PILOT IMPLEMENTATION OF INTEGRATED MATERIALS DATABASE

Task Order No. 4
Advanced Pavement and Materials Technical Assistance

FINAL REPORT
MDSHA Project No. SP108B4Z

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PILOT IMPLEMENTATION OF INTEGRATED MATERIALS DATABASE

OBJECTIVE

The objective of this project was to assist the Maryland State Highway Administration (MDSHA) in its pilot implementation of an integrated materials database for paving projects in Maryland. This Maryland Materials Database is intended to combine inventory, design, materials, construction, and performance data. Information for this database is obtained from existing MDSHA applications/databases, the MarylandWare mix design and QC/QA applications, and new applications/databases to be developed by MDSHA.

The University of Maryland's role was to modify the MarylandWare software to collect additional data fields required by the integrated materials database, to add pay factor calculation and reporting routines to the MarylandWare QC/QA module, and to implement suitable data export functionality for transferring data from the MarylandWare software to the integrated database.

WORK PLAN

The original work plan for this Task Order was organized into five subtasks:

Subtask 1: Modifications to MarylandWare Data Entry and Storage
Subtask 2: Addition of Pay Factor Routine
Subtask 3: Development of Data Export Utility
Subtask 4: Provide On-Site Assistance
Subtask 5: Implementation Report

Two additional subtasks were subsequently added to the work plan:

Subtask 6: Procure HMAView License
Subtask 7: Addition of Electronic Document and Image Storage Capability

This final report describes all software modifications and other work performed under this Task Order.

PROJECT ACCOMPLISHMENTS

The project accomplishments under each subtask are summarized in the following subsections.

Subtask 1: Modifications to MarylandWare Data Entry and Storage

Many desirable modifications to the MarylandWare software had been identified during planning meetings prior to the start of work under this Task Order. Definitions of lots and sublots (both for mix and for cores), the spatial referencing system (e.g., translations between latitude/longitude, milepoint, and station), and Mix Design/JMF identification standards (including the ability to change mix design or JMF IDs) were some of the key items requiring enhancement in the MarylandWare program.

Specific modifications made to the MarylandWare software and/or database to address data entry and storage issues include the following:

- Addition[1] of fields for aggregate type and aggregate source for Aggregate and RAP stockpiles. *Note: The new fields are added to the database via the UpgradeDB routine in order to maintain backward compatibility with older versions of the software.*
- Addition[2] of LA Abrasion, sulfate resistance, polish, and deleterious materials as default user-defined properties for Aggregate and RAP stockpiles. *Note: The UpgradeDB_2_3 routine populates these property fields with MDSHA-specific values (after checking that these properties have not previously been defined and/or that the user approved of overwriting any old user-defined properties and deleting all corresponding data). A Format field was also added to the UserTestMethods table for use in the frmEditAggregate and frmEditRap editing screens to display the user-defined properties in the correct format..*
- Addition[1] of paving contractor data field.
- Addition[2] of core thickness to material properties.
- Addition[1] of latitude and longitude fields for test data. *Note: These new fields are added to the TestData table via the UpgradeDB routine to maintain backward compatibility with earlier versions of the software and database. In addition, improvements were made to the frmEnterTestData editing screen for formatting of the test data display, automatic default entry of last-entered date/latitude/longitude, and deletion of empty records.*
- Checking of previous lists of bugs/desired modifications from Task Order No. 2 to ensure that all had been completed and tested.
- Modification of reports to include new/modified data fields.

Other miscellaneous small modifications made as part of subtask 1 include the following:

- QC/QA version set to 2.3.1. Same for all other modules.
- Fixed bug in frmNewID for QC/QA ProjectID; wasn't checking to make sure that ProjectID did not already exist in the database.
- Repopulated SortOrder and PropertyNumber in QCQAProgramOptions!GlobalProperties. PropertyNumber now contains the property number for the MD Materials database.
- Modified Help..Technical Support to refer to MarylandWare rather than AASHTOware.
- Modified Help…About to refer to MarylandWare instead of AASHTOware as appropriate.
- Fixed bug in data import routine: Could import producer's export file once into QC module, but then could not import updates. *Note*: Added call to InCollection in AreDifferentRecords routine to make sure that database record field is in import file Fields collection.

The installation CD for MarylandWare Version 2.3.1 (September 2002) incorporated all of the modifications listed above. This version of the program was used for pilot project data collection on the I-68 overlay project (Little Orleans west to M.V. Smith) constructed in the late summer and fall of 2002.

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[1] Includes modification of data entry screens and modification of underlying database.
[2] Implemented using the user-defined property feature of MarylandWare.

Some additional minor bugs (including some incompatibility problems caused by new versions of Microsoft Windows and Microsoft Office) were subsequently identified and fixed in Version 2.3.2 (March 2003). A new master installation CD was created for Version 2.3.2; 65 copies of this CD were produced and delivered to MDSHA in March 2003 for distribution to asphalt producers and contractors working for MDSHA. Note that Version 2.3.2 did not include an operational version of the pay factor routine (subtask 2).

Additional bugs/possible bugs/desired improvements in the MarylandWare data entry and storage routines have been identified since Version 2.3.2. These are listed in Appendix A. Note that this listing does not include the items identified in meetings at MDSHA in October and December 2004 after completion of work under this Task Order; these additional items are the subject of a separate proposal.

Subtask 2: Addition of Pay Factor Routine

Background

At the start of this task order, MDSHA used three sets of programs to collect QC/QA data and/or compute pay factors under their old specification:

1. *DOS Pay Factor Program.* Only MDSHA used this program. MDSHA receives paper copies of QC data from its contractors and QA data from state inspectors and then manually enters these into the program. The program computes the pay factors and generates reports.

2. *Access Database + Excel Spreadsheet*. The MDSHA and some of its contractors use this Access database developed internally by MDSHA for entering QC data. The contractors enter their QC data directly into the Access database and then send the database to MDSHA. At MDSHA the data are exported from Access into an Excel spreadsheet for calculation of the pay factors.

3. *MarylandWare QC Program*. This program in its original form only collects QC data but does not analyze it.

The overall objective behind the work in this subtask is to eliminate the first two sets of programs and consolidate everything into the MarylandWare software.

A separate program has been developed by The iEngineering Corporation for performing pay factor calculations under the new specification originally scheduled for implementation in 2003. Although the iEngineering software draws its data from the MarylandWare database, the "new" pay factor program did not have any bearing on the implementation of the "old" pay factor in the MarylandWare QC program.

MDSHA Pay Factor Specifications

The "old" specification for pay factor is in two parts: mix (production) pay factor and density (in-place) pay factor.

Mix Pay Factor

- Mix pay factor is based on QC tests performed by the producer at the plant. One set of QC tests is performed per mix sublot.

- A mix sublot is defined as one day's production or 1000 tons, whichever comes first. A mix lot is defined as 6000 tons. However, this information is not necessary since the pay factor is calculated over all lots within a specified time window (see next point).
- Mix pay factor is determined based on all sublots for all mixes produced by a given plant/producer over a specified time window.
- The pay factor algorithm is based upon deviations of the measured volumetric/gradation properties for each lot from the target values. Details of the production pay factor algorithm are given in *Statistical Analysis of Material Using Quality Level Analysis--MSMT Designation 730* (see Appendix B). Some additional definition of terms in this report: x = deviation of a given measured property value for a given sublot from the target; n = number of sublots within the specified production time window. The "allowable deviations" used in determining USL and LSL for each property are given in the computer printout *Mix PWSL/Pay Factor Summary Based on Prod Data* (see Appendix B) and in supplementary specification materials provided by MDSHA. The allowable deviations are fixed, and no adjustments are permitted by the user. However, the allowable deviations are different for Superpave dense graded and gap-graded mixes.
- In addition to the QC tests performed by the producer, the state performs QA tests to check producer test values. The acceptance criterion is that the QA test values must be within 2 standard deviations of the producer's mean QC value for the property as determined by the producer's QC data for the specified time period. The specified time period is defined from start of lot to the day of the QA test (usually corresponding to 6,000 tons of production).

Density Pay Factor

- Density pay factor is based upon nuclear gauge QC tests performed by the paving contractor at the job site. One nuclear gauge test is performed per in-place sublot.
- A density sublot is defined as 200 tons of in-place mixture. A density lot is defined as one day's production.
- Density pay factor is determined based on all nuclear gauge QC tests performed for a given mix at a given project for the specified day.
- Density pay factor is computed using techniques similar to those for mix pay factors. Detailed specification information have been provided by MDSHA.
- No QA tests are required for density.

All of the above refers to the "old" pay factor specification. Implementation of the "new" MDSHA pay factor specification began in 2003.

Implementation of Pay Factor Calculation into the MarylandWare QC Program

Database Changes/Issues

Changes to table structures are implemented in the code via the UpgradeDB subprogram in DBUpgrade source code module. This routine upgrades old database structures to maintain backward compatibility with the new code. Note that although the code creates the new table structure elements, it does not assign any values for these new fields to the existing records in the table (except for TestData table, as described below).

Specific modifications to the database structure performed as part of the pay factor implementation are as follows:

1. In ProjectInfo table, three sets of PlantID, PlantType, PlantLocation, MaximumCapacity fields were added. The two new sets are differentiated using suffixes of 2 and 3, respectively, except for PlantID1. Original field names, including MaterialsSupplier instead of PlantID for the first supplier, are retained for set 1 in order to maintain backward compatibility of the database.

2. A MixType field was added to the MixDesigns table. Permitted values are V=Virgin, R=RAP, T=Trinidad Lake Asphalt, GL=Glass, G=Gap-Graded, H=High Polish, and Null.

3. Changes to ProjectJMFS: A PlantID field was added to the ProjectJMFs table; a MixDesignID field was also added to this table so that mix type can be determined from corresponding mix design record. A PlantID was also added to the ProjectLTMFs table; however, here an additional MixDesignID field was not required as the mix type can be determined from corresponding mix design record.

4. A DustAsphaltRatio field was added to ProjectJMFs table.

5. A Boolean QAData field was added to the TestData table, with a default value of "False". The DBUpdate routine updates the QAData field for all records after field has been added to table.

6. Dust-to-Asphalt, Gmb, and % Gmb @ Nmax properties were added to the QCQAProgramOptions!GlobalProperties table.

7. A new PayFactorTolerances table was added to QCQAProgramOptions.mdb. The fields in the PayFactorTolerances table are as follows:

Field Name	Description	Type (length)
Property	Property name	Text (72)
MixType	Mix type; permitted values = "V", "R", "G"	Text (2)
NominalMaxSize	Nominal maximum aggregate size	Single
LowTol	Low tolerance for pay factor	Single
HighTol	High tolerance for pay factor	Single
LowSpec	Low specification limit for acceptance	Single
HighSpec	High specification limit for acceptance	Single

The fields were using values from the MDSHA specification as summarized in the Table 1 and Table 2 below. The ProjectJMFs field corresponding to each property is included for informational purposes.

Table 1. Pay Factor/Acceptance Tolerances for Dense Graded HMA (MixType=V or R)

Property	ProjectJMFs field	LowTol	HighTol	LowSpec	HighSpec
% Passing 50.0mm	Targetp50_0	-7	7	(Note 1)	(Note 1)
% Passing 37.5mm	Targetp37_5	-7	7	(Note 1)	(Note 1)
% Passing 25.0mm	Targetp25_0	-7	7	(Note 1)	(Note 1)

% Passing 19.0mm	Targetp19_0	-7	7	(Note 1)	(Note 1)
% Passing 12.5mm	Targetp12_5	-7	7	(Note 1)	(Note 1)
% Passing 9.5mm	Targetp9_5	-7	7	(Note 1)	(Note 1)
% Passing 4.75mm	Targetp4_75	-7	7	(Note 1)	(Note 1)
% Passing 2.36mm	Targetp2_36	-4	4	(Note 1)	(Note 1)
% Passing 1.18mm	Targetp1_18	-4	4	(Note 1)	(Note 1)
% Passing 0.60mm	Targetp0_60	-4	4	(Note 1)	(Note 1)
% Passing 0.30mm	Targetp0_30	-4	4	(Note 1)	(Note 1)
% Passing 0.15mm	Targetp0_15	-4	4	(Note 1)	(Note 1)
% Passing 0.075mm	Targetp0_075	-2	2	(Note 1)	(Note 1)
AC	Measured Pb	-0.40	0.40	(Note 1)[2]	(Note 1)[2]
Gmm	Measured Gmm	-0.030	0.030	(Note 1)	(Note 1)
Gmb	Measured Gmb	-0.022	0.022	(Note 1)	(Note 1)
% Gmb @ Nmax	Nmaximum Gmb	None	0.5	(Note 1)	(Note 1)
VTM	Ndesign Air Voids	-1.2[3]	1.2[3]	2.8[4]	5.2[4]
VMA[5]	Ndesign VMA	-1.2	1.2	(Note 1)	(Note 1)
VFA[5]	Ndesign VFA	-5	5	65	75
Dust-to-Asphalt[5]	Dust-to-Asphalt	--	--	0.6	1.6

[1]Use Target±Tolerance for specification limits.
[2]AC content between 5 to 8% for 4.75mm mixes.
[3]±2.0 for 4.75mm mixes.
[4]VTM between 2.0 and 5.0 for 4.75mm mixes.
[5]Does not apply to 4.75mm mixes.

Table 2. Pay Factor/Acceptance Tolerances for Gap Graded HMA (MixType=G)

Property	ProjectJMFs field	LowTol	HighTol	LowSpec	HighSpec
% Passing 50.0mm	Targetp50_0	--	--	--	--
% Passing 37.5mm	Targetp37_5	--	--	--	--
% Passing 25.0mm	Targetp25_0	--	--	--	--
% Passing 19.0mm	Targetp19_0	--	--	100	100
% Passing 12.5mm	Targetp12_5	-5	5	90	99
% Passing 9.5mm	Targetp9_5	-5	5	70	85
% Passing 4.75mm	Targetp4_75	-4	4	30	22
% Passing 2.36mm	Targetp2_36	-4	4	20	33
% Passing 1.18mm	Targetp1_18	-4	4	--	--
% Passing 0.60mm	Targetp0_60	-3	3	--	--
% Passing 0.30mm	Targetp0_30	-3	3	--	--
% Passing 0.15mm	Targetp0_15	-3	3	--	--
% Passing 0.075mm	Targetp0_075	-2	2	8	11
AC	Measured Pb	-0.40	0.40	6.5	--
Gmm	Measured Gmm	--	--	---	--
Gmb	Measured Gmb	--	--	--	--
VTM	Ndesign Air Voids	-1.2	1.2	2.8	5.2
VMA	Ndesign VMA	--	N.A.	17.0	--
VFA	Ndesign VFA	-5	5	65	75
Dust-to-Asphalt	Dust-to-Asphalt	--	--		--

Program Modifications

1. Changed code in frmProjectInfo_General to allow for input of up to 3 sets of PlantID, PlantType, PlantLocation, and MaximumCapacity fields. Also changed Production and In-Place QC/QA reports accordingly.

2. In mnuImportMixDesigns_Click routine in MDIForm1, MixType is now set to V or R (based on value of the true/false RAP field in the MixDesigns table in md.mdb) after import of each mix design. Added code to make this backward-compatible—i.e., populate the MixType fields to the MixDesign and ProjectLTMFs tables if a value does not already exist.

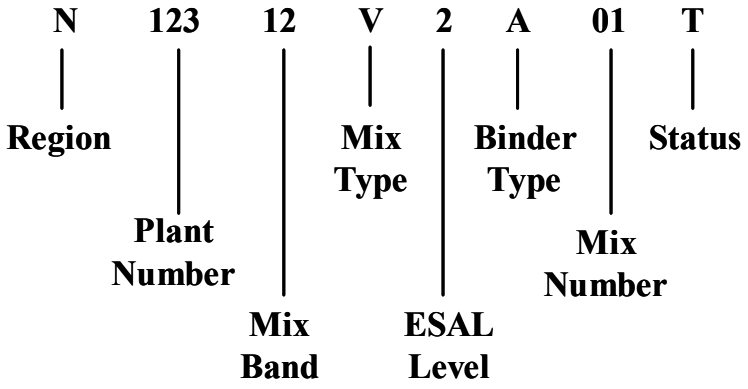
3. A Mix Type list box was added to frmEditMixDesign. Permitted values are V=Virgin, R=RAP, T=Trinidad Lake Asphalt, GL=Glass, G=Gap-Graded, H=High Polish, and Null. The default value for the MixType list box is extracted from the MixDesignID field; see the *2002 HMA Mix Design Number* documentation in Figure 1 for details.

4. Add code to cmdNew_Click routine in frmCreateJMF_JMFID to populate ProjectLTMFs!PlantID field. The value for the PlantID field is extracted from the JMFID field (lblBlendID.Text); see the *2002 HMA Mix Design Number* documentation in Figure 1 for details.

5. In the Form_Load routine in frmLotDefinitions, the PlantID, MixDesignID, and Dust Asphalt Ratio fields are populated if necessary.

6. Added code to QCQA project import/export to include new fields added to database.

2002 HMA Mix Design Number



Plant Number – The identification number of the plant

Mix Band – Old Mixes: **SF, SC, BC, BF, SR, SMA**
New Mixes: **04** (0.75), **09** (9.5), **12** (12.5), **19** (19.0), **25** (25.0), **37** (37.5)

Mix Type – **V**irgin, **R**ap, **T**LA (Trinidad Lake Asphalt), **Gl**ass, **G**ap Grade, **H**igh Polish

ESAL Level – (Refer to Proposed PP-28 Table 1)

Old Levels: A <0.3, **B** <1, **C** <3, **D** <10, **E** <30, **F** <100, **G** ≥100

New Levels:

Level	Design ESALs (Millions)	Compaction Parameters		
		Nini	Ndes	Nmax
1	< 0.3	6	50	75
2	0.3 to < 3	7	75	115
3	3 to < 10	8	100	160[a]
4	10 to 30	8	100	160[a]
5	>30	9	125	205

[a]Levels differ in required angularity, refer to aggregate consensus properties.

Binder Type – **A** (58-22), **B** (58-28), **C** (64-22), **D** (64-28), **E** (70-22), **F** (76-22)

Mix Number – **01** to **99**

Status – **T**entative, **F**inal

Figure 1. MDSHA mix design naming conventions.

Program Additions

1. Import Old QC Data selection added to File..Import menu.

2. A new routine was implemented for importing old QC data from the State Results table in the MDSHA Mix and Test Data database. This routine imports the JMF target values as well as the old QC data; see Appendix C documenting the JMF"s table in Mix and Test Data.mdb. When importing QC data from State Results table, the QAData field in the TestData table is set to "True".

3. Added a Tools menu to the menu bar, with menu selections Tools..Mix Pay Factor and Tools..Density Pay Factor (Figure 2).

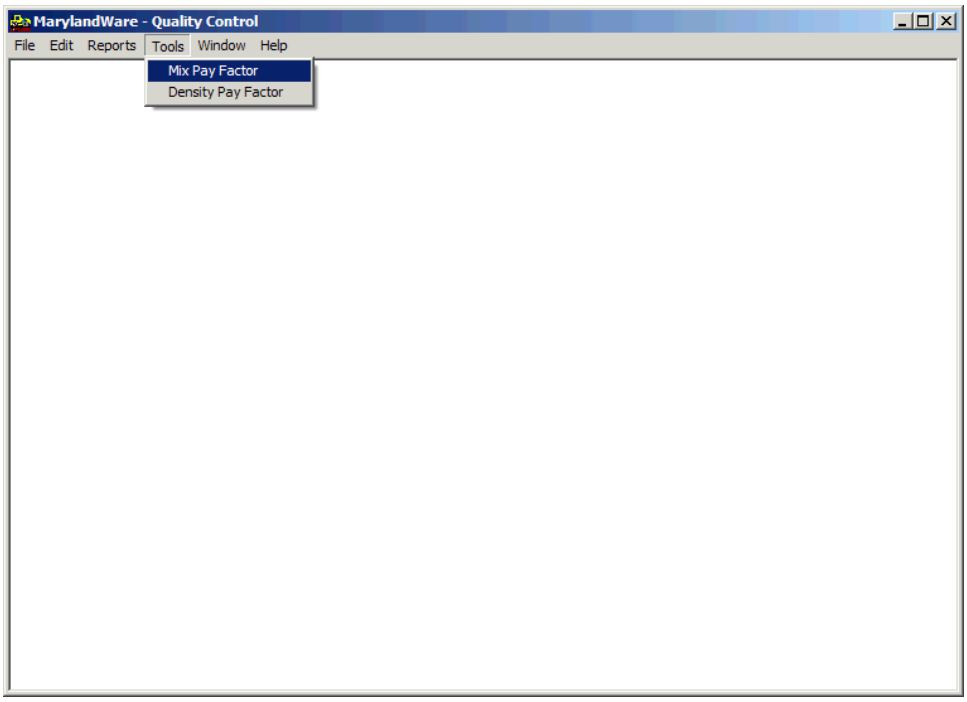


Figure 2. New Tools… menu for accessing pay factor calculations in QC/QA module.

4. Designed a new Mix Pay Factor query form (Figure 3). This form determines the list of ProjectID and JMFID values to be processed in the pay factor calculation. Input fields on the form include:

   - Producer drop list box, populated with PlantID values extracted from the PlantID field in the ProjectJMFs. Duplicate entries are removed and remaining entries are sorted alphabetically before displaying in the list box.
   - Begin Date text box; includes error checking to ensure that the entry is a valid date that occurs before the End Date value.
   - End Date text box; includes error checking to ensure that the entry is a valid date that occurs after the Begin Date value.
   - Compute Pay Factor command button. On click, the program performs all error checks on the input data, determines the list of JMFIDs corresponding to the specified PlantID

using data from the ProjectJMFs table, and then passes control to the Mix Pay Factor calculation routines.

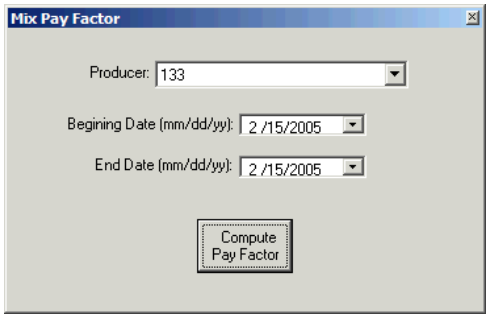


Figure 3. Mix pay factor query screen.

5. Designed and implemented the Mix Pay Factor reports (Figure 4, Figure 5). See Appendix B for documentation of the "old" mix pay factor calculation algorithm.

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MIX PWSL/PAY FACTOR SUMMARY BASED ON PRODUCTION DATA

Producer: 133
Start Date: 2/15/2000 **End Date:** 2/15/2005

Property	Tolerance +/-	Average(Dev)	Std Dev	PWSL	Pay Factor
% Passing 50.0mm	0	0.0	0.0	0.0	
% Passing 37.5mm	0	0.0	0.0	0.0	
% Passing 25.0mm	0	0.0	0.0	0.0	
% Passing 19.0mm	0	0.0	0.0	0.0	
% Passing 12.5mm	5	-0.3	0.0	100.0	
% Passing 9.5mm	5	2.6	0.0	100.0	1.00
% Passing 4.75mm	4	0.4	0.0	100.0	1.00
% Passing 2.36mm	4	-0.3	0.0	100.0	1.00
% Passing 1.18mm	4	-0.7	0.0	100.0	
% Passing 0.60mm	3	-0.2	0.0	100.0	
% Passing 0.30mm	3	0.2	0.0	100.0	1.00
% Passing 0.15mm	3	-0.1	0.0	100.0	
% Passing 0.075mm	2.0	0.50	0.00	100.0	1.00
AC	0.40	0.200	0.000	100.0	1.00
Gmm	0.000	-0.0080	0.0000	50.0	
Gmb	0.000	-0.0134	0.0000	50.0	
VTM	1.2	0.20	0.00	100.0	
VMA	0.0	0.40	0.00	50.0	
VFA	0.0	0.40	0.00	50.0	
Dust-to-Asphalt	0.00	0.400	0.000	50.0	

COMPOSITE PAY FACTOR 1.00

Figure 4. Mix pay factor report (part 1).

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PRODUCTION SUMMARY

Producer: 133
Start Date: 2/15/2000 **End Date:** 2/15/2005

ProjectID	JMFID	Production
AL698B51	W13312G4F01F	2000
	Total Production:	2000

Figure 5. Mix pay factor report (part 2).

6. Designed a new Density Pay Factor query form (Figure 6). This form determines the list of lots for a given ProjectID and JMFID to be processed in the pay factor calculation. Input fields on the form include:
   - ProjectID drop list box, populated with ProjectID values extracted from the ProjectJMFs table. Duplicate entries are removed and remaining entries are sorted alphabetically before displaying in the list box.
   - JMFID drop list, corresponding to the JMFIDs for the selected ProjectID.
   - Compute Pay Factor command button. On click, the program performs all error checks on the input data and then passes control to the Density Pay Factor calculation routines.

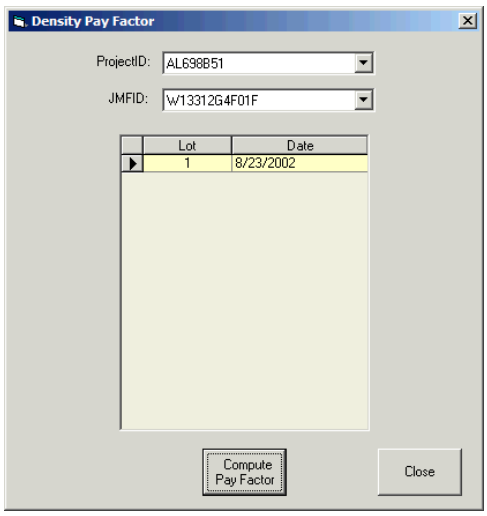

Figure 6. Density pay factor query screen.

7. Designed and implemented the Density Pay Factor report (Figure 7).

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DENSITY PAY FACTOR SUMMARY

ProjectID:	AL698B51	**JMFID:**	W13312G4F01F
MixDesignID:	W13312G4F01F	**Date of Placement:**	8/23/2002
Lot:	1	**Production:**	3000

Sublot	Average (Density)
1	94.1
2	94.1
3	No data

LOT PAY FACTOR: 0.88

Figure 7. Density pay factor report.

Subtask 3: Development of Data Export Utility

Functionality to export selected QC/QA data from MarylandWare to the Maryland Materials Database was added to the MarylandWare QC/QA application. Preliminary testing of this functionality was successfully performed on the University of Maryland network. However, as described later under Future Work, MDSHA has not been successful in implementing these export routines on their in-house network. Since a different data transfer mode was adopted for the pilot project, this problem was not pursued during the course of the task order work, and in fact the UMD team learned of this problem only at the end of the project. Resolution of this problem is therefore included as a future work item.

Subtask 4: Provide On-Site Assistance

C.W. Schwartz visited the contractor for the pilot paving project, P & W Excavating, prior to construction to ensure that the latest version of the MarylandWare software was installed on the contractor's computers and that the contractor's personnel understood the proper use of the software. Follow-up calls were made as necessary to ensure successful entry and transfer of all data for the pilot project.

As part of a larger effort to provide assistance to the Maryland contractor community on the proper operation of the MarylandWare software, we developed a short set of usage notes to guide contractors and producers on project setup and data entry for the QC module. These usage notes are included as Appendix D.

UMD personnel also participated in the half-day meeting with contractors at the Lutherville CID trailer on October 28, 2004. The purpose of this meeting, which was held after the completion of all work under this task order was to solicit feedback from current users of the MarylandWare software in preparation for future enhancements.

Subtask 5: Implementation Report

The present report is the final product from subtask 5. An installation CD containing the latest modified version of the MarylandWare software (v.2.4.1) is also included with this report.

Subtask 6: Procure HMAView License

This is the first of two added subtasks under this task order. HMAView is a web-based application developed by the University of Washington for storing, retrieving, monitoring, and analyzing design, construction, and performance data for hot-mix asphalt paving projects. HMAView links data from previously uncombined data sets and allows for users to seamlessly navigate and analyze across them. It integrates the design, construction, usage, and performance data via their geographic location along the roadway, enabling map-based navigation and data displays.

At the start of this task order, MDSHA had begun evaluating a prototype of the HMAView software to assess its usefulness to MDSHA operations. The results from the prototype were encouraging, and the capability to upload information from the MarylandWare and Maryland Materials Databases directly to HMAView was added to the project work scope. In order to accomplish this, the University executed a license for the HMAView software from the University of Washington on behalf of the MDSHA. A copy of the license agreement is included as Appendix E.

Subtask 7: Addition of Electronic Document and Image Storage Capability

A variety of documents are generated in the course of any paving project. These may include specifications, correspondence, reports, calculations, and others. Additionally, photographs and other images (e.g., infrared temperature profiles) may also be captured during construction. It is desirable that these documents and images are easily accessible to MSHA and contractor personnel working on the project. This was the objective of subtask 7 under this task order.

The MarylandWare QC/QA module was modified to accept electronic documents and images and store them in the database along with the other project information already compiled using the software. Specific items to implement this enhanced functionality are as follows:

1. Modification of the QC/QA database structure to provide electronic storage for electronic documents and images. This consisted of adding a new Documents table to the qc.mdb and qa.mdb databases. The structure of the new Documents table is as follows:

Field Name	Description	Type (length)
ProjectID	Project identifier	Text (20)
JMFID	Job Mix Formula identifier (optional)	Text (30)
LotDefinition	Lot number (optional)	Integer
SublotDefinition	Sublot number (optional)	Integer
Latitude	Latitude (optional)	Text (12)
Longitude	Longitude (optional)	Text (12)
Filename	Name of document file	Text (255)
DocumentDate	Date of document file (optional)	Date/Time
Comment	Additional comments (optional)	Text (255)

2. Addition of routines for input of electronic documents and images into the database. Electronic documents are provided as files to be read from diskettes or other electronic storage media and transferred to the QC/QA database on the host computer. Implementation in the QC module consists of a new menu selection Documents on the File..Import Data menu (Figure 8) that calls up a standard file selection dialog box (Figure 9) followed by a data entry screen in which the user can specify the ProjectID (and optionally the JMFID, latitude, and longitude) to which the document is to be associated (Figure 10).

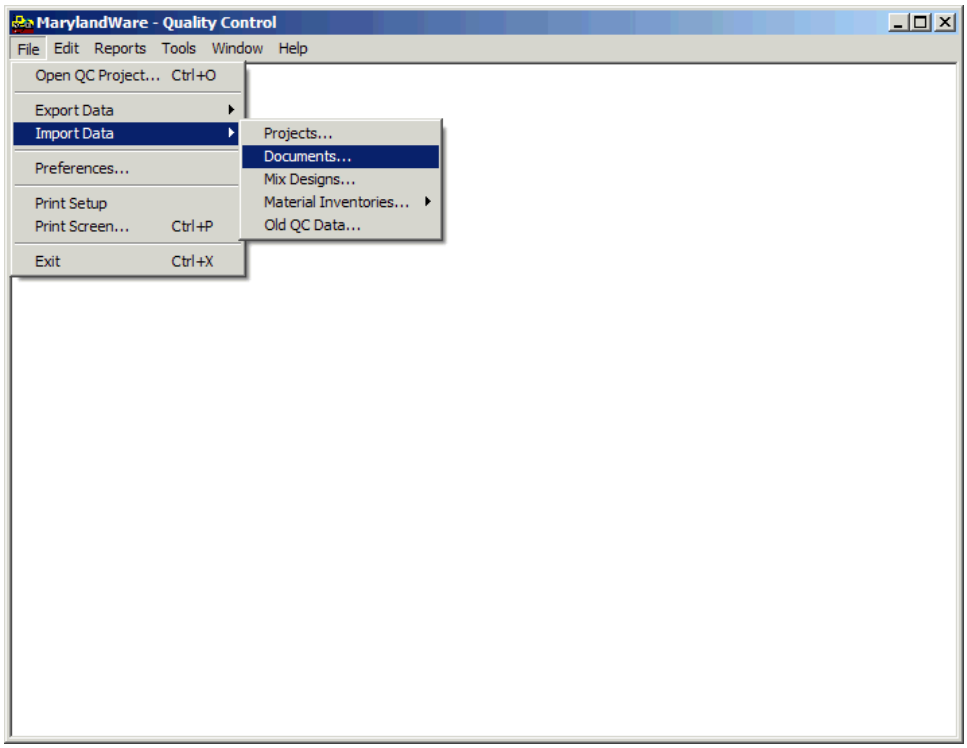


Figure 8. Import Data..Documents menu selection.

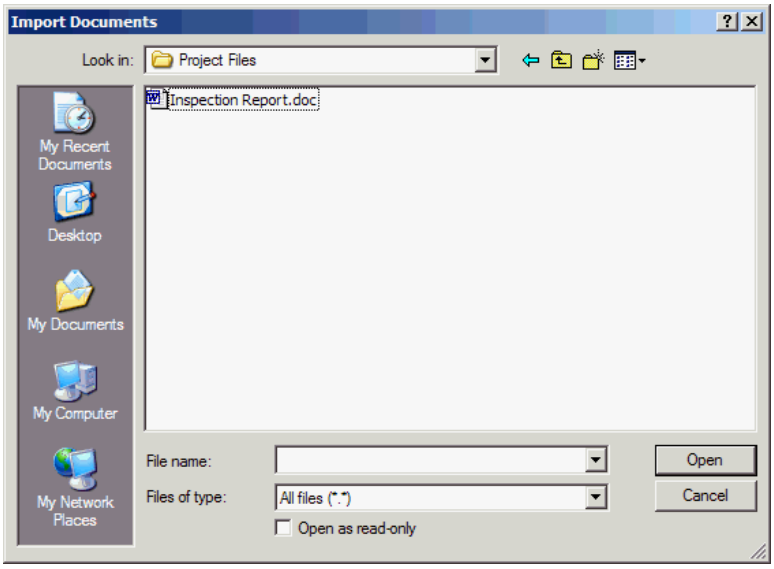


Figure 9. File selection dialog for importing documents.

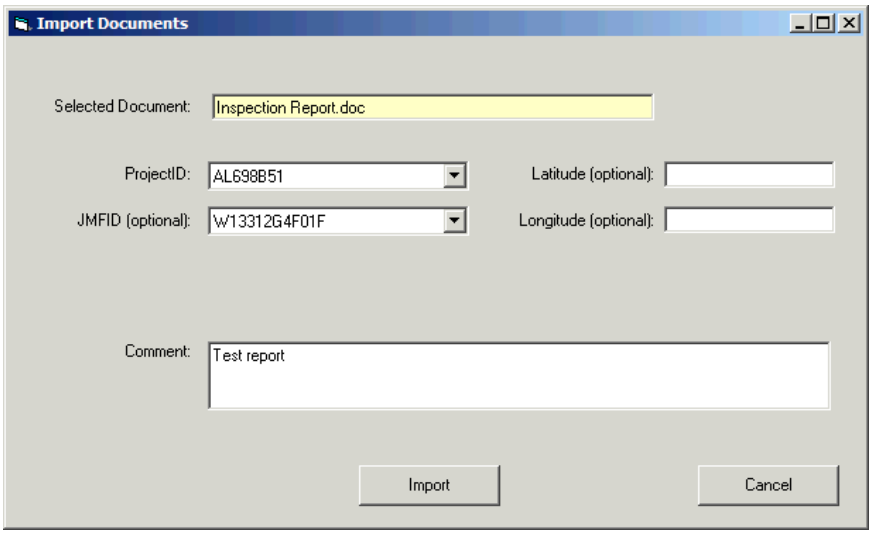


Figure 10. Document import information screen.

3. Imported electronic documents are retrieved via a Documents command button on the Production QC..Production Log (Figure 11) and In-Place QC..Paving Log screens. Clicking this button brings up the Production Documents screen (Figure 12), from which individual documents can be selected for viewing or deleting. Additional documents can also be imported via this screen.

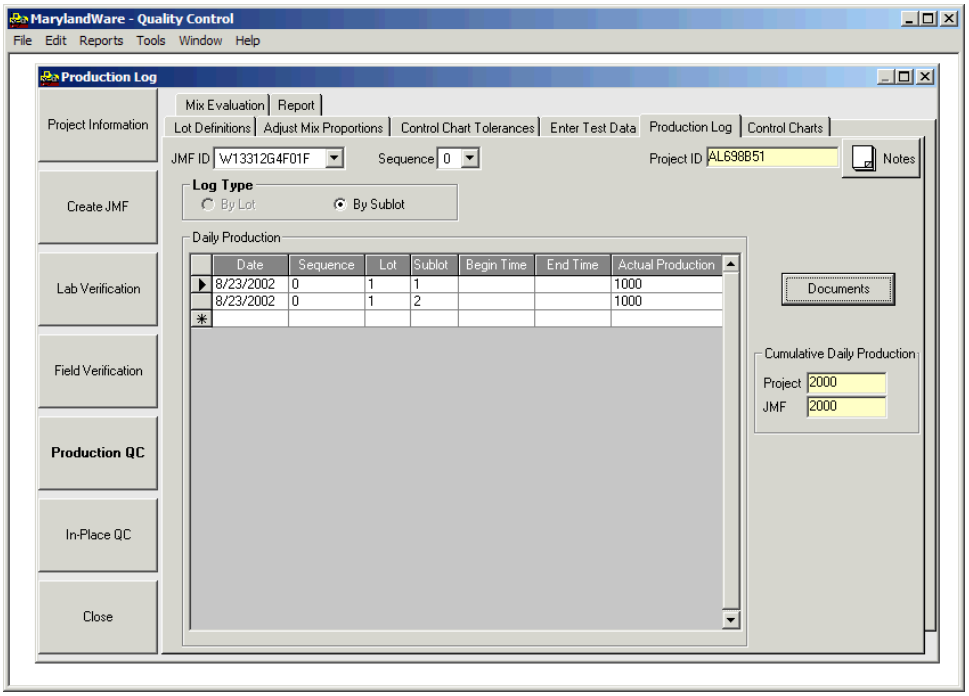


Figure 11. Access of imported documents from Production QC..Production Log screen.

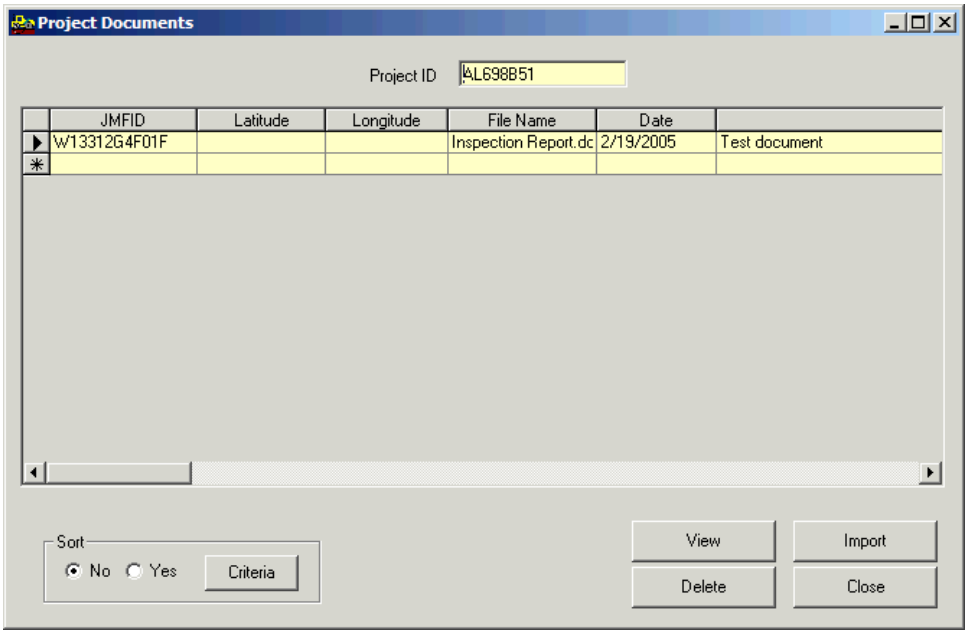


Figure 12. Project Documents selection screen.

4. Electronic document and image files are viewed and printed using their native software applications, e.g., Microsoft Office (Word, Excel, PowerPoint), Adobe Acrobat Reader, Microsoft Photo Editor, etc. These software applications must be installed on the host computer on which the MarylandWare electronic documents are to be viewed.

5. Database import/output routines were modified as appropriate for the new electronic document and image files.

FUTURE WORK

Lessons Learned During Pilot Project Implementation

The interactions between the enhanced MarylandWare software, the Maryland Materials Database, and the HMAView application were tested in a pilot project during overlay construction of a section of Interstate 68 in Western Maryland. Feedback was solicited from the various participants after completion of the project (principally G. Burke, W. Wells, J. Withee, and G. White). Noteworthy items learned from this feedback are itemized below:

- Most of the data required for the Maryland Materials Database is currently available, although it is often in scattered locations and in both electronic and paper files.

- Transferring information from existing databases and files to the Maryland Materials Database required varying degrees of manual effort. This will need to be streamlined for production application.

- Agreement is required for a consistent location reference system for all data elements (e.g., GPS latitude/longitude, mile point, or project station). This is a key requirement if data from disparate databases and sources are to be cross referenced.

- Some of the data elements originally intended for inclusion in the Maryland Materials Database turned out to be unfeasible to collect. An example of this is mixture temperature by load.

- The upload of data from MarylandWare to HMAView worked very smoothly from the contractor and MDSHA point of view. However, more automation of this process may be required from the HMAView end.

- There was considerable confusion over the proper way to enter the QC/QA data into the MarylandWare software. Specifically, the mix-related data must be entered under the Production QC/QA set of screens while the field density data must be entered via the In-Place QC/QA set of screens. The reason for this is that the lot and sublot sizes are different for mixture QC/QA than for in-place density. (Note: The Program Usage notes in Appendix D were developed to address this confusion.)

- Not all GPS location data were recorded during the pilot project. This in part was because this was a new procedure that was unfamiliar to the field personnel. In some cases, this was also due to lack of equipment (GPS transponders).

- It is important that field density core locations and sample numbers are recorded correctly and that all data are entered into the MarylandWare database. There were some errors in the way these data were collected during the pilot project.

- The original scheme to record separate GPS coordinates for each field core proved unworkable. Each core (with separate GPS coordinates) for a given lot/sublot is really

intended as a replicate, and therefore these should be entered as a single test record in the MarylandWare application. This issue needs further examination.

- Most bugs encountered in the HMAView application were fixed immediately.

- During the pilot project, there was no clear path on how data would flow from step to step. Data was coming to HMAView directly from contractors and from the MDSHA; these data were often redundant and in formats not easily negotiated.

- There was no clear business process for collecting and distributing the data during the pilot project.

Integration of MarylandWare with Maryland Materials Database

Full integration of MarylandWare export data into the Maryland Materials Database was not achieved in the project. The data transfer routines were successfully tested locally at the University of Maryland by exporting data from MarylandWare running on one computer to a copy of the Maryland Materials Database residing on another computer on the University of Maryland network. However, similar attempts to transfer data at the Western Regional Laboratory via the MDSHA computer network were unsuccessful. It is unclear whether this was due to a program interaction issue (e.g., MarylandWare expecting a different database structure than implemented in the Maryland Materials Database) or to internal MDSHA network issues.

The UMD team learned only recently of this data transfer problem. The problem was not raised as an issue when first encountered because Western Regional Laboratory personnel had decided early on to send the MarylandWare files directly to the University of Washington for import into HMAView for more "real time" data updates. This sidestepped the need to export from MarylandWare to the Materials Database as an intermediate step in transmitting the data into HMAView. Other data required by HMAView such as pavement design and pavement management information was pulled directly from the Maryland Materials Database.
This issue will need to be addressed in the future if the export from the Maryland Materials Database to HMAView becomes part of MDSHA's routine production work on all projects.

Next Steps

Specific future work items identified during the pilot project and over the entire implementation effort in this task order include the following:

- The project team should re-establish its end product goals. The desired final product and the steps needed to get there must be more crisply defined.

- The data items to be captured in the process should be reviewed, particularly in light of the new GPS cross-referencing and the final use envisioned for each data item. It is important that all critical data be collected and that non-useful data be eliminated. For example, additional fields for specification limits may be required for the Maryland Materials Database.

- The project team must create a data flow plan for the entire set of applications. This includes the sequence of data flow, what data are transported between applications, how data are handled in transport, error and quality checking, and other issues. For example: How does a

contractor submit its data to MDSHA? How are these data validated and accepted? How are these data passed on to the Maryland Materials Database and/or HMAView?

- Enhance the smooth data transfer between all of the various applications/databases feeding into/from the Maryland Materials Database. These include MarylandWare, HMAView, RideTool, and PIMS—Pavement Information Management System. This should occur after the data flow paths have been finalized.

- Revise the binder data transfer mechanism. Binder data should be transferred directly from BinderWare, not through PIMS.

- Production and Paving Log data should be imported directly from the Inspector's Daily Report application. This data transfer application has not yet been implemented.

- Some method is required to cross-reference data via GPS location in the MarylandWare, HMAView, and/or Maryland Materials Database applications. In the future, it is desirable to go to a problem area of pavement, enter the GPS coordinates into the program, and be able to access all core density, mixture, and other pavement data within a certain distance of the entered location.

- A method for alerting field personnel to potential problem areas in real time during construction based on the collected data is highly desirable. Ray Brown at NCAT has worked on this issue, and his work should be evaluated for possible incorporation into MarylandWare, HMAView, and/or the Maryland Materials Database.

- The revised system (new data flow procedures, data transfer routines, etc.) could be tested using the original pilot project data. This would help identify and problem areas needing correction.

- Consideration should be given to a follow-on pilot project, perhaps in conjunction with use of handheld field data collection systems. This would be a "hands off" operation to observe how the data flow procedures and systems work. Problem areas would be addressed as needed.

- Make decision on 100% implementation of the Maryland Materials Database considering the impacts to staff, equipment, and operations. Specific considerations include:
  - Process for accessing construction data must be revised to be a true real time system.
  - A dedicated staff member or team would be needed to manage the Maryland Materials Database and HMAView.
  - Contributing divisions/teams will need to revise operating procedures to routinely enter/export data to the Maryland Materials Database. The groups most involved are the Asphalt Team, Pavement Division, Contractors, and Construction Inspection.
  - Data Quality Control procedures for all information transferred to the Maryland Materials Databse must be implemented at the data export step.
  - Additional equipment will be required to collect location reference information for all data.

Much time has elapsed since the beginning or work under this task order and the pilot project. Modifications and enhancements to the MarylandWare software, the HMAView application, the Maryland Materials Database, and other MDSHA software applications/databases have continued throughout this period. In addition, the MDSHA has undergone an internal reorganization, and

many personnel originally involved in the Maryland Materials Database and other MDSHA applications are now assigned other responsibilities within the organization. Given this situation, some regrouping is appropriate before beginning any new work described in this section. This could best be accomplished via a one-day workshop with participants from each of the major applications areas and MDSAH technical groups. This workshop should focus on briefing all participants on the current status of each of the applications and with generating a data flow plan and development/implementation/evaluation strategies for the next round of enhancements.

APPENDIX A:

POTENTIAL FUTURE MODIFICATIONS TO

THE MARYLANDWARE SOFTWARE

Introduction

The following is a list of items/issues that have been identified as bugs/possible bugs/desired enhancements to the MarylandWare software. Some of the reported bugs have been sporadic and difficult to reproduce; some may in fact have already been fixed as part of other software modifications. This listing is included here simply as documentation of items that should be checked during any subsequent modifications to the MarylandWare software.

Prior Issues That May Still Need Resolution

1. MDSHA procedures require a change to the JMFID (i.e., changing the suffix) whenever the targets are changed. However, the MarylandWare program is designed to keep the JMFID constant and to track changes in the targets via the Sequence number. Some policy decisions regarding mix design and JMFIDs are required.

2. Lot and sublot definitions must be standardized, both for production (mix) sampling and for in-place (density) sampling.

3. MDSHA always designates any field verification initial lot as Lot 0. However, the MarylandWare QC/QA modules always starts at Lot 1. Either the software needs to be changed (the implications of this are unclear at present) or else MDSHA needs to adjust its policies.

4. Minor bugs/ operational issues:

    - Premature forced ejection from Edit Mix Design (QC/QA modules) after entering an invalid Gmm value. Data already entered are not saved.

    - Lot Definition for In-Place QC screen (QC/QA modules) should be checked to ensure that the column headings for the sampling plan grid are correct if lots are defined in terms of tonnage.

    - Current list of Control Chart properties (QC/QA modules) contains some duplicates due to merging of old and new (i.e., MDSHA-specific) properties. *Note: Most of this duplication has already been eliminated, but this should be double checked.*

    - There is an intermittent bug in the Verify Final Design screen in the Mix Design module. On some systems, accessing this screen causes a run time error and ejection from the program (even with the tutorial mix design); on other systems, this screen works just fine.

    - Vague report of bugs in the mix design import/export functionality.

    - Executables compiled under Windows 2000 do not run on user computers; problem is w/ licensing of Graphics Server control. *Note: This possibly will be solved using the VB6CLI.EXE fix from Microsoft; see the Microsoft KnowledgeBase online for more details.*

    - Standard deviation calculations in the QC/QA Mix Evaluation screen should be double checked. (Bramble; vague suggestion that calculations might not always be correct.)

- Make sure that the PWL calculations in the QC/QA Mix Evaluation screen are correct if Qu and/or Ql exactly coincide w/ spec limits. (Bramble)

- When the Edit Aggregate and Edit Binder screens are opened on top of a MDI child window, they immediately drop into the background. Need to find a way to keep these windows on top once opened.

- Possible bug printing RAP mix designs in the Mix Design module.

- Possible bug when adding/deleting lots and sublots in frmEnterTestData (QC/QA module). This needs further testing/evaluation.

- Potential bug (J. Greene report): Mix design is entered using Edit Mix Design. Then go to CreateJMF..Stockpiles; no JMFID in combo box. Go to CreateJMF..Agg Structure; don't see any JMF gradation. Go to CreateJMF..TrialPB; get RT Error 3021.

- In Edit Mix Design, where is binder grade entered and stored?

5. Enhancements suggested by users:

    - Would it be desirable to simply combine the Production and In-Place buttons?

    - Make the batch weight "sticky" in the Batching and Mixing Sheet screens in the Mix Design module. (Craig) (Suggestion: Make this a static variable. First time the screen is entered during a given session, the default value of 5000g will appear, but if the user changes this, then the most recently entered value will always display.)

    - Enhance the functionality of the Notes editor—e.g., keep track of JMFID, Seq. No., Lot and Sublot as well as ProjectID. Make sure that Notes print and export properly.

    - Add data validation check at exit from frmControlChartsTolerances (QC/QA modules) to make sure that lower spec limit is less than upper spec limit for all properties, that all offsets are positive, that PWL criterion is between 0 and 100, and that significance level is between 0 and 1.

Unresolved Known Bugs

- In CreateJMF_AggStructure, JMFID combo box (and data on screen) not updated properly after changing the MixDesignID. Also on this form, if Sum<>100, program still lets you choose another MixDesignID without resetting Sum to 100.

New Issues/Other Future Changes

- Check Print buttons on LotDefinitions, Evaluation forms; not clear that these still work with revised reporting code.

- Make Plant Type on general project information screen a pick list: Drum/Batch (Other?)

- Remove any remaining references to AASHTOWare (e.g., help screens, etc.).

- Make colors/gray scales on Mix Design, TestData, and Binder screens uniform and consistent with QC/QA module. Check colors at 32 bit color resolution to make sure that all are correct (e.g., all gray shades are consistent).

- The report generation routines often create many *.tmp files (apparently in both the program and database directory). Either the creation of these files must be eliminated, or code must be added at program exit to delete them.

APPENDIX B:

OLD PAY FACTOR SPECIFICATION

(MATERIALS PROVIDED BY MDSHA)

STATISTICAL ANALYSIS OF MATERIAL USING QUALITY LEVEL ANALYSIS

Rev. 3/97

MSMT Designation 730

SCOPE:

This procedure is used to determine the percent of test results that are within Specification limits. It is affected by shifts in the arithmetic mean ($\overline{X}$) and by the sample standard deviation(s). Analysis of each test parameter will be based on an Acceptable Quality Level (AQL) of 95.0 and a producer's risk of 0.05.

MATERIALS AND EQUIPMENT:

Not applicable.

TEST PROCEDURE:

Sampling and testing shall be performed as specified in the appropriate AASHTO, ASTM, MSMT procedure, or other standard as required by the Specifications.

CALCULATIONS:

Compute the quality level analysis as follows:

1. Determine the arithmetic mean ($\overline{X}$) of the test results:

$$\overline{X} = \frac{\Sigma x}{n}$$

where:

$\overline{X}$ = arithmetic mean of test results,

Σx = sum of test results,

x = individual test value, and

n = total number of test values.

2. Compute the sample standard deviation(s):

$$s = \sqrt{\frac{n\Sigma(x^2) - (\Sigma x^2)}{n(n-1)}}$$

where:

s = sample standard deviation.

3. Compute the upper quality index (Q_u):

$$Q_u = \frac{USL - \bar{X}}{s}$$

where:

Q_u = upper quality index, and

(upper specification limit) USL = target value* plus allowable deviation.

4. Compute the lower quality index (Q_L):

$$Q_L = \frac{\bar{X} - LSL}{s}$$

where:

Q_L = lower quality index, and

(lower specification limit) LSL = target value* minus allowable deviation.

* established during the field verification of design mix 904.06.03.

5. Compute the quality level:

$$PWSL = (P_u + P_L) - 100$$

where:

PWSL = percent within specification limit,

P_u = percent within the upper specification limit which corresponds to a given Q_u from Table 1.

If a USL is not specified, P_u shall be 100, and

P_L = percent within the lower specification limit which corresponds to a given Q_L from Table 1.

If a LSL is not specified, P_L shall be 100.

6. Determine the composite pay factor (CPF) for each lot:

$$CPF = \frac{f_1(PF_1) + f_2(PF_2) + \ldots f_j(PF_j)}{\Sigma f}$$

where:

f_j = price adjustment factor listed in (7) below for the applicable property,

PF_j = Pay factor for the applicable property from Table 2, and

Σf = sum of price adjustment factors.

7. Use the following (f) value for gradation and asphalt content to compute CPF:

CONSTITUENT	FACTOR (f)
Aggregate passing ⅜ in. sieve	2
Aggregate passing No. 4 sieve	6
Aggregate passing No. 8 sieve	10
Aggregate passing No. 50 sieve	6
Aggregate passing No. 200 sieve	20
Asphalt Cement	52

Analysis of compaction test results shall be performed separately using the pay factor directly to calculate the price adjustment.

REPORT:

Report the PWSL to the nearest whole number.

TABLE 1
QUALITY LEVEL ANALYSIS BY THE STANDARD DEVIATION METHOD

PU or PL %*	Upper Quality Index(QU) or Lower Quality Index (QL)														
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=18	n=19 to n=25	n=26 to n=37	n=38 to n=69	n=70 to n=200	n=201 to n=x
100	1.16	1.50	1.79	2.03	2.23	2.39	2.53	2.65	2.83	3.03	3.20	3.38	3.54	3.70	3.83
99		1.47	1.67	1.80	1.89	1.95	2.00	2.04	2.09	2.14	2.18	2.22	2.26	2.29	2.31
98	1.15	1.44	1.60	1.70	1.76	1.81	1.84	1.86	1.91	1.93	1.96	1.99	2.01	2.03	2.05
97		1.41	1.54	1.62	1.67	1.70	1.72	1.74	1.77	1.79	1.81	1.83	1.85	1.86	1.87
96	1.14	1.38	1.49	1.55	1.59	1.61	1.63	1.65	1.67	1.68	1.70	1.71	1.73	1.74	1.75
95		1.35	1.44	1.49	1.52	1.54	1.55	1.56	1.58	1.59	1.61	1.62	1.63	1.63	1.64
94	1.13	1.32	1.39	1.43	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.55
93		1.29	1.35	1.38	1.40	1.41	1.42	1.43	1.44	1.44	1.45	1.46	1.46	1.47	1.47
92	1.12	1.26	1.31	1.33	1.35	1.36	1.36	1.37	1.37	1.38	1.39	1.39	1.40	1.40	1.40
91	1.11	1.23	1.27	1.29	1.30	1.30	1.31	1.31	1.32	1.32	1.33	1.33	1.33	1.34	1.34
90	1.10	1.20	1.23	1.24	1.25	1.25	1.26	1.26	1.26	1.27	1.27	1.27	1.28	1.28	1.28
89	1.09	1.17	1.19	1.20	1.20	1.21	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.22	1.23
88	1.07	1.14	1.15	1.16	1.16	1.16	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
87	1.06	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.13	1.13
86	1.04	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
84	1.01	1.02	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
83	1.00	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.95	0.95	0.95
82	0.97	0.96	0.95	0.94	0.93	0.93	0.93	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
81	0.96	0.93	0.91	0.90	0.90	0.89	0.89	0.89	0.89	0.88	0.88	0.88	0.88	0.88	0.88
80	0.93	0.90	0.88	0.87	0.86	0.86	0.86	0.85	0.85	0.85	0.85	0.84	0.84	0.84	0.84
79	0.91	0.87	0.85	0.84	0.83	0.82	0.82	0.82	0.82	0.81	0.81	0.81	0.81	0.81	0.81
78	0.89	0.84	0.82	0.80	0.80	0.79	0.79	0.79	0.78	0.78	0.78	0.78	0.77	0.77	0.77
77	0.87	0.81	0.78	0.77	0.76	0.76	0.76	0.75	0.75	0.75	0.75	0.74	0.74	0.74	0.74
76	0.84	0.78	0.75	0.74	0.73	0.73	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.71	0.71
75	0.82	0.75	0.72	0.71	0.70	0.70	0.69	0.69	0.69	0.68	0.68	0.68	0.68	0.68	0.67
74	0.79	0.72	0.69	0.68	0.67	0.66	0.66	0.66	0.66	0.65	0.65	0.65	0.65	0.64	0.64
73	0.76	0.69	0.66	0.65	0.64	0.63	0.63	0.63	0.62	0.62	0.62	0.62	0.62	0.61	0.61
72	0.74	0.66	0.63	0.62	0.61	0.60	0.60	0.60	0.59	0.59	0.59	0.59	0.59	0.58	0.58
71	0.71	0.63	0.60	0.59	0.58	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.55	0.55
70	0.68	0.60	0.57	0.56	0.55	0.55	0.54	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.52
69	0.65	0.57	0.54	0.53	0.52	0.52	0.51	0.51	0.51	0.50	0.50	0.50	0.50	0.50	0.50
68	0.62	0.54	0.51	0.50	0.49	0.49	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47
67	0.59	0.51	0.47	0.47	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.44	0.44	0.44	0.44
66	0.56	0.48	0.45	0.44	0.44	0.43	0.43	0.43	0.42	0.42	0.42	0.42	0.41	0.41	0.41
65	0.52	0.45	0.43	0.41	0.41	0.40	0.40	0.40	0.40	0.39	0.39	0.39	0.39	0.39	0.39
64	0.49	0.42	0.40	0.39	0.38	0.38	0.37	0.37	0.37	0.37	0.36	0.36	0.36	0.36	0.36
63	0.46	0.39	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33
62	0.43	0.36	0.34	0.33	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31	0.31	0.31	0.31
61	0.39	0.33	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28
60	0.36	0.30	0.28	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25
59	0.32	0.27	0.25	0.25	0.24	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23
58	0.29	0.24	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20
57	0.25	0.21	0.20	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
56	0.22	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15
55	0.18	0.15	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
54	0.14	0.12	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	0.11	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
52	0.07	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
51	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

NOTE: For negative values of QU or QL, PU or PL is equal to 100 minus the table value for PU or PL. If the value of QU or QL does not correspond exactly to a figure in the table, use the next higher figure.

* Within limits for positive values of QU or QL.

TABLE 2 - PAY FACTORS

PAY FACTOR	Required Quality Level for a Given Sample Size(n) and Given Pay Factor														
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=18	n=19 to n=25	n=26 to n=37	n=38 to n=69	n=70 to n=200	n=201 to n=x
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
100	90	91	92	93	93	93	94	94	95	95	96	96	96	97	99
100	80	83	87	88	89	90	91	91	92	93	93	94	95	96	97
100	75	80	83	85	86	87	88	88	89	90	91	92	93	94	95
100	71	77	80	82	84	85	80	86	87	88	89	90	91	93	94
100	68	74	78	80	81	82	83	84	85	86	87	89	90	91	93
0.99	66	72	75	77	79	80	81	82	83	85	86	87	88	90	92
0.98	64	70	73	75	77	78	79	80	81	83	84	85	87	88	90
0.97	62	68	71	74	75	77	78	78	80	81	83	84	85	87	89
0.96	60	66	69	72	73	75	76	77	78	80	81	83	84	86	88
0.95	59	64	68	70	72	73	74	75	77	78	80	81	83	85	87
0.94	57	63	66	68	70	72	73	74	75	77	78	80	81	83	86
0.93	56	61	65	67	69	70	71	72	74	75	77	78	80	82	84
0.92	55	60	63	65	67	69	70	71	72	74	75	77	79	81	83
0.91	53	58	62	64	66	67	68	69	71	73	74	76	78	80	82
0.90	52	57	60	63	64	66	67	68	70	71	73	75	76	79	81
0.89	51	55	59	61	63	64	66	67	68	70	72	73	75	77	80
0.88	50	54	57	60	62	63	64	65	67	69	70	72	74	76	79
0.87	48	53	56	58	60	62	63	64	66	67	69	71	73	75	78
0.86	47	51	55	57	59	60	62	63	64	66	68	70	72	74	77
0.85	46	50	53	56	58	59	60	61	63	65	67	69	71	73	76
0.84	45	49	52	55	56	58	59	60	62	64	65	67	69	72	75
0.83	44	48	51	53	55	57	58	59	61	63	64	66	68	71	74
0.82	42	46	50	52	54	55	57	58	60	61	63	65	67	70	72
0.81	41	45	48	51	53	54	56	57	58	60	62	64	66	69	71
0.80	40	44	47	50	52	53	54	55	57	59	61	63	65	67	70
0.79	38	43	46	48	50	52	53	54	56	58	60	62	64	66	69
0.78	37	41	45	47	49	51	52	53	55	57	59	61	63	65	68
0.77	36	40	43	46	48	50	51	52	54	56	57	60	62	64	67
0.76	34	39	42	45	47	48	50	51	53	55	56	58	61	63	66
0.75	33	38	41	44	46	47	49	50	51	53	55	57	59	62	65

NOTE: To obtain a given pay factor, the computed Quality Level shall equal or exceed the value in the Table. Delete Pay Factor rows more than 1.0 where quality incentives are not allowed.

TABLE 3
REQUIRED TESTS

Lot Size = 3000 tons (max) of continuing production per design mix.
Sublot Size = 1000 tons (max) of continuing production or fraction thereof. A lot may have only one sublot less than 1000 ton.
All samples shall be split samples. The Contractor shall retain samples until notified by the Engineer.

MATERIAL	TEST	LOCATION	SAMPLE SIZE	FREQUENCY	
				CONTROL	ACCEPTANCE
Aggregate	Grading	Drum Plant: Belt Cut. Batch Plant: Hot Bin		1/1000 tons of continuing production/mix or 1/day/mix, whichever yields higher frequency.***	1/6000 tons of continuing production/mix
Asphalt Cement				1/day sampling only	1/2 day
Asphalt Mix	*Asphalt Content	Hauling Unit or Behind Paver		1/1000 tons of continuing production/mix or 1/day/mix, whichever yields higher frequency.***	1/6000 tons of continuing production/mix
	Maximum Specific Gravity	same as above		same as above	same as above
	**Marshall Test				
	*VTM *VMA *Flow *Stability	same as above		same as above. No flow or stability for control	1/6000 tons of continuing production/mix
	Compaction	Compacted pavement before traffic		In conformance with 504.03.09(e)	Core method: 3 cores/6000 tons of continuous production. Nuc/Core: 3 verif. cores/6000 tons of continuous production.
	Lot and Sublot size shall conform to Category 500.				

* Nuclear method shall be used for the quality assurance testing of asphalt content determination.
** Each Marshall test is an average of three specimens.
*** If production is <115 T/mix/day, then the requirement of 1/mix/day does not apply.

MIX PWSL/PAY FACTOR SUMMARY
BASED ON PROD DATA

PRODUCER: FRED. ASPH. LOCATION: FRED. MD.

PLANT NUMBER: 169

PAY FACTOR LOT - Start Date: 05/13/02 End Date: 05/20/02

TOTAL NUMBER OF SAMPLES: In Lot: 11 Calculated: 11

MIX COMPUTATION DATA

JMF	TOLERANCE	AVERAGE	STD DEV	PWSL	PAY FACTOR
2"	7 / -7	0.0	0.000	100.0	
11/2"	7 / -7	0.0	0.000	100.0	
1"	7 / -7	0.0	0.000	100.0	
3/4"	7 / -7	0.0	0.000	100.0	
1/2"	7 / -7	0.5	0.522	100.0	
3/8"	7 / -7	2.3	1.555	100.0	1.00
#4	7 / -7	-0.5	3.588	96.7	1.00
#8	4 / -4	1.2	2.401	87.1	1.00
#16	4 / -4	0.9	1.375	99.4	
#30	4 / -4	1.6	1.433	96.3	
#50	4 / -4	2.4	1.286	89.7	1.00
#100	4 / -4	2.2	0.982	97.8	
#200	2.0 / -2.0	1.2	0.693	87.7	1.00
ASPH	0.40 / -0.40	0.12	0.136	99.0	1.00
MAX	0.030 / -0.030	-0.002	0.004	100.0	
BULK	0.022 / -0.022	0.031	0.013	24.9	
VOIDS	1.2 / -1.2	-1.4	0.599	37.3	
VMA	NONE / -1.2	-1.0	0.436	67.3	
VFA	5.0 / -5.0	7.2	3.524	27.2	

COMPOSITE PAY FACTOR BY PRODUCTION: 1.00

CONTRACT NUMBER	MIXNUMBER	LOT	TOTAL TONNAGE
AW5935177	W0216909R4C01F		2202.60
FR349B5G	W0216912R2E01F		2023.30
HO843B51	W0216912R2C01F		2213.10

TOTAL TONS FOR DATE TO DATE LOT: 6439.00

Post-It® Fax Note 7671	Date 5/31	# of pages ▶
To Bill Wells	From G. Bu	
Co./Dept.	Co.	
Phone #	Phone #	
Fax #	Fax #	

ıty Acceptance Data Comparison

Producer: FRED. ASPH. Location: FRED. MD.

Band: 12R Plant Number: 169 Mixnumber: W0216912R2E01F

Acceptance Sample Date: 05/21/02 Log Number: 5402

Acceptance Production Lot - Start Date: 05/13/02 End Date: 05/20/02

Sieve Size	JMF	JMF Tolerance	Acceptance Sample	Meets Specs	Production Average	Production 2SD	Meet Accept
2"	100.0	100.0 - 93.0	100.0	Y	0.00	0.000	Y
1 1/2"	100.0	100.0 - 93.0	100.0	Y	0.00	0.000	Y
1"	100.0	100.0 - 93.0	100.0	Y	0.00	0.000	Y
3/4"	100.0	100.0 - 93.0	100.0	Y	0.00	0.000	Y
1/2"	98.0	100.0 - 91.0	99.0	Y	0.55	1.044	Y
3/8"	87.0	94.0 - 80.0	89.0	Y	2.27	3.110	Y
#4	50.0	57.0 - 43.0	50.0	Y	-0.45	7.176	Y
#8	27.0	31.0 - 23.0	24.0	Y	1.18	4.802	Y
#16	19.0	23.0 - 15.0	17.0	Y	0.91	2.750	Y
#30	13.0	17.0 - 9.0	12.0	Y	1.64	2.866	Y
#50	9.0	13.0 - 5.0	9.0	Y	2.36	2.572	Y
#100	7.0	11.0 - 3.0	7.0	Y	2.18	1.964	N
#200	6.5	8.5 - 4.5	5.4	Y	1.22	1.386	Y
ASPH	5.50	5.90 - 5.10	5.48	Y	0.12	0.272	Y
MAR	2.402	2.424 - 2.380	2.319	*	0.031	0.026	*
MAX	2.502	2.532 - 2.472	2.504	Y	-0.002	0.008	Y
VOIDS	4.0	5.2 - 2.8	7.4	N	-1.35	1.198	N
VMA	16.9	18.1 - 15.7	19.7	N	-1.00	0.872	N
VFA	76.3	78.0 - 65.0	62.6	N	7.21	7.048	N
D/B	0.90	1.60 - 0.60	0.98	Y	0.40	0.420	Y

* - This property is not part of Specification Requirements

NUCLEAR DENSITY PAY FACTOR SUMMARY FOR LOT

CONTRACT NUMBER: AW5935177

DATE LAID: 05/15/02 LOT NUMBER: 43

TONNAGE FOR (DENSITY) LOT: 1000.0 MIX NUMBER: W0216909R4C01F

MAXIMUM SP. GR. FOR LOT: 2.502 (PROD)

SUBLOT NUMBER	TEST	READING #1 (PCF)	READING #2 (PCF)	AVG PCF	AVG DENSITY	AVERAGE PCF	SUBLOT DENSITY
1	1	146.2	147.6	146.9	94.1		
	2	148.4	148.7	148.6	95.1	147.7	94.6
2	1	149.3	149.2	149.3	95.6		
	2	148.9	147.9	148.4	95.1	148.8	95.3
3	1	147.1	147.6	147.4	94.4		
	2	146.8	147.3	147.1	94.2	147.2	94.3
4	1	146.0	147.5	146.8	94.0		
	2	146.8	147.9	147.4	94.4	147.1	94.2
5	1	150.1	149.6	149.9	96.0		
	2	148.4	148.0	148.2	94.9	149.0	95.5
0	1	0.0	0.0	0.0	0.0		
	2	0.0	0.0	0.0	0.0	0.0	0.0
0	1	0.0	0.0	0.0	0.0		
	2	0.0	0.0	0.0	0.0	0.0	0.0
					LOT AVERAGE:	148.0	94.8

STANDARD DEVIATION: 0.589 PWSL: 100.0

LOT PAY FACTOR: 1.00

Original: Contract File w/Compaction Report
CC: Producer
Project Engineer

For Larry L. Michael
Team Leader
Asphalt Team

SHA-73.0-2N
Revised May, 1995
RT-70

MG 2.503

QC: ____
Acceptance: ____
I.A.S.T.: ____
Other: ____

MARYLAND
STATE HIGHWAY ADMINISTRATION
OFFICE OF MATERIALS & RESEARCH

HMA FIELD COMPACTION REPORT - NUCLEAR/CORE METHOD

Date Sampled: 5-15-02 Contract No: AW 593517 F.A.P. No: ____ Plant Location: Frederick, MD

Mix Design No: W011690984E01F Gauge Type: Troxler Serial No: 1728 Model No: 4640-B

Depth: 1" Laid Over: Base Lot No: ____ Lot Size: 1000 ST Max. Spec. Gravity: 2.503 = 156.2

Operator: [illegible] Witnessed By: David E. Shaffer Tested By: ____

SUBLOT NUMBER LANE 2	READING NO. 1 A pcf	READING NO. 1 B % Density	READING NO. 2 C pcf	READING NO. 2 D % Density	AVERAGE $\frac{B+D}{2}=E$ % Density	AVERAGE $\frac{A+C}{2}=F$ pcf	SUBLOT AVERAGE % DENSITY	CORE DENSITY pcf	AVERAGE 3 CORE DENSITY pcf (G)	AVERAGE 3 CORRESPONDING NUCLEAR DENSITIES pcf (F)	G - F pcf
1	146.2	93.6	147.6	94.5	94.1	146.9	94.6		—	—	—
	148.4	95.0	148.7	95.2	95.1	148.5					
2	149.3	95.6	149.2	95.5	95.6	149.3	95.3		PSWL =		
	148.9	95.3	147.9	94.7	95.0	148.4			PAY FACTOR =		
3	147.1	94.2	147.6	94.5	94.4	147.4	94.3				
	146.8	94.0	147.3	94.3	94.2	147.1					
4	146.0	93.5	147.5	94.4	94.0	146.7	94.2				
	146.8	94.0	147.9	94.7	94.4	147.4					
5	150.1	96.1	149.6	95.8	96.0	149.9	95.5				
	148.4	95.0	148.0	94.8	94.9	148.2					

CERTIFIED TECHNICIAN

1. Notify Project Engineer & Regional Lab if G - F > 3.0 pcf
2. Original to QA Folder
3. First carbon to Project
4. Second carbon to Plant Records
5. Third carbon for Project

NO CORING REQ.

PROJECT ENGINEER

1. Circle location where cores were taken.
2. Send first 3 copies to plant with cores.

AVERAGE 94.8
STANDARD DEVIATION

Attach location worksheet per MSMT 418

Sheet ____ of ____

APPENDIX C:

JMF TARGETS FOR OLD QC DATA IMPORT

JMF TARGETS FOR OLD QC DATA IMPORT

The JFM targets for the old QC data being imported into the MarylandWare are found in the JMF"s table in the same Mix and Test Data database containing the State Results table. The mapping between the fields in this table and the qc.mdb database in the Marylandware is as follows:

JMF"s Table (Mix and Test Data.mdb)	ProjectJMFs Table (qc.mdb)
ID	Not used
Date	Date
State Mix Number	JMFID
Plant Mix Number	Not used
2"	Targetp50_0
1 1/2"	Targetp37_5
1"	Targetp25_0
3/4 "	Targetp19_0
1/2 "	Targetp12_5
3/8 "	Targetp9_5
# 4	Targetp4_75
# 8	Targetp2_36
# 16	Targetp1_18
# 30	Targetp0_60
# 60	Targetp0_30
# 100	Targetp0_15
# 200	Targetp0_075
F/Ea	Dust-to-Asphalt
Gmm	Measured Gmm
Va	Ndesign Air Voids
VMA	Ndesign VMA
Gsb	Not used?
Gb	Not used?
Gmb	Measured Gmb
Gmb (Core) ??	Nmaximum Gmb ??[1]
Gse	Not used?
AC content	Measured Pb
Ncat calibration	Not used
Plant #	Plant
Location	Not used
Plug Size	Not used
# Nini	Not used
# Ndes	Not used
# Nmax	Not used
Binder	Not used
Vfa	Ndesign VFA
WT_RECID	Not used

[1]Imported Nmaximum Gmb will be % of Gmm, while data entered directly into Marylandware will be as absolute Gmb @Nmax. The pay factor calculation routine will have to detect and adapt to these different data.

Additional data fields in ProjectJMFs that must be populated:

Field	Value
ProjectID	Contract Number; get from either Plant Results or State Results table from record matching target State Mix Number
Activity	2
Locked	True

Columns

Name	Type	Size
ID	Number (Long)	4
Date	Date/Time	8
State Mix Number	Text	255
Plant Mix Number	Text	255
2 "	Number (Double)	8
1 1/2 "	Number (Double)	8
1 "	Number (Double)	8
3/4 "	Number (Double)	8
1/2 "	Number (Double)	8
3/8 "	Number (Double)	8
# 4	Number (Double)	8
# 8	Number (Double)	8
# 16	Number (Double)	8
# 30	Number (Double)	8
# 50	Number (Double)	8
# 100	Number (Double)	8
# 200	Number (Double)	8
F/Ea	Number (Double)	8
Gmm	Number (Double)	8
Va	Number (Double)	8
VMA	Number (Double)	8
Gsb	Number (Double)	8
Gb	Text	255
Gmb	Number (Double)	8
Gse	Number (Double)	8
AC content	Number (Double)	8
Ncat calibration	Text	255
Plant #	Number (Double)	8
Location	Text	255
Plug Size	Number (Double)	8
# Nini	Number (Double)	8
# Ndes	Number (Double)	8
# Nmax	Number (Double)	8
Binder	Text	255
Vfa	Text	255
WT_RECID	Number (Long)	4

Columns

Name	Type	Size
ProjectID	Text	20
Activity	Number (Integer)	2
JMFID	Text	30
Sequence	Number (Integer)	2
Date	Date/Time	8
Locked	Yes/No	1
Measured Pb	Number (Single)	4
Measured Gmb	Number (Single)	4
Measured Gmm	Number (Single)	4
Ninitial Gyrations	Number (Single)	4
Ninitial Gmb	Number (Single)	4
Ninitial Air Voids	Number (Single)	4
Ninitial VMA	Number (Single)	4
Ninitial VFA	Number (Single)	4
Ndesign Gyrations	Number (Single)	4
Ndesign Gmb	Number (Single)	4
Ndesign Air Voids	Number (Single)	4
Ndesign VMA	Number (Single)	4
Ndesign VFA	Number (Single)	4
Nmaximum Gyrations	Number (Single)	4
Nmaximum Gmb	Number (Single)	4
Nmaximum Air Voids	Number (Single)	4
Nmaximum VMA	Number (Single)	4
Nmaximum VFA	Number (Single)	4
CorrectionFactor	Number (Single)	4
Slope	Number (Single)	4
InPlace Gmb	Number (Single)	4
InPlace AV %	Number (Single)	4
InPlace VMA %	Number (Single)	4
InPlace VFA %	Number (Single)	4
InPlace Density	Number (Single)	4
Targetp50_0	Number (Single)	4
Targetp37_5	Number (Single)	4
Targetp25_0	Number (Single)	4
Targetp19_0	Number (Single)	4
Targetp12_5	Number (Single)	4
Targetp9_5	Number (Single)	4
Targetp4_75	Number (Single)	4
Targetp2_36	Number (Single)	4
Targetp1_18	Number (Single)	4
Targetp0_60	Number (Single)	4
Targetp0_30	Number (Single)	4
Targetp0_15	Number (Single)	4
Targetp0_075	Number (Single)	4
Core Thickness	Number (Long)	4

APPENDIX D:

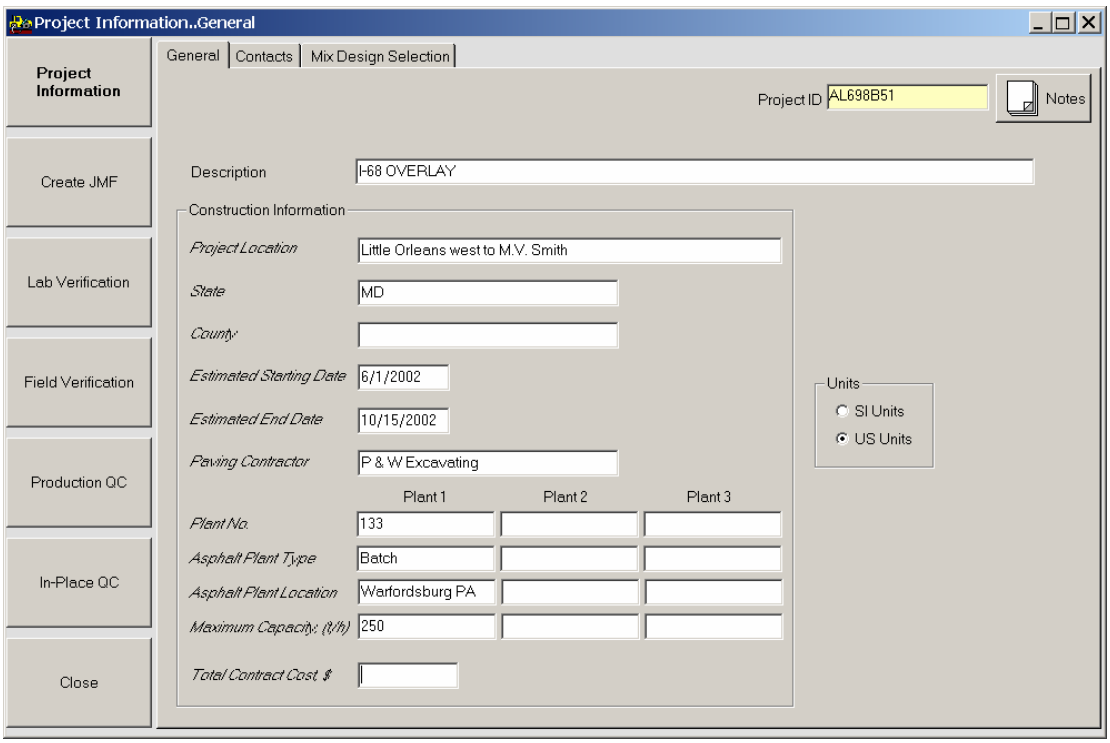
QC PROGRAM USAGE NOTES

QC PROGRAM USAGE NOTES

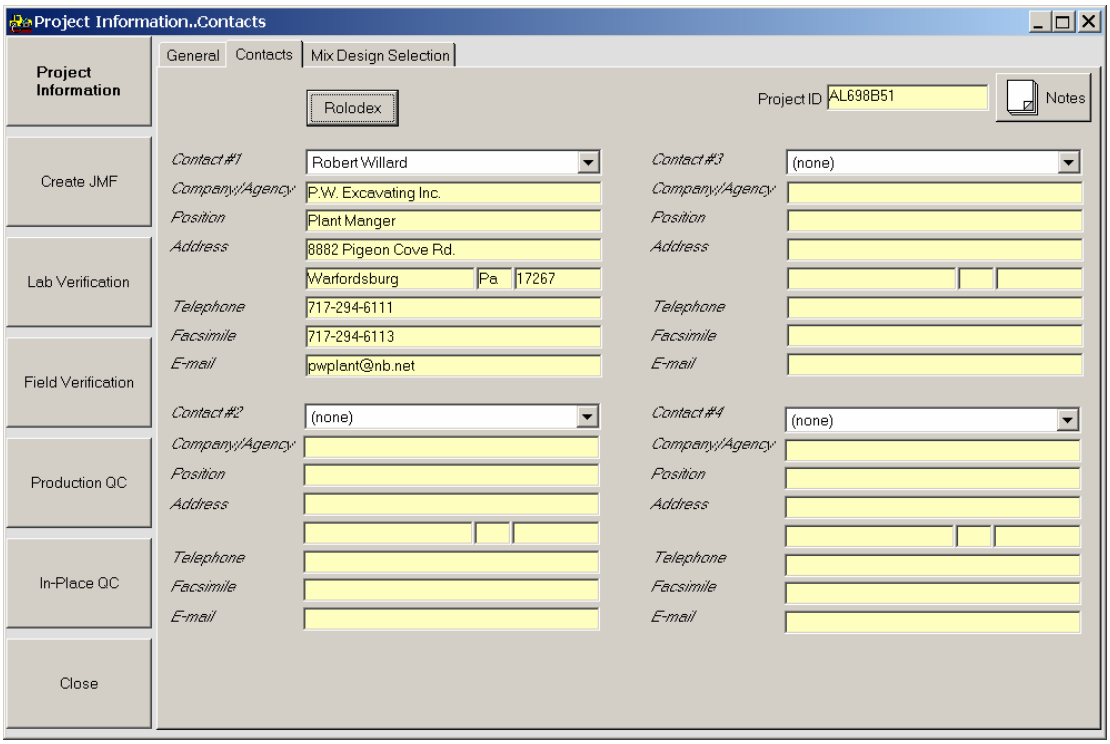
Charles Schwartz
University of Maryland
301.405.1962
schwartz@eng.umd.edu
March, 2003

1. Create a new QC project by selecting **File..Open..** from the main menu. Click **New** and enter ProjectID.

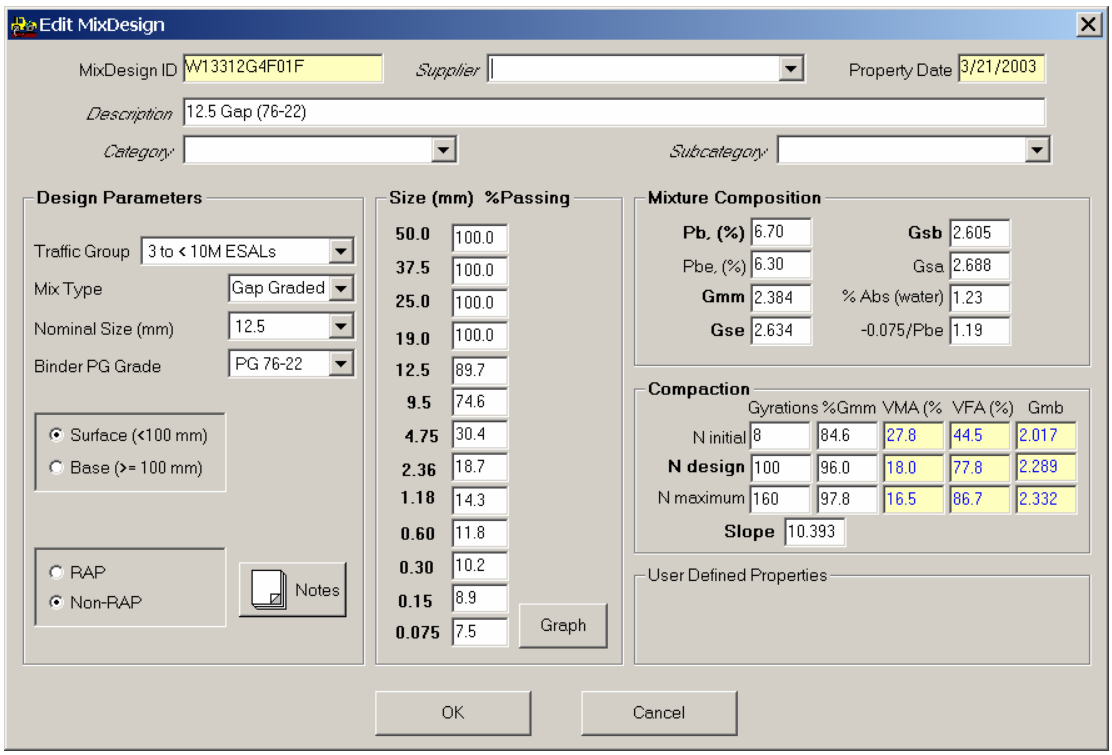
2. Enter general project information on **Project Information..General** form.

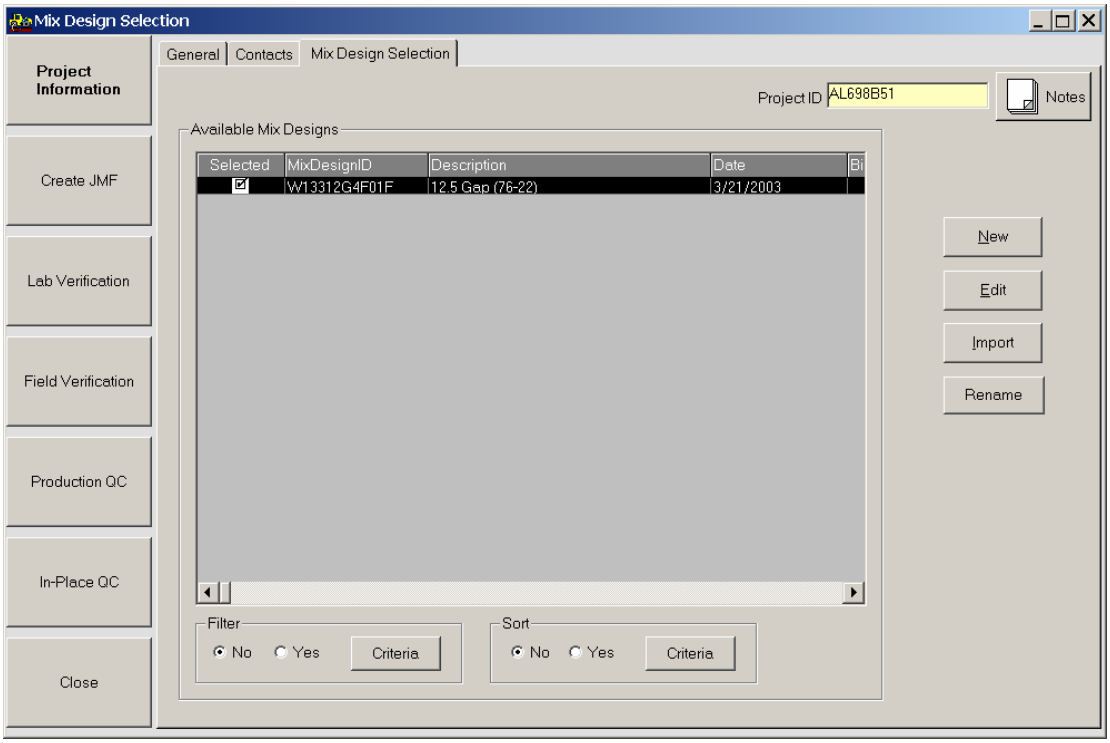


3. Enter project contact information on **Project Information..Contacts** form. Click **Rolodex** button to enter new contact. When finished, click OK and then select from list to enter into project information.

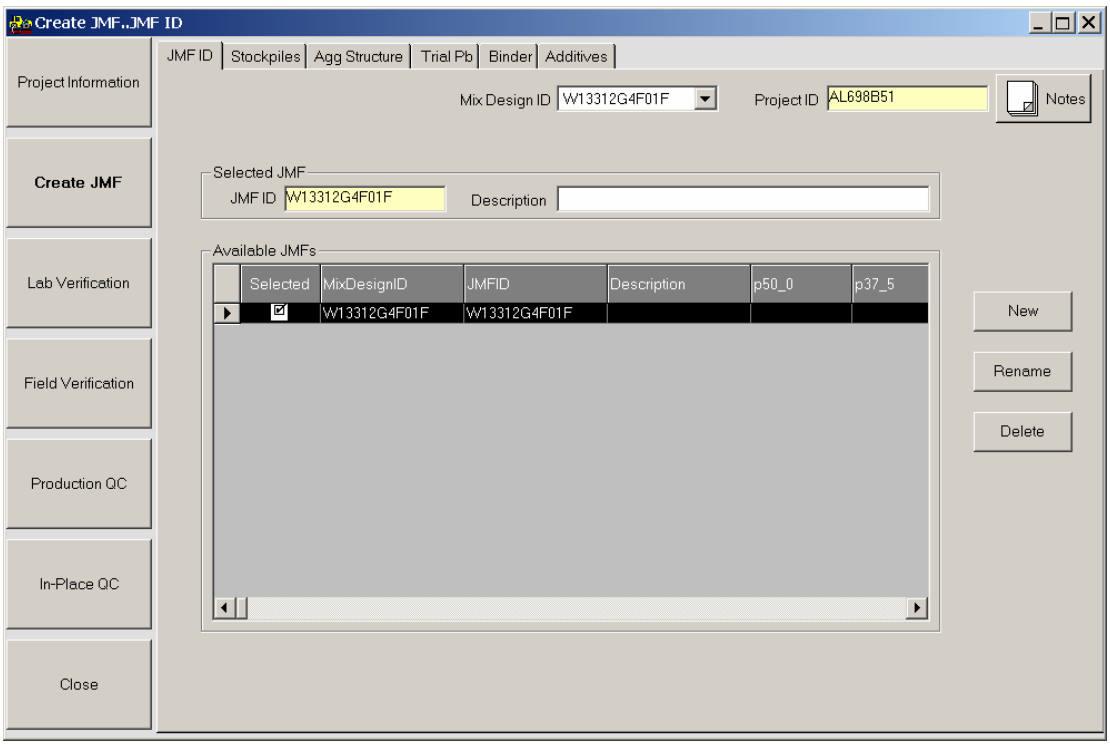


4. Enter mix design information via the **Project Information..Mix Design Selection** form. Click on **New** and enter mix information on **Edit Mix Design** form. When finished, click **OK** to return to the **Project Information..Mix Design Selection** form. Click the check box in the **Selected** column to select the mix design just entered.

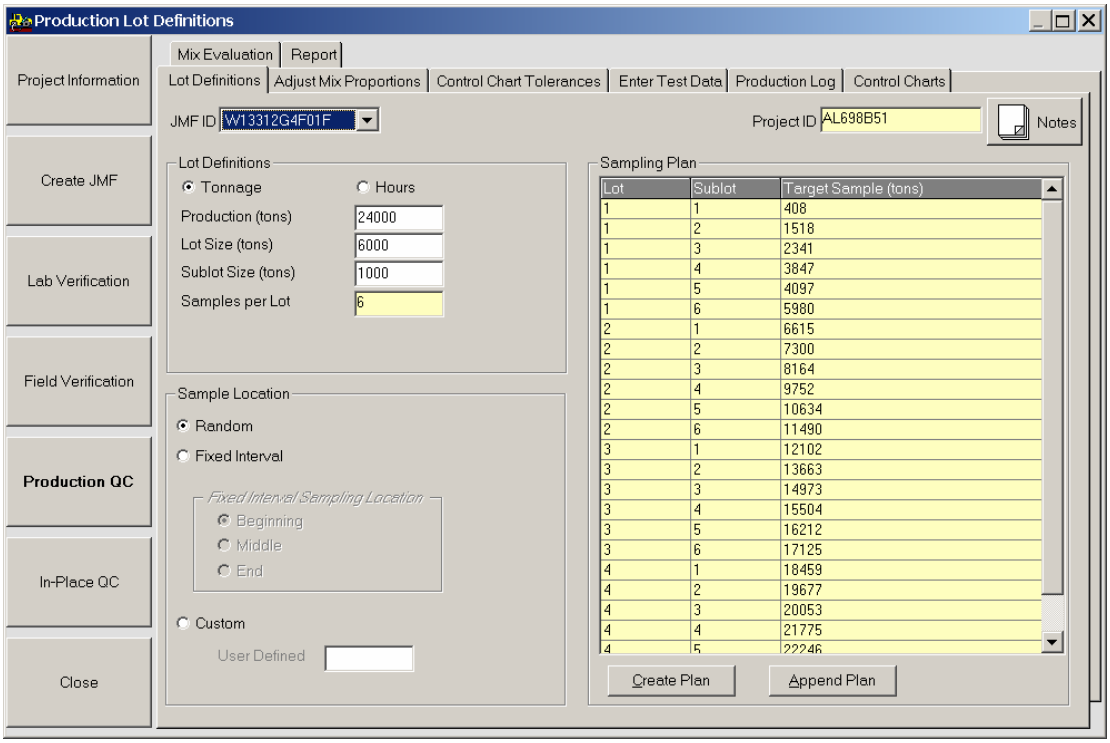




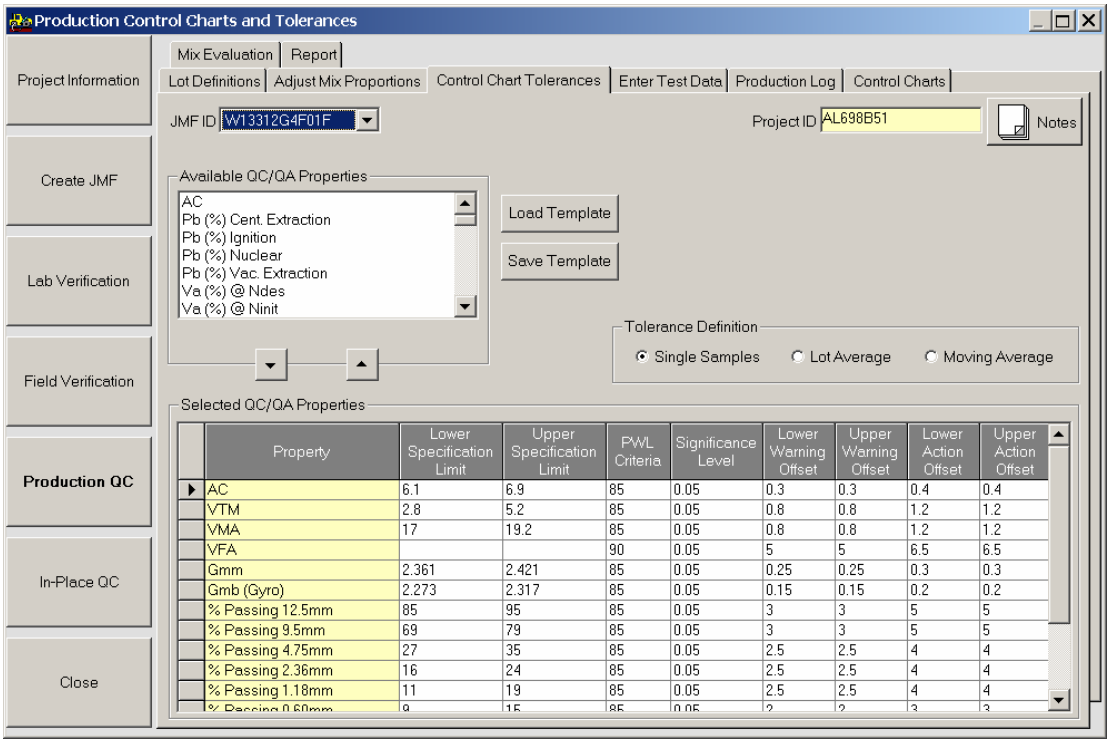
5. Create a JMF ID for the mix design on the **Create JMF..JMF ID** form. Click **New**; if the Mix Design ID (drop list box at the top of the form) conforms to MSHA naming conventions, a JMF ID matching the Mix Design ID will be suggested. Click **OK** to accept.



6. Define production lots and sublots on the **Production QC..Lot Definitions** form. After entering values for Total Production, Lot Size, and Sublot Size, click **Create Plan** to create a randomized set of sampling locations. *Note: Production and In-Place QC lots and sublots may be defined differently (i.e., have different sizes), so it is important that each category of QC testing be defined separately.*

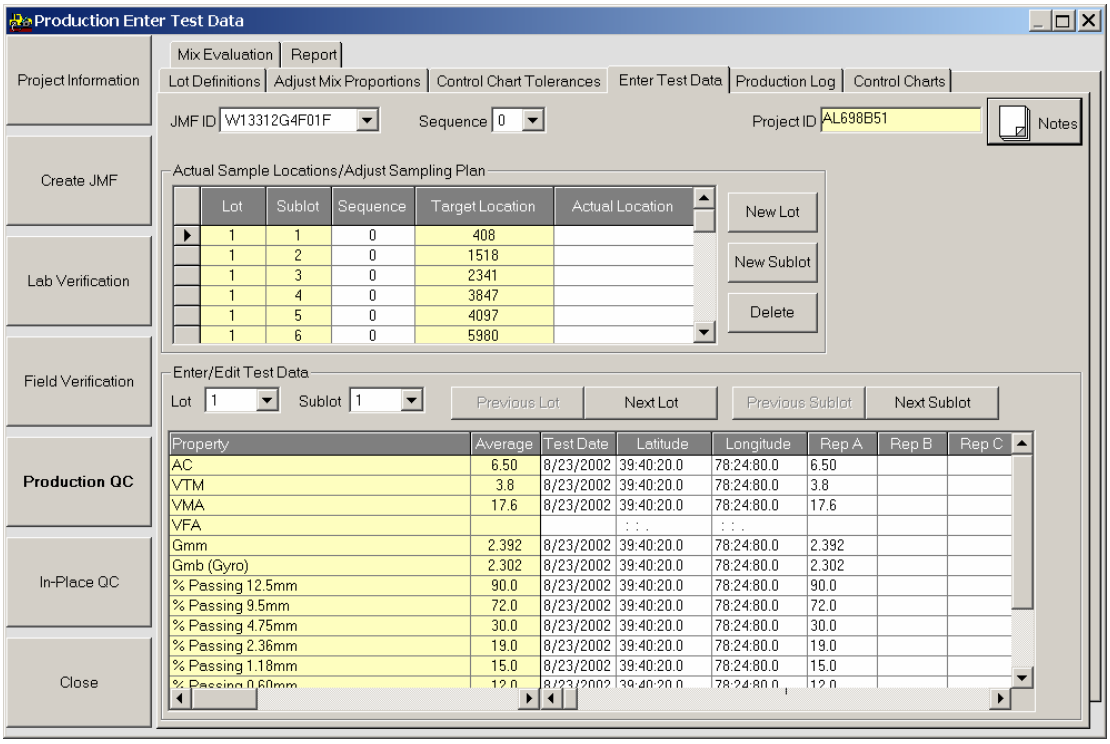


7. Define properties and limits for the production QC program on the **Production QC..Control Charts Tolerances** form. A template is provided for MSHA paving projects; click **Load Template** and select MSHA QC.qct file. *Note: Production and In-Place QC will involve different testing, so it is important that the test properties for each category of QC testing be defined separately.*

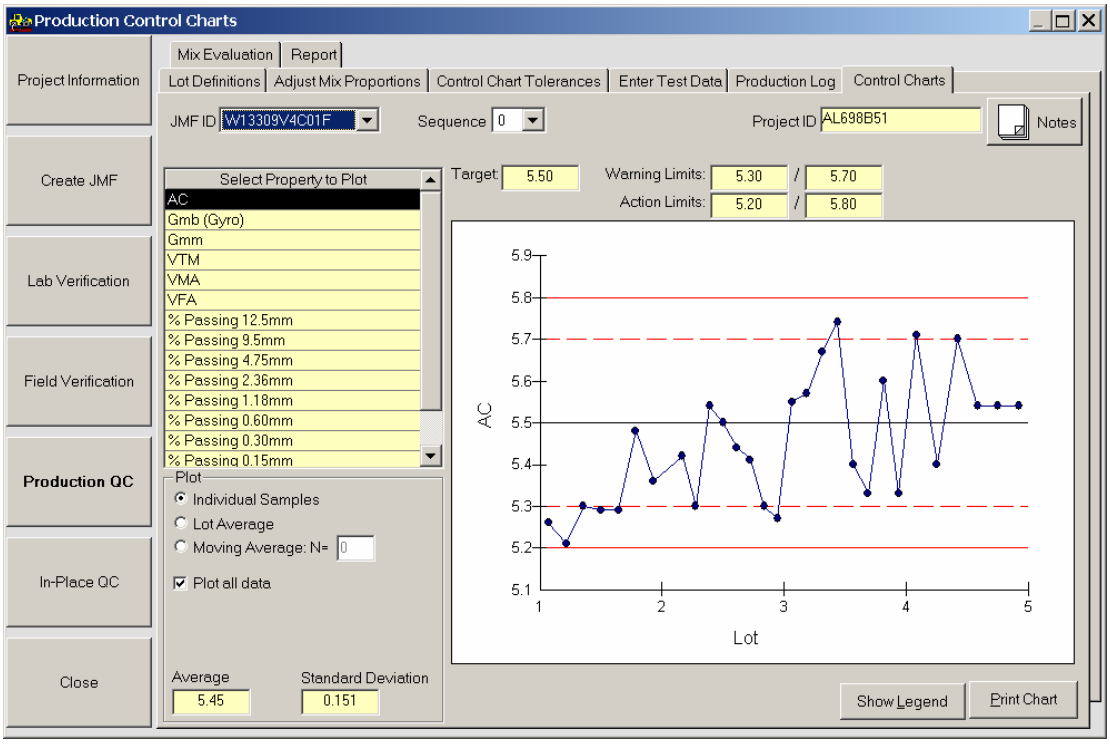


Property	Lower Specification Limit	Upper Specification Limit	PWL Criteria	Significance Level	Lower Warning Offset	Upper Warning Offset	Lower Action Offset	Upper Action Offset
AC	6.1	6.9	85	0.05	0.3	0.3	0.4	0.4
VTM	2.8	5.2	85	0.05	0.8	0.8	1.2	1.2
VMA	17	19.2	85	0.05	0.8	0.8	1.2	1.2
VFA			90	0.05	5	5	6.5	6.5
Gmm	2.361	2.421	85	0.05	0.25	0.25	0.3	0.3
Gmb (Gyro)	2.273	2.317	85	0.05	0.15	0.15	0.2	0.2
% Passing 12.5mm	85	95	85	0.05	3	3	5	5
% Passing 9.5mm	69	79	85	0.05	3	3	5	5
% Passing 4.75mm	27	35	85	0.05	2.5	2.5	4	4
% Passing 2.36mm	16	24	85	0.05	2.5	2.5	4	4
% Passing 1.18mm	11	19	85	0.05	2.5	2.5	4	4
% Passing 0.60mm	9	15	85	0.05	2	2	3	3

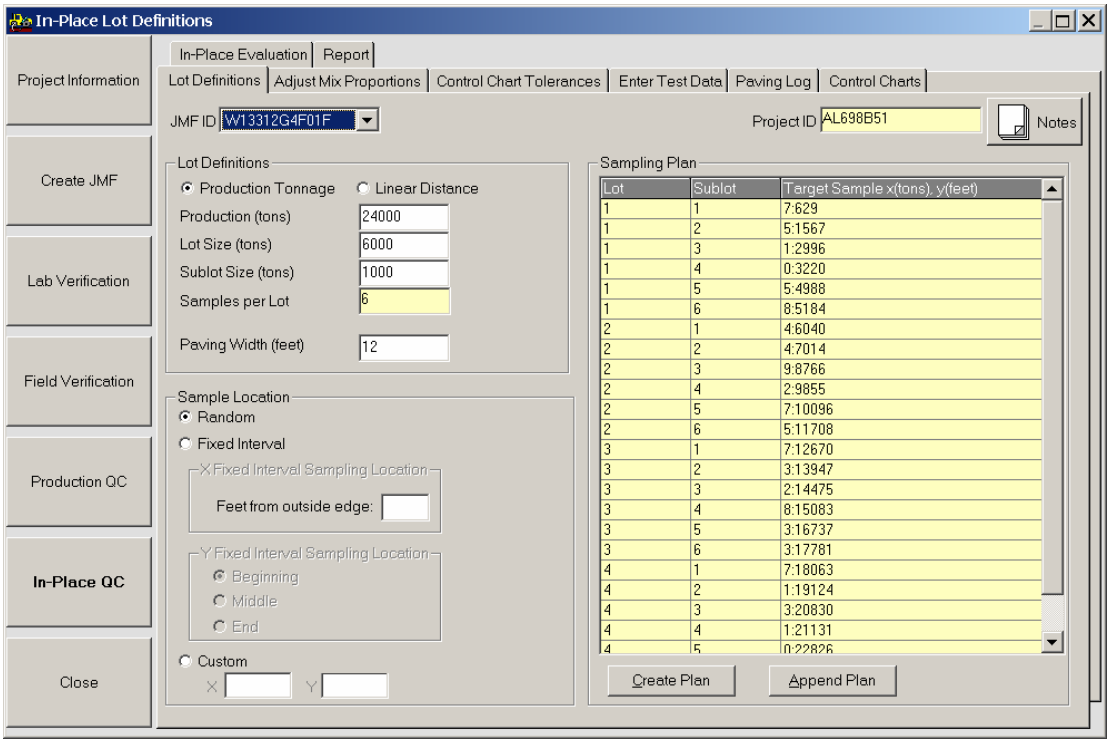
8. Enter production QC test data for each lot and sublot on the **Production QC..Enter Test Data** form.



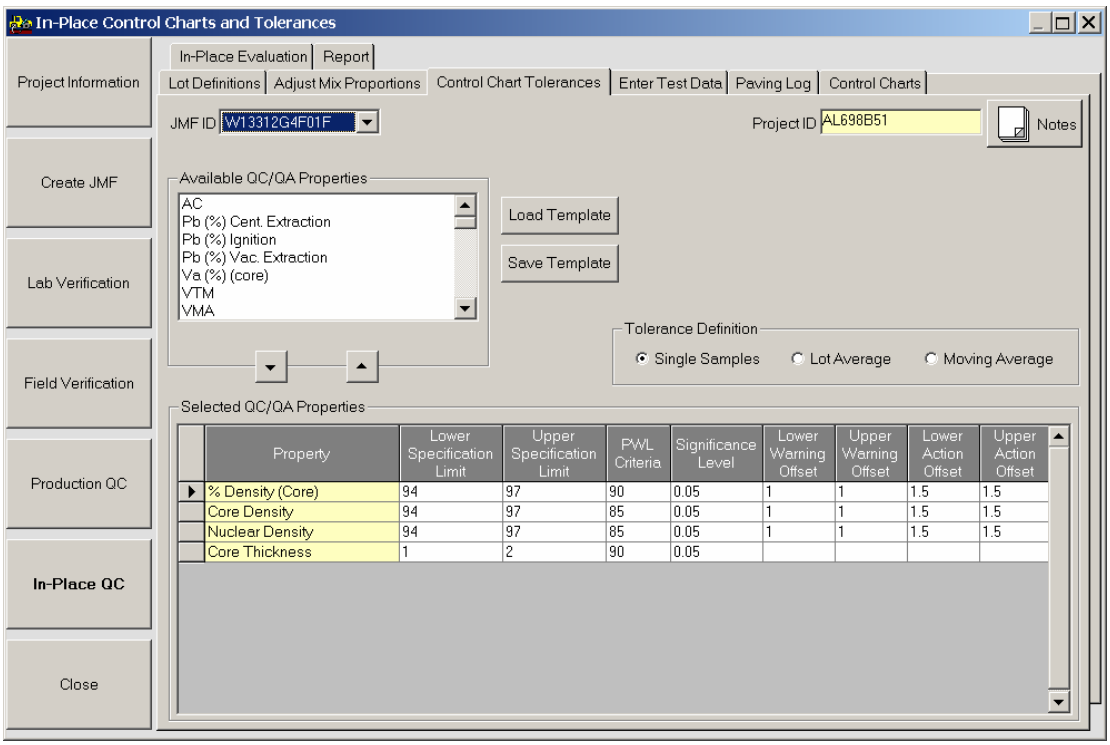
9. After entering production QC data, control charts may be viewed from the **Production QC..Control Charts** form.



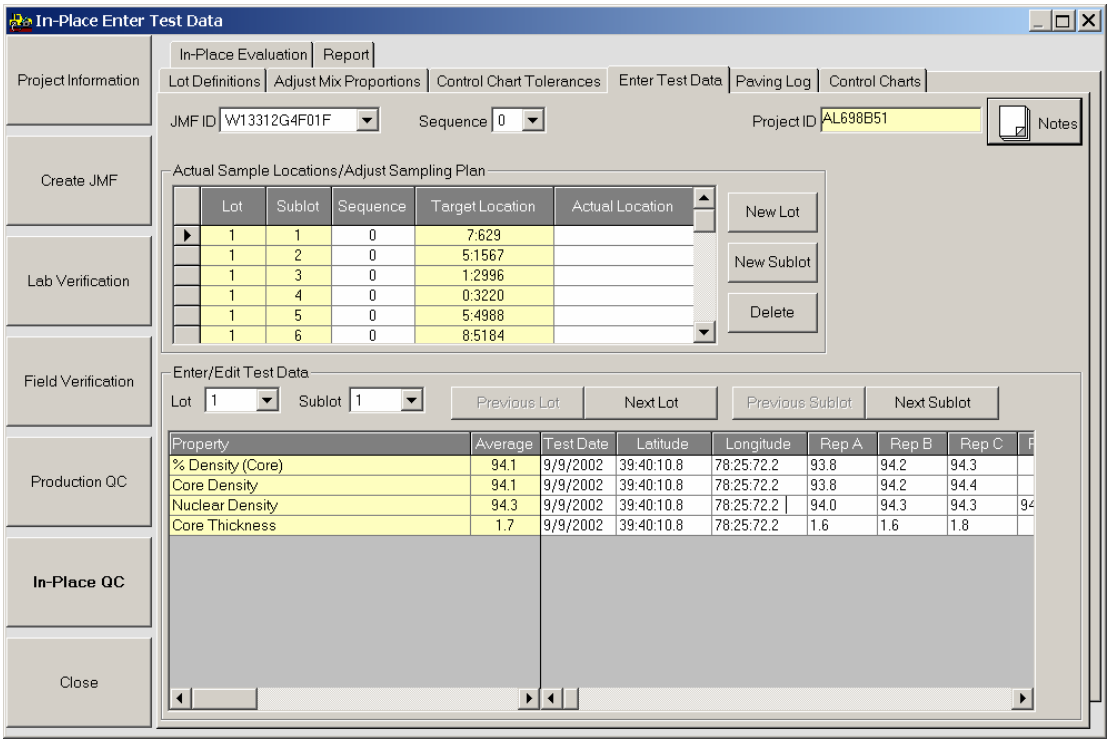
10. Define in-place lots and sublots on the **In-Place QC..Lot Definitions** form. After entering values for Total Production, Lot Size, Sublot Size, and Paving Width, click **Create Plan** to create a randomized set of sampling locations. *Note: Production and In-Place QC lots and sublots may be defined differently (i.e., have different sizes), so it is important that each category of QC testing be defined separately.*



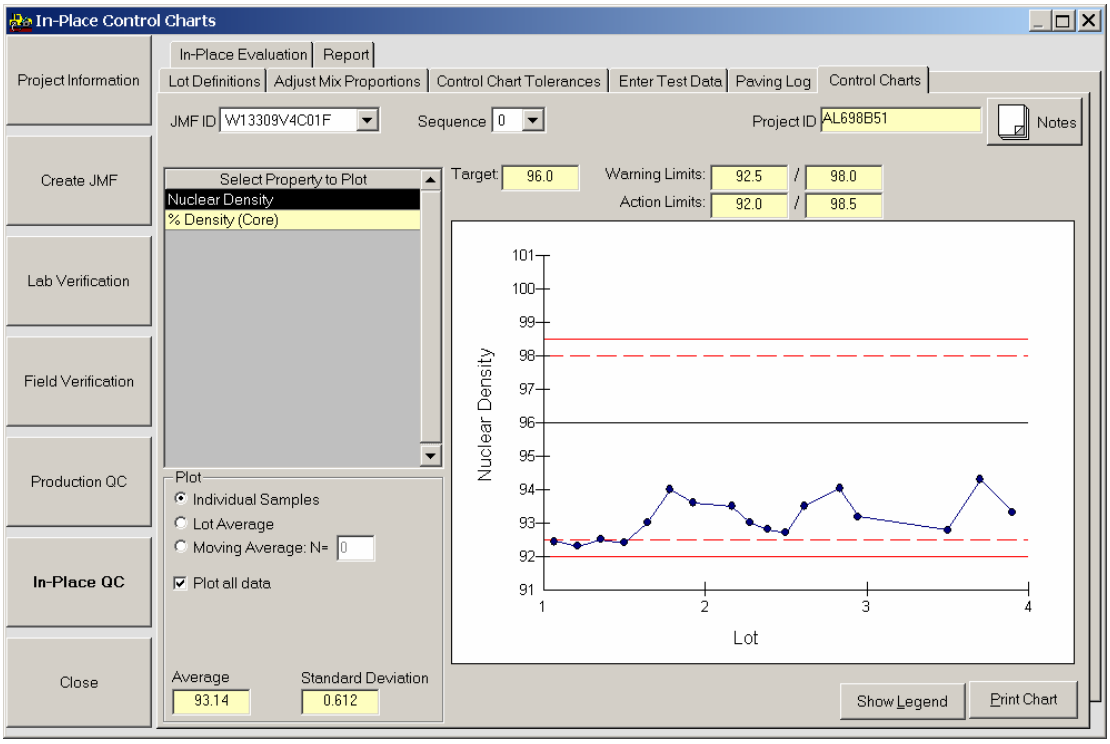
11. The properties and limits for the in-place QC program have already been loaded from the MSHA QC.qct file in step 7—see **In-Place QC..Control Charts Tolerances** form. *Note: Production and In-Place QC will involve different testing, so it is important that the test properties for each category of QC testing be defined separately.*



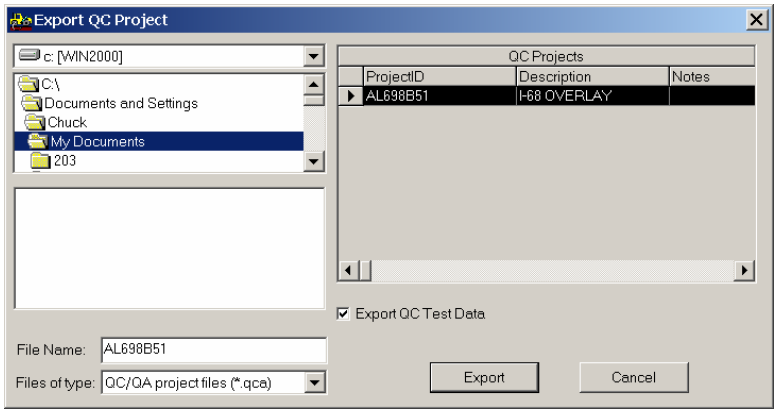
12. Enter in-place QC test data for each lot and sublot on the **In-Place QC..Enter Test Data** form.



13. After entering in-place QC data, control charts may be viewed from the **In-Place QC..Control Charts** form.



14. To export QC data to a file for transmission to MSHA, select **File..Export Data..Projects..To Text File..** from the main menu. Enter a file name on the **Export QC Project** form, make sure the **Export QC Data** box is checked, and then click **Export**.



APPENDIX E:

HMAVIEW LICENSE AGREEMENT