187 01NN**************	15	MD	187		0	0.65	0.91	0.897	0.91	38.99290805	-77.10742568	38.9929183	-77.10743893
15000MD00355 01NN**************	15	MD	355		0	5.84	6.38	5.84	5.996	39.04307296	-77.11083085	39.04308673	-77.11083711
15000MD00355 01NN**************	15	MD	355		0	5.84	6.38	5.996	6.018	39.04520211	-77.11183852	39.04521583	-77.11184452
15000MD00355 01NN**************	15	MD	355		0	5.84	6.38	6.018	6.38	39.04550435	-77.11197444	39.04551801	-77.1119807
15000MD00355 01NN**************	15	MD	355		0	18.95	19.7	18.95	19.384	39.19643037	-77.24440993	39.19644468	-77.24441369
15000MD00355 01NN**************	15	MD	355		0	18.95	19.7	19.384	19.506	39.19985437	-77.24507808	39.19986878	-77.24508044
15000MD00355 01NN**************	15	MD	355		0	18.95	19.7	19.506	19.7	39.20162137	-77.24536508	39.20163591	-77.24536751
16000MD00450 01EE**************	16	MD	450		0	3.5	4.19	3.5	4.16	38.95230222	-76.8839262	38.95230687	-76.88390868
16000MD00450 01EE**************	16	MD	450		0	3.5	4.19	4.16	4.168	38.95567738	-76.87288021	38.95568595	-76.87286491
16000MD00450 01EE**************	16	MD	450		0	3.5	4.19	4.168	4.19	38.95574539	-76.87275808	38.95575401	-76.87274294

Step 1. Using SQL Developer, run the script[06/12/2019] “1_Create Surface Type from B_LMY.txt” to create an auxiliary table that will be used to aggregate surface types from the “Business_Plan_LMY” table.

Step 2. Using SQL Developer, run the script “2_Join Samples with B_LMY Surface Type.txt” to merge the dataset created in Step 1 with the original HMPS Sample Section List. The output of this step will split some sample sections into distinct records based on varying surface types.

Step 3. Using SQL Developer, run the script “3_ZZ_EDW_SURFACE_BREAKS” to build another intermediate table based on the “EDW_Base_1” table. This will populate surface type information for sections that had missing information from the “Business_Plan_LMY” table.

Step 4. Using SQL Developer, run the script “POP_SURF_TYPE_HMIS” to populate surface type information that is still missing after Step 1 through Step 3 using the “HMIS_UNIVERSE_ALL_YEARS” table.

2- Sending List of Changes to DSD – *performed by DAT TL*

Summary: Under this task, the section modifications identified in the previous task are communicated to the DSD. Also, QC on the table is performed to verify that the new sections have unique identifiers. The DSD produces a new table that accounts for the section changes.

Step 5. Submit the list of section modifications (only affected locations and in excel csv format) to the DSD via email. The DSD will update and submit a final list of HPMS Sample Sections that includes the additional sections created a result of the surface type section splits back to the DAT.

Step 6. Inspect and verify that the newly submitted list has the “ORDER_ID” and “Sample_NUMBER” fields populated for all records, including the sections added during the previous task. In addition, verify that there is a unique identifier (ORDER_ID) for each sample record.

iii. If there are discrepancies encountered during verification, communicate issues to DSD and resolve them before continuing.

iv. Otherwise, proceed to Step 7.

3- Producing HPMS Sample Table – *performed by DAT TL*

Summary: This task uses the updated DSD Sample Section Table to produce the HPMS Section Table by populating, adding, and aggregating data fields.

Step 7. Using Oracle SQL Developer, run a series of packages and scripts to populate the data elements that are part of the submittal for the HPMS Sample locations. The table below shows the data elements that should be populated and the name of the package or script that should be used. Please note that the majority of the data elements are extracted from the HPMS Full-Extent Table already produced for the corresponding year[06/12/2019].

HPMS Sample Data Element	Method	Package/Script	Procedure
IRI	SCRIPT	POP_IRI_HPMS_SAMPLE.SQL	N/A
IRI_VALUE_DATE	SCRIPT	POP_IRI_DATE_HPMS_SAMPLE.SQL	N/A
CRACKING_PERCENT	SCRIPT	POP_CRACKING_PERCENT_HPMS_SAMPLE	N/A
CRACKING_VALUE_DATE	SCRIPT	POP_CRACKING_VALUE_DATE_HPMS_SAMPLE.SQL	N/A
RUTTING	SCRIPT	POP_RUTTING_HPMS_SAMPLE.SQL	N/A
RUTTING_VALUE_DATE	SCRIPT	POP_RUTTING_DATE_HPMS_SAMPLE.SQL	N/A
FAULTING	SCRIPT	POP_FAULT_HPMS_SAMPLE.SQL	N/A
FAULTING_VALUE_DATE	SCRIPT	POP_FAULT_VALUE_DATE_HPMS.SQL[06/12/2019]	N/A
THICKNESS_RIGID	PACKAGE	BING_HPMS_PAV	N/A
THICKNESS_FLEXIBLE	PACKAGE	BING_HPMS_PAV	N/A
BASE_THICKNESS	PACKAGE	BING_HPMS_PAV	N/A
YEAR_LAST_IMPROV	PACKAGE	BING_HPMS_PAV	N/A
YEAR_LAST_CONSTRUCTION	PACKAGE	BING_HPMS_PAV	N/A
LAST_OVERLAY_THICKNESS	PACKAGE	BING_HPMS_PAV	N/A
CURVE_A	PACKAGE	BING_HPMS_CON	HPMS_CURVE
CURVE_B	PACKAGE	BING_HPMS_CON	HPMS_CURVE
CURVE_C	PACKAGE	BING_HPMS_CON	HPMS_CURVE
CURVE_D	PACKAGE	BING_HPMS_CON	HPMS_CURVE
CURVE_E	PACKAGE	BING_HPMS_CON	HPMS_CURVE
CURVE_F	PACKAGE	BING_HPMS_CON	HPMS_CURVE
GRADE_A	PACKAGE	BING_HPMS_CON	HPMS_GRADE
GRADE_B	PACKAGE	BING_HPMS_CON	HPMS_GRADE
GRADE_C	PACKAGE	BING_HPMS_CON	HPMS_GRADE
GRADE_D	PACKAGE	BING_HPMS_CON	HPMS_GRADE
GRADE_E	PACKAGE	BING_HPMS_CON	HPMS_GRADE
GRADE_F	PACKAGE	BING_HPMS_CON	HPMS_GRADE

4- Performing QC of HPMS Sample Table – *performed by DAT TL*

Summary: Under this task, checks on the created HPMS Sample Table are performed in order to ensure that all fields are correct and complete, following the specifications in the HPMS Field Guide. Please note that the HPMS Field Guide changes regularly and some updates may require an update to the steps in this SOP.

Step 8. Once the HPMS Sample table is populated, perform quality checks to identify possible missing items or data discrepancies. Check for data that are outside the allowable ranges as specified in the HPMS Field Guide.

i. If data are found to be missing or outside the allowable ranges of the HPMS Field Guide specifications, investigate the flagged data to identify the source of the error. If a flagged data value is validated by the investigation, report as-is. Otherwise, correct error and revise table. Fixing errors may involve more ad hoc data analysis approaches, such as the usage of more granular data sources (e.g., in Base 1 and Base 4 tables).

ii. If no data are found to be missing or outside the allowable ranges of the HPMS Field Guide specifications, process is complete.

8.02 PRODUCTION OF HPMS FULL-EXTENT TABLE

8.02.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Maryland Department of Transportation State Highway Administration's (MDOT-SHA's) Data Warehouse Team (DWT) and Data Analysis Team (DAT) to produce the Highway Performance Monitoring System (HPMS) Full-Extent Table as required by the Federal Highway Administration (FHWA). This process is performed after the completion of Business Plan Tables (BPT) migration, as outlined in Migrating to Business Plan Tables. The HPMS Full-Extent Table is produced for delivery to the Data Services Division (DSD).

8.02.02 *Frequency*

The HPMS Full-Extent Table is produced once per year.

8.02.03 *Purpose*

The purpose of this SOP is to produce the annual HPMS Full-Extent Table, which meets FHWA requirements, and once completed to deliver the table to the DSD.

8.02.04 *Resource Requirements*

The production of the HPMS Full-Extent Table involves three people: (1) a DWT member who produces the table and performs quality control (QC), (2) the DAT Team Leader (TL), who provides support and performs quality assurance (QA), and (3) the Assistant Division Chief (ADC), who, as requested, performs further QA. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues are encountered.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Data Processing and QC	1	50.0
DAT TL	Support and QA	1	4.0
ADC	QA	1	AR[06/12/2019]

8.02.05 *Procedure*

The procedure required to produce the HPMS Full-Extent Table is comprised of the following five tasks:

(1) producing HPMS_NETWORK_CONDITION_100MMI Table,
(2) performing QC of HPMS_NETWORK_CONDITION_100MMI Table,
(3) creating view and notifying TL of completion,
(4) performing QA of HPMS_NETWORK_CONDITION_100MMI Table, and
(5) creating final dataset of HPMS Full-Extent Table and notifying ADC for further QA.

1- Producing HPMS_NETWORK_CONDITION_100MMI Table – *performed by DWT member*

Summary: Under this task, the four detailed tables (Final Condition Detail Table, Rut Detailed Table, Cracking Detailed Table, and Concrete Detailed Table) developed in accordance with Update Final Condition Detail Table, Update Rut Detailed Table, Update Cracking Detailed Table and Update Concrete Detailed Table are used to

adjust the section extents of the pavements in the network to adapt to FHWA HPMS requirements. The output is the creation of an intermediate table named HPMS_NETWORK_CONDITION_
100MMI that is used to produce the final Full-Extent Table.

Step 1. Check if there are any changes in HPMS requirements from the previous year.

i. If there are no changes, proceed to Step 2.

ii. If there are changes, modify code accordingly based on the new requirements. Discuss the HPMS requirement changes with respect to the previous year with the Assistant Division Chief (ADC) to confirm the packages will run properly.

Step 2. Using the SQL developer, run HPMS_CONDITION_100MMI package. The input will be the four detailed tables (Final Condition Detail Table, Rut Detailed Table, Cracking Detailed Table, and Concrete Detailed Table) developed in accordance with Update Final Condition Detail Table, Update Rut Detailed Table, Update Cracking Detailed Table and Update Concrete Detailed Table and the output will be the intermediate HPMS_NETWORK_CONDITION_100MMI Table.

2- Performing QC of HPMS_NETWORK_CONDITION_100MMI Table – *performed by DWT member*

Summary: Under this task, checks are conducted to confirm that the intermediate HPMS_NETWORK_CONDITION_100MMI Table was correctly populated based on completeness and then compares the data to last year's submission for quality purposes.

Step 3. Check for completeness.

i. Check number of records missing for each of the data elements. No missing records are allowed. Investigate any missing records and attempt to recover. If recovery is not possible, in some cases it is permitted to carry last year's value forward.

Step 4. Compare to last year's submission.

i. Check each rating group (% Poor, Fair, Good) for each condition metric. If the percent change is equal to or less than 1 point, do nothing. If the change is greater than 1 point, investigate the possible causes. Determine if the issue is related to data processing, or if it is a legitimate change in distress rating.

ii. Check surface types. Compare lane miles for each surface type. If the percent change is equal to or less than 1 point, do nothing. If the change is greater than 1 point, investigate the possible causes. Determine if the issue is related to data processing, or if it is a legitimate change in surface type amount.

3- Creating View and Notifying TL of Completion – *performed by DWT TL*

Summary: Under this task, gaps in the intermediate HPMS_NETWORK_
CONDITION_100MMI Table are filled with values from last year's table.

Step 5. Check if there are changes regarding the data structure of the view. If there are no changes, do nothing. If there are changes, first modify the HPMS[YY]_FULL_EXTENT_COND code accordingly; i.e., to reflect the revised data structure. Then, create the view in the production server called HPMS[YY]_FULL_EXTENT_COND. The view will fill in holes in current year's table using values from the previous year.

Step 6. Notify DAT Team Leader that the intermediate HPMS_NETWORK_CONDITION_100MMI Table is ready for QA and that the view, if necessary, has been created.

4- QA of HPMS_NETWORK_CONDITION_100MMI Table – *performed by DAT TL*

Summary: Under this task, the updated intermediate HPMS_NETWORK_CONDITION_100MMI Table resulting from Task 3 is first checked to confirm it has been correctly populated from a completeness viewpoint and then compares the data to table submissions from previous years for quality purposes.

Step 7. Check for completeness.

i. Compare total lane mileage from last year's reported HPMS data to the current year's report HPMS data (~ +/- 10 miles of last years). Check mileage by pavement type, last rehabilitation year, last construction date, and by other inventory data types.

1. If checks are acceptable, proceed to Step 8.
2. If checks result in differences greater than the defined tolerance, further investigation is required. For example, if aggregate difference in lane miles by county is positive, this may be to duplicated records or added miles, while if negative may be due to routes on which data were not collected. Use SQL Developer to locate where discrepancies are located. If the cause of the discrepancy is valid, accept as-is. As indicated in the HPMS Field Manual, last year's condition data may be used for a specific missing section (but confirm with HPMS Field Manual that this is allowed for metric in question). Otherwise, report section as missing value. If not valid, ask DWT staff member to fix the issue.

Step 8. Check for data sanity (i.e., range, acceptable values):

i. Using SQL Developer, follow HPMS manual guidelines for doing checks (ad hoc, no code exists). For example, check for International Roughness Index (IRI) values less than 30 in/mi and greater than 400 in/mi. Investigate source of the unacceptable value. If the value is a valid measurement with correct processing, submit it as-is and include a note to the Data Services Division (DSD) justifying the value. Otherwise, contact the TL of the department where the issue originated and request they investigate the issue until it is resolved.

Step 9. Check for discrepancies in the current year's HPMS data with respect to the last two years of HPMS data submitted.

Check overall mean values of condition metrics at State level to confirm they are within reasonable values. The mean IRI, cracking percent, rutting percent, and faulting[06/12/2019] percent change per year should not be more than +-2%. If values are reasonable, do nothing. If one or more checks result in a condition measurement difference outside the listed tolerance, discuss with ADC before continuing.

Step 10. Check for validity of non-condition data elements (data item numbered 54 through 62 in the HPMS Field Manual) by comparing them with the numbers in last year's HPMS submission.

i. Using Oracle SQL Developer, check that the construction year is consistent with last year's submittal.

ii. Using SQL Developer, compare surface types between this year and last year. If the surface type has changed, check for construction events. If there are discrepancies that cannot be resolved, discuss them with DPT staff before continuing.

5- Creating View of Full-Extent Table and Notifying ADC for further QA – *performed by DAT TL*

Summary: Under this task, a view that will extract data from another view (pav.conhist.HPMS17_FULL_EXTENT_COND) previously created by DWT staff will be created. This view will contain the finalized Full-Extent Table for QA review by the ADC and then submission to the DSD.

Step 11. Check if there are changes regarding the data structure of the view or the HPMS requirements. If there are no changes, do nothing. If there are changes, modify the HPMS_FULL_EXTENT code accordingly. Then, using Oracle SQL Developer, recreate the HPMS_FULL_EXTENT View within the "Pav_READ" user[06/12/2019].

Step 12. Notify ADC of completion of final data set for final review (see QA of HPMS Tables). Send email with name of the view that will be accessed through "Pav_READ" user.

8.03 QA OF HPMS TABLES

8.03.01 *General*

This section describes the standard operating procedure (SOP) used by the Assistant Division Chief (ADC) of the Pavement Management Division of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to perform quality assurance (QA) of the Highway Performance Monitoring System (HPMS) Sample Table and Full-Extent Table before they are submitted to the Data Services Division (DSD). This SOP is performed once the annual HPMS Sample Table and the HPMS Full-Extent Table are produced. It is the last step for the reporting of data to the Federal Highway Administration's (FHWA) HPMS.

8.03.02 *Frequency*

The QA of HPMS Sample Table and Full-Extent Table is performed once per year.

8.03.03 *Purpose*

The purpose of this SOP is:

- check that the HPMS Sample Table and the HPMS Full-Extent Table (1) have been correctly populated, (2) are complete, and (3) present an accurate description of the pavement network condition before the tables are delivered to the DSD;
- investigate, if needed, reasons that explain changes in the pavement network condition with respect to the previous year condition; and
- notify the DSD of delivery of the referenced tables and to have the DSD address data issues identified from their review of the submitted tables.

8.03.04 *Resource Requirements*

All the procedural steps for performing QA of the HPMS Sample Table and the HPMS Full-Extent Table are to be carried out by the ADC. However, this SOP may involve the Team Leaders (TL) from other pertinent groups, who as required would provide support and information to resolve data issues encountered during the QA process. The estimated effort levels in the table below represent the total time, in man-hours, to complete the process. These time estimates assume no issues are encountered.

Position	Function	Resources	Effort Level (man-hrs)
ADC	QA checks	1	8.0
FED TL	Issue resolution	1	AR[06/12/2019]
DPT TL	Issue resolution	1	AR[1]
DWT TL	Issue resolution	1	AR[1]
DAT TL	Issue resolution	1	AR[1]

8.03.05 *Procedure*

The procedure required to perform QA of the HPMS tables is comprised of the following two tasks:

(1) performing QA of HPMS Sample Table and Full-Extent Table, and
(2) delivering the above referenced HPMS Tables to DSD.

1- Performing QA of HPMS Sample Table and Full-Extent Table – *performed by ADC*

Summary: Under this task, the final quality checks on the HPMS Sample Table and HPMS Full-Extent Table will be performed before they are delivered to the DSD. The checks in this task serve as a means to confirm the quality of the processed data and, as appropriate, to further investigate the reasons behind the observed changes in the pavement network condition over a one year period of time.

Step 1. Using SQL Developer, check that the data in both the HPMS Sample Table and HPMS Full-Extent Table are complete.

i. Use data from the DSD's annual inventory table for the corresponding collection year to identify sections with missing data from HPMA Full-Extent Table.

ii. Use data from the DSD's Sample Section table for the corresponding collection year to identify sections with missing data from HPMA Sample Table.

Review the identified missing data, if any, from each table and discuss with appropriate MDOT-SHA TL whether those data can be recovered through reprocessing of the data. If feasible, then request MDOT-SHA TL to reprocess potentially recoverable data and confirm that these data have been effectively included in the referenced HPMS tables.

Step 2. Using SQL Developer, check that the data in both the HPMS Sample Table and HPMS Full-Extent Table have been populated correctly. For example, check that the correct data elements are associated with the correct surface type – e.g., faulting data should only be present for jointed concrete pavements and rutting data should only be present for asphalt concrete pavements. Proceed to next step if all data have been correctly populated. Otherwise, communicate data issues identified to the DAT TL for him/her to review these data and to make the appropriate corrections. Review HPMS tables corrected by DAT TL to confirm that the data issues identified have been resolved.

Step 3. Using SQL Developer and Microsoft Excel, query the HPMS Sample Table and HPMS Full-Extent Table for trends and summary statistics to evaluate the changes in condition of the pavement network over a one year period of time. Example checks performed include:

i. Check that data related to pavement condition metrics and HPMS condition ratings (percentage of lane miles in Good, Fair, and Poor condition) in the HPMS Full-Extent Table are reasonable as compared to summary statistics obtained from data collected for the State's Pavement Management System and to the values reported in the HPMS reports from the previous year. Also, check the reasonableness of the statistics relative to the trends over time; e.g., the total lanes miles reported for a given surface type is not expected to differ by more than 1% from the previous year.

ii. Check that data related to construction information (e.g., total lanes miles treated) in the HPMS Sample Table is reasonable when compared to the values reported in HPMS reports from the previous year.

Discuss data identified as suspicious (e.g., large changes from one year to the next or large discrepancies with data from other reports for the same data collection year) with pertinent MDOT-SHA TL to evaluate whether the issues are the result of improper or erroneous data processing or if they are due to changing conditions and circumstances (e.g., a significant reduction in treated miles from previous year may be explained by a decreased budget). Proceed to next step if all data have been correctly populated. Otherwise, request pertinent MDOT-SHA TL to address the data issues that have been identified. Lastly, review HPMS tables corrected by pertinent MDOT-SHA TL to confirm that all data issues have been resolved.

2- Reviewing and Finalizing HPMS tables with DSD – *performed by ADC*

Summary: Under this task, the HPMS Sample Table and the HPMS Full-Extent Table are finalized through an iterative process between the ADC and DSD in order to eliminate any remaining issues with the data in the referenced tables.

Step 4. Notify DSD that the HPMS Sample Table and HPMS Full-Extent Table are ready for their review[06/12/2019] and that the tables can be accessed through the "Pav_READ" user in the server.

Step 5. Upon receipt of DSD's review report with the identified HPMS data issues, if any, investigate whether these issues can be resolved through discussion with the pertinent MDOT-SHA TL. If any data can be recovered, take the necessary steps to recover them and update the tables. Identify and note a reason for unrecoverable data. Notify DSD that the tables are ready for re-review, identifying those data issues that were not resolved along with the reason why they could not be resolved.

Step 6. Repeat Step 5 until all remaining data issues highlighted in the DSD report are considered unrecoverable (e.g., missing data on sections under construction during the data collection season). Communicate to the DSD that the tables have been fully updated and that the work has been finalized.

9 TREND ANALYSIS

Click to go to Updating IRI Performance Model
Click to go to Updating Cracking Performance Models
Click to go to Updating Rutting Performance Model
Click to go to Updating Faulting Performance Model
Click to go to Updating Friction Performance Model

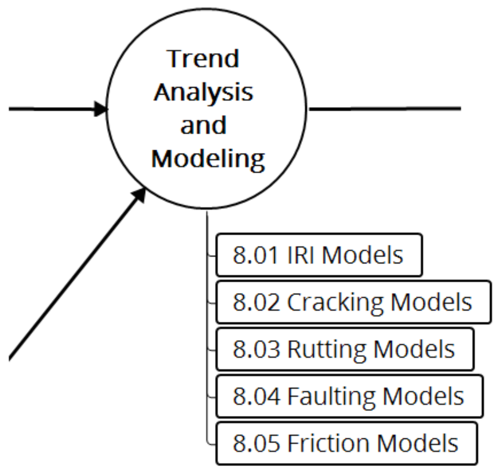


Figure 12: Trend Analysis Flowchart

This section describes the set of standard operating procedures (SOP) conducted mainly by staff from the Data Warehouse Team (DWT) and Data Analysis Team (DAT) of the Maryland Department of Transportation State Highway Administration's (MDOT-SHA) Office of Materials Technology (OMT) to perform the annual update the performance models for the pavement condition metrics. This section is divided into five SOPs: updating the IRI performance model, updating the cracking performance models, updating the rutting performance model, updating the faulting performance model, and updating the friction performance model.

9.01 UPDATING IRI PERFORMANCE MODEL

9.01.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Warehouse Team (DWT) and Data Analysis Team (DAT) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to update the International Roughness Index (IRI) performance model parameters as new IRI data are collected and processed. The IRI performance model follows the exponential function shown in the equation below[06/12/2019], which was developed from the analysis of historical MDOT-SHA IRI data.

$$\overline{IRI} = IRI_{in}\,\mu_1 \exp(\mu_1 \mu_2 AGE)$$

Where:	$\overline{IRI}$	=	estimated IRI value of pavement at age "AGE", in in/mile;
	IRI_{in}	=	Initial pavement IRI value, in in/mile;
	AGE	=	age of pavement for which IRI is estimated, in years;
	μ_1	=	parameter that captures effect of last treatment; and
	μ_2	=	parameter that captures effect of surface type, region, and functional class.

The equation parameters $\mu_1$and μ_2 are typically updated yearly to account for possible changes in IRI trends resulting from the most recent IRI data. The current values of $\mu_1$and μ_2 are listed in IRI Performance Model, while a summary of the most recent average yearly IRI percent changes as a function of pavement family are also provided.

9.01.02 *Frequency*

The update of IRI model parameters is typically performed once per year, after the end of the data collection season and once all data have been processed and migrated into the appropriate Business Plan Tables (see Migrating to Buiness Plan Tables).

9.01.03 *Purpose*

The purpose of this SOP is to update the IRI performance model parameters to incorporate the most recently collected and processed IRI data.

9.01.04 *Resource Requirements*

The updating of the IRI performance models involves the following three MDOT-SHA staff members: (1) a database management expert from the DWT to update model parameters, (2) a database management expert from the DAT to validate the estimated models, and (3) a supervisor – typically the Assistant Division Chief (ADC) – who, as required, provides guidance and decision-making. The estimated effort level shown in the table below represents the total time, in man-hours, to complete the update of the IRI performance model parameters. The estimate assumes no issues are encountered during the update process.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Model Estimation	1	16.0
DAT Staff	Model Validation	1	40.0 or as needed
ADC	Supervisor	1	As required[06/12/2019]

9.01.05 *Procedure*

The procedure required to update the IRI performance models is comprised of the following two tasks:

(1) estimation of new IRI model parameters, and
(2) QA new IRI model parameters.

1- Estimation of New IRI Model Parameters – *performed by DWT staff*

Summary: Under this task, the most recently collected and processed IRI data are used to estimate new model parameters.

Step 1. In Oracle SQL Developer, run package "IRI_MODELS" to estimate new model parameters for each pavement family. Part of this package includes the removal of outliers from the collected IRI data. See Outlier Review - Outlier Codes for details regarding the outlier review and methodology for identifying outliers in the IRI data.

Step 2. Once the IRI model parameters for all families have been updated, inform DAT that parameters are ready for QA.

2- QA of New IRI Model Parameters – *performed by DAT Staff*

Summary: Under this task, QA checks are used to confirm that the newly estimated IRI model parameters produce reasonable trends. The QA checks are performed using an existing MS Excel QA workbook template.

Step 3. Open the most recent MS Excel QA workbook template[06/12/2019] (sort by date modified) in the IRI models working folder.

Step 4. Copy and paste the family slopes from table "trend_iri_family_slopes" (located in Oracle SQL Developer as an output from the previous task) into the "slope" column (E) in the worksheet "Final Groups for IRI".

Step 5. Plot the IRI model function over 100 years for each pavement family to confirm that the trend looks reasonable. Refer to IRI Performance Model for the most recent average yearly IRI percent change for each pavement family.

IRI values are expected to deteriorate (i.e., increase) at about 2.4% per year on average, with some families deteriorating faster and others slower. Most families should reach an IRI value of 170 in/mile – lowest MDOT-SHA IRI trigger value (IRI_{RSL0}) corresponding to the Interstates functional class – within 100 years assuming an initial IRI value (immediately after last treatment) of 40 in/mile. Exceptions include reinforced concrete pavements and composite pavements with continuously reinforced concrete below the surface layer, which appear to deteriorate at a slower rate. The table below shows the IRI_{RSL_0} trigger values for the functional classes.

FUNC_CL	FC_DESCRIPTION	$IRI_{RSL\_0,\ in/mile}$
1	Rural Principal Arterial - Interstate	170
11	Urban Principal Arterial - Interstate	170
12	Urban Principal Arterial - Other Freeways	180
14	Urban Principal Arterial - Other	250
16	Urban Minor Arterial	265
17	Urban Major Collector	280
18	Urban Minor Collector	280
19	Urban Local	325
2	Rural Principal Arterial - Other Freeways	180
3	Rural Principal Arterial - Other	180
6	Rural Minor Arterial	250
7	Rural Major Collector	265
8	Rural Minor Collector	280
9	Rural Local	325

It is important to note that ride quality historically controls the condition of the lowest percentage of lane-miles among all five performance measures ranging between only 8-12% of the total lane-miles from 2014-2016. Therefore, it is reasonable to assume that the effect of IRI deterioration on overall pavement condition is somewhat insignificant when compared to the other four performance measures (i.e. rutting, structural and functional cracking, and friction.

i. If models pass the above referenced QA checks, proceed to Step 6.

ii. Otherwise, identify issues with the IRI model parameters and discuss remedial actions with appropriate personnel before continuing.

Step 6. As needed, write/update the IRI model parameters for each pavement family in C#. The existing IRI model parameters can be found in the worksheet "IRI Function," of the MS Excel QA workbook template. The updated parameters, and hence the IRI models, will be used later in the program optimization process (see Defining Network and Importing Data into the RoadCare Optimization Process).

9.02 UPDATING CRACKING PERFORMANCE MODELS

9.02.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Warehouse Team (DWT) and Data Analysis Team (DAT) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to update the cracking performance model parameters as new cracking data are collected and processed. This SOP covers the cracking performance model parameters used for predicting cracking condition metrics, including those used by the MDOT-SHA pavement management system (PMS) as well as those for submission to the Federal Highway Administration (FHWA) Highway Performance Monitoring System (HPMS). Those metrics are listed in the table below.

Surface Type	MDOT-SHA PMS metrics	FHWA HPMS metrics
Asphalt Concrete (AC)	Structural Cracking Density	Cracking Percent - AC
	Functional Cracking Density	
Jointed Concrete (JCP)	Structural Cracking Density	Cracking Percent - JCP
Continuously Reinforced Concrete (CRCP)	Structural Cracking Density	Cracking Percent - CRCP
	Functional Cracking Density	

The function selected to model Functional and Structural Cracking Density over time is the Gompertz model. This s-shape function is given by the following equation:

$$CD = \mathrm{L}\exp(-\exp\,(ll\_int + \; ll\_slp\; AGE))$$

Where:

CD = cracking density (functional or structural) of pavement at age “AGE”;
AGE = age of pavement since last treatment, in years;
L = model parameter (asymptotic cracking density value for large AGEs);
ll_int = first model parameter affecting model curvature/deterioration rate;
ll_slp = second model parameter affecting model curvature/deterioration rate.

The equation parameters *L*, *ll_int* and *ll_slp* are typically updated yearly to account for possible changes in cracking trends resulting from the most recent cracking data. The current values of the model parameters are provided in Cracking Performance Models according to pavement family.

9.02.02 *Frequency*

The update of MDOT-SHA cracking modeling parameters is typically performed once per year, after the end of the data collection season and once all data have been processed and migrated into the appropriate Business Plan Tables (see Migrating to Business Plan Tables).

9.02.03 *Purpose*

The purpose of this SOP is to update the MDOT-SHA cracking performance model parameters to incorporate the mostly recently collected and processed cracking data.

9.02.04 *Resource Requirements*

The updating of the cracking performance models involves the following three MDOT-SHA staff members: (1) a database management expert from the DWT to update model parameters, (2) an analyst from the DAT to validate the estimated models, and (3) a supervisor – typically the Assistant Division Chief (ADC) – who, as required, provides guidance and decision-making. The estimated effort level shown in the table below represents the total time, in man-hours, to complete the update of the cracking performance model parameters. The estimate assumes no issues are encountered during the update process.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Model Estimation	1	8
DAT Staff	Model Validation	1	40 or as needed
ADC	Supervisor	1	As required[06/12/2019]

9.02.05 *Procedure*

The procedure required to update the MDOT-SHA cracking performance models is comprised of the following two tasks:

(1) estimation of new model parameters, and
(2) QA new model parameters.

1- Estimation of New Cracking Model Parameters – *performed by DWT staff*

Summary: Under this task, the most recently collected and processed cracking data are used to estimate new model parameters.

Step 1. In Oracle SQL Developer, run package “CRACKING_MODELS” to estimate new model parameters for each pavement family.

Step 2. Once the cracking model parameters have been updated, inform DAT that the model parameters are ready to for QA.

2- QA of New Model Parameters – *performed by DAT Staff*

Summary: Under this task, QA checks are used to confirm that the newly estimated cracking model parameters produce reasonable trends. The QA checks are performed using an existing MS Excel QA template spreadsheet.

Step 3. Open the most recent MS Excel QA template spreadsheet in the cracking models working folder[06/12/2019] and sort by date modified. The QA template spreadsheet is called “Cracking_Density_Models_[MMDDYYYY].xlsx”.

Step 4. Check new estimate parameters for reasonableness and flag those models that exhibit unexpected trends. This is done by plotting the Gompertz curve for 100 years using the graph application in MS Excel to confirm that the trends look reasonable for all pavement families.

It is expected that the cracking density for most pavement families will deteriorate to the RSL0 value of the least important functional class in that family in 100 years, assuming an initial cracking density of 0. The tables below show the cracking density RSL0 values for the various pavement functional classes. This check should be performed before running the optimization and corrections to the pavement family slopes should be made as needed. Analysis of historical data shows that cracking deteriorates the fastest among all performance measures, controlling between 36%-41% of the total lane miles in the MDOT-SHA pavement network from 2015-2017. Therefore, it is reasonable to assume that the effect of cracking deterioration on overall pavement condition is quite significant.

FUNC_CL	FC_DESCRIPTION	FCD_{RSL_0}
1	Rural Principal Arterial - Interstate	25
11	Urban Principal Arterial - Interstate	25
2	Rural Principal Arterial - Other Freeways	35
12	Urban Principal Arterial - Other Freeways	35
3	Rural Principal Arterial - Other	35
14	Urban Principal Arterial - Other	35
6	Rural Minor Arterial	35
16	Urban Minor Arterial	35
7	Rural Major Collector	45
17	Urban Major Collector	45
8	Rural Minor Collector	45
18	Urban Minor Collector	45
9	Rural Local	50
19	Urban Local	50

FUNC_CL	FC_DESCRIPTION	SCD_{RSL_0}
1	Rural Principal Arterial - Interstate	15
11	Urban Principal Arterial - Interstate	15
2	Rural Principal Arterial - Other Freeways	35
12	Urban Principal Arterial - Other Freeways	35
3	Rural Principal Arterial - Other	35
14	Urban Principal Arterial - Other	35
6	Rural Minor Arterial	35
16	Urban Minor Arterial	35
7	Rural Major Collector	35
17	Urban Major Collector	35
8	Rural Minor Collector	35
18	Urban Minor Collector	35
9	Rural Local	40
19	Urban Local	40

The time to "zero RSL" for all pavement families is expected to be between 10 and 50 years and the second model parameter (slope ll_slp) should always be negative. Flagged models are subject to further investigation—not immediate rejection.

Step 5. As needed, write/update the cracking model parameters for each pavement family in C#. The existing functions can be found in Cracking Performance Models. The updated parameters and hence cracking models will be used later in the program optimization process.

9.03 UPDATING RUTTING PERFORMANCE MODEL

9.03.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Warehouse Team (DWT) and Data Analysis Team (DAT) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to update the rutting performance model parameters as new rutting data are collected and processed. The rutting performance model follows the linear function shown in the equation below, which was developed from the analysis of historical MDOT-SHA rutting data.

$$\overline{RD} = RD_{in} + \propto_1 AGE$$

Where:

$\overline{RD}$	= estimated rutting value of pavement at age "AGE", in inches;
RD_{in}	= initial pavement rutting value at time of last treatment, in inches;
AGE	= age of pavement for which rutting is estimated, in years;
$\propto_{\mathrm{i}}$	= parameter (equal to slope of linear regression) that captures effect of surface type and functional class.

The model, and more specifically the $\propto_{\mathrm{i}}$ parameter, is typically updated yearly to incorporate possible changes in rutting trends resulting from the most recent rutting data. The current value of $\propto_{\mathrm{i}}$ for the different pavement families are listed in Rutting Performance Model, along with the most recent rutting trend plots by pavement family and the specific C# functions.

9.03.02 *Frequency*

The update of rutting model parameter is typically performed once per year, after the end of the data collection season and once all data have been processed and migrated into the appropriate Business Plan Tables (see Migrating to Business Plan Tables).

9.03.03 *Purpose*

The purpose of this SOP is to update the rutting performance model parameter to incorporate the most recently collected and processed rutting data.

9.03.04 *Resource Requirements*

The updating of the rutting performance models involves the following three MDOT-SHA staff members: (1) a database management expert from the DWT to update model parameters, (2) an analyst from the DAT to validate the estimated models, and (3) a supervisor – typically the Assistant Division Chief (ADC) – who, as required, provides guidance and decision-making. The estimated effort level shown in the table below represents the total time, in man-hours, to complete the update of the rutting performance model parameter. The time estimate assumes no issues are encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Model Estimation	1	8.0
DAT Staff	Model Validation	1	40.0 or as needed
ADC	Supervisor	1	As required[06/12/2019]

9.03.05 *Procedure*

The procedure required to update the rutting performance model is comprised of the following two tasks:

(1) estimation of rutting new model parameter, and
(2) QA new rutting model parameter.

1- Estimation of New Rutting Model Parameter – *performed by DWT staff*

Summary: Under this task, the most recently collected and processed rutting data are used to estimate new model parameter.

Step 1. The "business_plan_trend_pkg" must be run in the ASSETDEV environment in Oracle SQL Developer before estimating the new rutting model parameter for each pavement family. This package will update the "business_plan_trend table." Ensure this has been completed prior to moving to Step 3.

2- QA of New Rutting Model Parameter – *performed by DAT Staff*

Summary: Under this task, QA checks are used to confirm that the newly estimated rutting model parameter for each pavement family produces reasonable trends. The QA checks are performed using an existing MS Excel QA workbook template.

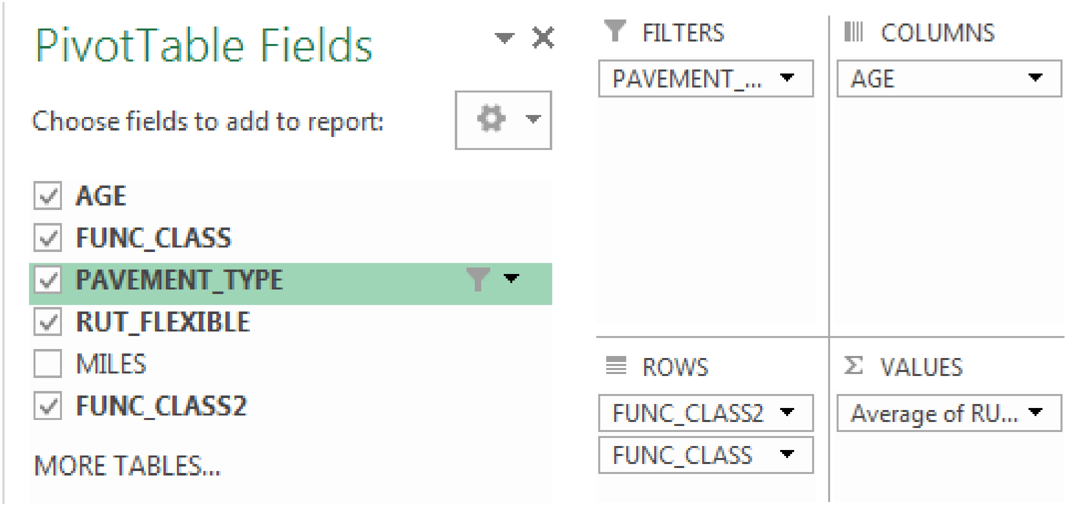
Step 2. Open the most recent MS Excel QA workbook template 06/12/2019 (sort by date modified) in the rutting models working folder.

Step 3. Connect to the ASSETDEV environment in Oracle SQL Developer and run the SQL statement stored in cell "F1" in the worksheet "Data." Paste the output of the SQL statement in the worksheet "Data" from cell A1. The source table in the SQL statement is "business_plan_trend."

Step 4. Create a pivot table from the pasted data by selecting "Insert" and then "Pivot Table" from the Excel ribbon. Select the table range of the data that was pasted in Step 3. Select "New Worksheet" and click "OK."

Step 5. On the new worksheet, filter the pivot table by surface type equal to "F" (Flexible) and organize the fields as shown in the below images.

PAVEMENT_TYPE	F															
Average of RUT_FLEXIBLE		AGE														
FUNC_CLASS2	FUNC_CLASS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
⊟1	1	0.098	0.112					0.23	0.231	0.22	0.26	0.211	0.171	0.159	0.186	0.144
⊟Group1	2	0.11	0.123	0.144	0.143	0.145	0.175	0.172	0.171	0.186	0.165	0.167	0.171	0.174	0.203	0.228
	3	0.108	0.16	0.142	0.129	0.13	0.151	0.153	0.153	0.153	0.153	0.137				
⊟6	6	0.1	0.11	0.106	0.122	0.116	0.128	0.139	0.135	0.144	0.158	0.174	0.185	0.186	0.196	0.19
⊟7	7	0.105	0.11	0.121	0.123	0.139	0.146	0.144	0.151	0.156	0.156	0.137	0.141	0.138	0.145	
⊟8	8	0.09	0.093	0.098	0.094	0.103	0.107	0.127	0.133	0.141	0.131	0.149	0.141	0.15	0.15	0.167
⊟9	9	0.081	0.11	0.088	0.098	0.113	0.087		0.145	0.11	0.144	0.137	0.145	0.155	0.101	
⊟11	11	0.142	0.131	0.152	0.16	0.157	0.177	0.187	0.201	0.19	0.205	0.196	0.179	0.216		
⊟12	12	0.142	0.147	0.169	0.151	0.135	0.153	0.154	0.156	0.182	0.17	0.19	0.208	0.207	0.271	0.232
⊟14	14	0.145	0.151	0.158	0.164	0.172	0.185	0.2	0.219	0.21	0.194	0.191	0.225	0.226	0.298	0.298
⊟16	16	0.133	0.125	0.136	0.135	0.148	0.151	0.168	0.179	0.191	0.206	0.214	0.219	0.221	0.228	0.206
⊟17	17	0.118	0.112	0.124	0.133	0.155	0.147	0.161	0.163	0.169	0.17	0.191	0.197	0.196	0.188	
⊞Group2		0.1065	0.107	0.097	0.101	0.148				0.21	0.1965	0.1805	0.1785	0.171	0.15	0.12



Step 6. Once the pivot table is organized, copy and paste the data underneath the pivot table in the same worksheet as shown in the below image.

Average of RUT_FLEXIBLE	Column Labels														
Row Labels	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0.098	0.112					0.23	0.231	0.22		0.211	0.171			
2	0.11	0.123	0.144	0.143	0.145	0.175	0.172	0.171	0.186						
3	0.108	0.16	0.142	0.129	0.13	0.151	0.153	0.153	0.153	0.153	0.137				
6	0.1	0.11	0.106	0.122	0.116	0.128	0.139	0.135	0.144	0.158	0.174	0.185	0.186	0.196	
7	0.105	0.11	0.121	0.123	0.139	0.146	0.144	0.151	0.156	0.156					
8	0.09	0.093	0.098	0.094	0.103	0.107	0.127	0.133	0.141	0.131	0.149	0.141	0.15	0.15	0.167
9	0.081	0.11	0.088	0.098	0.113			0.145		0.144	0.137	0.145	0.155		
11	0.142		0.152	0.16	0.157	0.177	0.187	0.201	0.19	0.205	0.196		0.216		
12	0.142	0.147	0.169	0.151	0.135	0.153	0.154	0.156	0.182	0.17	0.19	0.208	0.207	0.271	0.232
14	0.145	0.151	0.158	0.164	0.172	0.185	0.2	0.219	0.21	0.194	0.191	0.225	0.226	0.298	0.298
16	0.133	0.125	0.136	0.135	0.148	0.151	0.168	0.179	0.191	0.206	0.214	0.219	0.221	0.228	
17	0.118	0.112	0.124	0.133	0.155	0.147	0.161	0.163	0.169	0.17	0.191	0.197	0.196	0.188	
18	0.092	0.095	0.104							0.18	0.178				
19	0.121	0.119			0.148				0.21	0.213	0.183	0.216	0.197		
2"||FC=="3	0.109	0.1415	0.143			0.163	0.163	0.162	0.17					0.203	0.228
18"||FC=="19	0.1065	0.107	0.097	0.101	0.148				0.21	0.197					

Step 7. Perform a visual review of the data and remove any data points believed to be outliers, as illustrated by the yellow highlights in the above image. Previous experience with analyzing rutting data is required to perform this review.

Step 8. For each pavement family (or group of families), plot the rutting versus time model and obtain the slope by performing a linear regression in Excel. Review the plots for reasonableness and make adjustments to the groupings if necessary. For example, families exhibiting similar trends may be grouped together if the individual plots do not seem reasonable or the amount of data is insufficient. See Rutting Performance Model for the most recent plots by pavement family.

Step 9. As needed, write/update the rutting model parameter for each pavement family (or group of families) in C#. See Rutting Performance Model for the most recent model functions. The updated parameter for each pavement family, and hence rutting model, will be used later in the program optimization process (see Defining Network and Importing Data into the RoadCare Optimization Process).

Step 10. Repeat Step 4 through Step 9 for surface types “FCJ” (Flexible over JCP) and “FCC” (Flexible over CRCP).

9.04 UPDATING FAULTING PERFORMANCE MODEL

9.04.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Warehouse Team (DWT) and Data Analysis Team (DAT) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to update the faulting performance model parameters as new faulting data are collected and processed. The faulting performance model follows the linear function shown in the equation below, which was developed from the analysis of historical MDOT-SHA faulting data.

$$\overline{Faulting} = Faulting_{in} + \gamma_1 AGE$$

Where:

	$\overline{Faulting}$	= estimated faulting value at age "AGE," in inches;
	$Faulting_{in}$	= initial faulting value at time of last treatment, in inches;
	AGE	= age of pavement for which faulting is estimated, in years;
	γ_{i}	= parameter (equal to slope of linear regression) that captures effect of pavement type.

The model, and more specifically the γ_{i} parameter, is typically updated yearly to incorporate changes in faulting trends resulting from the most recent faulting data. The current values of γ_{i} for the jointed plain concrete (RJP) and jointed reinforced concrete (RJ) pavement families are provided in the table below. The number of years of historical data available to develop an estimate of the faulting model parameter were limited. Accordingly, improvements in the parameter are expected as additional data are incorporated in the coming years into the model development process.

Pavement Type	**Slope (γ_{i})**
Jointed Plain Concrete (RJP)	0.004
Jointed Reinforced Concrete (RJ)	0.008

9.04.02 *Frequency*

The update of faulting model parameter is typically performed once per year, after the end of the data collection season and once all data have been processed and migrated into the appropriate Business Plan Tables (see Migrating to Business Plan Tables).

9.04.03 *Purpose*

The purpose of this SOP is to update the faulting performance model parameter to incorporate the most recently collected and processed faulting data.

9.04.04 *Resource Requirements*

The updating of the faulting performance models involves the following three MDT SHA staff members: (1) a database management expert from the DWT to update model parameters, (2) an analyst from the DAT to validate the estimated models, and (3) a supervisor – typically the Assistant Division Chief (ADC) – who, as required, provides guidance and decision-making. The estimated effort level shown in the table below represents the total time, in man-hours, to complete the update of the faulting performance model parameter. The time estimate assumes no issues are encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Model Estimation	1	8.0
DAT Staff	Model Validation	1	20.0 or as needed
ADC	Supervisor	1	As required[06/12/2019]

9.04.05 *Procedure*

The procedure required to update the faulting performance model is comprised of the following two tasks:

(1) estimation of new faulting model parameters, and
(2) QA new faulting model parameters.

1- Estimation of New Faulting Model Parameter – *performed by DWT staff*

Summary: Under this task, the most recently collected and processed faulting data are used to estimate new model parameters.

Step 1. The “business_plan_trend_pkg” must be run in the ASSETDEV environment in Oracle SQL Developer before estimating new faulting model parameter for each pavement family. This package will update the “business_plan_trend table.” Ensure this has been completed prior to moving to Step 3.

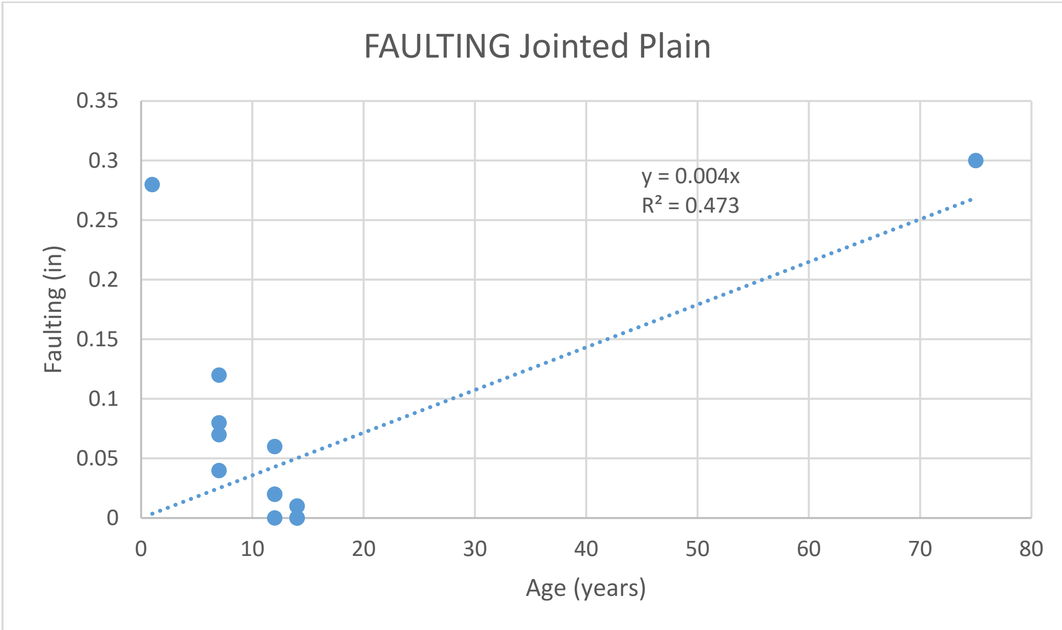
2- QA of New Faulting Model Parameter – *performed by DAT Staff*

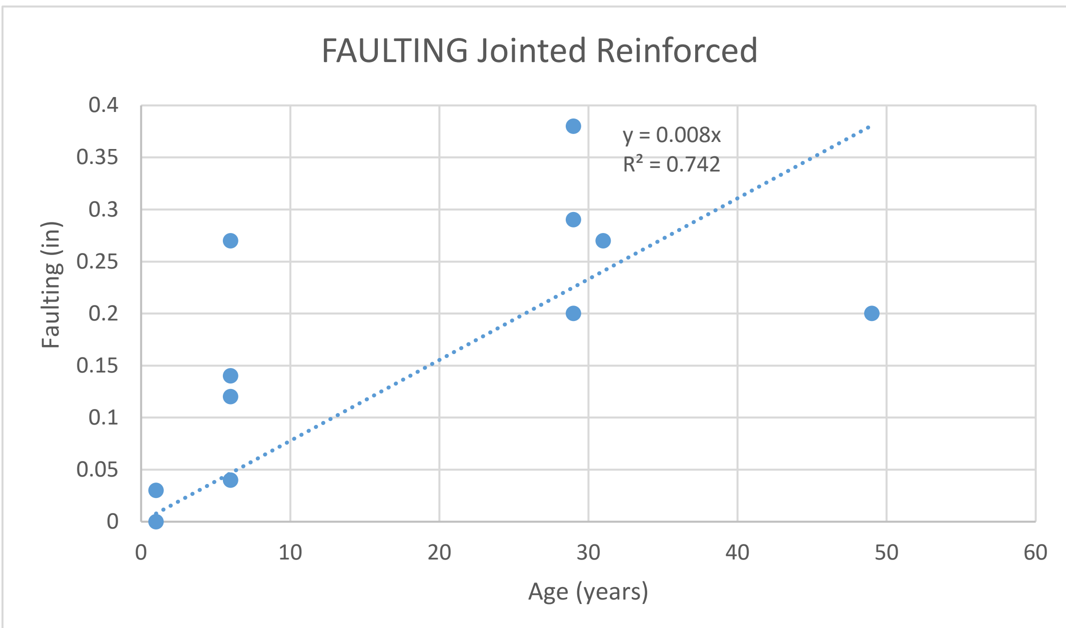
Summary: Under this task, QA checks are used to confirm that the newly estimated faulting model parameter for each pavement family produces reasonable trends. The QA checks are performed using an existing MS Excel QA workbook template.

Step 2. Open the most recent MS Excel QA workbook template[06/12/2019] (sort by date modified) in the faulting models working folder.

Step 3. Connect to the ASSETDEV environment in Oracle SQL Developer and run the SQL statement stored in cell “M1” in the worksheet “Sheet1.” Paste the output of the SQL statement in the Excel sheet. The source table in the SQL statement is “business_plan_trend.”

~~Step 4.~~ The model parameter for each pavement family is estimated using a linear regression in MS Excel and the data resulting from Step 3, as illustrated in the following two plots.





Step 5. Examine the faulting versus time plot for each pavement family (jointed plain and jointed reinforced concrete) using the output from the SQL statement in the previous step and check that the equations are showing reasonable results. If the two models pass the QA checks noted above, proceed to Step 6. Otherwise, identify issues and discuss remedial actions with appropriate personnel before continuing

i. The check is intended to confirm that faulting reaches a value of 0.15 inches or greater within 100 years from the time of the last treatment, which is assumed to have an initial faulting value of 0. This value of 0.15 inches corresponds to the “Poor” threshold for faulting specified in the final rule.

ii. It is expected that faulting for reinforced jointed concrete pavements deteriorate at a slower rate than jointed plain concrete pavements.

Step 6. As needed, write/update the faulting model parameter for each pavement of the two pavement families in C#. The updated parameter for each pavement family, and hence faulting model, will be used later in the program optimization process (see Defining Network and Importing Data into the RoadCare Optimization Process).

9.05 UPDATING FRICTION PERFORMANCE MODEL

9.05.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Warehouse Team (DWT) and Data Analysis Team (DAT) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to update the friction performance model parameter as new friction data are collected and processed. The friction performance model follows the linear function shown in the equation below, which was developed from the analysis of historical MDOT-SHA friction data.

$$\bar{F} = F_{in} + \propto_1 AGE$$

Where:

$\bar{F}$	=	estimated friction value of pavement at age “AGE”;
F_{in}	=	initial pavement friction value at time of last treatment;
AGE	=	age of pavement for which friction is estimated, in years;
$\propto_i$	=	parameter (equal to slope of linear regression) that captures effect of county and pavement functional class.

The model, and more specifically the $\propto_i$ parameter, is typically updated yearly to incorporate possible changes in friction trend from the most recent friction data. The current values for the different pavement families are listed in Friction Performance Model, along with the most recent friction trends and models by pavement family.

9.05.02 *Frequency*

The update of the MDOT-SHA friction model parameter is typically performed once per year, after the end of the data collection season and once all data have been processed and migrated into the appropriate Business Plan Tables (see Migrating to Business Plan Tables).

9.05.03 *Purpose*

The purpose of this SOP is to update the MDOT-SHA friction performance model parameter to incorporate the mostly recently collected and processed friction data.

9.05.04 *Resource Requirements*

The updating of the friction performance models involves the following three MDOT-SHA staff members: (1) a database management expert from the DWT to update model parameters, (2) an analyst from the DAT to validate the estimated models, and (3) a supervisor – typically the Assistant Division Chief (ADC) – who, as required, provides guidance and decision-making. The estimated effort level shown in the table below represents the total time, in man-hours, to complete the update of the friction performance model parameter. The time estimate assumes no issues are encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DWT Staff	Model Estimation	1	8.0
DAT Staff	Model Validation	1	40.0 or as needed
ADC	Supervisor	1	As required[06/12/2019]

9.05.05 *Procedure*

The procedure required to update the MDOT-SHA friction performance model is comprised of the following two tasks:

(1) estimation of new friction model parameter, and
(2) QA new friction model parameter.

1- Estimation of New Friction Model Parameter – *performed by DWT staff*

Summary: Under this task, the most recently collected and processed friction data are used to estimate new model parameters.

Step 1. Open the most recent MS Excel file[06/12/2019] (sort by date modified) in the friction models working folder.

Step 2. Connect to the ASSETDEV environment in Oracle SQL Developer and run the SQL statement stored in cell F1 of the worksheet "Data." The source table in the SQL statement is "friction." This will drop the existing table PAV_CONHIST.TREND_FRICTION_12_14_2017 and create a new table PAV_CONHIST.TREND_FRICTION [MM_DD_YYYY] (change date) with the updated data.

Step 3. While still in Oracle SQL Developer, run the SQL statement stored in cell E1 in the worksheet "Data." Paste the output of the SQL statement in the worksheet "Data" in cell A1.

2- QA of New Friction Model Parameter – *performed by DAT Staff*

Summary: Under this task, QA checks are used to confirm that the newly estimated friction model parameter for each pavement family produces reasonable trends. QA checks are performed using a MS Excel workbook.

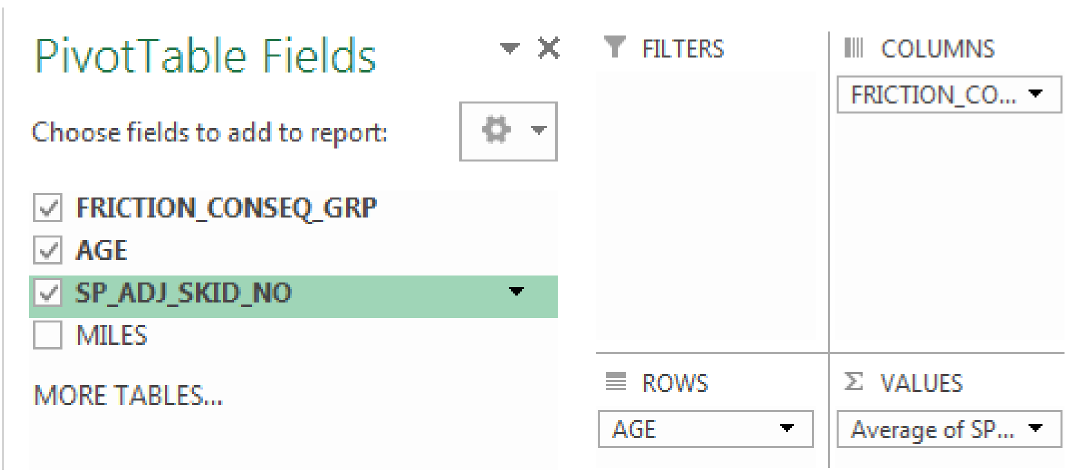
Step 4. Create a pivot table from the pasted data by selecting "Insert" and then "Pivot Table" from the MS Excel ribbon. Select the table range of the data that was pasted in Step 3. Select "Existing Worksheet" and click "OK."

Step 5. Organize the fields in the pivot table as shown in the below images.

Average of SP_ADJ_SKID_NO — Column Labels

Row Labels	10A	10C	10D	1A	1B	1C	1D	2A	2B	2C	2D	3A	3C	3D
1	48.1	51.8	52.9	46.8	51.6	47.4	48.8	47.6	57.4	43.8	44.2	44.7	45.3	41.8
2	47.2	50.9	48.8	43.5	51.7	47.9	48.8	47	56.8	41.9	44.2	47	42	41.1
3	50.6	50.6	50.9	41.2	51.4	45.5	45.4	47.4	50.5	43.1	43	46.9	45.1	40.3
4	48.9	50.9	48.9	44.8	50.8	46.1	44	47.5	53.5	45	43.4	45.5	44	40.9
5	50.1	45.2	50.4	44	48.8	47.3	44.7	50.6	52.5	43.7	42.2	43.2	45.7	42.3
6	48.1	45	50.1	44.5	46.7	47.7	43.8	48.5	53.3	42.6	43.5	43.2	45	40.5
7	49.4	47.5	50.3	46.2	49.1	48.4	44.4	46	55.3	40.6	43.2	43.1	44.8	42.2
8	46.6	46.1	49.3	45.3	50.6	46.7	45.1	48.2	52.6	40.9	43.2	49.7	44.8	42.9
9	47.3	46.6	47.2	43	45.8	45.3	46.1	49.6	50.2	41.8	42.3	39.6	47.3	41.5
10	45.3	43.4	47.7	44.8	49.2	45.7	46.5	41.9	50.2	41	43.4	44	45	40
11	46.9	44.6	46.9	47.4	48.9	46.7	48.2	42.6	52.2	41.3	42.1	37.9	46.6	41.5
12	48.7	47.3	43.8	48.1	47	46.5	48.3	42.9	50.7	41.6	42.2	42.4	42.7	39.1
13	45.4	48.9	44.6	41.7	42.8	44.3	47.8	42.1	53	41.4	42.1		42.2	39.4
14	47.2	47.2	43.6	42.8	41.3	47.4	47.9	41.5	49.5	40.5	40.6		44.3	37.8
15	45.9	48.3	46.8	44	44.8	46	48.9	37.5	53.3	40.6	42.7		41.6	39.6
16	46.2	50	46.1	36.3	44.7	46.2	48.7	34.3	52	40.3	41.6		40.5	37.4
17	42.5	56	46.5	36.8	49.2	47.1	47.8	36	49.9	38.8	42.4	34.7	40.3	38.5
18	44.5	52	47.1	33.8	44.7	47.9	44.9	35.3	50.7	39.6	41.1	35.8	39.9	37.8
19	38.7	53.5	49	33	50.8	49.2	46.5	34.1	51.3	40.2	41.9		39.6	38.2
20	39.4	54.8	44.3	30.1	39.5	49.8	50.8	35		42.8	41.9	36.4	42.5	36.9
21	42	58.6	45.4	28	41.9	48.7	38.4	33.7	51.9	42.4	41.8		44.4	35.3
22	40.4		47.4	28.2	44.4	45.7	33.9	31.2	55.9	42.8	41.7		50.8	36.3
23	40.4		44.6		42.3	47.7	36.6	40.5	52.7	42.4	42.5		44.2	37.4
24	40.6		45.6		38.2	45.4	31.8	40.3	63	43.5	37.7		40.4	35.8
25	27.9		48.9		38.1	44.4	27	38.5		38.6	39		36.2	40.3
26	31.7				36.3	48.5	33.8	34.4		39.7	36.4			38.9
27	35.8		45.1		40.5	45.1	41.6	36.9		30.3	41.9		34.3	39.9
28	32.5				43.3	44.9	43.3	36		34.9	40.3		34.2	39.8
29	27				42.9	42.7	41.8			32.7	35		34.7	45.9
30	35.1				47.7	48.2	41.4			26	33.9		33.9	44.1
31						42.5	42.4			22	34.4		33.4	44.8
32							49.1			26.5	34			28
33							48.3			30.6	35.3		33.8	33.3
34										27.6	36.3		28.8	27.7
35							43.4			33.9	33.7		27.7	24.7
36							46.5				36.7			22.3
37											38.1		33.9	24.2
38											37.9			30.2

Row Labels	4A	4B	4C	4D	5A	5B	5C	5D	6A	6B	6C	6D	7A	7B	7C	7D	8A	8B	8C	8D	9A	9B	9C	9D
1	42.8	46.6	42.5	39.3	46.8	49.7	45.7	44.9	42.1	50.4	45.3	41.1	48.5	53.4	51.2	50.3	47.6	48.5	49.3	46.8	44.5	48.2	48	44.4
2	45	48.3	42.5	38.2	46.9	48.6	45.6	44.7	43.1	51.9	42.9	39.2	48.1	54.3	50.3	49.2	45.7	51.7	47.9	45.4	44.2	47.5	47.6	44.6
3	44.5	43.8	42.8	38.2	46.7	50.9	46.2	44.5	44	52.5	42.4	39	45.9	53.6	50	48.5	45.9	49.2	50	45.2	44.4	47.6	49.2	44.5
4	46	43.8	41.5	38.2	46.2	49.6	46	44.7	43.6	50.9	41	38.2	44.2	52.4	50	48.7	45.5	51.3	48.1	46.7	44.3	48.6	49.2	44.7
5	44.1	44	41.5	37.2	46.3	49.1	44.9	44.7	42.4	49.8	42.2	37.4	47.7	53.2	48.8	48.4	46.2	50.2	48	45.1	42.7	46.7	48.6	45.2
6	43.3	42.6	41.7	37.4	46.9	48.7	45.8	44.4	43.2	45.5	42	37.9	46	51.6	48.8	48.5	45.4	45.4	48.4	46.1	43.8	44.8	46.5	46.3
7	43.9	41.7	41.3	37.6	46	50.3	44.9	44	45.4	58.1	39.8	37.6	45.5	51	50	48.8	46.9	51.8	47.7	44.8	42.5	48	47.7	46.2
8	38.2	41.5	41.1	37.6	43.7	50.4	44.5	43.4	45.7	53.9	40.2	37.9	46.7	52.3	50.5	49.4	45.6	51.1	48.4	47.6	45.1	49.7	47.8	46.2
9	45	44.4	39.7	37.2	42.4	48.9	43.3	42.3	45.3	48.1	39	36.7	48	53.2	49.9	48.3	46.6	48.2	48.6	46.1	45.6	46.3	47.9	45
10	41.5	42.1	40.3	35.2	40.8	50.2	45.7	42.7	42.7	45.6	38.9	38.8	48.2	50.2	50	48.4	50	51.1	46.2	47.6	45.6	47.2	47.3	45.1
11	36.7	41.7	40.6	36.4	42.1	50.5	45.1	41.9	40.2	51.4	39.7	38.9	49	51.5	48.6	48.1	50.3	46.8	47.3	45.9	44.4	44.9	45	43.4
12	39.6	41.4	39.3	36.3	38.7	49.5	44.5	40.6	38.6		40	37.4	50.8	51.4	49.2	47.7	49.7	45	47.5	46.6	44.6	46.5	43.9	43.2
13	41.8	41.4	40.6	34.9	39.3	50.1	42.5	40.2	43.4	42.4	38.4	38.1	50.8	51.8	48.8	47.8	49.5	52	47.7	46.7	45	47.7	43.7	43.2
14	42.2	43.1	39.1	36.3	40.6	47.7	41.9	41.2	40.9	44.6	40.1	37.5	50.8	51.2	49.4	48.6		46.1	48.1	45.7	44.1	46.5	42.9	42.5
15	40.2	46.6	40	36.7	40.6	47.4	41.9	41.5	43.7	34.5	40	37.2	53.5	53.7	49	48.3	50.2	54.6	48.8	47.3	45.6	49.4	43.1	41.8
16	39.3	47.9	39.1	33.9	35.7	50.5	43	40.1	40.2	40.2	37.9	36.4	44.4	50	49.1	46.2		53	50	51.2	45.5	47.4	42.3	43.7
17	39.5	44.8	36.1	33.7	39.9	48.2	42.6	40	37.8	48.9	37.9	36.9	52.6	50	50	49	39.3	59.2	49.9	48	45.6	48.5	44.5	42.6
18	30.3	48.9	32.9	33.5	38	47.8	39.1	41.7	41.5		40.1	36	51.4	54.1	49.1	47.9	40.6	52.9	49.8	45.8	45.6	46.7	43.9	42.3
19	34.9	46.2	32.9	34.6	36.7	49.8	42.3	42.8	36.6		40.4	37.4	48.7	52.8	47.1	50.1	43.2	56.9	51.2	43.7	46.3		46.2	42.5
20	34	47.6	37.7	34.5	37.6	50.2	39	41.8	36.4		35.9	38.2	46.9	53.8	44.6	47.6	47.6		50.8	46.1	45.5	46.4	47.5	43.2
21	42.9	46.4	34.7	36.8	34.1	46.6	42.9	41.4	36.7		41.9	36	50.9		43.9	46.9	46		51.4	47.4	44.1	41.9	47.6	42.8
22	37.1	40.6		35	39.3	63.6	40.7	42.4	36.8		42.5	34.5	48.4		41.2	43.8			52.4	40.5			47.5	45
23	27.4	43.5	38	30.4	41.7		42.7	41.2				35.6	45.7		39.6	44.5			50.4	29.9	39.9		46.2	44.2
24	25.5	42.2	34.9	35.4	43.8		46.7	45.2				35.7	46.7		41.2	40.3			55.6		35		47.7	41.5
25	28.5	47.7		32.2			41.4	44.9			46.7	36.9	44.4		44.7	42.9			55.2		44.8		38.2	41.9
26	29.6			26.9		49.7	44.4	39.2			42.7	35.9			44.6	41.6							38.3	42.5
27	25.8			27.1		46.9	43.4	42.2				36.6			47.9	43.3							48.8	43.4
28	31.8			30			41.8	40.4				30.4			43.8								50.9	42.9
29	34.3			45.1			37.3	38.5				29.1											40	42.4
30							41.1	43.2				33.4											36.3	40.2
31	44.3						40.6	38.6							54.1						38.3			44.9
32	36.5						39.7	44.3													36			39.3
33	32.4			30.4			39.5														45			40.6
34							21.7												56.9		41.2			39.4
35																					42.3			44.6
36																					44.6		55.4	
37								42.1													43.3			53.3
38								41													41.7			



slope	-0.655	-0.5036	-0.3022		-0.6635	-0.489	-0.2492	-0.2564	-0.4548	-0.3622	
AGE	1A	1B	1C	1D	2A	2B	2C	2D	3A	3C	3
0	47	52	48	49	48	58	44	45	45	46	
1	46.8	51.6	47.4	48.8	47.6	57.4	43.8	44.2	44.7	45.3	
2	43.5	51.7	47.9	48.8	47	56.8	41.9	44.2		42	
3	41.2	51.4	45.5	45.4	47.4	50.5	43.1	43		45.1	
4	44.8	50.8	46.1	44		53.5		43.4		44	
5	44	48.8	47.3	44.7		52.5		42.2	43.2	45.7	
6	44.5	46.7	47.7	43.8		53.3	42.6	43.5	43.2	45	
7	46.2	49.1	48.4	44.4	46	55.3	40.6	43.2	43.1	44.8	
8	45.3	50.6	46.7	45.1		52.6	40.9	43.2		44.8	
9	43	45.8	45.3	46.1		50.2	41.8	42.3	39.6		
10	44.8		45.7	46.5	41.9	50.2	41	43.4	44		
11		48.9	46.7	48.2	42.6	52.2	41.3	42.1	37.9		
12		47	46.5	48.3	42.9	50.7	41.6	42.2	42.4	42.7	
13	41.7	42.8	44.3	47.8	42.1	53	41.4	42.1		42.2	
14	42.8	41.3	47.4	47.9	41.5	49.5	40.5	40.6		44.3	
15	44	44.8	46	48.9	37.5	53.3	40.6	42.7		41.6	
16	36.3	44.7	46.2	48.7	34.3	52	40.3	41.6		40.5	
17	36.8			47.8	36	49.9	38.8	42.4	34.7	40.3	
18	33.8	44.7		44.9	35.3	50.7	39.6	41.1	35.8	39.9	
19	33			46.5	34.1	51.3	40.2			39.6	
20	30.1	39.5		50.8	35		42.8		36.4		
21	28	41.9		38.4	33.7	51.9	42.4				
22	28.2	44.4	45.7	33.9	31.2	55.9	42.8				

Step 6. Once the pivot table is organized, copy and paste the data into a new worksheet.

Step 7. Perform a visual review of the data and remove any data points believed to be outliers, as illustrated by the yellow highlights in the above image. Previous experience is required to perform this review.

Step 8. For each pavement family, plot friction versus time data and calculate the slope of the regression line using the graph application in MS Excel. Review plot for reasonableness and make adjustments to the groupings if necessary. See Friction Performance Model for the most recent plots by pavement family.

Step 9. As needed, write/update the friction model parameter for each pavement family in C#. See Friction Performance Model for the most recent model functions. The updated parameter for each pavement family will be used later in the program optimization process (see Defining Network and Importing Data in the RoadCare Optimization Process).

10 OPTIMIZATION

Click to go to Network Definition and Data Import
Click to go to Network Segmentation and Data Rollup
Click to go to Needs Analysis and Running Simulation Engine
Click to go to Generating Reports

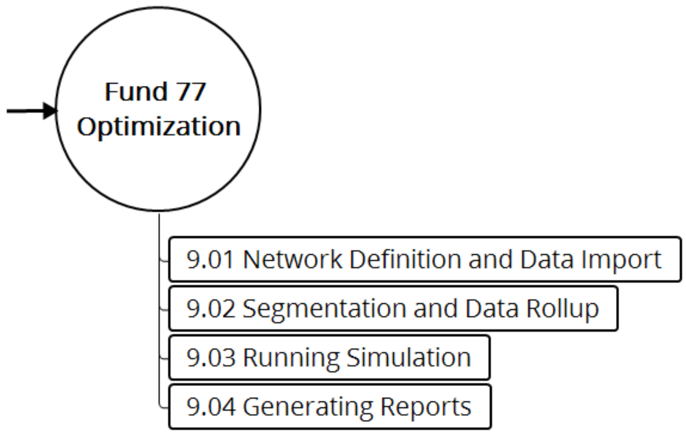


Figure 13: Optimization Flowchart

This section describes the set of standard operating procedures (SOP) conducted mainly by staff from the Data Analysis Team (DAT) of the Maryland Department of Transportation State Highway Administration's (MDOT-SHA) Office of Materials Technology (OMT) to perform the "Conditional RSL/Cost Optimization" in the asset management software, RoadCare, version 3.67. This section is divided into four SOPs: defining the network and importing new data, updating the network segmentation and performing the data rollup, performing a needs analysis and running the simulation engine, and generating reports. These SOPs may require multiple iterations to complete the optimization process.

10.01 DEFINING NETWORK AND IMPORTING DATA INTO THE ROADCARE OPTIMIZATION PROCESS

10.01.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Analysis Team (DAT) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to define the network of assets and to import the raw data associated with this network for input into the optimization process contained in the asset management software, RoadCare, version 3.67. The SOP described in this document may not be applicable to other versions of RoadCare.

10.01.02 *Frequency*

The network definition and data import for the RoadCare optimization process is performed once per year, after the end of the data collection season and once all data have been processed and migrated into the appropriate tables. Additionally, selected attribute data are deleted and re-imported whenever changes to the source tables occur, which typically happens several times per year.

10.01.03 *Purpose*

The purpose of this SOP is to prepare the input data required by the RoadCare optimization process by first defining the network of assets and then importing the required network data contained in Oracle tables.

10.01.04 *Resource Requirements*

The network definition and data import process involves one person: a DAT staff member knowledgeable of Oracle and the RoadCare software. The estimated effort level in the table below represents the total time, in man-hours, to complete the network definition and data import process. The time estimate assumes no issues are encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DAT Staff	Analyst	1	20.0

10.01.05 *Procedure*

The procedure required to perform the network definition and data import process is comprised of the following two components:

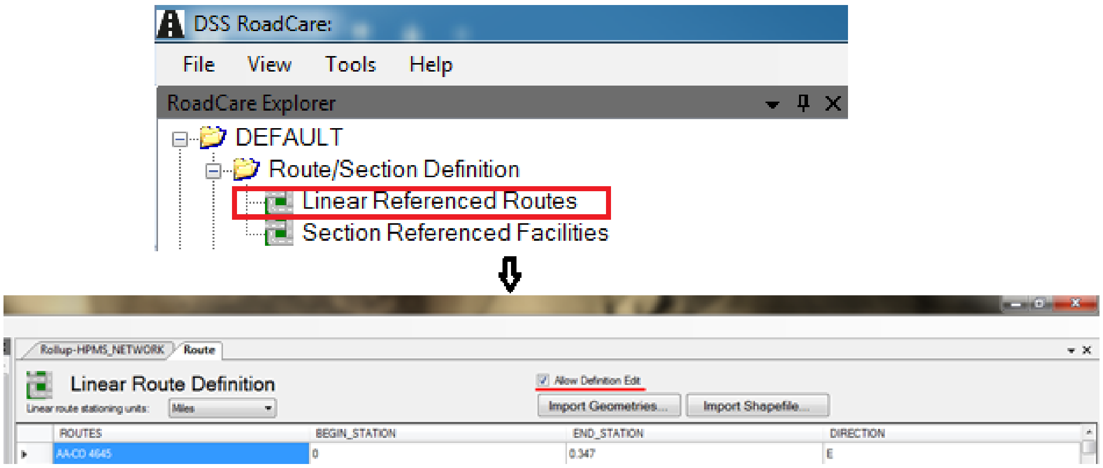
(1) define network, and
(2) import data.

1- Define Network – *performed by DAT staff*

Summary: Under this task, the RoadCare asset management software's "Route/Section Definition" module and a script run in Oracle SQL Developer are used to define the network of assets from the inventory data contained in the Oracle tables.

Step 1. Open RoadCare software.

Step 2. In RoadCare's "Explorer" panel, expand the "Route/Section Definition" folder and then double-click on "Linear Referenced Routes" to display the contents of the network. Each linear asset is defined by grid columns including name (ROUTES), stations (BEGIN_STATION and END_Station), and direction. Before entering data, select the "Allow Definition Edit" option located at the top of the window as shown in the below image.



Step 3. In Oracle SQL Developer, run the first SQL statement labeled "CREATE_INVENTORY" in the "RoadCare Data Import Queries latest.sql" file[06/12/2019] to update the materialized view called "RC_SECTION_MVIEW." Update the "HMIS_YEAR" field in the SQL statement to retrieve the latest inventory data.

Step 4. After the materialized view is updated in the SQL Developer, select "pavconhist_assetdev" in the drop-down box next to "Update using:" to replace existing inventory data in RoadCare with the most recent inventory data from the materialized view.

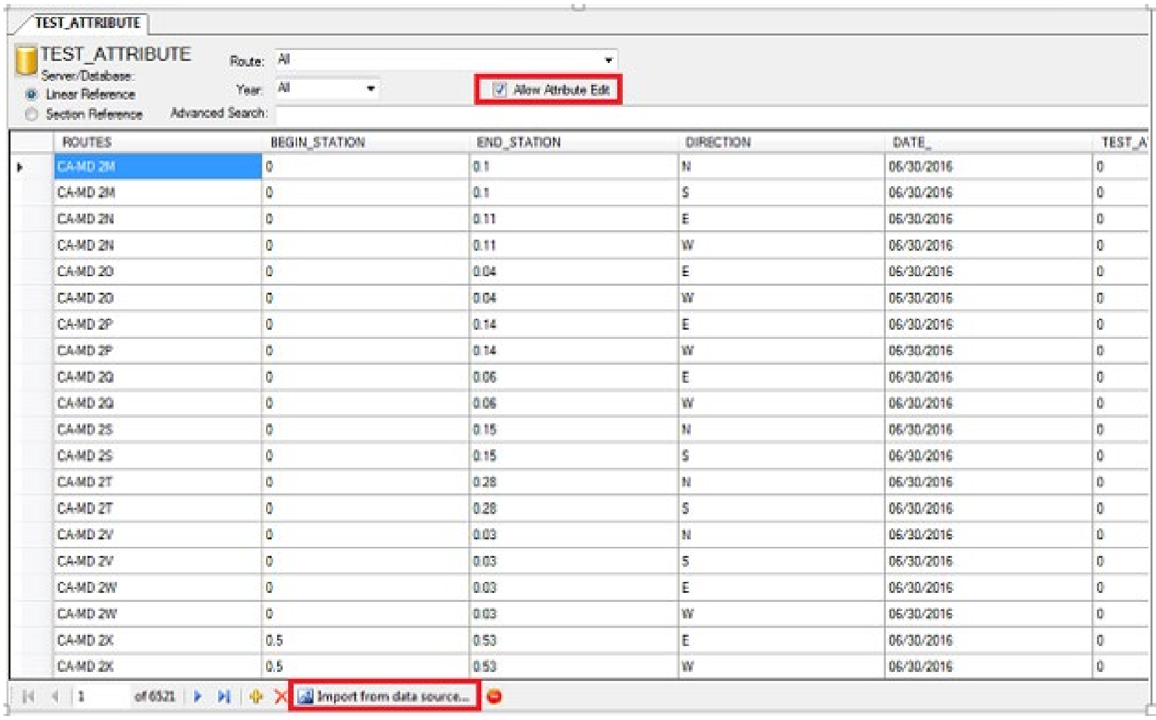
Step 5. Document changes to the inventory using the Access database and spreadsheet template[06/12/2019].

2- **Perform Data Import** – *performed by DAT Staff*

Summary: Under this task, raw data from various Oracle tables are validated for input into the RoadCare asset management software. These data represent the attributes that define the pavement network, which was updated in the previous task.

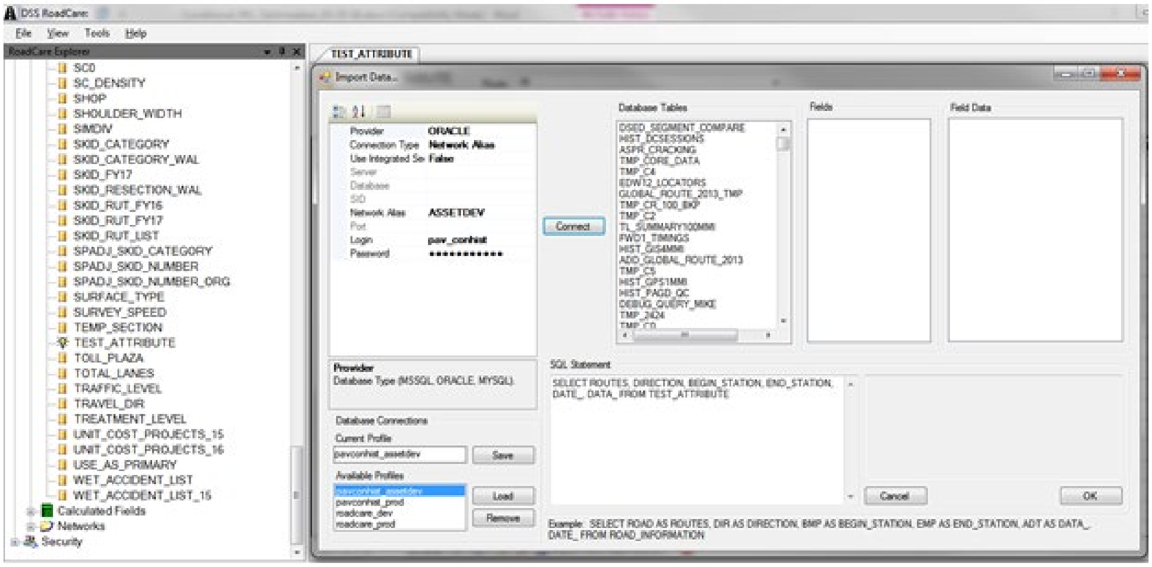
Step 6. Open RoadCare software.

Step 7. Double-click on an attribute name from the “Attributes (Raw)” list to show its contents in the display window. Check the box next (to the left) to “Allow Attribute Edit” at the top of the raw attribute data window, as shown in the below image.



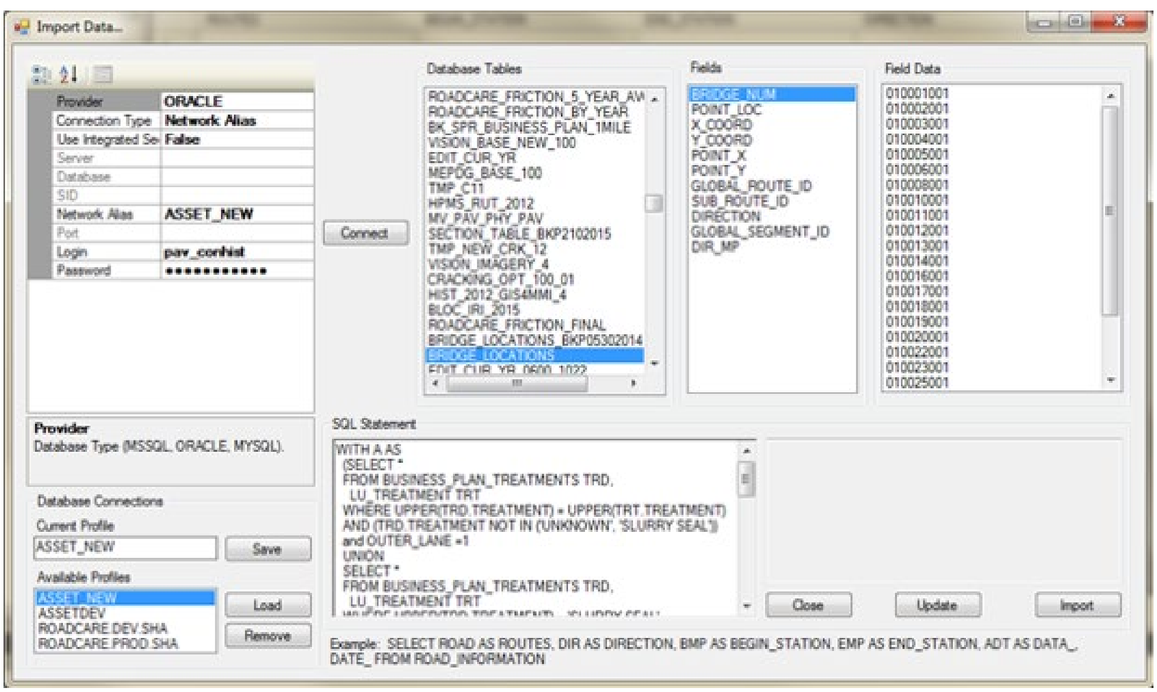
Step 8. Click the “Import from Data Source…” button, which is shown at the bottom of the raw attribute data window in the above image, to open the “Data Import” Window.

Step 9. Enter the database connection parameters in the left hand top portion of the “Data Import” window. The top left section of the window allows the user to select the provider name, server path, database name, to specify if the use of integrated security is active, and to enter login and password information. When placing the cursor on any of the referenced fields, a description of the item is provided at the bottom of the top-left pane, as shown in the below image. For example, when selecting “Database,” the area under the information input section reads “Name of the database in which the attribute data resides.” These descriptions are intended to aid the user in determining the appropriate input for each field.



Step 10. After introducing the required data into the "Data Import" window, click "Connect" to establish communication with the selected server and access the desired database, as shown in the above image.

Step 11. When a connection is established, the "Database Tables" section will be populated with the attributes found in selected database. Any value within the "Database Tables" section can be clicked to display the available fields under the "Fields" section. Likewise, clicking any field value displays the data available for that field in the "Field Data" section, as shown in the below image.

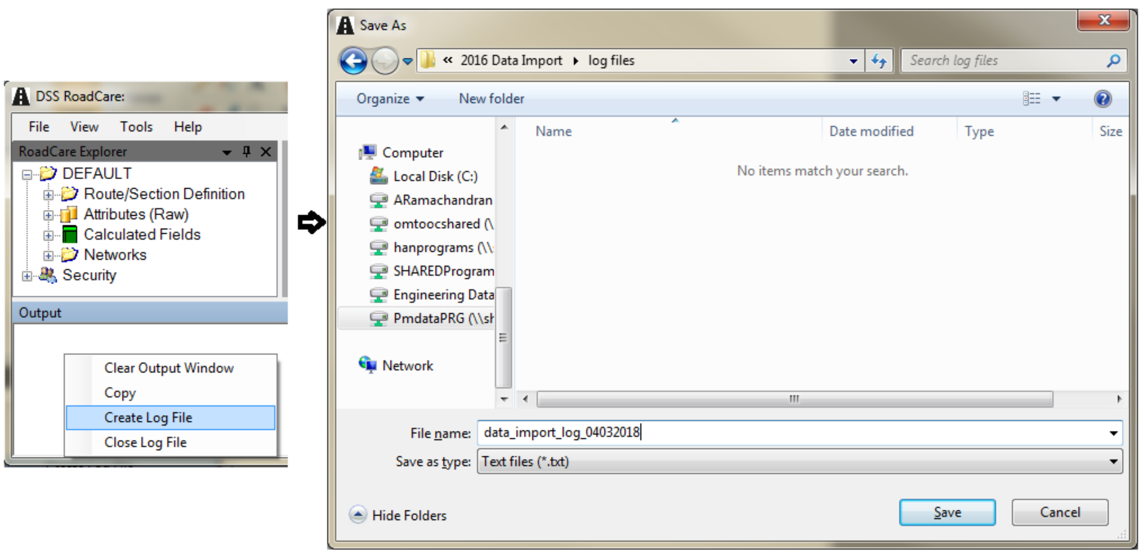


Step 12. After database connection has been established, navigate to the data import SQL statement titled "RoadCare Data Import Queries latest"[06/12/2019]. If a

connection cannot be established, discuss the matter with the database administrator before continuing.

Step 13. The attribute names in the .sql file will match the attribute names in RoadCare. For example, to find the SQL statement for Average IRI, open the .sql file in notepad, press Ctrl+F and search for “begin AVG_IRI.” Paste the appropriate SQL statement in the SQL statement text box and click the “Import” button to process the query. The resulting data entries are displayed in the attribute display window, while rejected data entries are displayed in the output window. Clicking the “Update” button will store the SQL statement and connection parameters in the RoadCare database for future data imports. This is the preferred method of import. For small datasets, the user can copy and paste the results from the SQL statement into the RoadCare attribute window data grid. It is important to note that the data import sql statement(s) must be updated to capture any changes to the source tables. For example, if the IRI data in business_plan_100mmi table is updated for the past five years, then the criteria filter for the “REPORTING_YEAR” field must be updated to include those five years of data. If one or more source tables are dropped or modified extensively, then the relevant data import SQL statements must be updated as well.

Step 14. After the data import is completed, right click anywhere in the output window and select “Create Log File” to save a copy of the data import log as shown in the below image.



10.02 NETWORK SEGMENTATION AND DATA ROLLUP

10.02.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Analysis Team (DAT) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to prepare collected data for the “Conditional RSL/Cost Optimization” process in the asset management software, RoadCare, version 3.67. The data preparation requires the creation and segmentation of a new network and the rollup of newly imported data. The SOP described in this document may not be applicable to other versions of RoadCare.

10.02.02 *Frequency*

Network segmentation, segmentation criteria definition and data rollup are performed by the MDOT-SHA once per year, after the end of the data collection season, once the data have been processed and migrated into the appropriate Business Plan Tables (see Migrating to Business Plan Tables). The procedure may need to be repeated multiple times during the iterative “Condition RSL/Cost Optimization” process.

10.02.03 *Purpose*

The purpose of this SOP is to prepare MDOT-SHA collected data for the “Conditional RSL/Cost Optimization” process in RoadCare version 3.67 software by creating a new network, defining the network segmentation criteria, and performing a data rollup.

10.02.04 *Resource Requirements*

Network segmentation, segmentation criteria definition, and data rollup requires one MDOT-SHA staff member: a DAT staff member knowledgeable in Oracle and RoadCare software. The estimated effort levels shown in the table below represents the total time, in man-hours, to complete the network definition, segmentation criteria definition and data rollup. These time estimates assume no issues are encountered during the process.

Position	Function	Resources	Effort Level (man-hrs)
DAT Staff	Analyst	1	AN 06/12/2019

10.02.05 *Procedure*

The procedure to perform the network segmentation, segmentation criteria definition and data rollup is comprised of the following four tasks:

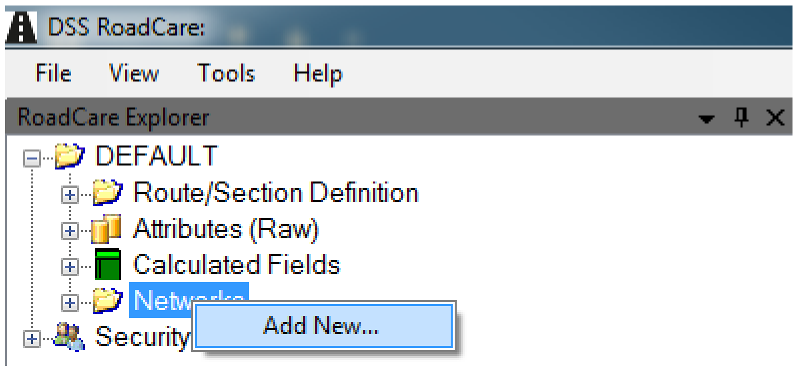
(1) create new network and define segmentation logic,
(2) review and update segmentation results,
(3) rollup data in network, and
(4) define network specific area.

1- Create New Network and Define Segmentation Logic – *performed by DAT Staff*

Summary: Under this task, the new network is created and the logic for segmentation of the network is determined using the "Segmentation Logic" module in version 3.67 of RoadCare.

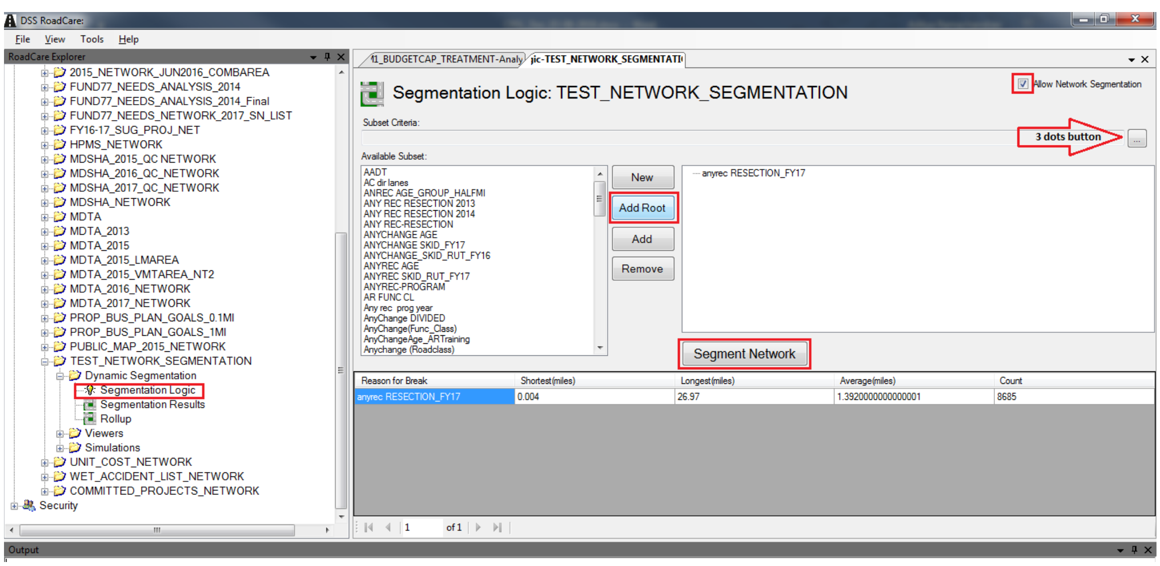
Step 1. Open RoadCare software.

Step 2. Right-click on the "Networks" module and select "Add New…" as shown in the figure below.



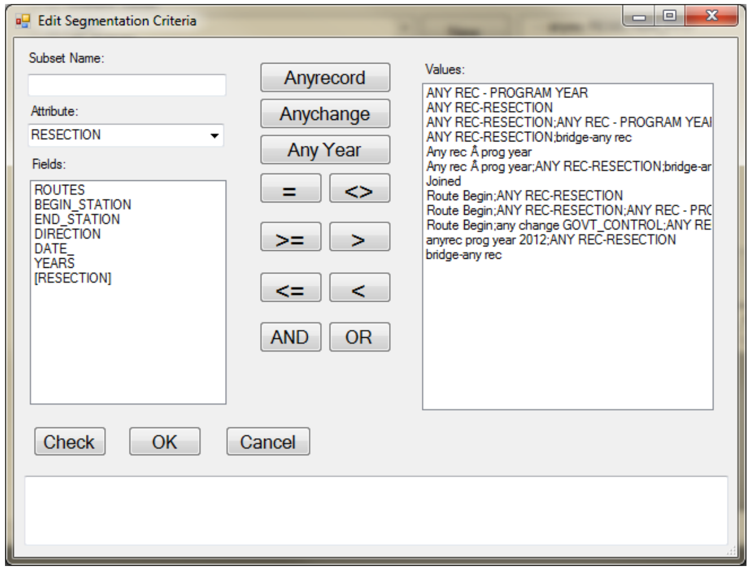
Step 3. Expand the options inside the "Networks" module by clicking on the "+" icon. Then, expand the options inside the "Dynamic Segmentation" menu that appears by clicking on the "+" icon

Step 4. Double-click the on "Segmentation Logic" listed under the "Dynamic Segmentation" menu to display the user-interface screen as shown in the below image.



Step 5. Check the box in the top-right corner next to "Allow Network Segmentation" as shown in the above image.

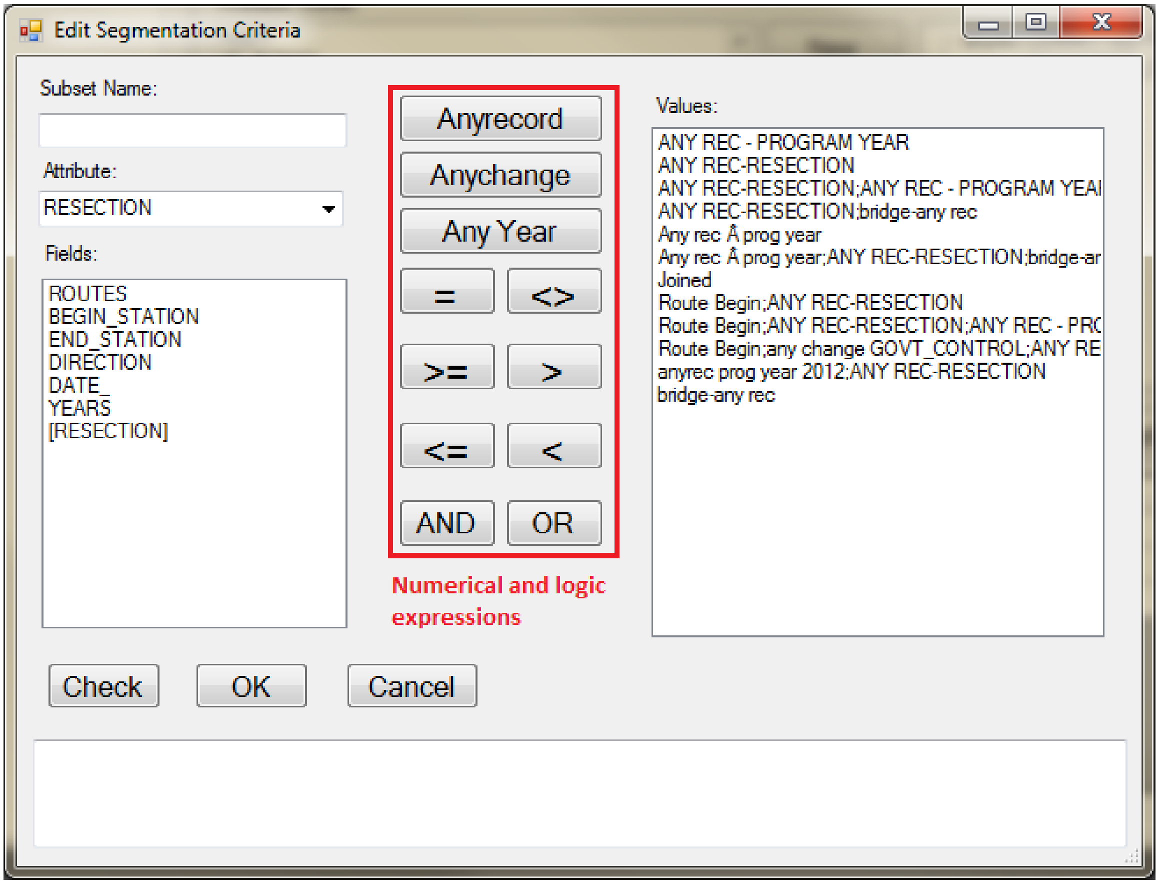
Step 6. To define the segment subset criteria, the user can type the numerical or logic expression in the "Subset Criteria" field or click the 3-dots button in the top-right corner as shown in the above image. The "Edit Segmentation Criteria" window will appear as shown in the below image.



Step 7. Add a name to the segmentation criteria by typing it under the "Subset Name" field as shown in the above image. As a rule of thumb, the name should be related or self-explain the criteria being used.

Step 8. Next, select the desired attribute from the pull-down menu under the title "Attribute" as shown in the above image. All raw attributes belonging to the current network are available for selection. Once an attribute is selected, the "Values" pane is populated with the corresponding values for the attribute based on the network's data. In addition, the "Fields" pane located under the "Attribute" list is populated with the information posted under each attribute table. For example, if the raw attribute IRI table contains data fields that include ROUTES, BEGIN_STATION, END_STATION, DIRECTION, DATE, and YEARS, they will all appear listed under Fields. The last entry in the "Fields" window is always the selected attribute, which appears within square brackets.

Step 9. Double-click on the desired field, then single-click on the numerical or logic expression, and finally double-click on value from the available list under the "Values" pane. As the field, expression, and values are selected, the bottom section of the pane is populated with expression for the segmentation criteria. Changes can be made directly by typing or erasing the expression. Once the criteria is input, the user can click on "Check" to verify how many sections the expression will yield, "OK" to accept the segmentation logic expression, or "Cancel" to return to the previous screen. If there is an error in the syntax of the segmentation expression, a message is displayed in the output window. The numerical and logic expressions available to construct the segmentation criteria are shown in the below image.



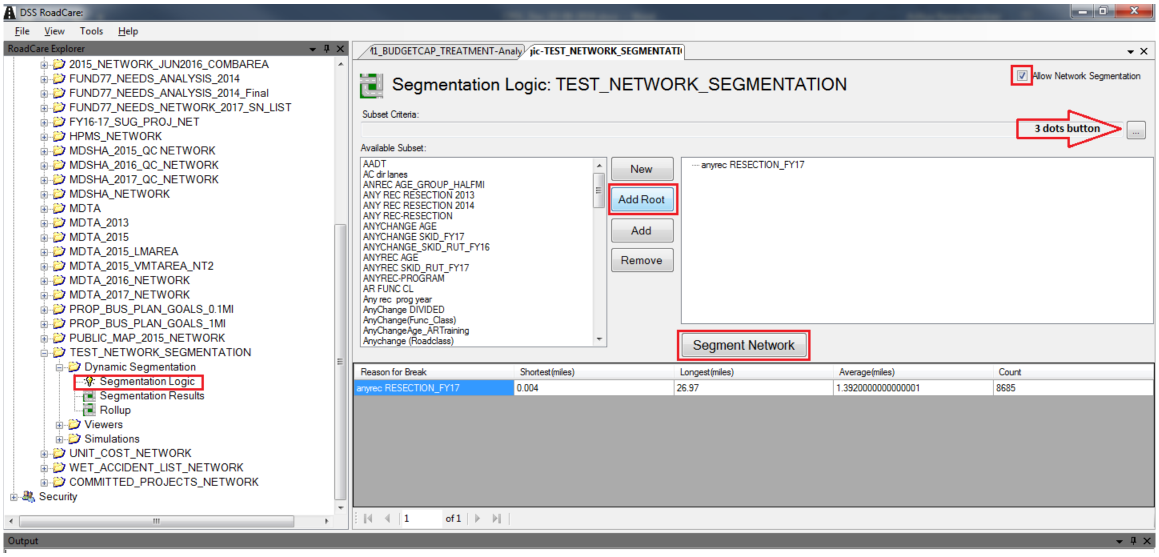
i. If the expression is correct when "Check" is selected, then click on "OK" to return to the previous screen.

ii. If the expression is not correct or returns a syntax error, revise the expression before clicking "OK".

Step 10. The "Segmentation Logic" screen will display the new segmentation expression under the "Subset Criteria" field, and the name of the newly created subset name is displayed under "Available Subset."

i. If more subsets need to be added, click on the "New" button located to the right of the "Available Subset" pane as shown in the image below. Repeat Step 7 through Step 9 for each subset that needs to be created. Many segmentation expressions can be input, and every time one is added, it is listed under the "Available Subset" pane.

ii. If all subsets have been created, proceed to Step 11.



Step 11. Create the network root for the network segmentation tree. The network segmentation tree is a hierarchical construction that allows for further refinement of the segments. There must be at least one root level entry in the network tree to run the segmentation. After creating the root, the user can add additional levels. To create the network root, select the desired root subset from the "Available Subset" list and click on "Add Root" (make sure the "Allow Network Segmentation" option is checked at the top right corner of the screen as shown in the above image). This will list the selected subset under the right pane of the window. Additional root-level subsets can be added following the same process.

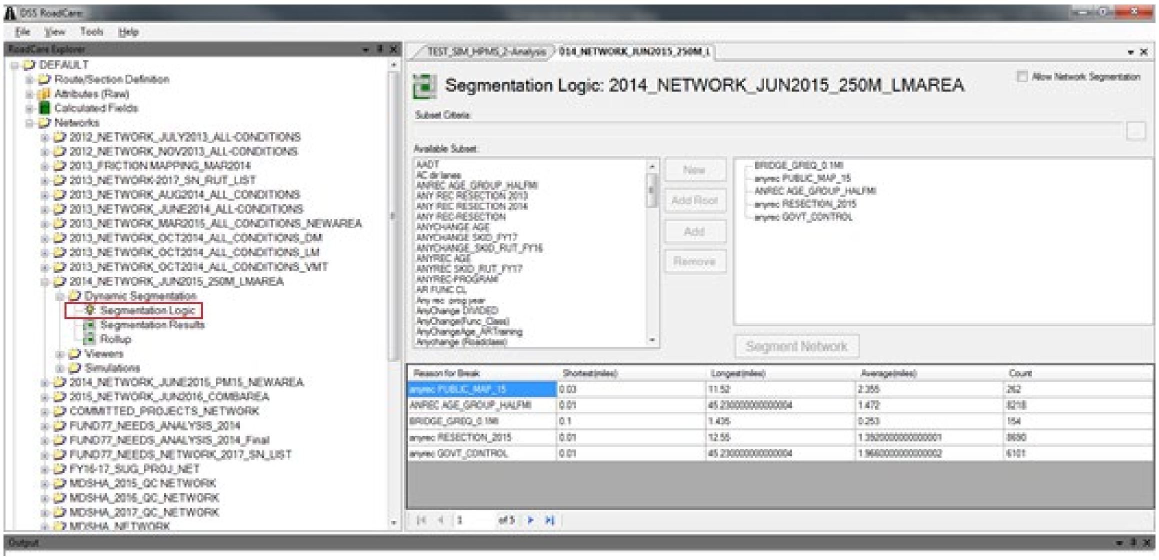
Step 12. To add additional segmentation tree levels, select a different subset from the "Available Subset" list, select the root subset from the right pane, and click on "Add". This will automatically add the selected subset as a stem or "child node" to the root subset and a "+" icon will appear next to the root subset name. To expand the network tree, click on the "+" icon.

i. If a child node is added by error or to a level in the network that it does not correspond to, it can be deleted by selecting the subset name on the right pane of the window and press the "Remove" button.

ii. To delete a subset from the "Available Subset" list, click on the subset name and press the "Delete" button. Note that the segmentation criteria "Anychange" and "Anyrecord" buttons cannot be included as child nodes; when this is attempted, the following error message is displayed on the output window: "Error: Cannot have ANYCHANGE, ANYRECORD in a child node."

Note: Also, note that the network segmentation should be as general as possible since further analysis will be based on the segmented network. To split the network and consider parts of it with certain characteristics, a subnetwork should be created first.

Step 13. After the network segmentation tree has been defined, it is time to segment the roadway network. To accomplish his, click on the "Segment Network" button. The entire definition of the roadway is determined using the contents of the network tree. If for any reason the segmentation cannot be done as specified, the output window will display an error message. If the segmentation is successful, the output window will display the time the segmentation was started and the time when the segmentation was completed. In addition, a summary of the segmentation criteria will be displayed detailing the reason for break (subset name), the Shortest segment distance, the longest segment distance, the average segment length, and the number of segments (i.e., Count). If several root subsets are used, a summary for each one of them is displayed (see below image).



2- Review and Edit Segmentation Results – *performed by DAT Staff*

Summary: Under this task, the segmentation results are reviewed and manually updated using the “Segmentation Results” module in RoadCare.

Step 14. Double-click on the “Segmentation Results” options located under the “Dynamic Segmentation” menu.

Step 15. The segmentation results will show the following fields: ROUTES, BEGIN_STATION, END_STATION, DIRECTION, and REASON (the reason for segmenting, in case two root subsets are used, for example) as shown in the below image. Using the “Route” pull-down menu, the user can choose to display all routes or choose a specific one. This is especially convenient when a large number of records exist in the network and the user wants to verify the information for particular ones. The segments can be manually modified by the user using one or more of the tools described below.

The segment length can be modified by changing the BEGIN_STATION and END_STATION limits. The user can type new values under each field for all the affected sections, as shown in the below image.

ROUTES	BEGIN_STATIOI	END_STATION	DIRECTION	Reason
1-IS 68	0.00	1.75	E	Route Begin;ANYCHANGE AGE;Anychange (Roadclass);AnyChange(Func_Class);Anychange(pav_type)
1-IS 68	1.75	2.37	E	Anychange (Roadclass);AnyChange(Func_Class)
1-IS 68	2.37	4.76	E	ANYCHANGE AGE
1-IS 68	4.76	7.42	E	ANYCHANGE AGE;Anychange (Roadclass);AnyChange(Func_Class)
1-IS 68	7.42	8.05	E	Anychange (Roadclass);AnyChange(Func_Class)
1-IS 68	8.05	11.43	E	ANYCHANGE AGE;Anychange(pav_type)

ROUTES	BEGIN_STATIOI	END_STATION	DIRECTION	Reason
1-IS 68	0.00	1.55	E	Route Begin;ANYCHANGE AGE;Anychange (Roadclass);AnyChange(Func_Class);Anychange(pav_type)
1-IS 68	1.55	2.35	E	Anychange (Roadclass);AnyChange(Func_Class)
1-IS 68	2.35	4.76	E	ANYCHANGE AGE
1-IS 68	4.76	7.42	E	ANYCHANGE AGE;Anychange (Roadclass);AnyChange(Func_Class)
1-IS 68	7.42	8.05	E	Anychange (Roadclass);AnyChange(Func_Class)
1-IS 68	8.05	11.43	E	ANYCHANGE AGE;Anychange(pav_type)

The segments can be further manipulated by clicking on “Join” or “Split” button located next to the “Route” pull-down menu. Highlight the records needing to be merged from the results grid and click on the “Join” Button, the segments will be combined in a single record and under the column field “Reason”, the legend “Joined” will appear. To split a segment, highlight the records that are to be divided from the results grid, enter the number of sections in the “Number of Split Sections” field, and click the “Split” Button. RoadCare will divide each of the selected segments evenly into the number of selected sections (e.g. if 3 segments are divided into 4 sections the result will be 12 sub-segments). Like the “Join” option, the legend “Split” will appear under the “Reason” column field.

ROUTES	BEGIN_STATION	END_STATION	DIRECTION	Reason
1-IS 68	0	2.37	E	Route Begin;
1-IS 68	2.37	4.76	E	PVMT_AGE
1-IS 68	4.76	8.05	E	PVMT_AGE
1-IS 68	8.05	11.79	E	Joined
1-IS 68	11.79	12.43	E	PVMT_AGE
1-IS 68	12.43	13.665	E	Split
1-IS 68	13.665	14.9	E	Split
1-IS 68	14.9	16.55	E	Split
1-IS 68	16.55	18.2	E	Split
1-IS 68	18.2	20.15	E	Split
1-IS 68	20.15	22.1	E	Split
1-IS 68	22.1	24.6	E	PVMT_AGE
1-IS 68	24.6	28.64	E	PVMT_AGE

The value under the Reason field changes to Joined or Split when combining or dividing segments

Additional options to view and manipulate the resulting segments are found in the bottom line toolbar located below the data grid. The toolbar is shown in the below image.

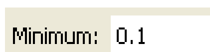
 Takes user to the first record on the list (row 1).

 Moves user to the previous record based on the current selected record. If the first record of the list is the one selected, the option is displayed as a gray icon, meaning that it is not available for selection.

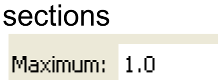
Shows position of the current selected record out of the total number of records. A specific record number can be selected by typing it in the window and pressing enter.

 Moves user to the next record based on the current selected record. If the last record of the list is the one selected, the option is displayed as a gray icon, meaning that it is not available for selection.

 Takes user to the last record on the list (last row).

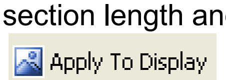


Defines minimum distance value for the sub-segments sections

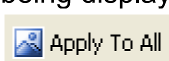


Defines maximum distance value for the sub-segments sections

Defines sub-segments gap intervals based on the section length and the minimum and maximum sub-segment sections values



Limits application of sub-segmentation to only the route being displayed



Sub-segmentation applied to all segmentation result records

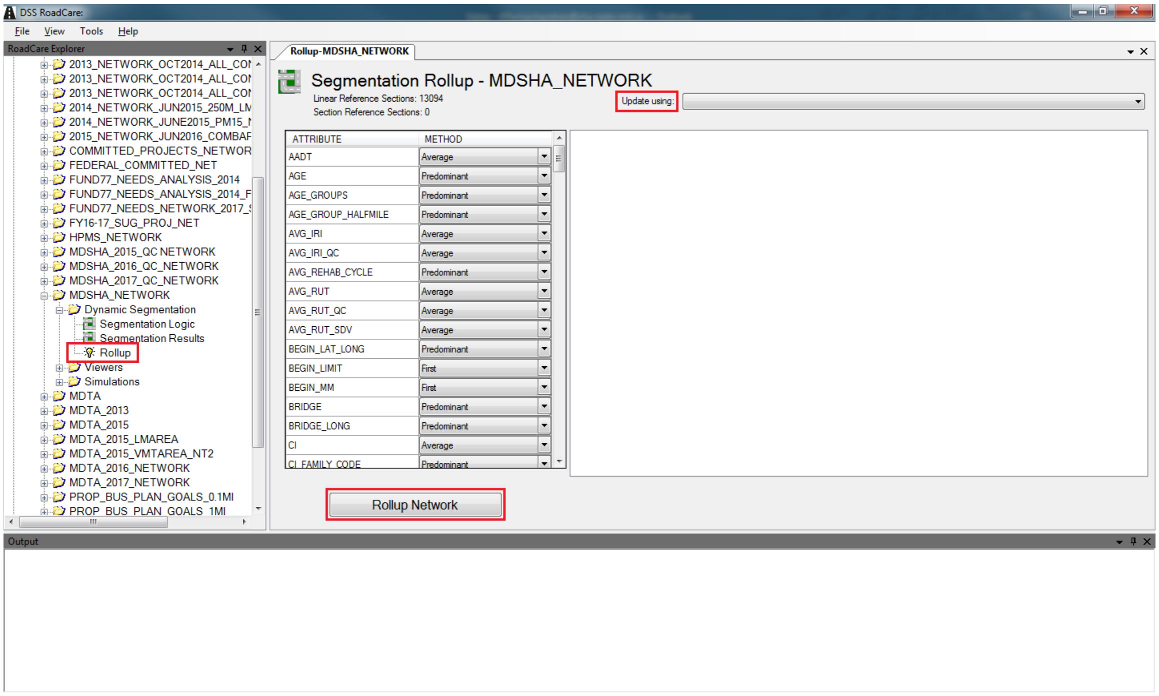
Once the manual segmentation is complete, proceed to the next task.

3- Perform Rollup – *performed by DAT Staff*

Summary: Under this task, the segmented database rollup rules are defined using the "Rollup" module in RoadCare.

Step 16. Rolled-up (or processed) data is the second level of data storage. It is obtained by assigning raw data to the segments created through dynamic segmentation, using appropriate data aggregating methods (average, minimum, maximum, first, last, predominant etc.) to arrive at a representative value for a section. The "Rollup" option allows the user to define the segmented database rollup rules. Two main factors contribute to the rollup rules: "Attribute" and "Method." The attribute information is extracted from the database and cannot be altered.

However, the user can specify the rollup method to aggregate and distribute the data for each attribute. To open the "Rollup" interface, double-click on the "Rollup" option under the "Dynamic Segmentation" menu. The "Segmentation Rollup" window interface will appear as shown in the below image.



Step 17. Every time an attribute is selected from the "Attribute" list, a list of values is displayed on the pane located to the right of the window. Properly select the "Method" for each "Attribute" by utilizing the table found in Optimization Data Rollup Methods.

Step 18. Once the appropriate method has been selected for each attribute, press the "*Rollup Network"* button located under the "Attribute" and "Method" list pane shown in the above image. The output window will show a message stating when the rollup began, the progress of the rollup for each attribute, and when the rollup finished. The user can copy the attribute rollup methods from another network and apply it to the current network by clicking the pull-down menu next to "Update using" and selecting the appropriate network name. See Optimization Data Rollup Methods for further details regarding specific implementation of network segmentation.

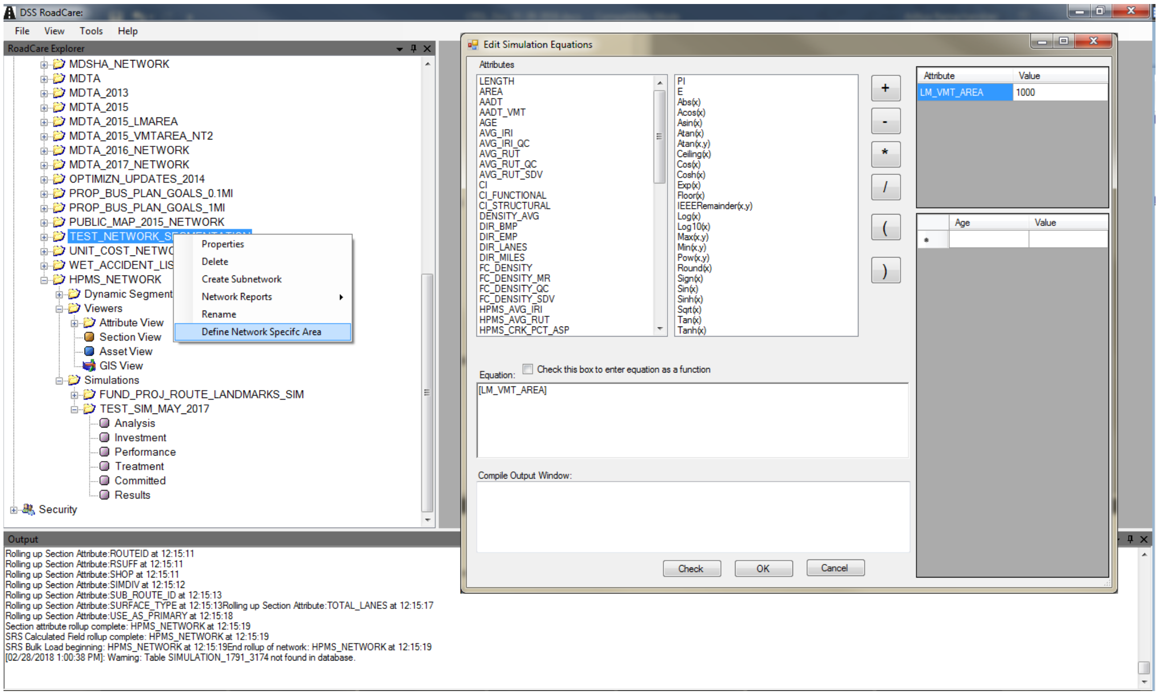
4- Define Network Specific Area – *performed by DAT Staff*

Summary: Under this task, the network specific area is defined in RoadCare. MDOT-SHA uses an average of Vehicle Miles Travelled (VMT) and Lane Miles (LM) to calculate the network-specific section area for treatment selection, benefit and remaining life calculations

Step 19. Open the MS Excel spreadsheet with calculations for network specific area[06/12/2019].

Step 20. Copy and paste these data into the attribute "LM_VMT_AREA."

Step 21. Right-click on the desired network and select "Define Network Specific Area." This opens a pop-up window where user can specify the attribute name that contains the area calculations in the equation box as shown in the below image.



Step 22. Click on "OK" button to save changes.

10.03 NEEDS ANALYSIS AND RUNNING SIMULATION ENGINE

10.03.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Analysis Team (DAT) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to prepare collected data for the "Conditional RSL/Cost Optimization" process in the RoadCare version 3.67 asset management software. This is accomplished by performing a needs analysis and running the RoadCare Simulation Engine. This SOP is performed after the data rollup is completed as described in Network Segmentation and Data Rollup. The RoadCare Simulation Engine requires the following five major inputs:

1. Analysis: inputs used to manage project selection methodology (optimization & prioritization) and spending rules (i.e., spend within defined budgets or determine required budgets to meet goals);
2. Investment: inputs used to manage budget types and annual amounts as well as inflation and discount rates;
3. Performance: inputs used to define equations for predicting future attribute values based on current values;
4. Treatment: inputs used to manage Maintenance and Rehabilitation (M&R) activities, requirements for feasibility, applicable budget type and unit costs, and consequences resulting from the activity; and
5. Committed: inputs used to manage projects that are planned/selected by the user independent of RoadCare's selection methodology and treatment definition constraints.

Note: The SOP described in this document may not be applicable to other versions of RoadCare.

10.03.02 *Frequency*

Performing a needs analysis and running the Simulation Engine is performed once per year, after the end of the data collection season, once the data have been processed and migrated into the appropriate Business Plan Tables (see Migrating to Business Plan Tables). The procedure may need to be repeated multiple times during the iterative "Condition RSL/Cost Optimization" process.

10.03.03 *Purpose*

The purpose of this SOP is to establish a required budget for the MDOT-SHA network by performing a needs analysis and then optimizing the budget allocation through the Simulation Engine in the RoadCare software.

10.03.04 *Resource Requirements*

Performing needs analysis and running the RoadCare Simulation Engine requires the following three MDOT-SHA staff members: (1) a DAT staff member knowledgeable in Oracle and RoadCare software to perform the needs analysis and run the simulation; (2) the Assistant Division Chief (ADC) to review the reports generated from the simulation and suggest revisions to the inputs where necessary; and (3) the Division Chief (DC) to provide guidance and decision-making during the ADC review. The estimated effort levels shown in the table below represent the total time, in man-hours, to complete the needs analysis and simulation process. These time estimates assume no issues are encountered during the procedure.

Position	Function	Resources	Effort Level (man-hrs)
DAT Staff	Analyst	1	AN[06/12/2019]
ADC	Review	1	AN
DC	Review	1	AN

10.03.05 *Procedure*

The procedure to run the RoadCare Simulation Engine is comprised of the following eight tasks:

(1) perform a needs analysis
(2) create a new Simulation,
(3) input the Analysis parameters,
(4) input the Investment parameters,
(5) input the Performance parameters,
(6) input the Treatment parameters
(7) input the Committed parameters, and
(8) run the simulation.

1- Perform a Needs Analysis – *performed by DAT analyst*

Summary: Under this task, a needs analysis is performed to identify the budget requirements for the pavement network. This analysis is performed only as required; i.e., if the simulation budget is not already available. Typically, a needs analysis is performed by running several “Conditional RSL As-Budget Permits” simulations by iteratively increasing the budget in the Investment window (See Task 4 - Total Investment of this SOP) to meet some pre-determined criteria. Simulations are run in a similar manner as explained in the following sections using the same inputs and criteria, and summaries from all sections reports are generated until these criteria are met. Some of these criteria are as follows.

i. How much money is needed to maintain current conditions?

ii. How much money is needed to attain MDOT-SHA’s business plan goal of RSL=20 in 10 years?

iii. How much money is needed to achieve a benefit target of X LMY in fiscal year Y?

In order to meet the MDOT-SHA business plan goal of 20 RSL with consistent funding, it has been determined that Fund 77 needs $260M to $270M each year overall, with construction remaining steady at $220M each year. This assumes a system preservation approach with Rehabilitation and Preventive Maintenance. This conclusion can be determined by summarizing various “All Sections” reports. Refer to the files below[06/12/2019] for more details.

i. Pavement RSL Predictions 2010-2027 - Adjusted with 220M v3.xlsx (Summary sheet)
ii. All_Sections - SW_SIM_BY_TREATMENT - DoNothing.xlsm (Do nothing simulation)

iii. All_Sections - SW_SIM_BY_TREATMENT - Optimized 220M.xlsm (data for $220M)

iv. All_Sections - SW_SIM_BY_TREATMENT - Optimized.xlsm (data for current budget)

If the simulation budgets has been finalized, then this task can be skipped altogether.

Step 1. Determine if a needs analysis must be performed based on the criteria described in the summary of Task 1.

i. If a needs analysis is required, proceed to Step 2.

ii. If a needs analysis is not required, skip to Step 3.

Step 2. Follow the steps described below for creating a simulation and adjusting the simulation input parameters. Iteratively increase the budget in the Investment window (See Task 4- Total Investment of this SOP) to meet some pre-determined criteria. The criteria for the needs analysis should be discussed with the ADC prior to completion of the needs analysis.

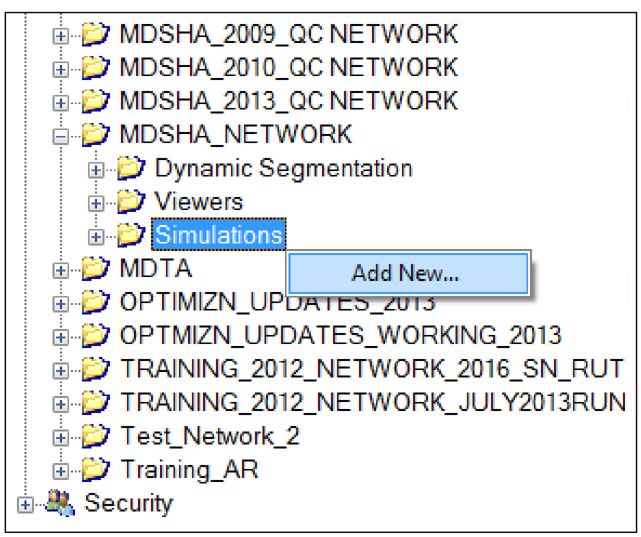
2- Create a New Simulation – *performed by DAT analyst*

Summary: Under this task, a Simulation is created using RoadCare for the desired network.

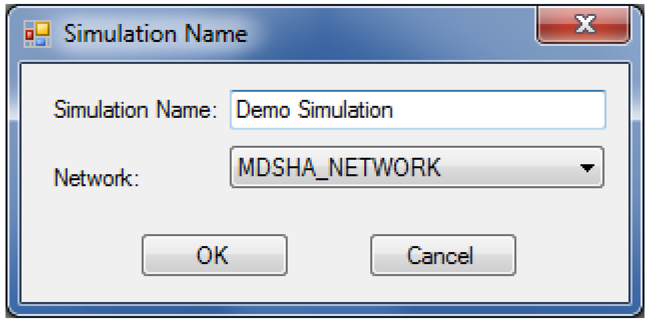
Step 3. Open RoadCare software.

Step 4. Expand the options inside the “Networks” module by clicking on the “+” icon. Then, expand the options inside the “2016_NETWORK_COMBAREA”[06/12/2019] menu that appears in the list by clicking on the “+” icon.

Step 5. Right-click the on “Simulations” listed under the “2016_NETWORK_COMBAREA” menu and select the “Add New” option, as shown in the below image.



Step 6. Type an appropriate simulation name in the text box next to “Simulation Name” and select the appropriate network from the drop-down list next to “Network,” as shown in the below image. After the simulation is created, a new folder with the simulation name is listed under the “Simulations” tab.



3- Analysis Input – *performed by DAT analyst*

Summary: Under this task, the parameters required for the Analysis module are input in RoadCare. The parameters are summarized below.

- Budget: spending rules that are used to limit the allocation of funding to feasible treatments.

- Weighting: input modifies the calculated benefit or remaining life by a user-selected parameter. The selected weighting parameter is directly multiplied by the calculated benefit to give a weighted benefit.

- Benefit: input determines which attribute is used in the Incremental benefit/cost calculations. It is recommended to select a benefit variable even when performing a remaining life analysis because the benefit can be calculated and reported, even if not used as a basis for treatment selection.

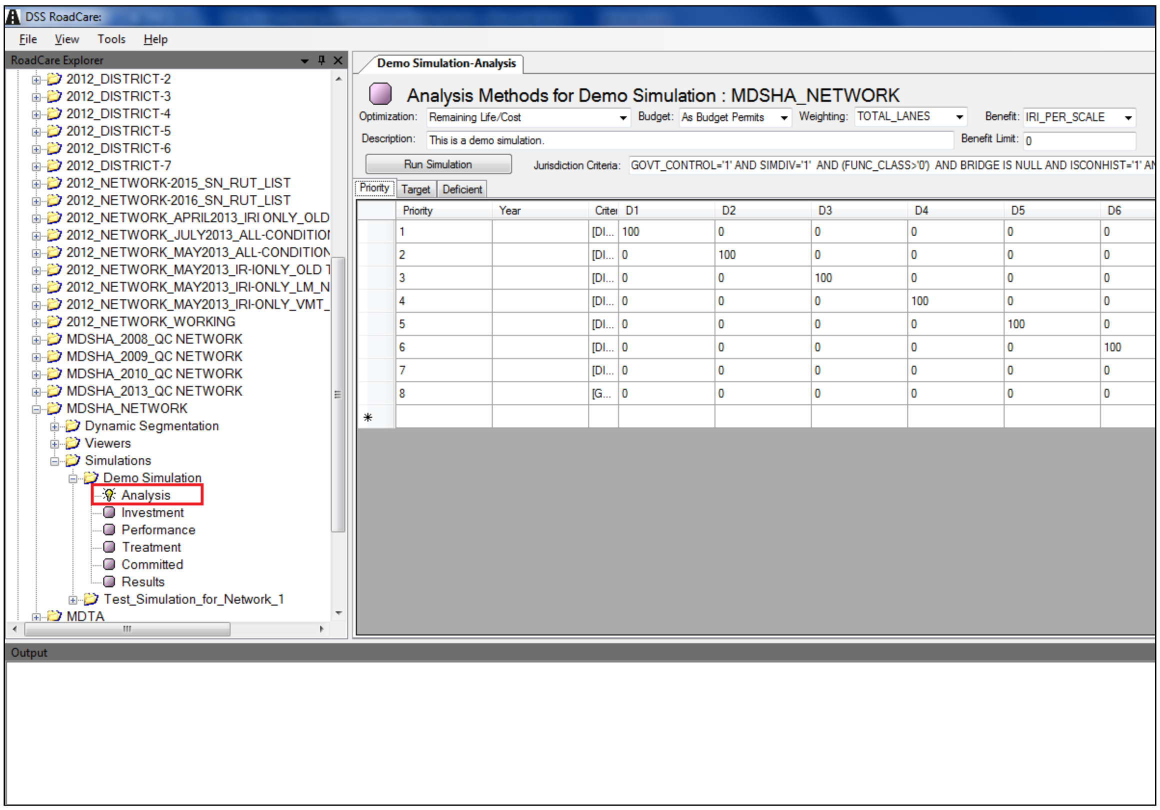
- Jurisdiction criteria: creates a subset of given network data. For example, if a network contains data for an entire state highway agency, the Jurisdiction input can be used to run a Simulation on only District 1.

- Priority: tab on the analysis window is used to set budget priorities and constraints. The priority column is an integer number greater than 0, with no numbers repeating. The criteria column contains the values that causes this priority to apply; e.g. [SHOP]='CAMBRIDGE' for all sections assigned to the Cambridge Shop. These criteria are applied for every year of the simulation and are based upon the predicted value of the included attributes. The funding levels for rehabilitation, maintenance, and/or construction or other user-defined investment criteria as defined by a positive number between 0 and 100 (i.e. 100% is input as 100). This number represents the maximum cumulative percent of the budget that may be spent on this priority or lower priority levels (priority 1 is the highest priority level). Any money not spent on a higher priority is available to be spent on lower priority treatments/sections. If the criteria field is left blank, the priority applies to all sections.

- Target: tab on the analysis window allows the user to input the network goals which the simulation engine will attempt to satisfy (not applicable for conditional RSL/cost optimization).

- Deficient: tab on the analysis window, allows the user to input the network deficiency targets which the simulation attempts to satisfy (not applicable for conditional RSL/cost optimization).

Step 7. Expand the options inside the newly created simulation in Step 6 by clicking on the "+" icon. Double-click on the first option, which is "Analysis," to display the main "Analysis" window as shown in the below image.



Step 8. Enter the required input data. Most inputs required for the simulation engine are conditional in nature. This means that the equation, constraint, or action is entirely dependent upon the current state or condition of each pavement management section. Simulation engine conditional statements are input using standard SQL query syntax. The interface includes a query builder and checker sub-module. For the "Analysis" sub-module, the window contains the following fields:

- Optimization,
- Budget,
- Weighting,
- Benefit,
- Description,

- Benefit Limit, and
- Jurisdiction Criteria.

In addition, tabs labeled Priority, Target, and Deficient allow entering additional input data. These inputs vary from one simulation to another. For more details on these inputs, please see RoadCare Help. Listed below are a set of possible inputs to use in a simulation.

Optimization – Conditional RSL/Cost.

Budget – As Budget Permits.

Weighting – None.

Benefit and Benefit Limit – Not applicable for Conditional RSL/Cost optimization.

Jurisdiction Criteria: Varies depending on the simulation; e.g. ISRAMP='0' AND GOVT_CONTROL='1' AND FUNC_CLASS IS NOT NULL AND SIMDIV='1' AND (END_STATION-BEGIN_STATION)>=0.5 AND TOTAL_LANE_MILES >'0' AND (FC_DENSITY>0 OR SC_DENSITY>0 OR AVG_RUT>0 OR AVG_IRI>0 OR SPADJ_SKID_NUMBER>0) AND AGE>=0

Priority – See Steps 10-16.

Target & Deficient – Not applicable for Conditional RSL/Cost Optimization.

Step 9. When all the data necessary for the simulation are correctly entered, select "Run Simulation" to start the simulation engine. Errors that occur during the compilation or run of the simulation will be displayed in the output window.

4- Total Investment – *performed by DAT analyst*

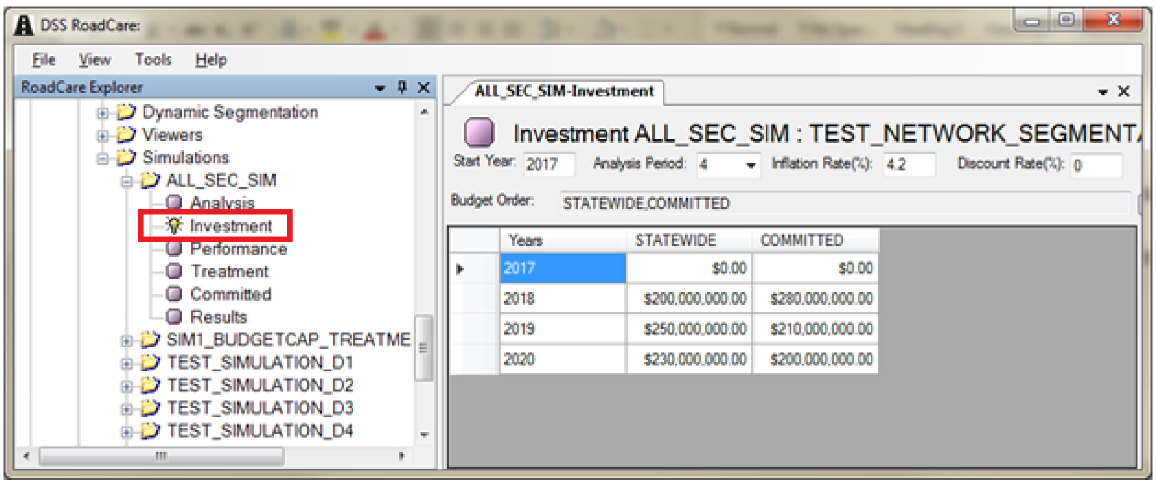
Summary: Under this task, the necessary parameters required for the Investment module are input in RoadCare.

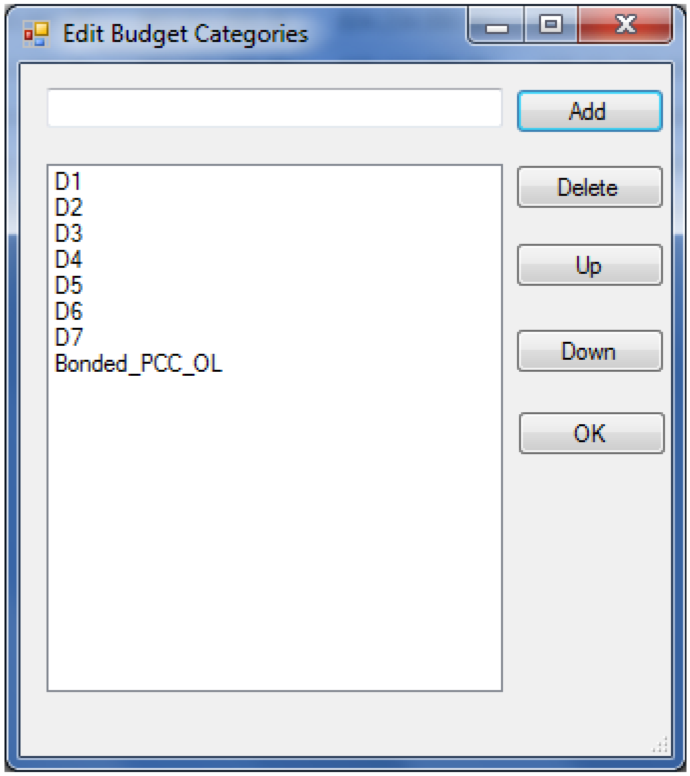
Step 10. In the "Explorer" window, double-click on the second option, "Investment," under the simulations module for the chosen network to display the main "Investment" window, as shown in the below image. Enter the following inputs:

- **Start year:** field used to define the first year of the simulation. For example, if the RoadCare database contains attribute data from 1999-2017, and a start year of 2020 is entered, RoadCare will roll forward the attributes according to the input performance equations. Usually, the start year is entered as the most recent inventory year plus 1.
- **Analysis period:** determines the number of years that a simulation will run. The analysis period should be at least 10 years for the State Optimization. The inflation rate (%) and discount rate (%) fields are used to determine the present value of treatments and committed projects.
- **Inflation rate:** 4.2% (most recent).
- **Discount rate:** 0%

- **Budget Order:** determines the budget expenditure hierarchy for the "As Budget Permits" and "Unlimited Budget" analyses.

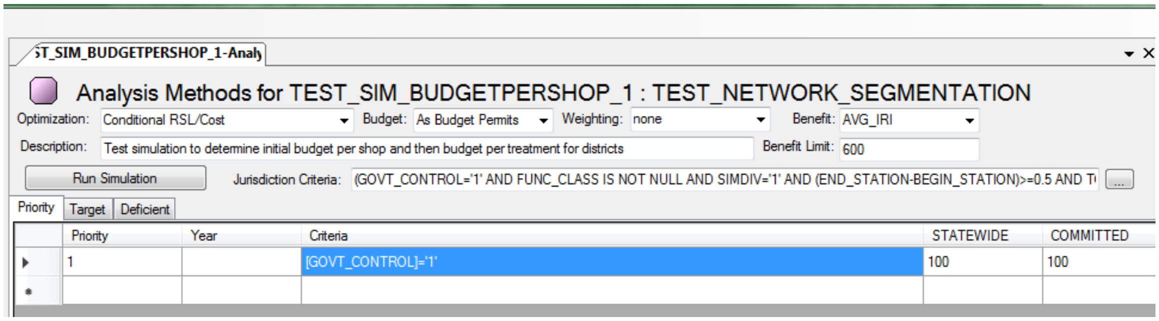
Contact the Chief Engineer's office to get the statewide construction budget for the next several years from the most recent CTP allocation and enter in the "STATEWIDE" budget category in the investment window. Note that committed projects must be in a separate budget category. For the "COMMITTED" category, add the cost of all committed projects by fiscal year to determine the budget. To add budget categories, click the 3 dots (…) button in the Investment window next to Budget order to display the Edit Budget Categories window shown in the image below. Type the name of the budget categories and click "Add". No budget categories names should contain spaces or single quotes. To change the order, select a given category and select "Up" or "Down" based on the desired order of the category in the list. Any category can also be deleted by highlighting the category name and selecting "Delete." Once the budget categories list is complete, select OK.





Step 11. Open the "Budget Per Shop" Excel file[06/12/2019]. Update all data in the worksheet "2016_SHA_Inventory" by running the SQL statements in cells I1, I21, I42, I69, K97, and P124 in Oracle SQL Developer in the production environment[06/12/2019]. Calculate $ MIN (%) and $ MAX (%) of LM and VMT for each Shop. Use LM if it is the max. This is called "DraftBudgetAlloc**"** in the Excel file.

Step 12. Run a "Conditional RSL/Cost - As Budget Permits" simulation with all committed projects and most recent construction budgets from OCE without priorities/budget allocation. The only criteria to use in this simulation is "[GOVT_CONTROL] = 1" as shown in the following image. Budget priorities and investment inputs are provided in the simulation "TEST_SIM_BUDGETPERSHOP_1" in RoadCare. All other inputs remain the same. To access this simulation, expand the options inside the "Networks" module by clicking on the "+" icon. Then, expand the options inside the "2016_NETWORK_COMBAREA" menu that appears in the list by clicking on the "+" icon. Then expand the options inside the "Simulations" module by clicking on the "+" icon. This will show the list of simulations under the selected network. Then expand the options inside the selected simulation by clicking on the "+" icon next to the simulation name. See Steps 3 through 7 for screenshots and more details.



Step 13. Once the simulation is complete, generate a "Targets/Suggested Projects Report" (see Generating Reports). Copy the budget allocation by shop from the "Targets" tab in the spreadsheet. These $ numbers will be called "OptimizResults."

Step 14. Paste "OptimizResults" in "BudgetPerShop" tab, Column V.

i. IF (OptimizResults<DraftBudgetAlloc or OptimizResults>DraftBudgetAlloc) then use DraftBudgetAlloc else use OptimizResults. This is labeled "DRAFT Budgetq" in the Excel file.

Step 15. Apply the following formula in column H: *=IF(DRAFT Budgetq=$ MIN (%),"MIN",IF(DRAFT Budgetq=$ MAX (%),"MAX",""))*

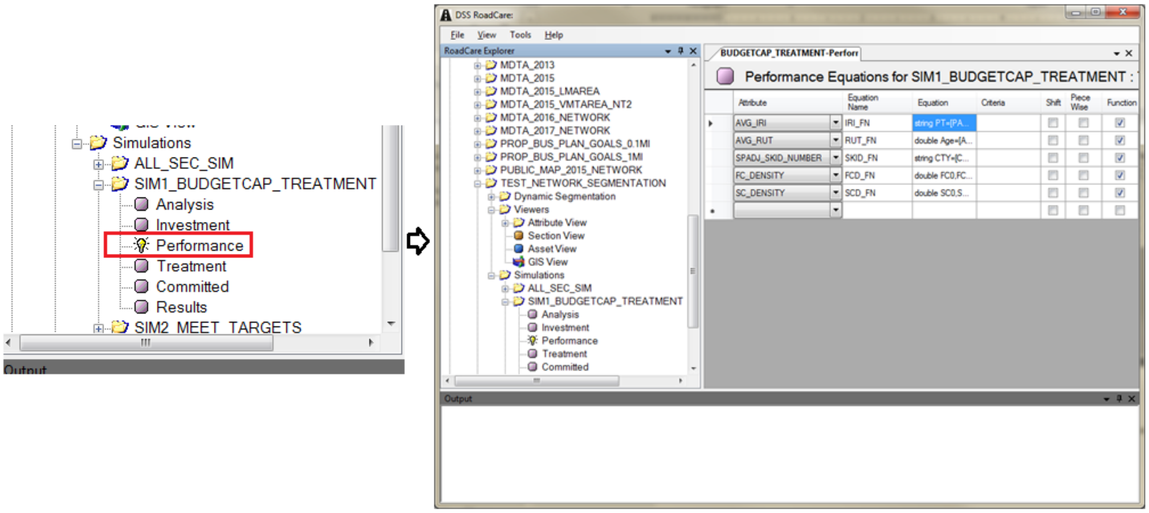
Step 16. In column K, adjust the budget per shop distributions that are not classified as MAX so that the total adds up to 100%. Note that cumulative budget distributions will be used in RoadCare in the priorities window. These numbers are available in tab "RoadCare BudgetperShop 02202018" in the Excel file. Copy and paste the data in this file (exclude headers) and paste into the "Priority" tab in RoadCare by selecting the first cell under the "Priority" column and pressing Ctrl+V on the keyboard to paste the data (see below image).

1	Priority Le	Year	ATTRIBUTE	STATEWIDE	COMMITTED
2	1		[SHOP]='CAMBRIDGE' AND [P	0.80	0
3	2		[SHOP]='PRINCESS ANNE' ANI	1.44	0
4	3		[SHOP]='SALISBURY' AND [PR(	4.57	0
5	4		[SHOP]='SNOW HILL' AND [PR	6.45	0

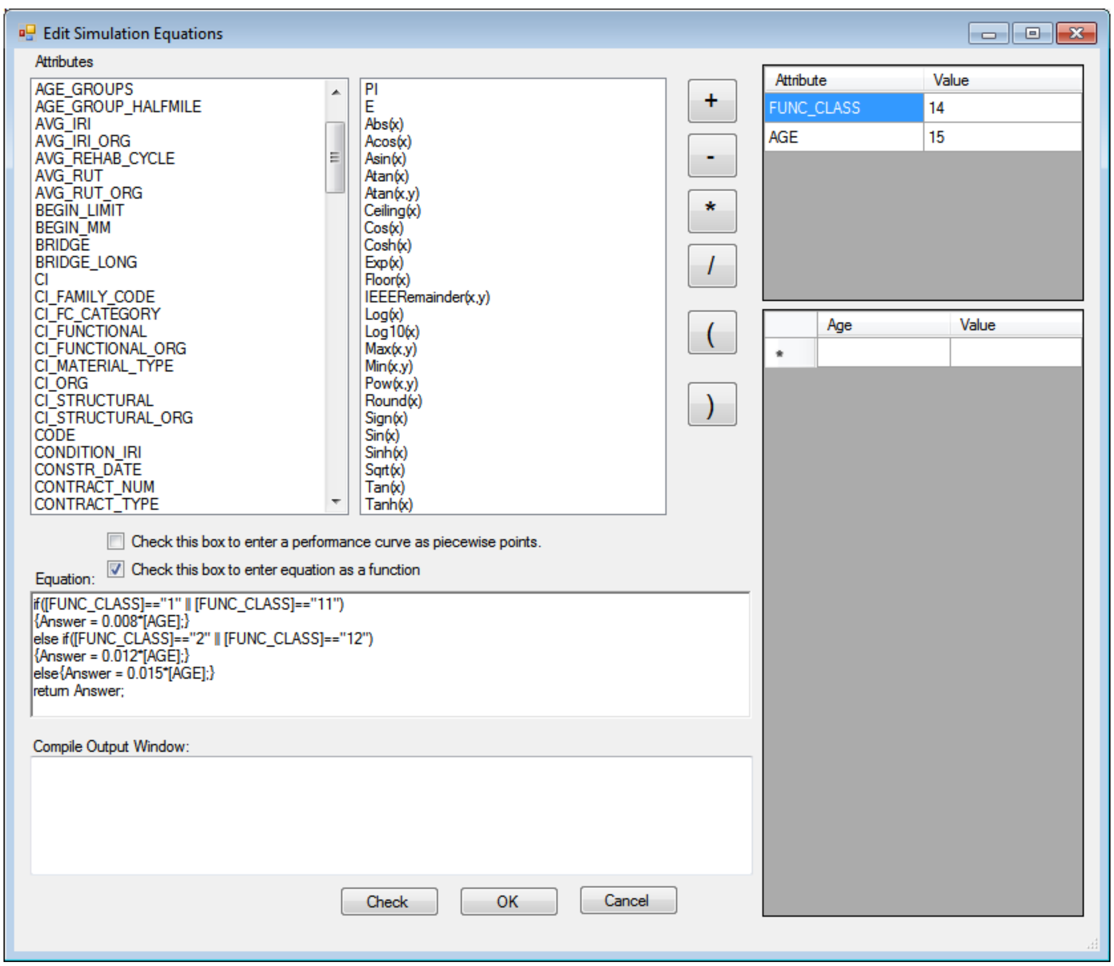
5- **Performance Models** – *performed by DAT analyst*

Summary: Under this task, the necessary parameters required for the performance module are input in RoadCare.

Step 17. In the "Explorer" window, double-click on the third option, "Performance," under the simulations module for the chosen network to display the main "Performance" window as shown in the below image.



Step 18. Double-click on the “AVG_IRI” field in the display window to open the “Edit Simulation Equations” window. Make sure “Check this box to enter equation as a function is checked.” Paste the updated C# function for IRI from the Excel file into the input window as shown in the image below. Click “OK.”



Step 19. Repeat Step 18 for the other four performance measures (functional cracking density, structural cracking density, rutting, and friction) by copying in the correct C# functions, updated in the Excel file, into the input window.

Step 20. Run a "Conditional RSL/Cost - As Budget Permits" simulation for at least 10 years using the most recent OCE budgets and treatment inputs. Budget priorities and investment inputs are provided in the simulation SIM1_BUDGETCAP_TREATMENT in RoadCare. All other inputs remain the same. To access this simulation, expand the options inside the "Networks" module by clicking on the "+" icon. Then, expand the options inside the "2016_NETWORK_COMBAREA" menu that appears in the list by clicking on the "+" icon. Then expand the options inside the "Simulations" module by clicking on the "+" icon. This will show the list of simulations under the selected network. Then expand the options inside the selected simulation by clicking on the "+" icon next to the simulation name. See Steps 3 through 7 for screenshots and more details.

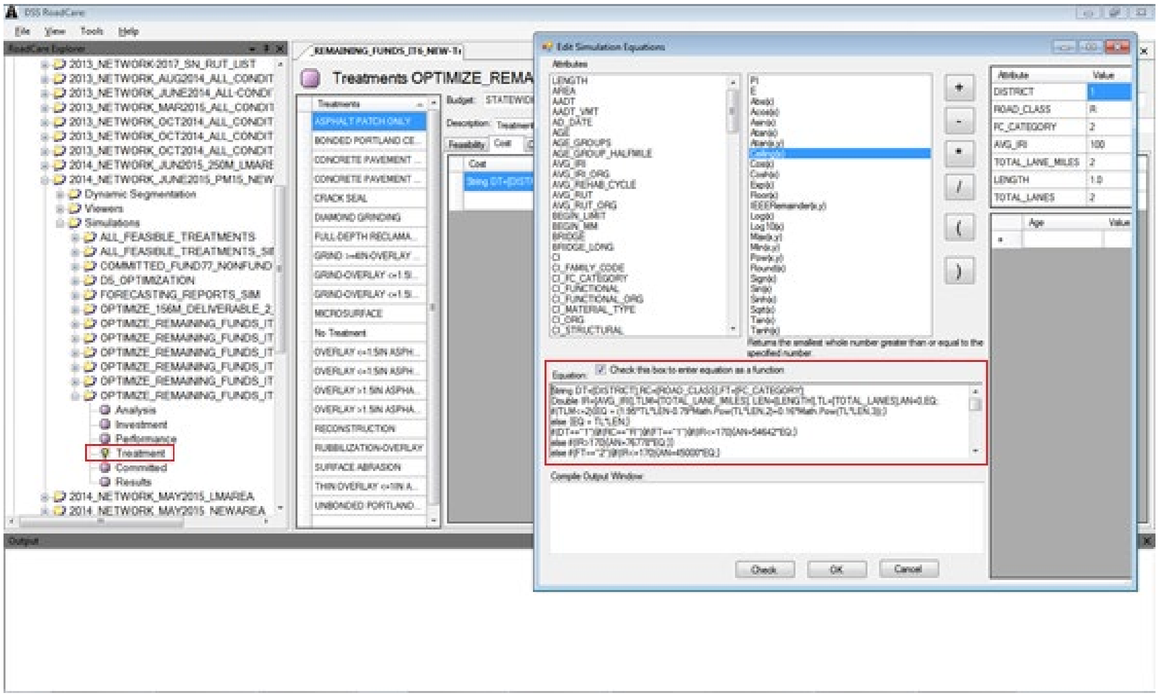
Step 21. Once the simulation is complete, generate a "Targets/Suggested Projects Report" (see Generating Reports) for the current optimization year to review the treatment life extension for suggested projects in the optimization year. Compare against the typical treatment life extension ranges specified in the supplemental treatment information section of the MDOT-SHA Pavement Design Guide.

i. If the predicted life extension for a specific treatment is outside the recommended range specified in the Design Guide, then the corresponding family of models (usually in cracking or IRI) must be revised to produce more reasonable results.

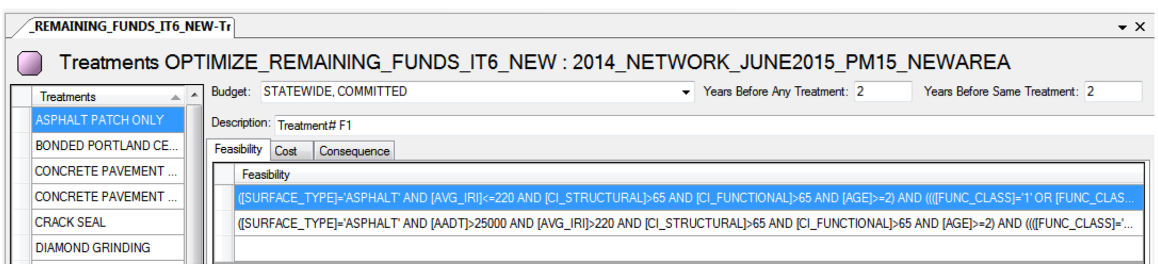
6- Treatments – *performed by DAT analyst*

Summary: Under this task, the parameters required for the Treatments module are input in RoadCare.

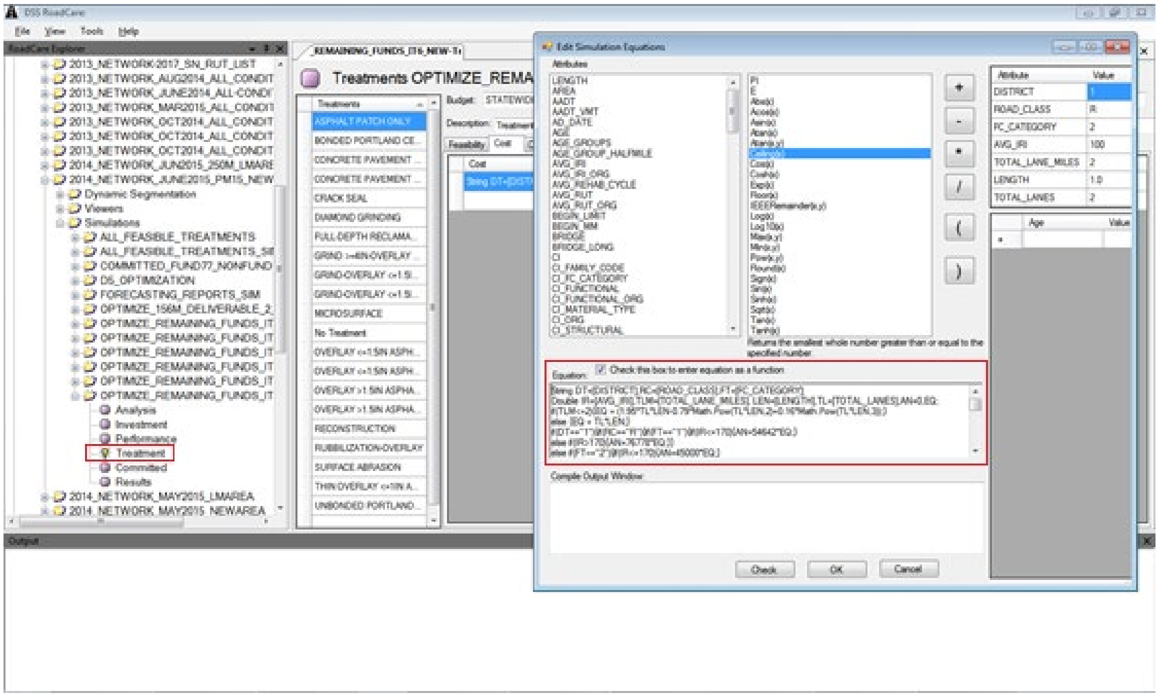
Step 22. In the "Explorer" window, double-click on the fourth option, "Treatment," under the simulations module for the chosen network to display the main "Treatment" window as shown in the below image.



Step 23. Open the "Feasibility" tab and ensure the feasibility criteria for each treatment are properly specified. Multiple feasibility conditions can be specified as shown in the below example for a treatment type called "Asphalt Patch Only."



Step 24. Open the "Cost" tab and specify the dollar amount to attach to each treatment. The cost can be defined in terms of an equation or a C# function. Unit cost data for each treatment is obtained using data from past construction projects. Unit cost is averaged for pavements grouped based on District, Road Class, Functional Class Category, and IRI condition and updated annually. The source for these costs is the "Treatment Tree" Excel file[06/12/2019]. The user must copy and paste the cost functions for each treatment from the "Treatment Tree" Excel file into the text box as shown in the below image.



Step 25. Run the following SQL statement to determine TOTAL_BID, LANE_MILES_RESURFACED, and COST_PER_LANE_MILE by fiscal year:

select fiscal_year, sum(total_bid) total_bid, sum(inv_emp - inv_bmp) lane_miles_resurfaced, sum(total_bid)/sum(inv_emp - inv_bmp) cost_per_lane_mile from business_plan_lmy where fund = 77

and treatment in (select treatment from lu_treatment where is_resurfacing = 1) and total_bid >0 and fiscal_year <2100 and max_layer_fy = 1 group by fiscal_year order by fiscal_year;

Step 26. Calculate the inflation rate using the “Solver” tool in Excel as shown in the below image.

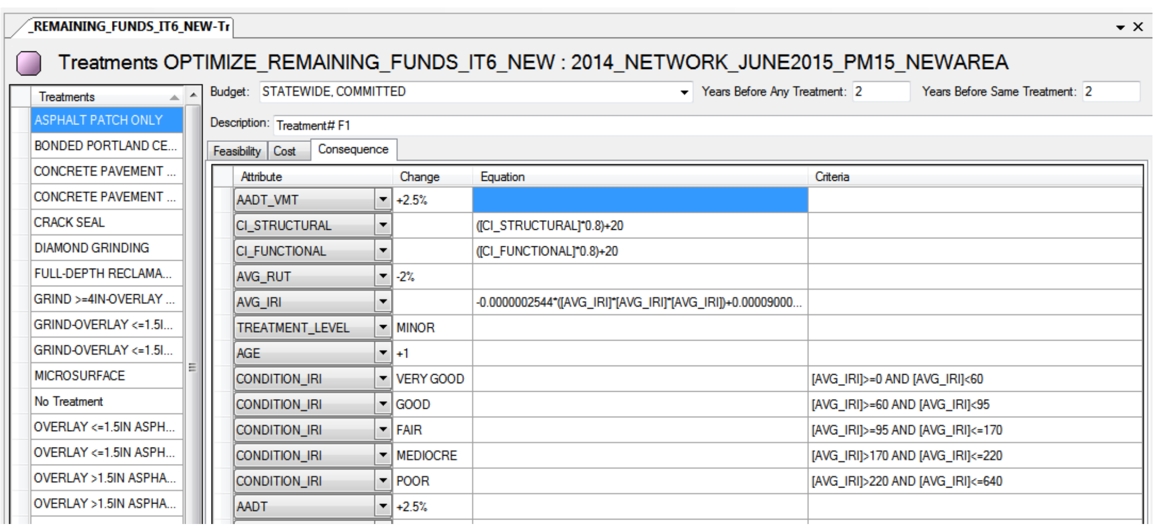
G	H	I	J	K	L	M	N	O	P	Q	R	S
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	0.9775	1.0186	1.0247	1.0635	1.070	1.071	1.070	1.096	1.079	1.044	1	0.986
	$273,561.10											
	$267,398.51	$184,569.71										
	$261,374.75	$187,998.25	$179,260.82									
	$255,486.69	$191,490.48	$183,680.19	$141,513.98								
	$249,731.27	$195,047.58	$188,208.50	$150,507.00	$145,178.60							
	$244,105.51	$198,670.76	$192,848.46	$160,071.51	$155,334.88	$154,247.45						
	$238,606.48	$202,361.23	$197,602.80	$170,243.84	$166,201.66	$165,270.20	$166,460.13					
	$233,231.32	$206,120.27	$202,474.36	$181,062.60	$177,828.64	$177,080.66	$178,036.02	$165,416.56				
	$227,977.26	$209,949.13	$207,466.01	$192,568.88	$190,269.02	$189,735.10	$190,416.92	$181,309.10	$187,064.06			
	$222,841.55	$213,849.11	$212,580.73	$204,806.37	$203,579.69	$203,293.86	$203,658.80	$198,728.53	$201,857.83	$208,618.42		
	$217,821.54	$217,821.54	$217,821.54	$217,821.54	$217,821.54	$217,821.54	$217,821.54	$217,821.54	$217,821.54	$217,821.54	$217,821.54	
												$214,771.41

Step 27. Use the inflation rates calculated in Step 26 to determine the historical unit cost for various treatments by running the SQL statement in the “Treatment Tree” Excel file (see column AW in worksheet “2007-CurYear Fund77 Projects”).

Step 28. Copy and paste the results of the SQL statement from the previous step into the table “TBL_UNIT_COST_PRJ” in the same worksheet. Exclude outliers by calculating the nth% percentile lower and upper limit for unit cost by treatment (start with 5% for LL and 95% for UL, but these numbers will vary by treatment type). These calculations are stored in the same worksheet in a summary table. If cost data are not available for a specific treatment, then assume a cost based on judgment/experience. The cost data and functions will be automatically updated in the individual treatment worksheets as they are linked to the summary table.

Step 29. Review the unit cost data for all treatments before the unit cost functions are entered in RoadCare.

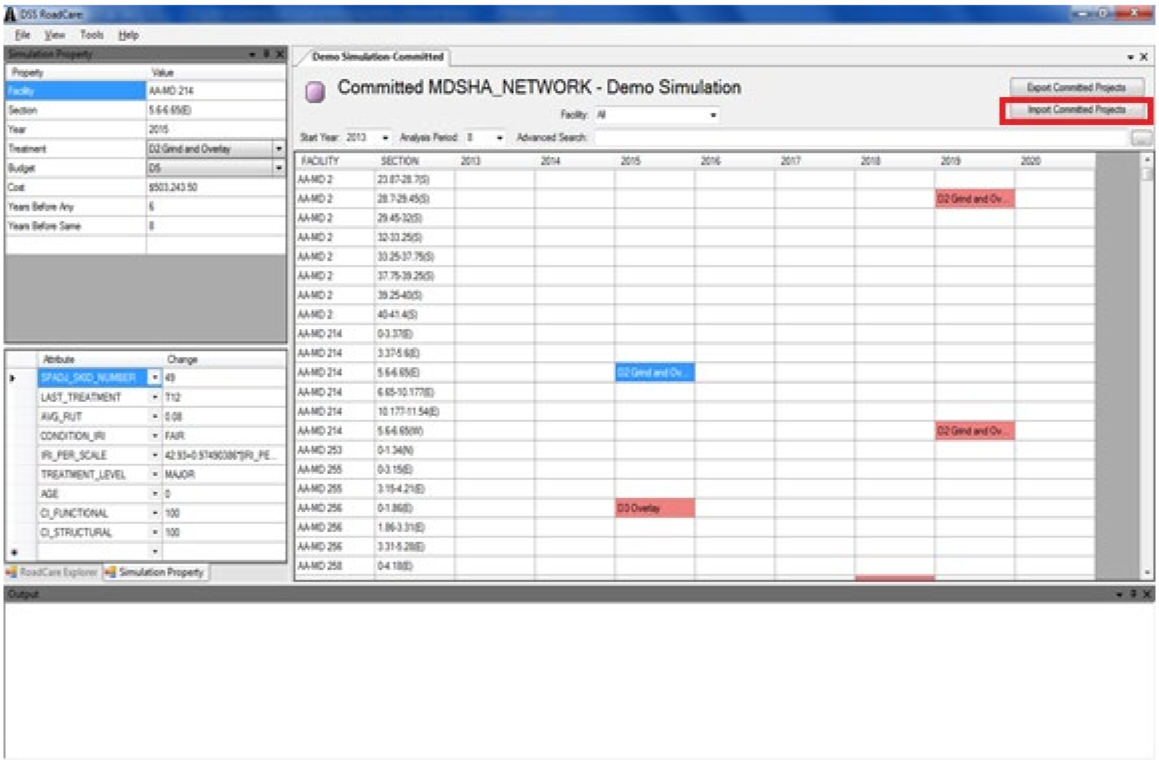
Step 30. Open the “Consequence” tab (see below image) and define what happens after a given treatment is selected. “Consequence” contains the “Attribute” that is affected, the “Change” that is applied, and the “Criteria”, which selects the appropriate consequence. An example of consequence definitions for treatment type “Asphalt Patch Only” is shown in the below example. Refer again to “Treatment Tree” Excel file for the most recent treatment consequences.



7- Committed Projects – *performed by DAT analyst*

Summary: Under this task, the parameters required for the “Committed” module are input in RoadCare.

Step 31. In the “Explorer” window, double-click on the fifth option, “Committed,” under the simulations module for the chosen network to display the main “Committed” window as shown in the below image. The available inputs include Facility, Start Year, Analysis Period, Advanced Search, as well as a grid with a list of facilities, sections, and years.



Step 32. To prescribe treatments, select a given "*Facility"* from the pull-down menu or use the "Advanced Search" option. Then, select a "*Start Year"* and the "*Analysis Period*;" usually, these two parameters match the investment input values. When the appropriate section is identified, click on the cell that corresponds to the year of interest.

Step 33. Subsequently, on the pane to the left labeled "Simulation Property," select the treatment type, the budget category that should be used to cover the cost of the treatment, as well as the total cost. Alternatively, committed projects could be imported as a tab delimited text file with the required parameters[06/12/2019]. The treatments defined under committed are accounted as mandatory activities during the simulation. Click the "Import Committed Projects" button in the top right-hand corner of the Committed Projects window. This will open a dialog box that will allow the user to import the Committed projects file.

8- Run Simulation – *performed by DAT analyst, ADC, and DC*

Summary: Under this task, the simulation is run in RoadCare to optimize the budget allocation for the pavement network. The results of this task will then be reviewed, and if revisions are required, another iteration of the entire process will be completed with the discussed implemented changes.

Step 34. Click “Run Simulation” in the “Analysis” window.

Step 35. Following Generating Reports, generate the required reports to be reviewed.

Step 36. Send reports to ADC and DC for review.

i. If changes are required, discuss next actions. Make adjustments to the segmentation, data rollup, or simulation inputs as needed. When adjustments are complete, return to Step 34.

ii. If no changes are required, the process is complete.

10.04 GENERATING REPORTS

10.04.01 *General*

This section describes the standard operating procedure (SOP) used by staff from the Data Analysis Team (DAT) of the Maryland Department of Transportation State Highway Administration (MDOT-SHA) to generate reports for the "Conditional RSL/Cost Optimization" process in the RoadCare version 3.67 asset management software. This SOP is performed after the simulation is completed as described in Needs Analysis and Running Simulation Engine.

Note: The SOP described in this document may not be applicable to other versions of RoadCare.

10.04.02 *Frequency*

The generation of reports is performed once per year, after the end of the data collection season, and once all data have been processed and migrated into the appropriate Business Plan Tables (see Migrating to Business Plan Tables). The reports may need to be generated multiple times during the iterative Condition RSL/Cost Optimization process.

10.04.03 *Purpose*

The purpose of this SOP is to generate budget reports for the yearly RoadCare simulation, which allocates funding for the needs identified in the pavement network.

10.04.04 *Resource Requirements*

Generating reports involves one person: a DAT staff member knowledgeable in RoadCare software. The estimated effort level shown in the table below represents the total time, in man-hours, to complete the report generation. This time estimate assumes no issues are encountered during the report generation process.

Position	Function	Resources	Effort Level (man-hrs)
DAT Staff	Analyst	1	1.0

10.04.05 *Procedure*

The procedure to generate reports in RoadCare is comprised of the following two tasks:

(1) generate standard reports, and
(2) generate special reports.

1- Generate Standard Reports – *performed by DAT Staff*

Summary: Under this task, standard reports from a funding needs simulation can be generated using the RoadCare software.

Step 4. Open RoadCare software.

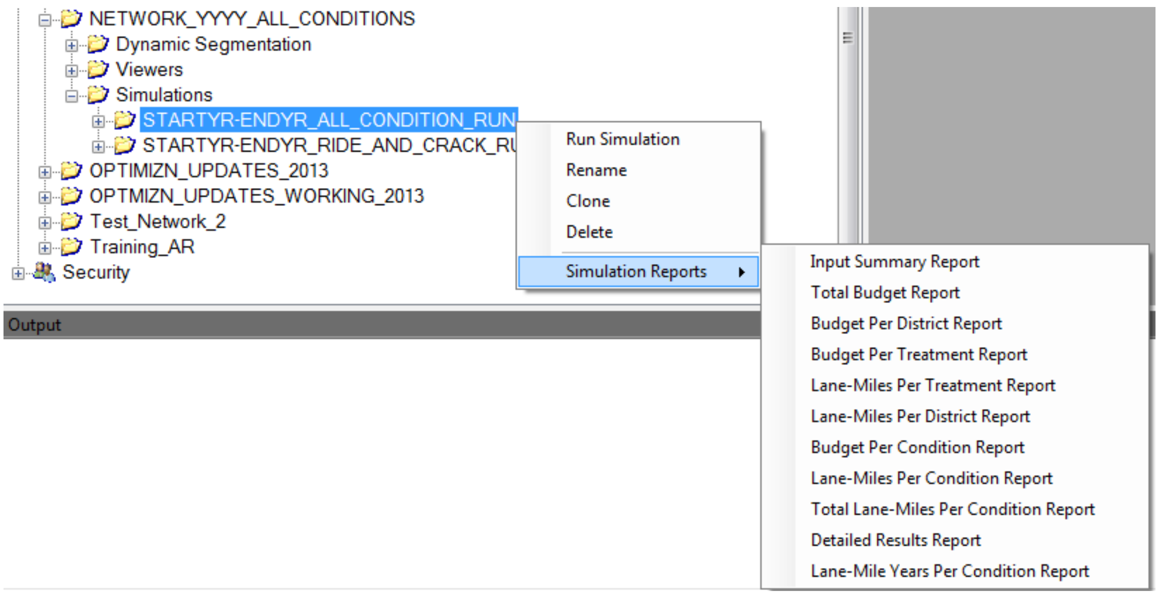
i. If the report that is to be generated is one of the standard reports, proceed to Step 8.

ii. If the report that is to be generated is a special report, proceed to Step 8 in Task 2.

Step 5. Expand the options inside the “Networks” module by clicking on the “+” icon. Then, expand the options inside the “MDSHA_NETWORK” menu that appears in the list by clicking on the “+” icon.

Step 6. Expand the options inside the “Simulations” module by clicking on the “+” icon.

Step 7. Right-click on the name of the desired simulation and then click on “Simulation Reports.” A menu of all the possible reports will appear. Click on the desired report. All reports will be outputted into a Microsoft Excel 2007 spreadsheet. The types of simulation reports that can be generated are shown in the below image.

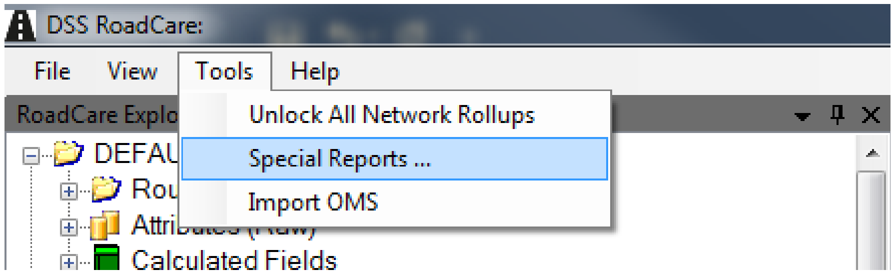


2- Generate Special Reports – *performed by DAT Staff*

Summary: Under this task, special reports from a funding needs simulation can be generated using the RoadCare software. For the purposes of the Condition RSL/Cost Optimization process, only the following three report types are relevant:

(1) “FY Targets and Suggested Projects Report”,
(2) “All Sections Shop DM Year & VMT Report”, and
(3) “Attribute View Report.”

Step 8. Select “Tools” from the RoadCare top menu and click on “Special Reports” from the drop-down menu, as shown in the below image.

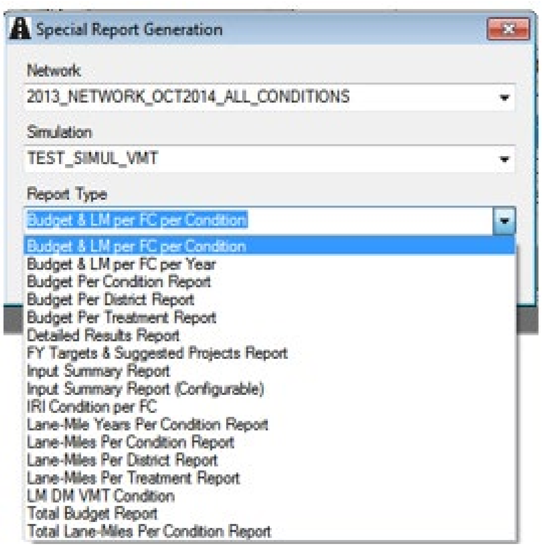


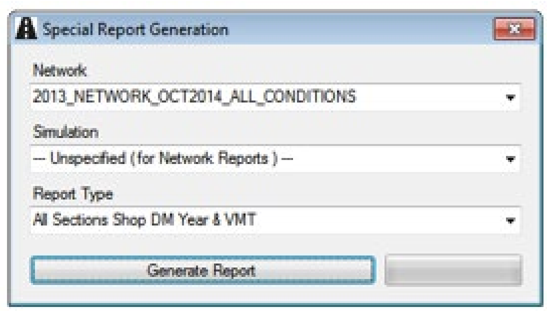
Step 9. On the “Special Report Generation” window, select the appropriate “Network,” “Simulation,” and “Report Type” from the drop-down menus, as shown in the below image.

i. If “FY Target & Suggested Projects Report” is selected, proceed to Step 10.

ii. If “All Sections Shop DM Year & VMT” is selected, skip to Step 15.

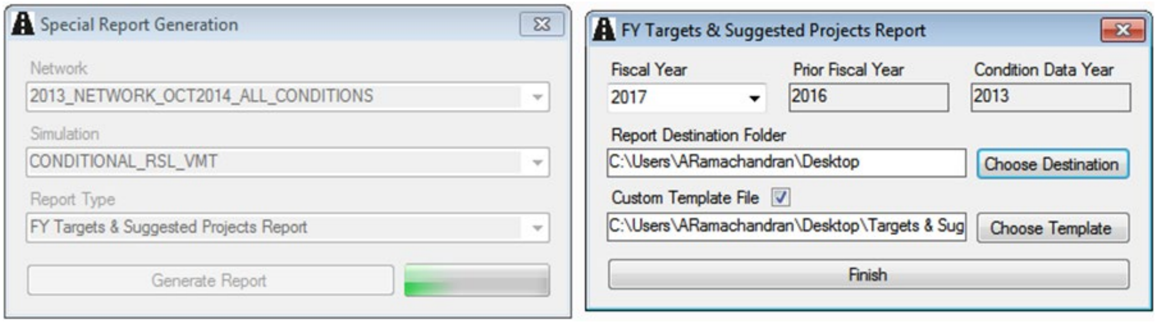
iii. If the “Attribute View Report” is required, exit the “Special Report Generation” window and skip to Step 20.





Step 10. Click “Generate Report.”

Step 11. In the subsequent window, select the appropriate “Fiscal Year” and “Destination Folder” and then click “Finish,” as shown in the below image. The user has the option of choosing a custom template file that can be edited if there is a need to modify existing summaries. The user must generate a statewide report for the optimization year and a preliminary report for the subsequent year.



Step 12. This "FY Target & Suggested Projects Report" generates a list of suggested projects and a list of pre-defined attribute values for each project in a selected simulation for a given fiscal year. This report also includes a comprehensive summary of budget and treatment distributions, benefit, suggested lane-miles and average life extension categorized by District, Maintenance Shop, Functional Class, Last Treatment, Treatment Type, and RSL Category. Open the Microsoft Excel file generated by the RoadCare software and review both the "Targets" and "Suggested Projects" reports as shown in the below images[06/12/2019].

Fund 77 FY20 Target Summary - Statewide

Targets:	Budget	Benefit (LMY)	Suggested Lane-Miles	Estimated $/LM	Average Life Extension	$/LMY	% of Overall $
	$202,023,872	14,552	1,470	$137,440	10	$13,882	
Preventive Maintenance involving UTBWC	$9,544,799	757	51	$185,375	15	$12,614	4.7%
Preventive Maintenance (other)	$16,582,954	2,671	703	$23,604	4	$6,208	8.2%
Minor Rehabilitation	$152,349,252	10,356	672	$226,694	15	$14,711	75.4%
Structural Overlay	$11,446,867	768	44	$261,147	18	$14,901	5.7%
Major Rehabilitation	$0	0	0	$0	0	$0	0%
Reconstruction	$0	0	0	$0	0	$0	0%
Traffic Barrier / ADA	$7,100,000	0	0	$0	0	$0	3.5%
Line Striping	$5,000,000	0	0	$0	0	$0	2.5%

Pre Treatment RSL Categories:		Budget	Benefit (LMY)	Suggested LM	$/LM	Average Life Extension	$/LMY
40 to 50 years	A	$0	0	0	0	0	$0
30 to <40 years	B	$2,307,358	276	88	$26,359	3	$8,373
20 to <30 years	C	$5,735,688	751	229	$25,095	3	$7,639
10 to <20 years	D	$50,290,411	3,479	441	$114,083	8	$14,455
<10 years	E	$76,849,912	5,486	393	$195,338	14	$14,008
0 years	F	$54,740,503	4,561	320	$171,295	14	$12,002

District	Budget	Benefit (LMY)	Suggested LM	$/LM	Average Life Extension	$/LMY
1	$12,950,009	1,069	113	$114,411	9	$12,115
2	$16,500,918	1,512	149	$110,639	10	$10,915
3	$50,775,622	2,696	300	$169,468	9	$18,836
4	$27,880,515	2,110	241	$115,562	9	$13,214
5	$38,030,974	3,110	272	$139,975	11	$12,227
6	$14,055,457	1,426	151	$92,873	9	$9,855
7	$36,830,377	2,630	244	$151,157	11	$14,006

Targets | Suggested Projects | Lookup & Notes

Detailed Project Summary - FY20 Suggested projects

See "Lookup & Notes" worksheet for notes

	Google Maps	VideoLog	District	County	Shop	Contract Type	Prefix	Route#	Suffix	Begin MP	End MP	Direction	Begin Landmark
4	Google Maps	VideoLog	1	DO	Cambridge	Microsurface	US	50		0.61	2.7	EB Only	0.10 mi W of Radiance Dr MU 1120
5	Google Maps	VideoLog	1	DO	Cambridge	Asphalt Paving	MD	313		7.92	8.44	All Dir	
6	Google Maps	VideoLog	1	DO	Cambridge	Asphalt Paving	MD	750		0	0.87	All Dir	Ocean Gateway US 50
7	Google Maps	VideoLog	1	DO	Cambridge	Asphalt Paving	US	50		4.65	6.71	EB Only	Austin Rd CO 181
8	Google Maps	VideoLog	1	SO	Princess Anne	Asphalt Paving	MD	673	A	0	0.53	All Dir	Crisfield Hwy (SB/L) MD 413
9	Google Maps	VideoLog	1	SO	Princess Anne	Asphalt Paving	US	13		6.3	7.1	SB Only	Spur to MD 920d
10	Google Maps	VideoLog	1	SO	Princess Anne	Asphalt Paving	MD	920		0	0.97	All Dir	
11	Google Maps	VideoLog	1	SO	Princess Anne	Asphalt Paving	US	13		19.58	20.17	SB Only	Jones Rd CO 30
12	Google Maps	VideoLog	1	WI	Salisbury	Chip Seal	MD	350		0.18	6.63	All Dir	End Municipal Maintenance
13	Google Maps	VideoLog	1	WI	Salisbury	Crack Seal	US	50		27.06	30.695	WB Only	Worcester Co/L
14	Google Maps	VideoLog	1	WI	Salisbury	Asphalt Paving	US	13	BU	4.17	8.137	All Dir	W College Ave MU 631
15	Google Maps	VideoLog	1	WI	Salisbury	UTBWC	US	13	BU	1.34	3.87	NB Only	0.18 mi S of S Division St MU 110
16	Google Maps	VideoLog	1	WI	Salisbury	Asphalt Paving	MD	346		0.67	1.2	All Dir	Out Corp Lmts Salisbury
17	Google Maps	VideoLog	1	WI	Salisbury	Asphalt Paving	US	50		0	0.75	WB Only	0.75 mi W of Dorchester Co/L
18	Google Maps	VideoLog	1	WI	Salisbury	Asphalt Paving	MD	992	A	0	0.74	All Dir	
19	Google Maps	VideoLog	1	WO	Snow Hill	Asphalt Patching	MD	378		0	1.49	All Dir	S 1st St MU 9015
20	Google Maps	VideoLog	1	WO	Snow Hill	Crack Seal	MD	374		8.02	8.7	All Dir	0.07 mi W of Prospect Dr MU 388
21	Google Maps	VideoLog	1	WO	Snow Hill	Crack Seal	MD	90		7.78	8.42	WB Only	0.64 mi W of Ocean Pkwy CO 583
22	Google Maps	VideoLog	1	WO	Snow Hill	Crack Seal	MD	575	A	0	0.533	All Dir	Worcester Hwy (SB/L) US 113
23	Google Maps	VideoLog	1	WO	Snow Hill	Crack Seal	MD	12		9.94	11.04	All Dir	Ayres Lane Rd CO 99
24	Google Maps	VideoLog	1	WO	Snow Hill	Crack Seal	US	113		32.86	37.49	SB Only	Delaware St/L
25	Google Maps	VideoLog	1	WO	Snow Hill	Microsurface	MD	90		9.21	9.94	EB Only	0.26 mi W of St Martins Neck Rd CO 220
26	Google Maps	VideoLog	1	WO	Snow Hill	Microsurface	MD	90		9.21	9.94	WB Only	0.47 mi W of St Martins Neck Rd CO 220
27	Google Maps	VideoLog	1	WO	Snow Hill	Asphalt Paving	MD	528		8.51	9.04	All Dir	1st St MD 378
28	Google Maps	VideoLog	1	WO	Snow Hill	Asphalt Paving	US	13		4.11	6.306	SB Only	0.42 mi S of Spur to Winter Quarters Dr
29	Google Maps	VideoLog	1	WO	Snow Hill	Asphalt Paving	US	50		0	4.98	EB Only	Struc #220001031 - Pocomoke River
30	Google Maps	VideoLog	1	WO	Snow Hill	Asphalt Paving	MD	756		0	1.17	All Dir	Linden Ave (Back) MU 340
31	Google Maps	VideoLog	2	QA	Centreville	Chip Seal	MD	18	A	4.59	5.39	All Dir	0.11 mi N of Shopping Center Rd CO 263
32	Google Maps	VideoLog	2	QA	Centreville	Chip Seal	MD	302		6.18	7.65	All Dir	
33	Google Maps	VideoLog	2	QA	Centreville	Crack Seal	US	301		32.39	36.94	NB Only	Sudlersville Rd MD 300
34	Google Maps	VideoLog	2	QA	Centreville	Crack Seal	US	301		11.82	13.52	NB Only	Ocean Gateway (Back) US 50

Targets | Suggested Projects | Lookup & Notes

Step 13. One of the optimization goals is to create realistic overall benefit targets that Districts must meet every year. Towards this end, the following actions must be reviewed[06/12/2019]:

i. Average unit cost for each treatment is compared with historical unit cost data and contractor bid tables for each District.

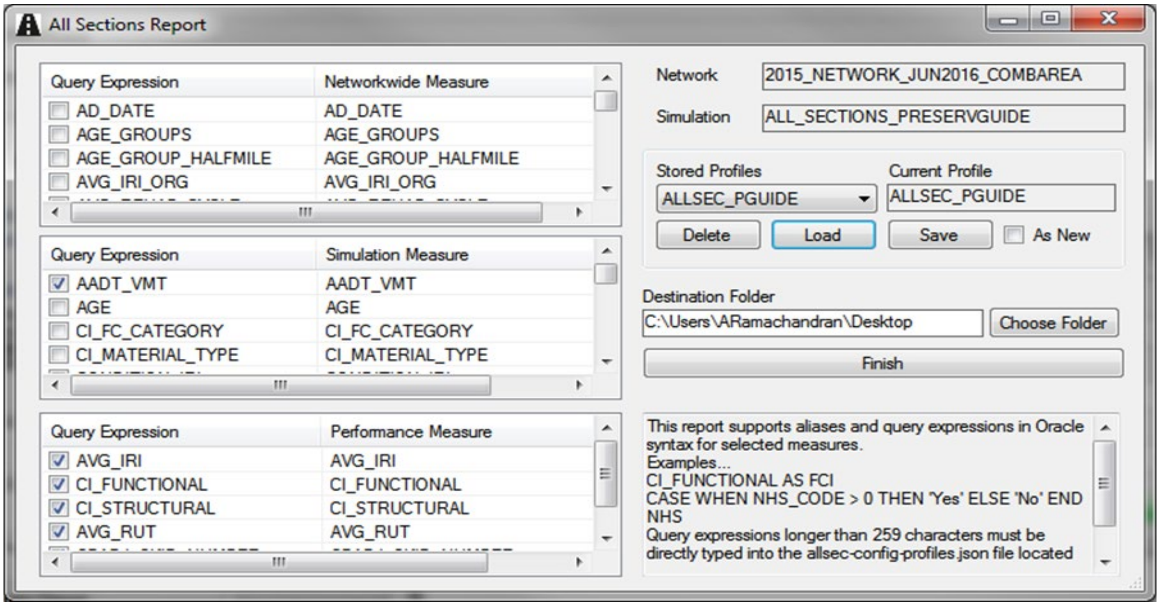
ii. Suggested lane miles (LM) per treatment should be high enough to be contract worthy. The exact number of LM varies by District and treatment.

iii. Average life extension should be within the range of expected values for the treatment.

iv. Overall benefit (LMY) and $/LMY Target by District.

Step 14. If no other reports are required, the procedure is complete. Otherwise, return to Step 9.

Step 15. Click "Generate Report" to open the "All Sections Shop DM Year & VMT Report" window, which is shown in the below image.



Step 16. Load a stored profile if available by selecting the appropriate profile name under “Stored Profiles” and then clicking “Load.”

i. If a stored profile is loaded, skip to Step 18.

ii. Otherwise, proceed to Step 17.

Step 17. If a profile does not already exist for a simulation, select the appropriate “Networkwide,” “Simulation,” and “Performance” measures in the three tables to the left of the above image. Check “As New,” then enter a profile name in the text box under “Current Profile” and click “Save.”

Step 18. Click “Choose Folder” to select a destination folder and then click “Finish” to start the report generation.

Step 19. The report will be saved as a Microsoft Excel 2007 macro-enabled workbook (.xlsm) in the folder selected by the user. This report shows performance data for selected sections from the current year, forecasted condition data, feasible treatments with their cost, benefit (LMY) and other relevant information across the entire network for data discovery and reference purposes.

Additionally, the report supports aliases and query expressions in standard Oracle SQL query syntax for selected measures. A couple of examples are shown below[06/12/2019]:

CI_FUNCTIONAL AS FCI
CASE WHEN NHS_CODE > 0 THEN 'Yes' ELSE 'No' END NHS

The report also includes a new interface, shown in the below image, which allows the user to identify potential project candidates by filtering the report based on specific criteria. To use this feature, the user must enable macros in the Microsoft Excel spreadsheet report.

Custom Filter

YEAR		COUNTY	SHOP	DIR MILES		LANE MILES		AADT		NHS	MAIN_LINE	PAVEMENT_TYPE
>=2018		WI				>2		>1000	<2000			=F

Examples

>=2018	<=2020	CE	ELKTON	>1		>=2	<5	<100000		Yes	1	*FC*
		<>CE	*ELK*	>1	<2			>1000	<2000	No	<>2	=F
			<>ELKTON					500				<>F

Filter All sections

Identify project candidates by Treatment and $/LMY

ASPHALT PATCH ONLY

Show Top candidates

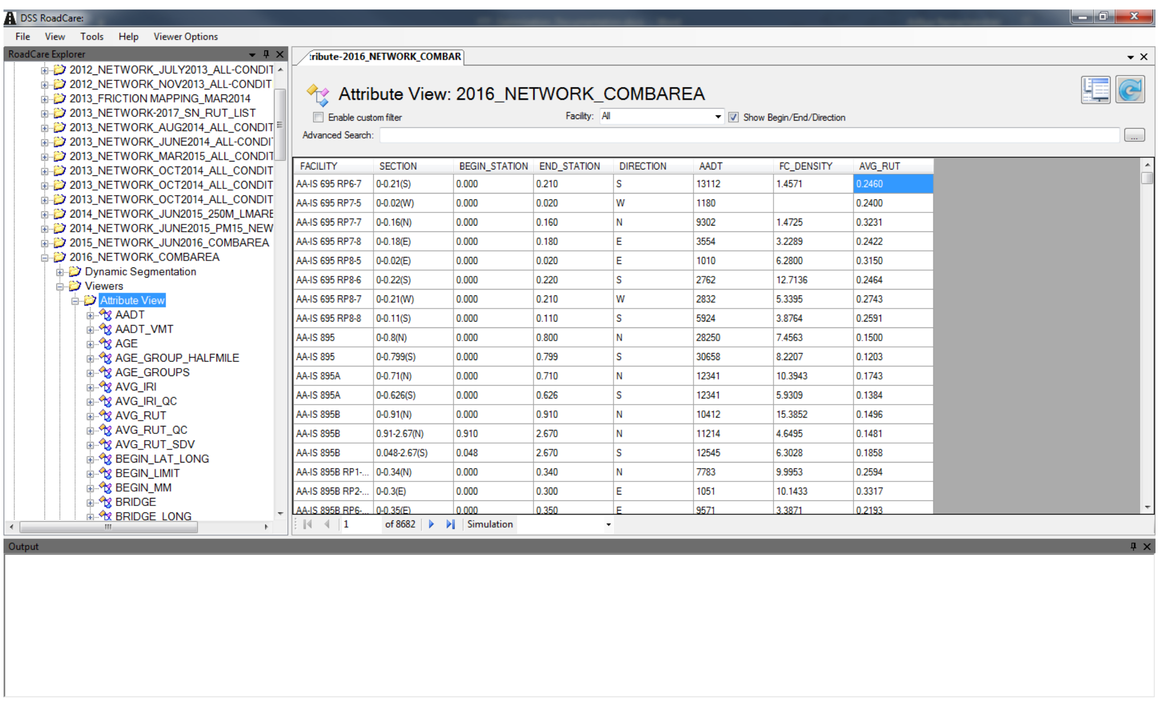
YEAR		COUNTY	SHOP	DIR MILES		LANE MILES		AADT		NHS	MAIN_LINE	ASPHALT PATCH ONLY $/LMY
>=2018	<=2019											<12000

Filter All sections

Step 20. If no other reports are required, the procedure is complete. Otherwise, return to Step 9.

Step 21. Return to the "RoadCare Explorer" window on the left hand side of the screen. Expand the options inside the "Viewers" module for the appropriate network by clicking on the "+" icon. Then, expand the options inside the "Attribute View" menu that appears in the list by clicking on the "+" icon.

Step 22. Double-click on an attribute to see its contents on the display window, as illustrated in the below image.

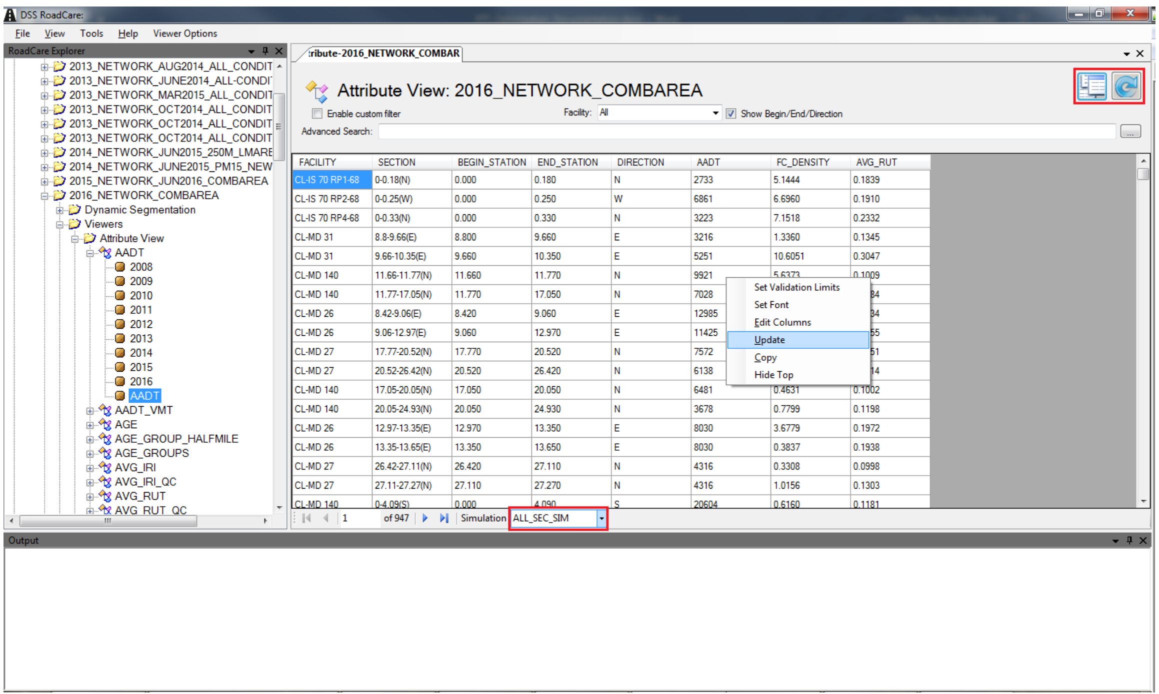


Step 23. The data grid lists "FACILITY," "SECTION," and the selected attribute values. In addition, the "BEGIN_STATION," "END_STATION," and "DIRECTION" fields can be displayed by checking "Show Begin/End/Direction" at the top of

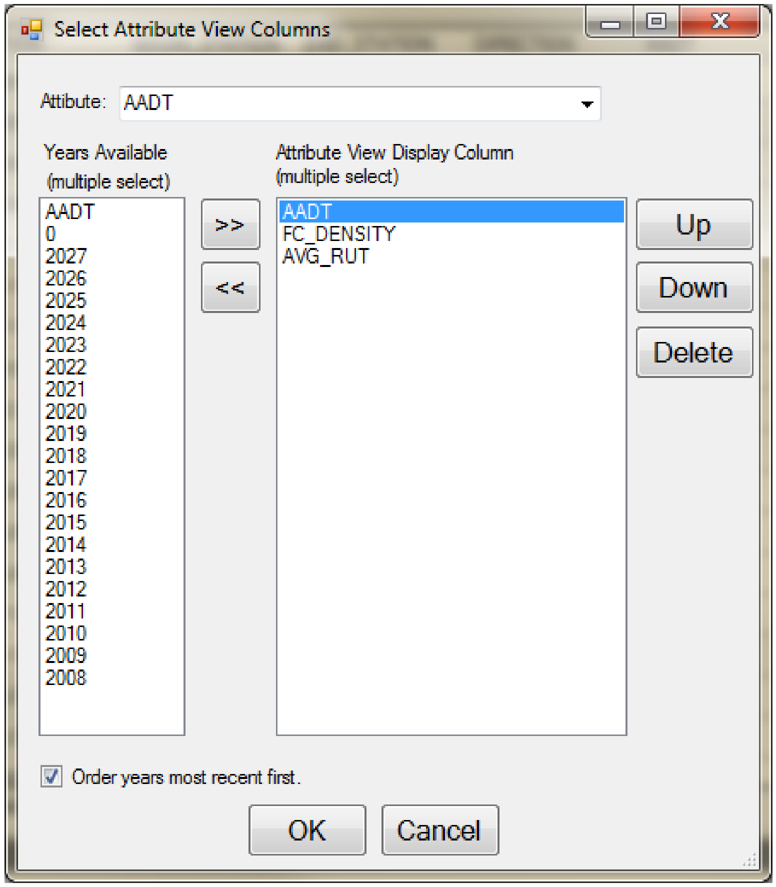
the viewer window. Clicking on any data grid column title sorts all the displayed data in ascending/descending order based on that attribute. Some cells in the data grid may appear empty. This is because the raw database did not have an attribute value for that specific section. For those sections, the default value used when the raw attribute was created is assigned during the analysis/simulation process. At the bottom of the data grid, the line toolbar allows the user to move within records and to display the attribute values that result from running a simulation.

Step 24. To display attribute values from a desired financial needs simulation, select the simulation name from the “Simulation” drop-down menu.

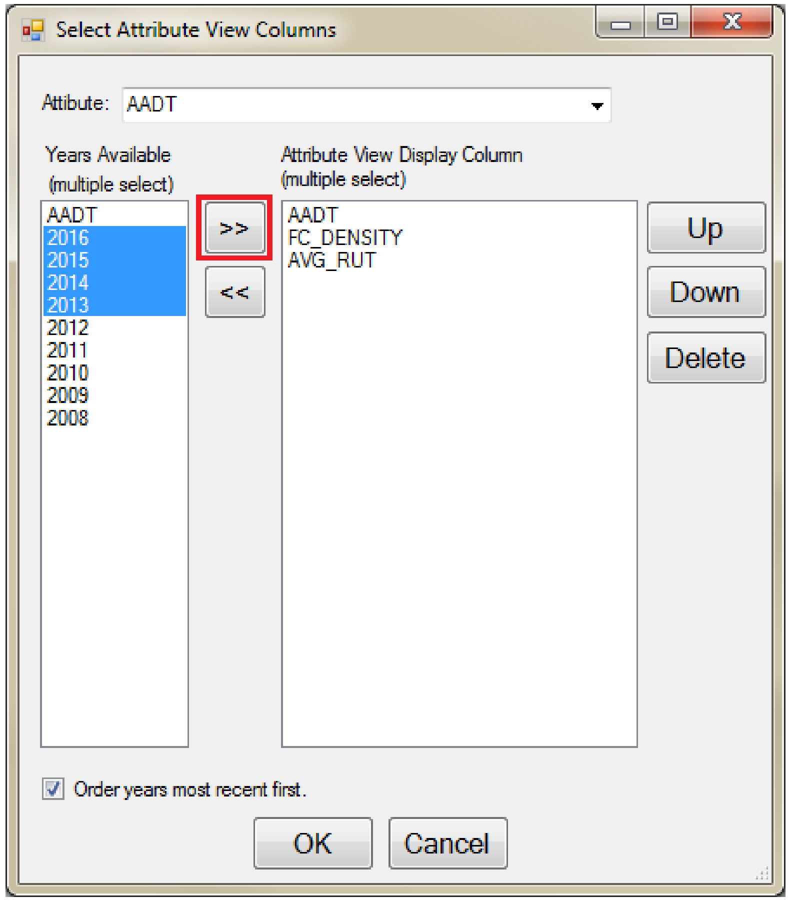
Step 25. Right-click on the results grid area and select “Update” to display the corresponding calculated attribute values, as illustrated in the below image.



Step 26. Right-click on the results grid area and select the “Edit Columns” option to display the “Select Attribute View Columns” window, which is shown in the below image.

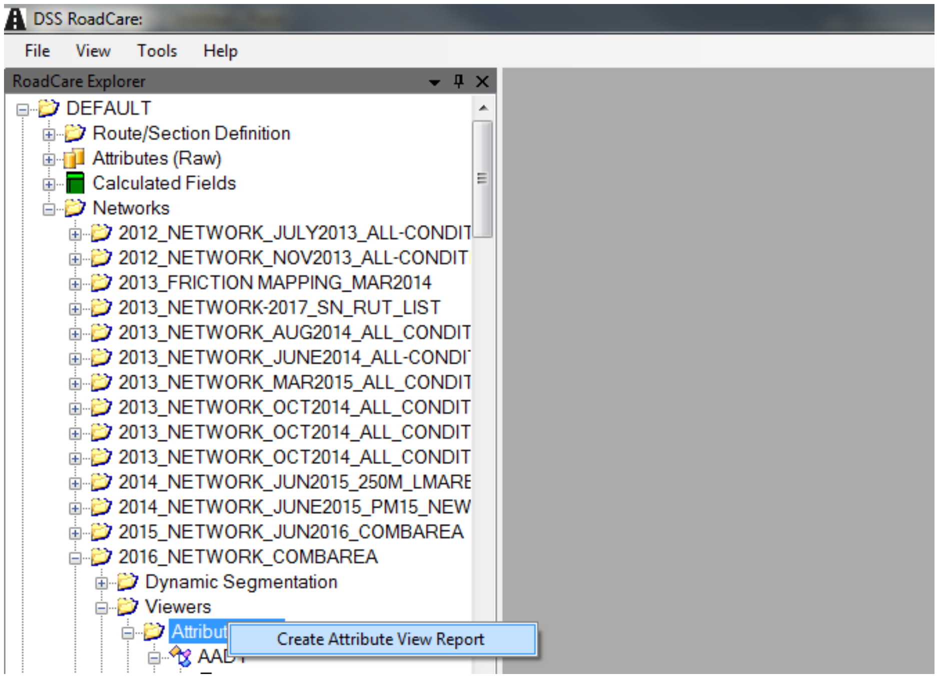


Step 27. From the “Attributes” drop-down menu located at the top of the “Select Attribute View Columns” window, select an attribute to display (e.g. AADT in the above example). If the attribute was included in the simulation criteria, future years will be available from the “Years Available (multiple select)” list. By default, the years are listed in ascending order; to reverse the order, uncheck the option “Order years most recent first.” The “Attribute View Display Column (multiple select)” contains the list of attributes that will be displayed. To add attributes to the display, highlight the desired attributes from the “Years Available (multiple select)” list and click the right-facing arrows icon shown in the below image.

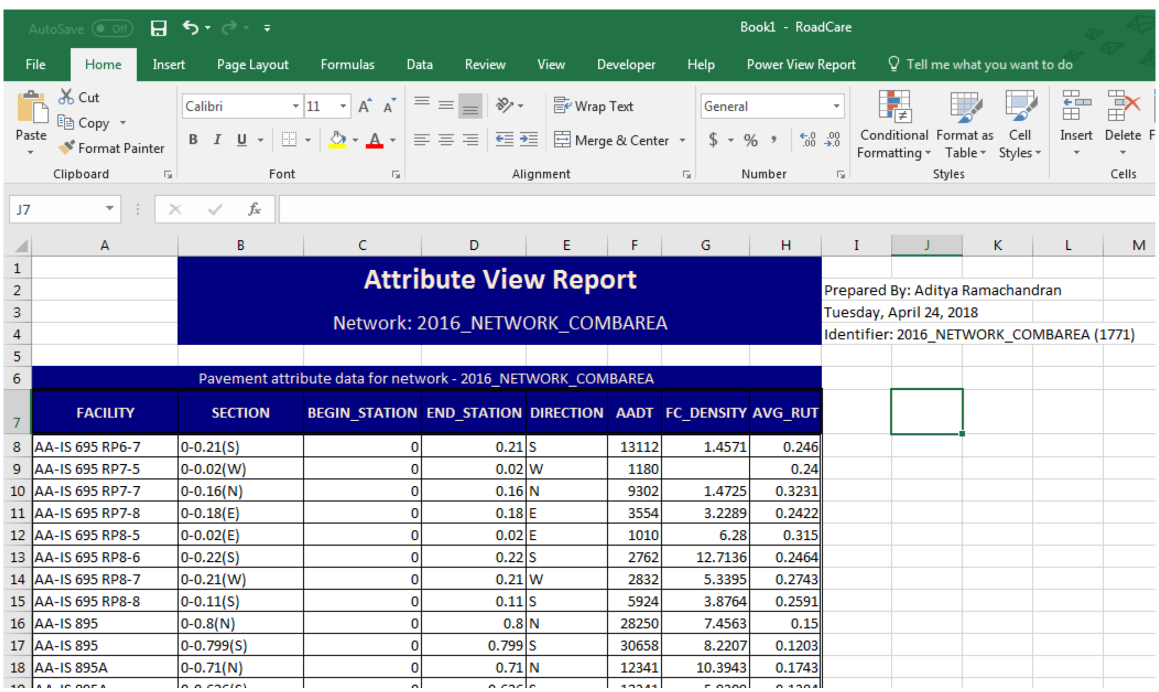


Step 28. The highlighted fields are now listed in the pane to the right labeled "Attribute View Display Column (multiple select)." These attribute values will be displayed in the "Attribute" view window. The order of the attributes can be sorted by choosing the "Up" or "Down buttons next to the "Attribute View Display Column (multiple select)" pane. The order in which the attributes are listed on the "Attribute View Display Column (multiple select)" pane is the actual order in which they will be displayed in the attribute view data grid. Attributes can be deleted from that list by highlighting them and pressing "Delete." The selected attributes will disappear from the list and also from the attribute view data grid. When the order is set, click "OK" to accept the selected display columns or click "Cancel" to go back to the previous screen.

Step 29. The selected attributes can be exported as a report in Microsoft Excel format. To generate the report, right-click on "Attribute View" under the "Viewers" menu on the "RoadCare Explorer Window" and select "Create Attribute View Report," as illustrated in the below image.



Step 30. The report will be displayed in Microsoft Excel format. An example of an attribute report is shown in the below image.



FACILITY	SECTION	BEGIN_STATION	END_STATION	DIRECTION	AADT	FC_DENSITY	AVG_RUT
AA-IS 695 RP6-7	0-0.21(S)	0	0.21	S	13112	1.4571	0.246
AA-IS 695 RP7-5	0-0.02(W)	0	0.02	W	1180		0.24
AA-IS 695 RP7-7	0-0.16(N)	0	0.16	N	9302	1.4725	0.3231
AA-IS 695 RP7-8	0-0.18(E)	0	0.18	E	3554	3.2289	0.2422
AA-IS 695 RP8-5	0-0.02(E)	0	0.02	E	1010	6.28	0.315
AA-IS 695 RP8-6	0-0.22(S)	0	0.22	S	2762	12.7136	0.2464
AA-IS 695 RP8-7	0-0.21(W)	0	0.21	W	2832	5.3395	0.2743
AA-IS 695 RP8-8	0-0.11(S)	0	0.11	S	5924	3.8764	0.2591
AA-IS 895	0-0.8(N)	0	0.8	N	28250	7.4563	0.15
AA-IS 895	0-0.799(S)	0	0.799	S	30658	8.2207	0.1203
AA-IS 895A	0-0.71(N)	0	0.71	N	12341	10.3943	0.1743

Step 31. If no other reports are required, the procedure is complete. Otherwise, return to Step 9.

11 APPENDICES

11.01 SKID COLLECTION LIST SQL STATEMENT

Use the following statement in Oracle SQL Developer to create the Skid Collection List. Any occurrence of “collection_2016” should be replaced with the current year’s date (e.g. for 2019, update to read “collection_2019”.

```
--FROM PAV_CONHIST DEVELOPMENT
SELECT RSECTION,
  DISTRICT,
  CO,
  ID_PREFIX,
  ID_RTE_NO,
  MUNICIPALITY,
  MP_SUFFIX,
  EXIT_NUMBER,
  RAMP_NUMBER,
  D,
  IS_INV_DIR,
  BEGIN_DIR_MP,
  END_DIR_MP,
  ROAD_NAME_START,
  BEGIN_DESCRIPTION,
  END_DESCRIPTION,
  SECTION_LENGTH,
  COLL_CATEGORY,
  CASE
    WHEN COLL_CATEGORY IN (4,8,9,10)
    AND DISTRICT       IN (1,2,3,4)
    AND SECTION_LENGTH >=0.1
    THEN 'D1, D2, D3, D4 SHORT_ROADS_AND_RAMPS'
    WHEN COLL_CATEGORY IN (4,8,9,10)
    AND DISTRICT       IN (5,6,7,8)
    AND SECTION_LENGTH >=0.1
```

```
    THEN 'D5, D6, D7, BC SHORT ROADS AND RAMPS'
    WHEN COLL_CATEGORY IN (3)
    THEN 'NON-INVENTORY DIRECTION >= 1 MILE '
    WHEN COLL_CATEGORY IN (5,7)
    THEN 'INVENTORY DIRECTION >= 1 MILE '
    WHEN ID_PREFIX IN ('DM','TL')
    THEN 'QC_TESTING'
    ELSE NULL
  END AS FRICTION_GROUP,
  --  PRIORITY ARAN_PRIORITY,
  GOVT_CONTROL,
  NHS_CODE,
  INV_BMP,
  INV_EMP,
  BEG_LAT,
  BEG_LONG,
  END_LAT,
  END_LONG,
  GLOBAL_ROUTE_ID,
  SUB_ROUTE_ID,
  ROUTE,
  TRIMROUTE,
  ROUTEID,
  MULTIPLE_BEG_INT,
  MULTIPLE_END_INT,
  RVISIKEY,
  ASSOCIATED_ID_PREFIX,
  FDIR,
  BEGIN_SECTION_DESC,
  BEGIN_SECTION_MILE_POINT,
  END_SECTION_DESC,
  END_SECTION_MILE_POINT,
  COLLECTION_YEAR
FROM
```

```
(
----Includes SHA and MDTA Routes in the Inventory Direction >=1 mile
SELECT *
FROM collection_list
WHERE collection_year = 2020
AND GOVT_CONTROL     IN (1,31)
 --  AND IS_INV_DIR     <> 1 --2019 Collection
  AND IS_INV_DIR     = 1  --2020 Collection
AND RAMP_NUMBER   IS NULL
--AND coll_category IN (3) --2019 Collection Non Inventory Direction
AND coll_category IN (5,7)  --2020 Collection - Inventory Direction
UNION
-- Includes Test Loops and Dummy Files
SELECT *
FROM collection_list C
WHERE id_prefix IN ('DM','TL')
 AND collection_year                  = 2020
UNION
--Includes Half of SHA and MDTA ramps and short roads >=0.10 (alternating
        years D1-D4, then D5-D8)
SELECT *
FROM collection_list C
WHERE RAMP_NUMBER IS NOT NULL
 --  AND DISTRICT      IN (1,2,3,4) --2019 Collection
   AND DISTRICT  IN (5,6,7,8)  --2020 Collection
AND collection_year                  = 2020
AND GOVT_CONTROL                     IN (1,31)
AND COLL_CATEGORY                    IN (4,8,9,10)
AND SECTION_LENGTH                   >=.1
AND (GLOBAL_ROUTE_ID, SUB_ROUTE_ID) IN
 (SELECT GLOBAL_ROUTE_ID,
   SUB_ROUTE_ID
 FROM
   (SELECT GLOBAL_ROUTE_ID,
```

```
          SUB_ROUTE_ID,
          SUM(DIR_EMP-DIR_BMP) MILES
        FROM SECTION_TABLE
        WHERE HMIS_YEAR = 2016  --Most recent inventory year
        GROUP BY GLOBAL_ROUTE_ID,
          SUB_ROUTE_ID
        )
      WHERE MILES >=0.1
      )
    )
  ORDER BY district,
    routeid,
begin_dir_mp;
```

11.02 TEST LOOP DATA ANALYSIS DETAILS

Data QC

Data QC checks are performed for data such as the ARAN vehicle's DMI, pavement imagery, IRI, rut, cracking (FCD and SCD), and CrossFall. The MDOT-SHA test loop data collection (and therefore data analysis) is divided into the following two types:

a. initial data collection program (pre-collection); and
b. three week MDOT-SHA test loop data collection program (throughout the FED collection and delivery season).

Pre-Collection Data Quality Acceptance - Initial Data Collection (10 MDOT-SHA test loop runs before data collection)

For each ARAN vehicle and within 30 days of the beginning of FED's ARAN collection season, 10 consecutive MDOT-SHA test loops runs are performed and the resulting data QC'd and QA'd by the FED Pavement Testing Team (PTT) ARAN staff, and the deliverables are provided to the Pavement and Geotechnical Division (PAGD) of the DPT for network uploading and SQL database importing.

DMI values should be within the range of 1,000 ± 1 millimiles for the 1,000 millimiles long DMI section.

For the remaining measures, which include IRI, cross slope, rut, cracking (FCD, SCD, percent cracking for concrete), and friction[06/12/2019], the following acceptance criteria is defined as follows:

- Results from each section are compared to the values predicted using the past five years of data for that section.
- Prediction is done using a linear trend line (linear regression) over the past five years of data (average section performance measure values for each year).

If the value for the current year is within the range defined by the equation[06/12/2019] below, then the data are accepted, and if other QC checks pass then routine MDOT-SHA data collection can start. Otherwise, the accuracy of the data should be investigated and the source of the issue should be addressed.

Current year's predicted value ±
(last year's 95th percentile – last year's 5th percentile)/2

Analysis and acceptance of the MDOT-SHA test loop data is conducted within 5 days of data collection. All parties involved are notified of the results.

Three Week Data Collection Program (3 MDOT-SHA test loop runs every 3 weeks during data collection season)

For each MDOT-SHA operated ARAN vehicle, 3 consecutive data collection runs are performed on 45 test loop sample sections, which provides the pavement management engineers with the opportunity to continuously control the accuracy and consistency of the ARAN data throughout the data collection season. The sample sections vary in length, pavement structure, pavement type, traffic level, number of lanes, distress level, etc. Once the test loop data have been collected and QC'd and QA'd by the FED PTT ARAN staff, the deliverables are then provided to the PAGD DPT for network uploading and SQL database importing.

If the average section performance measure value is within the range of the equation[06/12/2019] below, then the data are accepted, and if the remaining QC checks pass, then the routine data collection can start for the ARAN vehicle in question. Otherwise, the accuracy of the data should be investigated and the source(s) of issue should be addressed.

Current year's average value from initial collection ±
(last year's 95th percentile – last year's 5th percentile)/2

Analysis and acceptance of the MDOT-SHA test loop data is conducted within 5 days of data collection. All parties involved are notified of the results.

Error Resolution (Corrective Actions)

- Identifying issue sources:
  - Inquiry from FED for recent change of settings, maintenance activity, or suspicious observations.
  - Inquiry from DPT and DAT to make sure used protocols used are valid and the processing steps have been correctly followed.
  - Exploring other issues not considered above, such as but not limited to data collection equipment calibration, equipment configuration, data processing protocols, and data processing steps.
- Evaluating the data collected after the last acceptable MDOT-SHA test loop runs to determine the affected files.
- Decision-making for addressing issue:
  - Evaluating affected data and all possible solutions for correcting the data.
  - Establishing a course of action for replacing the affected data with acceptable data and, correcting the data if possible or sending a recollection list to FED.
- If the source of error is an ARAN-related change (settings or physical) then:
  - Addressing issue by FED
  - New MDOT-SHA test loop runs
  - MDOT-SHA test loop QC check
  - If QC check, passed then start routine ARAN data collection (and recollection, if needed).

Test Loop Section Classifications

Three defined groups of MDOT-SHA test loop sections are used for data QC purposes. The first group are Ground Truth (GT) sections. These sections have had manual inspection/detection performed along the section (entire or a part of section) by trained raters for one or more condition measures and/or will have manual detections performed in the future when needed. At present, the MDOT-SHA test loop has DMI, IRI, rut, and crack GT sections, which are listed in the below table. However, based on the need for GT studies, additional GT sections can be added to the list in the future.

Ground Truth Section	TL Segment	Pavement Type	Begin MP	End MP	Begin		End		Section Length (mile)
					Latitude	Longitude	Latitude	Longitude	
GT DMI section	22	Asphalt	7402.2	8404.35	39.154043759577846	-76.6748144217094	39.157287341389235	-76.65667903466958	1.00
GT IRI Section # 1	21 & 22	Asphalt	7209.41383	8408.99091	39.152812	-76.677961	39.15730352	-76.65658391	1199.58
GT IRI Section # 2	31 & 32& 33	AC/Conc. Bridge Deck/AC	10469.42	10595.2878	39.1650835	-76.64232933	39.166778	-76.64149728	125.87
GT Rut Section # 1	13	Asphalt	4910.06	5015.46	39.135567361866251	-76.668473234398192	39.135055463892392	-76.67027520991067	0.11
GT Rut Section # 2	39	Asphalt	11244.72	11298.21	39.164966732158682	-76.645302677066439	39.1648256451914	-76.646266099386835	0.05
GT Rut Section # 3	41	Asphalt	11511.34	11611.75	39.164371996985857	-76.650187970944373	39.164114971043148	-76.652031687517791	0.10
GT Rut Section # 4	43	Asphalt	12233.87	12339.24	39.163100863447191	-76.663443431859193	39.162967030126822	-76.6653228092672	0.11
GT Crack Section # 1	4	Asphalt - Ramp	1857.55	1966.64	39.164923054469	-76.644347058998832	39.163782631690708	-76.643579819959172	0.11
GT Crack Section # 2	15	Asphalt	5487.51	5680.11	39.135363166157653	-76.67885812476058	39.136171995324943	-76.682286702714464	0.19
GT Crack Section # 3	39	Asphalt	11244.72	11298.21	39.164966732158682	-76.645302677066439	39.1648256451914	-76.646266099386835	0.05
GT Crack Section # 4	43	Asphalt	12233.87	12339.24	39.163100863447191	-76.663443431859193	39.162967030126822	-76.6653228092672	0.11

These GT sections are used as a basis for verification and modification of pavement data collection and data processing techniques, protocols, and procedures for the year in which the GT study is conducted. GT studies are typically performed when a change takes place in the data collection and/or processing procedures and data quality control is needed for validating the data.

DMI GT section: The DMI section is exactly one mile long and it is used for controlling the accuracy of the ARAN vehicle's DMI.

IRI GT sections: The IRI GT testing was performed in the right wheel path of the IRI GT sections in 2015 using a SurPRO 3500. The results were compared with the ARAN IRI results for validation purposes.

Rut GT sections: The rut GT study was performed in 2013. Data were collected using the following four reference approaches:

- a 6-ft straightedge used to collect data in each half of the lane,
- a stringline stretched across the full width of the lane,
- a stringline stretched across 10-ft of the lane, and
- a stringline stretched across 8-ft of the lane.

The manual rut measurement methods were compared with each other and with the automated ARAN rut measurements. The study was performed to establish reference rut values for the rut GT sections and to modify the ARAN rut processing protocol to obtain the most precise and accurate data from ARAN measurements.

Crack GT sections: The crack GT sections are four short asphalt pavement sections with different distress levels and crack types. Unsealed and sealed cracks were manually traced on the pavement images along these sections for test loop run 8390S3H4, which was performed on March 9, 2018. These sections will be used as the basis for checking the accuracy and consistency of the automated crack detection by the ARAN data collected vehicle and Vision software.

Cracks on concrete pavements are detected manually. At present there are no concrete crack GT sections in the MDOT-SHA test loop, but since it is a manual process, all the concrete sections of the first 10 ARAN test loop data collections (pre-collection test loops) can be used as GT sections for controlling the consistency of detectors throughout the collection season.

GT sections for other measures: The second group of MDOT-SHA test loop sections are the sections that have 100% reliable data and are ideal for use in run comparisons or for research purposes. These sections are used for the 3-week MDOT-SHA test loop data QC. These sections are relevant to the performance measure being evaluated in terms of pavement type. Since the condition data are affected by ARAN transitioning from one lane to another lane, sections including lane transition zones are not a part of this group of test loop sections. For example, roughness, rutting, and other measures are only compared if the section does not include a lane transition zone or do not have any other event such as debris, damp pavement, or milled pavement that can affect the data quality. These sections are used for performing data QC checks throughout the collection season.

These QC sections are presented in the following table (assuming that the lane transition zones are the only existing event and no other event such as lane change, debris, wet pavement, and so forth exists):

Segment	DMI	IRI	Rut & Cross Slopel	Asphalt Crack Density	Percent Slabs Cracked (JCP)	CRCP ConcreteCracking	Faulting	Friction	Lane Transition
1	×	✓	✓	✓	×	×	×	✓	×
2	×	✓	✓	✓	×	×	×	✓	×
3	×	×	×	×	×	×	×	×	✓
4	×	✓	✓	✓	×	×	×	✓	×
5	×	×	×	×	×	×	×	×	✓
6	×	✓	×	×	×	✓	×	✓	×
7	×	×	×	×	×	×	×	×	✓
8	×	×	×	×	✓	×	✓	×	×
9	×	✓	✓	✓	×	×	×	✓	×
10	×	✓	✓	✓	×	×	×	✓	×
11	×	✓	✓	✓	×	×	×	✓	×
12	×	✓	✓	✓	×	×	×	✓	×
13	×	✓	✓	✓	×	×	×	✓	×
14	×	✓	✓	✓	×	×	×	✓	×
15	×	✓	✓	✓	×	×	×	✓	×
16	×	×	×	×	×	×	×	×	✓
17	×	✓	✓	✓	×	×	×	✓	×
18	×	✓	✓	✓	×	×	×	✓	×
19	×	✓	✓	✓	×	×	×	✓	×
20	×	✓	×	✓	×	×	×	✓	×
21	×	✓	✓	✓	×	×	×	✓	×
22	✓	✓	✓	✓	×	×	×	✓	×
23	×	✓	✓	✓	×	×	×	✓	×
24	×	✓	✓	✓	×	×	×	✓	×
25	×	×	×	×	×	×	×	×	×
26	×	✓	✓	✓	×	×	×	✓	×
27	×	×	×	×	✓	×	×	×	✓
28	×	✓	×	×	×	✓	×	✓	×
29	×	×	×	×	✓	×	×	×	✓
30	×	✓	×	×	×	✓	×	✓	×
31	×	×	×	✓	×	×	×	×	×
32	×	×	×	×	×	×	×	×	×
33	×	×	×	✓	×	×	×	×	×
34	×	×	×	×	×	×	×	×	×
35	×	×	×	×	✓	×	✓	×	×
36	×	✓	✓	✓	×	×	×	✓	×
37	×	×	×	×	×	×	×	×	✓
38	×	×	×	✓	×	×	×	×	×
39	×	×	×	✓	×	×	×	×	×
40	×	✓	✓	✓	×	×	×	✓	×
41	×	✓	✓	✓	×	×	×	✓	×
42	×	✓	✓	✓	×	×	×	✓	×
43	×	✓	✓	✓	×	×	×	✓	×
44	×	×	×	✓	×	×	×	×	×
45	×	✓	✓	✓	×	×	×	✓	×

The third group of MDOT-SHA test loop QC sections includes those relevant sections for each performance measure excluding the zones with unreliable data such as data from transition zones, milled sections, damp pavements, and so forth. That is, only data from the flagged milepoints are excluded from calculations.

Standard Deviation

In the outlier review process, as outlined in Outlier Review, the outliers for each section are determined by means of predicting the current year performance measure using the past 5 years of data and using the standard deviation for that measure to compare the actual current performance measure with the predicted value. The standard deviation used in the outlier review process for each measure is determined using the current year test loop data. Since the sections studied in the outlier review are of different lengths, a single standard deviation for reviewing all the sections cannot be used. The test loop data are used to determine length dependent standard deviations for each measure. That is, for each performance measure, data from different lengths of test loop sections are compared to determine the section length-dependent equation of the standard deviation. The shorter sections are expected to have wider ranges of variability and as a result in higher standard deviations. Matching sections with an initial length of 0.1 mile and with incremental length additions of 0.1 mile are compared to build the standard deviation equation based on the section length.

11.03 FUND TYPE

Each Contract has a fund type and it is standard that the last two digits of the seven digit FMIS number indicate the Fund Type. For Example: "PG6395177," the "77" indicates a resurfacing and rehabilitation project. This Appendix is a complete list of the Capital Program Fund Categories.

Major Projects Funding Categories

60 **Inter County Connector** (ICC)
70 **Primary**
71 **Secondary**
72 **Interstate**
73 **Woodrow Wilson Bridge**

System Preservation Funding Categories

11 **Federal/County**
12 **Highway and Safety Operations**
13 **Operations** - A & G Projects
14 **Maintenance**
15 **General Construction**
18 **High Priority Local Projects**
23 **Truck Weigh**
24 **Environmental Preservation** – Landscaping, wildflower seeding, reforestation and rest areas.
25 **Transportation Enhancements** – Urban greenways, rail-trail conversions, preservations of certain historic sites, landscaping and pedestrian and bicycle improvements.
26 **Noise Barriers** – Retrofit noise barriers along existing highways, barrier rehabilitation and noise berms.
27 **Rest Areas**
28 **Access Controls**
29 **Facilities and Equipment**
30 **Crash Prevention**
31 **Pilot Program** - Discontinued
32 **Guardrail End Treatment**
33 **ADA (American Disability Act) Retrofit**
38 **Communications**
39 **Capital Equipment**
46 **Statewide Planning & Research**
49 **Environmental Compliance**
68 **Stimulus Package**
74 **Drainage Improvements** – Areas of recurring flood damage or road closures.
75 **Emergencies** – Major storm damage, slope failures, sinkholes or other unforeseen roadway or bridge emergency. Must be approved by MDOT.
76 **Safety and Spot Improvements** – Safety improvements at high accident locations, intersection capacity improvements, slide repairs, roundabouts, ramp modifications and

R/R crossings.

77 **Resurfacing and Rehabilitation** – Resurfacing, including concrete patching/joint sealing and pavement markings.

78 **Pedestrian Access to Transit Stops**

79 **Sidewalks** – Construction of retrofit sidewalks along State highways and reconstruction of replacement of existing sidewalks if a part of a revitalization effort in an officially designated urban revitalization area.

80 **Bridge Replacement & Rehabilitation** – Bridge replacement, deck replacements, major rehabilitations, deck overlays, parapet modifications, repainting and spot painting and all structure condition inspections.

81 **Park and Ride** – Park and Ride Lots, lot expansions and lighting.

82 **TMDL Compliance** – Total Maximum Daily Load for stormwater management.

83 **Urban Street Reconstruction** – Rehabilitation through urban areas that include pavement and drainage reconstruction. Projects may include local participation for sidewalks, street furniture, landscaping and other urban amenity improvements.

84 **Community Safety & Enhancements** – Improvements where the emphasis is on enhancing the existing infrastructure to promote economic revitalization such as resurfacing, reconstructing drainage, curb and gutter, landscaping, signing, parking bays and lighting. Formerly Neighborhood Conservation.

85 **Traffic Management** – New signals, signal system construction, signal reconstruction, raised pavement markers, lighting and signing.

86 **CHART** – Advanced traffic management systems.

87 **Intersection Capacity**

88 **Bicycle Retrofit**

89 **Not in use**.

99 **Billwork**

11.04 POSPAC LIST FILES MACRO

Copy and paste as directed in Step 3 of Post-Processing of ARAN GPS Data.

```
Sub MainList()
'Updateby20150706
Set folder = Application.FileDialog(msoFileDialogFolderPicker)
If folder.Show <> -1 Then Exit Sub
xDir = folder.SelectedItems(1)
Call ListFilesInFolder(xDir, True)
End Sub
Sub ListFilesInFolder(ByVal xFolderName As String, ByVal xIsSubfolders As
Boolean)
Dim xFileSystemObject As Object
Dim xFolder As Object
Dim xSubFolder As Object
Dim xFile As Object
Dim rowIndex As Long
Set xFileSystemObject = CreateObject("Scripting.FileSystemObject")
Set xFolder = xFileSystemObject.GetFolder(xFolderName)
rowIndex = Application.ActiveSheet.Range("A65536").End(xlUp).Row + 1
For Each xFile In xFolder.Files
  Application.ActiveSheet.Cells(rowIndex, 1).Formula = xFile.Name
  rowIndex = rowIndex + 1
Next xFile
If xIsSubfolders Then
  For Each xSubFolder In xFolder.SubFolders
    ListFilesInFolder xSubFolder.Path, True
  Next xSubFolder
End If
Set xFile = Nothing
Set xFolder = Nothing
Set xFileSystemObject = Nothing
End Sub
Function GetFileOwner(ByVal xPath As String, ByVal xName As String)
Dim xFolder As Object
Dim xFolderItem As Object
Dim xShell As Object
xName = StrConv(xName, vbUnicode)
xPath = StrConv(xPath, vbUnicode)
Set xShell = CreateObject("Shell.Application")
Set xFolder = xShell.Namespace(StrConv(xPath, vbFromUnicode))
If Not xFolder Is Nothing Then
  Set xFolderItem = xFolder.ParseName(StrConv(xName, vbFromUnicode))
End If
If Not xFolderItem Is Nothing Then
  GetFileOwner = xFolder.GetDetailsOf(xFolderItem, 8)
Else
  GetFileOwner = ""
End If
Set xShell = Nothing
Set xFolder = Nothing
Set xFolderItem = Nothing
End Function
```

11.05 BASE REPORT

The table below indicates the parameters required to generate the base report for collected ARAN data.

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
IDLocator	-	-	-	-	-
IDSession	-	-	-	-	-
BeginDistanceStamp	-	-	-	-	-
EndDistanceStamp	-	-	-	-	-
BeginChainage	-	-	-	-	-
EndChainage	-	-	-	-	-
Status	-	-	-	-	-
REPORTING_YEAR	FIRST		'2017'		Text
COLLECT_DATE	FIRST		[DCSessions].[DCSTimeStamp]		Text
COUNTY	FIRST		[Locators].[L_County]		Text
MUNICIPALITY	FIRST		[RoutedSegments].[MUNICIPALITY]		Text
ID_PREFIX	FIRST		[RoutedSegments].[ID_PREFIX]		Text
ID_ROUTE_NO	FIRST		[RoutedSegments].[ID_RTE_NO]		Text
MP_SUFFIX	FIRST		[RoutedSegments].[MP_SUFFIX]		Text
DIRECTION	FIRST		[Locators].[L_Dir]		Text
EXIT_NUMBER	FIRST		[RoutedSegments].[EXIT_NUMBER]		Text
RAMP_NUMBER	FIRST		[RoutedSegments].[RAMP_NUMBER]		Text
ASSOCIATED_ID_PREFIX	FIRST		[RoutedSegments].[ASSOCIATED_ID_PREFIX]		Text
GLOBAL_ROUTE_ID	FIRST		[RoutedSegments].[GLOBAL_ROUTE_ID]		NUMBER
SUB_ROUTE_ID	FIRST		[RoutedSegments].[SUB_ROUTE_ID]		NUMBER
ROUTEID	FIRST		COMPUTE {RoutedSegments, FIRST([ROUTEID]), , 0, 0}	HMIS ROUTEID, AS INPUT IN THE EFS	Text
DIR_BMP	FIRST			Will be populated in Oracle. Beginchainage/1000 for "matched" records	NUMBER
DIR_EMP	FIRST			Will be populated in Oracle. Enddistancestamp/1000 for "matched" records	NUMBER
INV_BMP	FIRST			Will be populated in Oracle.	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
INV_EMP	FIRST			Will be populated in Oracle	NUMBER
UNIQUERUN	FIRST		COMPUTE {DCSessions, FIRST([UniqueRun]), , 0, 0}		Text
COLLECTION_VEHICLE	FIRST		[DCSessions].[CollectionVehicle]		NUMBER
VERSION	FIRST		[DCSessions].[ARANVersion]		Text
SAT_NUMBER	AVG		COMPUTE {VehiclePositions, SUM([Satellites]), , 0, 0}		NUMBER
STATION_TIME	AVG		COMPUTE {StationData, AVG([StationTime]), , 0, 0}		NUMBER
ELAPSED_TIME	AVG		COMPUTE {StationData, AVG([ElapsedTime]), , 0, 0}		NUMBER
SPEED	AVG		COMPUTE {StationData, AVG([Speed]), , 0, 0}*2.23694	M/H	NUMBER
SPEED_FIRSTRAW	FIRST		[StationData].[Speed]*2.23694	M/H	NUMBER
GPS_LAT_BEGIN	FIRST		COMPUTE {VehiclePositions, FIRST([Latitude]), , 0, 0}*57.2958		NUMBER
GPS_LONG_BEGIN	FIRST		COMPUTE {VehiclePositions, FIRST([Longitude]), , 0, 0}*57.2958		NUMBER
GPS_LAT_END	LAST		COMPUTE {VehiclePositions, LAST([Latitude]), , 0, 0}*57.2958		NUMBER
GPS_LONG_END	LAST		COMPUTE {VehiclePositions, LAST([Longitude]), , 0, 0}*57.2958		NUMBER
ELEV_AVG	AVG		COMPUTE {VehiclePositions, AVG([Elevation]), , 0, 0}*3.2808399	FT	NUMBER
GRADE_AVG	AVG		COMPUTE {VehicleOrientations, AVG([Grade]), , 0, 0}*100		NUMBER
L_FAULTING_COUNT	COUNT		COMPUTE {ConcreteFaults, AVG([Height]), [location]='LeftFault', 0, 0}	COUNT	NUMBER
L_FAULTING_HEIGHT	FIRST		COMPUTE {ConcreteFaults, FIRST([Height]),[location]='LeftFault' , 0, 0}*39.3701	IN	NUMBER
R_FAULTING_COUNT	COUNT		COMPUTE {ConcreteFaults, AVG([Height]),[location]='RightFault' , 0, 0}	COUNT	NUMBER
R_FAULTING_HEIGHT	FIRST		COMPUTE {ConcreteFaults, FIRST([Height]),[location]='RightFault' , 0, 0}*39.3701	IN	NUMBER
FAULTING_LCMS_ABS_AVG_IN	AVG		COMPUTE {Faults, AVG([ABS_AvgFault]), , 0, 0}	Absolute Value Faulting, IN	NUMBER
FAULTING_LCMS_MIN_IN	MIN		COMPUTE {FaultsReport, MIN([FaultMeasurement*1000 / 25.4]), , 0, 0}	Minimum Fault Value. Not the absolute value, just the minimum raw value, which can be negative., IN	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
FAULTING_LCMS_MAX_IN	MAX		COMPUTE {FaultsReport, MAX([FaultMeasurement*1000 / 25.4]), , 0, 0}	Maximum faulting value, IN	NUMBER
ROLL	AVG		COMPUTE {TransverseData, AVG([Roll]), , 0, 0}*100		NUMBER
PITCH	AVG		COMPUTE {AttitudeData, AVG([Pitch]), , 0, 0}*100		NUMBER
ELEV_BEGIN	FIRST		COMPUTE {VehiclePositions, FIRST([Elevation]), , 0, 0}*3.2808399	FT	NUMBER
ELEV_END	LAST		COMPUTE {VehiclePositions, LAST([Elevation]), , 0, 0}*3.2808399	FT	NUMBER
L_IRI_FIRSTRAW	FIRST		[StationData].[LeftIRI]*63.36	IN/MILE	NUMBER
R_IRI_FIRSTRAW	FIRST		[StationData].[RightIRI]*63.36	IN/MILE	NUMBER
L_RUT_FIRSTRAW	FIRST		[RutData].[LeftRut]*1000/25.4	IN	NUMBER
R_RUT_FIRSTRAW	FIRST		[RutData].[RightRut]*1000/25.4	IN	NUMBER
EVENT_DEBRIS_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Debris', 0, 0}>0;	1; 0		NUMBER
EVENT_STOPBAR_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Stop_Bar', 0, 0}>0;	1;0		NUMBER
EVENT_LANE_DEVIATION_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Lane_Deviation', 0, 0}>0;	1;0		NUMBER
EVENT_MILLED_SURFACE_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Milled_Pavement', 0, 0}>0;	1;0		NUMBER
EVENT_BRIDGE_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Bridge', 0, 0}>0;	1;0		NUMBER
EVENT_CRACK_SEAL_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Sealed_Cracking_Exists', 0, 0}>0;	1;0		NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
EVENT_CROSSWALK_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Crosswalk', 0, 0}>0;	1;0		NUMBER
EVENT_RAILROAD_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Railroad', 0, 0}>0;	1;0		NUMBER
EVENT_DISREGARD_CRACK_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Disregard_Cracking', 0, 0}>0;	1;0		NUMBER
EVENT_BRICK_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Brick_Pavement', 0, 0}>0;	1;0		NUMBER
EVENT_BAD_IMAGE_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Bad_Image', 0, 0}>0;	1;0		NUMBER
EVENT_CRCP_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_CRCP_Exists', 0, 0}>0;	1;0		NUMBER
EVENT_JCP_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_JCP_Exists', 0, 0}>0;	1;0		NUMBER
EVENT_WET_SURFACE_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Wet_Surface', 0, 0}>0;	1;0		NUMBER
EVENT_PAVE_CHANGE_OFFICE	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Pave_Change', 0, 0}>=0;	1;0		NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
JCP_CRACKED_SLAB	SUM		COMPUTE {ManualDistressesValues, COUNT([DistressTypeName]),[DistressTypeName]='JCP_Cracked_Slab', 0, 0}	COUNT	NUMBER
JCP_INTACT_SLAB	SUM		COMPUTE {ManualDistressesValues, COUNT([DistressTypeName]),[DistressTypeName]='Intact_JCP_Slab', 0, 0}	COUNT	NUMBER
CRCP_PATCH_CONCRETE	SUM	COMPUTE {ManualDistressesValues, SUM([Area*10.7639]), [DistressTypeName]='CRCP_Patch_Concrete', 0, 0}>0;	COMPUTE {ManualDistressesValues, SUM([Area*10.7639]), [DistressTypeName]='CRCP_Patch_Concrete', 0, 0};0	SQFT	NUMBER
CRCP_PATCH_ASPHALT	SUM	COMPUTE {ManualDistressesValues, SUM([Area * 10.7639]), [DistressTypeName]='CRCP_Patch_Asphalt', 0, 0}>0;	COMPUTE {ManualDistressesValues, SUM([Area * 10.7639]), [DistressTypeName]='CRCP_Patch_Asphalt', 0, 0};0	SQFT	NUMBER
CRCP_PUNCHOUT	SUM	COMPUTE {ManualDistressesValues, SUM([Area * 10.7639]), [DistressTypeName] = 'CRCP_Punchout', 0, 0}>0;	COMPUTE {ManualDistressesValues, SUM([Area * 10.7639]), [DistressTypeName] = 'CRCP_Punchout', 0, 0};0	SQFT	NUMBER
CRCP_LONG	SUM	COMPUTE {ManualDistressesValues, SUM([Area * 10.7639]), [DistressTypeName] = 'CRCP_Long', 0, 0}>0;	COMPUTE {ManualDistressesValues, SUM([Area * 10.7639]), [DistressTypeName] = 'CRCP_Long', 0, 0};0	SQFT	NUMBER
EVENT_LANE_DEVIATION_FIELD	MAX	COMPUTE {CollectedSpanEvents , FIRST([Length]),[EventName]='Lane', 0, 0}>0;	1;0		NUMBER
EVENT_CONSTRUCTION_FIELD	MAX	COMPUTE {CollectedSpanEvents , FIRST([Length]),[EventName]='Construction', 0, 0}>0;	1;0		NUMBER
EVENT_NEW_PAVEMENT_FIELD	MAX	COMPUTE {CollectedSpanEvents , FIRST([Length]),[EventName]='New', 0, 0}>0;	1;0		NUMBER
EVENT_MILLED_FIELD	MAX	COMPUTE {CollectedSpanEvents , FIRST([Length]),[EventName]='Milled', 0, 0}>0;	1;0		NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
EVENT_ROUNDABOUT_FIELD	MAX	COMPUTE {CollectedSpanEvents , FIRST([Length]),[EventName]='Roundabout', 0, 0}>0;	1;0		NUMBER
EVENT_WET_FIELD	MAX	COMPUTE {CollectedSpanEvents , FIRST([Length]),[EventName]='Wet', 0, 0}>0;	1;0		NUMBER
EVENT_DEBRIS_FIELD	MAX	COMPUTE {CollectedSpanEvents , FIRST([Length]),[EventName]='Desbris', 0, 0}>0;	1;0		NUMBER
EVENT_ROAD_CLOSED_FIELD	MAX	COMPUTE {CollectedPointEvents, FIRST([MaxSeparation]),[EventName]='Closed', 0, 0}>0;	1;0		NUMBER
EVENT_RUMBLE_STRIP_FIELD	MAX	COMPUTE {CollectedPointEvents, FIRST([MaxSeparation]),[EventName]='Strips', 0, 0}>0;	1;0		NUMBER
EVENT_TRAFFIC_FIELD	MAX	COMPUTE {CollectedPointEvents, FIRST([MaxSeparation]),[EventName]='Traffic', 0, 0}>0;	1;0		NUMBER
ImageROW	FIRST		COMPUTE {Image, LASTKNOWN([JPEGNAME]), [Name] = 'ROW', 1, 1}		TEXT
ImageLeft	FIRST		COMPUTE {Image, LASTKNOWN([JPEGNAME]), [Name] = 'Left', 1, 1}		TEXT
ImagePavement_Optical	FIRST		COMPUTE {Image, LASTKNOWN([JPEGNAME]), [Name] = 'Pavement', 0, 0}		TEXT
ImagePavement_Depth	FIRST		COMPUTE {Image, LASTKNOWN([JPEGNAME]), [Name] = 'LCMSRange', 0, 0}		TEXT
ImagePavement_3D	FIRST		COMPUTE {Image, LASTKNOWN([JPEGNAME]), [Name] = 'LCMS3D', 0, 0}		TEXT
IMAGEPATH_ROW	FIRST		COMPUTE {Image, LASTKNOWN([imagepath]), [Name] = 'ROW' , 0, 0}		TEXT
IMAGEPATH_LEFT	FIRST		COMPUTE {Image, LASTKNOWN([imagepath]), [Name] = 'LEFT', 0, 0}		TEXT
IMAGEPATH_PAVEMENT_OPTICAL	FIRST		COMPUTE {Image, LASTKNOWN([imagepath]), [Name] = 'Pavement', 0, 0}		TEXT
IMAGEPATH_PAVEMENT_DEPTH	FIRST		COMPUTE {Image, LASTKNOWN([imagepath]), [Name] = 'LCMSRange', 0, 0}		TEXT
IMAGEPATH_PAVEMENT_3D	FIRST		COMPUTE {Image, LASTKNOWN([imagepath]), [Name] = 'LCMS3D', 0, 0}		TEXT

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
IMAGENAME_ROW	FIRST		COMPUTE {Image, LASTKNOWN([IMAGENAME]), [Name] = 'ROW' , 0, 0}		TEXT
IMAGENAME_LEFT	FIRST		COMPUTE {Image, LASTKNOWN([imagename]), [Name] = 'LEFT', 0, 0}		TEXT
IMAGENAME_PAVEMENT_OPTICAL	FIRST		COMPUTE {Image, LASTKNOWN([imagename]), [Name] = 'PAVEMENT', 0, 0}		TEXT
IMAGENAME_PAVEMENT_DEPTH	FIRST		COMPUTE {Image, LASTKNOWN([imagename]), [Name] = 'LCMSRange', 0, 0}		TEXT
IMAGENAME_PAVEMENT_3D	FIRST		COMPUTE {Image, LASTKNOWN([imagename]), [Name] = 'LCMS3D', 0, 0}		TEXT
IMAGEFRAME	FIRST		COMPUTE {Image, FIRST([imageframe]), , 0, 0}		TEXT
LANEWIDTH_AVG	AVG		COMPUTE {Lanewidth, AVG([Lanewidth]), [lanewidth]>0, 0, 0}*3.280839895	FT	NUMBER
LANEWIDTH_FIRST	FIRST		COMPUTE {Lanewidth, FIRST([Lanewidth]), [lanewidth]>0, 0, 0}*3.280839895	FT	NUMBER
LeftOffset	AVG		COMPUTE {CalculatedRutValues, AVG([LeftOffset]),[IsValid] = 1 and [RutCalculationMethod] = 'Wire', 0, 0}*3.280839895	FT	NUMBER
RightOffset	AVG		COMPUTE {CalculatedRutValues, AVG([RightOffset]),[IsValid] = 1 and [RutCalculationMethod] = 'Wire', 0, 0}*3.280839895	FT	NUMBER
CrossFallinPercent	AVG		COMPUTE {CalculatedRutValues, AVG([CrossFallInPercent]),[IsValid] =1 and [RutCalculationMethod] = 'Wire', 0, 0}		NUMBER
CrossFallinRadians	AVG		COMPUTE {CalculatedRutValues, AVG([CrossfallInRadians]),[IsValid] =1 and [RutCalculationMethod] = 'Wire' , 0, 0}		NUMBER
LeftPondDepth	AVG		COMPUTE {CalculatedRutValues, FIRST([LeftPondDepth]), [LeftPondIsValid]=1 and [IsValid]=1 and [RutCalculationMethod] = 'Wire' , 0, 0}*1000/25.4	IN	NUMBER
RightPondDepth	AVG		COMPUTE {CalculatedRutValues, AVG([RightPondArea]), [RightPondIsValid]=1 and [IsValid]=1 and [RutCalculationMethod] = 'Wire' , 0, 0}*1000/25.4	IN	NUMBER
LeftPondArea	AVG		COMPUTE {CalculatedRutValues, AVG([LeftPondArea]),[LeftPondIsValid]=1 and [IsValid]=1 and [RutCalculationMethod] = 'Wire', 0, 0}*(1000/25.4)*(1000/25.4)	SQIN	NUMBER
RightPondArea	AVG		COMPUTE {CalculatedRutValues, AVG([RightPondArea]),[RightPondIsValid]=1 and [IsValid] = 1 and [RutCalculationMethod] = 'Wire', 0, 0}*(1000/25.4)*(1000/25.4)	SQIN	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
LaneOffset	AVG		COMPUTE {CalculatedRutValues, AVG([LaneOffset]), [IsValid] = 1 and [RutCalculationMethod] = 'Wire', 0, 0}*3.280839895	FT	NUMBER
RutCalculationMethod	FIRST		COMPUTE {CalculatedRutValues, FIRST([RutCalculationMethod]), , 0, 0}		TEXT
LeftEdgeType	FIRST		COMPUTE {CalculatedRutValues, FIRST([LeftEdgeType]),[IsValid] = 1 and [LeftEdgeIsValid] =1 and [RutCalculationMethod] = 'Wire' , 0, 0}		TEXT
RightEdgeType	FIRST		COMPUTE {CalculatedRutValues, FIRST([RightEdgeType]),[IsValid] = 1 and [RightEdgeIsValid] = 1 and [RutCalculationMethod] = 'Wire' , 0, 0}		TEXT
L_RUT_WIRE	AVG		COMPUTE {CalculatedRutValues, AVG([LeftRut]), [LeftRutIsValid] =1 and [IsValid] = 1 and [RutCalculationMethod] = 'Wire', 0, 0}*1000/25.4	IN	NUMBER
R_RUT_WIRE	AVG		COMPUTE {CalculatedRutValues, AVG([RightRut]), [RightRutIsValid]=1 and [IsValid]=1 and [RutCalculationMethod] = 'Wire', 0, 0}*1000/25.4	IN	NUMBER
AVG_WIRE_RUT	AVG		((COMPUTE {CalculatedRutValues, AVG([LeftRut]), [LeftRutIsValid]=1 and [IsValid]=1 and [RutCalculationMethod] = 'Wire', 0, 0}*1000/25.4)+(COMPUTE {CalculatedRutValues, AVG([RightRut]), [RightRutIsValid]=1 and [IsValid]=1 and [RutCalculationMethod] = 'Wire', 0, 0}*1000/25.4))/2	IN	NUMBER
L_RUT_RAW	AVG		COMPUTE {RutData, AVG([LeftRut]), , 0, 0}*1000/25.4	IN	NUMBER
R_RUT_RAW	AVG		COMPUTE {RutData, AVG([RightRut]), , 0, 0}*1000/25.4	IN	NUMBER
AVG_RUT_RAW	AVG		(COMPUTE {RutData, AVG([LeftRut]), , 0, 0}*1000/25.4 + COMPUTE {RutData, AVG([RightRut]), , 0, 0}*1000/25.4)/2	IN	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
L_IRI_ADJ_SP_CH	AVG			This field is intentionally left blank when reported out of Vision. It will be populated with adjusted left IRI values to consider the change in travel speed of the vehicle during collection., IN/MILE	NUMBER
R_IRI_ADJ_SP_CH	AVG			This field is intentionally left blank when reported out of Vision. It will be populated with adjusted right IRI values to consider the change in travel speed of the vehicle during collection., IN/MILE	NUMBER
PERC_IRI_FROM_SP_CH	AVG			This field is intentionally left blank when reported out of Vision. It will be populated with a code indicating the extent and type of vehicle acceleration / deceleration during collection., IN/MILE	NUMBER
L_IRI	AVG		COMPUTE {PProcRoughness, AVG([LeftIRI]), , 0, 0}*63.36	IN/MILE	NUMBER
R_IRI	AVG		COMPUTE {PProcRoughness, AVG([RightIRI]), , 0, 0}*63.36	IN/MILE	NUMBER
L_IRI_STATION DATA	AVG		COMPUTE {StationData, AVG([LeftIRI]), , 0, 0}*63.36	IN/MILE	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
R_IRI_STATION DATA	AVG		COMPUTE {StationData, AVG([RightIRI]), , 0, 0}*63.36	IN/MILE	NUMBER
L_IRI_PROCESSED	AVG		COMPUTE {PProcRoughness, AVG([LeftIRI]), , 0, 0}*63.36	IN/MILE	NUMBER
R_IRI_PROCESSED	AVG		COMPUTE {PProcRoughness, AVG([RightIRI]), , 0, 0}*63.36	IN/MILE	NUMBER
RAVELING_AFFECTED_PERC	AVG		COMPUTE {RavelingReport, AVG([AffectedPercentage]), , 0, 0}		NUMBER
RAVELING_MEAN_RI_CM3M2	AVG		COMPUTE {RavelingReport, AVG([MeanRI]), , 0, 0}		NUMBER
RAVELING_MEAN_EXIST_RI_CM3M2	AVG		COMPUTE {RavelingReport, AVG([MeanExistingRI]), , 0, 0}		NUMBER
RAVELING_MEAN_RPI_CM3M2	AVG		COMPUTE {RavelingReport, AVG([MeanRPI]), , 0, 0}		NUMBER
RAVELING_MEAN_AVC_CM3M2	AVG		COMPUTE {RavelingReport, AVG([MeanAVC]), , 0, 0}		NUMBER
JOINT_LENGTH_TRANS_FT	SUM		COMPUTE {JointsReport, SUM([Length]),[Transverse]=1 , 0, 0}*3.28084	FT	NUMBER
JOINT_HEIGHT_TRANS_IN	AVG		COMPUTE {JointsReport, AVG([Height]), [Transverse]=1 , 0, 0}*39.37008	IN	NUMBER
JOINT_LENGTH_LONG_FT	SUM		COMPUTE {JointsReport, SUM([Length]),[Transverse]=0 , 0, 0}*3.28084	FT	NUMBER
JOINT_HEIGHT_LONG_IN	AVG		COMPUTE {JointsReport, AVG([Height]), [Transverse]=0 , 0, 0}*39.37008	IN	NUMBER
POTHOLE_AREA_L_SQIN	SUM		COMPUTE {POTHOLESREPORT, SUM([AREA]), [SEVERITY] = 'Low', 0, 0}*1000/25.4*1000/25.4	SQIN	NUMBER
POTHOLE_MAX_DEPTH_L_IN	MAX		COMPUTE {POTHOLESREPORT, MAX([MAXIMUMDEPTH]), [SEVERITY] = 'Low', 0, 0}*1000/25.4	IN	NUMBER
POTHOLE_AREA_M_SQIN	SUM		COMPUTE {POTHOLESREPORT, SUM([AREA]), [SEVERITY] = 'Moderate', 0, 0}*1000/25.4*1000/25.4	SQIN	NUMBER
POTHOLE_MAX_DEPTH_M_IN	MAX		COMPUTE {POTHOLESREPORT, MAX([MAXIMUMDEPTH]), [SEVERITY] = 'Moderate', 0, 0}*1000/25.4	IN	NUMBER
POTHOLE_AREA_H_SQIN	SUM		COMPUTE {POTHOLESREPORT, SUM([AREA]), [SEVERITY] = 'High', 0, 0}*1000/25.4*1000/25.4	SQIN	NUMBER
POTHOLE_MAX_DEPTH_H_IN	MAX		COMPUTE {POTHOLESREPORT, MAX([MAXIMUMDEPTH]), [SEVERITY] = 'High', 0, 0}*1000/25.4	IN	NUMBER
POTHOLE_DEPTH_AREA_INSQIN	SUM		COMPUTE {POTHOLESREPORT, SUM([MAXIMUMDEPTH*AREA]), , 0, 0}*1000/25.4*1000/25.4*1000/25.4	CUBIC IN	NUMBER
MPD_LE_IN	AVG	COMPUTE {PProcTexture, AVG([MPD ^(Inch)]), [wheelpath] = 1, 0, 0}	COMPUTE {PProcTexture, AVG([MPD ^(Inch)]), [wheelpath] = 1, 0, 0}	IN	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
MPD_LWP_IN	AVG	COMPUTE {PProcTexture, AVG([MPD ^(Inch)]), [wheelpath] = 2, 0, 0}>0	COMPUTE {PProcTexture, AVG([MPD ^(Inch)]), [wheelpath] = 2, 0, 0}	IN	NUMBER
MPD_CTR_IN	AVG	COMPUTE {PProcTexture, AVG([MPD ^(Inch)]), [wheelpath] = 3, 0, 0} >0	COMPUTE {PProcTexture, AVG([MPD ^(Inch)]), [wheelpath] = 3, 0, 0}	IN	NUMBER
MPD_RE_IN	AVG	COMPUTE {PProcTexture, AVG([MPD ^(Inch)]), [wheelpath] = 5, 0, 0} > 0	COMPUTE {PProcTexture, AVG([MPD ^(Inch)]), [wheelpath] = 5, 0, 0}	IN	NUMBER
MPD_RWP_IN	AVG	COMPUTE {PProcTexture, AVG([MPD ^(Inch)]), [wheelpath] = 4, 0, 0} > 0	COMPUTE {PProcTexture, AVG([MPD ^(Inch)]), [wheelpath] = 4, 0, 0}	IN	NUMBER
PVT_TY_ASPHALT_FT	SUM		COMPUTE {RatedEvents, SUM([Length]),[eventtypename] = 'LCMS' and [Eventscorename] ='Asphalt' , 0, 0}*3.28084	FT	NUMBER
PVT_TY_CONCRETE_FT	SUM		COMPUTE {RatedEvents, SUM([Length]),[eventtypename] = 'LCMS' and [Eventscorename] ='Concrete' , 0, 0}*3.28084	FT	NUMBER
PVT_TY_GROOVED_CONC_LONG_FT	SUM		COMPUTE {RatedEvents, SUM([Length]),[eventtypename] = 'LCMS' and [Eventscorename] ='Grooved Concrete - Longitudinal' , 0, 0}*3.28084	FT	NUMBER
PVT_TY_GROOVED_CONC_TRANS_FT	SUM		COMPUTE {RatedEvents, SUM([Length]),[eventtypename] = 'LCMS' and [Eventscorename] ='Grooved Concrete - Transversal' , 0, 0}*3.28084	FT	NUMBER
PVT_TY_LEFT_JOINT_CT	SUM		COMPUTE {RatedEvents, COUNT([Eventscorename]),[EventTypeName]='LCMS' and [Eventscorename] ='Left Joint', 0, 0}	COUNT	NUMBER
PVT_TY_RIGHT_JOINT_CT	SUM		COMPUTE {RatedEvents, COUNT([Eventscorename]),[EventTypeName]='LCMS' and [Eventscorename] ='Right Joint', 0, 0}	COUNT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
EXCLUDED_FROM_CRACK_DATA	MAX	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Milled_Pavement', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Bridge', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Railroad', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Disregard_Cracking', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Brick_Pavement', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Bad_Image', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_CRCP_Exists', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_JCP_Exists', 0, 0}>0	1;1;1;1;1;1;1;1;0		NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
LONGITUDINAL_LWP_MAP21EXTENT	SUM	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Milled_Pavement', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Bridge', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Railroad', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Disregard_Cracking', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Brick_Pavement', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Bad_Image', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_CRCP_Exists', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_JCP_Exists', 0, 0}>0	NULL:NULL;NULL:NULL;NULL:NULL:NULL:NULL;COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] in ('Longitudinal Crack (LWP)','Longitudinal Sealed Crack (LWP)') and [MetricName] = 'CrackExtent' and [Length]>0, 0, 0}*3.280839895	FT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
LONGITUDINAL_RWP_MAP21EXTENT	SUM	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Milled_Pavement', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Bridge', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Railroad', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Disregard_Cracking', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Brick_Pavement', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Bad_Image', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_CRCP_Exists', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_JCP_Exists', 0, 0}>0	NULL:NULL;NULL:NULL;NULL:NULL:NULL:NULL;COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] in ('Longitudinal Crack (RWP)','Longitudinal Sealed Crack (RWP)') and [MetricName] = 'CrackExtent' and [Length]>0, 0, 0}*3.280839895	FT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
SC_CRACK_AREA	SUM	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Milled_Pavement', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Bridge', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Railroad', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Disregard_Cracking', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Brick_Pavement', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Bad_Image', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_CRCP_Exists', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_JCP_Exists', 0, 0}>0	NULL:NULL;NULL:NULL;NULL:NULL:NULL:NULL;COMPUTE {PIVOT_Distress, SUM([CrackLength * Width]), [DistressTypeName] in ('Longitudinal Crack (LWP)', 'Longitudinal Crack (RWP)') and [Length]>0,0, 0}*3.280839895*3.280839895	SQFT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
FC_CRACK_AREA	SUM	COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Milled_Pavement', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Bridge', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Railroad', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Disregard_Cracking', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Brick_Pavement', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_Bad_Image', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_CRCP_Exists', 0, 0}>0;COMPUTE {manualdistressesvalues, FIRST([Length]),[distresstypename]='Event_JCP_Exists', 0, 0}>0	NULL:NULL;NULL:NULL;NULL:NULL:NULL:NULL;COMPUTE {PIVOT_Distress, SUM([CrackLength * Width]), [DistressTypeName] in ('Longitudinal Crack (CTR)', 'Longitudinal Crack (LE)', 'Longitudinal Crack (RE)','Transverse Crack') and [Length]>0,0, 0}*3.280839895*3.280839895	SQFT	NUMBER
LONGITUDINAL_LE_SEALED	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Sealed Crack (LE)' and [SeverityName] = 'SEALED' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
LONGITUDINAL_LWP_SEALED	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Sealed Crack (LWP)' and [SeverityName] = 'SEALED' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONGITUDINAL_CTR_SEALED	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Sealed Crack (CTR)' and [SeverityName] = 'SEALED' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONGITUDINAL_RWP_SEALED	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Sealed Crack (RWP)' and [SeverityName] = 'SEALED' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONGITUDINAL_RE_SEALED	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Sealed Crack (RE)' and [SeverityName] = 'SEALED' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
TRANSVERSE_ALL_SEALED	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Transverse Sealed Crack' and [SeverityName] = 'SEALED' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LE_CW_1_16	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LE)' and [SeverityName] = 'crackwidth_1_16' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LE_CW_1_8	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LE)' and [SeverityName] = 'crackwidth_1_8' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
LONG_LE_CW_1_4	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LE)' and [SeverityName] = 'crackwidth_1_4 ' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LE_CW_3_8	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LE)' and [SeverityName] = 'crackwidth_3_8' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LE_CW_1_2	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LE)' and [SeverityName] = 'crackwidth_1_2' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LE_CW_3_4	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LE)' and [SeverityName] = 'crackwidth_3_4' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LE_CW_1_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LE)' and [SeverityName] = 'crackwidth_1_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LE_CW_1_1_2	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LE)' and [SeverityName] = 'crackwidth_1_1_2' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LE_CW_2_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LE)' and [SeverityName] = 'crackwidth_2_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
LONG_LE_CW_3_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LE)' and [SeverityName] = 'crackwidth_3_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LE_CW_OVER3	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LE)' and [SeverityName] = 'crackwidth_Over3' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LWP_CW_1_16	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LWP)' and [SeverityName] = 'crackwidth_1_16' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LWP_CW_1_8	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LWP)' and [SeverityName] = 'crackwidth_1_8' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LWP_CW_1_4	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LWP)' and [SeverityName] = 'crackwidth_1_4 ' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LWP_CW_3_8	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LWP)' and [SeverityName] = 'crackwidth_3_8' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LWP_CW_1_2	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LWP)' and [SeverityName] = 'crackwidth_1_2' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
LONG_LWP_CW_3_4	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LWP)' and [SeverityName] = 'crackwidth_3_4' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LWP_CW_1_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LWP)' and [SeverityName] = 'crackwidth_1_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LWP_CW_1_1_2	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LWP)' and [SeverityName] = 'crackwidth_1_1_2' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LWP_CW_2_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LWP)' and [SeverityName] = 'crackwidth_2_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LWP_CW_3_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LWP)' and [SeverityName] = 'crackwidth_3_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_LWP_CW_OVER3	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (LWP)' and [SeverityName] = 'crackwidth_Over3' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_CTR_CW_1_16	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (CTR)' and [SeverityName] = 'crackwidth_1_16' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
LONG_CTR_CW_1_8	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (CTR)' and [SeverityName] = 'crackwidth_1_8' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_CTR_CW_1_4	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (CTR)' and [SeverityName] = 'crackwidth_1_4 ' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_CTR_CW_3_8	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (CTR)' and [SeverityName] = 'crackwidth_3_8' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_CTR_CW_1_2	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (CTR)' and [SeverityName] = 'crackwidth_1_2' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_CTR_CW_3_4	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (CTR)' and [SeverityName] = 'crackwidth_3_4' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_CTR_CW_1_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (CTR)' and [SeverityName] = 'crackwidth_1_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_CTR_CW_1_1_2	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (CTR)' and [SeverityName] = 'crackwidth_1_1_2' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
LONG_CTR_CW_2_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (CTR)' and [SeverityName] = 'crackwidth_2_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_CTR_CW_3_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (CTR)' and [SeverityName] = 'crackwidth_3_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_CTR_CW_OVER3	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (CTR)' and [SeverityName] = 'crackwidth_Over3' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RWP_CW_1_16	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RWP)' and [SeverityName] = 'crackwidth_1_16' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RWP_CW_1_8	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RWP)' and [SeverityName] = 'crackwidth_1_8' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RWP_CW_1_4	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RWP)' and [SeverityName] = 'crackwidth_1_4 ' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RWP_CW_3_8	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RWP)' and [SeverityName] = 'crackwidth_3_8' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
LONG_RWP_CW_1_2	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RWP)' and [SeverityName] = 'crackwidth_1_2' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RWP_CW_3_4	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RWP)' and [SeverityName] = 'crackwidth_3_4' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RWP_CW_1_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RWP)' and [SeverityName] = 'crackwidth_1_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RWP_CW_1_1_2	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RWP)' and [SeverityName] = 'crackwidth_1_1_2' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RWP_CW_2_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RWP)' and [SeverityName] = 'crackwidth_2_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RWP_CW_3_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RWP)' and [SeverityName] = 'crackwidth_3_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RWP_CW_OVER3	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RWP)' and [SeverityName] = 'crackwidth_Over3' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
LONG_RE_CW_1_16	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RE)' and [SeverityName] = 'crackwidth_1_16' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RE_CW_1_8	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RE)' and [SeverityName] = 'crackwidth_1_8' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RE_CW_1_4	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RE)' and [SeverityName] = 'crackwidth_1_4 ' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RE_CW_3_8	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RE)' and [SeverityName] = 'crackwidth_3_8' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RE_CW_1_2	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RE)' and [SeverityName] = 'crackwidth_1_2' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RE_CW_3_4	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RE)' and [SeverityName] = 'crackwidth_3_4' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RE_CW_1_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RE)' and [SeverityName] = 'crackwidth_1_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
LONG_RE_CW_1_1_2	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RE)' and [SeverityName] = 'crackwidth_1_1_2' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RE_CW_2_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RE)' and [SeverityName] = 'crackwidth_2_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RE_CW_3_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RE)' and [SeverityName] = 'crackwidth_3_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
LONG_RE_CW_OVER3	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Longitudinal Crack (RE)' and [SeverityName] = 'crackwidth_Over3' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
TRANS_CW_1_16	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Transverse Crack' and [SeverityName] = 'crackwidth_1_16' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
TRANS_CW_1_8	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Transverse Crack' and [SeverityName] = 'crackwidth_1_8' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
TRANS_CW_1_4	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Transverse Crack' and [SeverityName] = 'crackwidth_1_4 ' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
TRANS_CW_3_8	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Transverse Crack' and [SeverityName] = 'crackwidth_3_8' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
TRANS_CW_1_2	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Transverse Crack' and [SeverityName] = 'crackwidth_1_2' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
TRANS_CW_3_4	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Transverse Crack' and [SeverityName] = 'crackwidth_3_4' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
TRANS_CW_1_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Transverse Crack' and [SeverityName] = 'crackwidth_1_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
TRANS_CW_1_1_2	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Transverse Crack' and [SeverityName] = 'crackwidth_1_1_2' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
TRANS_CW_2_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Transverse Crack' and [SeverityName] = 'crackwidth_2_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
TRANS_CW_3_IN	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Transverse Crack' and [SeverityName] = 'crackwidth_3_in' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER
TRANS_CW_OVER3	SUM		COMPUTE {RatedDistressesValues, SUM([MetricValue]), [DistressTypeName] = 'Transverse Crack' and [SeverityName] = 'crackwidth_Over3' and [MetricName] = 'CrackLength' AND [Length]>0, 0, 0}*3.280839895	FT	NUMBER

Column Name	Aggregation	Conditional Split	Transformation	Description	Type
BLEEDING_PERCENT_LWP	AVG		COMPUTE {Bleedings, AVG([Percentage]), [WheelPath]='Left', 0, 0}		NUMBER
BLEEDING_INDEX_LWP	AVG		COMPUTE {Bleedings, AVG([INDEX]), [WheelPath]='Left', 0, 0}		NUMBER
BLEEDING_SEVERITY_LWP	AVG		COMPUTE {Bleedings, AVG([SEVERITY]), [WheelPath]='Left', 0, 0}		NUMBER
BLEEDING_PERCENT_RWP	AVG		COMPUTE {Bleedings, AVG([Percentage]), [WheelPath]='Right', 0, 0}		NUMBER
BLEEDING_INDEX_RWP	AVG		COMPUTE {Bleedings, AVG([INDEX]), [WheelPath]='Right', 0, 0}		NUMBER
BLEEDING_SEVERITY_RWP	AVG		COMPUTE {Bleedings, AVG([SEVERITY]), [WheelPath]='Right', 0, 0}		NUMBER
PICKOUT_AREA_SQFT	SUM		COMPUTE {PickoutReport, SUM([Area]), , 0, 0}*3.280839895*3.280839895	SQFT	NUMBER
PICKOUT_RADIUS_FT	AVG		COMPUTE {PickoutReport, AVG([Radius]), , 0, 0}*3.280839895	FT	NUMBER
PICKOUT_COUNT	COUNT		COMPUTE {PickoutReport, COUNT([Distancestamp]), , 0, 0}	COUNT	NUMBER

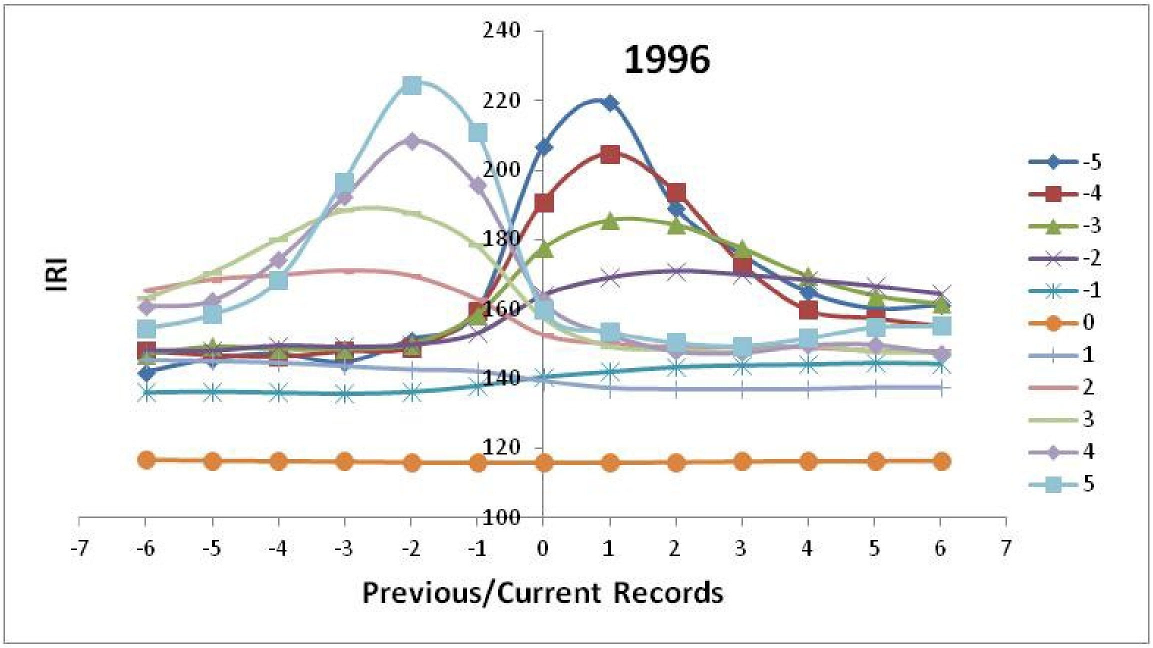
11.06 IRI SPEED ADJUSTMENT

Below are the steps followed to establish the equations for the IRI adjustment based on change in speed (updated January 26, 2018).

Step 1. Calculate the change in speed (current record speed – previous record speed) between consecutive data stations and average IRI values (only valid if less than 9999) for a specific number of previous and next records depending on the data collection year (see table below for historical data).

YEAR	Data Collection Interval Miles (Feet)	Previous Records (from current record) for Analysis (Distance in feet)	Next Records (from current record) for Analysis (Distance in feet)
1995	0.02 (105.6)	6 (633.6)	6 (633.6)
1996	0.02 (105.6)	6 (633.6)	6 (633.6)
1997	0.02 (105.6)	6 (633.6)	6 (633.6)
1998	0.02 (105.6)	6 (633.6)	6 (633.6)
1999	0.02 (105.6)	6 (633.6)	6 (633.6)
2000	0.02 (105.6)	6 (633.6)	6 (633.6)
2001	0.01 (52.8)	12 (633.6)	12 (633.6)
2002	0.01 (52.8)	12 (633.6)	12 (633.6)
2003	0.01 (52.8)	12 (633.6)	12 (633.6)
2004	0.01 (52.8)	12 (633.6)	12 (633.6)
2005	0.01 (52.8)	12 (633.6)	12 (633.6)
2006	0.01 (52.8)	12 (633.6)	12 (633.6)
2007	0.01 (52.8)	12 (633.6)	12 (633.6)
2008	0.01 (52.8)	12 (633.6)	12 (633.6)
2009	0.01 (52.8)	12 (633.6)	12 (633.6)
2010	0.01 (52.8)	12 (633.6)	12 (633.6)
2011	0.01 (52.8)	12 (633.6)	12 (633.6)
2012	0.005 (26.4)	24 (633.6)	24 (633.6)
2013	0.004 (21.1)	30 (633)	30 (633)
2014	0.004 (21.1)	30 (633)	30 (633)
2015	0.004 (21.1)	30 (633)	30 (633)

Step 2. Plot the graphs for each year with previous and next record numbers (-5 to +5) in the x-axis and IRI values at each speed change (acceleration and deceleration) on the y-axis. Speed change occurs at the current station and only speed change values between -5 and 5 are selected for analysis since more than 95% of the data have the speed change values within this range (see sample graph shown below).



As seen from the above graph, for deceleration, some of the "next records" are significantly higher than the "previous records". In the case of acceleration, some of the "previous records" are higher than the "next records". Based on the shape of graphs a decision will be made on number of previous and next records that are affected by speed change and need to be adjusted using the curve's baseline. Since station intervals are different between years, the number of affected stations are different.

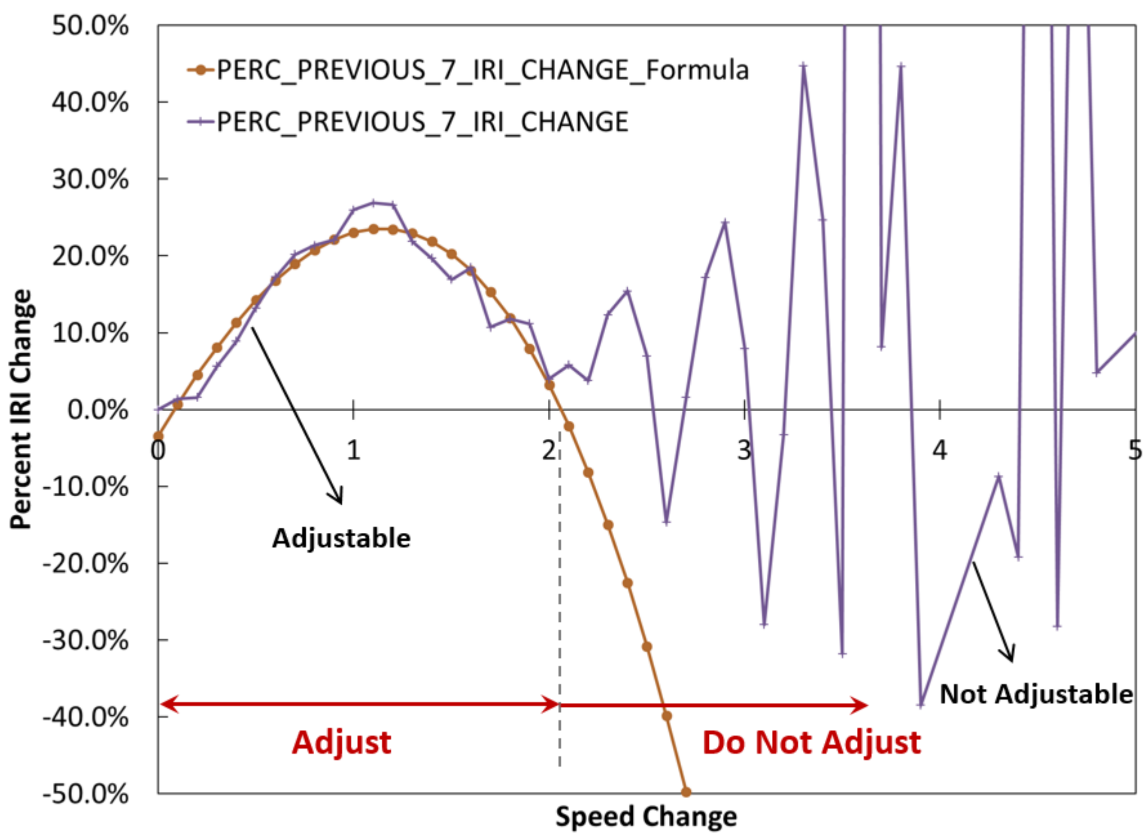
Step 3. In order to adjust the IRI values, the adjustment baseline should be determined. In the case of deceleration, the flat part of the curve right before the jump in IRI graph, and in the case of acceleration, the flat part of the graph right after the IRI curve flattens after the hump were chosen for calculating the baseline. The points selected for calculating the baseline (average IRI of selected stations) and adjustment for different years are shown in the table below.

Year (s)	Baseline		Adjust	
	Deceleration	Acceleration	Deceleration	Acceleration
1995-2000	Prev. 3 to prev. 6	Next 2 to next 6	Prev. 1 to next 4	Prev. 4 to next 1
2001-2005	Prev. 6 to prev. 10	Next 3 to next 8	Prev. 2 to next 6	Prev. 6 to next 1
2006-2011	Prev. 6 to prev. 10	Next 3 to next 8	Prev. 1 to next 5	Prev. 5 to next 1
2012	Prev. 9 to prev. 18	Next 5 to next 14	Prev. 1 to next 10	Prev. 8 to next 1
2013-2015	Prev. 9 to Prev. 14	Next 8 to next 13	Prev. 5 to next 12	Prev. 12 to next 5

Step 4. Calculate the percent change in IRI (compared to the baseline) of each speed change (separately for deceleration and acceleration) at each station included in the study.

Step 5. Establish third degree polynomial equations for deceleration and acceleration at each affected station (previous, current, and next stations) based on the percent change IRI values for the affected station and speed changes at the current location. The third-degree polynomial equations are developed after several iterations (i.e. the percent change between baseline IRI value and to be adjusted IRI value should not be significantly high) to make sure the equation is only used for the adjustable ranges of speed change. The threshold speed changes are established beyond which either the IRI values are excluded from reporting or the original IRI value retained without any adjustment. The records with speed changes below the threshold value will be adjusted. The equation used for fitting is: $y = (C_3 * X^3) + (C_2 * X^2) + (C_1 * X^1) + b$.

Step 6. Evaluate the shape of the curve after each iteration. A typical curve should be in the shape of a semi-circle i.e., it should start at zero (no change in speed and so no change in IRI), increase, then decrease, and at some point, cross the zero and become negative (percent change in IRI value is negative). The curve not only should have the right shape but also should follow the percent IRI change curve closely before crossing the zero line. For each station, percent IRI changes follow a trend up to a certain speed change (threshold) and beyond that speed change become scattered and difficult to adjust using an equation. Thus, the IRI values are adjusted where the equation matches the percent IRI changes closely and beyond the threshold the IRI values are either excluded from reports or the original IRI values are retained (see below graph for illustration).



Step 7. If the curve deviates from the "Typical" curve, then the equation should be adjusted by changing the data range. Performed iterations until the best fit is reached and the curve looks like a described typical shape. If even after

several iterations, the curve keeps on going upward instead of going downward and crossing the zero after some point, then the engineer should determine the threshold value of speed change/percent change in IRI value beyond which the IRI value will be either "excluded/not reported" or retained as original.

Step 8. For the curves that go downward and cross zero, the threshold speed change/ percent change in IRI value will be the zero crossing point of the curve and IRI values beyond this point are retained and reported as they are (original values). However, if beyond the threshold, the percent IRI change curve continues to have an upward or downward trend (not scattered around the line y=0), then the IRI values are excluded from reporting for speed changes beyond the threshold.

Step 9. Once the coefficients (C_3, C_2, C_1 and b) are determined for deceleration and acceleration for each affected station (previous or next from current record), these numbers are exported to Oracle to be used for calculating the adjusted IRI values. If a station has multiple adjustment factors (the current station moves along the road and thus each station can have different adjustment factors), the maximum adjustment will be considered.

Step 10. If the percent adjustment is ≤8% then the original IRI value will be reported as is and no adjustment will be made. If the percent adjustment is >8% then the original IRI value will be adjusted and the adjusted value will be reported.

Step 11. If the speed is <15 mph, the IRI value will be excluded and will not be reported. If the speed is ≥15 mph, the IRI value will be either adjusted or the original value be reported in accordance with the requirements stated above.

The final results of the "effect of speed change on IRI" study for years 1995 to 2015 are presented in the following table:

Year(s)	Station	Name	m_3	m_2	m_1	b	Beyond Adj Threshold (Exclude Or original)	Adj between 0 and
1995-2000 DECEL	-1	PERC_AVG_PREV_IRI_Change	-0.00116	-0.02198	-0.11711	-0.08318	O	-14
	0	PERC_AVG_CUR_IRI_CHANGE	-0.00217	-0.03130	-0.20593	-0.12910	E	-14
	1	PERC_AVG_NEXT_IRI_CHANGE	-0.00002	0.00216	-0.10718	-0.05477	E	-14
	2	PERC_AVG_NEXT_2_IRI_CHANGE	-0.00154	-0.03338	-0.22732	-0.13379	E	-14
	3	PERC_AVG_NEXT_3_IRI_CHANGE	-0.00013	-0.00686	-0.07670	-0.00289	O	-14
	4	PERC_AVG_NEXT_4_IRI_CHANGE	-0.00061	-0.01301	-0.08209	-0.00458	O	-14
1995-2000 ACCEL	-4	PERC_AVG_PREV_4_IRI_Change	0.00075	-0.01877	0.12645	-0.03976	O	10
	-3	PERC_AVG_PREV_3_IRI_CHANGE	-0.00017	-0.00351	0.09993	-0.03005	O	10
	-2	PERC_AVG_PREV_2_IRI_CHANGE	-0.00268	0.03324	0.01137	0.00422	E	5
	-1	PERC_AVG_PREV_IRI_CHANGE	-0.00163	0.02206	0.01614	-0.00156	E	10
	0	PERC_AVG_CUR_IRI_CHANGE	0.00002	-0.00216	0.03358	-0.01246	O	10
	1	PERC_AVG_NEXT_IRI_CHANGE	0.00008	-0.00079	0.01173	-0.00815	O	10
2001-2005	-2	PERC_PREVIOUS_2_IRI_CHANGE	0.00072	0.00721	-0.02428	-0.01603	O	-12

Year(s)	Station	Name	m_3	m_2	m_1	b	Beyond Adj Threshold (Exclude Or original)	Adj between 0 and
DECEL	-1	PERC_PREVIOUS_IRI_CHANGE	0.01869	0.08010	0.01197	-0.00069	O	-11
	0	PERC_CUR_IRI_CHANGE	0.00053	-0.01307	-0.34568	-0.31056	E	-8
	1	PERC_NEXT_IRI_CHANGE	0.00214	0.03017	-0.12731	-0.02076	E	-7.3
	2	PERC_NEXT_2_IRI_CHANGE	0.00356	0.01917	-0.17969	-0.04994	O	-11
	3	PERC_NEXT_3_IRI_CHANGE	-0.00038	-0.02186	-0.22645	-0.05445	O	-12
	4	PERC_NEXT_4_IRI_CHANGE	0.02454	0.09335	-0.04579	0.00320	O	-8.2
	5	PERC_NEXT_5_IRI_CHANGE	0.01512	0.04367	-0.07957	-0.00087	O	-7
	6	PERC_NEXT_6_IRI_CHANGE	0.00273	-0.01361	-0.12185	-0.00197	O	-5
2001-2005 ACCEL	-6	PERC_PREVIOUS_6_IRI_CHANGE	0.00317	-0.04867	0.18700	-0.02473	O	7
	-5	PERC_PREVIOUS_5_IRI_CHANGE	0.00305	-0.04734	0.20904	-0.02855	O	11
	-4	PERC_PREVIOUS_4_IRI_CHANGE	0.00126	-0.03899	0.27189	-0.08652	O	11
	-3	PERC_PREVIOUS_3_IRI_CHANGE	0.00112	-0.04209	0.35558	-0.14980	O	11
	-2	PERC_PREVIOUS_2_IRI_CHANGE	-0.00611	0.05319	0.11003	-0.04261	E	10.2
	-1	PERC_PREVIOUS_IRI_CHANGE	-0.00276	0.02538	0.08636	-0.01779	E	7.5
	0	PERC_CUR_IRI_CHANGE	-0.00204	0.00761	0.05302	-0.00244	O	7
	1	PERC_NEXT_IRI_CHANGE	0.00091	-0.01042	0.04497	-0.00673	O	7
2006-2011 DECEL	-1	PERC_PREVIOUS_IRI_CHANGE	-0.01714	-0.06903	-0.12196	-0.00228	O	-2
	0	PERC_CUR_IRI_CHANGE	0.00102	0.00119	-0.09409	-0.00276	E	-6.5
	1	PERC_NEXT_IRI_CHANGE	0.00183	0.00535	-0.14952	-0.04700	E	-6.5
	2	PERC_NEXT_2_IRI_CHANGE	0.00511	0.02864	-0.08809	-0.00936	O	-8
	3	PERC_NEXT_3_IRI_CHANGE	0.00007	-0.01187	-0.13590	-0.01302	O	-11
	4	PERC_NEXT_4_IRI_CHANGE	0.00580	0.01847	-0.07835	-0.00080	O	-5.6
	5	PERC_NEXT_5_IRI_CHANGE	0.00978	0.02161	-0.07577	-0.00002	O	-6
2006-2011 ACCEL	-5	PERC_PREVIOUS_5_IRI_CHANGE	0.00499	-0.08172	0.27239	-0.05097	O	4.4
	-4	PERC_PREVIOUS_4_IRI_CHANGE	-0.00603	0.01800	0.10471	0.00239	O	6.2
	-3	PERC_PREVIOUS_3_IRI_CHANGE	0.00376	-0.08346	0.40320	-0.15034	O	6.5
	-2	PERC_PREVIOUS_2_IRI_CHANGE	0.00117	-0.03477	0.22926	-0.04137	E	9.4
	-1	PERC_PREVIOUS_IRI_CHANGE	-0.01225	0.05972	0.06044	-0.04615	E	5.7
	0	PERC_CUR_IRI_CHANGE	-0.01112	0.05732	-0.02522	-0.00104	O	4.7
	1	PERC_NEXT_IRI_CHANGE	-0.00483	0.02905	-0.01443	-0.00262	O	5.6
2012 DECEL	-1	PERC_PREVIOUS_IRI_CHANGE	0.01729	-0.05790	-0.20439	-0.00951	O	-2.1
	0	PERC_CUR_IRI_CHANGE	0.13573	0.26871	-0.01729	-0.00034	O	-2.1
	1	PERC_NEXT_IRI_CHANGE	0.10029	0.22843	-0.03596	-0.00114	E	-2.5
	2	PERC_NEXT_2_IRI_CHANGE	0.12142	0.29474	-0.00907	-0.00287	E	-2.5
	3	PERC_NEXT_3_IRI_CHANGE	0.08226	0.28588	0.03517	-0.00212	E	-3.4

Year(s)	Station	Name	m_3	m_2	m_1	b	Beyond Adj Threshold (Exclude Or original)	Adj between 0 and
	4	PERC_NEXT_4_IRI_CHANGE	0.06541	0.18791	-0.06089	-0.00140	E	-3
	5	PERC_NEXT_5_IRI_CHANGE	0.06089	0.16298	-0.07247	-0.00195	E	-3.2
	6	PERC_NEXT_6_IRI_CHANGE	0.07148	0.16349	-0.07148	-0.00166	O	-2.7
	7	PERC_NEXT_7_IRI_CHANGE	0.03793	0.06310	-0.12112	-0.00143	O	-2.9
	8	PERC_NEXT_8_IRI_CHANGE	-0.01378	-0.05821	-0.16589	-0.00251	O	-2.2
	9	PERC_NEXT_9_IRI_CHANGE	0.04063	0.08397	-0.07354	-0.00065	O	-2.8
	10	PERC_NEXT_10_IRI_CHANGE	0.01092	-0.03087	-0.15878	-0.00691	O	-2.7
2012 ACCEL	-8	PERC_PREVIOUS_8_IRI_CHANGE	-0.19276	0.34384	0.04407	-0.00199	O	2
	-7	PERC_PREVIOUS_7_IRI_CHANGE	-0.33409	0.75262	-0.18066	-0.00018	O	2
	-6	PERC_PREVIOUS_6_IRI_CHANGE	-0.36747	0.94653	-0.31198	-0.00294	O	2.2
	-5	PERC_PREVIOUS_5_IRI_CHANGE	-0.49045	1.23441	-0.44638	-0.00193	O	2.1
	-4	PERC_PREVIOUS_4_IRI_CHANGE	-0.40732	1.07071	-0.38984	-0.00176	O	2.2
	-3	PERC_PREVIOUS_3_IRI_CHANGE	-0.35207	0.96729	-0.38855	-0.00139	O	2.3
	-2	PERC_PREVIOUS_2_IRI_CHANGE	-0.27263	0.68402	-0.23191	-0.00373	O	2.2
	-1	PERC_PREVIOUS_IRI_CHANGE	-0.24323	0.59040	-0.20703	-0.00389	O	2.1
	0	PERC_CUR_IRI_CHANGE	-0.19633	0.45747	-0.15961	-0.00428	O	2
	1	PERC_NEXT_IRI_CHANGE	-0.14449	0.33082	-0.13090	-0.00129	O	1.8
2013-2015 DECEL	-5	PERC_PREVIOUS_5_IRI_CHANGE_Formula	0.00229	-0.03412	-0.07052	-0.00462	O	-1.5
	-4	PERC_PREVIOUS_4_IRI_CHANGE_Formula	-0.00594	-0.04018	-0.06889	0.00321	O	-2.4
	-3	PERC_PREVIOUS_3_IRI_CHANGE_Formula	-0.01200	-0.11101	-0.15129	-0.00442	O	-1.6
	-2	PERC_PREVIOUS_2_IRI_CHANGE_Formula	-0.06664	-0.28180	-0.30174	-0.02083	O	-1.8
	-1	PERC_PREVIOUS_IRI_CHANGE_Formula	-0.07625	-0.29471	-0.33336	-0.01863	E	-2.4
	0	PERC_CUR_IRI_CHANGE_Formula	-0.04436	-0.18910	-0.27884	-0.01440	E	-2.5
	1	PERC_NEXT_IRI_CHANGE_Formula	-0.01298	-0.04557	-0.17321	0.00481	E	-2.5
	2	PERC_NEXT_2_IRI_CHANGE_Formula	-0.01246	-0.04168	-0.20861	-0.00495	E	-3
	3	PERC_NEXT_3_IRI_CHANGE_Formula	0.00972	0.01461	-0.18929	-0.00051	O	-5.2
	4	PERC_NEXT_4_IRI_CHANGE_Formula	0.01914	0.02410	-0.21317	-0.01063	O	-4
	5	PERC_NEXT_5_IRI_CHANGE_Formula	0.00351	-0.05990	-0.30682	-0.02718	O	-4
	6	PERC_NEXT_6_IRI_CHANGE_Formula	-0.00333	-0.09431	-0.33125	-0.02870	O	-3.8
	7	PERC_NEXT_7_IRI_CHANGE_Formula	0.05887	0.09816	-0.16763	-0.00385	O	-2.7
	8	PERC_NEXT_8_IRI_CHANGE_Formula	0.03904	0.02926	-0.21036	-0.00841	O	-2.7
	9	PERC_NEXT_9_IRI_CHANGE_Formula	-0.00520	-0.11336	-0.30998	-0.02030	O	-3.1
	10	PERC_NEXT_10_IRI_CHANGE_Formula	0.00178	-0.09249	-0.27703	-0.01406	O	-2.3
	11	PERC_NEXT_11_IRI_CHANGE_Formula	0.02047	-0.04249	-0.22880	-0.00690	O	-2.4
	12	PERC_NEXT_12_IRI_CHANGE_Formula	-0.00293	-0.11079	-0.26417	-0.00984	O	-2.4
2013-2015	-12	PERC_PREVIOUS_12_IRI_CHANGE_Formula	0.02778	-0.26908	0.40049	-0.01831	O	1.7

Year(s)	Station	Name	m_3	m_2	m_1	b	Beyond Adj Threshold (Exclude Or original)	Adj between 0 and
ACCEL	-11	PERC_PREVIOUS_11_IRI_CHANGE_Formula	0.05413	-0.32881	0.44995	-0.02393	O	2
	-10	PERC_PREVIOUS_10_IRI_CHANGE_Formula	0.05342	-0.33693	0.47913	-0.02945	O	2.1
	-9	PERC_PREVIOUS_9_IRI_CHANGE_Formula	0.03102	-0.28365	0.46888	-0.03069	O	2
	-8	PERC_PREVIOUS_8_IRI_CHANGE_Formula	0.00534	-0.22313	0.45779	-0.03330	O	2.1
	-7	PERC_PREVIOUS_7_IRI_CHANGE_Formula	-0.03595	-0.12353	0.42416	-0.03423	O	2
	-6	PERC_PREVIOUS_6_IRI_CHANGE_Formula	-0.09425	0.02266	0.36036	-0.03329	O	2
	-5	PERC_PREVIOUS_5_IRI_CHANGE_Formula	-0.19830	0.31719	0.18291	-0.01922	O	2.1
	-4	PERC_PREVIOUS_4_IRI_CHANGE_Formula	-0.24017	0.49000	0.05472	-0.00837	O	2.1
	-3	PERC_PREVIOUS_3_IRI_CHANGE_Formula	-0.19014	0.42620	0.06539	-0.01249	O	2.3
	-2	PERC_PREVIOUS_2_IRI_CHANGE_Formula	-0.13620	0.41526	-0.03116	0.00587	E	2.9
	-1	PERC_PREVIOUS_IRI_CHANGE_Formula	-0.01119	0.14443	0.09402	-0.00972	E	2
	0	PERC_CUR_IRI_CHANGE_Formula	-0.04055	0.17229	0.03630	-0.00232	E	2
	1	PERC_NEXT_IRI_CHANGE_Formula	-0.00325	0.07170	0.03694	-0.00100	E	2.5
	2	PERC_NEXT_2_IRI_CHANGE_Formula	0.02206	-0.04167	0.10236	-0.01325	E	2.4
	3	PERC_NEXT_3_IRI_CHANGE_Formula	0.03593	-0.09168	0.11552	-0.01510	E	2.4
	4	PERC_NEXT_4_IRI_CHANGE_Formula	-0.09615	0.22503	-0.09393	0.00748	O	1.8
	5	PERC_NEXT_5_IRI_CHANGE_Formula	-0.07561	0.18395	-0.08516	0.00662	O	1.8

11.07 EXAMPLES FOR CHANGING LATITUDE/LONGITUDE

Below is an example of a latitude and longitude that needs to be changed. The green balloon should be at the gore (the place where the two solid white lines meet). Since the balloon is more than 4.2 millimiles from the gore, a change is required.

Below is another example of a balloon that is not at the gore but is within the 4.2 millimiles tolerance distance. Therefore, the latitude and longitude do not need to be changed.

Below is an example of the collection stopping before the balloon (displayed in Vision in this case as a pink triangle). Since the ending location is correct, and the problem is that the collection did not continue to the end of the route, a gap should be placed instead of changing the latitude and longitude (see Route Matching).

11.08 OUTLIER REVIEW - OUTLIER CODES

The table below is a list of active outlier codes (as of 2017).

The “ID” field is displayed as “OUTLIER_ID” in Oracle and represents the corresponding outlier code number of a specific outlier explanation.

The “DESCRIPTION” field is displayed as “OUTLIER_DESCRIP” in Oracle and provides a brief description of the type of outlier code.

The “YEAR” field is displayed as “CUR_OR_PREV_YEAR” in Oracle and describes what year’s data the outlier code applies to. For example, the “CUR” codes in this table are applied to the current year’s collection data (in this case, 2017), while the “PREV” codes in the table are applied to previous years’ collection data (in this case, 2013 through 2016).

The “COMMENTS” field provides more context regarding the nature and definition of the outlier code.

ID	DESCRIP	YEAR	COMMENTS
1	Lane Change	CUR	Lane change observed, during current season's data collection. If 2017 data are in question, the current season refers to 2017 data collection.
3	New Pave	CUR	New pavement surface observed.
5	Construction	CUR	Construction activities observed.
6	Road Widened	CUR	Road widening observed.
11	Lane Change	PREV	Lane change observed, during previous seasons' data collections. If current season is 2017, the previous seasons refer to 2013 to 2016 data collection.
13	New Pave	PREV	New pavement surface observed, during previous seasons' data collection.
15	Construction	PREV	Construction activities observed, during pervious seasons' data collection.
16	Road Widened	PREV	Road widening observed during previous seasons' data collection.
18	Start/end mile point are different	PREV	Location differences in starting or ending mile points being greater than 100 ft between different data collection.
21	Right IRI > 640	CUR	Right IRI greater than 640 in/mile.
22	Speed < 15	CUR	Speed less than 15 miles/hour.
24	Distress	PREV	Distresses observed, during previous season's data collection.
25	No Reason	CUR	No clear explanations on why outliers occur.
27	Left IRI > 640	CUR	Left IRI greater than 640 in/mile.
33	Bridge/Structure	CUR	Bridge/structure observed.
34	Railroad Crossing	CUR	Railroad crossing observed.
35	Roundabout	CUR	Roundabout observed.
36	Concrete	CUR	Concrete pavement observed.
37	Rumble_Strip	CUR	Rumble strip observed.
38	OFFICE_STOPBAR	CUR	Code automatically created for stop-bar flagged by data processing team.
39	OFFICE_CROSSWALK	CUR	Code automatically created for crosswalk flagged by data processing team.
40	OFFICE_CRCP	CUR	Code automatically created for CRCP flagged by data processing team.

ID	DESCRIP	YEAR	COMMENTS
41	OFFICE_JCP	CUR	Code automatically created for JCP flagged by data processing team.
42	OFFICE_BRICK	CUR	Code automatically created for brick flagged by data processing team.
43	OFFICE_DEBRIS	CUR	Code automatically created for debris flagged by data processing team.
44	OFFICE_CRACK_SEAL	CUR	Code automatically created for crack seal flagged by data processing team.
45	OFFICE_LANE_DEVIATION	CUR	Code automatically created for lane deviation flagged by data processing team.
46	OFFICE_MILLED_SURFACE	CUR	Code automatically created for milled surface flagged by data processing team.
47	OFFICE_BRIDGE	CUR	Code automatically created for bridge flagged by data processing team.
48	OFFICE_RAILROAD	CUR	Code automatically created for railroad flagged by data processing team.
49	OFFICE_DISREGARD_CRACK	CUR	Code automatically created for disregarded crack flagged by data processing team.
50	OFFICE_BAD_IMAGE	CUR	Code automatically created for bad image flagged by data processing team.
51	ARAN_Lane Deviation	CUR	Code automatically created for lane deviation flagged by ARAN operator.
52	ARAN_New Pavement	CUR	Code automatically created for new pavement flagged by ARAN operator.
53	ARAN_Bridge	CUR	Code automatically created for bridge flagged by ARAN operator.
54	ARAN_Railroad	CUR	Code automatically created for railroad crossing flagged by ARAN operator.
55	ARAN_Crack Seal	CUR	Code automatically created for crack seal flagged by ARAN operator.
56	ARAN_Concrete	CUR	Code automatically created for concrete flagged by ARAN operator.
57	ARAN_Rumble_Strip	CUR	Code automatically created for rumble strip flagged by ARAN operator.
58	ARAN_Construction	CUR	Code automatically created for construction flagged by ARAN operator.
59	ARAN_Debris	CUR	Code automatically created for debris flagged by ARAN operator.
60	Raised_Crosswalk_ Historic_Data	PREV	Raised crosswalk observed, during previous seasons' data collection.
61	ARAN_Damp_Pavement	CUR	Code automatically created for damp or wet pavement flagged by ARAN operator.
62	NEW_PAVEMENT_CONST_HISTORY	CUR	New pavement based on construction history records.
63	Minor Location Difference	CUR	Minor (shorter than 100 ft) location differences observed from one year to another, most at the beginning or ending mileposts.
64	Lane Configuration Change	CUR	Lane configuration change observed.
99	OTHER	CUR	Other reasons.

11.09 IRI PERFORMANCE MODEL

The following tables provide current information for IRI model parameters.

Current IRI μ_1 Values by Last Treatment

Last Treatment	μ_1
Mill and Overlay with >1.5” Grade Increase – Gap	0.800
Mill >4” Overlay with Asphalt	0.810
Cold-in-place Recycling Overlay	0.810
Break Crack Seat Overlay	0.810
Rubbilization Overlay	0.810
Reconstruction	0.810
Mill and Overlay with <1.5” Grade Increase – Gap	0.820
Overlay with >1.5” Grade Increase – Gap	0.820
Bonded Portland Cement Concrete Overlay	0.830
Mill and Overlay with >1.5” Grade Increase	0.850
Micro Surfacing	0.900
High Friction Surface	0.900
Mill and Overlay with <1.5” Grade Increase	0.978
Mill Ultrathin Bonded Wearing Course	0.978
Other	1.000
Overlay <1.5” Asphalt	1.023
Thin Overlay <1” Asphalt	1.065

Current IRI μ_2 Values by Family

Pavement Type	Region	Functional Class	Family	μ_2
Flexible	Mountain	2, 3	1	0.0322
Flexible	Mountain	7, 14, 17	2	0.0255
Flexible	Mountain	16, 18, 19	3	0.0255
Flexible	Central	2, 3, 7, 17	4	0.0219
Flexible	Central	12, 14, 16	5	0.0181
Flexible	Central	18, 19	6	0.0212
Flexible	Coastal	2, 7, 14, 17, 18	7	0.0219
Flexible	Coastal	3, 12, 16	8	0.0180
Flexible	Coastal	19	9	0.0214
Flexible	All	1,11	10	0.0178
Flexible	Mountain and Central	6, 8	11	0.0239
Flexible	Mountain and Central	9	12	0.0242
Flexible	Coastal	6, 8	13	0.0219
Flexible	Coastal	9	14	0.0191
Flexible over JCP	Mountain	8, 9, 18, 19	15	0.0171
Flexible over JCP	Mountain	1, 2, 11, 12, 14, 17	16	0.0267
Flexible over JCP	Central	8, 9, 17	17	0.0269
Flexible over JCP	Central	14	18	0.0279
Flexible over JCP	Central	2, 12, 19	19	0.0241
Flexible over JCP	Central	18	20	0.0516
Flexible over JCP	Central	1,11	21	0.0184
Flexible over JCP	Coastal	6, 8, 9, 12, 14, 17, 18, 19	22	0.0306
Flexible over JCP	Coastal	1, 2, 11	23	0.0377
Flexible over JCP	Mountain and Central	6	24	0.0260
Flexible over JCP[06/12/2019]	Mountain	7	25	[4]
Flexible over JCP[4]	Mountain	16	26	[4]
Flexible over JCP	Central	7	27	0.0321
Flexible over JCP	Central	16	28	0.0261
Flexible over JCP	Coastal	7	29	0.0328
Flexible over JCP	Coastal	16	30	0.0176
Flexible over JCP	All	3	31	0.0265
Flexible over CRCP	All	All	32	0.0095
Rigid Jointed	All	All	33	0.0120
Rigid Jointed Plain	All	All	34	0.0220
Rigid Continuous	All	All	35	0.0114
Other	-	-	-	0.0239

IRI Table "trend_iri_family_slopes" with Most Recent Percent Change and Mileage by Family

IRI_FAMILY[06/12/2019]	WT_AVG_PCT_IRI_CHANGE, %	MILES_INCLUDED, miles
1	0.03215	603.6
2	0.02553	1551.8
3	0.02545	588.3
4	0.02192	4198.4
5	0.01806	9521.5
6	0.01254	327
7	0.02193	10051.7
8	0.01798	1752.5
9	0.02143	149.1
10	0.01784	3933.8
11	0.02391	6647.6
12	0.02422	562.1
13	0.02188	5155.7
14	0.01907	762
15	0.01713	357.1
16	0.02665	677.1
17	0.02687	675.1
18	0.02793	2648
19	0.02412	1160.3
20	0.05163	105.4
21	0.01835	1466.5
22	0.03061	6566.2
23	0.03768	1309.1
24	0.026	1918.5
25	N/A	0
26	N/A	0
27	0.03213	2123
28	0.02605	2406.3
29	0.03283	4935.3
30	0.01762	594.7
31	0.02647	123.6
32	0.00945	510
33	0.01195	91.4
34	0.02199	63.7
35	0.01135	322.1

11.10 CRACKING PERFORMANCE MODELS

The following tables and scripts provide current information for cracking model parameters.

Table 1: FC Density Model parameters

Treatment Group	Pavement type	Region	Func. Class	L_tilde (Ld)	ll_int (li)	ll_slp (ls)
1	All	All	1	90637719.44	2.8083	-0.0046
C	All	1	14	266.3311	1.4455	-0.0255
2	Composite	1	14	1787.4858	1.948	-0.0111
2	Flexible	1	14	6.03267E+20	3.8714	-0.0029
3	All	2	14	1.06942E+39	4.4886	-0.0009
C	All	2	14	86.8394	1.6175	-0.0618
2	Composite	2	14	150.0416	1.3954	-0.05
2	Flexible	2	14	275.4735	1.6585	-0.0442
3	All	3	14	4103.2955	2.2241	-0.0275
4	All	3	14	55.5406	1.0076	-0.1419
C	All	3	14	41969.4996	2.3521	-0.0217
2	Composite	3	14	117.5573	1.4525	-0.0749
2	Flexible	3	14	125.2176	1.5761	-0.0606
4	All	1 or 2	14	76.2935	1.0401	-0.0643
1	All	All	14	1.00288E+18	3.6796	-0.0019
A	All	All	14	2.15601E+18	3.7308	-0.0031
1	Composite	All	2-3-6	584.7963	1.464	-0.0102
1	Flexible	All	2-3-6	138.1563	1.1843	-0.0417
C	All	1	7-8-9	305.5609	1.7251	-0.031
3	All	2	7-8-9	1956.3351	2.0539	-0.0189
C	All	2	7-8-9	599.4863	1.8873	-0.0317
C	All	3	7-8-9	21079742451	3.1608	-0.0081
3	Composite	3	7-8-9	6.21395E+15	3.5844	-0.0067
3	Flexible	3	7-8-9	1361.205	1.941	-0.0285
1	Composite	All	7-8-9	215.1996	1.3605	-0.0575
2	Composite	All	7-8-9	341.6614	1.7043	-0.0338
4	Composite	All	7-8-9	6.04754E+22	3.9402	-0.0045
6	Composite	All	7-8-9	50.5424	1.0538	-0.0821
10	Composite	All	7-8-9	Ld1=50.5424;li1=1.0538;ls1=-0.0821;Ld2=573.153;li2=1.5699;ls2=-0.0145;		
1	Flexible	All	7-8-9	109.2627	1.248	-0.0402
2	Flexible	All	7-8-9	6966.2944	2.1961	-0.0176
4	Flexible	All	7-8-9	145528821.1	2.8511	-0.0076
6	Flexible	All	7-8-9	60.3093	1.4039	-0.1222

Treatment Group	Pavement type	Region	Func. Class	L_tilde (Ld)	Il_int (li)	Il_slp (ls)
7	Flexible	All	7-8-9	10471052.58	2.7114	-0.0162
10	Flexible	All	7-8-9	Ld1=60.3093;li1=1.4039;ls1=-0.1222;Ld2=10471052.5813;li2=2.7114;ls2=-0.0162;		
6	Composite	All	11-12-14	76.9602	1.2325	-0.073
10	Composite	All	11-12-14	Ld1=76.9602;li1=1.2325;ls1=-0.073;Ld2=573.153;li2=1.5699;ls2=-0.0145;		
6	Flexible	All	11-12-14	9.89737E+30	4.2652	-0.0023
7	Flexible	All	11-12-14	1882.4205	1.9344	-0.0382
10	Flexible	All	11-12-14	Ld1=98973660234.9642*Math.Pow(10,20);li1=4.2652;ls1=-0.0023;Ld2=1882.4205;li2=1.9344;ls2=-0.0382;		
3	All	2	11-12	89359137.61	2.9464	-0.015
5	All	2	11-12	1662.1596	1.9936	-0.0288
3	All	3	11-12	3794.5556	1.951	-0.0064
5	All	1 or 3	11-12	50.4719	1.1323	-0.0834
1	All	All	11-12	2.27747E+16	3.5918	-0.0025
4	All	All	11-12	50.3632	0.8305	-0.0947
A	All	All	11-12	2683.6544	2.0435	-0.0171
C	All	All	11-12	2492522027	3.0629	-0.009
2	Composite	All	11-12	111.6238	1.2991	-0.053
2	Flexible	All	11-12	2516.3924	2.013	-0.0291
B	All	2	11-12-14-16-17-18-19	600	1.9327	-0.0345
C	All	1	1-2-3-6	106.2486	1.5597	-0.0593
2	Composite	1	1-2-3-6	97.2449	1.3891	-0.0457
3	All	2	1-2-3-6	431.2878	1.7957	-0.0347
C	All	2	1-2-3-6	7.16067E+17	3.7176	-0.0039
2	Composite	2	1-2-3-6	4709385.613	2.7561	-0.0194
3	All	3	1-2-3-6	1789.58	1.9201	-0.0212
4	All	3	1-2-3-6	78.314	1.1183	-0.1146
2	Composite	3	1-2-3-6	28894462.16	2.8285	-0.0165
C	Composite	3	1-2-3-6	170.3627	1.499	-0.0455
C	Flexible	3	1-2-3-6	397.2458	1.7853	-0.0385
4	All	1 or 2	1-2-3-6	13659.7542	2.1062	-0.0159
6	Composite	All	1-2-3-6	6073.429	2.1367	-0.0255
10	Composite	All	1-2-3-6	Ld1=6073.429;li1=2.1367;ls1=-0.0255;Ld2=573.153;li2=1.5699;ls2=-0.0145;		
2	Flexible	All	1-2-3-6	367611295.6	2.9757	-0.0088
6	Flexible	All	1-2-3-6	951.8987	1.9191	-0.0352
7	Flexible	All	1-2-3-6	201234894.5	2.9441	-0.0166

Treatment Group	Pavement type	Region	Func. Class	L_tilde (Ld)	ll_int (li)	ll_slp (ls)
10	Flexible	All	1-2-3-6	Ld1=951.8987;li1=1.9191;ls1=-0.0352;Ld2=201234894.491;li2=2.9441;ls2=-0.0166;		
B	All	2	1-2-3-6-7-8-9	9.38799E+14	3.5453	-0.005
2	Composite	1	16-17-18-19	1032.0372	1.8994	-0.025
2	Flexible	1	16-17-18-19	5437.0356	2.1001	-0.0225
3	All	2	16-17-18-19	860.3014	1.938	-0.0366
2	Composite	2	16-17-18-19	437.9597	1.735	-0.0345
2	Flexible	2	16-17-18-19	720.4722	1.8432	-0.0266
3	All	3	16-17-18-19	573.903	1.7447	-0.0175
4	All	3	16-17-18-19	1382900.394	2.5519	-0.0148
2	Composite	3	16-17-18-19	404.1978	1.6935	-0.0352
2	Flexible	3	16-17-18-19	130.2758	1.7928	-0.0733
4	Composite	1 or 2	16-17-18-19	1.43697E+27	4.1141	-0.0035
4	Flexible	1 or 2	16-17-18-19	58.1315	1.0264	-0.0862
A	All	All	16-17-18-19	19646019564	3.1712	-0.009
1	Composite	All	16-17-18-19	511.7243	1.5606	-0.029
6	Composite	All	16-17-18-19	1.04014E+36	4.402	-0.0008
10	Composite	All	16-17-18-19	Ld1=10401445555430400*Math.Pow(10,20);li1=4.402;ls1=-0.0008;Ld2=573.153;li2=1.5699;ls2=-0.0145;		
C	Composite	All	16-17-18-19	2704.5306	2.0572	-0.0246
1	Flexible	All	16-17-18-19	1.27334E+24	3.9863	-0.0011
6	Flexible	All	16-17-18-19	2.21779E+35	4.384	-0.0012
7	Flexible	All	16-17-18-19	73.0759	1.4134	-0.151
10	Flexible	All	16-17-18-19	Ld1=221778.766348933*Math.Pow(10,30);li1=4.384;ls1=-0.0012;Ld2=73.0759;li2=1.4134;ls2=-0.151;		
C	Flexible	All	16-17-18-19	44859729.16	2.8931	-0.0125
5	All	All	16-17-18-19-14	398.49	1.7958	-0.0324
5	All	All	1-7-8-9-2-3-6	2701.4546	2.077	-0.0293
A	All	All	1-7-8-9-2-3-6	62120662.97	2.8845	-0.0138
3	All	1	All	122962.0574	2.4522	-0.0095
B	All	1	All	2013.4766	2.079	-0.0346
B	All	3	All	1709.5229	1.9365	-0.0165
8	All	All	All	1.71116E+11	3.2614	-0.0093
7	Composite	All	All	573.153	1.5699	-0.0145
N/A	N/A	1	1	3.99E+22	3.93	-0.01
N/A	N/A	2	1	280	1.75	-0.04
N/A	N/A	3	1	280	1.75	-0.04

Treatment Group	Pavement type	Region	Func. Class	L_tilde (Ld)	Il_int (Ii)	Il_slp (Is)
N/A	N/A	1	2-3-6	763	1.72	-0.01
N/A	N/A	2	2-3-6	108	1.34	-0.04
N/A	N/A	3	2-3-6	29300	2.28	-0.02
N/A	N/A	1	7-8-9	220	1.58	-0.03
N/A	N/A	2	7-8-9	1170	1.88	-0.02
N/A	N/A	3	7-8-9	582	1.77	-0.04
N/A	N/A	1	11-12	593	1.61	-0.02
N/A	N/A	2	11-12	718	1.82	-0.03
N/A	N/A	3	11-12	378	1.67	-0.03
N/A	N/A	1	14	104	1.42	-0.03
N/A	N/A	2	14	238	1.52	-0.04
N/A	N/A	3	14	631	1.82	-0.04
N/A	N/A	1	16-17-18-19	325	1.63	-0.02
N/A	N/A	2	16-17-18-19	104	1.35	-0.04
N/A	N/A	3	16-17-18-19	153	1.5	-0.04

Table 2: SC Density Model parameters

Treatment Group	Pavement type	Region	Func. Class	L_tilde (Ld)	ll_int (li)	ll_slp (ls)
1	All	All	1	75.4278	1.8473	-0.1143
C	All	1	14	4.75248E+25	4.0944	-0.0029
2	Composite	1	14	3.47062E+22	3.9847	-0.0035
2	Flexible	1	14	298.7579	2.0722	-0.0526
3	All	2	14	3.81056E+35	4.4145	-0.002
C	All	2	14	93.7206	1.9854	-0.0693
2	Composite	2	14	232006421	3.024	-0.0152
2	Flexible	2	14	4.89637E+16	3.6892	-0.0084
3	All	3	14	3.35974E+33	4.384	-0.0036
4	All	3	14	262.8322	1.4992	-0.0224
C	All	3	14	6.52682E+22	3.9954	-0.0047
2	Composite	3	14	18265317.62	2.9518	-0.0297
2	Flexible	3	14	5.14982E+22	3.9923	-0.0055
4	All	1 or 2	14	289.443	1.5248	-0.0211
1	All	All	14	792.3727	1.8366	-0.0405
A	All	All	14	4.18279E+13	3.5095	-0.0099
1	Composite	All	2-3-6	112.2041	1.3241	-0.042
1	Flexible	All	2-3-6	510.6388	1.729	-0.0364
C	All	1	7-8-9	8.50373E+13	3.534	-0.0097
3	All	2	7-8-9	6218479.458	2.8513	-0.0153
C	All	2	7-8-9	1.26984E+14	3.537	-0.0092
C	All	3	7-8-9	80144088.86	2.9847	-0.0161
3	Composite	3	7-8-9	5.64932E+22	3.9899	-0.008
3	Flexible	3	7-8-9	7.27463E+16	3.6944	-0.0097
1	Composite	All	7-8-9	213.0146	1.5618	-0.0778
2	Composite	All	7-8-9	7762591.691	2.8461	-0.0167
4	Composite	All	7-8-9	620288.2706	2.4844	-0.0038
6	Composite	All	7-8-9	76.1753	1.5778	-0.0364
10	Composite	All	7-8-9	Ld1=76.1753;li1=1.5778;ls1=-0.0364;Ld2=467.7251;li2=1.9154;ls2=-0.0684;		
1	Flexible	All	7-8-9	4657209.606	2.7342	-0.022
2	Flexible	All	7-8-9	9.59826E+13	3.5271	-0.0089
4	Flexible	All	7-8-9	1532.5528	1.7333	-0.0123
6	Flexible	All	7-8-9	4.00975E+11	3.3658	-0.0228
7	Flexible	All	7-8-9	645.599	1.9055	-0.073
10	Flexible	All	7-8-9	Ld1=400975145472.392;li1=3.3658;ls1=-0.0228;Ld2=645.599;li2=1.9055;ls2=-0.073;		
6	Composite	All	11-12-14	56.1012	1.6191	-0.0758

Treatment Group	Pavement type	Region	Func. Class	L_tilde (Ld)	ll_int (li)	ll_slp (ls)
10	Composite	All	11-12-14	Ld1=56.1012;li1=1.6191;ls1=-0.0758;Ld2=467.7251;li2=1.9154;ls2=-0.0684;		
6	Flexible	All	11-12-14	252636546.4	3.0582	-0.0175
7	Flexible	All	11-12-14	109.6255	1.7694	-0.0889
10	Flexible	All	11-12-14	Ld1=252636546.4457;li1=3.0582;ls1=-0.0175;Ld2=109.6255;li2=1.7694;ls2=-0.0889;		
3	All	2	11-12	4.5551E+39	4.5402	-0.0019
5	All	2	11-12	3.12277E+28	4.2252	-0.0032
3	All	3	11-12	37964958115	3.2774	-0.0123
5	All	1 or 3	11-12	76695580.37	3.0379	-0.0123
1	All	All	11-12	7.28212E+25	4.1089	-0.0019
4	All	All	11-12	1.19669E+11	3.2652	-0.0123
A	All	All	11-12	257.2113	2.2446	-0.0478
C	All	All	11-12	1.08028E+19	3.8394	-0.0081
2	Composite	All	11-12	2.84956E+12	3.415	-0.0068
2	Flexible	All	11-12	5.08808E+20	3.9143	-0.0074
B	All	2	11-12-14-16-17-18-19	1.26807E+14	3.576	-0.0063
C	All	1	1-2-3-6	4.18041E+21	3.9646	-0.0064
2	Composite	1	1-2-3-6	1052792.426	2.7573	-0.0252
3	All	2	1-2-3-6	1.83458E+28	4.2083	-0.005
C	All	2	1-2-3-6	228005.7859	2.6686	-0.0206
2	Composite	2	1-2-3-6	1.06513E+11	3.3238	-0.0154
3	All	3	1-2-3-6	442.6717	2.0893	-0.052
4	All	3	1-2-3-6	84.7338	1.3176	-0.0884
2	Composite	3	1-2-3-6	2599368.844	2.8142	-0.018
C	Composite	3	1-2-3-6	14868.0287	2.4005	-0.0265
C	Flexible	3	1-2-3-6	1.29154E+16	3.6623	-0.0064
4	All	1 or 2	1-2-3-6	2716.8385	1.9974	-0.0138
6	Composite	All	1-2-3-6	22015.125	2.5034	-0.0316
10	Composite	All	1-2-3-6	Ld1=22015.125;li1=2.5034;ls1=-0.0316;Ld2=467.7251;li2=1.9154;ls2=-0.0684;		
2	Flexible	All	1-2-3-6	1.47011E+17	3.7223	-0.0052
6	Flexible	All	1-2-3-6	1.21619E+22	3.9576	-0.0054
7	Flexible	All	1-2-3-6	12702.3337	2.4296	-0.0567
10	Flexible	All	1-2-3-6	Ld1=121.619407645123*Math.Pow(10,20);li1=3.9576;ls1=-0.0054;Ld2=12702.3337;li2=2.4296;ls2=-0.0567;		

Treatment Group	Pavement type	Region	Func. Class	L_tilde (Ld)	II_int (Ii)	II_slp (Is)
B	All	2	1-2-3-6-7-8-9	582.5478	2.2089	-0.0197
2	Composite	1	16-17-18-19	1.94491E+17	3.7262	-0.0082
2	Flexible	1	16-17-18-19	7809.8883	2.3498	-0.0355
3	All	2	16-17-18-19	207.9771	1.9912	-0.0568
2	Composite	2	16-17-18-19	1721605.631	2.7579	-0.0209
2	Flexible	2	16-17-18-19	4.72506E+21	3.9406	-0.0059
3	All	3	16-17-18-19	2.61569E+17	3.7161	-0.0061
4	All	3	16-17-18-19	560.9015	1.555	-0.0141
2	Composite	3	16-17-18-19	69.4426	1.7037	-0.0774
2	Flexible	3	16-17-18-19	671.6257	2.2066	-0.0565
4	Composite	1 or 2	16-17-18-19	372.3782	1.5649	-0.0217
4	Flexible	1 or 2	16-17-18-19	2067.2575	1.7989	-0.0119
A	All	All	16-17-18-19	739.2838	2.0345	-0.0385
1	Composite	All	16-17-18-19	2.38079E+17	3.6591	-0.0027
6	Composite	All	16-17-18-19	1958.3861	2.0325	-0.0116
10	Composite	All	16-17-18-19	Ld1=1958.3861;Ii1=2.0325;Is1=-0.0116;Ld2=467.7251;Ii2=1.9154;Is2=-0.0684;		
C	Composite	All	16-17-18-19	726334947.4	3.0971	-0.0132
1	Flexible	All	16-17-18-19	3.72605E+11	3.2569	-0.0065
6	Flexible	All	16-17-18-19	128076.7042	2.5111	-0.0236
7	Flexible	All	16-17-18-19	51.1047	1.7873	-0.2267
10	Flexible	All	16-17-18-19	Ld1=128076.7042;Ii1=2.5111;Is1=-0.0236;Ld2=51.1047;Ii2=1.7873;Is2=-0.2267;		
C	Flexible	All	16-17-18-19	4730810253	3.1961	-0.0152
5	All	All	16-17-18-19-14	45.6078	1.8813	-0.1221
5	All	All	1-7-8-9-2-3-6	3.24984E+33	4.3845	-0.0021
A	All	All	1-7-8-9-2-3-6	54.3291	1.9695	-0.1039
3	All	1	All	32864163.85	2.9756	-0.0152
B	All	1	All	32864163.85	2.9756	-0.0152
B	All	3	All	32864163.85	2.9756	-0.0152
8	All	All	All	32864163.85	2.9756	-0.0152
7	Composite	All	All	467.7251	1.9154	-0.0684

Treatment Group	Pavement type	Region	Func. Class	L_tilde (Ld)	ll_int (li)	ll_slp (ls)
N/A	N/A	1	1	1920	2.32	-0.02
N/A	N/A	2	1	1500	2.27	-0.01
N/A	N/A	3	1	1500	2.27	-0.01
N/A	N/A	1	2-3-6	8.08E+11	3.35	-0.01
N/A	N/A	2	2-3-6	31300	2.4	-0.02
N/A	N/A	3	2-3-6	8.38E+17	3.76	-0.01
N/A	N/A	1	7-8-9	658	2.01	-0.05
N/A	N/A	2	7-8-9	746	1.97	-0.03
N/A	N/A	3	7-8-9	420	1.99	-0.06
N/A	N/A	1	11-12	1.12E+24	4.04	-0.01
N/A	N/A	2	11-12	6.65E+19	3.87	-0.01
N/A	N/A	3	11-12	3.05E+12	3.42	-0.01
N/A	N/A	1	14	4.06E+17	3.74	-0.01
N/A	N/A	2	14	586	1.96	-0.04
N/A	N/A	3	14	8.92E+12	3.44	-0.01
N/A	N/A	1	16-17-18-19	727	2.03	-0.04
N/A	N/A	2	16-17-18-19	654	1.93	-0.03
N/A	N/A	3	16-17-18-19	656	1.98	-0.04

Table 3: Treatment Group definitions

#	Last applied treatment
1	ASPHALT PATCH ONLY, POTHOLE PATCHING
2	MILL-OVERLAY <=1.5IN GRADE INCREASE
3	OVERLAY <=1.5IN ASPHALT, MILL-ULTRATHIN BONDED WEARING COURSE
4	CRACK SEAL, JOINT RESEALING
5	MILL-OVERLAY <=1.5IN GRADE INCREASE - GAP
6	THIN OVERLAY <=1IN ASPHALT, HOT-IN-PLACE RECYCLING
7	MICRO SURFACING, CAPE SEAL, HIGH FRICTION SURFACE
8	OVERLAY <=1.5IN ASPHALT - GAP, ULTRATHIN BONDED WEARING COURSE
9	SURFACE ABRASION
10	FOG SEAL, REJUVANATOR, CHIP SEAL, SAND SEAL
A	RECONSTRUCTION, MILL >=4IN-OVERLAY WITH ASPHALT, RUBBILIZATION-OVERLAY, COLD-IN-PLACE RECYCLING-OVERLAY, BREAK-CRACK-SEAT-OVERLAY, FULL-DEPTH RECLAMATION-OVERLAY
B	OVERLAY >1.5IN ASPHALT - GAP, MILL-OVERLAY >1.5IN GRADE INCREASE - GAP
C	OVERLAY >1.5IN ASPHALT, MILL-OVERLAY >1.5IN GRADE INCREASE

Table 4: Highway Functional Classes

Functional Class	Description
1	Rural Principal Arterial - Interstate
2	Rural Principal Arterial - Other Freeways
3	Rural Principal Arterial - Other
6	Rural Minor Arterial
7	Rural Major Collector
8	Rural Minor Collector
9	Rural Local
11	Urban Principal Arterial - Interstate
12	Urban Principal Arterial - Other Freeways
14	Urban Principal Arterial - Other
16	Urban Minor Arterial
17	Urban Major Collector
18	Urban Minor Collector
19	Urban Local

Table 5: Region Definitions

1 = Mountain	2 = Central	3 = Coastal

FC Density Function

```
double
        FC0,FCage,FCDMR=[FC_DENSITY_MR],age=[AGE],Ld=0,li=0,ls=0,
        gt=0,Ld1=0,li1=0,ls1=0,Ld2=0,li2=0,ls2=0;
string
        PT=[PAVEMENT_TYPE],RG=[REGION],LT=[LAST_TREATMENT],F
        C=[FUNC_CLASS];


if((FC=="1")&&(gt==0)){if((LT=="ASPHALT PATCH ONLY"||LT=="POTHOLE
        PATCHING")){Ld=90637719.4409;li=2.8083;ls=-0.0046;gt=1;}}
if((FC=="14")&&(gt==0)){if(RG=="1"&&(LT=="OVERLAY >1.5IN
        ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE
        INCREASE")){Ld=266.3311;li=1.4455;ls=-0.0255;gt=1;}
else
        if(RG=="1"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
        ="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=1787.4858;li=1.948;ls=-0.0111;gt=1;}
else if(RG=="1"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE
        INCREASE")){Ld=6.03267467669406*Math.Pow(10,20);li=3.8714;ls=
        -0.0029;gt=1;}
else if(RG=="2"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
        ULTRATHIN BONDED WEARING
        COURSE")){Ld=10694218632770800000*Math.Pow(10,20);li=4.488
        6;ls=-0.0009;gt=1;}
else if(RG=="2"&&(LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY
        >1.5IN GRADE INCREASE")){Ld=86.8394;li=1.6175;ls=-
        0.0618;gt=1;}
else
        if(RG=="2"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
        ="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=150.0416;li=1.3954;ls=-0.05;gt=1;}
else if(RG=="2"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE INCREASE")){Ld=275.4735;li=1.6585;ls=-
        0.0442;gt=1;}
else if(RG=="3"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
        ULTRATHIN BONDED WEARING
        COURSE")){Ld=4103.2955;li=2.2241;ls=-0.0275;gt=1;}
else if(RG=="3"&&(LT=="CRACK SEAL"||LT=="JOINT
        RESEALING")){Ld=55.5406;li=1.0076;ls=-0.1419;gt=1;}
else if(RG=="3"&&(LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY
        >1.5IN GRADE INCREASE")){Ld=41969.4996;li=2.3521;ls=-
        0.0217;gt=1;}
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else
        if(RG=="3"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
        ="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=117.5573;li=1.4525;ls=-0.0749;gt=1;}
else if(RG=="3"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE INCREASE")){Ld=125.2176;li=1.5761;ls=-
        0.0606;gt=1;}
else if(RG=="1"||RG=="2"&&(LT=="CRACK SEAL"||LT=="JOINT
        RESEALING")){Ld=76.2935;li=1.0401;ls=-0.0643;gt=1;}
else if((LT=="ASPHALT PATCH ONLY"||LT=="POTHOLE
        PATCHING")){Ld=1002.87617756533*Math.Pow(10,15);li=3.6796;ls
        =-0.0019;gt=1;}
else if((LT=="RECONSTRUCTION"||LT=="MILL >=4IN-OVERLAY WITH
        ASPHALT"||LT=="RUBBILIZATION-OVERLAY"||LT=="COLD-IN-
        PLACE RECYCLING-OVERLAY"||LT=="BREAK-CRACK-SEAT-
        OVERLAY"||LT=="FULL-DEPTH RECLAMATION-
        OVERLAY")){Ld=215600901.711267*Math.Pow(10,10);li=3.7308;ls=-
        0.0031;gt=1;}}
if((FC=="2"||FC=="3"||FC=="6")&&(gt==0)){if((PT=="FCC"||PT=="FCJ"||PT=="CO
        MPOSITE")&&(LT=="ASPHALT PATCH ONLY"||LT=="POTHOLE
        PATCHING")){Ld=584.7963;li=1.464;ls=-0.0102;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="ASPHALT PATCH
        ONLY"||LT=="POTHOLE PATCHING")){Ld=138.1563;li=1.1843;ls=-
        0.0417;gt=1;}}
if((FC=="7"||FC=="8"||FC=="9")&&(gt==0)){if(RG=="1"&&(LT=="OVERLAY
        >1.5IN ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE
        INCREASE")){Ld=305.5609;li=1.7251;ls=-0.031;gt=1;}
else if(RG=="2"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
        ULTRATHIN BONDED WEARING
        COURSE")){Ld=1956.3351;li=2.0539;ls=-0.0189;gt=1;}
else if(RG=="2"&&(LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY
        >1.5IN GRADE INCREASE")){Ld=599.4863;li=1.8873;ls=-
        0.0317;gt=1;}
else if(RG=="3"&&(LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY
        >1.5IN GRADE
        INCREASE")){Ld=2.10797424508439*Math.Pow(10,10);li=3.1608;ls=
        -0.0081;gt=1;}
else
        if(RG=="3"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
        ="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-ULTRATHIN BONDED
        WEARING
        COURSE")){Ld=621395.355961961*Math.Pow(10,10);li=3.5844;ls=-
        0.0067;gt=1;}
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else if(RG=="3"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="OVERLAY <=1.5IN
        ASPHALT"||LT=="MILL-ULTRATHIN BONDED WEARING
        COURSE")){Ld=1361.205;li=1.941;ls=-0.0285;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="ASPHALT
        PATCH ONLY"||LT=="POTHOLE
        PATCHING")){Ld=215.1996;li=1.3605;ls=-0.0575;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE INCREASE")){Ld=341.6614;li=1.7043;ls=-
        0.0338;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="CRACK
        SEAL"||LT=="JOINT
        RESEALING")){Ld=604.754119009586*Math.Pow(10,20);li=3.9402;l
        s=-0.0045;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="THIN OVERLAY
        <=1IN ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=50.5424;li=1.0538;ls=-0.0821;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="FOG
        SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
        SEAL")){Ld1=50.5424;li1=1.0538;ls1=-
        0.0821;Ld2=573.153;li2=1.5699;ls2=-0.0145;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="ASPHALT PATCH
        ONLY"||LT=="POTHOLE PATCHING")){Ld=109.2627;li=1.248;ls=-
        0.0402;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=6966.2944;li=2.1961;ls=-0.0176;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="CRACK SEAL"||LT=="JOINT
        RESEALING")){Ld=145528821.0712;li=2.8511;ls=-0.0076;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="THIN OVERLAY <=1IN
        ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=60.3093;li=1.4039;ls=-0.1222;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MICRO SURFACING"||LT=="CAPE
        SEAL"||LT=="HIGH FRICTION
        SURFACE")){Ld=10471052.5813;li=2.7114;ls=-0.0162;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="FOG
        SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
        SEAL")){Ld1=60.3093;li1=1.4039;ls1=-
        0.1222;Ld2=10471052.5813;li2=2.7114;ls2=-0.0162;gt=1;}}
if((FC=="11"||FC=="12"||FC=="14")&&(gt==0)){if((PT=="FCC"||PT=="FCJ"||PT=="
        COMPOSITE")&&(LT=="THIN OVERLAY <=1IN
        ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=76.9602;li=1.2325;ls=-0.073;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="FOG
        SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
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        SEAL")){Ld1=76.9602;li1=1.2325;ls1=-
        0.073;Ld2=573.153;li2=1.5699;ls2=-0.0145;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="THIN OVERLAY <=1IN
        ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=98973660234.9642*Math.Pow(10,20);li=4.2652;l
        s=-0.0023;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MICRO SURFACING"||LT=="CAPE
        SEAL"||LT=="HIGH FRICTION
        SURFACE")){Ld=1882.4205;li=1.9344;ls=-0.0382;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="FOG
        SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
        SEAL")){Ld1=98973660234.9642*Math.Pow(10,20);li1=4.2652;ls1=-
        0.0023;Ld2=1882.4205;li2=1.9344;ls2=-0.0382;gt=1;}}
if((FC=="11"||FC=="12")&&(gt==0)){if(RG=="2"&&(LT=="OVERLAY <=1.5IN
        ASPHALT"||LT=="MILL-ULTRATHIN BONDED WEARING
        COURSE")){Ld=89359137.6056;li=2.9464;ls=-0.015;gt=1;}
else if(RG=="2"&&(LT=="MILL-OVERLAY <=1.5IN GRADE INCREASE -
        GAP")){Ld=1662.1596;li=1.9936;ls=-0.0288;gt=1;}
else if(RG=="3"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
        ULTRATHIN BONDED WEARING
        COURSE")){Ld=3794.5556;li=1.951;ls=-0.0064;gt=1;}
else if(RG=="1"||RG=="3"&&(LT=="MILL-OVERLAY <=1.5IN GRADE
        INCREASE - GAP")){Ld=50.4719;li=1.1323;ls=-0.0834;gt=1;}
else if((LT=="ASPHALT PATCH ONLY"||LT=="POTHOLE
        PATCHING")){Ld=22.7746814420507*Math.Pow(10,15);li=3.5918;ls
        =-0.0025;gt=1;}
else if((LT=="CRACK SEAL"||LT=="JOINT
        RESEALING")){Ld=50.3632;li=0.8305;ls=-0.0947;gt=1;}
else if((LT=="RECONSTRUCTION"||LT=="MILL >=4IN-OVERLAY WITH
        ASPHALT"||LT=="RUBBILIZATION-OVERLAY"||LT=="COLD-IN-
        PLACE RECYCLING-OVERLAY"||LT=="BREAK-CRACK-SEAT-
        OVERLAY"||LT=="FULL-DEPTH RECLAMATION-
        OVERLAY")){Ld=2683.6544;li=2.0435;ls=-0.0171;gt=1;}
else if((LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY >1.5IN
        GRADE INCREASE")){Ld=2492522026.8003;li=3.0629;ls=-
        0.009;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE INCREASE")){Ld=111.6238;li=1.2991;ls=-
        0.053;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=2516.3924;li=2.013;ls=-0.0291;gt=1;}}
if((FC=="11"||FC=="12"||FC=="14"||FC=="16"||FC=="17"||FC=="18"||FC=="19")&
        &(gt==0)){if(RG=="2"&&(LT=="OVERLAY >1.5IN ASPHALT -
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            GAP"||LT=="MILL-OVERLAY >1.5IN GRADE INCREASE -
            GAP")){Ld=600;li=1.9327;ls=-0.0345;gt=1;}}
if((FC=="1"||FC=="2"||FC=="3"||FC=="6")&&(gt==0)){if(RG=="1"&&(LT=="OVERL
            AY >1.5IN ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE
            INCREASE")){Ld=106.2486;li=1.5597;ls=-0.0593;gt=1;}
else
            if(RG=="1"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
            ="MILL-OVERLAY <=1.5IN GRADE
            INCREASE")){Ld=97.2449;li=1.3891;ls=-0.0457;gt=1;}
else if(RG=="2"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
            ULTRATHIN BONDED WEARING
            COURSE")){Ld=431.2878;li=1.7957;ls=-0.0347;gt=1;}
else if(RG=="2"&&(LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY
            >1.5IN GRADE
            INCREASE")){Ld=71606660.6601704*Math.Pow(10,10);li=3.7176;ls=
            -0.0039;gt=1;}
else
            if(RG=="2"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
            ="MILL-OVERLAY <=1.5IN GRADE
            INCREASE")){Ld=4709385.6133;li=2.7561;ls=-0.0194;gt=1;}
else if(RG=="3"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
            ULTRATHIN BONDED WEARING
            COURSE")){Ld=1789.58;li=1.9201;ls=-0.0212;gt=1;}
else if(RG=="3"&&(LT=="CRACK SEAL"||LT=="JOINT
            RESEALING")){Ld=78.314;li=1.1183;ls=-0.1146;gt=1;}
else
            if(RG=="3"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
            ="MILL-OVERLAY <=1.5IN GRADE
            INCREASE")){Ld=28894462.1571;li=2.8285;ls=-0.0165;gt=1;}
else
            if(RG=="3"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
            ="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY >1.5IN
            GRADE INCREASE")){Ld=170.3627;li=1.499;ls=-0.0455;gt=1;}
else if(RG=="3"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="OVERLAY >1.5IN
            ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE
            INCREASE")){Ld=397.2458;li=1.7853;ls=-0.0385;gt=1;}
else if(RG=="1"||RG=="2"&&(LT=="CRACK SEAL"||LT=="JOINT
            RESEALING")){Ld=13659.7542;li=2.1062;ls=-0.0159;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="THIN OVERLAY
            <=1IN ASPHALT"||LT=="HOT-IN-PLACE
            RECYCLING")){Ld=6073.429;li=2.1367;ls=-0.0255;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="FOG
            SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
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        SEAL")){Ld1=6073.429;li1=2.1367;ls1=-
        0.0255;Ld2=573.153;li2=1.5699;ls2=-0.0145;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=367611295.5788;li=2.9757;ls=-0.0088;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="THIN OVERLAY <=1IN
        ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=951.8987;li=1.9191;ls=-0.0352;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MICRO SURFACING"||LT=="CAPE
        SEAL"||LT=="HIGH FRICTION
        SURFACE")){Ld=201234894.491;li=2.9441;ls=-0.0166;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="FOG
        SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
        SEAL")){Ld1=951.8987;li1=1.9191;ls1=-
        0.0352;Ld2=201234894.491;li2=2.9441;ls2=-0.0166;gt=1;}}
if((FC=="1"||FC=="2"||FC=="3"||FC=="6"||FC=="7"||FC=="8"||FC=="9")&&(gt==0))
        {if(RG=="2"&&(LT=="OVERLAY >1.5IN ASPHALT -
        GAP"||LT=="MILL-OVERLAY >1.5IN GRADE INCREASE -
        GAP")){Ld=93879.8842929807*Math.Pow(10,10);li=3.5453;ls=-
        0.005;gt=1;}}
if((FC=="16"||FC=="17"||FC=="18"||FC=="19")&&(gt==0)){if(RG=="1"&&(PT=="F
        CC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE INCREASE")){Ld=1032.0372;li=1.8994;ls=-
        0.025;gt=1;}
else if(RG=="1"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE INCREASE")){Ld=5437.0356;li=2.1001;ls=-
        0.0225;gt=1;}
else if(RG=="2"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
        ULTRATHIN BONDED WEARING
        COURSE")){Ld=860.3014;li=1.938;ls=-0.0366;gt=1;}
else
        if(RG=="2"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
        ="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=437.9597;li=1.735;ls=-0.0345;gt=1;}
else if(RG=="2"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE INCREASE")){Ld=720.4722;li=1.8432;ls=-
        0.0266;gt=1;}
else if(RG=="3"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
        ULTRATHIN BONDED WEARING
        COURSE")){Ld=573.903;li=1.7447;ls=-0.0175;gt=1;}
else if(RG=="3"&&(LT=="CRACK SEAL"||LT=="JOINT
        RESEALING")){Ld=1382900.3943;li=2.5519;ls=-0.0148;gt=1;}
else
        if(RG=="3"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
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        ="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=404.1978;li=1.6935;ls=-0.0352;gt=1;}
else if(RG=="3"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE INCREASE")){Ld=130.2758;li=1.7928;ls=-
        0.0733;gt=1;}
else
        if(RG=="1"||RG=="2"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSIT
        E")&&(LT=="CRACK SEAL"||LT=="JOINT
        RESEALING")){Ld=14369723.9977432*Math.Pow(10,20);li=4.1141;l
        s=-0.0035;gt=1;}
else if(RG=="1"||RG=="2"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="CRACK
        SEAL"||LT=="JOINT RESEALING")){Ld=58.1315;li=1.0264;ls=-
        0.0862;gt=1;}
else if((LT=="RECONSTRUCTION"||LT=="MILL >=4IN-OVERLAY WITH
        ASPHALT"||LT=="RUBBILIZATION-OVERLAY"||LT=="COLD-IN-
        PLACE RECYCLING-OVERLAY"||LT=="BREAK-CRACK-SEAT-
        OVERLAY"||LT=="FULL-DEPTH RECLAMATION-
        OVERLAY")){Ld=19646019564.2089;li=3.1712;ls=-0.009;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="ASPHALT
        PATCH ONLY"||LT=="POTHOLE
        PATCHING")){Ld=511.7243;li=1.5606;ls=-0.029;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="THIN OVERLAY
        <=1IN ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=10401445555430400*Math.Pow(10,20);li=4.402;l
        s=-0.0008;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="FOG
        SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
        SEAL")){Ld1=10401445555430400*Math.Pow(10,20);li1=4.402;ls1=-
        0.0008;Ld2=573.153;li2=1.5699;ls2=-0.0145;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="OVERLAY
        >1.5IN ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE
        INCREASE")){Ld=2704.5306;li=2.0572;ls=-0.0246;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="ASPHALT PATCH
        ONLY"||LT=="POTHOLE
        PATCHING")){Ld=12733.4191692852*Math.Pow(10,20);li=3.9863;ls
        =-0.0011;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="THIN OVERLAY <=1IN
        ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=221778.766348933*Math.Pow(10,30);li=4.384;ls
        =-0.0012;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MICRO SURFACING"||LT=="CAPE
        SEAL"||LT=="HIGH FRICTION
        SURFACE")){Ld=73.0759;li=1.4134;ls=-0.151;gt=1;}
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else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="FOG SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND SEAL")){Ld1=221778.766348933*Math.Pow(10,30);li1=4.384;ls1=-0.0012;Ld2=73.0759;li2=1.4134;ls2=-0.151;gt=1;}

else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE INCREASE")){Ld=44859729.159;li=2.8931;ls=-0.0125;gt=1;}}

if((FC=="16"||FC=="17"||FC=="18"||FC=="19"||FC=="14")&&(gt==0)){if((LT=="MILL-OVERLAY <=1.5IN GRADE INCREASE - GAP")){Ld=398.49;li=1.7958;ls=-0.0324;gt=1;}}

if((FC=="1"||FC=="7"||FC=="8"||FC=="9"||FC=="2"||FC=="3"||FC=="6")&&(gt==0)) {if((LT=="MILL-OVERLAY <=1.5IN GRADE INCREASE - GAP")){Ld=2701.4546;li=2.077;ls=-0.0293;gt=1;}

else if((LT=="RECONSTRUCTION"||LT=="MILL >=4IN-OVERLAY WITH ASPHALT"||LT=="RUBBILIZATION-OVERLAY"||LT=="COLD-IN-PLACE RECYCLING-OVERLAY"||LT=="BREAK-CRACK-SEAT-OVERLAY"||LT=="FULL-DEPTH RECLAMATION-OVERLAY")){Ld=62120662.968;li=2.8845;ls=-0.0138;gt=1;}}

if(gt==0){if(RG=="1"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-ULTRATHIN BONDED WEARING COURSE")){Ld=122962.0574;li=2.4522;ls=-0.0095;gt=1;}

else if(RG=="1"&&(LT=="OVERLAY >1.5IN ASPHALT - GAP"||LT=="MILL-OVERLAY >1.5IN GRADE INCREASE - GAP")){Ld=2013.4766;li=2.079;ls=-0.0346;gt=1;}

else if(RG=="3"&&(LT=="OVERLAY >1.5IN ASPHALT - GAP"||LT=="MILL-OVERLAY >1.5IN GRADE INCREASE - GAP")){Ld=1709.5229;li=1.9365;ls=-0.0165;gt=1;}

else if((LT=="OVERLAY <=1.5IN ASPHALT - GAP"||LT=="ULTRATHIN BONDED WEARING COURSE")){Ld=171115888500.86;li=3.2614;ls=-0.0093;gt=1;}

else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="MICRO SURFACING"||LT=="CAPE SEAL"||LT=="HIGH FRICTION SURFACE")){Ld=573.153;li=1.5699;ls=-0.0145;gt=1;}}

if((FC=="1")&&(gt==0)){if(RG=="1"){Ld=399*Math.Pow(10,20);li=3.93;ls=-0.01;gt=1;}

else if(RG=="2"){Ld=280;li=1.75;ls=-0.04;gt=1;}

else if(RG=="3"){Ld=280;li=1.75;ls=-0.04;gt=1;}}

if((FC=="2"||FC=="3"||FC=="6")&&(gt==0)){if(RG=="1"){Ld=763;li=1.72;ls=-0.01;gt=1;}

else if(RG=="2"){Ld=108;li=1.34;ls=-0.04;gt=1;}

else if(RG=="3"){Ld=29300;li=2.28;ls=-0.02;gt=1;}}
```

```
if((FC=="7"||FC=="8"||FC=="9")&&(gt==0)){if(RG=="1"){Ld=220;li=1.58;ls=-
        0.03;gt=1;}
else if(RG=="2"){Ld=1170;li=1.88;ls=-0.02;gt=1;}
else if(RG=="3"){Ld=582;li=1.77;ls=-0.04;gt=1;}}
if((FC=="11"||FC=="12")&&(gt==0)){if(RG=="1"){Ld=593;li=1.61;ls=-0.02;gt=1;}
else if(RG=="2"){Ld=718;li=1.82;ls=-0.03;gt=1;}
else if(RG=="3"){Ld=378;li=1.67;ls=-0.03;gt=1;}}
if((FC=="14")&&(gt==0)){if(RG=="1"){Ld=104;li=1.42;ls=-0.03;gt=1;}
else if(RG=="2"){Ld=238;li=1.52;ls=-0.04;gt=1;}
else if(RG=="3"){Ld=631;li=1.82;ls=-0.04;gt=1;}}
if((FC=="16"||FC=="17"||FC=="18"||FC=="19")&&(gt==0)){if(RG=="1"){Ld=325;li=
        1.63;ls=-0.02;gt=1;}
else if(RG=="2"){Ld=104;li=1.35;ls=-0.04;gt=1;}
else if(RG=="3"){Ld=153;li=1.5;ls=-0.04;gt=1;}}

if(FCDMR==0){FCDMR=0.01;}
if(LT=="MILL-ULTRATHIN BONDED WEARING COURSE"||LT=="ULTRATHIN
        BONDED WEARING COURSE"){
FCage=Ld*Math.Exp(-Math.Exp(li+ls*age))*4;
FC0=Ld*Math.Exp(-Math.Exp(li+ls*0))*4;
}
else if(LT=="FOG SEAL"||LT=="REJUVANATOR"||LT=="CHIP
        SEAL"||LT=="SAND SEAL"){
FCage=Ld1*Math.Exp(-Math.Exp(li1+ls1*age))*0.4+Ld2*Math.Exp(-
        Math.Exp(li2+ls2*age))*0.6;
FC0=Ld1*Math.Exp(-Math.Exp(li1+ls1*0))*0.4+Ld2*Math.Exp(-
        Math.Exp(li2+ls2*0))*0.6;
}
else{
FCage=Ld*Math.Exp(-Math.Exp(li+ls*age));
FC0=Ld*Math.Exp(-Math.Exp(li+ls*0));}
if(FCDMR<=FC0){Answer=FCage-FC0;}
else{Answer=FCage;}
return Answer;
```

SC Density Function

```
double
        SC0,SCage,SCDMR=[SC_DENSITY_MR],age=[AGE],Ld=0,li=0,ls=0
        ,gt=0,Ld1=0,li1=0,ls1=0,Ld2=0,li2=0,ls2=0;
string
        PT=[PAVEMENT_TYPE],RG=[REGION],LT=[LAST_TREATMENT],F
        C=[FUNC_CLASS];
if((FC=="1")&&(gt==0)){if((LT=="ASPHALT PATCH ONLY"||LT=="POTHOLE
        PATCHING")){Ld=75.4278;li=1.8473;ls=-0.1143;gt=1;}}
if((FC=="14")&&(gt==0)){if(RG=="1"&&(LT=="OVERLAY >1.5IN
        ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE
        INCREASE")){Ld=475248.294659273*Math.Pow(10,20);li=4.0944;ls=
        -0.0029;gt=1;}
else
        if(RG=="1"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
        ="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=347.061977009049*Math.Pow(10,20);li=3.9847;ls=
        -0.0035;gt=1;}
else if(RG=="1"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE INCREASE")){Ld=298.7579;li=2.0722;ls=-
        0.0526;gt=1;}
else if(RG=="2"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
        ULTRATHIN BONDED WEARING
        COURSE")){Ld=381056.048639361*Math.Pow(10,30);li=4.4145;ls=-
        0.002;gt=1;}
else if(RG=="2"&&(LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY
        >1.5IN GRADE INCREASE")){Ld=93.7206;li=1.9854;ls=-
        0.0693;gt=1;}
else
        if(RG=="2"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
        ="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=232006421.0355;li=3.024;ls=-0.0152;gt=1;}
else if(RG=="2"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE
        INCREASE")){Ld=4896371.86214469*Math.Pow(10,10);li=3.6892;ls=
        -0.0084;gt=1;}
else if(RG=="3"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
        ULTRATHIN BONDED WEARING
        COURSE")){Ld=335974272.41171*Math.Pow(10,25);li=4.384;ls=-
        0.0036;gt=1;}
else if(RG=="3"&&(LT=="CRACK SEAL"||LT=="JOINT
        RESEALING")){Ld=262.8322;li=1.4992;ls=-0.0224;gt=1;}
else if(RG=="3"&&(LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY
        >1.5IN GRADE
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INCREASE")){Ld=652.682102347311*Math.Pow(10,20);li=3.9954;ls=-0.0047;gt=1;}
else if(RG=="3"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="MILL-OVERLAY <=1.5IN GRADE INCREASE")){Ld=18265317.6231;li=2.9518;ls=-0.0297;gt=1;}
else if(RG=="3"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY <=1.5IN GRADE INCREASE")){Ld=514.982069631293*Math.Pow(10,20);li=3.9923;ls=-0.0055;gt=1;}
else if(RG=="1"||RG=="2"&&(LT=="CRACK SEAL"||LT=="JOINT RESEALING")){Ld=289.443;li=1.5248;ls=-0.0211;gt=1;}
else if((LT=="ASPHALT PATCH ONLY"||LT=="POTHOLE PATCHING")){Ld=792.3727;li=1.8366;ls=-0.0405;gt=1;}
else if((LT=="RECONSTRUCTION"||LT=="MILL >=4IN-OVERLAY WITH ASPHALT"||LT=="RUBBILIZATION-OVERLAY"||LT=="COLD-IN-PLACE RECYCLING-OVERLAY"||LT=="BREAK-CRACK-SEAT-OVERLAY"||LT=="FULL-DEPTH RECLAMATION-OVERLAY")){Ld=4182.78688673652*Math.Pow(10,10);li=3.5095;ls=-0.0099;gt=1;}}
if((FC=="2"||FC=="3"||FC=="6")&&(gt==0)){if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="ASPHALT PATCH ONLY"||LT=="POTHOLE PATCHING")){Ld=112.2041;li=1.3241;ls=-0.042;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="ASPHALT PATCH ONLY"||LT=="POTHOLE PATCHING")){Ld=510.6388;li=1.729;ls=-0.0364;gt=1;}}
if((FC=="7"||FC=="8"||FC=="9")&&(gt==0)){if(RG=="1"&&(LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE INCREASE")){Ld=85037347834966;li=3.534;ls=-0.0097;gt=1;}
else if(RG=="2"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-ULTRATHIN BONDED WEARING COURSE")){Ld=6218479.4581;li=2.8513;ls=-0.0153;gt=1;}
else if(RG=="2"&&(LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE INCREASE")){Ld=126984274512314;li=3.537;ls=-0.0092;gt=1;}
else if(RG=="3"&&(LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE INCREASE")){Ld=80144088.8551;li=2.9847;ls=-0.0161;gt=1;}
else if(RG=="3"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-ULTRATHIN BONDED WEARING COURSE")){Ld=564.932399692712*Math.Pow(10,20);li=3.9899;ls=-0.008;gt=1;}
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else if(RG=="3"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="OVERLAY <=1.5IN
        ASPHALT"||LT=="MILL-ULTRATHIN BONDED WEARING
        COURSE")){Ld=7274634.69497847*Math.Pow(10,10);li=3.6944;ls=-
        0.0097;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="ASPHALT
        PATCH ONLY"||LT=="POTHOLE
        PATCHING")){Ld=213.0146;li=1.5618;ls=-0.0778;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE INCREASE")){Ld=7762591.6914;li=2.8461;ls=-
        0.0167;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="CRACK
        SEAL"||LT=="JOINT RESEALING")){Ld=620288.2706;li=2.4844;ls=-
        0.0038;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="THIN OVERLAY
        <=1IN ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=76.1753;li=1.5778;ls=-0.0364;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="FOG
        SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
        SEAL")){Ld1=76.1753;li1=1.5778;ls1=-
        0.0364;Ld2=467.7251;li2=1.9154;ls2=-0.0684;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="ASPHALT PATCH
        ONLY"||LT=="POTHOLE
        PATCHING")){Ld=4657209.6055;li=2.7342;ls=-0.022;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=95982573657203;li=3.5271;ls=-0.0089;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="CRACK SEAL"||LT=="JOINT
        RESEALING")){Ld=1532.5528;li=1.7333;ls=-0.0123;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="THIN OVERLAY <=1IN
        ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=400975145472.392;li=3.3658;ls=-0.0228;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MICRO SURFACING"||LT=="CAPE
        SEAL"||LT=="HIGH FRICTION
        SURFACE")){Ld=645.599;li=1.9055;ls=-0.073;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="FOG
        SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
        SEAL")){Ld1=400975145472.392;li1=3.3658;ls1=-
        0.0228;Ld2=645.599;li2=1.9055;ls2=-0.073;gt=1;}}
if((FC=="11"||FC=="12"||FC=="14")&&(gt==0)){if((PT=="FCC"||PT=="FCJ"||PT=="
        COMPOSITE")&&(LT=="THIN OVERLAY <=1IN
        ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=56.1012;li=1.6191;ls=-0.0758;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="FOG
        SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
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            SEAL")){Ld1=56.1012;li1=1.6191;ls1=-
            0.0758;Ld2=467.7251;li2=1.9154;ls2=-0.0684;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="THIN OVERLAY <=1IN
            ASPHALT"||LT=="HOT-IN-PLACE
            RECYCLING")){Ld=252636546.4457;li=3.0582;ls=-0.0175;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MICRO SURFACING"||LT=="CAPE
            SEAL"||LT=="HIGH FRICTION
            SURFACE")){Ld=109.6255;li=1.7694;ls=-0.0889;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="FOG
            SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
            SEAL")){Ld1=252636546.4457;li1=3.0582;ls1=-
            0.0175;Ld2=109.6255;li2=1.7694;ls2=-0.0889;gt=1;}}
if((FC=="11"||FC=="12")&&(gt==0)){if(RG=="2"&&(LT=="OVERLAY <=1.5IN
            ASPHALT"||LT=="MILL-ULTRATHIN BONDED WEARING
            COURSE")){Ld=4555096024.28126*Math.Pow(10,30);li=4.5402;ls=-
            0.0019;gt=1;}
else if(RG=="2"&&(LT=="MILL-OVERLAY <=1.5IN GRADE INCREASE -
            GAP")){Ld=312277401.799835*Math.Pow(10,20);li=4.2252;ls=-
            0.0032;gt=1;}
else if(RG=="3"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
            ULTRATHIN BONDED WEARING
            COURSE")){Ld=37964958115.2038;li=3.2774;ls=-0.0123;gt=1;}
else if(RG=="1"||RG=="3"&&(LT=="MILL-OVERLAY <=1.5IN GRADE
            INCREASE - GAP")){Ld=76695580.3749;li=3.0379;ls=-0.0123;gt=1;}
else if((LT=="ASPHALT PATCH ONLY"||LT=="POTHOLE
            PATCHING")){Ld=728211.849279491*Math.Pow(10,20);li=4.1089;ls
            =-0.0019;gt=1;}
else if((LT=="CRACK SEAL"||LT=="JOINT
            RESEALING")){Ld=119668831116.782;li=3.2652;ls=-0.0123;gt=1;}
else if((LT=="RECONSTRUCTION"||LT=="MILL >=4IN-OVERLAY WITH
            ASPHALT"||LT=="RUBBILIZATION-OVERLAY"||LT=="COLD-IN-
            PLACE RECYCLING-OVERLAY"||LT=="BREAK-CRACK-SEAT-
            OVERLAY"||LT=="FULL-DEPTH RECLAMATION-
            OVERLAY")){Ld=257.2113;li=2.2446;ls=-0.0478;gt=1;}
else if((LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY >1.5IN
            GRADE
            INCREASE")){Ld=1080282746.3041*Math.Pow(10,10);li=3.8394;ls=-
            0.0081;gt=1;}
else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="MILL-OVERLAY
            <=1.5IN GRADE INCREASE")){Ld=2849556354718;li=3.415;ls=-
            0.0068;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY <=1.5IN GRADE
            INCREASE")){Ld=5.08808444115597*Math.Pow(10,20);li=3.9143;ls=
            -0.0074;gt=1;}}
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if((FC=="11"||FC=="12"||FC=="14"||FC=="16"||FC=="17"||FC=="18"||FC=="19")&
        &(gt==0)){if(RG=="2"&&(LT=="OVERLAY >1.5IN ASPHALT -
        GAP"||LT=="MILL-OVERLAY >1.5IN GRADE INCREASE -
        GAP")){Ld=126806671084707;li=3.576;ls=-0.0063;gt=1;}}

if((FC=="1"||FC=="2"||FC=="3"||FC=="6")&&(gt==0)){if(RG=="1"&&(LT=="OVERL
        AY >1.5IN ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE
        INCREASE")){Ld=41.8040558403263*Math.Pow(10,20);li=3.9646;ls=
        -0.0064;gt=1;}

else
        if(RG=="1"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
        ="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=1052792.4264;li=2.7573;ls=-0.0252;gt=1;}

else if(RG=="2"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
        ULTRATHIN BONDED WEARING
        COURSE")){Ld=183457661.715306*Math.Pow(10,20);li=4.2083;ls=-
        0.005;gt=1;}

else if(RG=="2"&&(LT=="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY
        >1.5IN GRADE INCREASE")){Ld=228005.7859;li=2.6686;ls=-
        0.0206;gt=1;}

else
        if(RG=="2"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
        ="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=106513001677.249;li=3.3238;ls=-0.0154;gt=1;}

else if(RG=="3"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
        ULTRATHIN BONDED WEARING
        COURSE")){Ld=442.6717;li=2.0893;ls=-0.052;gt=1;}

else if(RG=="3"&&(LT=="CRACK SEAL"||LT=="JOINT
        RESEALING")){Ld=84.7338;li=1.3176;ls=-0.0884;gt=1;}

else
        if(RG=="3"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
        ="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=2599368.8437;li=2.8142;ls=-0.018;gt=1;}

else
        if(RG=="3"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
        ="OVERLAY >1.5IN ASPHALT"||LT=="MILL-OVERLAY >1.5IN
        GRADE INCREASE")){Ld=14868.0287;li=2.4005;ls=-0.0265;gt=1;}

else if(RG=="3"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="OVERLAY >1.5IN
        ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE
        INCREASE")){Ld=12915430597549900;li=3.6623;ls=-0.0064;gt=1;}

else if(RG=="1"||RG=="2"&&(LT=="CRACK SEAL"||LT=="JOINT
        RESEALING")){Ld=2716.8385;li=1.9974;ls=-0.0138;gt=1;}

else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="THIN OVERLAY
        <=1IN ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=22015.125;li=2.5034;ls=-0.0316;gt=1;}
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else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="FOG
        SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
        SEAL")){Ld1=22015.125;li1=2.5034;ls1=-
        0.0316;Ld2=467.7251;li2=1.9154;ls2=-0.0684;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=14701100.3697198*Math.Pow(10,10);li=3.7223;ls=
        -0.0052;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="THIN OVERLAY <=1IN
        ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=121.619407645123*Math.Pow(10,20);li=3.9576;l
        s=-0.0054;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MICRO SURFACING"||LT=="CAPE
        SEAL"||LT=="HIGH FRICTION
        SURFACE")){Ld=12702.3337;li=2.4296;ls=-0.0567;gt=1;}
else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="FOG
        SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
        SEAL")){Ld1=121.619407645123*Math.Pow(10,20);li1=3.9576;ls1=-
        0.0054;Ld2=12702.3337;li2=2.4296;ls2=-0.0567;gt=1;}}
if((FC=="1"||FC=="2"||FC=="3"||FC=="6"||FC=="7"||FC=="8"||FC=="9")&&(gt==0))
        {if(RG=="2"&&(LT=="OVERLAY >1.5IN ASPHALT -
        GAP"||LT=="MILL-OVERLAY >1.5IN GRADE INCREASE -
        GAP")){Ld=582.5478;li=2.2089;ls=-0.0197;gt=1;}}
if((FC=="16"||FC=="17"||FC=="18"||FC=="19")&&(gt==0)){if(RG=="1"&&(PT=="F
        CC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE
        INCREASE")){Ld=19449091.0508668*Math.Pow(10,10);li=3.7262;ls=
        -0.0082;gt=1;}
else if(RG=="1"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE INCREASE")){Ld=7809.8883;li=2.3498;ls=-
        0.0355;gt=1;}
else if(RG=="2"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
        ULTRATHIN BONDED WEARING
        COURSE")){Ld=207.9771;li=1.9912;ls=-0.0568;gt=1;}
else
        if(RG=="2"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
        ="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=1721605.6314;li=2.7579;ls=-0.0209;gt=1;}
else if(RG=="2"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE
        INCREASE")){Ld=47.2506007250682*Math.Pow(10,20);li=3.9406;ls=
        -0.0059;gt=1;}
else if(RG=="3"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
        ULTRATHIN BONDED WEARING
        COURSE")){Ld=26156886.9283831*Math.Pow(10,10);li=3.7161;ls=-
        0.0061;gt=1;}
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else if(RG=="3"&&(LT=="CRACK SEAL"||LT=="JOINT
        RESEALING")){Ld=560.9015;Ii=1.555;Is=-0.0141;gt=1;}

else
        if(RG=="3"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=
        ="MILL-OVERLAY <=1.5IN GRADE
        INCREASE")){Ld=69.4426;Ii=1.7037;Is=-0.0774;gt=1;}

else if(RG=="3"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="MILL-OVERLAY
        <=1.5IN GRADE INCREASE")){Ld=671.6257;Ii=2.2066;Is=-
        0.0565;gt=1;}

else
        if(RG=="1"||RG=="2"&&(PT=="FCC"||PT=="FCJ"||PT=="COMPOSIT
        E")&&(LT=="CRACK SEAL"||LT=="JOINT
        RESEALING")){Ld=372.3782;Ii=1.5649;Is=-0.0217;gt=1;}

else if(RG=="1"||RG=="2"&&(PT=="F"||PT=="FLEXIBLE")&&(LT=="CRACK
        SEAL"||LT=="JOINT RESEALING")){Ld=2067.2575;Ii=1.7989;Is=-
        0.0119;gt=1;}

else if((LT=="RECONSTRUCTION"||LT=="MILL >=4IN-OVERLAY WITH
        ASPHALT"||LT=="RUBBILIZATION-OVERLAY"||LT=="COLD-IN-
        PLACE RECYCLING-OVERLAY"||LT=="BREAK-CRACK-SEAT-
        OVERLAY"||LT=="FULL-DEPTH RECLAMATION-
        OVERLAY")){Ld=739.2838;Ii=2.0345;Is=-0.0385;gt=1;}

else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="ASPHALT
        PATCH ONLY"||LT=="POTHOLE
        PATCHING")){Ld=238.079002878799*Math.Pow(10,15);Ii=3.6591;Is
        =-0.0027;gt=1;}

else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="THIN OVERLAY
        <=1IN ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=1958.3861;Ii=2.0325;Is=-0.0116;gt=1;}

else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="FOG
        SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
        SEAL")){Ld1=1958.3861;Ii1=2.0325;Is1=-
        0.0116;Ld2=467.7251;Ii2=1.9154;Is2=-0.0684;gt=1;}

else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="OVERLAY
        >1.5IN ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE
        INCREASE")){Ld=726334947.4193;Ii=3.0971;Is=-0.0132;gt=1;}

else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="ASPHALT PATCH
        ONLY"||LT=="POTHOLE
        PATCHING")){Ld=372604640857.231;Ii=3.2569;Is=-0.0065;gt=1;}

else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="THIN OVERLAY <=1IN
        ASPHALT"||LT=="HOT-IN-PLACE
        RECYCLING")){Ld=128076.7042;Ii=2.5111;Is=-0.0236;gt=1;}

else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="MICRO SURFACING"||LT=="CAPE
        SEAL"||LT=="HIGH FRICTION
        SURFACE")){Ld=51.1047;Ii=1.7873;Is=-0.2267;gt=1;}
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else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="FOG
        SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND
        SEAL")){Ld1=128076.7042;li1=2.5111;ls1=-
        0.0236;Ld2=51.1047;li2=1.7873;ls2=-0.2267;gt=1;}

else if((PT=="F"||PT=="FLEXIBLE")&&(LT=="OVERLAY >1.5IN
        ASPHALT"||LT=="MILL-OVERLAY >1.5IN GRADE
        INCREASE")){Ld=4730810253.4084;li=3.1961;ls=-0.0152;gt=1;}}

if((FC=="16"||FC=="17"||FC=="18"||FC=="19"||FC=="14")&&(gt==0)){if((LT=="MIL
        L-OVERLAY <=1.5IN GRADE INCREASE -
        GAP")){Ld=45.6078;li=1.8813;ls=-0.1221;gt=1;}}

if((FC=="1"||FC=="7"||FC=="8"||FC=="9"||FC=="2"||FC=="3"||FC=="6")&&(gt==0))
        {if((LT=="MILL-OVERLAY <=1.5IN GRADE INCREASE -
        GAP")){Ld=324983517.00409*Math.Pow(10,25);li=4.3845;ls=-
        0.0021;gt=1;}

else if((LT=="RECONSTRUCTION"||LT=="MILL >=4IN-OVERLAY WITH
        ASPHALT"||LT=="RUBBILIZATION-OVERLAY"||LT=="COLD-IN-
        PLACE RECYCLING-OVERLAY"||LT=="BREAK-CRACK-SEAT-
        OVERLAY"||LT=="FULL-DEPTH RECLAMATION-
        OVERLAY")){Ld=54.3291;li=1.9695;ls=-0.1039;gt=1;}}

if(gt==0){if(RG=="1"&&(LT=="OVERLAY <=1.5IN ASPHALT"||LT=="MILL-
        ULTRATHIN BONDED WEARING
        COURSE")){Ld=32864163.8456;li=2.9756;ls=-0.0152;gt=1;}

else if(RG=="1"&&(LT=="OVERLAY >1.5IN ASPHALT - GAP"||LT=="MILL-
        OVERLAY >1.5IN GRADE INCREASE -
        GAP")){Ld=32864163.8456;li=2.9756;ls=-0.0152;gt=1;}

else if(RG=="3"&&(LT=="OVERLAY >1.5IN ASPHALT - GAP"||LT=="MILL-
        OVERLAY >1.5IN GRADE INCREASE -
        GAP")){Ld=32864163.8456;li=2.9756;ls=-0.0152;gt=1;}

else if((LT=="OVERLAY <=1.5IN ASPHALT - GAP"||LT=="ULTRATHIN
        BONDED WEARING COURSE")){Ld=32864163.8456;li=2.9756;ls=-
        0.0152;gt=1;}

else if((PT=="FCC"||PT=="FCJ"||PT=="COMPOSITE")&&(LT=="MICRO
        SURFACING"||LT=="CAPE SEAL"||LT=="HIGH FRICTION
        SURFACE")){Ld=467.7251;li=1.9154;ls=-0.0684;gt=1;}}

if((FC=="1")&&(gt==0)){if(RG=="1"){Ld=1920;li=2.32;ls=-0.02;gt=1;}

else if(RG=="2"){Ld=1500;li=2.27;ls=-0.01;gt=1;}

else if(RG=="3"){Ld=1500;li=2.27;ls=-0.01;gt=1;}}

if((FC=="2"||FC=="3"||FC=="6")&&(gt==0)){if(RG=="1"){Ld=808000000000;li=3.3
        5;ls=-0.01;gt=1;}

else if(RG=="2"){Ld=31300;li=2.4;ls=-0.02;gt=1;}

else if(RG=="3"){Ld=83800000*Math.Pow(10,10);li=3.76;ls=-0.01;gt=1;}}
```

```
if((FC=="7"||FC=="8"||FC=="9")&&(gt==0)){if(RG=="1"){Ld=658;li=2.01;ls=-0.05;gt=1;}
else if(RG=="2"){Ld=746;li=1.97;ls=-0.03;gt=1;}
else if(RG=="3"){Ld=420;li=1.99;ls=-0.06;gt=1;}}
if((FC=="11"||FC=="12")&&(gt==0)){if(RG=="1"){Ld=11200*Math.Pow(10,20);li=4.04;ls=-0.01;gt=1;}
else if(RG=="2"){Ld=6650000000*Math.Pow(10,10);li=3.87;ls=-0.01;gt=1;}
else if(RG=="3"){Ld=305*Math.Pow(10,10);li=3.42;ls=-0.01;gt=1;}}
if((FC=="14")&&(gt==0)){if(RG=="1"){Ld=40600000*Math.Pow(10,10);li=3.74;ls=-0.01;gt=1;}
else if(RG=="2"){Ld=586;li=1.96;ls=-0.04;gt=1;}
else if(RG=="3"){Ld=892*Math.Pow(10,10);li=3.44;ls=-0.01;gt=1;}}
if((FC=="16"||FC=="17"||FC=="18"||FC=="19")&&(gt==0)){if(RG=="1"){Ld=727;li=2.03;ls=-0.04;gt=1;}
else if(RG=="2"){Ld=654;li=1.93;ls=-0.03;gt=1;}
else if(RG=="3"){Ld=656;li=1.98;ls=-0.04;gt=1;}}
if(SCDMR==0){SCDMR=0.01;}
if(LT=="MILL-ULTRATHIN BONDED WEARING COURSE"||LT=="ULTRATHIN BONDED WEARING COURSE"){
SCage=Ld*Math.Exp(-Math.Exp(li+ls*age))*4;
SC0=Ld*Math.Exp(-Math.Exp(li+ls*0))*4;
}
if(LT=="FOG SEAL"||LT=="REJUVANATOR"||LT=="CHIP SEAL"||LT=="SAND SEAL"){
SCage=Ld1*Math.Exp(-Math.Exp(li1+ls1*age))*0.4+Ld2*Math.Exp(-Math.Exp(li2+ls2*age))*0.6;
SC0=Ld1*Math.Exp(-Math.Exp(li1+ls1*0))*0.4+Ld2*Math.Exp(-Math.Exp(li2+ls2*0))*0.6;
}
else{
SCage=Ld*Math.Exp(-Math.Exp(li+ls*age));
SC0=Ld*Math.Exp(-Math.Exp(li+ls*0));}
if(SCDMR<=SC0){Answer=SCage-SC0;}
else{Answer=SCage;}
return Answer;
```

11.11 RUTTING PERFORMANCE MODEL

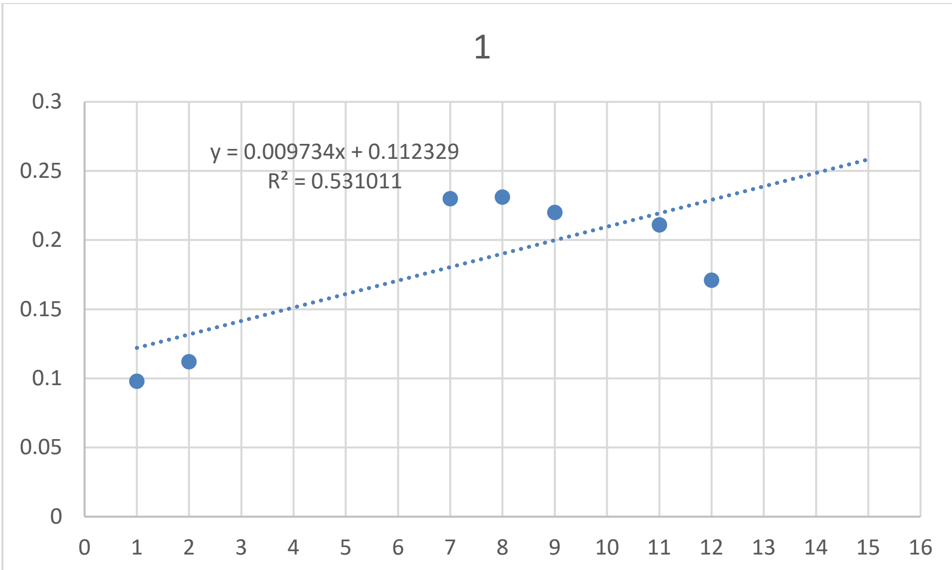
The following tables and scripts provide current information for rutting model parameters.

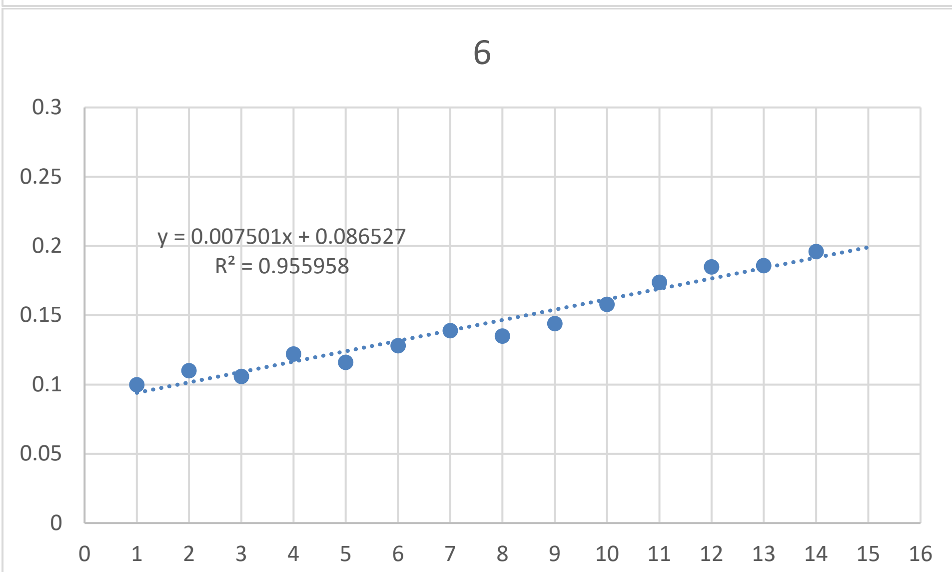
Rutting Families by Functional Class and Surface Type

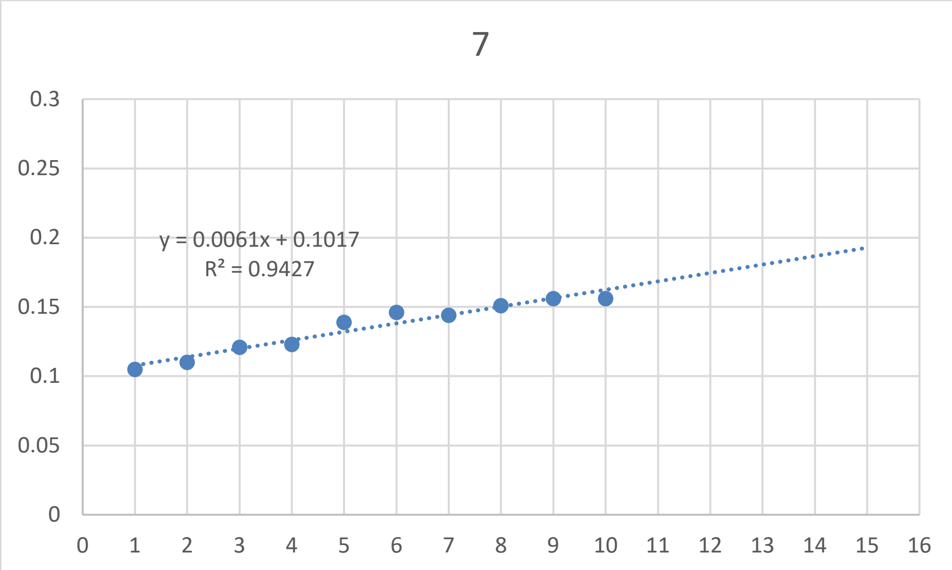
Pavement Type	Functional Class	Family	Slope
Flexible	1	1	0.009734
Flexible	2, 3	2	0.006751
Flexible	6	3	0.007501
Flexible	7	4	0.006067
Flexible	8	5	0.005461
Flexible	9	6	0.005617
Flexible	11	7	0.006402
Flexible	12	8	0.007211
Flexible	14	9	0.009364
Flexible	16	10	0.008818
Flexible	17	11	0.006681
Flexible	18, 19	12	0.012963
Flexible over JCP	1	13	0.005547
Flexible over JCP	2, 3	14	0.007607
Flexible over JCP	6	15	0.003558
Flexible over JCP	7	16	0.005257
Flexible over JCP	8	17	0.003640
Flexible over JCP	9	18	0.007894
Flexible over JCP	11	19	0.010929
Flexible over JCP	12	20	0.004071
Flexible over JCP	14	21	0.005700
Flexible over JCP	16	22	0.007545
Flexible over JCP	17	23	0.006164
Flexible over JCP	18, 19	24	0.005736
Flexible over CRCP	1	25	0.003421
Flexible over CRCP	11	26	0.017038

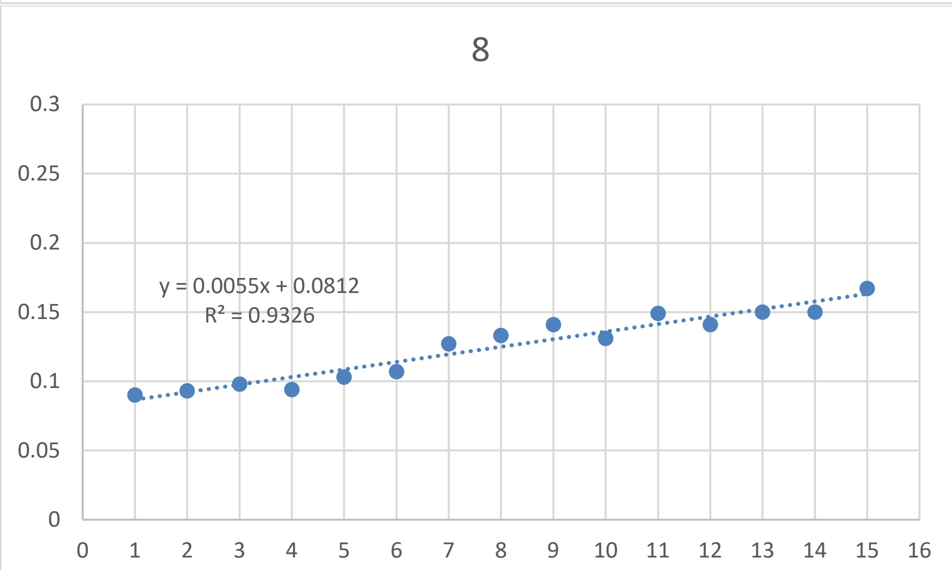
Most Recent Plots by Family

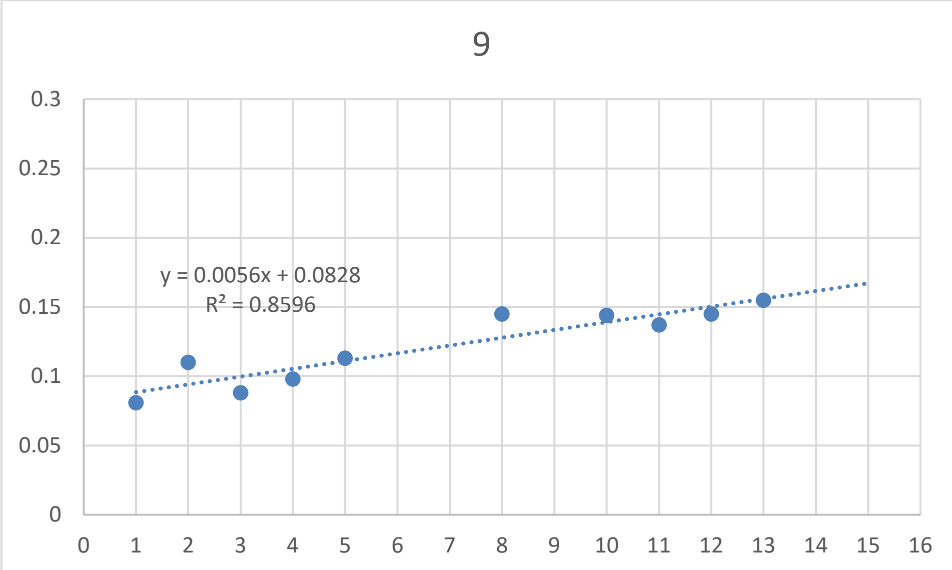
<u>"F" (Flexible)</u>

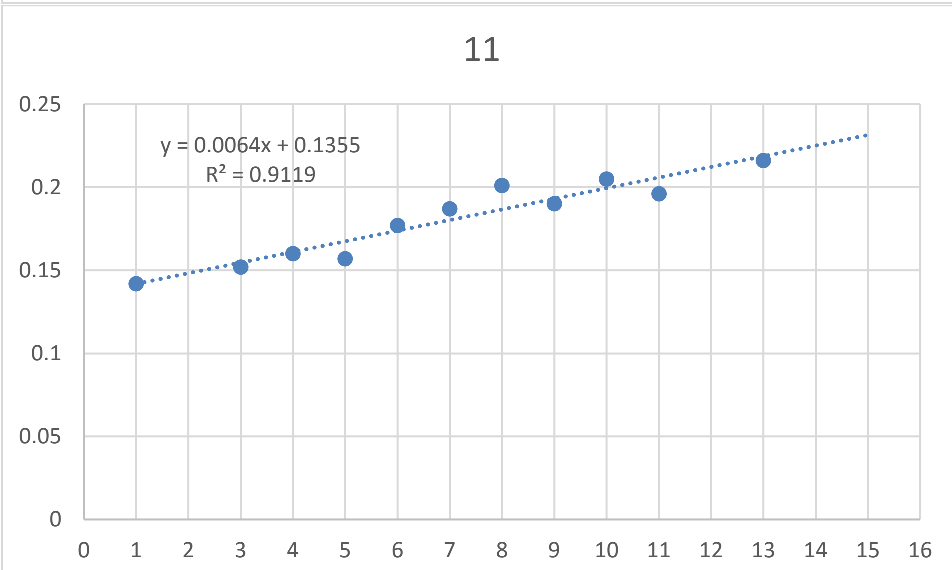


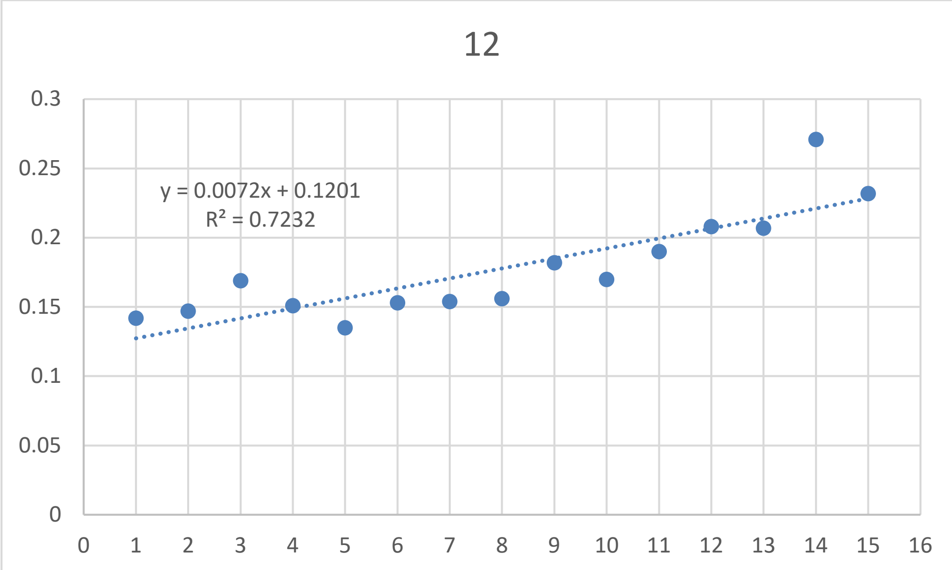


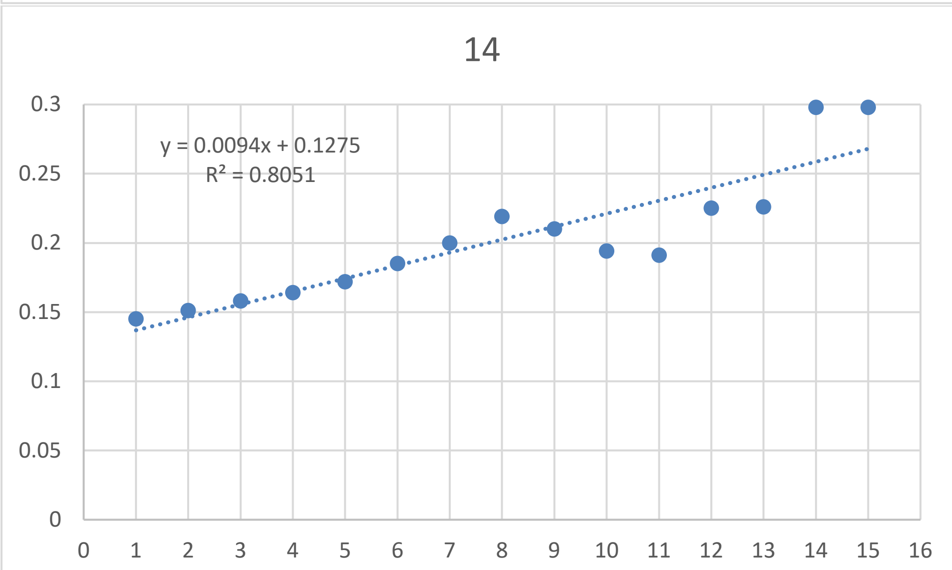

7
0.3
0.25
0.2
0.15
0.1
0.05
0
y = 0.0061x + 0.1017
R² = 0.9427
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

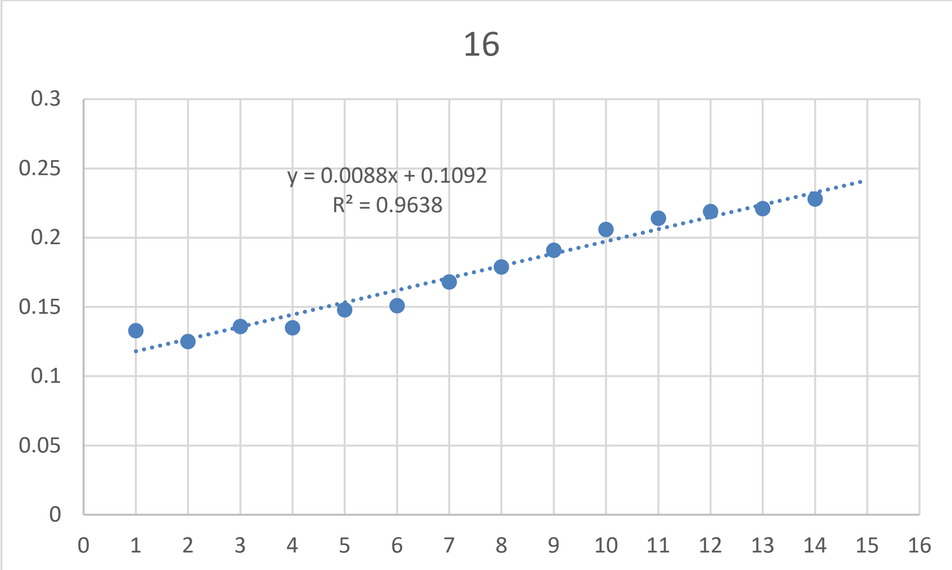

8
0.3
0.25
0.2
0.15
0.1
0.05
0
y = 0.0055x + 0.0812
R² = 0.9326
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

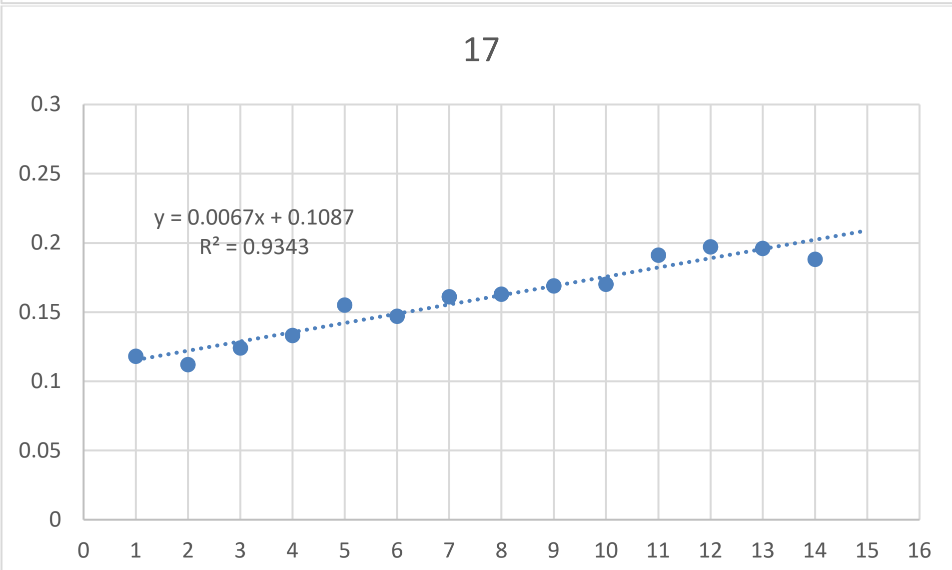

9
y = 0.0056x + 0.0828
R² = 0.8596
0.3
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

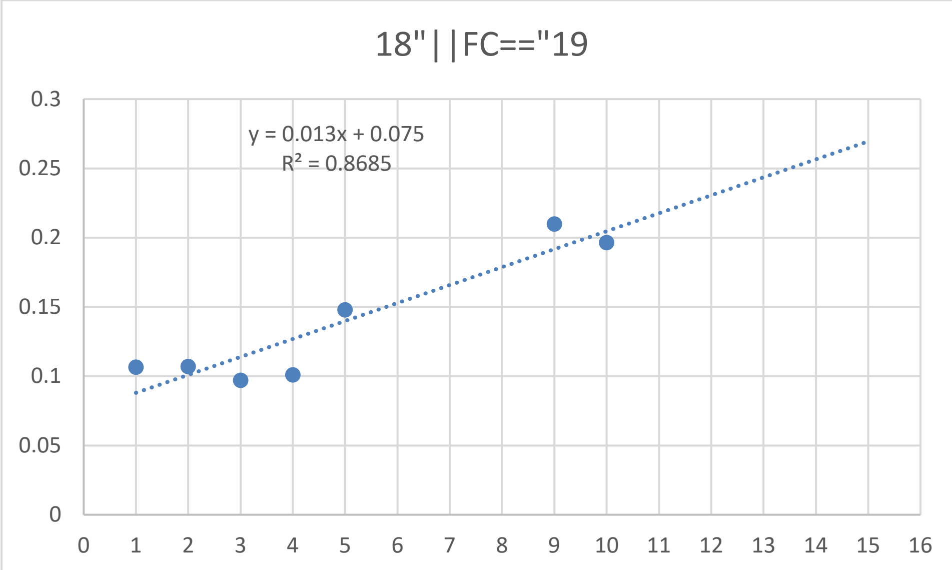

11
y = 0.0064x + 0.1355
R² = 0.9119
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16


12
y = 0.0072x + 0.1201
R² = 0.7232
0.3
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

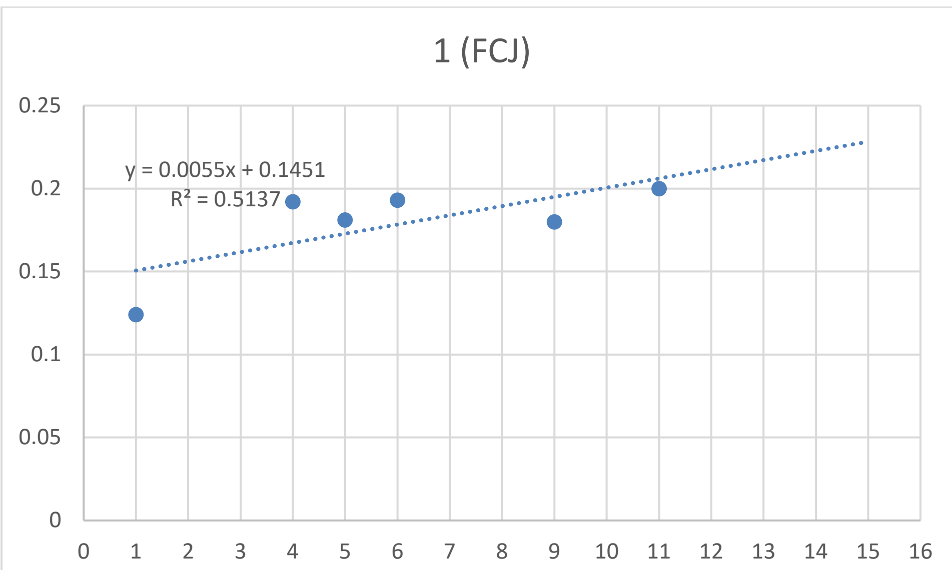

14
y = 0.0094x + 0.1275
R² = 0.8051
0.3
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

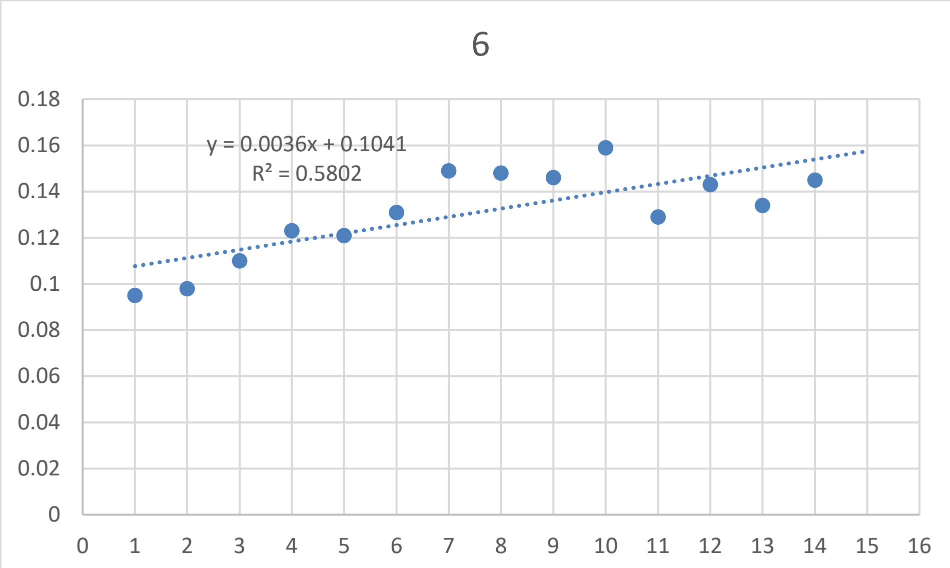

16
y = 0.0088x + 0.1092
R² = 0.9638
0.3
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

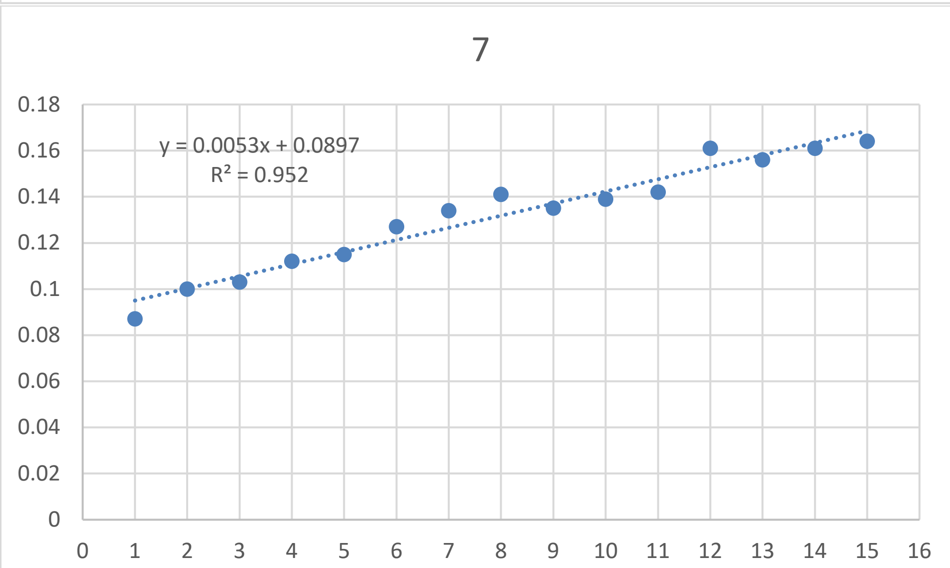

17
y = 0.0067x + 0.1087
R² = 0.9343
0.3
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

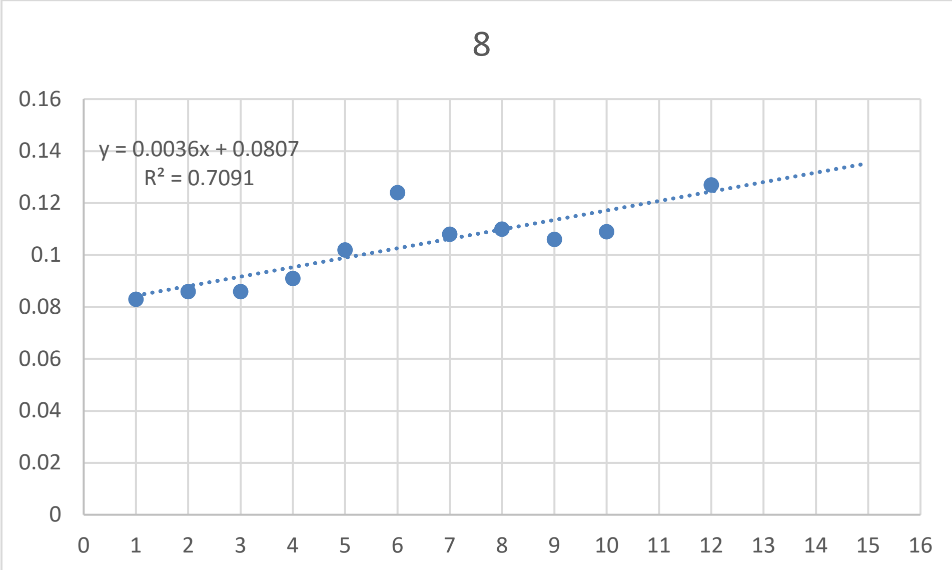


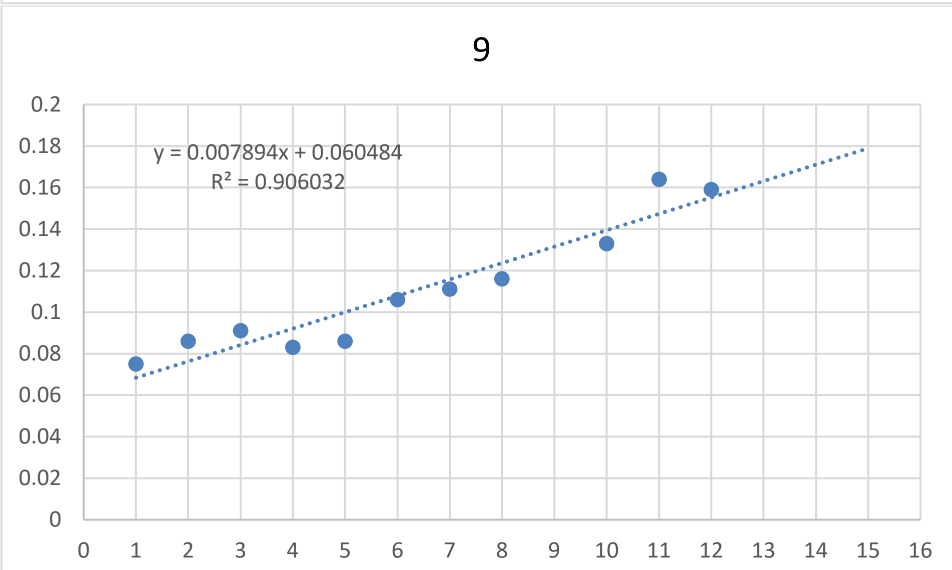
"FCJ" (Flexible over JCP)

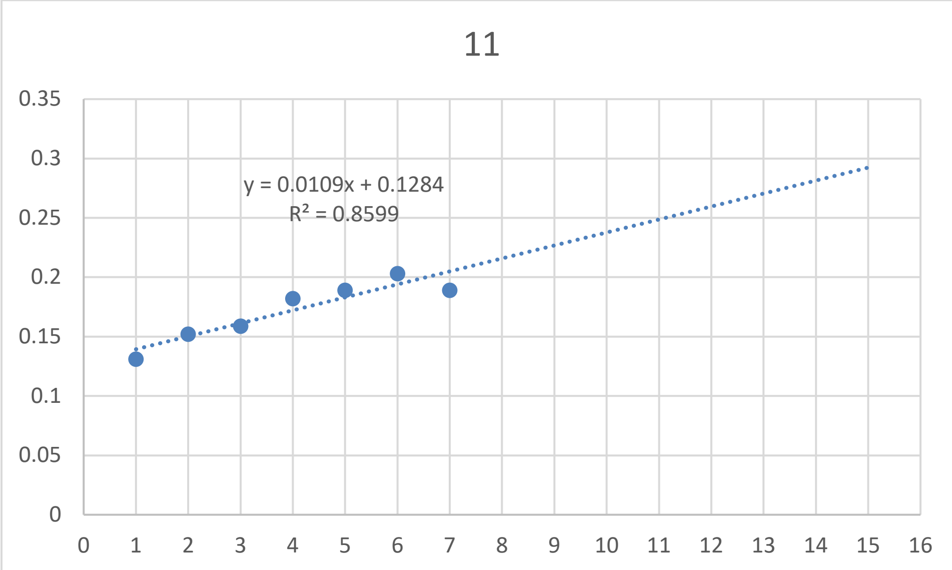


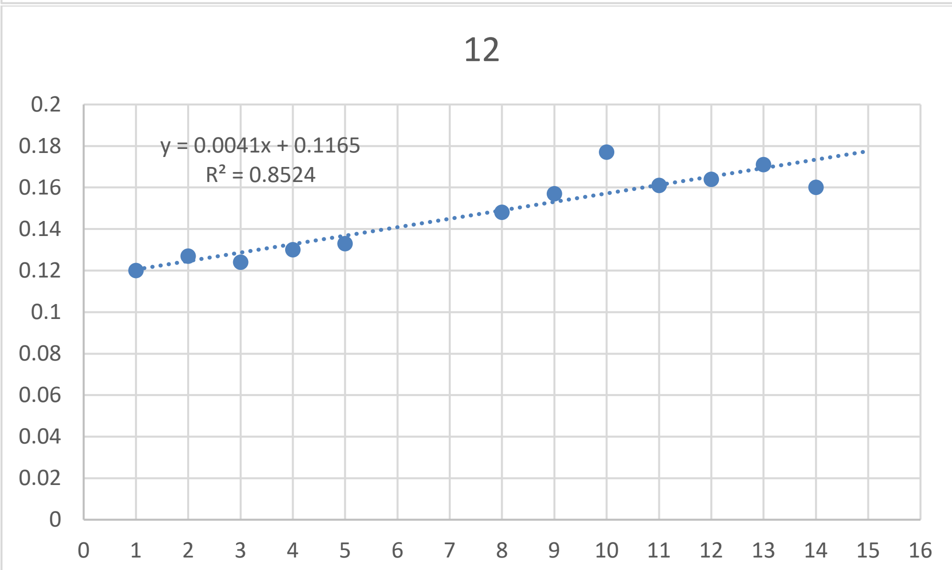

6
y = 0.0036x + 0.1041
R² = 0.5802
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

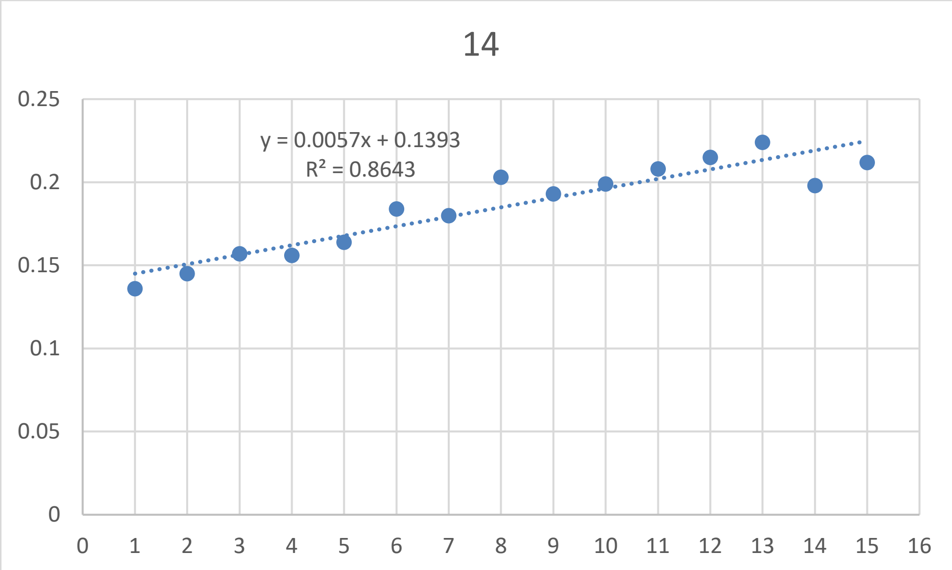

7
y = 0.0053x + 0.0897
R² = 0.952
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

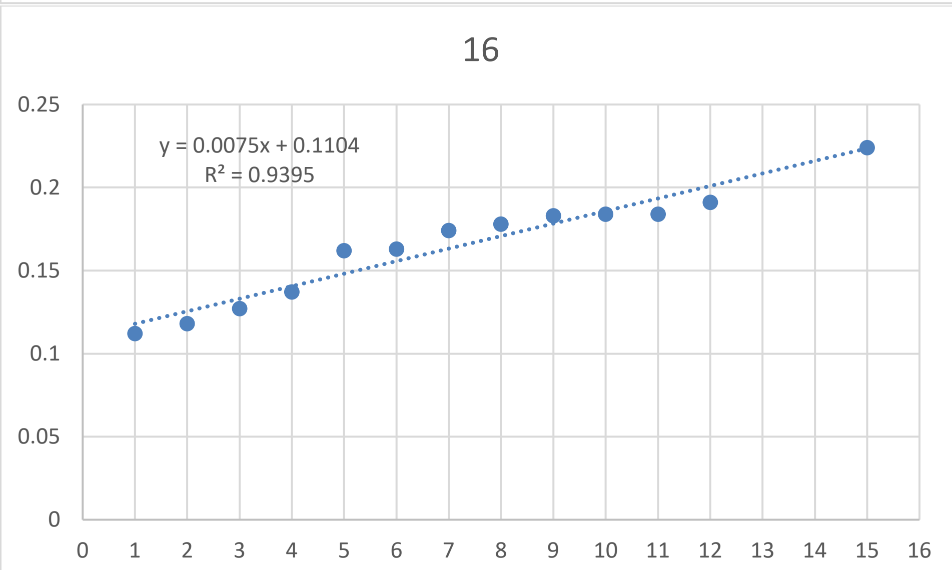

8
y = 0.0036x + 0.0807
R² = 0.7091
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

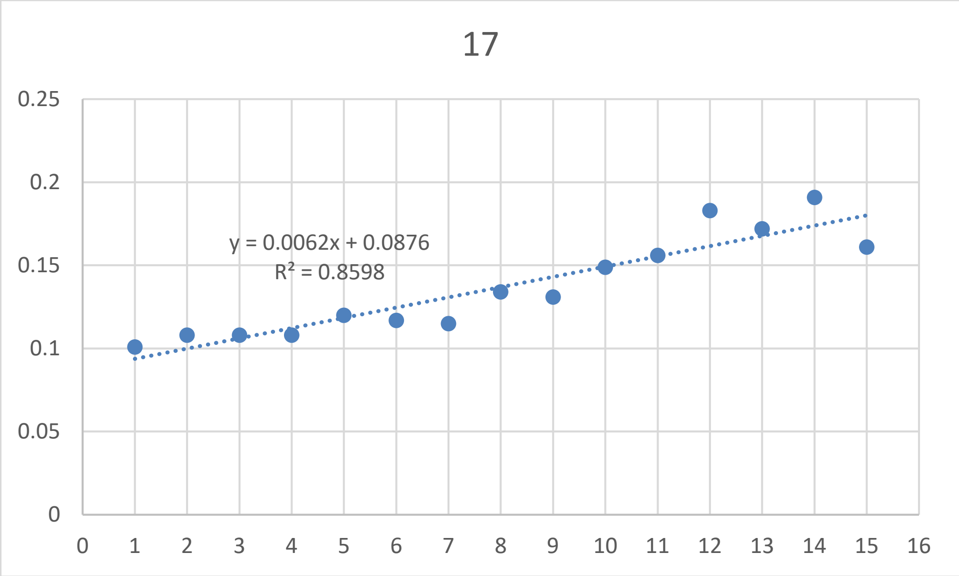

9
y = 0.007894x + 0.060484
R² = 0.906032
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

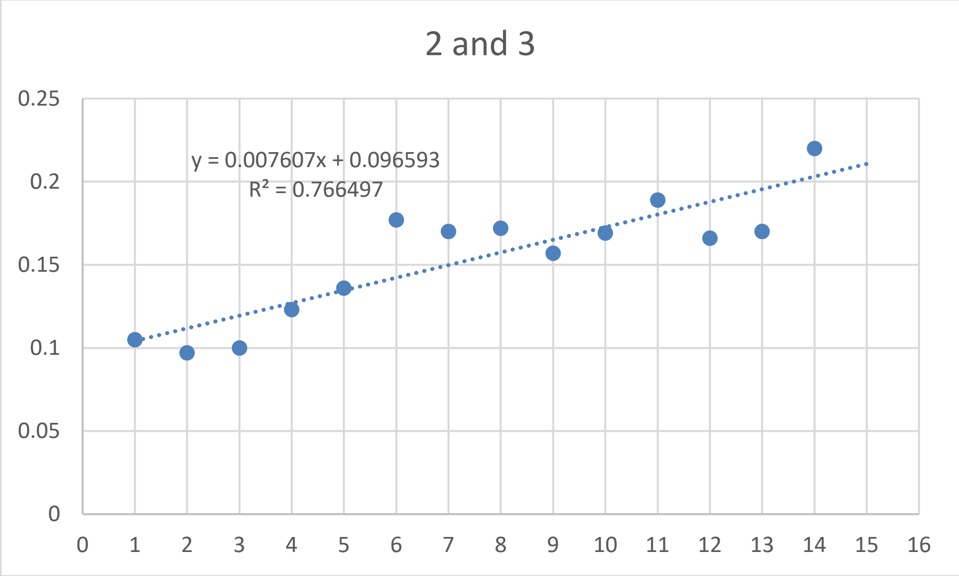

11
y = 0.0109x + 0.1284
R² = 0.8599
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

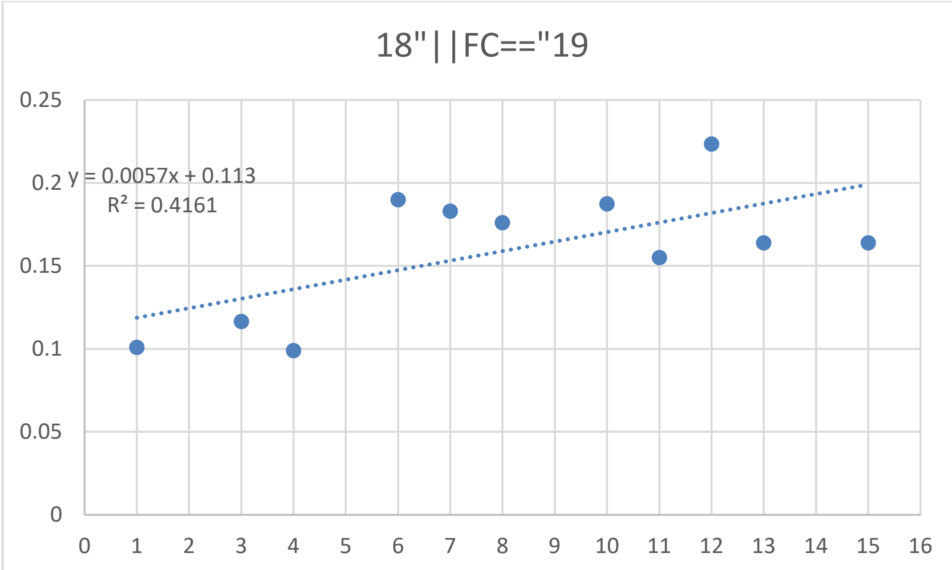

12
y = 0.0041x + 0.1165
R² = 0.8524
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16


14
y = 0.0057x + 0.1393
R² = 0.8643
0.25
0.2
0.15
0.1
0.05
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

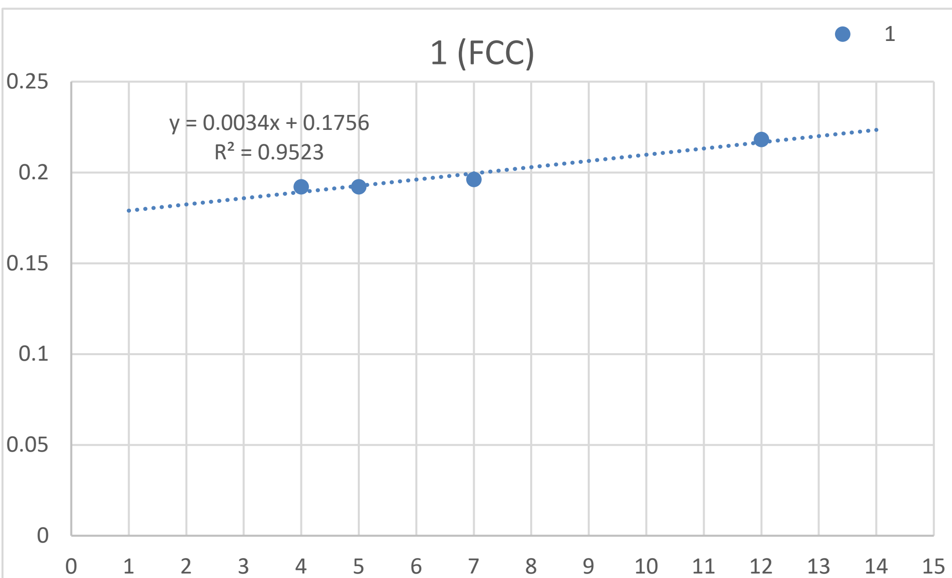

16
y = 0.0075x + 0.1104
R² = 0.9395
0.25
0.2
0.15
0.1
0.05
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

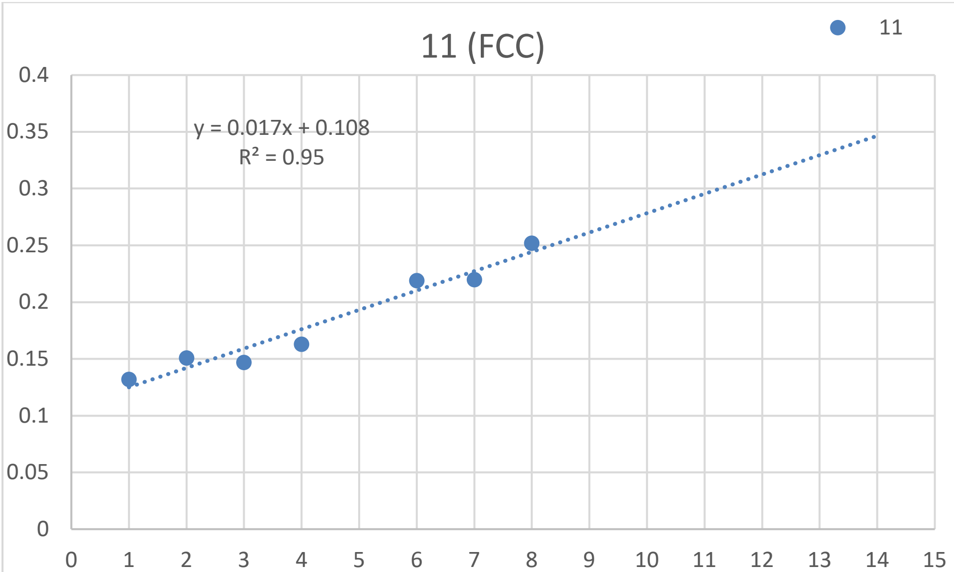

17
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
y = 0.0062x + 0.0876
R² = 0.8598


2 and 3
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
y = 0.007607x + 0.096593
R² = 0.766497



“FCC” (Flexible over CRCP)




11 (FCC)
11
y = 0.017x + 0.108
R² = 0.95
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Most Recent Model Functions

```
double age=[AGE], SL, avg_rut = [AVG_RUT];
string FC=[FUNC_CLASS], PT=[PAVEMENT_TYPE];

if(PT=="F"||PT=="FLEXIBLE"){
if(FC=="1"){SL=0.009734;}
else if(FC=="6"){SL=0.007501;}
else if(FC=="7"){SL=0.006067;}
else if(FC=="8"){SL=0.005461;}
else if(FC=="9"){SL=0.005617;}
else if(FC=="11"){SL=0.006402;}
else if(FC=="12"){SL=0.007211;}
else if(FC=="14"){SL=0.009364;}
else if(FC=="16"){SL=0.008818;}
else if(FC=="17"){SL=0.006681;}
else if(FC=="2"||FC=="3"){SL=0.006751;}
else if(FC=="18"||FC=="19"){SL=0.012963;}

else if(PT=="FCJ"||PT=="COMPOSITE"){
if(FC=="1"){SL=0.005547;}
else if(FC=="6"){SL=0.003558;}
else if(FC=="7"){SL=0.005257;}
else if(FC=="8"){SL=0.00364;}
else if(FC=="9"){SL=0.007894;}
else if(FC=="11"){SL=0.010929;}
else if(FC=="12"){SL=0.004071;}
else if(FC=="14"){SL=0.0057;}
else if(FC=="16"){SL=0.007545;}
else if(FC=="17"){SL=0.006164;}
else if(FC=="2"||FC=="3"){SL=0.007607;}
else if(FC=="18"||FC=="19"){SL=0.005736;}

else if(PT=="FCC"){
if(FC=="1"){SL=0.003421;}
else if(FC=="11"){SL=0.017038;}}

Answer = SL*age + avg_rut;
return Answer;
```

11.12 FRICTION PERFORMANCE MODEL

The following tables and scripts provide current information for friction model parameters.

Friction Families by County and Functional Class

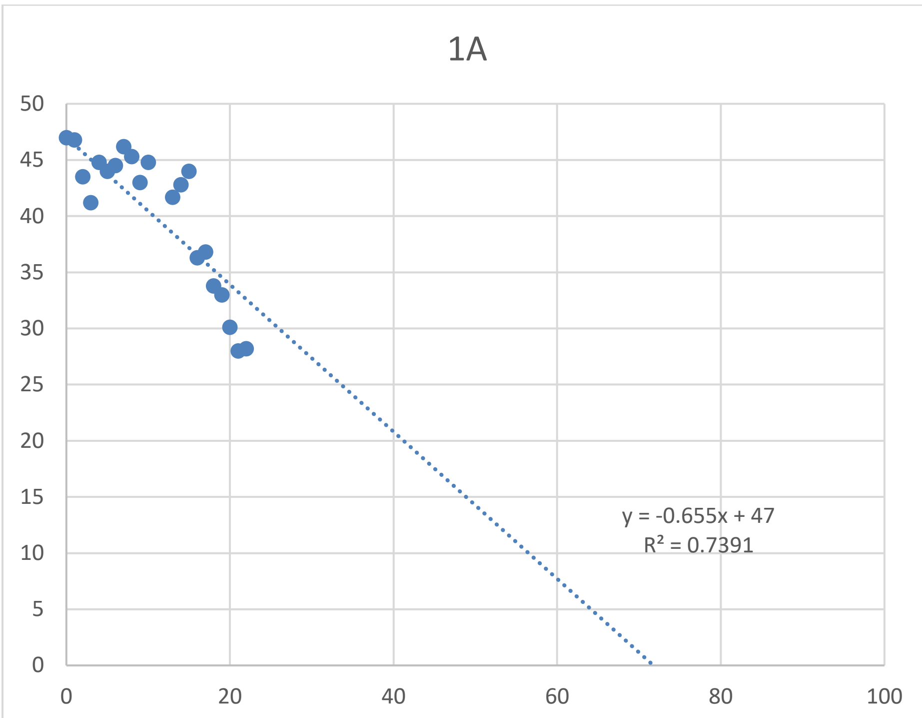
County	Functional Class	Family	Slope
CA, QA	1, 2, 11	1A	-0.6550
CA, QA	9, 18, 19	1B	-0.5036
CA, QA	7, 12, 17	1C	-0.3022
CA, QA	3, 6, 8, 14, 16	1D	-0.3906
CH, HO, WA	1, 2, 11	2A	-0.6635
CH, HO, WA	9, 18, 19	2B	-0.4890
CH, HO, WA	7, 12, 17	2C	-0.2492
CH, HO, WA	3, 6, 8, 14, 16	2D	-0.2564
BA	1, 2, 11	3A	-0.4548
BA	7, 12, 17	3C	-0.3622
BA	3, 6, 8, 14, 16	3D	-0.2978
MO, AA	1, 2, 11	4A	-0.5653
MO, AA	9, 18, 19	4B	-0.5048
MO, AA	7, 12, 17	4C	-0.2890
MO, AA	3, 6, 8, 14, 16	4D	-0.3314
SM, FR, CL	1, 2, 11	5A	-0.5805
SM, FR, CL	9, 18, 19	5B	-0.2526
SM, FR, CL	7, 12, 17	5C	-0.2141
SM, FR, CL	3, 6, 8, 14, 16	5D	-0.2038
PG, AL	1, 2, 11	6A	-0.3108
PG, AL	9, 18, 19	6B	-0.6394
PG, AL	7, 12, 17	6C	-0.5430
PG, AL	3, 6, 8, 14, 16	6D	-0.2319
CE, KE, TA, CO, WI	1, 2, 11	7A	-0.2021
CE, KE, TA, CO, WI	9, 18, 19	7B	-0.2807
CE, KE, TA, CO, WI	7, 12, 17	7C	-0.3189
CE, KE, TA, CO, WI	3, 6, 8, 14, 16	7D	-0.3444
SO, DO	1, 2, 11	8A	-0.3635
SO, DO	9, 18, 19	8B	-0.2526
SO, DO	7, 12, 17	8C	-0.2457
SO, DO	3, 6, 8, 14, 16	8D	-0.1868
HA, WO	1, 2, 11	9A	-0.3064
HA, WO	9, 18, 19	9B	-0.2730
HA, WO	7, 12, 17	9C	-0.3906
HA, WO	3, 6, 8, 14, 16	9D	-0.2420
GA	1, 2, 11	10A	-0.4593
GA	7, 12, 17	10C	-0.7543
GA	3, 6, 8, 14, 16	10D	-0.4686

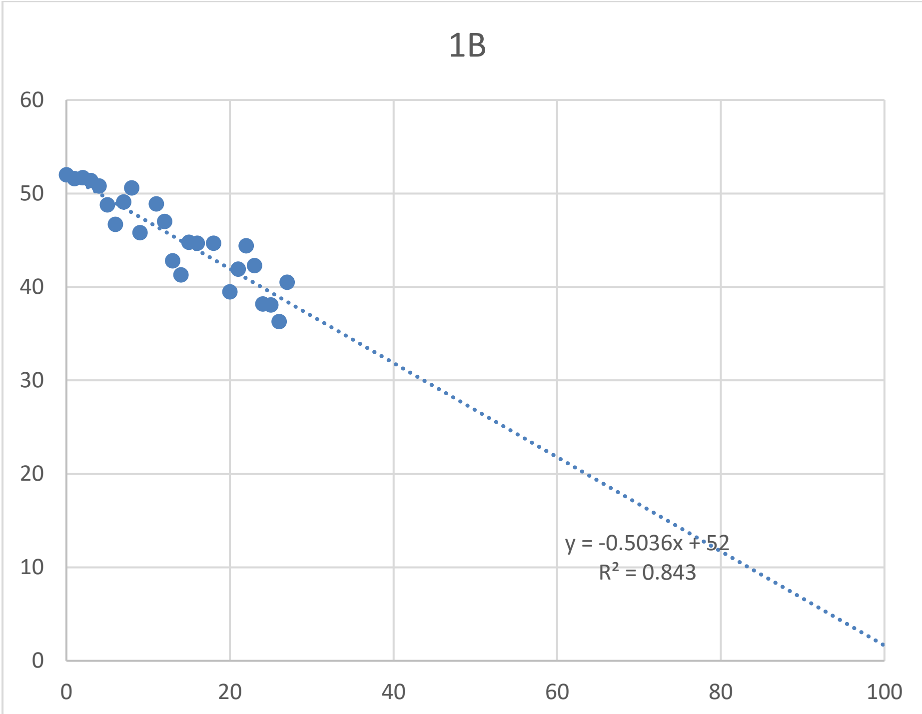
Most Recent Plots by Family

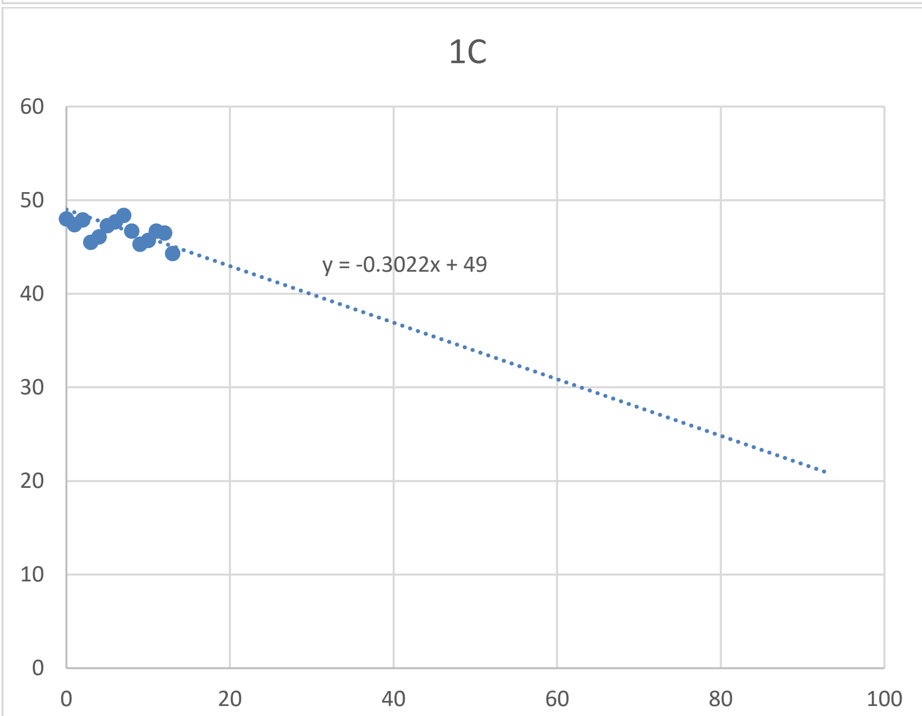
Titles are Family Names

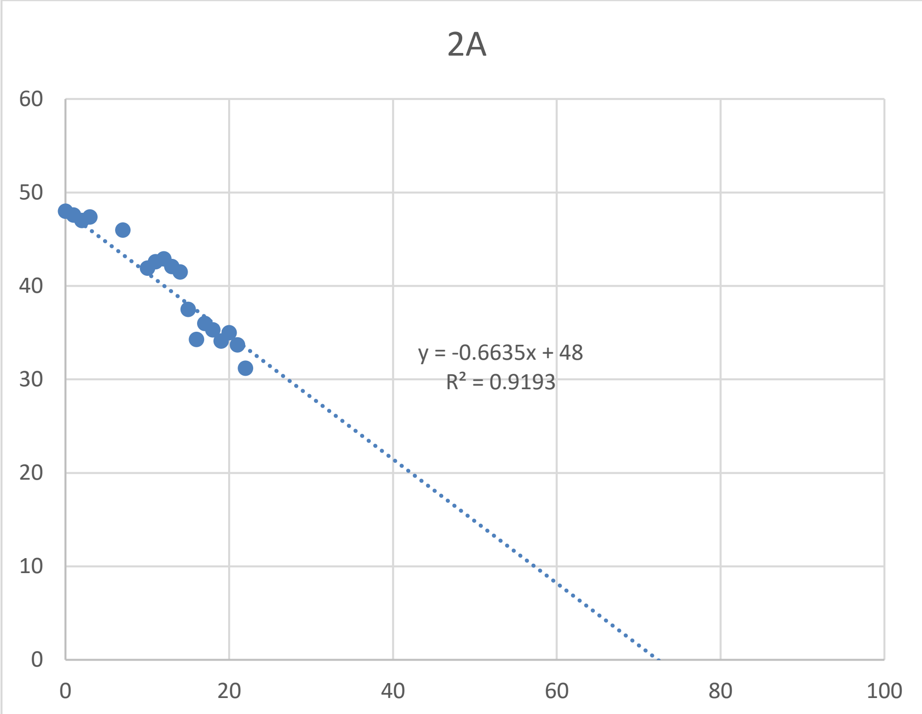
X-axis is age in years

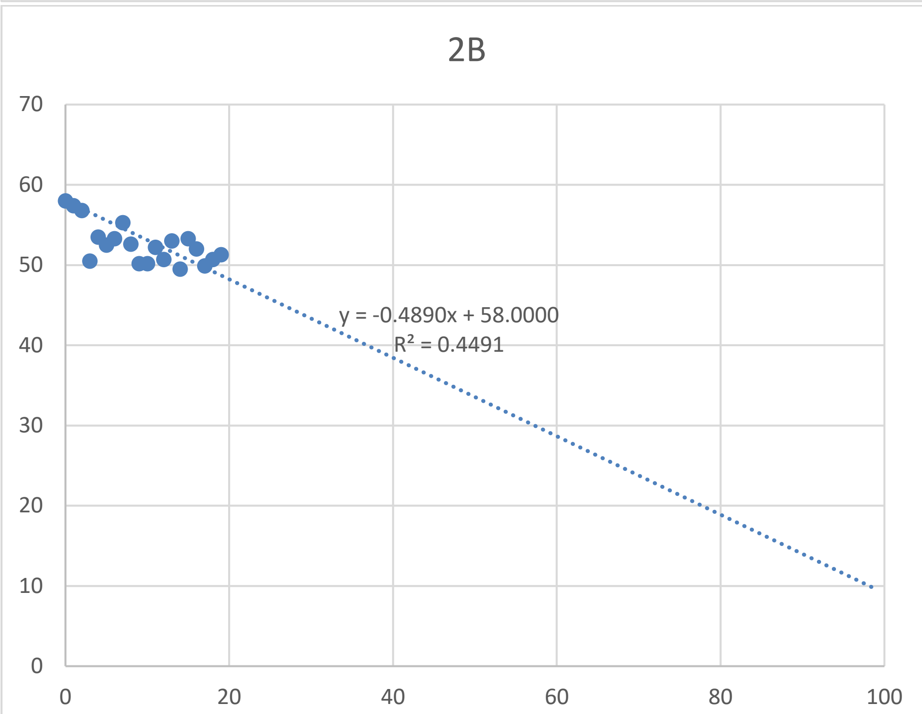
Y-axis is friction value

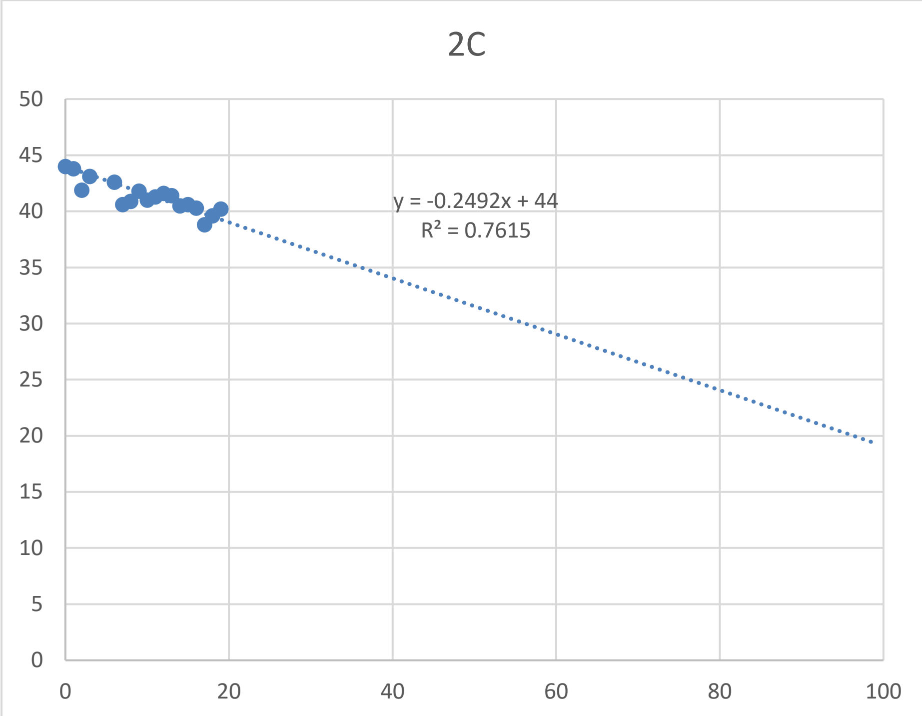


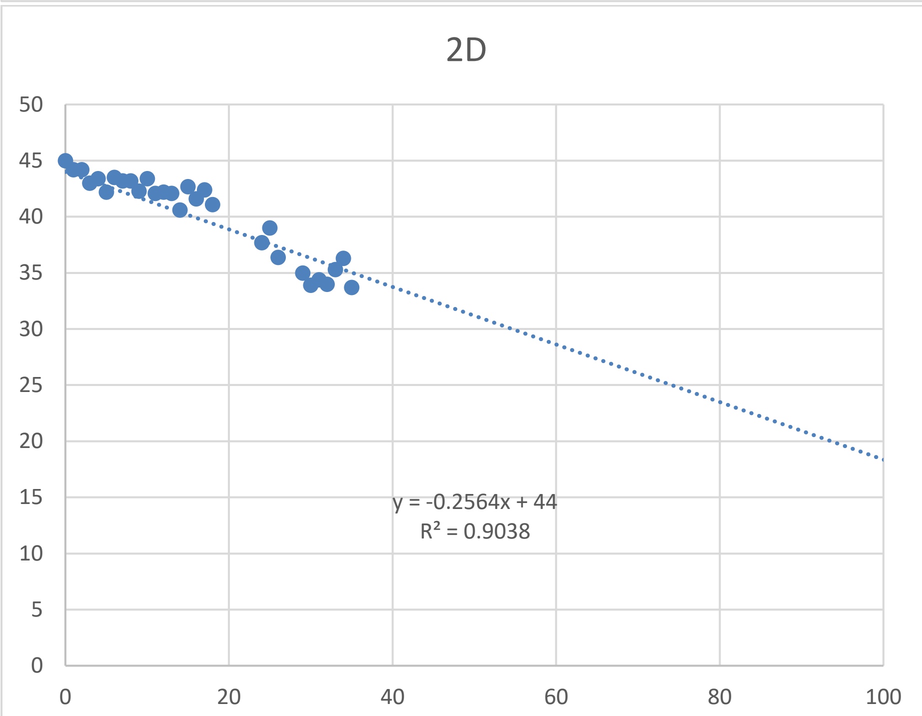

1B
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.5036x + 52
R² = 0.843

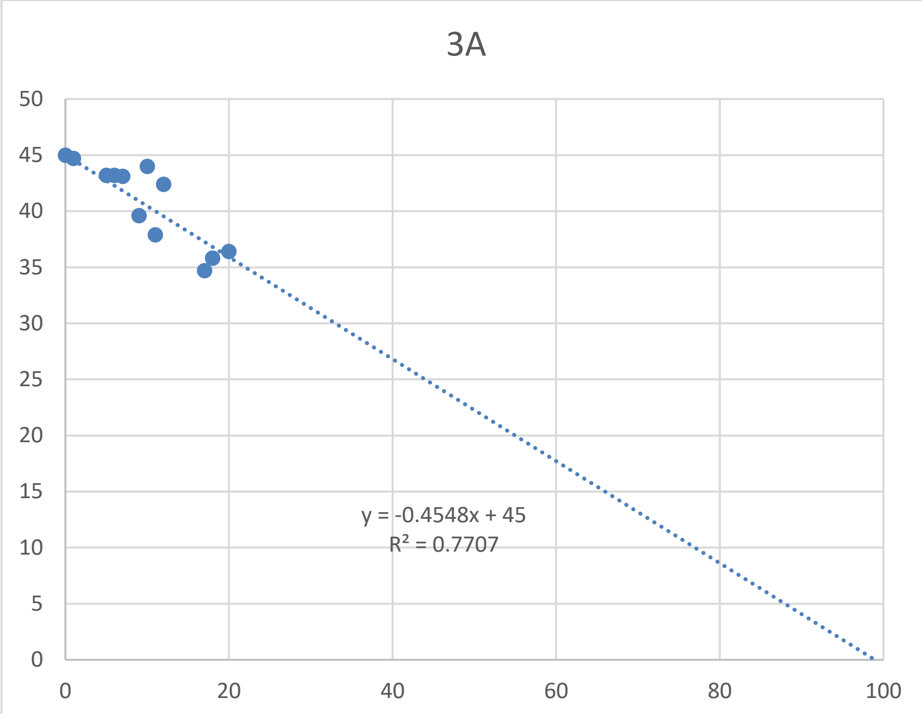

1C
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.3022x + 49

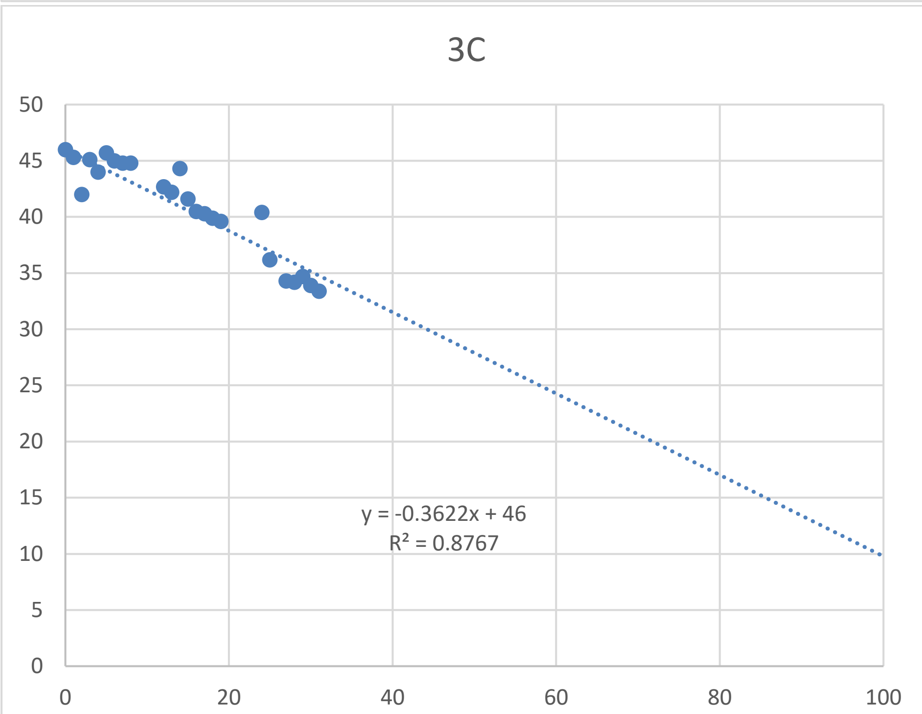

2A
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.6635x + 48
R^2 = 0.9193

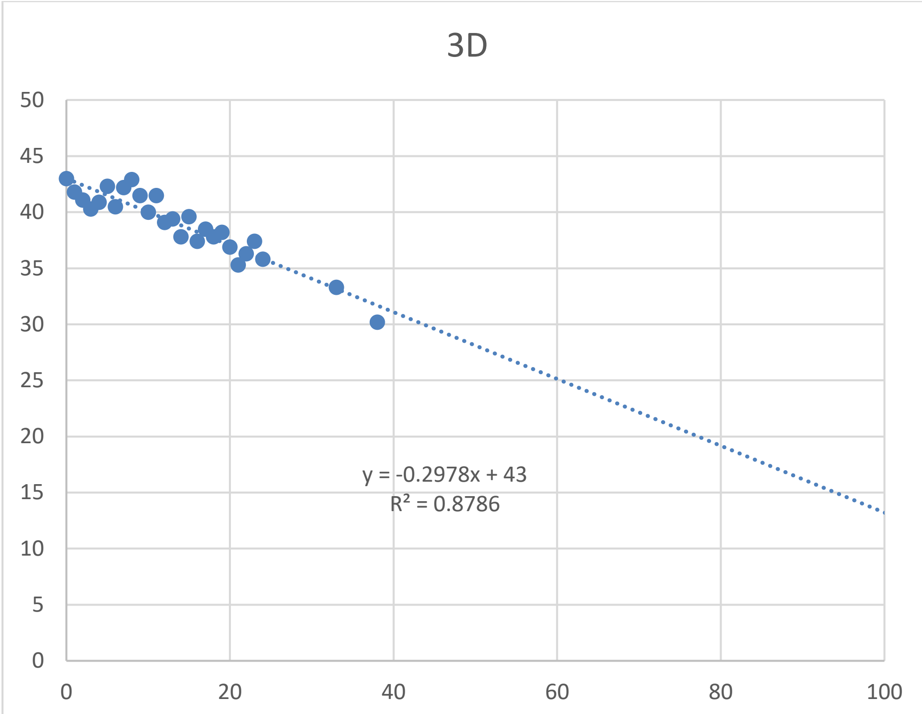

2B
70
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.4890x + 58.0000
R^2 = 0.4491

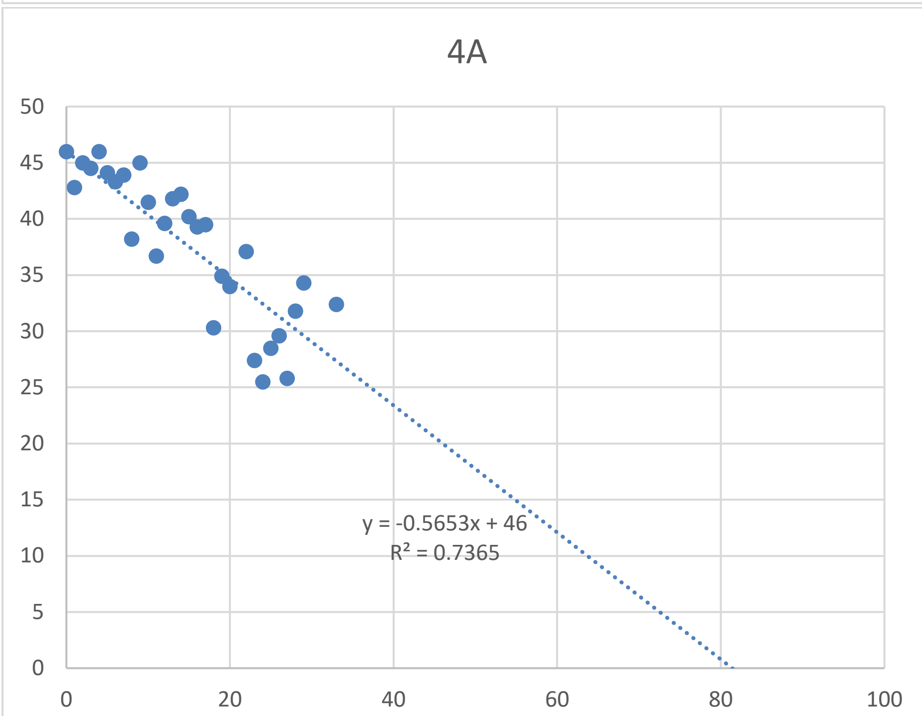

2C
y = -0.2492x + 44
R² = 0.7615
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100

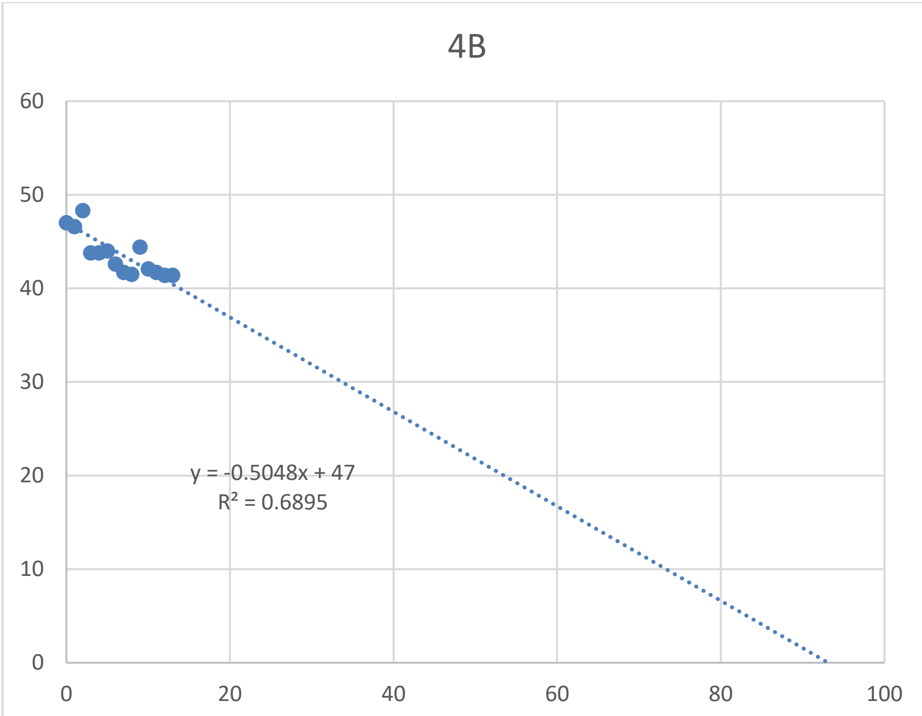

2D
y = -0.2564x + 44
R² = 0.9038
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100

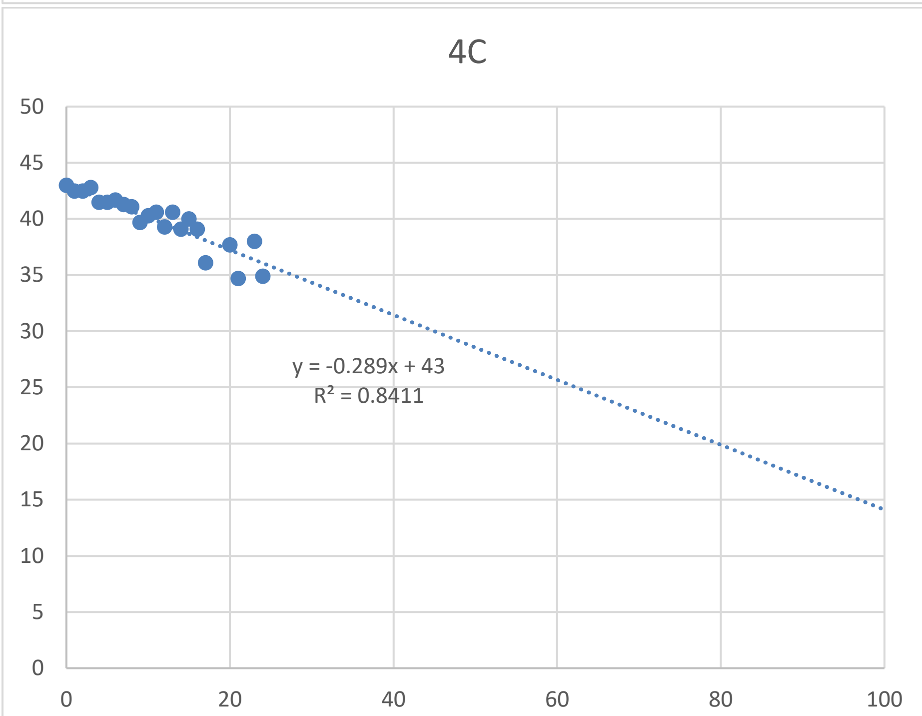

3A
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
y = -0.4548x + 45
R² = 0.7707

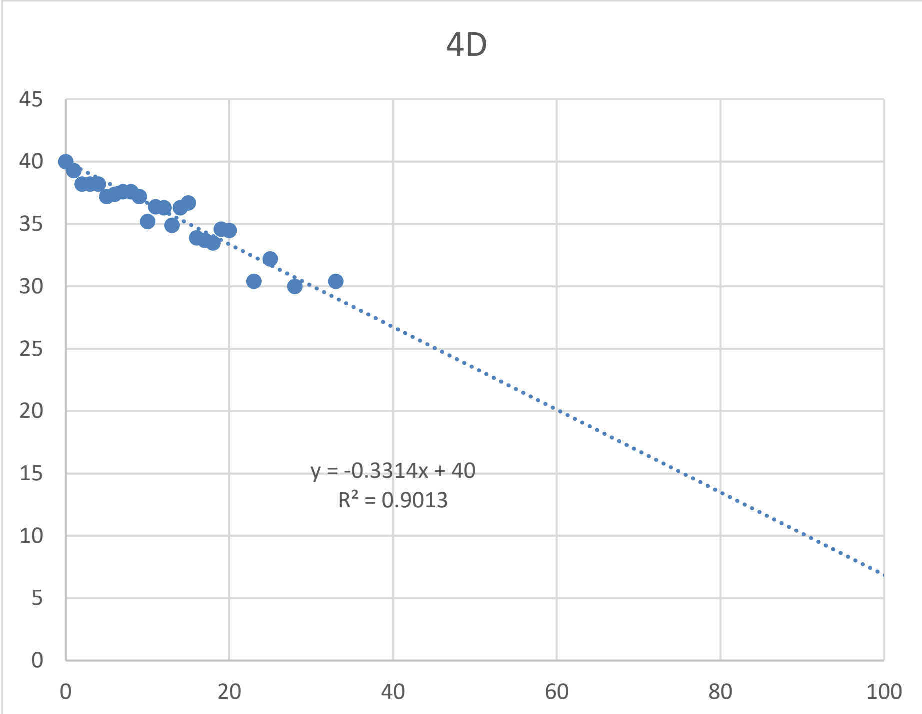

3C
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
y = -0.3622x + 46
R² = 0.8767

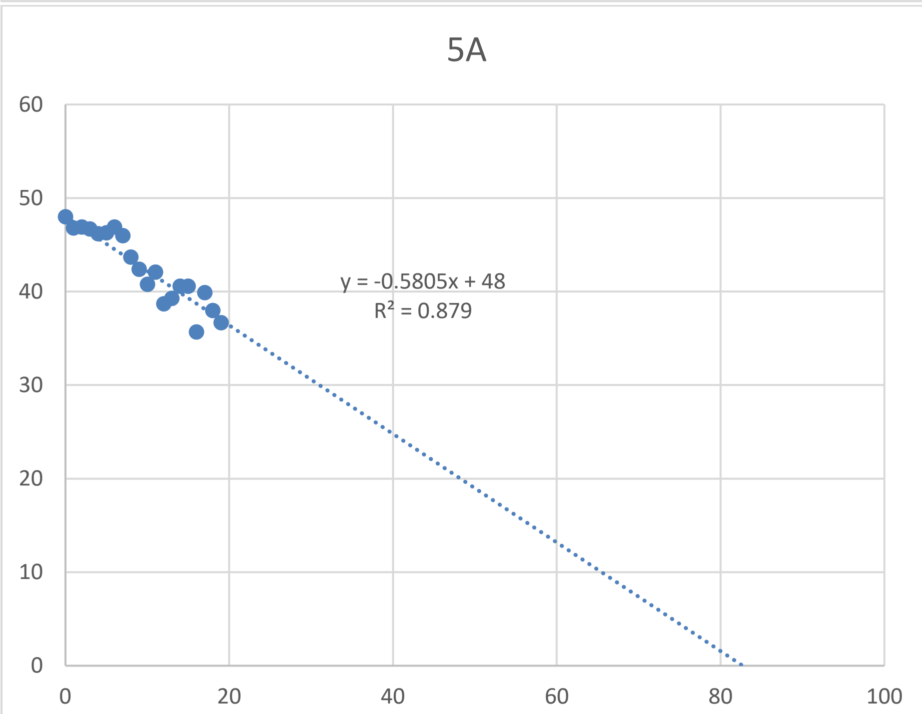

3D
y = -0.2978x + 43
R^2 = 0.8786
0
5
10
15
20
25
30
35
40
45
50
0
20
40
60
80
100

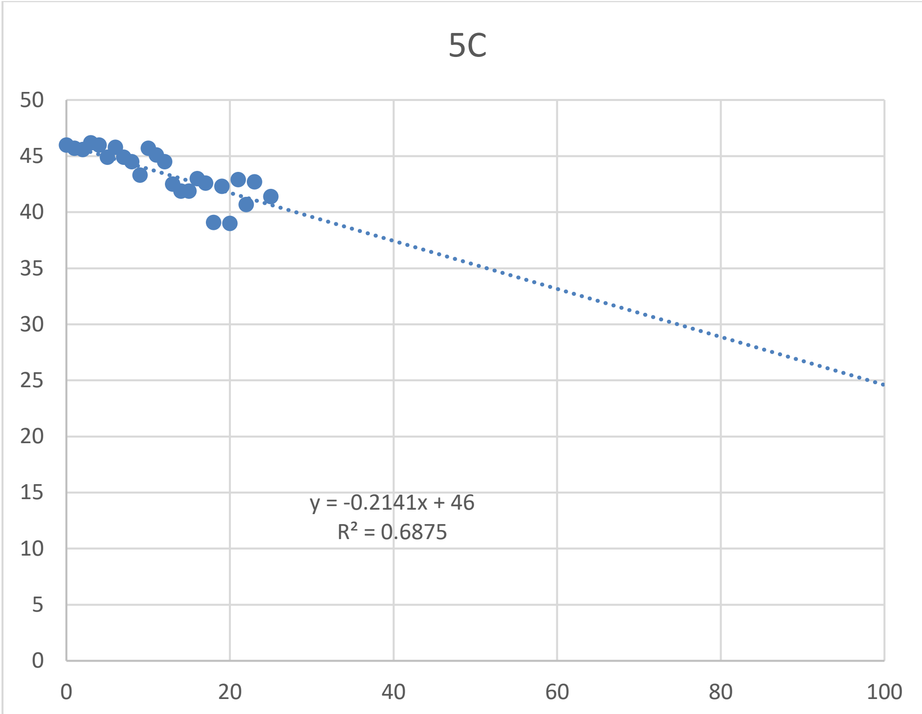

4A
y = -0.5653x + 46
R^2 = 0.7365
0
5
10
15
20
25
30
35
40
45
50
0
20
40
60
80
100

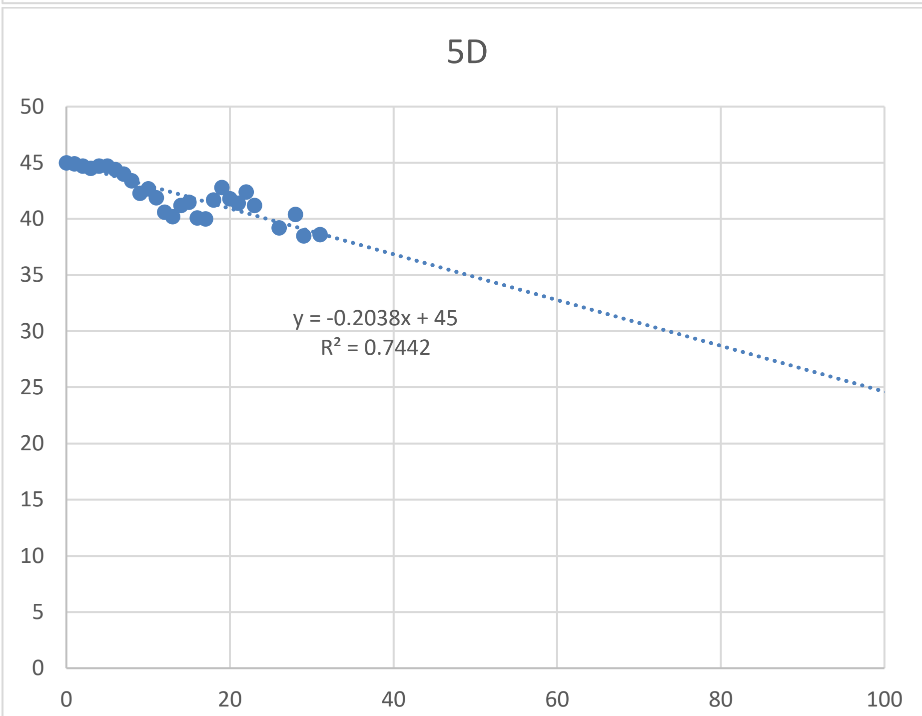

4B
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.5048x + 47
R^2 = 0.6895

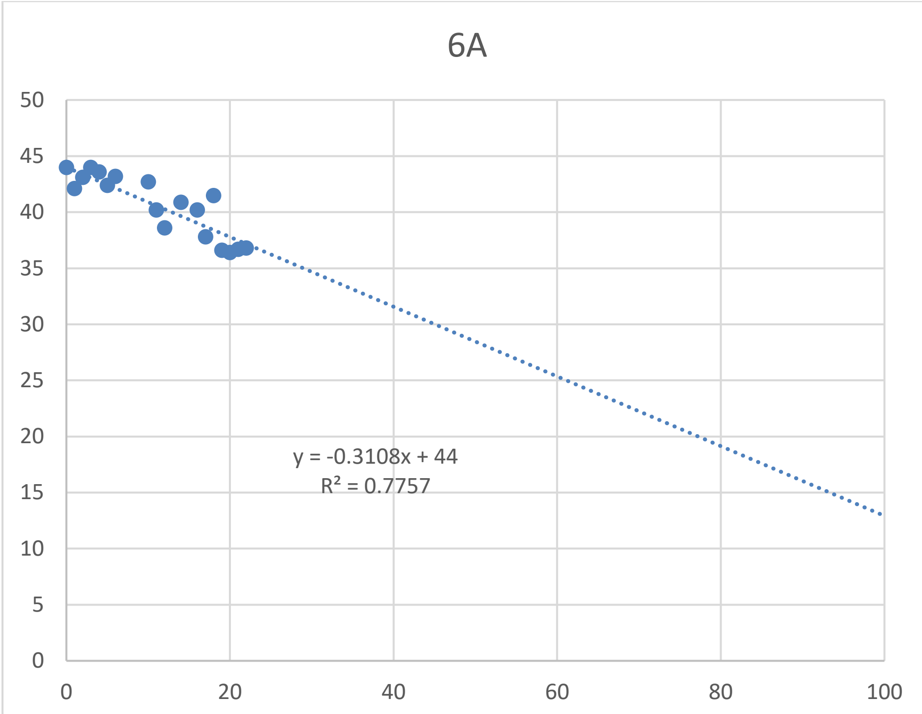

4C
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
y = -0.289x + 43
R^2 = 0.8411

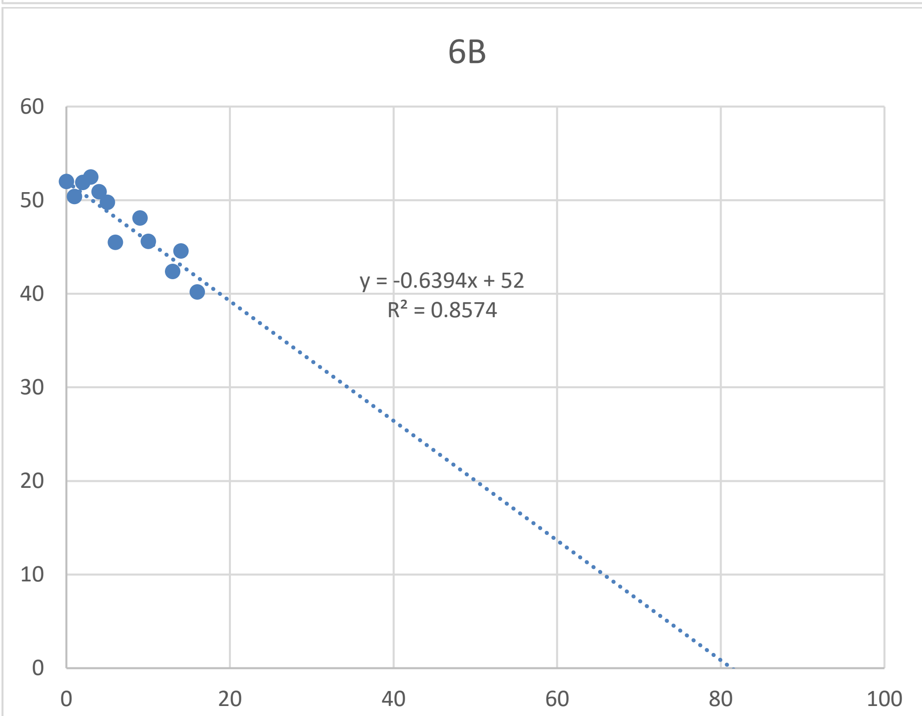

4D
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
y = -0.3314x + 40
R² = 0.9013

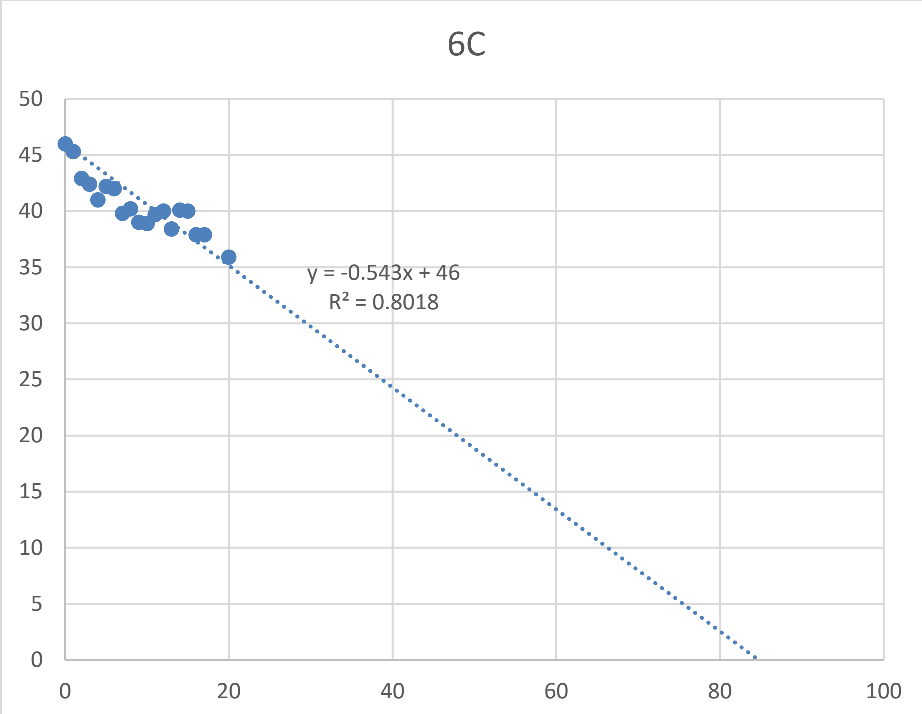

5A
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.5805x + 48
R² = 0.879

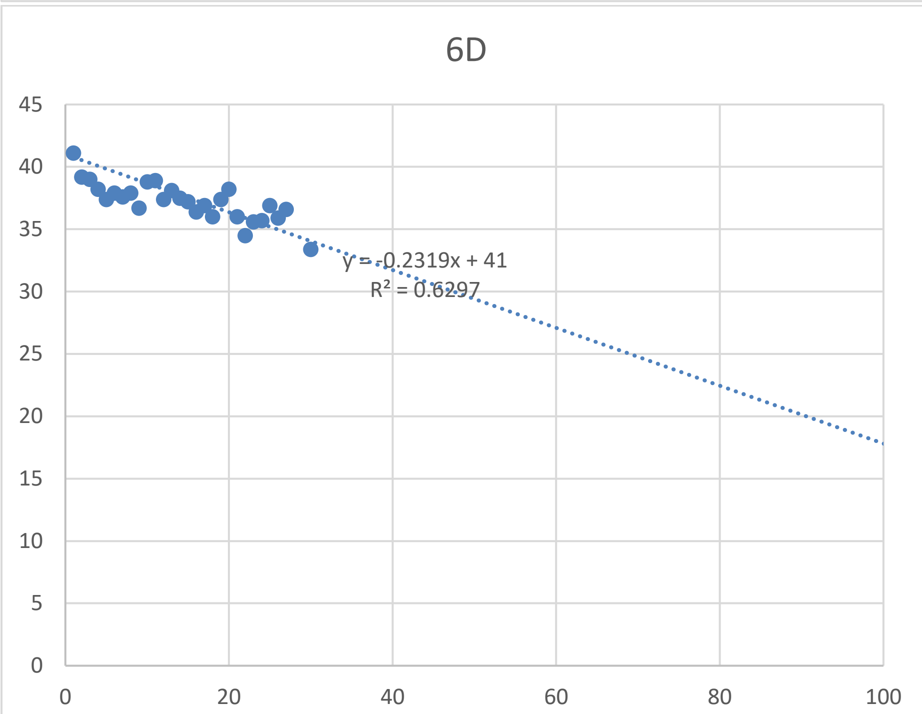

5C
y = -0.2141x + 46
R² = 0.6875
0
5
10
15
20
25
30
35
40
45
50
0
20
40
60
80
100

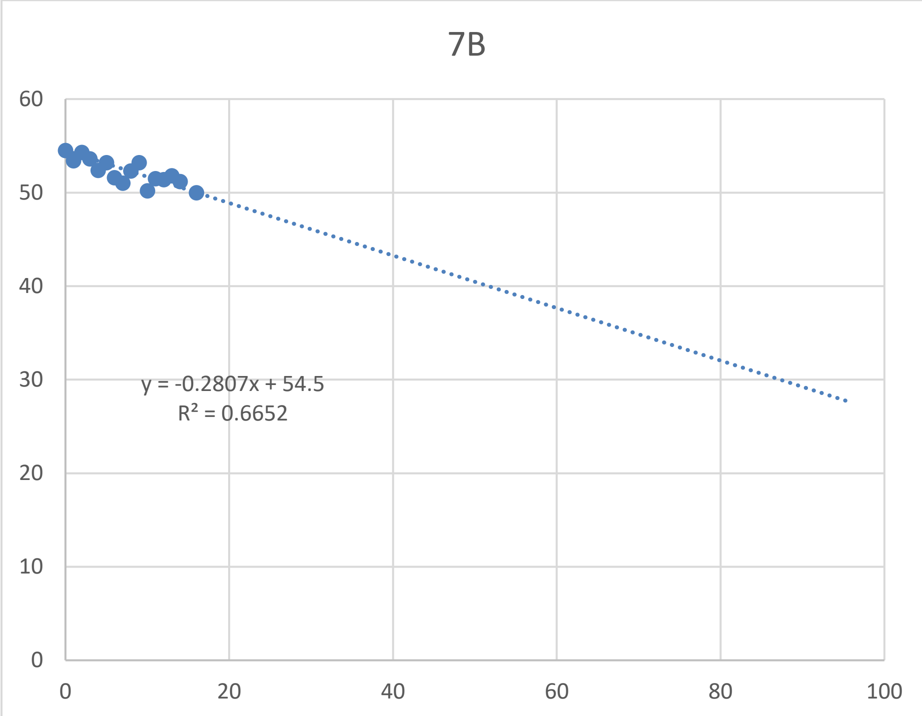

5D
y = -0.2038x + 45
R² = 0.7442
0
5
10
15
20
25
30
35
40
45
50
0
20
40
60
80
100

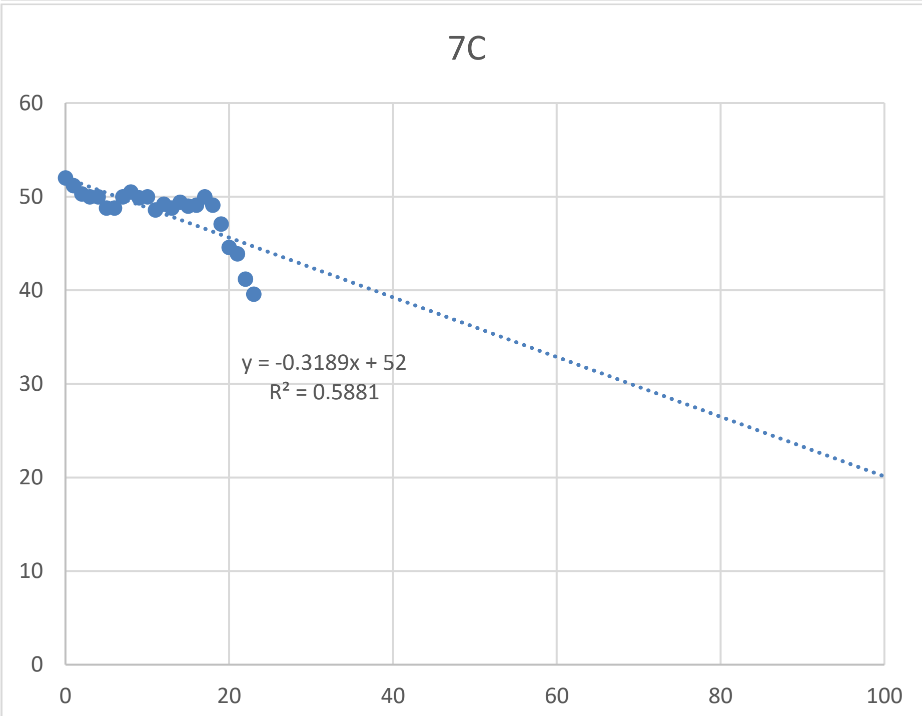

6A
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
y = -0.3108x + 44
R^2 = 0.7757

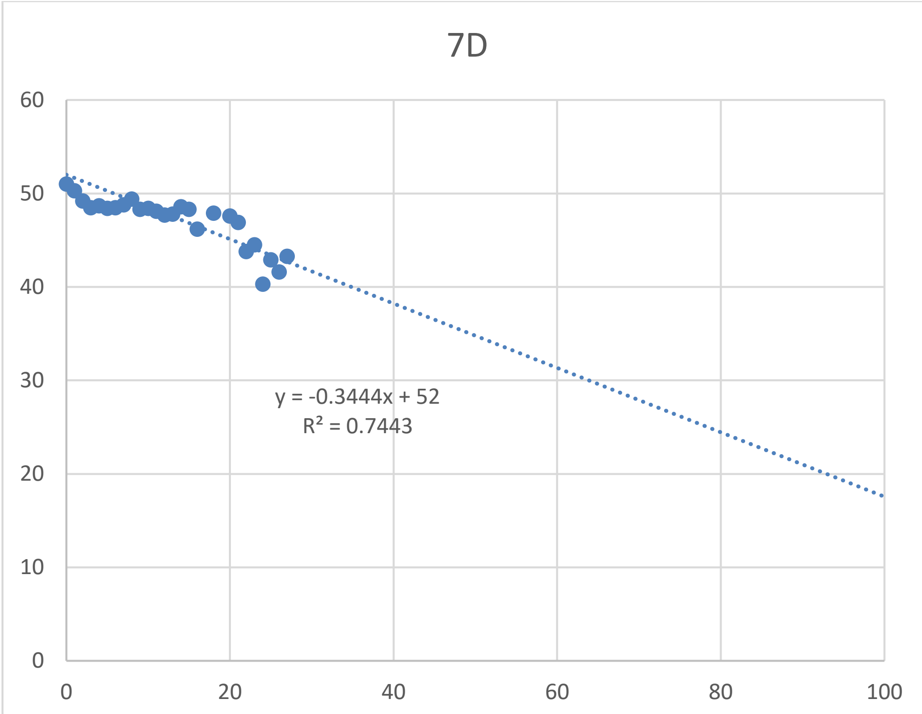

6B
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.6394x + 52
R^2 = 0.8574

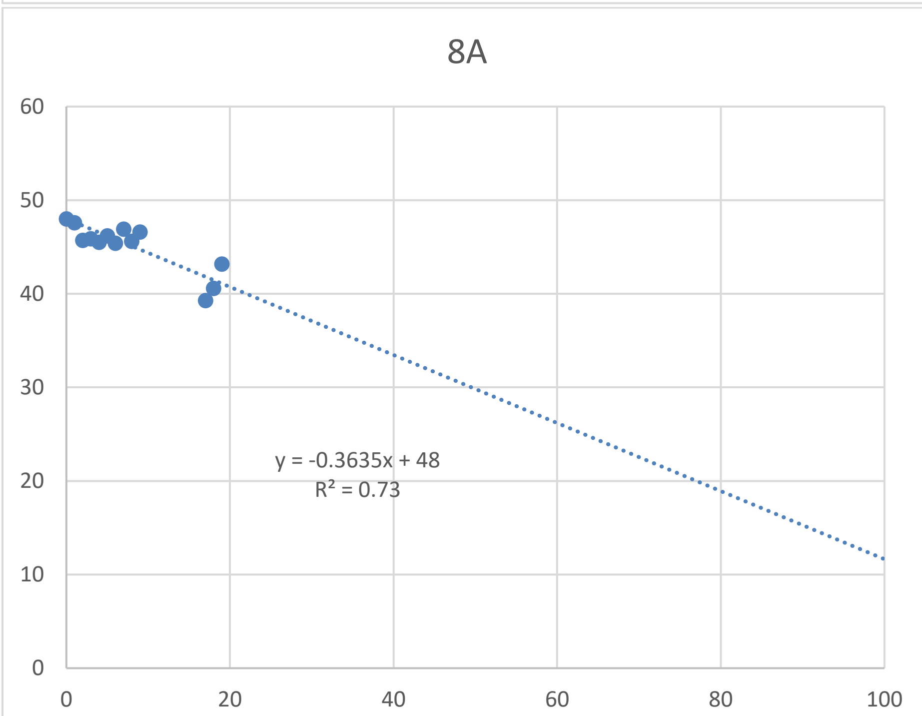

6C
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
y = -0.543x + 46
R² = 0.8018

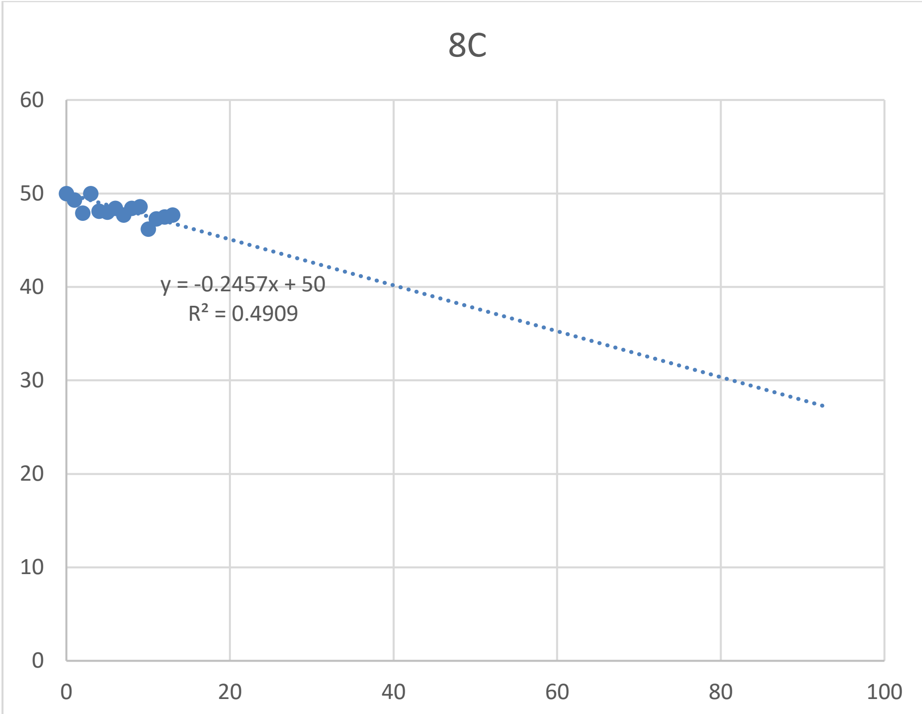

6D
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
y = -0.2319x + 41
R² = 0.6297

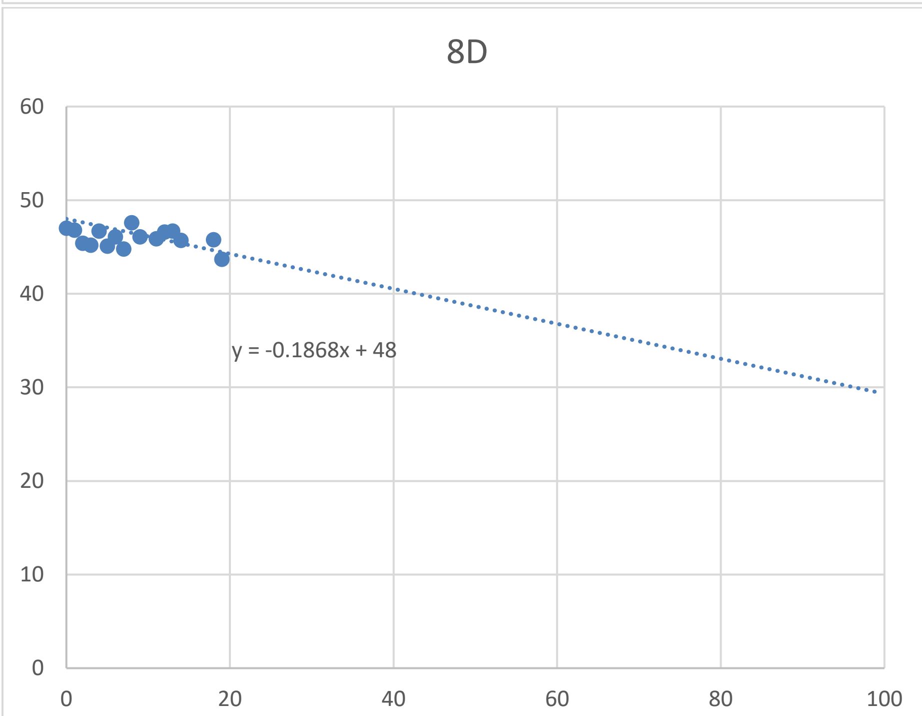

7B
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.2807x + 54.5
R^2 = 0.6652

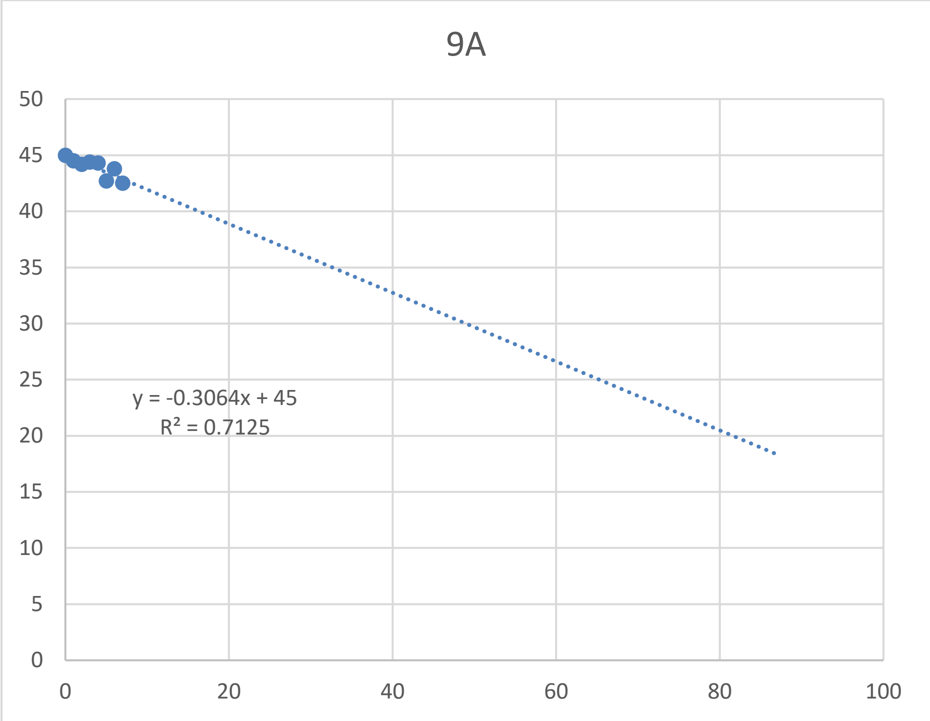

7C
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.3189x + 52
R^2 = 0.5881

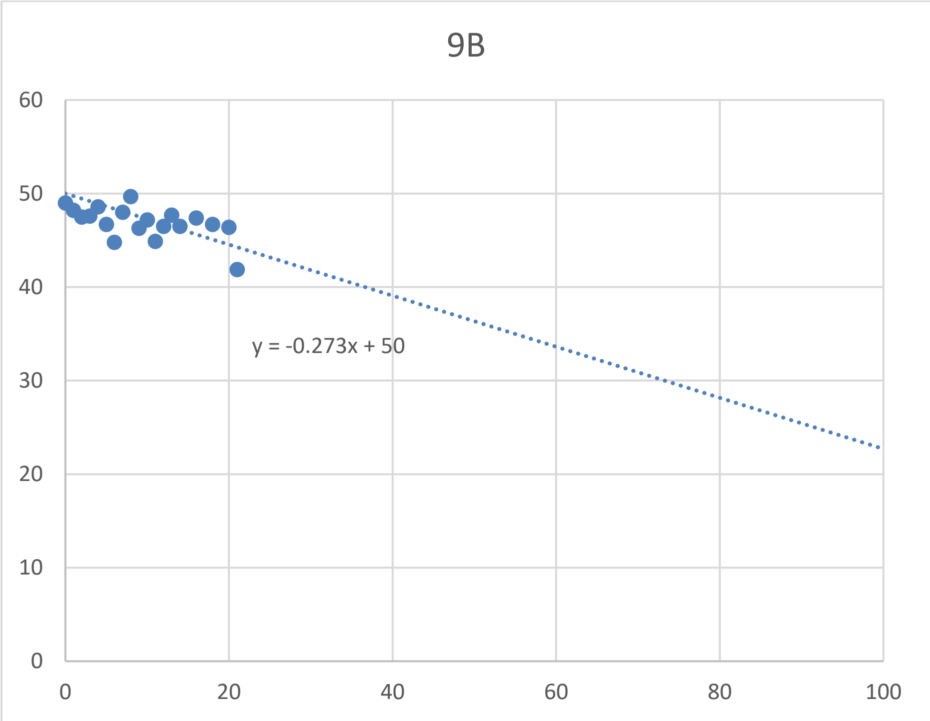

7D
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.3444x + 52
R² = 0.7443

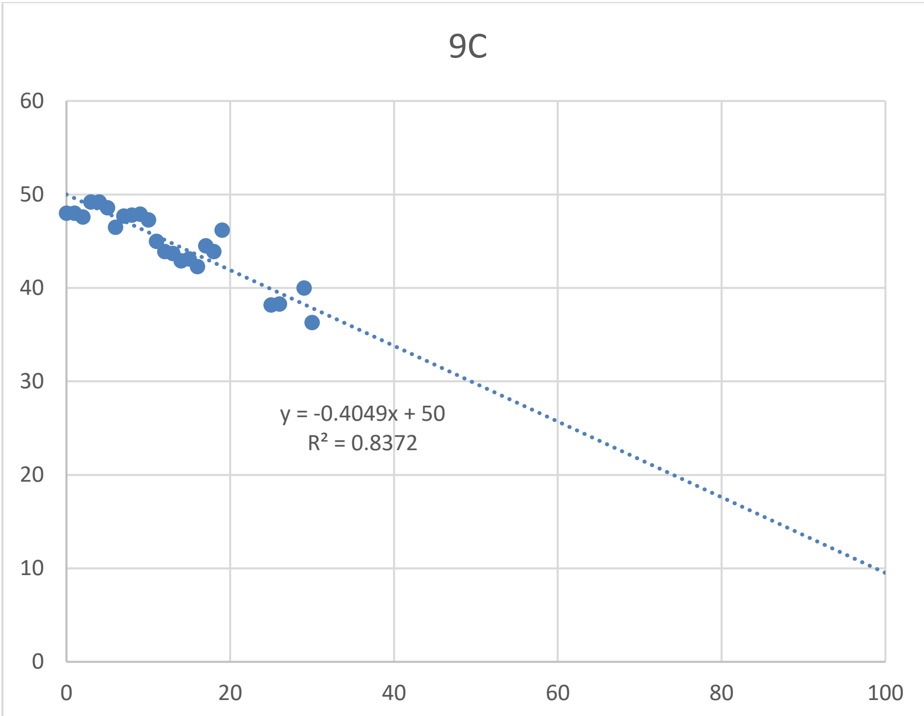

8A
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.3635x + 48
R² = 0.73

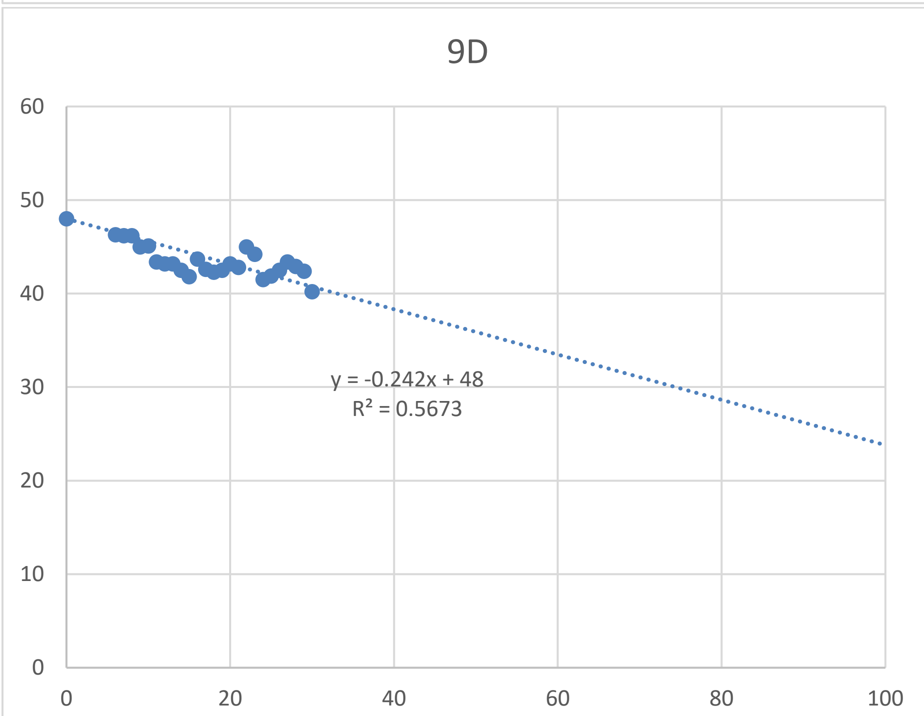

8C
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.2457x + 50
R^2 = 0.4909

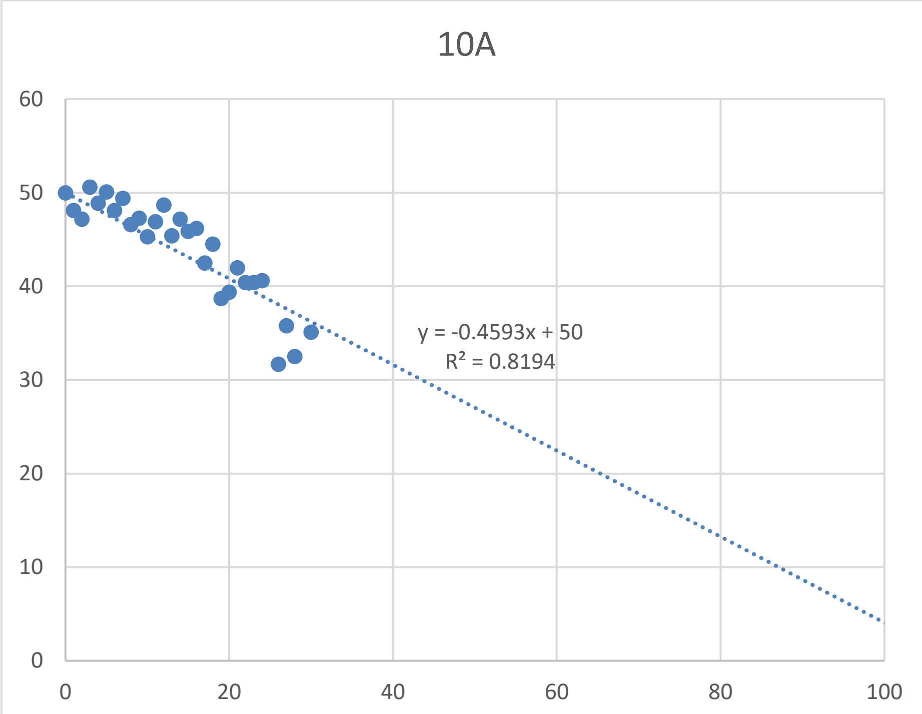

8D
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.1868x + 48

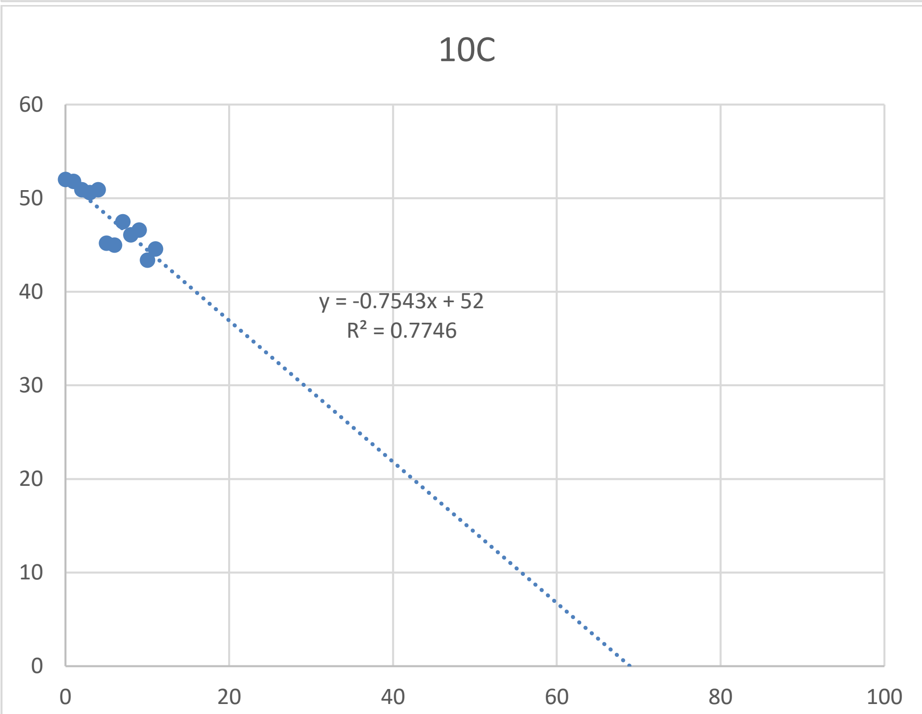

9A
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
y = -0.3064x + 45
R² = 0.7125

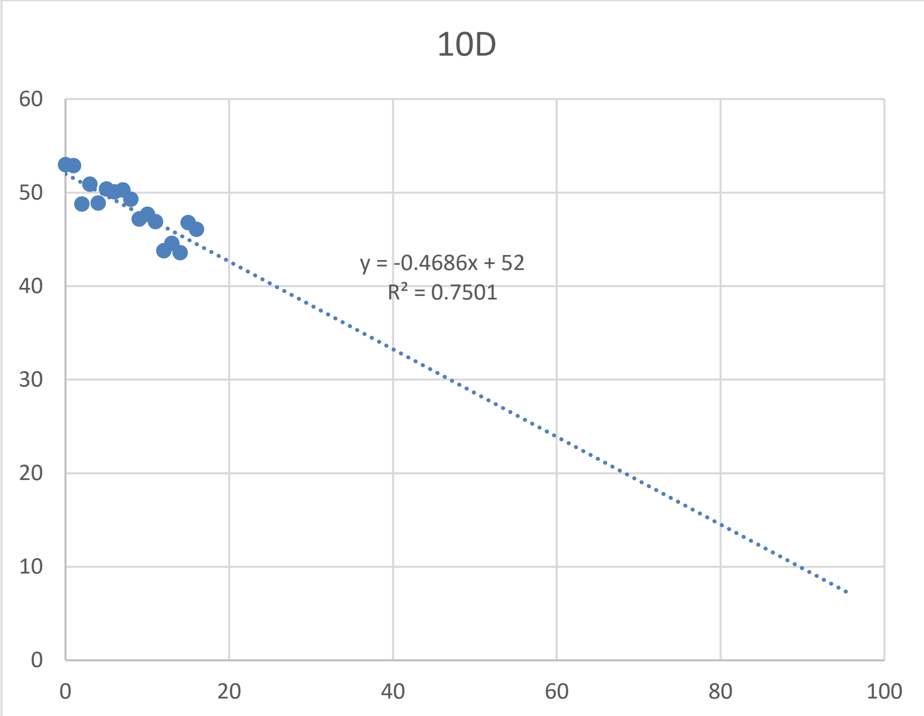

9B
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.273x + 50


9C
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.4049x + 50
R² = 0.8372


9D
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.242x + 48
R² = 0.5673


10A
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.4593x + 50
R² = 0.8194


10C
60
50
40
30
20
10
0
0
20
40
60
80
100
y = -0.7543x + 52
R² = 0.7746


10D
y = -0.4686x + 52
R² = 0.7501
60
50
40
30
20
10
0
0
20
40
60
80
100

Most Recent Model Functions

```
// C# Function for friction models updated 12-15-2017
string CTY=[COUNTY],FC=[FUNC_CLASS];
double SL=0, SKID=[SPADJ_SKID_NUMBER],age=[AGE];
if((CTY=="CA"||CTY=="QA") && (FC=="1"||FC=="2"||FC=="11")){SL=-0.655;}
else if((CTY=="CA"||CTY=="QA") && (FC=="9"||FC=="18"||FC=="19")){SL=-0.5036;}
else if((CTY=="CA"||CTY=="QA") && (FC=="7"||FC=="12"||FC=="17")){SL=-0.3022;}
else if((CTY=="CA"||CTY=="QA") &&
(FC=="3"||FC=="6"||FC=="8"||FC=="16"||FC=="14")){SL=-0.3906;}
else if((CTY=="CH"||CTY=="HO"||CTY=="WA") && (FC=="1"||FC=="2"||FC=="11")){SL=-
0.6635;}
else if((CTY=="CH"||CTY=="HO"||CTY=="WA") &&
(FC=="9"||FC=="18"||FC=="19")){SL=-0.489;}
else if((CTY=="CH"||CTY=="HO"||CTY=="WA") &&
(FC=="7"||FC=="12"||FC=="17")){SL=-0.2492;}
else if((CTY=="CH"||CTY=="HO"||CTY=="WA") &&
(FC=="3"||FC=="6"||FC=="8"||FC=="16"||FC=="14")){SL=-0.2564;}
else if((CTY=="BA") && (FC=="1"||FC=="2"||FC=="11")){SL=-0.4548;}
else if((CTY=="BA") && (FC=="7"||FC=="12"||FC=="17")){SL=-0.3622;}
else if((CTY=="BA") && (FC=="3"||FC=="6"||FC=="8"||FC=="16"||FC=="14")){SL=-
0.2978;}
else if((CTY=="MO"||CTY=="AA") && (FC=="1"||FC=="2"||FC=="11")){SL=-0.5653;}
else if((CTY=="MO"||CTY=="AA") && (FC=="9"||FC=="18"||FC=="19")){SL=-0.5048;}
else if((CTY=="MO"||CTY=="AA") && (FC=="7"||FC=="12"||FC=="17")){SL=-0.289;}
else if((CTY=="MO"||CTY=="AA") &&
(FC=="3"||FC=="6"||FC=="8"||FC=="16"||FC=="14")){SL=-0.3314;}
else if((CTY=="SM"||CTY=="FR"||CTY=="CL") && (FC=="1"||FC=="2"||FC=="11")){SL=-
0.5805;}
else if((CTY=="SM"||CTY=="FR"||CTY=="CL") && (FC=="9"||FC=="18"||FC=="19")){SL=-
0.2526;}
else if((CTY=="SM"||CTY=="FR"||CTY=="CL") && (FC=="7"||FC=="12"||FC=="17")){SL=-
0.2141;}
else if((CTY=="SM"||CTY=="FR"||CTY=="CL") &&
(FC=="3"||FC=="6"||FC=="8"||FC=="16"||FC=="14")){SL=-0.2038;}
else if((CTY=="PG"||CTY=="AL") && (FC=="1"||FC=="2"||FC=="11")){SL=-0.3108;}
else if((CTY=="PG"||CTY=="AL") && (FC=="9"||FC=="18"||FC=="19")){SL=-0.6394;}
else if((CTY=="PG"||CTY=="AL") && (FC=="7"||FC=="12"||FC=="17")){SL=-0.543;}
else if((CTY=="PG"||CTY=="AL") &&
(FC=="3"||FC=="6"||FC=="8"||FC=="16"||FC=="14")){SL=-0.2319;}
else if((CTY=="CE"||CTY=="KE"||CTY=="TA"||CTY=="CO"||CTY=="WI") &&
(FC=="1"||FC=="2"||FC=="11")){SL=-0.2021;}
else if((CTY=="CE"||CTY=="KE"||CTY=="TA"||CTY=="CO"||CTY=="WI") &&
(FC=="9"||FC=="18"||FC=="19")){SL=-0.2807;}
else if((CTY=="CE"||CTY=="KE"||CTY=="TA"||CTY=="CO"||CTY=="WI") &&
(FC=="7"||FC=="12"||FC=="17")){SL=-0.3189;}
```

```
else if((CTY=="CE"||CTY=="KE"||CTY=="TA"||CTY=="CO"||CTY=="WI") &&
(FC=="3"||FC=="6"||FC=="8"||FC=="16"||FC=="14")){SL=-0.3444;}
else if((CTY=="SO"||CTY=="DO") && (FC=="1"||FC=="2"||FC=="11")){SL=-0.3635;}
else if((CTY=="SO"||CTY=="DO") && (FC=="9"||FC=="18"||FC=="19")){SL=-0.2526;}
else if((CTY=="SO"||CTY=="DO") && (FC=="7"||FC=="12"||FC=="17")){SL=-0.2457;}
else if((CTY=="SO"||CTY=="DO") &&
(FC=="3"||FC=="6"||FC=="8"||FC=="16"||FC=="14")){SL=-0.1868;}
else if((CTY=="HA"||CTY=="WO") && (FC=="1"||FC=="2"||FC=="11")){SL=-0.3064;}
else if((CTY=="HA"||CTY=="WO") && (FC=="9"||FC=="18"||FC=="19")){SL=-0.273;}
else if((CTY=="HA"||CTY=="WO") && (FC=="7"||FC=="12"||FC=="17")){SL=-0.3906;}
else if((CTY=="HA"||CTY=="WO") &&
(FC=="3"||FC=="6"||FC=="8"||FC=="16"||FC=="14")){SL=-0.242;}
else if((CTY=="GA") && (FC=="1"||FC=="2"||FC=="11")){SL=-0.4593;}
else if((CTY=="GA") && (FC=="7"||FC=="12"||FC=="17")){SL=-0.7543;}
else if((CTY=="GA") && (FC=="3"||FC=="6"||FC=="8"||FC=="16"||FC=="14")){SL=-
0.4686;}
else {SL = -0.3906;}
Answer = SL * age + SKID;

return Answer;
```

11.13 OPTIMIZATION DATA ROLLUP METHODS

The following table and supporting information relate to the data rollup process in RoadCare.

Rollup Methods by Attribute

To accomplish the stated objective, use the following data rollup methods for each specified attribute using RoadCare:

Attribute	Avg	First	Last	Max	None	Predominant	Std. Dev	Sum
AADT	*							
AGE						*		
AGE_GROUP_HALFMILE						*		
AGE_GROUPS						*		
AVG_IRI	*							
AVG_IRI_QC	*							
AVG_REHAB_CYCLE					*			
AVG_RUT	*							
AVG_RUT_QC	*							
AVG_RUT_SDV							*	
BEGIN_LAT_LONG		*						
BEGIN_LIMIT		*						
BEGIN_MM		*						
BRIDGE						*		
BRIDGE_LONG						*		
CI	*							
CI_FAMILY_CODE					*			
CI_FC_CATEGORY						*		
CI_FUNCTIONAL	*							
CI_MATERIAL_TYPE						*		
CI_STRUCTURAL	*							
CODE						*		
CONDITION_IRI						*		
COUNTY						*		
CRACK_SEAL_EXISTS						*		
CRACKING_SEG_GROUP						*		
CURB						*		
CY17_PMT_PROJECTS					*			
D3_CS_CANDIDATES					*			
D3_EXCLUSIONS						*		
D3_MICRO_FY18					*			
DENSITY_AVG					*			

Attribute	Avg	First	Last	Max	None	Predominant	Std. Dev	Sum
DIR_BMP		*						
DIR_EMP			*					
DIR_LANES	*							
DIR_MILES								*
DISTRICT						*		
DIVIDED						*		
END_LAT_LONG			*					
END_LIMIT			*					
END_MM			*					
EVENT_PAVE_CHANGE						*		
EXIT_NUMBER						*		
FC_CATEGORY						*		
FC_DENSITY	*							
FC_DENSITY_MR	*							
FC_DENSITY_QC	*							
FC_DENSITY_SDV							*	
FRICTION_RUT_13					*			
FRICTION_RUT_14					*			
FUNC_CLASS						*		
FUND_RTE_LIST_LMR						*		
FY16_17_SUG_PRJ						*		
GLOBAL_ROUTE_ID						*		
GOVT_CONTROL						*		
HMIS_ROUTEID						*		
HPMS_AVG_IRI					*			
HPMS_AVG_RUT					*			
HPMS_CRK_PCT_ASP					*			
HPMS_CRK_PCT_CRC					*			
HPMS_CRK_PCT_JCP					*			
HPMS_FAULTING					*			
HPMS_SEGMENTATION						*		
HPMS_SURFACE_TYPE					*			
INITIAL_SKID_NUMBER					*			
INV_CHANGE					*			
IRI_PER_SCALE					*			
IRI_PHASE4_SEG_GAPS					*			
ISCONHIST						*		
ISRAMP						*		
LANE_WIDTH					*			

Attribute	Avg	First	Last	Max	None	Predominant	Std. Dev	Sum
LAST_MAINT_TREATMENT						*		
LAST_MAINT_YEAR						*		
LAST_PMAINT_TREATMENT						*		
LAST_PMAINT_YEAR						*		
LAST_REHAB_TREATMENT						*		
LAST_REHAB_YEAR						*		
LAST_TREATMENT						*		
LAST_YEAR						*		
LM_DM_VMT_AREA_16					*			
LM_DM_VMT_AREA_17					*			
LM_DM_VMT_AREA_PM15					*			
LM_VMT_AREA	*							
LM_VMT_AREA_15					*			
MAIN_LINE						*		
MAPPING_AGE					*			
MAPPING_LAST_YEAR					*			
MDTA_FACILITY					*			
MDTA_SEG					*			
NHS_CODE						*		
ONE_MILE_OR_MORE						*		
PAVED_AREA_SY								*
PAVEMENT_TYPE						*		
PCC_SEGMENTS						*		
PRIMARY_DIRECTION						*		
PROGRAM					*			
PROGRAM_COST					*			
PROGRAM_COST_FY12					*			
PROGRAM_FY12					*			
PROGRAM_FY13					*			
PROGRAM_YEAR					*			
PROGRAM_YEAR_FY12					*			
PROGRAM_YEAR_FY13					*			
PROGRAM_YEAR_FY14					*			
PROGRAM_YEAR_FY15					*			
PROGRAM_YEAR_FY16						*		
PROGRAM_YEAR_FY17						*		
PROGRAM_YEAR_MDTA						*		
PROGYEAR13_EXTRA					*			
PROPOSED						*		

Attribute	Avg	First	Last	Max	None	Predominant	Std. Dev	Sum
PUBLIC_MAP_15						*		
PUBLIC_MAP_15_BEGLMT						*		
PUBLIC_MAP_15_ENDLMT						*		
R_IRI	*							
RAMP_NUMBER						*		
REGION						*		
RESECTION					*			
RESECTION_2013					*			
RESECTION_2014					*			
RESECTION_2015					*			
RESECTION_FY16					*			
RESECTION_FY17						*		
RESECTION_OCT2014					*			
RESECTION_OPT2015					*			
RESECTION_PUBLIC_MAP_15						*		
RIGHTIRI_QC	*							
RNUM						*		
ROAD_CLASS						*		
ROAD_NAME						*		
ROUTE						*		
ROUTEID						*		
RSL_WORST_SUM	*							
RSUFF						*		
RUT_FY17					*			
RUT_SEVERITY				*				
SC_DENSITY	*							
SC_DENSITY_MR	*							
SC_DENSITY_QC	*							
SC_DENSITY_SDV							*	
SECTIONS_WO_AGE					*			
SHOP						*		
SHOULDER_WIDTH					*			
SIMDIV						*		
SKID_CATEGORY					*			
SKID_CATEGORY_WAL					*			
SKID_FY17					*			
SKID_RESECTION_WAL					*			
SKID_RUT_FY16					*			
SKID_RUT_FY17					*			

Attribute	Avg	First	Last	Max	None	Predominant	Std. Dev	Sum
SKID_RUT_LIST					*			
SPADJ_SKID_CATEGORY						*		
SPADJ_SKID_NUMBER	*							
SPADJ_SKID_NUMBER_QC	*							
SPEED_ARAN	*							
SPEED_LIMIT						*		
SPEED_SKID	*							
SUB_ROUTE_ID	*							
SURFACE_TYPE						*		
SURVEY_SPEED					*			
TEST_ATTRIBUTE					*			
TOLL_PLAZA					*			
TOTAL_LANES	*							
TREATMENT_LEVEL						*		
UNIT_COST_PROJECTS_15					*			
UNIT_COST_PROJECTS_16					*			
USE_AS_PRIMARY						*		
WET_ACCIDENT_LIST					*			
WET_ACCIDENT_LIST_15					*			
WET_ACCIDENT_LIST_16					*			

Network Segmentation Implementation Details

To accomplish the stated objective, perform segmentation on the newly created network using the following segmentation logic using RoadCare:

1. split: any change GOVT_CONTROL
2. split: any record PROGRAM_YEAR_FY18 - committed projects from PMT, non Fund77 projects, and construction history.
3. split: any record PCC (concrete)
4. split: any record long bridge (bridge >= 0.25 mile)
5. split: any record EVENT_PAVE_CHANGE (source vision base report)

In “Segmentation Results,” set minimum = 0.5, set maximum = 6, increments = Exact. Click on “Apply to all sections” button. This will set the minimum and maximum section length to 0.5 miles and 6 miles, respectively, unless they are split due to the five reasons listed above.

Once done, rollup network and then create an “Attribute View Report” by selecting the following attributes: BRIDGE_LONG, EVENT_PAVE_CHANGE, **CRACKING_SEG_GROUP**, FC_DENSITY, SC_DENSITY, GOVT_CONTROL, PCC_SEGMENTS, PROGRAM_YEAR_FY17, AGE_GROUPS, SIMDIV, USE_AS_PRIMARY, and BEGIN_LIMIT.

Next, create a spreadsheet template for segmentation using the resulting “attribute view report.’
CRACKING_SEG_GROUP is a formula field in the spreadsheet. It is defined as
CASE
 WHEN SC_DENSITY<5 and FC_DENSITY<4 THEN 1
 WHEN SC_DENSITY<5 and FC_DENSITY>=4 AND FC_DENSITY<10 THEN 2
 WHEN SC_DENSITY<5 and FC_DENSITY>=10 THEN 3
 WHEN SC_DENSITY>=5 AND SC_DENSITY<25 and FC_DENSITY<10 THEN 4
 WHEN SC_DENSITY>=5 AND SC_DENSITY<25 and FC_DENSITY>=10 THEN 5
 WHEN SC_DENSITY>=25 THEN 6
 END CRACKING_SEG_GROUP

If there is a pavement change recorded for any part of the route (i.e. count EVENT_PAVE_CHANGE >0), then make the following changes in the spreadsheet:

- join adjacent sections that belong to the same cracking group, and
- if there is no cracking data available, then just use the “event_pave_change” field for segmentation.

If there is no recorded pavement change for any part of the route (i.e. count EVENT_PAVE_CHANGE =0) then make the following change in the spreadsheet:

- join adjacent sections that belong to the same cracking group, or
- else split the section where the difference in pavement age is greater than five years.

Next, update committed project limits so that there are no small sections adjacent to the committed project, as illustrated in the example below.

ROUTE	BMP_ORG	EMP_ORG	BMP_NEW	EMP_NEW	DIR	YEAR	TREATMENT
WO-MD 707E	0.07	0.82	0.07	0.827	W	2017	CRACK SEAL

ROUTE	SECTION	Original segmentation	Updated segmentation
WO-MD 707E	0.07-0.1(W)	Route Begin - committed project	Route Begin - committed project
WO-MD 707E	0.1-0.82(W)	join: with previous section - committed project	join: with previous section - committed project
WO-MD 707E	0.82-0.827(W)	split: committed project end	join: with previous section - committed project

Once done, review the remaining long/short sections and make changes as needed. Next, copy and paste these sections into a new attribute called “RESECTION_FY18” (see Data Import). Lastly, segment the network using the segmentation logic “Anyrecord” RESECTION FY18 and rollup the network.

11.14 PAVEMENT FRICTION MANAGEMENT PROGRAM SQL PACKAGES

The following SQL package is used to break the network at every road feature or event that effects friction demand:

```
--- PACKAGE SPEC
CREATE OR REPLACE PACKAGE FRICTION_GUIDE_PKG AS --  4HRS TO RUN

--EXECUTE FRICTION_GUIDE_PKG.FMG_MAIN(2016,2019,NULL);

PROCEDURE P_SKID_INVENTORY (INV_YEAR NUMBER);-- 1 MINUTE
PROCEDURE FMG_MAIN (INV_YEAR NUMBER, COND_YEAR NUMBER,COUNTY_IN VARCHAR2);
PROCEDURE P_DH_GRADE (P_YEAR NUMBER);
PROCEDURE P_CURVE_RUT(P_YEAR NUMBER);
PROCEDURE P_FMG_BASE_SEGMENTATION(INV_YEAR NUMBER, COND_YEAR
NUMBER,COUNTY_IN VARCHAR2 ); -- 3HRS
PROCEDURE P_FMG_INTERMED_SEGMENTATION; --1MIN
PROCEDURE P_FMG_FINAL_SEGMENTATION;
PROCEDURE P_FMG_ATTRIBUTE_UPDATE;

END FRICTION_GUIDE_PKG;

---PACKAGE BODY
CREATE OR REPLACE PACKAGE BODY FRICTION_GUIDE_PKG -- 4HRS TO RUN
AS
 PROCEDURE P_SKID_INVENTORY(
   INV_YEAR NUMBER)
 AS
  CURSOR C1-- CURSOR TO DECLARE TAB1
  IS
   SELECT HMIS_YEAR,
    GLOBAL_ROUTE_ID,
    SUB_ROUTE_ID,
    ROUTEID,
    HMIS_ROUTEID,
    DIRECTION,
    DIR_BMP,
    DIR_EMP,
    INV_BMP,
    INV_EMP,
    GOVT_CONTROL
   FROM SECTION_TABLE
   WHERE 1=0;
 TYPE TYP1
IS
 TABLE OF C1%ROWTYPE;
 TAB1 TYP1;
 V_DIRBMP  NUMBER;
 V_DIREMP  NUMBER;
 V_INVBMP  NUMBER;
 V_INVEMP  NUMBER;
 V_INV_DIR NUMBER;
BEGIN
 EXECUTE IMMEDIATE 'TRUNCATE TABLE SKID_INVENTORY';
 FOR SEC_TABLE IN -- FOR LOOP COLLECTING AND LOOPING DISTINCT GRID, SRID IN A GIVEN
YEAR
 (SELECT DISTINCT HMIS_YEAR,
  GLOBAL_ROUTE_ID,
  SUB_ROUTE_ID,
```

```
  GOVT_CONTROL,
  ROUTEID,
  HMIS_ROUTEID,
  DIRECTION
 FROM SECTION_TABLE
 WHERE HMIS_YEAR = INV_YEAR
  --AND GOVT_CONTROL =1 ---CHANGED BY RG ON 4/11/2020
 AND GOVT_CONTROL IN (1,31) ---CHANGED BY RG ON 4/11/2020
  --  AND GLOBAL_ROUTE_ID IN(75307,75315,24004, 9212, 805,37037)
 ORDER BY GLOBAL_ROUTE_ID,
  SUB_ROUTE_ID
 )
 LOOP
  V_INV_DIR := NULL; -- RESETTING THE VARIABLE
  SELECT HMIS_YEAR,
   GLOBAL_ROUTE_ID,
   SUB_ROUTE_ID,
   ROUTEID,
   HMIS_ROUTEID,
   DIRECTION,
   DIR_BMP,
   DIR_EMP,
   INV_BMP,
   INV_EMP,
   GOVT_CONTROL BULK COLLECT
  INTO TAB1
  FROM SECTION_TABLE
  WHERE HMIS_YEAR     = SEC_TABLE.HMIS_YEAR
  AND GLOBAL_ROUTE_ID =SEC_TABLE.GLOBAL_ROUTE_ID
  AND DIRECTION       = SEC_TABLE.DIRECTION
  AND HMIS_ROUTEID    =SEC_TABLE.HMIS_ROUTEID
  AND GOVT_CONTROL    = SEC_TABLE.GOVT_CONTROL
  ORDER BY HMIS_YEAR,
   GLOBAL_ROUTE_ID,
   SUB_ROUTE_ID,
   DIR_BMP,
   DIR_EMP;
  BEGIN -- THIS BLOCK IS FIND OUT THE INVENTORY DIRECTION OF A ROUTE. IF NO MATCHES
ARE FOUND IN THE GLOBAL TABLES, ITS WRITTEN OUT IN THE EXCEPTION PART.
   SELECT DISTINCT USE_AS_PRIMARY
   INTO V_INV_DIR
   FROM SECTION_TABLE
   WHERE GLOBAL_ROUTE_ID =SEC_TABLE.GLOBAL_ROUTE_ID
   AND SUB_ROUTE_ID      = SEC_TABLE.SUB_ROUTE_ID
   AND HMIS_YEAR         =INV_YEAR;
  EXCEPTION
  WHEN NO_DATA_FOUND THEN
   DBMS_OUTPUT.PUT_LINE('NO RECORDS FOUND IN SECTION TABLE FOR
'||SEC_TABLE.GLOBAL_ROUTE_ID||' - '||SEC_TABLE.SUB_ROUTE_ID||' - '||SEC_TABLE.DIRECTION);
  END;
  --DBMS_OUTPUT.PUT_LINE(V_INV_DIR);
  V_DIRBMP    := NULL;
  V_DIREMP    := NULL;
  V_INVBMP    := NULL;
  V_INVEMP    := NULL;
  IF V_INV_DIR IS NOT NULL THEN
   FOR I IN 1..TAB1.COUNT
   LOOP
    IF TAB1.COUNT = 1 THEN -- IF ONLY ONE RECORD EXISTS FOR THE ROUTE
     INSERT
     INTO SKID_INVENTORY
```

```
      (
       INV_YEAR,
       GLOBAL_ROUTE_ID,
       SUB_ROUTE_ID,
       ROUTEID,
       HMIS_ROUTEID,
       DIRECTION,
       DIR_BMP,
       DIR_EMP,
       INV_BMP,
       INV_EMP,
       GOVT_CONTROL
      )
      VALUES
      (
       TAB1(I).HMIS_YEAR,
       TAB1(I).GLOBAL_ROUTE_ID,
       TAB1(I).SUB_ROUTE_ID,
       TAB1(I).ROUTEID,
       TAB1(I).HMIS_ROUTEID,
       TAB1(I).DIRECTION,
       TAB1(I).DIR_BMP,
       TAB1(I).DIR_EMP,
       TAB1(I).INV_BMP,
       TAB1(I).INV_EMP,
       TAB1(I).GOVT_CONTROL
      );
    ELSIF TAB1.COUNT > 1 THEN
     IF I        = 1 THEN
      V_DIRBMP   := TAB1(I).DIR_BMP;
      V_DIREMP   := TAB1(I).DIR_EMP;
      V_INVBMP   := TAB1(I).INV_BMP;
      V_INVEMP   := TAB1(I).INV_EMP;
      --DBMS_OUTPUT.PUT_LINE('1ST-'||V_DIRBMP||'-'||V_DIREMP);
     ELSIF I             >1 THEN              -- IF THE ROUTE HAS MULTIPLE RECORDS
      IF TAB1(I).DIR_BMP <= TAB1(I-1).DIR_EMP THEN -- IF THE CURRENT RECORD IS LESS THAN
.04 MILES AWAY FROM THE PREVIOUS RECORD, THE RECORDS ARE ASSUMED CONTINOUS--
TAKEN OUT ON 5/23/2017 DUE TO CASES LIKE GRID 1461
       V_DIREMP      := TAB1(I).DIR_EMP;
       IF V_INV_DIR    =1 THEN
        V_INVEMP     := TAB1(I).INV_EMP;
       ELSE
        V_INVBMP := TAB1(I).INV_BMP;
       END IF;
      ELSIF TAB1(I).DIR_BMP > TAB1(I-1).DIR_EMP THEN -- IF THE CURRENT RECORD IS MORE
THAN .04 MILES AWAY FROM THE PREVIOUS RECORD, THE RECORDS ARE ASSUMED NON-
CONTINOUS AND A BREAK IS INTRODUCED -- TAKEN OUT ON 5/23/2017 DUE TO CASES LIKE GRID
1461
       -- DBMS_OUTPUT.PUT_LINE('2ND-'||V_DIRBMP||'-'||V_DIREMP);
       INSERT
       INTO SKID_INVENTORY
        (
         INV_YEAR,
         GLOBAL_ROUTE_ID,
         SUB_ROUTE_ID,
         ROUTEID,
         HMIS_ROUTEID,
         DIRECTION,
         DIR_BMP,
         DIR_EMP,
         INV_BMP,
```

```
          INV_EMP,
          GOVT_CONTROL
        )
        VALUES
        (
          TAB1(I).HMIS_YEAR,
          TAB1(I).GLOBAL_ROUTE_ID,
          TAB1(I).SUB_ROUTE_ID,
          TAB1(I).ROUTEID,
          TAB1(I).HMIS_ROUTEID,
          TAB1(I).DIRECTION,
          V_DIRBMP,
          V_DIREMP,
          V_INVBMP,
          V_INVEMP,
          TAB1(I).GOVT_CONTROL
        );
      V_DIRBMP := TAB1(I).DIR_BMP;
      V_DIREMP := TAB1(I).DIR_EMP;
      --IF V_INV_DIR =1 THEN
      V_INVEMP := TAB1(I).INV_EMP;
      -- ELSE
      V_INVBMP := TAB1(I).INV_BMP;
      -- END IF;
    END IF;
  END IF;
  IF I =TAB1.COUNT THEN -- ONE FINAL INSERT IS DONE AT THE LAST RECORD.
    INSERT
    INTO SKID_INVENTORY
      (
        INV_YEAR,
        GLOBAL_ROUTE_ID,
        SUB_ROUTE_ID,
        ROUTEID,
        HMIS_ROUTEID,
        DIRECTION,
        DIR_BMP,
        DIR_EMP,
        INV_BMP,
        INV_EMP,
        GOVT_CONTROL
      )
      VALUES
      (
        TAB1(I).HMIS_YEAR,
        TAB1(I).GLOBAL_ROUTE_ID,
        TAB1(I).SUB_ROUTE_ID,
        TAB1(I).ROUTEID,
        TAB1(I).HMIS_ROUTEID,
        TAB1(I).DIRECTION,
        V_DIRBMP,
        V_DIREMP,
        V_INVBMP,
        V_INVEMP,
        TAB1(I).GOVT_CONTROL
      );
    --DBMS_OUTPUT.PUT_LINE('3RD-'||V_DIRBMP||'-'||V_DIREMP);
  END IF;
 END IF;
END LOOP;
COMMIT;
```

```
  END IF;
 END LOOP;
MERGE INTO SKID_INVENTORY A USING
( SELECT DISTINCT LU.DISTRICT,
  -- SEC.GOVT_CONTROL
  SEC.COUNTY,
  SEC.MUNICIPALITY,
  SEC.ROUTE,
  SEC.RNUM,
  SEC.RSUFF,
  SEC.ASSOCIATED_ID_PREFIX,
  SEC.EXIT_NUMBER,
  SEC.RAMP_NUMBER,
  SEC.GLOBAL_ROUTE_ID,
  SEC.SUB_ROUTE_ID
 FROM SECTION_TABLE SEC,
  SKID_INVENTORY BUS,
  PAVCORE.LU_COUNTY LU
 WHERE SEC.HMIS_YEAR    = INV_YEAR
 AND SEC.GLOBAL_ROUTE_ID = BUS.GLOBAL_ROUTE_ID
 AND SEC.SUB_ROUTE_ID    = BUS.SUB_ROUTE_ID
 AND LU.COUNTY_CODE      = SEC.COUNTY
)
B ON (A.GLOBAL_ROUTE_ID = B.GLOBAL_ROUTE_ID AND A.SUB_ROUTE_ID = B.SUB_ROUTE_ID)
WHEN MATCHED THEN
 UPDATE
 SET A.DISTRICT         = B.DISTRICT,
  A.COUNTY             = B.COUNTY,
  A.MUNICIPALITY       = B.MUNICIPALITY,
  A.ROUTE              = B.ROUTE,
  A.RNUM               = B.RNUM,
  A.RSUFF              = B.RSUFF,
  A.ASSOCIATED_ID_PREFIX= B.ASSOCIATED_ID_PREFIX,
  A.EXIT_NUMBER        = B.EXIT_NUMBER,
  A.RAMP_NUMBER        = B.RAMP_NUMBER;
 --- ADDRESS THE ROUTES WITH MAIN_LINE CODE 9 WHICH WE DIDNT USE IN SECTION_TABLE
DUE TO MISSING ATTRIBUTES
 MERGE INTO SKID_INVENTORY A USING
 (SELECT DISTINCT ROUTEID
 FROM HMIS_UNIVERSE_ALL_YEARS
 WHERE MAIN_LINE            =9
 AND YEAR                  =INV_YEAR
 ) B ON (SUBSTR(A.ROUTEID,1,14) = SUBSTR(B.ROUTEID,1,14))
WHEN MATCHED THEN
 UPDATE SET A.HMIS_ROUTEID = B.ROUTEID WHERE A.SUB_ROUTE_ID =2;
 COMMIT;
 -- ADDEDON 9/21/2021 TO ADDRESS CASES WHEN NON INVENTORY DIR_BMP IS NOT ZERO LIKE
75315
 UPDATE SKID_INVENTORY
 SET DIR_BMP=ROUND(DIR_BMP,2),
  INV_BMP  = ROUND(INV_BMP,2);
 --  FOR I  IN
 --  (SELECT *  FROM SKID_INVENTORY
 --  WHERE (GLOBAL_ROUTE_ID, SUB_ROUTE_ID) IN
 --    (SELECT GLOBAL_ROUTE_ID, SUB_ROUTE_ID
 --    FROM
 --     (SELECT GLOBAL_ROUTE_ID, SUB_ROUTE_ID,
 --       COUNT(*)
 --     FROM SKID_INVENTORY
 --     WHERE SUB_ROUTE_ID = 2
 --       --AND SUBSTR(HMIS_ROUTEID,16,1)<>9
```

```
--      GROUP BY GLOBAL_ROUTE_ID,
--       SUB_ROUTE_ID
--      HAVING COUNT(*)=1
--      )
--    )
--  AND DIR_BMP>0
--  ORDER BY 1,2
--  )
--  LOOP
--    IF I.INV_BMP = 0 THEN
--      UPDATE SKID_INVENTORY
--      SET DIR_BMP           =INV_BMP,
--        DIR_EMP            = INV_EMP
--      WHERE GLOBAL_ROUTE_ID = I.GLOBAL_ROUTE_ID
--      AND SUB_ROUTE_ID      = I.SUB_ROUTE_ID;
--    ELSE
--      UPDATE SKID_INVENTORY
--      SET DIR_BMP           =0,
--        DIR_EMP            = DIR_EMP-DIR_BMP
--      WHERE GLOBAL_ROUTE_ID = I.GLOBAL_ROUTE_ID
--      AND SUB_ROUTE_ID      = I.SUB_ROUTE_ID;
--    END IF;
--  END LOOP;
END P_SKID_INVENTORY;
PROCEDURE FMG_MAIN(
    INV_YEAR  NUMBER,
    COND_YEAR NUMBER,
    COUNTY_IN VARCHAR2)
AS
  INDEX_CHECK NUMBER;
BEGIN
  -- DBMS_SQLTUNE.ACCEPT_SQL_PROFILE(TASK_NAME => 'STANAME7943', TASK_OWNER =>
'PAV_CONHIST', REPLACE => TRUE);
  --DBMS_SQLTUNE.ACCEPT_SQL_PROFILE(TASK_NAME => 'STANAME88142',  TASK_OWNER =>
'PAV_CONHIST', REPLACE => TRUE);
  DBMS_PROFILER.START_PROFILER(SYSDATE);
  SHA_OPTIMIZE2;
  --  P_DH_GRADE (COND_YEAR);-- RUN ONCE FOR THE WHOLE NETWORK
  --  P_CURVE_RUT (COND_YEAR);-- RUN ONCE FOR THE WHOLE NETWORK
  --  INSERT
  --  INTO PROC_PKG_RUN_LOG VALUES
  --    (
  --      'BEGIN P_SKID_INVENTORY',
  --      SYSTIMESTAMP
  --    );
  --  COMMIT;
  --  P_SKID_INVENTORY(INV_YEAR);
  SELECT COUNT(*)
  INTO INDEX_CHECK -- CHECKS FOR INDEX INDX1_BUSSPLAN_1MILE AND DROPS IT IF IT EXITS
  FROM USER_INDEXES
  WHERE INDEX_NAME= 'FMG_BASE_IDX1';
  IF INDEX_CHECK  =1 THEN
    EXECUTE IMMEDIATE 'DROP INDEX FMG_BASE_IDX1';
  END IF;
  SELECT COUNT(*)
  INTO INDEX_CHECK -- CHECKS FOR INDEX INDX1_BUSSPLAN_1MILE AND DROPS IT IF IT EXITS
  FROM USER_INDEXES
  WHERE INDEX_NAME= 'FMG_BASE_IDX2';
  IF INDEX_CHECK  =1 THEN
    EXECUTE IMMEDIATE 'DROP INDEX FMG_BASE_IDX2';
  END IF;
```

```
 INSERT
 INTO PROC_PKG_RUN_LOG VALUES
   (
    'BEGIN P_FMG_BASE_SEGMENTATION',
    SYSTIMESTAMP
   );
 COMMIT;
 P_FMG_BASE_SEGMENTATION(INV_YEAR , COND_YEAR, COUNTY_IN );
 SELECT COUNT(*)
 INTO INDEX_CHECK -- CHECKS FOR INDEX INDX1_BUSSPLAN_1MILE AND DROPS IT IF IT EXITS
 FROM USER_INDEXES
 WHERE INDEX_NAME= 'FMG_BASE_IDX1';
 IF INDEX_CHECK  =0 THEN
   EXECUTE IMMEDIATE 'CREATE INDEX FMG_BASE_IDX1 ON
FMG_BASE_SEGMENTS(COLLECT_YEAR,
GLOBAL_ROUTE_ID,
SUB_ROUTE_ID,
BMP,
EMP)
';
 END IF;
 SELECT COUNT(*)
 INTO INDEX_CHECK -- CHECKS FOR INDEX INDX1_BUSSPLAN_1MILE AND DROPS IT IF IT EXITS
 FROM USER_INDEXES
 WHERE INDEX_NAME= 'FMG_BASE_IDX2';
 IF INDEX_CHECK  =0 THEN
   EXECUTE IMMEDIATE 'CREATE INDEX FMG_BASE_IDX2 ON
FMG_BASE_SEGMENTS(COLLECT_YEAR,
HMIS_ROUTEID,
EMP,
GLOBAL_ROUTE_ID,
SUB_ROUTE_ID
)
';
 END IF;
 INSERT
 INTO PROC_PKG_RUN_LOG VALUES
   (
    'BEGIN P_FMG_INTERMED_SEGMENTATION',
    SYSTIMESTAMP
   );
 COMMIT;
 P_FMG_INTERMED_SEGMENTATION;
 INSERT
 INTO PROC_PKG_RUN_LOG VALUES
   (
    'BEGIN P_FMG_FINAL_SEGMENTATION',
    SYSTIMESTAMP
   );
 COMMIT;
 P_FMG_FINAL_SEGMENTATION;
 INSERT
 INTO PROC_PKG_RUN_LOG VALUES
   (
    'BEGIN P_FMG_ATTRIBUTE_UPDATE',
    SYSTIMESTAMP
   );
 COMMIT;
 P_FMG_ATTRIBUTE_UPDATE;
 INSERT
 INTO PROC_PKG_RUN_LOG VALUES
```

```
    (
     'END P_FMG_ATTRIBUTE_UPDATE',
     SYSTIMESTAMP
    );
  COMMIT;
  DBMS_PROFILER.STOP_PROFILER;
END FMG_MAIN ;
PROCEDURE P_DH_GRADE
  (
    P_YEAR NUMBER
  )
AS
  CURSOR C0
  IS
    SELECT DISTINCT S.GLOBAL_ROUTE_ID,
      S.SUB_ROUTE_ID
    FROM FINAL_CONDITION_DETAIL_SKID S
    WHERE COLLECT_YEAR = P_YEAR
      -- AND GLOBAL_ROUTE_ID = 1400
      --AND SUB_ROUTE_ID    =1
      --   AND COUNTY ='AL'
      --    AND EXISTS
      --      (SELECT NULL
      --      FROM FMG_MANUAL_ROUTES M
      --      WHERE S.GLOBAL_ROUTE_ID= M.GLOBAL_ROUTE_ID
      --      AND S.SUB_ROUTE_ID     = M.SUB_ROUTE_ID
      --      )
    ORDER BY 1,2 ;
TYPE TYP0
IS
  TABLE OF C0%ROWTYPE;
  TAB0 TYP0;
  CURSOR C1
  IS
    SELECT * FROM DH_GRADE_SKID ;
TYPE TYP1
IS
  TABLE OF C1%ROWTYPE;
  TAB1 TYP1;
  V_BMP NUMBER;
  V_EMP NUMBER;
BEGIN
  EXECUTE IMMEDIATE ' TRUNCATE TABLE DH_GRADE_SKID';
  OPEN C0;
  LOOP
    FETCH C0 BULK COLLECT INTO TAB0 LIMIT 100;
    EXIT
  WHEN TAB0.COUNT =0;
    FOR N IN 1..TAB0.COUNT
    LOOP
      SELECT * BULK COLLECT
      INTO TAB1
      FROM
        (SELECT P_YEAR,
          TAB0(N).GLOBAL_ROUTE_ID,
          TAB0(N).SUB_ROUTE_ID,
          BMP DIR_BMP,
          EMP DIR_EMP,
          EMP-BMP SEC_LENGTH,
          SEC_ATTRIBUTE
        FROM
```

```
    (SELECT MIN(DIR_BMP) BMP,
     MAX(DIR_EMP) EMP,
     SEC_ATTRIBUTE,
     SEC_RN
    FROM
     (SELECT DIR_BMP,
      DIR_EMP,
      SEC_ATTRIBUTE,
      RN_,
      ROW_NUMBER() OVER(ORDER BY RN_) -ROW_NUMBER() OVER(PARTITION BY
SEC_ATTRIBUTE ORDER BY RN_) AS SEC_RN
     FROM
      (SELECT TT.*,
       ROWNUM RN_ -- THIS SUBQUERY SORTS THE INCOMING ATTRIBUTE AND SUPPLIES THE
RN FIELD.
      FROM
       ( SELECT DISTINCT DIR_BMP,
        DIR_EMP,
        CASE
         WHEN GRADE>-5
         THEN 'NO_DH_GRADE'
         WHEN GRADE >= -10
         AND GRADE  <= -5
         THEN 'DH_GRADE_5_TO_10'
         WHEN GRADE < -10
         THEN 'DH_GRADE_10'
        END SEC_ATTRIBUTE
       FROM FINAL_CONDITION_DETAIL_SKID
       WHERE COLLECT_YEAR  = P_YEAR
       AND GLOBAL_ROUTE_ID = TAB0(N).GLOBAL_ROUTE_ID
       AND SUB_ROUTE_ID    = TAB0(N).SUB_ROUTE_ID
       ORDER BY 1
       ) TT
      )
     )
    GROUP BY SEC_ATTRIBUTE,
     SEC_RN
    )
    --  WHERE SEC_ATTRIBUTE IN ('DH_GRADE_10','DH_GRADE_5_TO_10')
   )
  WHERE SEC_ATTRIBUTE ='DH_GRADE_5_TO_10'
  ORDER BY 1,2,3,4 ;
  V_BMP := NULL;
  V_EMP := NULL;
  FOR I IN 1..TAB1.COUNT
  LOOP
   IF I               = 1 THEN
    V_BMP              := TAB1(I).DIR_BMP;
    V_EMP              := TAB1(I).DIR_EMP;
   ELSIF I              > 1 THEN
    IF TAB1(I).DIR_BMP   <= TAB1(I - 1).DIR_EMP+.01 THEN
     V_EMP             := TAB1(I).DIR_EMP;
    ELSIF TAB1(I).DIR_BMP > TAB1(I - 1).DIR_EMP+.01 THEN
     INSERT
     INTO DH_GRADE_SKID VALUES
      (
       TAB1(I).COLLECT_YEAR,
       TAB1(I).GLOBAL_ROUTE_ID,
       TAB1(I).SUB_ROUTE_ID,
       V_BMP,
       V_EMP,
```

```
          NULL,
          TAB1(I).SEC_ATTRIBUTE
         );
        V_BMP := TAB1(I).DIR_BMP;
        V_EMP := TAB1(I).DIR_EMP;
       END IF;
      END IF;
      IF I = TAB1.COUNT THEN
       INSERT
       INTO DH_GRADE_SKID VALUES
        (
         TAB1(I).COLLECT_YEAR,
         TAB1(I).GLOBAL_ROUTE_ID,
         TAB1(I).SUB_ROUTE_ID,
         V_BMP,
         V_EMP,
         NULL,
         TAB1(I).SEC_ATTRIBUTE
        );
      END IF;
     END LOOP;
    END LOOP;
  END LOOP;
  CLOSE C0;
  -- DH_GRADE_10 LOOP
  OPEN C0;
  LOOP
   FETCH C0 BULK COLLECT INTO TAB0 LIMIT 100;
   EXIT
  WHEN TAB0.COUNT =0;
   FOR N IN 1..TAB0.COUNT
   LOOP
    SELECT * BULK COLLECT
    INTO TAB1
    FROM
     (SELECT P_YEAR,
      TAB0(N).GLOBAL_ROUTE_ID,
      TAB0(N).SUB_ROUTE_ID,
      BMP DIR_BMP,
      EMP DIR_EMP,
      EMP-BMP SEC_LENGTH,
      SEC_ATTRIBUTE
     FROM
      (SELECT MIN(DIR_BMP) BMP,
       MAX(DIR_EMP) EMP,
       SEC_ATTRIBUTE,
       SEC_RN
      FROM
       (SELECT DIR_BMP,
        DIR_EMP,
        SEC_ATTRIBUTE,
        RN_,
        ROW_NUMBER() OVER(ORDER BY RN_) -ROW_NUMBER() OVER(PARTITION BY
SEC_ATTRIBUTE ORDER BY RN_) AS SEC_RN
       FROM
        (SELECT TT.*,
         ROWNUM RN_ -- THIS SUBQUERY SORTS THE INCOMING ATTRIBUTE AND SUPPLIES THE
RN FIELD.
        FROM
         ( SELECT DISTINCT DIR_BMP,
          DIR_EMP,
```

```
          CASE
           WHEN GRADE>-5
           THEN 'NO_DH_GRADE'
           WHEN GRADE >= -10
           AND GRADE  <= -5
           THEN 'DH_GRADE_5_TO_10'
           WHEN GRADE < -10
           THEN 'DH_GRADE_10'
          END SEC_ATTRIBUTE
         FROM FINAL_CONDITION_DETAIL_SKID
         WHERE COLLECT_YEAR  = P_YEAR
         AND GLOBAL_ROUTE_ID = TAB0(N).GLOBAL_ROUTE_ID
         AND SUB_ROUTE_ID    = TAB0(N).SUB_ROUTE_ID
         ORDER BY 1
         ) TT
        )
       )
      GROUP BY SEC_ATTRIBUTE,
       SEC_RN
      )
      --  WHERE SEC_ATTRIBUTE IN ('DH_GRADE_10','DH_GRADE_5_TO_10')
     )
    WHERE SEC_ATTRIBUTE ='DH_GRADE_10'
    ORDER BY 1,2,3,4 ;
    V_BMP := NULL;
    V_EMP := NULL;
    FOR I IN 1..TAB1.COUNT
    LOOP
     IF I              = 1 THEN
      V_BMP            := TAB1(I).DIR_BMP;
      V_EMP            := TAB1(I).DIR_EMP;
     ELSIF I             > 1 THEN
      IF TAB1(I).DIR_BMP   <= TAB1(I - 1).DIR_EMP+.01 THEN
       V_EMP           := TAB1(I).DIR_EMP;
      ELSIF TAB1(I).DIR_BMP > TAB1(I - 1).DIR_EMP+.01 THEN
       INSERT
       INTO DH_GRADE_SKID VALUES
        (
         TAB1(I).COLLECT_YEAR,
         TAB1(I).GLOBAL_ROUTE_ID,
         TAB1(I).SUB_ROUTE_ID,
         V_BMP,
         V_EMP,
         NULL,
         TAB1(I).SEC_ATTRIBUTE
        );
       V_BMP := TAB1(I).DIR_BMP;
       V_EMP := TAB1(I).DIR_EMP;
      END IF;
     END IF;
     IF I = TAB1.COUNT THEN
      INSERT
      INTO DH_GRADE_SKID VALUES
       (
        TAB1(I).COLLECT_YEAR,
        TAB1(I).GLOBAL_ROUTE_ID,
        TAB1(I).SUB_ROUTE_ID,
        V_BMP,
        V_EMP,
        NULL,
        TAB1(I).SEC_ATTRIBUTE
```

```
        );
      END IF;
     END LOOP;
    END LOOP;
  END LOOP;
  CLOSE C0;
  UPDATE DH_GRADE_SKID
  SET SEC_LENGTH = DIR_EMP- DIR_BMP;
END P_DH_GRADE;
PROCEDURE P_CURVE_RUT(
    P_YEAR NUMBER)
AS
  CNT       NUMBER;
  YEAR_LOOP NUMBER ;
BEGIN
  EXECUTE IMMEDIATE 'TRUNCATE TABLE FINAL_CONDITION_DETAIL_SKID';
  FOR I IN
  (SELECT DISTINCT GLOBAL_ROUTE_ID,
    SUB_ROUTE_ID
  FROM SKID_INVENTORY
    -- WHERE GLOBAL_ROUTE_ID =809
    -- AND SUB_ROUTE_ID      =1
  ORDER BY 1,2
  )
  LOOP
    YEAR_LOOP      := P_YEAR;
    WHILE YEAR_LOOP>=P_YEAR-10
    LOOP
      SELECT COUNT(*)
      INTO CNT
      FROM FINAL_CONDITION_DETAIL
      WHERE GLOBAL_ROUTE_ID = I.GLOBAL_ROUTE_ID
      AND SUB_ROUTE_ID      = I.SUB_ROUTE_ID
      AND COLLECT_YEAR      = YEAR_LOOP;
      --  DBMS_OUTPUT.PUT_LINE(YEAR_LOOP||'-'||38||'-'||CNT);
      IF CNT >0 THEN
        INSERT INTO FINAL_CONDITION_DETAIL_SKID
        SELECT P_YEAR COLLECT_YEAR,
          COLLECT_YEAR SOURCE_YEAR,
          GLOBAL_ROUTE_ID,
          SUB_ROUTE_ID,
          DIR_BMP,
          DIR_EMP,
          INV_BMP,
          INV_EMP,
          L_RUT,
          R_RUT,
          GRADE
        FROM FINAL_CONDITION_DETAIL
        WHERE GLOBAL_ROUTE_ID = I.GLOBAL_ROUTE_ID
        AND SUB_ROUTE_ID      = I.SUB_ROUTE_ID
        AND COLLECT_YEAR      = YEAR_LOOP
        ORDER BY DIR_BMP;
        --DBMS_OUTPUT.PUT_LINE(56);
        EXIT;
      ELSE
        SELECT COUNT(*)
        INTO CNT
        FROM FINAL_CONDITION_DETAIL
        WHERE GLOBAL_ROUTE_ID_ORG = I.GLOBAL_ROUTE_ID
        AND SUB_ROUTE_ID_ORG      = I.SUB_ROUTE_ID
```

```
        AND COLLECT_YEAR          = YEAR_LOOP;
        IF CNT                    >0 THEN
          INSERT INTO FINAL_CONDITION_DETAIL_SKID
          SELECT P_YEAR COLLECT_YEAR,
            COLLECT_YEAR SOURCE_YEAR,
            GLOBAL_ROUTE_ID_ORG,
            SUB_ROUTE_ID_ORG,
            DIR_BMP_ORG,
            DIR_EMP_ORG,
            INV_BMP_ORG,
            INV_EMP_ORG,
            L_RUT,
            R_RUT,
            GRADE
          FROM FINAL_CONDITION_DETAIL
          WHERE GLOBAL_ROUTE_ID_ORG = I.GLOBAL_ROUTE_ID
          AND SUB_ROUTE_ID_ORG      = I.SUB_ROUTE_ID
          AND COLLECT_YEAR          = YEAR_LOOP
          ORDER BY DIR_BMP;
          --        DBMS_OUTPUT.PUT_LINE(85);
          EXIT;
        ELSE
          YEAR_LOOP:=YEAR_LOOP-1;
          -- DBMS_OUTPUT.PUT_LINE(YEAR_LOOP||'-'||59||'-'||CNT);
        END IF;
      END IF;
    END LOOP;
  END LOOP;
END P_CURVE_RUT;
PROCEDURE P_FMG_BASE_SEGMENTATION(
    INV_YEAR  NUMBER,
    COND_YEAR NUMBER,
    COUNTY_IN VARCHAR2)
AS
  CURSOR C1
  IS
    SELECT BMP,
      EMP
    FROM FMG_BASE_SEGMENTS;
TYPE TYP1
IS
  TABLE OF C1%ROWTYPE;
  TAB1 TYP1;
  MAX_MP     NUMBER;
  MIN_MP     NUMBER;
  ROUTE_CNT  NUMBER;
  DIR_MAX_MP NUMBER;
  DIR_MIN_MP NUMBER;
BEGIN
  EXECUTE IMMEDIATE 'TRUNCATE TABLE FMG_BASE_SEGMENTS';
  FOR ROUTE_LIST IN
  (SELECT DISTINCT S.GLOBAL_ROUTE_ID,
    S.SUB_ROUTE_ID,
    S.GOVT_CONTROL,
    S.HMIS_ROUTEID,
    S.DIR_BMP,
    S.DIR_EMP,
    S.INV_BMP,
    S.INV_EMP
  FROM SKID_INVENTORY S
  WHERE COUNTY =
```

```
  CASE
   WHEN COUNTY_IN IS NOT NULL
   THEN COUNTY_IN
   ELSE COUNTY
  END
  --  WHERE EXISTS
  --    (SELECT NULL
  --    FROM FMG_MANUAL_ROUTES M
  --    WHERE S.GLOBAL_ROUTE_ID= M.GLOBAL_ROUTE_ID
  --    AND S.SUB_ROUTE_ID     = M.SUB_ROUTE_ID
  --    )
  -- AND GLOBAL_ROUTE_ID IN(37037, 805)
  -- AND SUB_ROUTE_ID    =2
 ORDER BY 1,2,5
 )
 LOOP
  IF ROUTE_LIST.SUB_ROUTE_ID =1 OR (ROUTE_LIST.SUB_ROUTE_ID =2 AND
SUBSTR(ROUTE_LIST.HMIS_ROUTEID,16,1)=9 ) THEN --- NON INV DIRECTION IN UNIVERSE TABLE
   INSERT
   INTO FMG_BASE_SEGMENTS
    (
     COLLECT_YEAR,
     GOVT_CONTROL,
     HMIS_ROUTEID,
     GLOBAL_ROUTE_ID,
     SUB_ROUTE_ID,
     BMP,
     EMP
    )
   -- SPEED LIMIT CRITERIA
  WITH SPEED_LIMIT AS
   ( SELECT DISTINCT ROUTEID,
    ID_MP BMP,
    ID_MP+SECTION_LENGTH EMP,
    CASE
     WHEN H.SPEED_LIMIT>=55-- CHANGED ON 9/17/2021 BASED ON EMAIL FROM PD
     THEN 'ABOVE_55'
     WHEN H.SPEED_LIMIT>=35
     AND H.SPEED_LIMIT  <55
     THEN 'BELOW_55'
     ELSE 'BELOW_35'
    END SEC_ATTRIBUTE
   FROM HMIS_UNIVERSE_ALL_YEARS H
   WHERE YEAR  = INV_YEAR
   AND ROUTEID = ROUTE_LIST.HMIS_ROUTEID
    --AND MEDIAN_TY IN (4,5)
   ORDER BY ID_MP
   ),
   --    WITH SPEED_LIMIT AS
   --     (SELECT MIN(DIR_BMP) BMP,
   --       MAX(DIR_EMP) EMP,
   --       SEC_ATTRIBUTE,
   --       SEC_RN
   --     FROM
   --       (SELECT DIR_BMP,
   --         DIR_EMP,
   --         SEC_ATTRIBUTE,
   --         RN_,
   --         ROW_NUMBER() OVER(ORDER BY RN_) -ROW_NUMBER() OVER(PARTITION BY
SEC_ATTRIBUTE ORDER BY RN_) AS SEC_RN
   --       FROM
```

```
--         (SELECT TT.*,
--           ROWNUM RN_ -- THIS SUBQUERY SORTS THE INCOMING ATTRIBUTE AND SUPPLIES
THE RN FIELD.
--         FROM
--           ( SELECT DISTINCT ROUTEID,
--             ID_MP DIR_BMP,
--             ID_MP+SECTION_LENGTH DIR_EMP,
--             CASE
--               WHEN SPEED_LIMIT>=55
--               THEN 'ABOVE_55'
--               ELSE 'BELOW_55'
--             END SEC_ATTRIBUTE
--           FROM HMIS_UNIVERSE_ALL_YEARS
--           WHERE YEAR  = INV_YEAR
--           AND ROUTEID = ROUTE_LIST.HMIS_ROUTEID
--             --AND MEDIAN_TY IN (4,5)
--           ORDER BY ID_MP
--           ) TT
--         )
--       )
--     GROUP BY SEC_ATTRIBUTE,
--       SEC_RN
--     ),
-- DIVIDED VS UNDIVIDED CRITERIA
DIVIDED AS
( SELECT DISTINCT ROUTEID,
  ID_MP BMP,
  ID_MP+SECTION_LENGTH EMP,
  CASE
    WHEN MEDIAN_TY IN (4,5)
    THEN 'UNDIVIDED'
    ELSE 'DIVIDED'
  END SEC_ATTRIBUTE
FROM HMIS_UNIVERSE_ALL_YEARS
WHERE YEAR  = INV_YEAR
AND ROUTEID = ROUTE_LIST.HMIS_ROUTEID
  --AND MEDIAN_TY IN (4,5)
ORDER BY ID_MP
),
--     DIVIDED AS
--     (SELECT MIN(DIR_BMP) BMP,
--       MAX(DIR_EMP) EMP,
--       SEC_ATTRIBUTE,
--       SEC_RN
--     FROM
--       (SELECT DIR_BMP,
--         DIR_EMP,
--         SEC_ATTRIBUTE,
--         RN_,
--         ROW_NUMBER() OVER(ORDER BY RN_) -ROW_NUMBER() OVER(PARTITION BY
SEC_ATTRIBUTE ORDER BY RN_) AS SEC_RN
--       FROM
--         (SELECT TT.*,
--           ROWNUM RN_ -- THIS SUBQUERY SORTS THE INCOMING ATTRIBUTE AND SUPPLIES
THE RN FIELD.
--         FROM
--           ( SELECT DISTINCT ROUTEID,
--             ID_MP DIR_BMP,
--             ID_MP+SECTION_LENGTH DIR_EMP,
--             CASE
--               WHEN MEDIAN_TY IN (4,5)
```

```
--             THEN 'UNDIVIDED'
--             ELSE 'DIVIDED'
--            END SEC_ATTRIBUTE
--           FROM HMIS_UNIVERSE_ALL_YEARS
--           WHERE YEAR  = INV_YEAR
--           AND ROUTEID = ROUTE_LIST.HMIS_ROUTEID
--            --AND MEDIAN_TY IN (4,5)
--           ORDER BY ID_MP
--           ) TT
--          )
--         )
--      GROUP BY SEC_ATTRIBUTE,
--       SEC_RN
--      ORDER BY 1
--      ),
-- RUT>.25 CRITERIA
RUT AS
(SELECT *
FROM
  ( SELECT DISTINCT DIR_BMP BMP,
   DIR_EMP EMP,
   CASE
    WHEN (L_RUT+R_RUT)/2 >0.25
    THEN 'HIGH_RUT'
    ELSE 'LOW_RUT'
   END SEC_ATTRIBUTE
  FROM FINAL_CONDITION_DETAIL_SKID
  WHERE COLLECT_YEAR  = COND_YEAR
  AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
  AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
   -- AND (L_RUT+R_RUT)/2 >0.25
   --  AND DIR_BMP       >=0
   --  AND DIR_EMP        < 1
  ORDER BY 1
  ) TT
WHERE SEC_ATTRIBUTE ='HIGH_RUT'
) ,
--      RUT AS
--      (SELECT *
--      FROM
--       (SELECT MIN(DIR_BMP) BMP,
--         MAX(DIR_EMP) EMP,
--         SEC_ATTRIBUTE,
--         DISTANCE
--       FROM
--         (SELECT DIR_BMP,
--           DIR_EMP,
--           SEC_ATTRIBUTE,
--           RN_,
--           ROW_NUMBER() OVER(ORDER BY RN_) -ROW_NUMBER() OVER(PARTITION BY
SEC_ATTRIBUTE ORDER BY RN_) AS DISTANCE
--         FROM
--           (SELECT TT.*,
--            ROWNUM RN_ -- THIS SUBQUERY SORTS THE INCOMING ATTRIBUTE AND SUPPLIES
THE RN FIELD.
--           FROM
--            ( SELECT DISTINCT DIR_BMP DIR_BMP,
--             DIR_EMP DIR_EMP,
--             CASE
--              WHEN (L_RUT+R_RUT)/2 >0.25
--              THEN 'HIGH_RUT'
```

```
--              ELSE 'LOW_RUT'
--             END SEC_ATTRIBUTE
--            FROM FINAL_CONDITION_DETAIL_SKID
--            WHERE COLLECT_YEAR  = COND_YEAR
--            AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
--            AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
--             -- AND (L_RUT+R_RUT)/2 >0.25
--             --  AND DIR_BMP       >=0
--             --  AND DIR_EMP        < 1
--            ORDER BY 1
--            ) TT
--           )
--          )
--       GROUP BY SEC_ATTRIBUTE,
--         DISTANCE
--       )
--     WHERE SEC_ATTRIBUTE ='HIGH_RUT'
--     ),
-- CURVE > 250 CRITERIA
--   CURVE AS
--   (SELECT
--     CASE
--       WHEN ADJ_BMP<ROUTE_LIST.DIR_BMP
--       THEN ROUTE_LIST.DIR_BMP
--       ELSE ADJ_BMP
--     END DIR_BMP,
--     CASE
--       WHEN ADJ_EMP>ROUTE_LIST.DIR_EMP
--       THEN ROUTE_LIST.DIR_EMP
--       ELSE ADJ_EMP
--     END DIR_EMP,
--     SEC_ATTRIBUTE
--   FROM
--     (SELECT BMP ,
--       EMP,
--       SEC_LENGTH,
--       CASE
--         WHEN SEC_LENGTH<.1
--         THEN ROUND(BMP-((.1-SEC_LENGTH)/2),3)
--         ELSE BMP
--       END ADJ_BMP,
--       CASE
--         WHEN SEC_LENGTH<.1
--         THEN ROUND(EMP+((.1-SEC_LENGTH)/2),3)
--         ELSE EMP
--       END ADJ_EMP,
--       SEC_ATTRIBUTE
--     FROM
--       (SELECT DIR_BMP BMP,
--         DIR_EMP EMP,
--         DIR_EMP-DIR_BMP SEC_LENGTH,
--         CASE
--           WHEN RADIUS <=25000
--           AND RADIUS   > 0
--           THEN 'CURVE_750'
--           ELSE 'CURVE_NOT750'
--         END SEC_ATTRIBUTE
--       FROM CURVE_H_SHA_NETWORK@PAV_CONHIST_ASSET
--       WHERE YEAR          = COND_YEAR
--       AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
--       AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
```

```
--       )
--     )
--    WHERE SEC_ATTRIBUTE = 'CURVE_750'
--    ),
CURVE AS
(SELECT BMP DIR_BMP,
  EMP DIR_EMP,
  SEC_ATTRIBUTE
FROM
  (SELECT DIR_BMP BMP,
    DIR_EMP EMP,
    DIR_EMP-DIR_BMP SEC_LENGTH,
    CASE
      --          WHEN RADIUS <=250*3.28 --CHANGED ON 12/16/2020 BASED ON THE EMAIL FROM
BX
      WHEN RADIUS <=250*3 --CHANGED ON 09/17/2021 BASED ON THE EMAIL FROM PD
      AND RADIUS   > 0
      THEN 'CURVE_750'
      WHEN RADIUS <=250 *6 --CHANGED ON 10/07/2021 BASED ON THE EMAIL FROM KM
      AND RADIUS   > 250*3
      THEN 'CURVE_1500'
      ELSE 'CURVE_NOT750'
    END SEC_ATTRIBUTE
  FROM CURVE_H_SHA_NETWORK@PAV_CONHIST_ASSET
  WHERE YEAR          = COND_YEAR
  AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
  AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
  )
  --WHERE SEC_ATTRIBUTE = 'CURVE_750'
WHERE SEC_ATTRIBUTE <> 'CURVE_NOT750'--CHANGED ON 10/07/2021 BASED ON THE EMAIL
FROM KM
),
-- INTERSECTIONS
INTERSECTIONS AS
(SELECT
  CASE
    WHEN ID_MP-.1>=0
    THEN ID_MP-.1
    ELSE 0
  END BMP,
  ID_MP EMP,
  MP_INT_RTE_NAME SEC_ATTRIBUTE
FROM HMIS_MASTER_ALL_YEARS
WHERE YEAR             = INV_YEAR
AND ROUTEID            = ROUTE_LIST.HMIS_ROUTEID
AND MP_LOCATION_TYPE <> 2
AND (MP_INT_TYPE       > 0
AND MP_INT_TYPE        < 100
AND MP_INT_TYPE NOT  IN (7,10,14))
),
-- DOWN HILL GRADE CRITERIA
--    DH_GRADE AS
--    (SELECT
--      CASE
--        WHEN ADJ_BMP<ROUTE_LIST.DIR_BMP
--        THEN ROUTE_LIST.DIR_BMP
--        ELSE ADJ_BMP
--      END BMP,
--      CASE
--        WHEN ADJ_EMP>ROUTE_LIST.DIR_EMP
--        THEN ROUTE_LIST.DIR_EMP
```

```
--       ELSE ADJ_EMP
--     END EMP,
--     SEC_ATTRIBUTE
--   FROM
--     (SELECT BMP ORG_BMP,
--       EMP ORG_EMP,
--       SEC_LENGTH,
--       CASE
--         WHEN SEC_LENGTH<.1
--         THEN ROUND(BMP-((.1-SEC_LENGTH)/2),3)
--         ELSE BMP
--       END ADJ_BMP,
--       CASE
--         WHEN SEC_LENGTH<.1
--         THEN ROUND(EMP+((.1-SEC_LENGTH)/2),3)
--         ELSE EMP
--       END ADJ_EMP,
--       SEC_ATTRIBUTE
--     FROM
--       (SELECT BMP,
--         EMP,
--         EMP-BMP SEC_LENGTH,
--         SEC_ATTRIBUTE
--       FROM
--         (SELECT MIN(DIR_BMP) BMP,
--           MAX(DIR_EMP) EMP,
--           SEC_ATTRIBUTE,
--           SEC_RN
--         FROM
--           (SELECT DIR_BMP,
--             DIR_EMP,
--             SEC_ATTRIBUTE,
--             RN_,
--             ROW_NUMBER() OVER(ORDER BY RN_) -ROW_NUMBER() OVER(PARTITION BY
SEC_ATTRIBUTE ORDER BY RN_) AS SEC_RN
--           FROM
--             (SELECT TT.*,
--               ROWNUM RN_ -- THIS SUBQUERY SORTS THE INCOMING ATTRIBUTE AND SUPPLIES
THE RN FIELD.
--             FROM
--               ( SELECT DISTINCT DIR_BMP,
--                 DIR_EMP,
--                 CASE
--                   WHEN GRADE>-5
--                   THEN 'NO_DH_GRADE'
--                   WHEN GRADE >= -6
--                   AND GRADE  <= -5
--                   THEN 'DH_GRADE_5_TO_10'
--                   WHEN GRADE < -6
--                   THEN 'DH_GRADE_10'
--                 END SEC_ATTRIBUTE
--               FROM FINAL_CONDITION_DETAIL_SKID
--               WHERE COLLECT_YEAR  = COND_YEAR
--               AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
--               AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
--               ORDER BY 1
--               ) TT
--             )
--           )
--         GROUP BY SEC_ATTRIBUTE,
--           SEC_RN
```

```
--        )
--      WHERE SEC_ATTRIBUTE IN ('DH_GRADE_10','DH_GRADE_5_TO_10')
--        -- AND EMP         -BMP    >=.1
--      )
--    )
--   ),
DH_GRADE AS
(SELECT *
FROM DH_GRADE_SKID
WHERE SEC_LENGTH   >=.03
AND COLLECT_YEAR    = COND_YEAR
AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
),
-- ON AND OFF RAMP
RAMP AS
(SELECT
  CASE
    WHEN ID_MP-.1>=0
    THEN ID_MP-.1
    ELSE 0
  END BMP,
  ID_MP EMP,
  'RAMP' SEC_ATTRIBUTE
FROM HMIS_MASTER_ALL_YEARS
WHERE YEAR          = INV_YEAR
AND ROUTEID         = ROUTE_LIST.HMIS_ROUTEID
AND MP_LOCATION_TYPE = 2
AND ID_PREFIX       <>'RP'
AND (MP_INT_RTE_NAME LIKE '%TO '
  ||ID_PREFIX
  ||' '
  ||ID_RTE_NO
  ||TRIM(MP_SUFFIX)
  ||' '
  ||MP_DIRECTION
  ||'%'
OR MP_INT_RTE_NAME LIKE '%FR '
  ||ID_PREFIX
  ||' '
  ||ID_RTE_NO
  ||TRIM(MP_SUFFIX)
  ||' '
  ||MP_DIRECTION
  ||'%')
UNION
SELECT
  CASE
    WHEN ID_MP-.1>=0
    THEN ID_MP-.1
    ELSE 0
  END BMP,
  ID_MP EMP,
  'RAMP' SEC_ATTRIBUTE
FROM HMIS_MASTER_ALL_YEARS
WHERE YEAR          = INV_YEAR
AND ROUTEID         = ROUTE_LIST.HMIS_ROUTEID
AND MP_LOCATION_TYPE = 2
AND ID_PREFIX       <>'RP'
AND (MP_INT_RTE_NAME LIKE '%TO '
  ||ID_PREFIX
```

```
  ||' '
  ||ID_RTE_NO
  ||TRIM(MP_SUFFIX)
  ||' '
  ||
  CASE
    WHEN MP_DIRECTION ='E'
    THEN 'N'
    WHEN MP_DIRECTION ='W'
    THEN 'S'
    WHEN MP_DIRECTION ='N'
    THEN 'E'
    WHEN MP_DIRECTION ='S'
    THEN 'W'
  END
  ||'%'
OR MP_INT_RTE_NAME LIKE '%FR '
  ||ID_PREFIX
  ||' '
  ||ID_RTE_NO
  ||TRIM(MP_SUFFIX)
  ||' '
  ||
  CASE
    WHEN MP_DIRECTION ='E'
    THEN 'N'
    WHEN MP_DIRECTION ='W'
    THEN 'S'
    WHEN MP_DIRECTION ='N'
    THEN 'E'
    WHEN MP_DIRECTION ='S'
    THEN 'W'
  END
  ||'%')
UNION
SELECT
  CASE
    WHEN ID_MP-.1>=0
    THEN ID_MP-.1
    ELSE 0
  END BMP,
  ID_MP EMP,
  'RAMP' SEC_ATTRIBUTE
FROM HMIS_MASTER_ALL_YEARS
WHERE YEAR          = INV_YEAR
AND ROUTEID         = ROUTE_LIST.HMIS_ROUTEID
AND MP_LOCATION_TYPE = 2
AND ID_PREFIX       ='RP'
AND (MP_INT_RTE_NAME LIKE '% '
  || TRIM(SUBSTR(ROAD_NAME,1,7))
  || '%')
ORDER BY BMP
),
--TRAFFIC LIGHTS, STOP SIGN, ROUNDABOUT, RAIL ROAD CROSSINGS
SITE_CAT_1 AS
(SELECT
  CASE
    WHEN ID_MP-.1>=0
    THEN ID_MP-.1
    ELSE 0
  END BMP,
```

```
    ID_MP EMP,
    -- MP_INT_RTE_NAME,
    --MP_INT_TYPE,
    CASE
      WHEN MP_INT_RTE_NAME LIKE '%TRAFFIC SIGNAL%'
      THEN 'TRAFFIC_SIGNAL'
      WHEN MP_INT_RTE_NAME LIKE '%STOP SIGN%'
      THEN 'STOP_SIGN'
      WHEN (MP_INT_RTE_NAME LIKE '%ROUNDABOUT%'
      AND MP_INT_RTE_NAME NOT LIKE '%END ROUNDABOUT%')
      THEN 'ROUND_ABOUT'
      WHEN MP_INT_RTE_NAME LIKE '%SPUR TO%'
      THEN 'GIVE_WAY'
      WHEN MP_INT_RTE_NAME LIKE '%RAILROAD CROSSING%'
      THEN 'RAIL_ROAD'
        --WHEN (MP_INT_TYPE > 0 AND MP_INT_TYPE < 100 AND MP_INT_TYPE NOT IN (7,10,14))
THEN 'INERSECTION'
    END SEC_ATTRIBUTE
   FROM HMIS_MASTER_ALL_YEARS
   WHERE YEAR  = INV_YEAR
   AND ROUTEID = ROUTE_LIST.HMIS_ROUTEID
   AND (MP_INT_RTE_NAME LIKE '%TRAFFIC SIGNAL%'
   OR MP_INT_RTE_NAME LIKE '%STOP SIGN%'
   OR (MP_INT_RTE_NAME LIKE '%ROUNDABOUT%'
   AND MP_INT_RTE_NAME NOT LIKE '%END ROUNDABOUT%')
   OR MP_INT_RTE_NAME LIKE '%SPUR TO%'
   OR MP_INT_RTE_NAME LIKE '%RAILROADC ROSSING%'
    -- OR (MP_INT_TYPE > 0 AND MP_INT_TYPE < 100 AND MP_INT_TYPE NOT IN (7,10,14))
    )
   UNION
   --PEDESTRIAN CROSSING
   SELECT
    CASE
      WHEN DIR_EMP-.1>=0
      THEN DIR_EMP-.1
      ELSE 0
    END BMP,
    DIR_EMP EMP, --NULL,
    'PEDESTRIAN_CROSSING' PEDESTRIAN_CROSSING
   FROM EDW18_BASE_4@PAV_CONHIST_ASSET
   WHERE GLOBAL_ROUTE_ID      = ROUTE_LIST.GLOBAL_ROUTE_ID
   AND SUB_ROUTE_ID           = ROUTE_LIST.SUB_ROUTE_ID
   AND STATUS                 = 'MATCHED'
   AND EVENT_CROSSWALK_OFFICE = 1
   ),
   FINAL_SEG AS
   ( SELECT BMP FROM SPEED_LIMIT
   UNION
   SELECT EMP FROM SPEED_LIMIT
   UNION
   SELECT BMP FROM DIVIDED
   UNION
   SELECT EMP FROM DIVIDED
   UNION
   SELECT BMP FROM RUT
   UNION
   SELECT EMP FROM RUT
   UNION
   SELECT BMP FROM INTERSECTIONS
   UNION
   SELECT EMP FROM INTERSECTIONS
```

```
  UNION
  SELECT DIR_BMP FROM CURVE
  UNION
  SELECT DIR_EMP FROM CURVE
  UNION
  SELECT DIR_BMP FROM DH_GRADE
  UNION
  SELECT DIR_EMP FROM DH_GRADE
  UNION
  SELECT BMP FROM RAMP
  UNION
  SELECT EMP FROM RAMP
  UNION
  SELECT BMP FROM SITE_CAT_1
  UNION
  SELECT EMP FROM SITE_CAT_1 ORDER BY 1
  )
 SELECT COND_YEAR,
  ROUTE_LIST.GOVT_CONTROL,
  ROUTE_LIST.HMIS_ROUTEID,
  ROUTE_LIST.GLOBAL_ROUTE_ID,
  ROUTE_LIST.SUB_ROUTE_ID,
  BMP,
  EMP
 FROM
  ( SELECT BMP, LEAD (BMP) OVER ( ORDER BY BMP) EMP FROM FINAL_SEG
  )
 WHERE EMP IS NOT NULL
 AND BMP   >=0
 AND BMP   <> EMP
 AND BMP   >=ROUTE_LIST.DIR_BMP
 AND EMP   <=ROUTE_LIST.DIR_EMP
 ORDER BY BMP;
 UPDATE FMG_BASE_SEGMENTS
 SET INV_BMP        = BMP,
  INV_EMP          = EMP
 WHERE SUB_ROUTE_ID  =1
 AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID;
 MERGE INTO FMG_BASE_SEGMENTS A USING
 (SELECT F.ROWID ROW_ID,
  G.REVERSE_MILEPOINT INV_BMP
 FROM FMG_BASE_SEGMENTS F,
  GLOBAL_SEGMENT_PAV G
 WHERE F.GLOBAL_ROUTE_ID= G.GLOBAL_ROUTE_ID
 AND F.SUB_ROUTE_ID     = G.SUB_ROUTE_ID
 AND F.EMP              = G.BEGINNING_MILEPOINT
 AND F.SUB_ROUTE_ID     =2
 AND G.GLOBAL_ROUTE_ID  = ROUTE_LIST.GLOBAL_ROUTE_ID
 AND G.RETIRE_DATE     IS NULL
 ) B ON ( A.ROWID       = B.ROW_ID)
WHEN MATCHED THEN
 UPDATE
 SET A.INV_BMP = B.INV_BMP;
 MERGE INTO FMG_BASE_SEGMENTS A USING
 (SELECT F.ROWID ROW_ID,
  G.REVERSE_MILEPOINT INV_EMP
 FROM FMG_BASE_SEGMENTS F,
  GLOBAL_SEGMENT_PAV G
 WHERE F.GLOBAL_ROUTE_ID= G.GLOBAL_ROUTE_ID
 AND F.SUB_ROUTE_ID     = G.SUB_ROUTE_ID
 AND F.BMP              = G.BEGINNING_MILEPOINT
```

```
  AND F.SUB_ROUTE_ID     =2
  AND G.GLOBAL_ROUTE_ID  = ROUTE_LIST.GLOBAL_ROUTE_ID
  AND G.RETIRE_DATE      IS NULL
  ) B ON ( A.ROWID       = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE
  SET A.INV_EMP = B.INV_EMP;
  -- DIVIDED UPDATE
  MERGE INTO FMG_BASE_SEGMENTS A USING
  ( SELECT DISTINCT F.ROWID ROW_ID,
    F.BMP,
    F.EMP,-- H.MEDIAN_TY,
    CASE
      WHEN MEDIAN_TY IN (4,5)
      THEN 'UNDIVIDED'
      ELSE 'DIVIDED'
    END SEC_ATTRIBUTE
  FROM HMIS_UNIVERSE_ALL_YEARS H ,
    FMG_BASE_SEGMENTS F
  WHERE H.YEAR       = INV_YEAR
  AND F.COLLECT_YEAR = COND_YEAR
    --   AND H.ROUTEID      = ROUTE_LIST.HMIS_ROUTEID
  AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
  AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
  AND F.BMP          >= ROUTE_LIST.DIR_BMP
  AND F.EMP          <= ROUTE_LIST.DIR_EMP
  AND F.HMIS_ROUTEID   = H.ROUTEID
  AND ( (ID_MP       >= F.BMP
  AND ID_MP          <F.EMP)
  OR (F.BMP          >= ID_MP
  AND F.EMP          <= ID_MP+SECTION_LENGTH) )
  ) B ON (A.ROWID      = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE
  SET A.DIVIDED = B.SEC_ATTRIBUTE;
  -- SPEED LIMIT UPDATE
  MERGE INTO FMG_BASE_SEGMENTS A USING
  ( SELECT DISTINCT F.ROWID ROW_ID,
    F.BMP,
    F.EMP,-- H.MEDIAN_TY,
    CASE
      WHEN H.SPEED_LIMIT>=55-- CHANGED ON 9/17/2021 BASED ON EMAIL FROM PD
      THEN 'ABOVE_55'
      WHEN H.SPEED_LIMIT>=35
      AND H.SPEED_LIMIT  <55
      THEN 'BELOW_55'
      ELSE 'BELOW_35'
    END SEC_ATTRIBUTE
  FROM HMIS_UNIVERSE_ALL_YEARS H ,
    FMG_BASE_SEGMENTS F
  WHERE H.YEAR       = INV_YEAR
  AND F.COLLECT_YEAR = COND_YEAR
    --   AND H.ROUTEID      = ROUTE_LIST.HMIS_ROUTEID
  AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
  AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
  AND F.BMP          >= ROUTE_LIST.DIR_BMP
  AND F.EMP          <= ROUTE_LIST.DIR_EMP
  AND F.HMIS_ROUTEID   = H.ROUTEID
  AND ( (ID_MP       >= F.BMP
  AND ID_MP          <F.EMP)
  OR (F.BMP          >= ID_MP
```

```
  AND F.EMP          <= ID_MP+SECTION_LENGTH) )
  ) B ON (A.ROWID      = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE
  SET A.SPEED_LIMIT = B.SEC_ATTRIBUTE;
  -- RUT
  MERGE INTO FMG_BASE_SEGMENTS A USING
  (SELECT
    /*+ INDEX(H FINAL_COND_NEW_LOCATOR_IDX2) */
    DISTINCT F.ROWID ROW_ID,
    F.BMP,
    F.EMP,-- H.MEDIAN_TY,
    --H.DIR_BMP, H.DIR_EMP,
    'HIGH_RUT' SEC_ATTRIBUTE
  FROM FINAL_CONDITION_DETAIL_SKID H ,
    FMG_BASE_SEGMENTS F
  WHERE H.COLLECT_YEAR = COND_YEAR
  AND F.COLLECT_YEAR   = H.COLLECT_YEAR
    --    AND H.ROUTEID      = ROUTE_LIST.HMIS_ROUTEID
  AND F.GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
  AND F.SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
  AND F.BMP           >= ROUTE_LIST.DIR_BMP
  AND F.EMP           <= ROUTE_LIST.DIR_EMP
  AND F.GLOBAL_ROUTE_ID = H.GLOBAL_ROUTE_ID
  AND F.SUB_ROUTE_ID    = H.SUB_ROUTE_ID
  AND (L_RUT+R_RUT)/2   >0.25
    --    AND ( (H.DIR_BMP     >=F.BMP
    --    AND H.DIR_EMP       <=F.EMP)
    --    OR (H.DIR_BMP       <F.BMP
    --    AND H.DIR_EMP        >F.EMP)
    --    OR (H.DIR_BMP       <=F.BMP
    --    AND H.DIR_EMP        >F.BMP) )
  AND (H.DIR_BMP <=F.BMP
  AND H.DIR_EMP  >=F.EMP)
    -- ORDER BY 2
  ) B ON (A.ROWID = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE
  SET A.RUT = B.SEC_ATTRIBUTE;
  -- CURVE
  MERGE INTO FMG_BASE_SEGMENTS A USING
  (SELECT *
  FROM
    (SELECT DISTINCT F.ROWID ROW_ID,
      F.BMP,
      F.EMP,
      SEC_ATTRIBUTE
    FROM FMG_BASE_SEGMENTS F,
      (SELECT *
      FROM
        (SELECT DIR_BMP ,
          DIR_EMP ,
          DIR_EMP-DIR_BMP SEC_LENGTH,
          CASE
              -- WHEN RADIUS <=250*3.28 --CHANGED ON 12/16/2020 BASED ON THE EMAIL FROM BX
            WHEN RADIUS <=250*3 --CHANGED ON 09/17/2021 BASED ON THE EMAIL FROM PD
            AND RADIUS    > 0
            THEN 'CURVE_750'
            WHEN RADIUS <=250 *6 --CHANGED ON 10/07/2021 BASED ON THE EMAIL FROM KM
            AND RADIUS    > 250*3
            THEN 'CURVE_1500'
```

```
          ELSE 'CURVE_NOT750'
         END SEC_ATTRIBUTE
        FROM CURVE_H_SHA_NETWORK@PAV_CONHIST_ASSET
        WHERE YEAR          = COND_YEAR
        AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
        AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
        )
        --WHERE SEC_ATTRIBUTE = 'CURVE_750'
       WHERE SEC_ATTRIBUTE <> 'CURVE_NOT750'--CHANGED ON 10/07/2021 BASED ON THE
EMAIL FROM KM
       ) H
      WHERE F.COLLECT_YEAR  = COND_YEAR
      AND F.BMP            >= ROUTE_LIST.DIR_BMP
      AND F.EMP            <= ROUTE_LIST.DIR_EMP
      AND F.GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
      AND F.SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
       --     AND ( (H.DIR_BMP     >=F.BMP
       --     AND H.DIR_EMP        <=F.EMP)
       --     OR (H.DIR_BMP        <F.BMP
       --     AND H.DIR_EMP         >F.EMP)
       --     OR (H.DIR_BMP        <=F.BMP
       --     AND H.DIR_EMP         >F.BMP) )
      AND (H.DIR_BMP <=F.BMP
      AND H.DIR_EMP  >=F.EMP)
      ORDER BY 2
      )
      --WHERE SEC_ATTRIBUTE = 'CURVE_750'
    WHERE SEC_ATTRIBUTE <> 'CURVE_NOT750'--CHANGED ON 10/07/2021 BASED ON THE EMAIL
FROM KM
    ) B ON (A.ROWID      = B.ROW_ID)
  WHEN MATCHED THEN
    UPDATE
    SET A.CURVE = B.SEC_ATTRIBUTE;
    -- INTERSECTIONS
    MERGE INTO FMG_BASE_SEGMENTS A USING
    (SELECT *
    FROM
      (SELECT DISTINCT F.ROWID ROW_ID,
        F.BMP,
        F.EMP,
        H.ID_MP,
        MP_INT_RTE_NAME SEC_ATTRIBUTE,
        ROW_NUMBER() OVER ( PARTITION BY F.ROWID ORDER BY ID_MP,MP_INT_RTE_NAME) RN
      FROM HMIS_MASTER_ALL_YEARS H ,
        FMG_BASE_SEGMENTS F
      WHERE H.YEAR       = INV_YEAR
      AND F.COLLECT_YEAR = COND_YEAR
        --   AND H.ROUTEID       = ROUTE_LIST.HMIS_ROUTEID
      AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
      AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
      AND F.BMP           >= ROUTE_LIST.DIR_BMP
      AND F.EMP           <= ROUTE_LIST.DIR_EMP
      AND F.HMIS_ROUTEID   = H.ROUTEID
      AND (F.BMP          >= ID_MP -.1
      AND F.EMP           <= ID_MP)
      AND (MP_INT_TYPE     > 0
      AND MP_INT_TYPE      < 100
      AND MP_INT_TYPE NOT IN (7,10,14))
      )
    WHERE RN        =1
    ) B ON (A.ROWID = B.ROW_ID)
```

```
WHEN MATCHED THEN
 UPDATE
 SET A.INTERSECTIONS = B.SEC_ATTRIBUTE;
 -- DOWNHILL_GRAD
 --DH_GRADE_5_TO_10
 MERGE INTO FMG_BASE_SEGMENTS A USING
 ( SELECT DISTINCT F.ROWID ROW_ID,
   H.SEC_ATTRIBUTE
 FROM FMG_BASE_SEGMENTS F,
   (SELECT *
   FROM DH_GRADE_SKID
   WHERE SEC_LENGTH  >=.03
   AND SEC_ATTRIBUTE IN ('DH_GRADE_5_TO_10')
   )H
 WHERE F.COLLECT_YEAR = COND_YEAR
   --    AND H.ROUTEID       = ROUTE_LIST.HMIS_ROUTEID
 AND F.GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
 AND F.SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
 AND F.BMP            >= ROUTE_LIST.DIR_BMP
 AND F.EMP            <= ROUTE_LIST.DIR_EMP
 AND F.GLOBAL_ROUTE_ID = H.GLOBAL_ROUTE_ID
 AND F.SUB_ROUTE_ID    = H.SUB_ROUTE_ID
 AND F.COLLECT_YEAR    = H.COLLECT_YEAR
 AND ( (H.DIR_BMP     >=F.BMP
 AND H.DIR_EMP        <=F.EMP)
 OR (H.DIR_BMP        <F.BMP
 AND H.DIR_EMP         >F.EMP)
 OR (H.DIR_BMP       <=F.BMP
 AND H.DIR_EMP         >F.BMP) )
 )B ON (A.ROWID       = B.ROW_ID)
WHEN MATCHED THEN
 UPDATE
 SET A.DOWNHILL_GRADE = B.SEC_ATTRIBUTE;
 --DH_GRADE_10
 MERGE INTO FMG_BASE_SEGMENTS A USING
 ( SELECT DISTINCT F.ROWID ROW_ID,
   H.SEC_ATTRIBUTE
 FROM FMG_BASE_SEGMENTS F,
   (SELECT *
   FROM DH_GRADE_SKID
   WHERE SEC_LENGTH>=.03
   AND SEC_ATTRIBUTE= ('DH_GRADE_10')
   )H
 WHERE F.COLLECT_YEAR = COND_YEAR
   --    AND H.ROUTEID       = ROUTE_LIST.HMIS_ROUTEID
 AND F.GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
 AND F.SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
 AND F.BMP            >= ROUTE_LIST.DIR_BMP
 AND F.EMP            <= ROUTE_LIST.DIR_EMP
 AND F.GLOBAL_ROUTE_ID = H.GLOBAL_ROUTE_ID
 AND F.SUB_ROUTE_ID    = H.SUB_ROUTE_ID
 AND F.COLLECT_YEAR    = H.COLLECT_YEAR
 AND ( (H.DIR_BMP     >=F.BMP
 AND H.DIR_EMP        <=F.EMP)
 OR (H.DIR_BMP        <F.BMP
 AND H.DIR_EMP         >F.EMP)
 OR (H.DIR_BMP       <=F.BMP
 AND H.DIR_EMP         >F.BMP) )
 )B ON (A.ROWID       = B.ROW_ID)
WHEN MATCHED THEN
 UPDATE
```

```
  SET A.DOWNHILL_GRADE = B.SEC_ATTRIBUTE;
  -- RAMP
  -- ROUTE IS NOT A RAMP - DIRECTION CHANGE
  MERGE INTO FMG_BASE_SEGMENTS A USING
  (SELECT *
  FROM
    (SELECT DISTINCT F.ROWID ROW_ID,
      F.BMP,
      F.EMP,
      H.ID_MP,
      MP_INT_RTE_NAME SEC_ATTRIBUTE,
      ROW_NUMBER() OVER ( PARTITION BY F.ROWID ORDER BY ID_MP,MP_INT_RTE_NAME) RN
    FROM HMIS_MASTER_ALL_YEARS H ,
      FMG_BASE_SEGMENTS F
    WHERE H.YEAR        = INV_YEAR
    AND F.COLLECT_YEAR = COND_YEAR
      --    AND H.ROUTEID       = ROUTE_LIST.HMIS_ROUTEID
    AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
    AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
    AND F.BMP           >= ROUTE_LIST.DIR_BMP
    AND F.EMP           <= ROUTE_LIST.DIR_EMP
    AND F.HMIS_ROUTEID   = H.ROUTEID
    AND (F.BMP          >= ID_MP -.1
    AND F.EMP           <= ID_MP)
    AND MP_LOCATION_TYPE = 2
    AND ID_PREFIX       <>'RP'
    AND (MP_INT_RTE_NAME LIKE '%TO '
      ||ID_PREFIX
      ||' '
      ||ID_RTE_NO
      ||TRIM(MP_SUFFIX)
      ||' '
      ||MP_DIRECTION
      ||'%'
    OR MP_INT_RTE_NAME LIKE '%FR '
      ||ID_PREFIX
      ||' '
      ||ID_RTE_NO
      ||TRIM(MP_SUFFIX)
      ||' '
      ||MP_DIRECTION
      ||'%')
    )
  WHERE RN        =1
  ) B ON (A.ROWID = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE
  SET A.RAMP = B.SEC_ATTRIBUTE;
  -- ROUTE IS NOT A RAMP - DIRECTION CHANGE
  MERGE INTO FMG_BASE_SEGMENTS A USING
  (SELECT *
  FROM
    (SELECT DISTINCT F.ROWID ROW_ID,
      F.BMP,
      F.EMP,
      H.ID_MP,
      MP_INT_RTE_NAME SEC_ATTRIBUTE,
      ROW_NUMBER() OVER ( PARTITION BY F.ROWID ORDER BY ID_MP,MP_INT_RTE_NAME) RN
    FROM HMIS_MASTER_ALL_YEARS H ,
      FMG_BASE_SEGMENTS F
    WHERE H.YEAR        = INV_YEAR
```

```
   AND F.COLLECT_YEAR = COND_YEAR
     --    AND H.ROUTEID       = ROUTE_LIST.HMIS_ROUTEID
   AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
   AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
   AND F.BMP          >= ROUTE_LIST.DIR_BMP
   AND F.EMP          <= ROUTE_LIST.DIR_EMP
   AND F.HMIS_ROUTEID   = H.ROUTEID
   AND (F.BMP         >= ID_MP -.1
   AND F.EMP          <= ID_MP)
   AND MP_LOCATION_TYPE = 2
   AND ID_PREFIX       <>'RP'
   AND (MP_INT_RTE_NAME LIKE '%TO '
     ||ID_PREFIX
     ||' '
     ||ID_RTE_NO
     ||TRIM(MP_SUFFIX)
     ||' '
     ||
     CASE
       WHEN MP_DIRECTION ='E'
       THEN 'N'
       WHEN MP_DIRECTION ='W'
       THEN 'S'
       WHEN MP_DIRECTION ='N'
       THEN 'E'
       WHEN MP_DIRECTION ='S'
       THEN 'W'
     END
     ||'%'
   OR MP_INT_RTE_NAME LIKE '%FR '
     ||ID_PREFIX
     ||' '
     ||ID_RTE_NO
     ||TRIM(MP_SUFFIX)
     ||' '
     ||
     CASE
       WHEN MP_DIRECTION ='E'
       THEN 'N'
       WHEN MP_DIRECTION ='W'
       THEN 'S'
       WHEN MP_DIRECTION ='N'
       THEN 'E'
       WHEN MP_DIRECTION ='S'
       THEN 'W'
     END
     ||'%')
   )
  WHERE RN        =1
  ) B ON (A.ROWID = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE
  SET A.RAMP = B.SEC_ATTRIBUTE;
  -- ROUTE IS A RAMP
  MERGE INTO FMG_BASE_SEGMENTS A USING
  (SELECT *
  FROM
   (SELECT DISTINCT F.ROWID ROW_ID,
     F.BMP,
     F.EMP,
     H.ID_MP,
```

```
    MP_INT_RTE_NAME SEC_ATTRIBUTE,
    ROW_NUMBER() OVER ( PARTITION BY F.ROWID ORDER BY ID_MP,MP_INT_RTE_NAME) RN
   FROM HMIS_MASTER_ALL_YEARS H ,
    FMG_BASE_SEGMENTS F
   WHERE H.YEAR       = INV_YEAR
   AND F.COLLECT_YEAR = COND_YEAR
    --   AND H.ROUTEID       = ROUTE_LIST.HMIS_ROUTEID
   AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
   AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
   AND F.BMP          >= ROUTE_LIST.DIR_BMP
   AND F.EMP          <= ROUTE_LIST.DIR_EMP
   AND F.HMIS_ROUTEID   = H.ROUTEID
   AND (F.BMP         >= ID_MP -.1
   AND F.EMP          <= ID_MP)
   AND MP_LOCATION_TYPE = 2
   AND ID_PREFIX       ='RP'
   AND (MP_INT_RTE_NAME LIKE '% '
    || TRIM(SUBSTR(ROAD_NAME,1,7))
    || '%')
   )
  WHERE RN       =1
  ) B ON (A.ROWID = B.ROW_ID)
 WHEN MATCHED THEN
  UPDATE
  SET A.RAMP = B.SEC_ATTRIBUTE;
  -- CAT ONE FEATURES
  MERGE INTO FMG_BASE_SEGMENTS A USING
  (SELECT *
  FROM
   (SELECT DISTINCT F.ROWID ROW_ID,
    F.BMP,
    F.EMP,
    H.ID_MP,
    CASE
     WHEN MP_INT_RTE_NAME LIKE '%TRAFFIC SIGNAL%'
     THEN 'TRAFFIC_SIGNAL'
     WHEN MP_INT_RTE_NAME LIKE '%STOP SIGN%'
     THEN 'STOP_SIGN'
     WHEN (MP_INT_RTE_NAME LIKE '%ROUNDABOUT%'
     AND MP_INT_RTE_NAME NOT LIKE '%END ROUNDABOUT%')
     THEN 'ROUND_ABOUT'
     WHEN MP_INT_RTE_NAME LIKE '%SPUR TO%'
     THEN 'GIVE_WAY'
     WHEN MP_INT_RTE_NAME LIKE '%RAILROAD CROSSING%'
     THEN 'RAIL_ROAD'
    END SEC_ATTRIBUTE,
    ROW_NUMBER() OVER ( PARTITION BY F.ROWID ORDER BY ID_MP,MP_INT_RTE_NAME) RN
   FROM HMIS_MASTER_ALL_YEARS H ,
    FMG_BASE_SEGMENTS F
   WHERE H.YEAR       = INV_YEAR
   AND F.COLLECT_YEAR = COND_YEAR
    --   AND H.ROUTEID       = ROUTE_LIST.HMIS_ROUTEID
   AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
   AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
   AND F.BMP          >= ROUTE_LIST.DIR_BMP
   AND F.EMP          <= ROUTE_LIST.DIR_EMP
   AND F.HMIS_ROUTEID   = H.ROUTEID
   AND (F.BMP         >= ID_MP -.1
   AND F.EMP          <= ID_MP)
   AND (MP_INT_RTE_NAME LIKE '%TRAFFIC SIGNAL%'
   OR MP_INT_RTE_NAME LIKE '%STOP SIGN%'
```

```
    OR (MP_INT_RTE_NAME LIKE '%ROUNDABOUT%'
    AND MP_INT_RTE_NAME NOT LIKE '%END ROUNDABOUT%')
    OR MP_INT_RTE_NAME LIKE '%SPUR TO%'
    OR MP_INT_RTE_NAME LIKE '%RAILROADC ROSSING%' )
    )
   WHERE RN       =1
   ) B ON (A.ROWID = B.ROW_ID)
  WHEN MATCHED THEN
   UPDATE
   SET A.CAT_ONE_FEATURES = B.SEC_ATTRIBUTE;
   -- PEDESTRIAN CROSSING
   MERGE INTO FMG_BASE_SEGMENTS A USING
   ( SELECT DISTINCT F.ROWID ROW_ID,
    F.BMP,
    F.EMP,-- H.MEDIAN_TY,
    --H.DIR_BMP, H.DIR_EMP,
    'PEDESTRIAN_CROSSING' SEC_ATTRIBUTE
   FROM EDW18_BASE_4@PAV_CONHIST_ASSET H ,
    FMG_BASE_SEGMENTS F
   WHERE F.COLLECT_YEAR = COND_YEAR
    --         AND H.ROUTEID      = ROUTE_LIST.HMIS_ROUTEID
   AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
   AND F.SUB_ROUTE_ID  = ROUTE_LIST.SUB_ROUTE_ID
    -- AND  F.HMIS_ROUTEID     = '13000US00001  01NN**************'
   AND F.BMP              >= ROUTE_LIST.DIR_BMP
   AND F.EMP              <= ROUTE_LIST.DIR_EMP
   AND F.GLOBAL_ROUTE_ID      = H.GLOBAL_ROUTE_ID
   AND F.SUB_ROUTE_ID        = H.SUB_ROUTE_ID
   AND STATUS               = 'MATCHED'
   AND EVENT_CROSSWALK_OFFICE = 1
   AND ( (H.DIR_EMP-.1       >=F.BMP
   AND H.DIR_EMP            <=F.EMP)
   OR (H.DIR_EMP-.1          <F.BMP
   AND H.DIR_EMP             >F.EMP)
   OR (H.DIR_EMP-.1          <=F.BMP
   AND H.DIR_EMP             >F.BMP) )
    --ORDER BY 2
   ) B ON (A.ROWID = B.ROW_ID)
  WHEN MATCHED THEN
   UPDATE SET A.CAT_ONE_FEATURES = B.SEC_ATTRIBUTE;
   -- SITE CATEGORY UPDATE
   --  UPDATE FMG_BASE_SEGMENTS
   --  SET SITE_CATEGORY       = 1
   --  WHERE (CAT_ONE_FEATURES IS NOT NULL-- CHANGED ON 9/17/2021 BASED ON EMAIL
FROM PD
   --  AND SPEED_LIMIT        ='ABOVE_55')
   --  AND SITE_CATEGORY       IS NULL
   --  AND GLOBAL_ROUTE_ID      = ROUTE_LIST.GLOBAL_ROUTE_ID
   --  AND SUB_ROUTE_ID        = ROUTE_LIST.SUB_ROUTE_ID;
   --  UPDATE FMG_BASE_SEGMENTS
   --  SET SITE_CATEGORY   = 2
   --  WHERE (CURVE       IS NOT NULL
   --  OR DOWNHILL_GRADE   ='DH_GRADE_10'
   --  OR RAMP           IS NOT NULL)
   --  AND SITE_CATEGORY  IS NULL
   --  AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
   --  AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID;
   --  UPDATE FMG_BASE_SEGMENTS
   --  SET SITE_CATEGORY         = 3
   --  WHERE ( (CAT_ONE_FEATURES IS NOT NULL
   --  AND SPEED_LIMIT          ='BELOW_55')-- CHANGED ON 9/17/2021 BASED ON EMAIL FROM PD
```

```
  -- OR ((INTERSECTIONS        IS NOT NULL
  -- OR DOWNHILL_GRADE          ='DH_GRADE_5_TO_10')
  -- AND SPEED_LIMIT          IN ('ABOVE_55','BELOW_55') )
  -- OR (DIVIDED              ='UNDIVIDED'
  -- AND SPEED_LIMIT           ='ABOVE_55'
  -- AND RUT                  ='HIGH_RUT') )
  -- AND SITE_CATEGORY         IS NULL
  -- AND GLOBAL_ROUTE_ID        = ROUTE_LIST.GLOBAL_ROUTE_ID
  -- AND SUB_ROUTE_ID          = ROUTE_LIST.SUB_ROUTE_ID;
  -- UPDATE FMG_BASE_SEGMENTS
  -- SET SITE_CATEGORY          = 4
  -- WHERE ( (CAT_ONE_FEATURES IS NOT NULL
  -- AND SPEED_LIMIT           ='BELOW_35')-- CHANGED ON 9/17/2021 BASED ON EMAIL FROM PD
  -- OR ( DIVIDED              ='UNDIVIDED'
  -- AND (SPEED_LIMIT          IN ('BELOW_55','BELOW_35')-- CHANGED ON 9/17/2021 BASED ON
EMAIL FROM PD
  -- OR RUT                  IS NULL) )
  -- OR ( (INTERSECTIONS       IS NOT NULL
  -- OR DOWNHILL_GRADE          ='DH_GRADE_5_TO_10')
  -- AND SPEED_LIMIT          IN ('BELOW_35') )
  -- OR (DIVIDED              ='DIVIDED'
  -- AND SPEED_LIMIT           ='ABOVE_55'
  -- AND RUT                  ='HIGH_RUT') )
  -- AND SITE_CATEGORY         IS NULL
  -- AND GLOBAL_ROUTE_ID        = ROUTE_LIST.GLOBAL_ROUTE_ID
  -- AND SUB_ROUTE_ID          = ROUTE_LIST.SUB_ROUTE_ID;
  -- UPDATE FMG_BASE_SEGMENTS
  -- SET SITE_CATEGORY   = 5
  -- WHERE ( DIVIDED      ='DIVIDED'
  -- AND (SPEED_LIMIT   IN ('BELOW_55','BELOW_35')-- CHANGED ON 9/17/2021 BASED ON EMAIL
FROM PD
  -- OR RUT            IS NULL) )
  -- AND SITE_CATEGORY  IS NULL
  -- AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
  -- AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID;
  COMMIT;
 ELSE --- NON-INV DIRECTION NOT IN UNIVERSE MASTER TABLES
  SELECT MAX(DIR_EMP),
   MIN(DIR_BMP)
  INTO MAX_MP,
   MIN_MP
  FROM SKID_INVENTORY
  WHERE GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
  AND SUB_ROUTE_ID      = 1;
  SELECT MAX(DIR_EMP),
   MIN(DIR_BMP)-- TO ADRESS CASES LIKE 24004
  INTO DIR_MAX_MP,
   DIR_MIN_MP
  FROM SKID_INVENTORY
  WHERE GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
  AND SUB_ROUTE_ID      = 2;
  SELECT COUNT(*)-- TO CHECK IF A ROUTE HAS MORE THAN ONE ROW IN THE SKID INVENTORY
  INTO ROUTE_CNT
  FROM SKID_INVENTORY
  WHERE GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
  AND SUB_ROUTE_ID      = ROUTE_LIST.SUB_ROUTE_ID;
  INSERT
  INTO FMG_BASE_SEGMENTS
   (
    COLLECT_YEAR,
    GOVT_CONTROL,
```

```
    HMIS_ROUTEID,
    GLOBAL_ROUTE_ID,
    SUB_ROUTE_ID,
    BMP,
    EMP
   )
  -- SPEED LIMIT CRITERIA
 WITH SPEED_LIMIT AS
  ( SELECT DISTINCT ROUTEID,
   ID_MP BMP,
   ID_MP+SECTION_LENGTH EMP,
   CASE
    WHEN H.SPEED_LIMIT>=55-- CHANGED ON 9/17/2021 BASED ON EMAIL FROM PD
    THEN 'ABOVE_55'
    WHEN H.SPEED_LIMIT>=35
    AND H.SPEED_LIMIT  <55
    THEN 'BELOW_55'
    ELSE 'BELOW_35'
   END SEC_ATTRIBUTE
  FROM HMIS_UNIVERSE_ALL_YEARS H
  WHERE YEAR  = INV_YEAR
  AND ROUTEID = ROUTE_LIST.HMIS_ROUTEID
   --AND MEDIAN_TY IN (4,5)
  ORDER BY ID_MP
  ),
  --  WITH SPEED_LIMIT AS
  --   (SELECT MIN(DIR_BMP) BMP,
  --    MAX(DIR_EMP) EMP,
  --    SEC_ATTRIBUTE,
  --    SEC_RN
  --   FROM
  --    (SELECT DIR_BMP,
  --     DIR_EMP,
  --     SEC_ATTRIBUTE,
  --     RN_,
  --     ROW_NUMBER() OVER(ORDER BY RN_) -ROW_NUMBER() OVER(PARTITION BY
SEC_ATTRIBUTE ORDER BY RN_) AS SEC_RN
  --    FROM
  --     (SELECT TT.*,
  --      ROWNUM RN_ -- THIS SUBQUERY SORTS THE INCOMING ATTRIBUTE AND SUPPLIES
THE RN FIELD.
  --     FROM
  --      ( SELECT DISTINCT ROUTEID,
  --       ID_MP DIR_BMP,
  --       ID_MP+SECTION_LENGTH DIR_EMP,
  --       CASE
  --        WHEN SPEED_LIMIT>=55
  --        THEN 'ABOVE_55'
  --        ELSE 'BELOW_55'
  --       END SEC_ATTRIBUTE
  --      FROM HMIS_UNIVERSE_ALL_YEARS
  --      WHERE YEAR  = INV_YEAR
  --      AND ROUTEID = ROUTE_LIST.HMIS_ROUTEID
  --       --AND MEDIAN_TY IN (4,5)
  --      ORDER BY ID_MP
  --      ) TT
  --     )
  --    )
  --   GROUP BY SEC_ATTRIBUTE,
  --    SEC_RN
  --   ),
```

```
-- DIVIDED VS UNDIVIDED CRITERIA
--   DIVIDED AS
--   (SELECT MIN(DIR_BMP) BMP,
--     MAX(DIR_EMP) EMP,
--     SEC_ATTRIBUTE,
--     SEC_RN
--   FROM
--     (SELECT DIR_BMP,
--       DIR_EMP,
--       SEC_ATTRIBUTE,
--       RN_,
--       ROW_NUMBER() OVER(ORDER BY RN_) -ROW_NUMBER() OVER(PARTITION BY
SEC_ATTRIBUTE ORDER BY RN_) AS SEC_RN
--     FROM
--       (SELECT TT.*,
--         ROWNUM RN_ -- THIS SUBQUERY SORTS THE INCOMING ATTRIBUTE AND SUPPLIES
THE RN FIELD.
--       FROM
--         ( SELECT DISTINCT ROUTEID,
--           ID_MP DIR_BMP,
--           ID_MP+SECTION_LENGTH DIR_EMP,
--           CASE
--             WHEN MEDIAN_TY IN (4,5)
--             THEN 'UNDIVIDED'
--             ELSE 'DIVIDED'
--           END SEC_ATTRIBUTE
--         FROM HMIS_UNIVERSE_ALL_YEARS
--         WHERE YEAR  = INV_YEAR
--         AND ROUTEID = ROUTE_LIST.HMIS_ROUTEID
--           --AND MEDIAN_TY IN (4,5)
--         ORDER BY ID_MP
--         ) TT
--       )
--     )
--   GROUP BY SEC_ATTRIBUTE,
--     SEC_RN
--   ORDER BY 1
--   ),
DIVIDED AS
( SELECT DISTINCT ROUTEID,
  ID_MP BMP,
  ID_MP+SECTION_LENGTH EMP,
  CASE
    WHEN MEDIAN_TY IN (4,5)
    THEN 'UNDIVIDED'
    ELSE 'DIVIDED'
  END SEC_ATTRIBUTE
FROM HMIS_UNIVERSE_ALL_YEARS
WHERE YEAR  = INV_YEAR
AND ROUTEID = ROUTE_LIST.HMIS_ROUTEID
  --AND MEDIAN_TY IN (4,5)
ORDER BY ID_MP
) ,
RUT AS
(SELECT *
FROM
  ( SELECT DISTINCT DIR_BMP BMP,
    DIR_EMP EMP,
    CASE
      WHEN (L_RUT+R_RUT)/2 >0.25
      THEN 'HIGH_RUT'
```

```
      ELSE 'LOW_RUT'
    END SEC_ATTRIBUTE
  FROM FINAL_CONDITION_DETAIL_SKID
  WHERE COLLECT_YEAR  = COND_YEAR
  AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
  AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
    -- AND (L_RUT+R_RUT)/2 >0.25
    --  AND DIR_BMP       >=0
    --  AND DIR_EMP        < 1
  ORDER BY 1
  ) TT
WHERE SEC_ATTRIBUTE ='HIGH_RUT'
),
-- RUT>.25 CRITERIA
--    RUT AS
--    (SELECT *
--    FROM
--      (SELECT MIN(DIR_BMP) BMP,
--        MAX(DIR_EMP) EMP,
--        SEC_ATTRIBUTE,
--        DISTANCE
--      FROM
--        (SELECT DIR_BMP,
--          DIR_EMP,
--          SEC_ATTRIBUTE,
--          RN_,
--          ROW_NUMBER() OVER(ORDER BY RN_) -ROW_NUMBER() OVER(PARTITION BY
SEC_ATTRIBUTE ORDER BY RN_) AS DISTANCE
--        FROM
--          (SELECT TT.*,
--            ROWNUM RN_ -- THIS SUBQUERY SORTS THE INCOMING ATTRIBUTE AND SUPPLIES
THE RN FIELD.
--          FROM
--            ( SELECT DISTINCT DIR_BMP DIR_BMP,
--              DIR_EMP DIR_EMP,
--              CASE
--                WHEN (L_RUT+R_RUT)/2 >0.25
--                THEN 'HIGH_RUT'
--                ELSE 'LOW_RUT'
--              END SEC_ATTRIBUTE
--            FROM FINAL_CONDITION_DETAIL_SKID
--            WHERE COLLECT_YEAR  = COND_YEAR
--            AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
--            AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
--              -- AND (L_RUT+R_RUT)/2 >0.25
--              --  AND DIR_BMP       >=0
--              --  AND DIR_EMP        < 1
--            ORDER BY 1
--            ) TT
--          )
--        )
--      GROUP BY SEC_ATTRIBUTE,
--        DISTANCE
--      )
--    WHERE SEC_ATTRIBUTE ='HIGH_RUT'
--    ),
CURVE AS
(SELECT BMP DIR_BMP,
  EMP DIR_EMP,
  SEC_ATTRIBUTE
FROM
```

```
  (SELECT DIR_BMP BMP,
   DIR_EMP EMP,
   DIR_EMP-DIR_BMP SEC_LENGTH,
   CASE
     -- WHEN RADIUS <=250*3.28 --CHANGED ON 12/16/2020 BASED ON THE EMAIL FROM BX
    WHEN RADIUS <=250*3 --CHANGED ON 09/17/2021 BASED ON THE EMAIL FROM PD
    AND RADIUS   > 0
    THEN 'CURVE_750'
    WHEN RADIUS <=250 *6 --CHANGED ON 10/07/2021 BASED ON THE EMAIL FROM KM
    AND RADIUS   > 250*3
    THEN 'CURVE_1500'
    ELSE 'CURVE_NOT750'
   END SEC_ATTRIBUTE
  FROM CURVE_H_SHA_NETWORK@PAV_CONHIST_ASSET
  WHERE YEAR         = COND_YEAR
  AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
  AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
  )
  --WHERE SEC_ATTRIBUTE = 'CURVE_750'
 WHERE SEC_ATTRIBUTE <> 'CURVE_NOT750'--CHANGED ON 10/07/2021 BASED ON THE EMAIL
FROM KM
 ),
 -- INTERSECTIONS
 INTERSECTIONS AS
 (SELECT
  CASE
   WHEN ID_MP+.1>=MAX_MP
   THEN MAX_MP
   ELSE ID_MP+.1
  END EMP,
  ID_MP BMP,
  MP_INT_RTE_NAME SEC_ATTRIBUTE
 FROM HMIS_MASTER_ALL_YEARS
 WHERE YEAR           = INV_YEAR
 AND ROUTEID          = ROUTE_LIST.HMIS_ROUTEID
 AND MP_LOCATION_TYPE <> 2
 AND (MP_INT_TYPE      > 0
 AND MP_INT_TYPE       < 100
 AND MP_INT_TYPE NOT  IN (7,10,14))
 ),
 DH_GRADE AS
 (SELECT *
 FROM DH_GRADE_SKID
 WHERE SEC_LENGTH   >=.03
 AND COLLECT_YEAR    = COND_YEAR
 AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
 AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
 ),
 -- ON AND OFF RAMP
 RAMP AS
 (SELECT
  CASE
   WHEN ID_MP+.1>=MAX_MP
   THEN MAX_MP
   ELSE ID_MP+.1
  END EMP,
  ID_MP BMP,
  'RAMP' SEC_ATTRIBUTE
 FROM HMIS_MASTER_ALL_YEARS
 WHERE YEAR          = INV_YEAR
 AND ROUTEID         = ROUTE_LIST.HMIS_ROUTEID
```

```
AND MP_LOCATION_TYPE = 2
AND ID_PREFIX       <>'RP'
AND (MP_INT_RTE_NAME LIKE '%TO '
  ||ID_PREFIX
  ||' '
  ||ID_RTE_NO
  ||TRIM(MP_SUFFIX)
  ||' '
  ||MP_DIRECTION
  ||'%'
OR MP_INT_RTE_NAME LIKE '%FR '
  ||ID_PREFIX
  ||' '
  ||ID_RTE_NO
  ||TRIM(MP_SUFFIX)
  ||' '
  ||MP_DIRECTION
  ||'%')
UNION
SELECT
  CASE
    WHEN ID_MP+.1>=MAX_MP
    THEN MAX_MP
    ELSE ID_MP+.1
  END EMP,
  ID_MP BMP,
  'RAMP' SEC_ATTRIBUTE
FROM HMIS_MASTER_ALL_YEARS
WHERE YEAR          = INV_YEAR
AND ROUTEID         = ROUTE_LIST.HMIS_ROUTEID
AND MP_LOCATION_TYPE = 2
AND ID_PREFIX       <>'RP'
AND (MP_INT_RTE_NAME LIKE '%TO '
  ||ID_PREFIX
  ||' '
  ||ID_RTE_NO
  ||TRIM(MP_SUFFIX)
  ||' '
  ||
  CASE
    WHEN MP_DIRECTION ='E'
    THEN 'N'
    WHEN MP_DIRECTION ='W'
    THEN 'S'
    WHEN MP_DIRECTION ='N'
    THEN 'E'
    WHEN MP_DIRECTION ='S'
    THEN 'W'
  END
  ||'%'
OR MP_INT_RTE_NAME LIKE '%FR '
  ||ID_PREFIX
  ||' '
  ||ID_RTE_NO
  ||TRIM(MP_SUFFIX)
  ||' '
  ||
  CASE
    WHEN MP_DIRECTION ='E'
    THEN 'N'
    WHEN MP_DIRECTION ='W'
```

```
    THEN 'S'
    WHEN MP_DIRECTION ='N'
    THEN 'E'
    WHEN MP_DIRECTION ='S'
    THEN 'W'
  END
  ||'%')
UNION
SELECT
  CASE
    WHEN ID_MP+.1>=MAX_MP
    THEN MAX_MP
    ELSE ID_MP+.1
  END EMP,
  ID_MP BMP,
  'RAMP' SEC_ATTRIBUTE
FROM HMIS_MASTER_ALL_YEARS
WHERE YEAR          = INV_YEAR
AND ROUTEID         = ROUTE_LIST.HMIS_ROUTEID
AND MP_LOCATION_TYPE = 2
AND ID_PREFIX       ='RP'
AND (MP_INT_RTE_NAME LIKE '% '
  || TRIM(SUBSTR(ROAD_NAME,1,7))
  || '%')
ORDER BY BMP
),
--TRAFFIC LIGHTS, STOP SIGN, ROUNDABOUT, RAIL ROAD CROSSINGS
SITE_CAT_1 AS
(SELECT
  CASE
    WHEN ID_MP+.1>=MAX_MP
    THEN MAX_MP
    ELSE ID_MP+.1
  END EMP,
  ID_MP BMP,
  -- MP_INT_RTE_NAME,
  --MP_INT_TYPE,
  CASE
    WHEN MP_INT_RTE_NAME LIKE '%TRAFFIC SIGNAL%'
    THEN 'TRAFFIC_SIGNAL'
    WHEN MP_INT_RTE_NAME LIKE '%STOP SIGN%'
    THEN 'STOP_SIGN'
    WHEN (MP_INT_RTE_NAME LIKE '%ROUNDABOUT%'
    AND MP_INT_RTE_NAME NOT LIKE '%END ROUNDABOUT%')
    THEN 'ROUND_ABOUT'
    WHEN MP_INT_RTE_NAME LIKE '%SPUR TO%'
    THEN 'GIVE_WAY'
    WHEN MP_INT_RTE_NAME LIKE '%RAILROAD CROSSING%'
    THEN 'RAIL_ROAD'
      --WHEN (MP_INT_TYPE > 0 AND MP_INT_TYPE < 100 AND MP_INT_TYPE NOT IN (7,10,14))
THEN 'INERSECTION'
  END SEC_ATTRIBUTE
FROM HMIS_MASTER_ALL_YEARS
WHERE YEAR  = INV_YEAR
AND ROUTEID = ROUTE_LIST.HMIS_ROUTEID
AND (MP_INT_RTE_NAME LIKE '%TRAFFIC SIGNAL%'
OR MP_INT_RTE_NAME LIKE '%STOP SIGN%'
OR (MP_INT_RTE_NAME LIKE '%ROUNDABOUT%'
AND MP_INT_RTE_NAME NOT LIKE '%END ROUNDABOUT%')
OR MP_INT_RTE_NAME LIKE '%SPUR TO%'
OR MP_INT_RTE_NAME LIKE '%RAILROADC ROSSING%'
```

```
  -- OR (MP_INT_TYPE > 0 AND MP_INT_TYPE < 100 AND MP_INT_TYPE NOT IN (7,10,14))
  )
UNION
--PEDESTRIAN CROSSING
SELECT
  CASE
    WHEN DIR_EMP-.1>=0
    THEN DIR_EMP-.1
    ELSE 0
  END BMP,
  DIR_EMP EMP, --NULL,
  'PEDESTRIAN_CROSSING' PEDESTRIAN_CROSSING
FROM EDW18_BASE_4@PAV_CONHIST_ASSET
WHERE GLOBAL_ROUTE_ID      = ROUTE_LIST.GLOBAL_ROUTE_ID
AND SUB_ROUTE_ID           = ROUTE_LIST.SUB_ROUTE_ID
AND STATUS                 = 'MATCHED'
AND EVENT_CROSSWALK_OFFICE = 1
),
--    FINAL_SEG AS
--    (SELECT MAX_MP- EMP BMP FROM SPEED_LIMIT S
--    UNION
--    SELECT MAX_MP- BMP EMP FROM SPEED_LIMIT S
--    UNION
--    SELECT MAX_MP- EMP BMP FROM DIVIDED S
--    UNION
--    SELECT MAX_MP- BMP EMP FROM DIVIDED S
--    UNION
--    SELECT BMP FROM RUT
--    UNION
--    SELECT EMP FROM RUT
--    UNION
--    SELECT MAX_MP- EMP BMP FROM INTERSECTIONS S
--    UNION
--    SELECT MAX_MP- BMP EMP FROM INTERSECTIONS S
--    UNION
--    SELECT DIR_BMP FROM CURVE
--    UNION
--    SELECT DIR_EMP FROM CURVE
--    UNION
--    SELECT DIR_BMP FROM DH_GRADE
--    UNION
--    SELECT DIR_EMP FROM DH_GRADE
--    UNION
--    SELECT MAX_MP- EMP BMP FROM RAMP S
--    UNION
--    SELECT MAX_MP- BMP EMP FROM RAMP S
--    UNION
--    SELECT MAX_MP- EMP BMP FROM SITE_CAT_1 S
--    UNION
--    SELECT MAX_MP- BMP EMP FROM SITE_CAT_1 S ORDER BY 1
--    )
FINAL_SEG AS
(SELECT MAX_MP- EMP+DIR_MIN_MP BMP FROM SPEED_LIMIT S
UNION
SELECT MAX_MP- BMP+DIR_MIN_MP EMP FROM SPEED_LIMIT S
UNION
SELECT MAX_MP- EMP+DIR_MIN_MP BMP FROM DIVIDED S
UNION
SELECT MAX_MP- BMP+DIR_MIN_MP EMP FROM DIVIDED S
UNION
SELECT BMP FROM RUT
```

```
 UNION
 SELECT EMP FROM RUT
 UNION
 SELECT MAX_MP- EMP+DIR_MIN_MP BMP FROM INTERSECTIONS S
 UNION
 SELECT MAX_MP- BMP+DIR_MIN_MP EMP FROM INTERSECTIONS S
 UNION
 SELECT DIR_BMP FROM CURVE
 UNION
 SELECT DIR_EMP FROM CURVE
 UNION
 SELECT DIR_BMP FROM DH_GRADE
 UNION
 SELECT DIR_EMP FROM DH_GRADE
 UNION
 SELECT MAX_MP- EMP+DIR_MIN_MP BMP FROM RAMP S
 UNION
 SELECT MAX_MP- BMP+DIR_MIN_MP EMP FROM RAMP S
 UNION
 SELECT MAX_MP- EMP+DIR_MIN_MP BMP FROM SITE_CAT_1 S
 UNION
 SELECT MAX_MP- BMP+DIR_MIN_MP EMP FROM SITE_CAT_1 S ORDER BY 1
 )
SELECT COND_YEAR,
 ROUTE_LIST.GOVT_CONTROL,
 ROUTE_LIST.HMIS_ROUTEID,
 ROUTE_LIST.GLOBAL_ROUTE_ID,
 ROUTE_LIST.SUB_ROUTE_ID,
 BMP,
 EMP
FROM
 ( SELECT BMP, LEAD (BMP) OVER ( ORDER BY BMP) EMP FROM FINAL_SEG
 )
WHERE EMP IS NOT NULL
AND BMP   >=0
AND BMP   <> EMP
AND BMP   >= -- CHANGED ON 9/17/21 BASED ON EMAIL FROM PD
 CASE
  WHEN ROUTE_CNT> 1
  THEN ROUTE_LIST.DIR_BMP
  ELSE DIR_MIN_MP
 END-- TO ADDRESS ROUTES WITH MULTIPLE ROWS.
AND EMP <=
 CASE
  WHEN ROUTE_CNT> 1
  THEN ROUTE_LIST.DIR_EMP
  ELSE DIR_MAX_MP
 END
ORDER BY BMP;
--- UPDATING INV MILEPOINTS
-- CHANGED ON 9/17/21 BASED ON EMAIL FROM PD
--  IF MIN_MP> 0 AND DIR_MIN_MP=0 THEN--- TO ADDRESS CASES LIKE 24004
--   UPDATE FMG_BASE_SEGMENTS F
--   SET INV_BMP          = MAX_MP- EMP,
--     INV_EMP            = MAX_MP- BMP
--   WHERE F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
--   AND F.SUB_ROUTE_ID     = ROUTE_LIST.SUB_ROUTE_ID;
--  ELSE
--   UPDATE FMG_BASE_SEGMENTS F
--   SET INV_BMP          = MAX_MP- EMP+MIN_MP,
--     INV_EMP            = MAX_MP- BMP+MIN_MP
```

```
--   WHERE F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
--   AND F.SUB_ROUTE_ID     = ROUTE_LIST.SUB_ROUTE_ID;
-- END IF;
UPDATE FMG_BASE_SEGMENTS F
SET INV_BMP           = MAX_MP- EMP+DIR_MIN_MP,
  INV_EMP             = MAX_MP- BMP+DIR_MIN_MP
WHERE F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
AND F.SUB_ROUTE_ID     = ROUTE_LIST.SUB_ROUTE_ID;
DELETE
FROM FMG_BASE_SEGMENTS F
WHERE F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
AND F.SUB_ROUTE_ID     = ROUTE_LIST.SUB_ROUTE_ID
AND (INV_BMP           <MIN_MP
OR INV_EMP             >MAX_MP) ;
COMMIT;
-- DIVIDED UPDATE
BEGIN
  MERGE INTO FMG_BASE_SEGMENTS A USING
  ( SELECT DISTINCT F.ROWID ROW_ID,
    F.INV_BMP,
    F.INV_EMP,-- H.MEDIAN_TY,
    CASE
      WHEN MEDIAN_TY IN (4,5)
      THEN 'UNDIVIDED'
      ELSE 'DIVIDED'
    END SEC_ATTRIBUTE
  FROM HMIS_UNIVERSE_ALL_YEARS H ,
    FMG_BASE_SEGMENTS F
  WHERE H.YEAR       = INV_YEAR
  AND F.COLLECT_YEAR = COND_YEAR
    --   AND H.ROUTEID      = ROUTE_LIST.HMIS_ROUTEID
  AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
  AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
    -- AND F.INV_BMP     >= ROUTE_LIST.INV_BMP --CHANGED FROM ROUTE_LIST.DIR_BMP TO
INV_BMP OM 11/8 BY RG
    -- AND F.INV_EMP     <= ROUTE_LIST.INV_EMP --CHANGED FROM ROUTE_LIST.DIR_EMP TO
INV_EMP OM 11/8 BY RG
  AND F.HMIS_ROUTEID = H.ROUTEID
  AND ( (ID_MP      >= F.INV_BMP
  AND ID_MP         <F.INV_EMP)
  OR (F.INV_BMP     >= ID_MP
  AND F.INV_EMP     <= ID_MP+SECTION_LENGTH) )
  ) B ON (A.ROWID    = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE
  SET A.DIVIDED = B.SEC_ATTRIBUTE;
EXCEPTION
WHEN OTHERS THEN
  DBMS_OUTPUT.PUT_LINE('LINE2043- '||ROUTE_LIST.HMIS_ROUTEID);
END;
-- SPEED LIMIT UPDATE
MERGE INTO FMG_BASE_SEGMENTS A USING
( SELECT DISTINCT F.ROWID ROW_ID,
  F.INV_BMP,
  F.INV_EMP,-- H.MEDIAN_TY,
  CASE
    WHEN H.SPEED_LIMIT>=55-- CHANGED ON 9/17/2021 BASED ON EMAIL FROM PD
    THEN 'ABOVE_55'
    WHEN H.SPEED_LIMIT>=35
    AND H.SPEED_LIMIT  <55
    THEN 'BELOW_55'
```

```
    ELSE 'BELOW_35'
  END SEC_ATTRIBUTE
 FROM HMIS_UNIVERSE_ALL_YEARS H ,
  FMG_BASE_SEGMENTS F
 WHERE H.YEAR       = INV_YEAR
 AND F.COLLECT_YEAR = COND_YEAR
  --   AND H.ROUTEID      = ROUTE_LIST.HMIS_ROUTEID
 AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
 AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
  --  AND F.INV_BMP     >= ROUTE_LIST.INV_BMP --CHANGED FROM ROUTE_LIST.DIR_BMP TO
INV_BMP OM 11/8 BY RG
  -- AND F.INV_EMP     <= ROUTE_LIST.INV_EMP --CHANGED FROM ROUTE_LIST.DIR_EMP TO
INV_EMP OM 11/8 BY RG
 AND F.HMIS_ROUTEID = H.ROUTEID
 AND ( (ID_MP      >= F.INV_BMP
 AND ID_MP         <F.INV_EMP)
 OR (F.INV_BMP     >= ID_MP
 AND F.INV_EMP     <= ID_MP+SECTION_LENGTH) )
 ) B ON (A.ROWID    = B.ROW_ID)
WHEN MATCHED THEN
 UPDATE
 SET A.SPEED_LIMIT = B.SEC_ATTRIBUTE;
 -- RUT
 MERGE INTO FMG_BASE_SEGMENTS A USING
 ( SELECT DISTINCT F.ROWID ROW_ID,
  F.BMP,
  F.EMP,-- H.MEDIAN_TY,
  --H.DIR_BMP, H.DIR_EMP,
  'HIGH_RUT' SEC_ATTRIBUTE
 FROM FINAL_CONDITION_DETAIL_SKID H ,
  FMG_BASE_SEGMENTS F
 WHERE H.COLLECT_YEAR = COND_YEAR
 AND F.COLLECT_YEAR   = H.COLLECT_YEAR
  --   AND H.ROUTEID      = ROUTE_LIST.HMIS_ROUTEID
 AND F.GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
 AND F.SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
 AND F.BMP             >= MIN_MP
 AND F.EMP             <= MAX_MP
 AND F.GLOBAL_ROUTE_ID = H.GLOBAL_ROUTE_ID
 AND F.SUB_ROUTE_ID    = H.SUB_ROUTE_ID
 AND (L_RUT+R_RUT)/2   >0.25
  --   AND ( (H.DIR_BMP     >=F.BMP
  --   AND H.DIR_EMP       <=F.EMP)
  --   OR (H.DIR_BMP       <F.BMP
  --   AND H.DIR_EMP        >F.EMP)
  --   OR (H.DIR_BMP       <=F.BMP
  --   AND H.DIR_EMP        >F.BMP) )
 AND (H.DIR_BMP <=F.BMP
 AND H.DIR_EMP  >=F.EMP)
  --  ORDER BY 2
 ) B ON (A.ROWID = B.ROW_ID)
WHEN MATCHED THEN
 UPDATE
 SET A.RUT = B.SEC_ATTRIBUTE;
 -- CURVE
 MERGE INTO FMG_BASE_SEGMENTS A USING
 (SELECT *
 FROM
  (SELECT DISTINCT F.ROWID ROW_ID,
    F.BMP,
    F.EMP,
```

```
    SEC_ATTRIBUTE
   FROM FMG_BASE_SEGMENTS F,
    (SELECT *
    FROM
      (SELECT DIR_BMP ,
        DIR_EMP ,
        DIR_EMP-DIR_BMP SEC_LENGTH,
        CASE
            -- WHEN RADIUS <=250*3.28 --CHANGED ON 12/16/2020 BASED ON THE EMAIL FROM BX
          WHEN RADIUS <=250*3 --CHANGED ON 09/17/2021 BASED ON THE EMAIL FROM PD
          AND RADIUS   > 0
          THEN 'CURVE_750'
          WHEN RADIUS <=250 *6 --CHANGED ON 10/07/2021 BASED ON THE EMAIL FROM KM
          AND RADIUS   > 250*3
          THEN 'CURVE_1500'
          ELSE 'CURVE_NOT750'
        END SEC_ATTRIBUTE
      FROM CURVE_H_SHA_NETWORK@PAV_CONHIST_ASSET
      WHERE YEAR          = COND_YEAR
      AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
      AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
      )
      --WHERE SEC_ATTRIBUTE = 'CURVE_750'
    WHERE SEC_ATTRIBUTE <> 'CURVE_NOT750'--CHANGED ON 10/07/2021 BASED ON THE EMAIL
FROM KM
    ) H
   WHERE F.COLLECT_YEAR  = COND_YEAR
   AND F.BMP           >= MIN_MP
   AND F.EMP           <= MAX_MP
   AND F.GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
   AND F.SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
   AND (H.DIR_BMP       <=F.BMP
   AND H.DIR_EMP        >=F.EMP)
   ORDER BY 2
   )
   --WHERE SEC_ATTRIBUTE = 'CURVE_750'
  WHERE SEC_ATTRIBUTE <> 'CURVE_NOT750'--CHANGED ON 10/07/2021 BASED ON THE EMAIL
FROM KM
  ) B ON (A.ROWID       = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE
  SET A.CURVE = B.SEC_ATTRIBUTE;
  -- INTERSECTIONS
  MERGE INTO FMG_BASE_SEGMENTS A USING
  (SELECT *
  FROM
   (SELECT DISTINCT F.ROWID ROW_ID,
    F.INV_BMP,
    F.INV_EMP,
    H.ID_MP,
    MP_INT_RTE_NAME SEC_ATTRIBUTE,
    ROW_NUMBER() OVER ( PARTITION BY F.ROWID ORDER BY ID_MP,MP_INT_RTE_NAME) RN
   FROM HMIS_MASTER_ALL_YEARS H ,
    FMG_BASE_SEGMENTS F
   WHERE H.YEAR        = INV_YEAR
   AND F.COLLECT_YEAR = COND_YEAR
    --    AND H.ROUTEID       = ROUTE_LIST.HMIS_ROUTEID
   AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
   AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
    --    AND F.INV_BMP     >= ROUTE_LIST.INV_BMP --CHANGED FROM ROUTE_LIST.DIR_BMP TO
INV_BMP OM 11/8 BY RG
```

```
    --  AND F.INV_EMP     <= ROUTE_LIST.INV_EMP --CHANGED FROM ROUTE_LIST.DIR_EMP TO
INV_EMP OM 11/8 BY RG
   AND F.HMIS_ROUTEID   = H.ROUTEID
   AND (F.INV_BMP      >= ID_MP
   AND F.INV_EMP       <= ID_MP+.1)
   AND (MP_INT_TYPE     > 0
   AND MP_INT_TYPE      < 100
   AND MP_INT_TYPE NOT IN (7,10,14))
   )
  WHERE RN        =1
  ) B ON (A.ROWID = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE
  SET A.INTERSECTIONS = B.SEC_ATTRIBUTE;
  -- DOWNHILL_GRAD
  --DH_GRADE_5_TO_10
  MERGE INTO FMG_BASE_SEGMENTS A USING
  ( SELECT DISTINCT F.ROWID ROW_ID,
   H.SEC_ATTRIBUTE
  FROM FMG_BASE_SEGMENTS F,
   (SELECT *
   FROM DH_GRADE_SKID
   WHERE SEC_LENGTH  >=.03
   AND SEC_ATTRIBUTE IN ('DH_GRADE_5_TO_10')
   )H
  WHERE F.COLLECT_YEAR = COND_YEAR
   --    AND H.ROUTEID       = ROUTE_LIST.HMIS_ROUTEID
  AND F.GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
  AND F.SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
  AND F.BMP            >= MIN_MP
  AND F.EMP            <= MAX_MP
  AND F.GLOBAL_ROUTE_ID = H.GLOBAL_ROUTE_ID
  AND F.SUB_ROUTE_ID    = H.SUB_ROUTE_ID
  AND F.COLLECT_YEAR    = H.COLLECT_YEAR
  AND ( (H.DIR_BMP      >=F.BMP
  AND H.DIR_EMP        <=F.EMP)
  OR (H.DIR_BMP        <F.BMP
  AND H.DIR_EMP         >F.EMP)
  OR (H.DIR_BMP       <=F.BMP
  AND H.DIR_EMP         >F.BMP) )
  )B ON (A.ROWID        = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE
  SET A.DOWNHILL_GRADE = B.SEC_ATTRIBUTE;
  --DH_GRADE_10
  MERGE INTO FMG_BASE_SEGMENTS A USING
  ( SELECT DISTINCT F.ROWID ROW_ID,
   H.SEC_ATTRIBUTE
  FROM FMG_BASE_SEGMENTS F,
   (SELECT *
   FROM DH_GRADE_SKID
   WHERE SEC_LENGTH>=.03
   AND SEC_ATTRIBUTE= ('DH_GRADE_10')
   )H
  WHERE F.COLLECT_YEAR = COND_YEAR
   --    AND H.ROUTEID       = ROUTE_LIST.HMIS_ROUTEID
  AND F.GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
  AND F.SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID
  AND F.BMP            >= MIN_MP
  AND F.EMP            <= MAX_MP
  AND F.GLOBAL_ROUTE_ID = H.GLOBAL_ROUTE_ID
```

```
 AND F.SUB_ROUTE_ID    = H.SUB_ROUTE_ID
 AND F.COLLECT_YEAR    = H.COLLECT_YEAR
 AND ( (H.DIR_BMP     >=F.BMP
 AND H.DIR_EMP        <=F.EMP)
 OR (H.DIR_BMP        <F.BMP
 AND H.DIR_EMP         >F.EMP)
 OR (H.DIR_BMP       <=F.BMP
 AND H.DIR_EMP         >F.BMP) )
 )B ON (A.ROWID        = B.ROW_ID)
WHEN MATCHED THEN
 UPDATE
 SET A.DOWNHILL_GRADE = B.SEC_ATTRIBUTE;
 -- RAMP
 -- ROUTE IS NOT A RAMP
 MERGE INTO FMG_BASE_SEGMENTS A USING
 (SELECT *
 FROM
  (SELECT DISTINCT F.ROWID ROW_ID,
   F.INV_BMP,
   F.INV_EMP,
   H.ID_MP,
   MP_INT_RTE_NAME SEC_ATTRIBUTE,
   ROW_NUMBER() OVER ( PARTITION BY F.ROWID ORDER BY ID_MP,MP_INT_RTE_NAME) RN
  FROM HMIS_MASTER_ALL_YEARS H ,
   FMG_BASE_SEGMENTS F
  WHERE H.YEAR       = INV_YEAR
  AND F.COLLECT_YEAR = COND_YEAR
   --    AND H.ROUTEID       = ROUTE_LIST.HMIS_ROUTEID
  AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
  AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
   -- AND F.INV_BMP     >= ROUTE_LIST.INV_BMP --CHANGED FROM ROUTE_LIST.DIR_BMP TO
INV_BMP OM 11/8 BY RG
   --AND F.INV_EMP     <= ROUTE_LIST.INV_EMP --CHANGED FROM ROUTE_LIST.DIR_EMP TO
INV_EMP OM 11/8 BY RG
  AND F.HMIS_ROUTEID   = H.ROUTEID
  AND (F.INV_BMP      >= ID_MP
  AND F.INV_EMP       <= ID_MP +.1)
  AND MP_LOCATION_TYPE = 2
  AND ID_PREFIX       <>'RP'
  AND (MP_INT_RTE_NAME LIKE '%TO '
   ||ID_PREFIX
   ||' '
   ||ID_RTE_NO
   ||TRIM(MP_SUFFIX)
   ||' '
   ||MP_DIRECTION
   ||'%'
  OR MP_INT_RTE_NAME LIKE '%FR '
   ||ID_PREFIX
   ||' '
   ||ID_RTE_NO
   ||TRIM(MP_SUFFIX)
   ||' '
   ||MP_DIRECTION
   ||'%')
  )
 WHERE RN        =1
 ) B ON (A.ROWID = B.ROW_ID)
WHEN MATCHED THEN
 UPDATE
 SET A.RAMP = B.SEC_ATTRIBUTE;
```

```
 -- ROUTE IS NOT A RAMP - DIRECTION CHANGE
 MERGE INTO FMG_BASE_SEGMENTS A USING
 (SELECT *
 FROM
   (SELECT DISTINCT F.ROWID ROW_ID,
     F.INV_BMP,
     F.INV_EMP,
     H.ID_MP,
     MP_INT_RTE_NAME SEC_ATTRIBUTE,
     ROW_NUMBER() OVER ( PARTITION BY F.ROWID ORDER BY ID_MP,MP_INT_RTE_NAME) RN
   FROM HMIS_MASTER_ALL_YEARS H ,
     FMG_BASE_SEGMENTS F
   WHERE H.YEAR       = INV_YEAR
   AND F.COLLECT_YEAR = COND_YEAR
     --    AND H.ROUTEID       = ROUTE_LIST.HMIS_ROUTEID
   AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
   AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
     -- AND F.INV_BMP      >= ROUTE_LIST.INV_BMP --CHANGED FROM ROUTE_LIST.DIR_BMP TO
INV_BMP OM 11/8 BY RG
     --AND F.INV_EMP      <= ROUTE_LIST.INV_EMP --CHANGED FROM ROUTE_LIST.DIR_EMP TO
INV_EMP OM 11/8 BY RG
   AND F.HMIS_ROUTEID   = H.ROUTEID
   AND (F.INV_BMP      >= ID_MP
   AND F.INV_EMP       <= ID_MP +.1)
   AND MP_LOCATION_TYPE = 2
   AND ID_PREFIX       <>'RP'
   AND (MP_INT_RTE_NAME LIKE '%TO '
     ||ID_PREFIX
     ||' '
     ||ID_RTE_NO
     ||TRIM(MP_SUFFIX)
     ||' '
     ||
     CASE
       WHEN MP_DIRECTION ='E'
       THEN 'N'
       WHEN MP_DIRECTION ='W'
       THEN 'S'
       WHEN MP_DIRECTION ='N'
       THEN 'E'
       WHEN MP_DIRECTION ='S'
       THEN 'W'
     END
     ||'%'
   OR MP_INT_RTE_NAME LIKE '%FR '
     ||ID_PREFIX
     ||' '
     ||ID_RTE_NO
     ||TRIM(MP_SUFFIX)
     ||' '
     ||
     CASE
       WHEN MP_DIRECTION ='E'
       THEN 'N'
       WHEN MP_DIRECTION ='W'
       THEN 'S'
       WHEN MP_DIRECTION ='N'
       THEN 'E'
       WHEN MP_DIRECTION ='S'
       THEN 'W'
     END
```

```
    ||'%')
  )
  WHERE RN       =1
  ) B ON (A.ROWID = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE
  SET A.RAMP = B.SEC_ATTRIBUTE;
  -- ROUTE IS A RAMP
  MERGE INTO FMG_BASE_SEGMENTS A USING
  (SELECT *
  FROM
   (SELECT DISTINCT F.ROWID ROW_ID,
    F.INV_BMP,
    F.INV_EMP,
    H.ID_MP,
    MP_INT_RTE_NAME SEC_ATTRIBUTE,
    ROW_NUMBER() OVER ( PARTITION BY F.ROWID ORDER BY ID_MP,MP_INT_RTE_NAME) RN
   FROM HMIS_MASTER_ALL_YEARS H ,
    FMG_BASE_SEGMENTS F
   WHERE H.YEAR       = INV_YEAR
   AND F.COLLECT_YEAR = COND_YEAR
     --    AND H.ROUTEID      = ROUTE_LIST.HMIS_ROUTEID
   AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
   AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
     --   AND F.INV_BMP     >= ROUTE_LIST.INV_BMP --CHANGED FROM ROUTE_LIST.DIR_BMP TO
INV_BMP OM 11/8 BY RG
     --  AND F.INV_EMP     <= ROUTE_LIST.INV_EMP --CHANGED FROM ROUTE_LIST.DIR_EMP TO
INV_EMP OM 11/8 BY RG
   AND F.HMIS_ROUTEID   = H.ROUTEID
   AND (F.INV_BMP      >= ID_MP
   AND F.INV_EMP       <= ID_MP +.1)
   AND MP_LOCATION_TYPE = 2
   AND ID_PREFIX        ='RP'
   AND (MP_INT_RTE_NAME LIKE '% '
    || TRIM(SUBSTR(ROAD_NAME,1,7))
    || '%')
   )
  WHERE RN       =1
  ) B ON (A.ROWID = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE
  SET A.RAMP = B.SEC_ATTRIBUTE;
  -- CAT ONE FEATURES
  MERGE INTO FMG_BASE_SEGMENTS A USING
  (SELECT *
  FROM
   (SELECT DISTINCT F.ROWID ROW_ID,
    F.INV_BMP,
    F.INV_EMP,
    H.ID_MP,
    CASE
     WHEN MP_INT_RTE_NAME LIKE '%TRAFFIC SIGNAL%'
     THEN 'TRAFFIC_SIGNAL'
     WHEN MP_INT_RTE_NAME LIKE '%STOP SIGN%'
     THEN 'STOP_SIGN'
     WHEN (MP_INT_RTE_NAME LIKE '%ROUNDABOUT%'
     AND MP_INT_RTE_NAME NOT LIKE '%END ROUNDABOUT%')
     THEN 'ROUND_ABOUT'
     WHEN MP_INT_RTE_NAME LIKE '%SPUR TO%'
     THEN 'GIVE_WAY'
     WHEN MP_INT_RTE_NAME LIKE '%RAILROAD CROSSING%'
```

```
      THEN 'RAIL_ROAD'
     END SEC_ATTRIBUTE,
     ROW_NUMBER() OVER ( PARTITION BY F.ROWID ORDER BY ID_MP,MP_INT_RTE_NAME) RN
    FROM HMIS_MASTER_ALL_YEARS H ,
     FMG_BASE_SEGMENTS F
    WHERE H.YEAR       = INV_YEAR
    AND F.COLLECT_YEAR = COND_YEAR
     --    AND H.ROUTEID      = ROUTE_LIST.HMIS_ROUTEID
    AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
    AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
     -- AND F.INV_BMP     >= ROUTE_LIST.INV_BMP --CHANGED FROM ROUTE_LIST.DIR_BMP TO
INV_BMP OM 11/8 BY RG
     --AND F.INV_EMP     <= ROUTE_LIST.INV_EMP --CHANGED FROM ROUTE_LIST.DIR_EMP TO
INV_EMP OM 11/8 BY RG
    AND F.HMIS_ROUTEID = H.ROUTEID
    AND (F.INV_BMP    >= ID_MP
    AND F.INV_EMP     <= ID_MP +.1)
    AND (MP_INT_RTE_NAME LIKE '%TRAFFIC SIGNAL%'
    OR MP_INT_RTE_NAME LIKE '%STOP SIGN%'
    OR (MP_INT_RTE_NAME LIKE '%ROUNDABOUT%'
    AND MP_INT_RTE_NAME NOT LIKE '%END ROUNDABOUT%')
    OR MP_INT_RTE_NAME LIKE '%SPUR TO%'
    OR MP_INT_RTE_NAME LIKE '%RAILROADC ROSSING%' )
    )
  WHERE RN       =1
  ) B ON (A.ROWID = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE
  SET A.CAT_ONE_FEATURES = B.SEC_ATTRIBUTE;
  -- PEDESTRIAN CROSSING
  MERGE INTO FMG_BASE_SEGMENTS A USING
  ( SELECT DISTINCT F.ROWID ROW_ID,
    F.INV_BMP,
    F.INV_EMP,-- H.MEDIAN_TY,
    --H.DIR_BMP, H.DIR_EMP,
    'PEDESTRIAN_CROSSING' SEC_ATTRIBUTE
  FROM EDW18_BASE_4@PAV_CONHIST_ASSET H ,
    FMG_BASE_SEGMENTS F
  WHERE F.COLLECT_YEAR = COND_YEAR
    --    AND H.ROUTEID      = ROUTE_LIST.HMIS_ROUTEID
  AND F.GLOBAL_ROUTE_ID= ROUTE_LIST.GLOBAL_ROUTE_ID
  AND F.SUB_ROUTE_ID   = ROUTE_LIST.SUB_ROUTE_ID
    -- AND  F.HMIS_ROUTEID     = '13000US00001  01NN**************'
    --   AND F.INV_BMP     >= ROUTE_LIST.DIR_BMP
    --  AND F.INV_EMP     <= ROUTE_LIST.DIR_EMP
  AND F.BMP              >= MIN_MP
  AND F.EMP              <= MAX_MP
  AND F.GLOBAL_ROUTE_ID      = H.GLOBAL_ROUTE_ID
  AND F.SUB_ROUTE_ID         = H.SUB_ROUTE_ID
  AND STATUS                 = 'MATCHED'
  AND EVENT_CROSSWALK_OFFICE = 1
  AND ( (H.DIR_EMP-.1       >=F.INV_BMP
  AND H.DIR_EMP            <=F.INV_EMP)
  OR (H.DIR_EMP-.1          <F.INV_BMP
  AND H.DIR_EMP             >F.INV_EMP)
  OR (H.DIR_EMP-.1         <=F.INV_BMP
  AND H.DIR_EMP             >F.INV_BMP) )
  ORDER BY 2
  ) B ON (A.ROWID = B.ROW_ID)
WHEN MATCHED THEN
  UPDATE SET A.CAT_ONE_FEATURES = B.SEC_ATTRIBUTE;
```

```
  -- SITE CATEGORY UPDATE
  --    UPDATE FMG_BASE_SEGMENTS
  --    SET SITE_CATEGORY       = 1
  --    WHERE (CAT_ONE_FEATURES IS NOT NULL-- CHANGED ON 9/17/2021 BASED ON EMAIL
FROM PD
  --    AND SPEED_LIMIT         ='ABOVE_55')
  --    AND SITE_CATEGORY       IS NULL
  --    AND GLOBAL_ROUTE_ID     = ROUTE_LIST.GLOBAL_ROUTE_ID
  --    AND SUB_ROUTE_ID        = ROUTE_LIST.SUB_ROUTE_ID;
  --    UPDATE FMG_BASE_SEGMENTS
  --    SET SITE_CATEGORY   = 2
  --    WHERE (CURVE      IS NOT NULL
  --    OR DOWNHILL_GRADE   ='DH_GRADE_10'
  --    OR RAMP           IS NOT NULL)
  --    AND SITE_CATEGORY  IS NULL
  --    AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
  --    AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID;
  --    UPDATE FMG_BASE_SEGMENTS
  --    SET SITE_CATEGORY         = 3
  --    WHERE ( (CAT_ONE_FEATURES IS NOT NULL
  --    AND SPEED_LIMIT          ='BELOW_55')-- CHANGED ON 9/17/2021 BASED ON EMAIL FROM PD
  --    OR ((INTERSECTIONS       IS NOT NULL
  --    OR DOWNHILL_GRADE         ='DH_GRADE_5_TO_10')
  --    AND SPEED_LIMIT          IN ('ABOVE_55','BELOW_55') )
  --    OR (DIVIDED              ='UNDIVIDED'
  --    AND SPEED_LIMIT          ='ABOVE_55'
  --    AND RUT                  ='HIGH_RUT') )
  --    AND SITE_CATEGORY         IS NULL
  --    AND GLOBAL_ROUTE_ID       = ROUTE_LIST.GLOBAL_ROUTE_ID
  --    AND SUB_ROUTE_ID          = ROUTE_LIST.SUB_ROUTE_ID;
  --    UPDATE FMG_BASE_SEGMENTS
  --    SET SITE_CATEGORY         = 4
  --    WHERE ( (CAT_ONE_FEATURES IS NOT NULL
  --    AND SPEED_LIMIT          ='BELOW_35')-- CHANGED ON 9/17/2021 BASED ON EMAIL FROM PD
  --    OR ( DIVIDED             ='UNDIVIDED'
  --    AND (SPEED_LIMIT         IN ('BELOW_55','BELOW_35')-- CHANGED ON 9/17/2021 BASED ON
EMAIL FROM PD
  --    OR RUT                  IS NULL) )
  --    OR ( (INTERSECTIONS      IS NOT NULL
  --    OR DOWNHILL_GRADE         ='DH_GRADE_5_TO_10')
  --    AND SPEED_LIMIT          IN ('BELOW_35') )
  --    OR (DIVIDED              ='DIVIDED'
  --    AND SPEED_LIMIT          ='ABOVE_55'
  --    AND RUT                  ='HIGH_RUT') )
  --    AND SITE_CATEGORY         IS NULL
  --    AND GLOBAL_ROUTE_ID       = ROUTE_LIST.GLOBAL_ROUTE_ID
  --    AND SUB_ROUTE_ID          = ROUTE_LIST.SUB_ROUTE_ID;
  --    UPDATE FMG_BASE_SEGMENTS
  --    SET SITE_CATEGORY   = 5
  --    WHERE ( DIVIDED      ='DIVIDED'
  --    AND (SPEED_LIMIT   IN ('BELOW_55','BELOW_35')-- CHANGED ON 9/17/2021 BASED ON EMAIL
FROM PD
  --    OR RUT           IS NULL) )
  --    AND SITE_CATEGORY  IS NULL
  --    AND GLOBAL_ROUTE_ID = ROUTE_LIST.GLOBAL_ROUTE_ID
  --    AND SUB_ROUTE_ID    = ROUTE_LIST.SUB_ROUTE_ID;
END IF;
COMMIT;
END LOOP;
UPDATE FMG_BASE_SEGMENTS
SET SITE_CATEGORY       = 1
```

```
WHERE (CAT_ONE_FEATURES IS NOT NULL-- CHANGED ON 9/17/2021 BASED ON EMAIL FROM PD
AND SPEED_LIMIT        ='ABOVE_55')
AND SITE_CATEGORY      IS NULL ;
UPDATE FMG_BASE_SEGMENTS
SET SITE_CATEGORY  = 2
WHERE (CURVE       = 'CURVE_750'-- CHANGED ON 10/07 BASED ON EMAIL FROM KM
OR DOWNHILL_GRADE  ='DH_GRADE_10'
OR RAMP            IS NOT NULL)
AND SITE_CATEGORY IS NULL ;
UPDATE FMG_BASE_SEGMENTS
SET SITE_CATEGORY        = 3
WHERE ( (CAT_ONE_FEATURES IS NOT NULL
AND SPEED_LIMIT          ='BELOW_55')-- CHANGED ON 9/17/2021 BASED ON EMAIL FROM PD
OR (INTERSECTIONS        IS NOT NULL
AND SPEED_LIMIT          IN ('ABOVE_55','BELOW_55') )
OR (DOWNHILL_GRADE       ='DH_GRADE_5_TO_10'
AND SPEED_LIMIT          IN ('ABOVE_55','BELOW_55') )
OR (DIVIDED              ='UNDIVIDED'
AND SPEED_LIMIT          ='ABOVE_55'
AND RUT                  ='HIGH_RUT')
OR (CURVE                = 'CURVE_1500' -- CHANGED ON 10/07 BASED ON EMAIL FROM KM
AND SPEED_LIMIT          IN ('ABOVE_55','BELOW_55') ))
AND SITE_CATEGORY        IS NULL ;
UPDATE FMG_BASE_SEGMENTS
SET SITE_CATEGORY        = 4
WHERE ( (CAT_ONE_FEATURES IS NOT NULL
AND SPEED_LIMIT          ='BELOW_35')-- CHANGED ON 9/17/2021 BASED ON EMAIL FROM PD
OR ( DIVIDED             ='UNDIVIDED'
AND (SPEED_LIMIT         IN ('BELOW_55','BELOW_35')-- CHANGED ON 9/17/2021 BASED ON EMAIL
FROM PD
OR RUT                   IS NULL) )
OR ( INTERSECTIONS       IS NOT NULL
AND SPEED_LIMIT          IN ('BELOW_35') )
OR ( DOWNHILL_GRADE      ='DH_GRADE_5_TO_10'
AND SPEED_LIMIT          IN ('BELOW_35') )
OR (DIVIDED              ='DIVIDED'
AND SPEED_LIMIT          ='ABOVE_55'
AND RUT                  ='HIGH_RUT')
OR (CURVE                = 'CURVE_1500' -- CHANGED ON 10/07 BASED ON EMAIL FROM KM
AND SPEED_LIMIT          IN ('BELOW_35') )
)
AND SITE_CATEGORY        IS NULL ;
UPDATE FMG_BASE_SEGMENTS
SET SITE_CATEGORY  = 5
WHERE ( DIVIDED    ='DIVIDED'
AND (SPEED_LIMIT  IN ('BELOW_55','BELOW_35')-- CHANGED ON 9/17/2021 BASED ON EMAIL FROM
PD
OR RUT          IS NULL)
)
AND SITE_CATEGORY IS NULL;
UPDATE FMG_BASE_SEGMENTS
SET SITE_CATEGORY =
  CASE
    WHEN SITE_CATEGORY IN (1,2)
    THEN 1
    WHEN SITE_CATEGORY IN (3)
    THEN 2
    WHEN SITE_CATEGORY IN (4,5)
    THEN 3
  END;
COMMIT;
```

```
END P_FMG_BASE_SEGMENTATION;
PROCEDURE P_FMG_INTERMED_SEGMENTATION
AS
  CURSOR C0
  IS
    SELECT SITE_CATEGORY FROM FMG_BASE_SEGMENTS;
TYPE TYP0
IS
  TABLE OF C0% ROWTYPE;
  TAB0 TYP0;
  CURSOR C1
  IS
    SELECT BMP,
      EMP
    FROM FMG_BASE_SEGMENTS;
TYPE TYP1
IS
  TABLE OF C1% ROWTYPE;
  TAB1 TYP1;
  V_BMP NUMBER;
  V_EMP NUMBER;
BEGIN
  EXECUTE IMMEDIATE' TRUNCATE TABLE FMG_FINAL_SEGMENTS';
  FOR SEG IN
  (SELECT DISTINCT COLLECT_YEAR,
    HMIS_ROUTEID,
    GLOBAL_ROUTE_ID,
    SUB_ROUTE_ID,
    GOVT_CONTROL
  FROM FMG_BASE_SEGMENTS
  )
  LOOP
    SELECT DISTINCT SITE_CATEGORY BULK COLLECT
    INTO TAB0
    FROM FMG_BASE_SEGMENTS
    WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
    AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
    AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
    AND GOVT_CONTROL    =SEG.GOVT_CONTROL
    ORDER BY SITE_CATEGORY ;
    FOR N IN 1..TAB0.COUNT
    LOOP
      SELECT BMP,
        EMP BULK COLLECT
      INTO TAB1
      FROM FMG_BASE_SEGMENTS
      WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
      AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
      AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
      AND GOVT_CONTROL    =SEG.GOVT_CONTROL
      AND SITE_CATEGORY   = TAB0(N).SITE_CATEGORY
      ORDER BY BMP;
      V_BMP := NULL;
      V_EMP := NULL;
      FOR I IN 1..TAB1.COUNT
      LOOP
        IF I            = 1 THEN
          V_BMP          := TAB1(I).BMP;
          V_EMP          := TAB1(I).EMP;
        ELSIF I            > 1 THEN
          IF TAB1(I).BMP     = TAB1(I - 1).EMP THEN
```

```
        V_EMP          := TAB1(I).EMP;
      ELSIF TAB1(I).BMP <> TAB1(I - 1).EMP THEN
        INSERT
        INTO FMG_FINAL_SEGMENTS
          (
            COLLECT_YEAR,
            HMIS_ROUTEID,
            GLOBAL_ROUTE_ID,
            SUB_ROUTE_ID,
            GOVT_CONTROL,
            BMP,
            EMP,
            SITE_CATEGORY_ORG
          )
          VALUES
          (
            SEG.COLLECT_YEAR,
            SEG.HMIS_ROUTEID,
            SEG.GLOBAL_ROUTE_ID,
            SEG.SUB_ROUTE_ID,
            SEG.GOVT_CONTROL,
            V_BMP,
            V_EMP,
            TAB0(N).SITE_CATEGORY
          );
        V_BMP := TAB1(I).BMP;
        V_EMP := TAB1(I).EMP;
      END IF;
    END IF;
    IF I = TAB1.COUNT THEN
      INSERT
      INTO FMG_FINAL_SEGMENTS
        (
          COLLECT_YEAR,
          HMIS_ROUTEID,
          GLOBAL_ROUTE_ID,
          SUB_ROUTE_ID,
          GOVT_CONTROL,
          BMP,
          EMP,
          SITE_CATEGORY_ORG
        )
        VALUES
        (
          SEG.COLLECT_YEAR,
          SEG.HMIS_ROUTEID,
          SEG.GLOBAL_ROUTE_ID,
          SEG.SUB_ROUTE_ID,
          SEG.GOVT_CONTROL,
          V_BMP,
          V_EMP,
          TAB0(N).SITE_CATEGORY
        );
    END IF;
  END LOOP;
 END LOOP;
END LOOP;
UPDATE FMG_FINAL_SEGMENTS SET SEC_LENGTH = EMP-BMP;
COMMIT;
END P_FMG_INTERMED_SEGMENTATION;
PROCEDURE P_FMG_FINAL_SEGMENTATION
```

```
AS
  CURSOR C0
  IS
    SELECT SITE_CATEGORY FROM FMG_BASE_SEGMENTS;
TYPE TYP0
IS
  TABLE OF C0% ROWTYPE;
  TAB0 TYP0;
  CURSOR C1
  IS
    SELECT BMP,
      EMP
    FROM FMG_BASE_SEGMENTS;
TYPE TYP1
IS
  TABLE OF C1% ROWTYPE;
  TAB1 TYP1;
  V_BMP NUMBER;
  V_EMP NUMBER;
BEGIN
  EXECUTE IMMEDIATE' TRUNCATE TABLE FMG_SITE_CATEGORY';
  FOR SEG IN
  (SELECT DISTINCT COLLECT_YEAR,
    HMIS_ROUTEID,
    GLOBAL_ROUTE_ID,
    SUB_ROUTE_ID,
    GOVT_CONTROL
  FROM FMG_BASE_SEGMENTS
    --WHERE COUNTY ='AL'
  )
  LOOP
    SELECT DISTINCT SITE_CATEGORY BULK COLLECT
    INTO TAB0
    FROM FMG_BASE_SEGMENTS
    WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
    AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
    AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
    AND GOVT_CONTROL    = SEG.GOVT_CONTROL
    ORDER BY SITE_CATEGORY ;
    FOR N IN 1..TAB0.COUNT
    LOOP
      SELECT BMP,
        EMP BULK COLLECT
      INTO TAB1
      FROM FMG_BASE_SEGMENTS
      WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
      AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
      AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
      AND GOVT_CONTROL    = SEG.GOVT_CONTROL
      AND SITE_CATEGORY   = TAB0(N).SITE_CATEGORY
      ORDER BY BMP;
      V_BMP := NULL;
      V_EMP := NULL;
      FOR I IN 1..TAB1.COUNT
      LOOP
        IF I               = 1 THEN
          V_BMP           := TAB1(I).BMP;
          V_EMP           := TAB1(I).EMP;
        ELSIF I            > 1 THEN
          IF TAB1(I).BMP     = TAB1(I - 1).EMP THEN
            V_EMP         := TAB1(I).EMP;
```

```
          ELSIF TAB1(I).BMP <> TAB1(I - 1).EMP THEN
           INSERT
           INTO FMG_SITE_CATEGORY
            (
             COLLECT_YEAR,
             HMIS_ROUTEID,
             GLOBAL_ROUTE_ID,
             SUB_ROUTE_ID,
             GOVT_CONTROL,
             BMP,
             EMP,
             SITE_CATEGORY
            )
            VALUES
            (
             SEG.COLLECT_YEAR,
             SEG.HMIS_ROUTEID,
             SEG.GLOBAL_ROUTE_ID,
             SEG.SUB_ROUTE_ID,
             SEG.GOVT_CONTROL,
             V_BMP,
             V_EMP,
             TAB0(N).SITE_CATEGORY
            );
           V_BMP := TAB1(I).BMP;
           V_EMP := TAB1(I).EMP;
          END IF;
         END IF;
         IF I = TAB1.COUNT THEN
          INSERT
          INTO FMG_SITE_CATEGORY
           (
            COLLECT_YEAR,
            HMIS_ROUTEID,
            GLOBAL_ROUTE_ID,
            SUB_ROUTE_ID,
            GOVT_CONTROL,
            BMP,
            EMP,
            SITE_CATEGORY
           )
           VALUES
           (
            SEG.COLLECT_YEAR,
            SEG.HMIS_ROUTEID,
            SEG.GLOBAL_ROUTE_ID,
            SEG.SUB_ROUTE_ID,
            SEG.GOVT_CONTROL,
            V_BMP,
            V_EMP,
            TAB0(N).SITE_CATEGORY
           );
         END IF;
        END LOOP;
       END LOOP;
      END LOOP;
      COMMIT;
END P_FMG_FINAL_SEGMENTATION;
PROCEDURE P_FMG_ATTRIBUTE_UPDATE
AS
TYPE TYPE1
```

```
IS
  TABLE OF VARCHAR2
  (
    4000
  )
  ;
  TAB1 TYPE1;
  SEC_ATTRIBUTE VARCHAR2(4000);
BEGIN
  FOR SEG IN
  (SELECT COLLECT_YEAR,
      GLOBAL_ROUTE_ID,
      SUB_ROUTE_ID,
      BMP,
      EMP
    FROM FMG_SITE_CATEGORY
      --WHERE GLOBAL_ROUTE_ID =805
    ORDER BY COLLECT_YEAR,
      GLOBAL_ROUTE_ID,
      SUB_ROUTE_ID,
      BMP
  )
  LOOP
    /*** DIVIDED ***/
    SELECT DISTINCT DIVIDED BULK COLLECT
    INTO TAB1
    FROM FMG_BASE_SEGMENTS
    WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
    AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
    AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
    AND BMP             >= SEG.BMP
    AND EMP             <= SEG.EMP
      -- AND DIVIDED        IS NOT NULL
      ;
    SEC_ATTRIBUTE :=NULL;
    FOR I IN 1..TAB1.COUNT
    LOOP
      IF I           =1 THEN
        SEC_ATTRIBUTE:= TAB1(I);
        --  DBMS_OUTPUT.PUT_LINE('LINE 1'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
      END IF;
      IF I >1 --AND I          <TAB1.COUNT
        THEN
        SEC_ATTRIBUTE:= SEC_ATTRIBUTE||','||TAB1(I);
        --  DBMS_OUTPUT.PUT_LINE('LINE 2'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
      END IF;
      IF I =TAB1.COUNT THEN
        -- DBMS_OUTPUT.PUT_LINE('LINE 3'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
        UPDATE FMG_SITE_CATEGORY
        SET DIVIDED         = SEC_ATTRIBUTE
        WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
        AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
        AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
        AND BMP             = SEG.BMP
        AND EMP             = SEG.EMP;
      END IF;
    END LOOP;
    /*** SPEED LIMIT ****/
    SELECT DISTINCT SPEED_LIMIT BULK COLLECT
    INTO TAB1
    FROM FMG_BASE_SEGMENTS
```

```
WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
AND BMP          >= SEG.BMP
AND EMP          <= SEG.EMP
  --AND SPEED_LIMIT    IS NOT NULL
  ;
SEC_ATTRIBUTE :=NULL;
FOR I IN 1..TAB1.COUNT
LOOP
  IF I          =1 THEN
    SEC_ATTRIBUTE:= TAB1(I);
  END IF;
  IF I >1 --AND I          <TAB1.COUNT
    THEN
    SEC_ATTRIBUTE:= SEC_ATTRIBUTE||','||TAB1(I);
  END IF;
  IF I =TAB1.COUNT THEN
    UPDATE FMG_SITE_CATEGORY
    SET SPEED_LIMIT     = SEC_ATTRIBUTE
    WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
    AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
    AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
    AND BMP             = SEG.BMP
    AND EMP             = SEG.EMP;
  END IF;
END LOOP;
/*** RUT ***/
SELECT DISTINCT
  CASE
    WHEN RUT IS NULL
    THEN 'LOW_RUT'
    ELSE RUT
  END BULK COLLECT
INTO TAB1
FROM FMG_BASE_SEGMENTS
WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
AND BMP          >= SEG.BMP
AND EMP          <= SEG.EMP
  -- AND RUT           IS NOT NULL
  ;
SEC_ATTRIBUTE :=NULL;
FOR I IN 1..TAB1.COUNT
LOOP
  IF I          =1 THEN
    SEC_ATTRIBUTE:= TAB1(I);
    --   DBMS_OUTPUT.PUT_LINE('LINE 1'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
  END IF;
  IF I >1 --AND I          <TAB1.COUNT
    THEN
    SEC_ATTRIBUTE:= SEC_ATTRIBUTE||','||TAB1(I);
    -- DBMS_OUTPUT.PUT_LINE('LINE 2'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
  END IF;
  IF I =TAB1.COUNT THEN
    UPDATE FMG_SITE_CATEGORY
    SET RUT            = SEC_ATTRIBUTE
    WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
    AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
    AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
```

```
    AND BMP          = SEG.BMP
    AND EMP          = SEG.EMP;
  END IF;
END LOOP;
/*** INTERSECTIONS ***/
SELECT DISTINCT INTERSECTIONS BULK COLLECT
INTO TAB1
FROM FMG_BASE_SEGMENTS
WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
AND BMP          >= SEG.BMP
AND EMP          <= SEG.EMP
AND INTERSECTIONS  IS NOT NULL ;
SEC_ATTRIBUTE      :=NULL;
FOR I IN 1..TAB1.COUNT
LOOP
  IF I          =1 THEN
    SEC_ATTRIBUTE:= TAB1(I);
    -- DBMS_OUTPUT.PUT_LINE('LINE 1'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
  END IF;
  IF I >1 --AND I          <TAB1.COUNT
    THEN
    SEC_ATTRIBUTE:= SEC_ATTRIBUTE||','||TAB1(I);
    -- DBMS_OUTPUT.PUT_LINE('LINE 2'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
  END IF;
  IF I =TAB1.COUNT THEN
    -- DBMS_OUTPUT.PUT_LINE('LINE 3'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
    UPDATE FMG_SITE_CATEGORY
    SET INTERSECTIONS   = SEC_ATTRIBUTE
    WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
    AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
    AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
    AND BMP          = SEG.BMP
    AND EMP          = SEG.EMP;
  END IF;
END LOOP;
/*** DOWNHILL_GRADE ***/
SELECT DISTINCT
  CASE
    WHEN DOWNHILL_GRADE IS NULL
    THEN 'NO_GRADE'
    ELSE DOWNHILL_GRADE
  END BULK COLLECT
INTO TAB1
FROM FMG_BASE_SEGMENTS
WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
AND BMP          >= SEG.BMP
AND EMP          <= SEG.EMP
  -- AND DOWNHILL_GRADE          IS NOT NULL
  ;
SEC_ATTRIBUTE :=NULL;
FOR I IN 1..TAB1.COUNT
LOOP
  IF I          =1 THEN
    SEC_ATTRIBUTE:= TAB1(I);
    -- DBMS_OUTPUT.PUT_LINE('LINE 1'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
  END IF;
  IF I >1 --AND I          <TAB1.COUNT
```

```
    THEN
    SEC_ATTRIBUTE:= SEC_ATTRIBUTE||','||TAB1(I);
    --   DBMS_OUTPUT.PUT_LINE('LINE 2'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
  END IF;
  IF I =TAB1.COUNT THEN
    UPDATE FMG_SITE_CATEGORY
    SET DOWNHILL_GRADE  = SEC_ATTRIBUTE
    WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
    AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
    AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
    AND BMP             = SEG.BMP
    AND EMP             = SEG.EMP;
  END IF;
END LOOP;
/*** RAMP ***/
SELECT DISTINCT RAMP BULK COLLECT
INTO TAB1
FROM FMG_BASE_SEGMENTS
WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
AND BMP           >= SEG.BMP
AND EMP           <= SEG.EMP
AND RAMP           IS NOT NULL ;
SEC_ATTRIBUTE      :=NULL;
FOR I IN 1..TAB1.COUNT
LOOP
  IF I           =1 THEN
    SEC_ATTRIBUTE:= TAB1(I);
    --  DBMS_OUTPUT.PUT_LINE('LINE 1'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
  END IF;
  IF I >1 --AND I          <TAB1.COUNT
    THEN
    SEC_ATTRIBUTE:= SEC_ATTRIBUTE||','||TAB1(I);
    --  DBMS_OUTPUT.PUT_LINE('LINE 2'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
  END IF;
  IF I =TAB1.COUNT THEN
    -- DBMS_OUTPUT.PUT_LINE('LINE 3'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
    UPDATE FMG_SITE_CATEGORY
    SET RAMP            = SEC_ATTRIBUTE
    WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
    AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
    AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
    AND BMP             = SEG.BMP
    AND EMP             = SEG.EMP;
  END IF;
END LOOP;
/*** CURVE ***/
SELECT DISTINCT
  CASE
    WHEN CURVE IS NULL
    THEN 'NO_CURVE'
    ELSE CURVE
  END BULK COLLECT
INTO TAB1
FROM FMG_BASE_SEGMENTS
WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
AND BMP           >= SEG.BMP
AND EMP           <= SEG.EMP
```

```
    -- AND CURVE          IS NOT NULL
    ;
  SEC_ATTRIBUTE :=NULL;
  FOR I IN 1..TAB1.COUNT
  LOOP
   IF I          =1 THEN
    SEC_ATTRIBUTE:= TAB1(I);
    --  DBMS_OUTPUT.PUT_LINE('LINE 1'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
   END IF;
   IF I >1 --AND I          <TAB1.COUNT
    THEN
    SEC_ATTRIBUTE:= SEC_ATTRIBUTE||','||TAB1(I);
    --  DBMS_OUTPUT.PUT_LINE('LINE 2'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
   END IF;
   IF I =TAB1.COUNT THEN
    UPDATE FMG_SITE_CATEGORY
    SET CURVE          = SEC_ATTRIBUTE
    WHERE COLLECT_YEAR  = SEG.COLLECT_YEAR
    AND GLOBAL_ROUTE_ID = SEG.GLOBAL_ROUTE_ID
    AND SUB_ROUTE_ID    = SEG.SUB_ROUTE_ID
    AND BMP            = SEG.BMP
    AND EMP            = SEG.EMP;
   END IF;
  END LOOP;
  /*** CAT_ONE_FEATURES ***/
  SELECT DISTINCT CAT_ONE_FEATURES BULK COLLECT
  INTO TAB1
  FROM FMG_BASE_SEGMENTS
  WHERE COLLECT_YEAR    = SEG.COLLECT_YEAR
  AND GLOBAL_ROUTE_ID   = SEG.GLOBAL_ROUTE_ID
  AND SUB_ROUTE_ID      = SEG.SUB_ROUTE_ID
  AND BMP              >= SEG.BMP
  AND EMP              <= SEG.EMP
  AND CAT_ONE_FEATURES IS NOT NULL ;
  SEC_ATTRIBUTE       :=NULL;
  FOR I IN 1..TAB1.COUNT
  LOOP
   IF I          =1 THEN
    SEC_ATTRIBUTE:= TAB1(I);
    --  DBMS_OUTPUT.PUT_LINE('LINE 1'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
   END IF;
   IF I >1 --AND I          <TAB1.COUNT
    THEN
    SEC_ATTRIBUTE:= SEC_ATTRIBUTE||','||TAB1(I);
    --  DBMS_OUTPUT.PUT_LINE('LINE 2'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
   END IF;
   IF I =TAB1.COUNT THEN
    -- DBMS_OUTPUT.PUT_LINE('LINE 3'||'-'||SEG.BMP||'-'||SEC_ATTRIBUTE);
    UPDATE FMG_SITE_CATEGORY
    SET CAT_ONE_FEATURES = SEC_ATTRIBUTE
    WHERE COLLECT_YEAR   = SEG.COLLECT_YEAR
    AND GLOBAL_ROUTE_ID  = SEG.GLOBAL_ROUTE_ID
    AND SUB_ROUTE_ID     = SEG.SUB_ROUTE_ID
    AND BMP             = SEG.BMP
    AND EMP             = SEG.EMP;
   END IF;
  END LOOP;
  COMMIT;
 END LOOP;
END P_FMG_ATTRIBUTE_UPDATE;
END FRICTION_GUIDE_PKG;
```

11.15 CHANGE LOG

The following lists the changes made since the previous version of this Guide was published on-line.

Last Publish Date:

Date	Section	Change
10/18/2021	7.01.01	Site Categories were reduced from 5 to 3 and, consequently, Site Category descriptions, Investigatory Skid Numbers, and Intervention Skid Numbers were revised. The Site Category table was updated accordingly.
10/18/2021	7.02.05	The procedures were updated to reflect the changes made to the Site Category table.
10/18/2021	7.05.05	The procedures, the update of skid data collection list steps and the example skid data collection list table were revised to reflect the changes made to the Site Category table.
10/18/2021	11.14	Friction SQL package was updated to reflect the changes in the Site Categories