Development and Implementation of the Next Generation Bridge Management System for Wisconsin Phase I

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16. Abstract

With the enactment of the Moving Ahead for Progress in the 21st Century (MAP-21) legislation, each state must report element-level data to the Secretary of Transportation within two years. All highway bridges on the National Highway System (NHS) will need to be inspected pursuant to the revised standards that entail using the 2013 AASHTO Manual for Bridge Element Inspection for National Bridge Elements (NBEs), Bridge Management Elements (BMEs), and Agency Defined Elements (ADEs). In the case of the state of Wisconsin, NHS and non-NHS structures will be inspected with the new AASHTO elements.

This interim report describes the process used to convert the CoRe Structural Element Data to the NBEs, BMEs, and ADEs using the AASHTO Element Migrator from the current HSI to a new version of the HSI capable of assimilating bridge inspection information in compliance with the MAP-21 requirements. The report includes three distinct sections. The first section describes the process used to extract the CoRe bridge inspection information from the existing HSI, the development of the migration rules for all the bridge elements in the HSI, and the use of the AASHTO Migration Tool (Migrator) to develop an XML file with the results of the migration process. The second section outlines the development of a software application utility created to import the XML files from the Migrator to a revised version of the HSI. The third section contains appendices summarizing the literature research and the file names for the SQL code developed to complete Phase 1 of this project outlined in the deliverables for each section.

This report also includes a section with recommendations to place WisDOT in a strategic position to export HSI information to forecast bridge needs and prioritize bridge preservation and replacement work using the BrM 5.2.X software to be released in 2015.

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Background

The state of Wisconsin bridge network system consists of 14,022 structures that carry highway traffic. There are 5,196 state-owned bridges and 8,826 bridges owned by local units of government. Routine inspections for all of these bridges are conducted once every two years in accordance with federal requirements. All bridges in the network are inspected using the National Bridge Inspection (NBI) ratings, as well as bridge element condition ratings. The dual inspection of the bridge structures in the network began in 1998 using the AASHTO *Guide for Commonly Recognized (CoRe) Structural Elements*, published in 1997.

With the enactment of the Moving Ahead for Progress in the 21st Century (MAP-21) legislation, each state must report element-level data to the Secretary of Transportation within two years. All highway bridges on the National Highway System (NHS) will need to be inspected pursuant to the revised standards that entail using the 2013 AASHTO *Manual for Bridge Element Inspection* for National Bridge Elements (NBEs), Bridge Management Elements (BMEs), and Agency Defined Elements (ADEs). In the case of the state of Wisconsin, NHS and non-NHS structures will be inspected with the new AASHTO elements.

The Wisconsin Deportment of Transportation (WisDOT) uses their Highway Structures Information System (HSI) to collect and store bridge and other transportation asset inspection information. The goal of this system is to assist with the implementation of a strategic approach to maximize the benefits from resources used to preserve, operate, and expand their structures network. In order to provide the system with a solid foundation under the MAP-21 requirements, a conversion of the CoRe Structural Elements to the AASHTO 2013 National Bridge Elements and Bridge Management Elements is needed.

This interim report describes the process used to convert the CoRe Structural Element Data to the NBEs, BMEs, and ADEs using the AASHTO Element Migrator from the current HSI to a new version of the HSI capable of assimilating bridge inspection information in compliance with the MAP-21 requirements. The report includes three distinct sections. The first section describes the process used to extract the CoRe bridge inspection information from the existing HSI, the development of the migration rules for all the bridge elements in the HSI, and the use of the AASHTO Migration Tool (Migrator) to develop an XML file with the results of the migration process. The second section outlines the development of a software application utility created to import the XML files from the Migrator to a revised version of the HSI. The third section contains appendices summarizing the literature research and the file names for the SQL code developed to complete Phase 1 of this project outlined in the deliverables for each section.

This report also includes a section with recommendations to place WisDOT in a strategic position to export HSI information to forecast bridge needs and prioritize bridge preservation and replacement work using the BrM 5.2.X software to be released in 2015.

CoRe HSI Bridge Inspection Information Migration Process

The data migration process was planned with the knowledge that WisDOT maintains its element data in several related tables in the HSI that in combination were presented in a set of views that correspond to the BrM/Pontis tables ELEMDEFS and ELEMINSP, which are the sources of data for the Migrator. The Migrator software only understands and processes XML text data presented following its input and output XML schemas, which are largely defined based on the Pontis element-related tables. This requires all of the HSI data to be downloaded as XML files for processing by the Migrator. For documentation purposes, it should be noted that the Migrator does not provide functionality to migrate general structure information or general inspection information; it only migrates element specifications and inspection results in two XML files.

The migration process entails three main steps:

- Evaluating the HSI CoRe element data.
- Extracting and reorganizing the existing HSI data for migration.
- Transforming the data for migration to BrM/Pontis for testing.

Evaluating the HSI CoRe Element Data

This step entails the enumeration of all the element types used in Wisconsin, the verification that element ID and element TYPE codes are consistent with the Migrator input XML schema, and the identification of variances. Close coordination with the Project Oversight Committee (POC) was followed to document the relationship of WisDOT elements to the new AASHTO elements. The wall elements in the HSI are not included in this project.

A few iterations were needed to:

- Identify any elements that are to be deprecated and/or combined into new AASHTO elements during this process.
- Identify element characteristics affecting migration, such as number of condition states for each element.
- Identify any needed transformation rules for WisDOT specific elements, including rules for the WisDOT elements not found in the standard rule set, as well as those that are at variance with the assumptions or specifications of the standard Migrator rules.
- Confirm that element data state quantities add up to element total quantities.

A list of Assessments (physical element structure or site condition) was compiled by the WisDOT BOS and reviewed with the POC and the Research Team. The Assessments were treated in the same manner as the 2013 AASHTO elements, which is essentially the same as a Smart Flag/Defect to highlight an element with a meaningful condition but no recommended actions.

Table 1 Assessments List

Assessment Number	Name	Qty	Description
9001	Drainage - Approach	ea.	This defines drainage systems for the approach sections of the bridge.
9004	Drainage - Deck	ea.	This defines drainage systems for the approach sections of the bridge.
9007	Median	ea.	Use for medians. Do not use for curbs, as the definition for these are contained in the railing
9009	Sidewalk	ea.	Use for sidewalks. Do not use for curbs, as the definition for these are contained in the railing
9010	Aesthetic Treatments	ea.	Defines the condition of the aesthetic coating or treatment on a bridge structure. One each per bridge with Aesthetic treatments.
9011	Utilities	ea.	Defines utilities that are attached to bridge structures.
9020	Movable Bridge - Counterweight	ea.	Defines the condition of the counterweight system used for movable bridges.
9021	Movable Bridge - Cables	ea.	Defines the condition of the cables on a movable bridge.
9030	Signs - Object Markers	ea.	Defines the condition of bridge object markers or culvert markers.
9031	Signs - Narrow Bridge	ea.	Defines the condition of Narrow Bridge Signs on a Narrow Structure.
9032	Signs - One Lane Bridge	ea.	Defines the condtion of One Lane Bridge signs on a One Lane Bridge
9033	Signs - Vertical Clearance	ea.	Defines all vertical clearance signs (both near bridge and advanced warning).
9034	Signs - Weight Limit Posting	ea.	Defines all weight limit posting signs (both near bridge and advanced warning).
9035	Signs - Other	ea.	Can be used to define signage on bridge other than what is listed in specific sign assessment language.
9040	Slope Prot. - Asphaltic	ea.	Defines slopes protected by asphaltic systems.
9041	Slope Prot. - Bare	ea.	Defines slopes that have no protection systems.
9042	Slope Prot. - Concrete	ea.	Defines slopes protected by concrete.
9043	Slope Prot. - Crushed Aggregate Sprayed w/ Bit.	ea.	Defines slopes protected by crushed aggregate sprayed w/ Bit.
9044	Slope Prot. - Epoxy coated Crushed Agg	ea.	Defines slopes that are protected by Epoxy Coated Aggregate Slope Paving
9045	Slope Prot. - Riprap	ea.	Defines slopes protected by riprap.
9046	Slope Prot. - Select Crushed Material	ea.	Defines slopes protected by select crushed material.
9047	Slope Prot. - Other	ea.	Defines other slopes not included in the specific definitions from other slope protection.
9167	Steel Diaphragm	ea.	Steel diaphragm members between girders
9168	Concrete Diaphragm	ea.	Reinforced concrete diaphragms.
9169	Lateral Bracing	ea.	Lateral Bracing System.
9248	Culvert End Treatment	ea.	This element applies to culvert headwalls, aprons or other end treatments (any material). The quantity is expressed as an "each" item -

Assessment Number	Name	Qty	Description
9250	**Cross Bracing or Struts**	ea.	**Defines all types of cross bracing systems not defined by other elements.**
9290	**Dolphin or Fender System**	ea.	**Defines systems used to protect bridge substructure units from vessel collisions.**
9322	**Approach Roadway - Concrete (non-**	ea.	**This defines approach roadway sections that are concrete but are not designed as a structural slab.**
9323	**Approach Roadway - Asphalt**	ea.	**This defines approach roadway sections that are composed of asphalt.**
9324	**Approach Roadway - Gravel**	ea.	**This defines approach roadway sections that are composed of gravel.**
9325	**Roadway Over Structure**	ea.	**This element defines the roadway over a buried culvert or arch where there is more than 9" of fill.**
9335	**Decorative Rail**	ea.	**Non-structural decorative**
9336	**Luminaire Bases**	ea.	**Defines the base unit of Luminaire supports typically located on traffic railing on the bridge.**
9337	**Protective Screening**	ea.	**Protective screening or fencing on a bridge structure.**

Deliverable: Review/Update of a Microsoft Excel workbook file with tabs for Bridge Elements, New Element Definitions, Defects, Assessment Definitions, and Wall Elements (see the following graphic). The protective System Relationships and Defect Relationships tabs were created later by the WisDOT BOS.
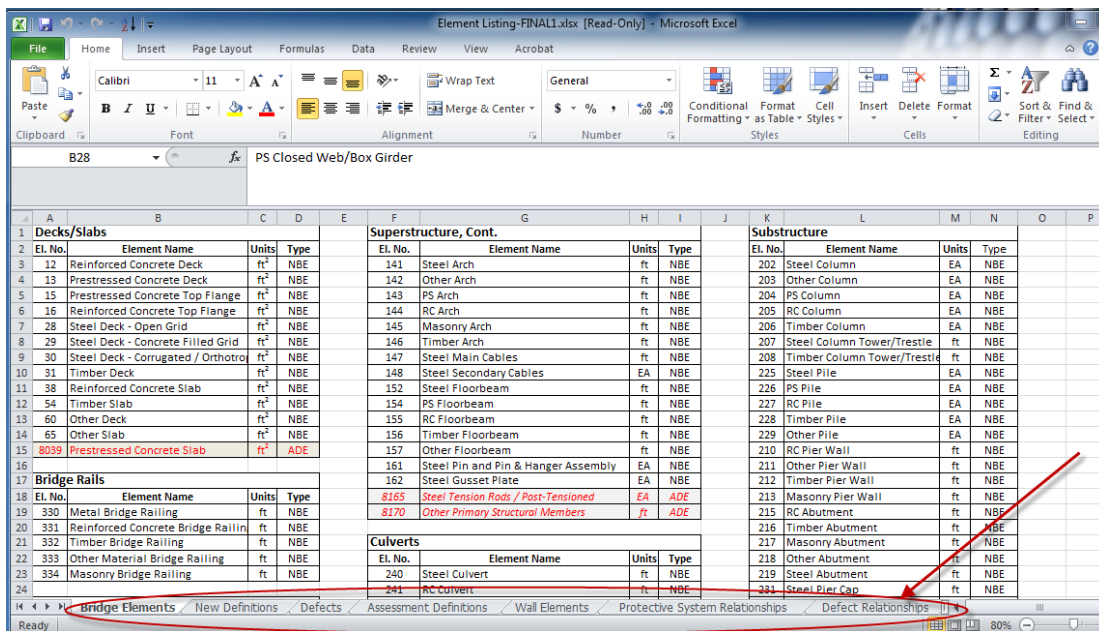
Extracting and Reorganizing the Existing HSI Data for Migration

This step is needed to present the element HSI data in a format consistent with the Migrator requirements. Using Structured Query Language (SQL), "Cloaking" Tables and Views need to be created to imitate the Pontis 4.x table equivalents that the Migrator is designed to read.

The data processing steps are as follows:

Note that the SQL code is embedded in this word document, just double click on the icon to open a file:

1) Create view to simulate ELEMDEFS

Script_Create_Materi
alized_View_ELEMDEF

2) Created view to simulate key attributes of BRIDGE

Script_Create_Materi
alized_View_BRIDGE.

3) Created table to calculate an INSPKEY for every WisDOT inspection ID

Script_Create_Worki
ng_Table_WRK_INSP

4) Created view to simulate key attributes of STRUCTURE_UNIT

Script_Create_Materi
alized_View_STRUCT\

5) Created view to simulate key attributes of ROADWAY

Script_Create_Materi
alized_View_ROADW/

6) Created view to simulate ELEMINSP

Script_Create_Materi
alized_View_ELEMINS

7) Created views on subordinate Pontis tables

SQL> CREATE VIEW METRIC_ENGLISH AS SELECT * FROM PONTIS.METRIC_ENGLISH;

View created

SQL> CREATE VIEW DATADICT AS SELECT * FROM PONTIS.DATADICT;

View created

8) Internal download query used by migrator is:

SELECT bridge.brkey,

inspevnt.inspkey,

inspevnt.inspdate,

eleminsp.strunitkey,

eleminsp.elemkey,

d.statecnt,

eleminsp.envkey,

eleminsp.quantity,

eleminsp.elem_scale_factor,

eleminsp.qtystate1,

eleminsp.qtystate2,

eleminsp.qtystate3,

eleminsp.qtystate4,

eleminsp.qtystate5,

structure_unit.strunitkey

FROM

bridge,

roadway,

structure_unit,

inspevnt,

eleminsp,

elemdefs d

WHERE (bridge.brkey = eleminsp.brkey AND

 bridge.brkey = roadway.brkey AND

  roadway.on_under =

  (SELECT MIN(r2.on_under)

   FROM   roadway r2

   WHERE r2.brkey = bridge.brkey)) AND

 bridge.brkey=structure_unit.brkey AND

 structure_unit.strunitkey = eleminsp.strunitkey AND

 bridge.brkey = inspevnt.brkey AND

 inspevnt.inspkey = eleminsp.inspkey AND

 d.elemkey = eleminsp.elemkey /*AND

 inspevnt.inspdate >= ? {0}*/

ORDER BY bridge.brkey,

 inspevnt.inspdate DESC,

 inspevnt.inspkey,

 eleminsp.elemkey,

 eleminsp.strunitkey,

 eleminsp.envkey

9) Updated INSPEVNT,ELEMINSP materialized views and the related table WRK_INSPKEYS

 a) Add an index to DT_STIN_ITEM

  -- Create/Recreate primary, unique and foreign key constraints

  alter table DT_STIN_ITEM

add constraint DT_STIN_ITEM_PK01 primary key (STIN_ID, STIN_ELMT_CD, STIN_ELMT_ENVR_NB)

using index

tablespace PROJNDX

pctfree 0

initrans 2

maxtrans 255

storage

(

  initial 160K

  next 1M

  minextents 1

  maxextents unlimited

);

b) Create the table WRK_INSPKEYS

Script_Create_Working_Table_WRK_INSP

This step is used to run lines 31 to 58 of the script

c) Create the materialized view INSPEVNT. It has only a partial image of the Pontis INSPEVNT table -   enough to query on from the Migrator

see file >>> Script_Create_Materialized_View_INSPEVNT.sql

>>> Generates 138,872 synthetic rows

DROP MATERIALIZED VIEW INSPEVNT;

CREATE MATERIALIZED VIEW INSPEVNT

REFRESH FORCE ON DEMAND

AS

SELECT inspkeys.strc_id AS BRKEY, inspkeys.INSPKEY, insp.stin_dt as INSPDATE, insp.stin_tycd as STIN_TYCD

 FROM WRK_INSPKEYS inspkeys INNER JOIN   dt_strc_insp insp

   on inspkeys.strc_id = insp.strc_id and inspkeys.stin_id = insp.stin_id and UPPER(TRIM(insp.stin_tycd)) IN ('R' , 'INI');

   d) Create the materialized view ELEMINSP

    This is the FULL image of the INSPEVNT table

          see file >>> Script_Create_Materialized_View_ELEMINSP.sql

          >>> Generates 1,295,746 synthetic rows

10) Exported generated data from INSPEVNT and ELEMINSP again.

11) Download all data to Migrator from ELEMINSP materialized view (synthetic data)

12) Migration rules modifications for 2013-07-30

   a) Rules changed to migrate all WisDOTslope protection types to 9010 - generic

   b) Rules changed to migate WisDOT 148 to 8165

   c) Rules removed for 146 and 147

   d) Rules changed to force WisDOT curb 410 to sidewalks assessment 9009

   e) Rules changed to force WisDOT sidewalks/medians 415 to median assessment 9007

   f) All WisDOT wingwalls now go to 8608 'Other Walls'

   g) WisDOT 172 and 171 go to 8167 Steel Diaphragm

h) WisDOT 250 goes to 8168 Concrete Diaphragm

i) WisDOT 174 and 175 go to 8169 Lateral Bracing (as far as I can stell, there are only steel elements for this.)

j) WisDOT 236 goes to 8250 - X-bracing (only timber as far as I can tell).

k) WisDOT 405 goes to 9004 - Deck drainage. It is impossible to tell if 405 is deck or approach drainage - requires field verification.

l) WisDOT 340,341,342,343,344 slope protections go to generic slope protection assessment 9010

13) Attempted and succeeded migrating data for districts 1 and 7 following the migrator instructions to connect to the database.

During the testing phase, some minor issues with quantities were found and solved with direction from the POC. Also, the migrator filter was adjusted to retrieve only the appropriate inspection types and to select just the last inspection per bridge.

Deliverable: *The following SQL scripts to create the tables and views were delivered to WisDOT via FTP on July 31, 2013.*

Name

- Query Match WisDOT Elements to Pontis 4 ELEMDEFS.sql
- Query_Show_Elements_With_All_Zero_Quantities.sql
- Query_Show_ELEMINSP_data_for_BRKEY_B260007.sql
- Query_Show_Generated_STATEDFS_For_Dummy_Element_666.sql
- Query_Show_WisDOT_DT_STIN_ELMT_as_ELEMDEFS.sql
- Script_Create_Materialized_View_BRIDGE.sql
- Script_Create_Materialized_View_ELEMDEFS.sql
- Script_Create_Materialized_View_ELEMINSP.sql
- Script_Create_Materialized_View_INSPEVNT.sql
- Script_Create_Materialized_View_ROADWAY.sql
- Script_Create_Materialized_View_STRUCTURE_UNIT.sql
- Script_Create_View_MRRACTDF.sql
- Script_Create_View_STATEDFS.sql
- Script_Create_Working_Table_WRK_INSPKEYS.sql
- Script_Insert_MRRACTDF.sql
- Script_Insert_STATEDFS.sql

Note that the insert scripts need to be processed after the create scripts.

## Transforming the Data for Migration to BrM/Pontis for Testing

The third and final step of the migration process consists of importing the existing WisDOT element specifications XML file using the Migrator. During the test phase, the element definitions file was successfully verified to work with the Pontis 5.1.3 release provided by WisDOT.

The steps followed to test the import the XML into Pontis 5.1.3 are:

1. Edit the NBI file to change the bridge_id column to remove the bridge_id trailing zeroes to match the XML migrator format
2. Import the edited NBI file into an empty Pontis 5.1.3 database
3. Make sure that the elemddefs table rows, match the Element definition XML File
4. Import the XML element data from the Migrator Results

At this point, the existing (default) migration rules were updated to process WisDOT elements where applicable and new rules for Agency Defined Elements (ADEs) were created. The validation of all element migration rules was completed using the imported elements specification XML file.

The element specifications file from the Migrator is one of the necessary inputs to the Pontis 5.1.3 BMS and is also needed in the new HSI database. By design, the file lacks condition state and actions language. A manual or automated process is needed to write the condition state and actions language for the elements. The HSI database information contains dimensional quantities in English units, so the XML file input and output must be set to this unit system, as shown below.
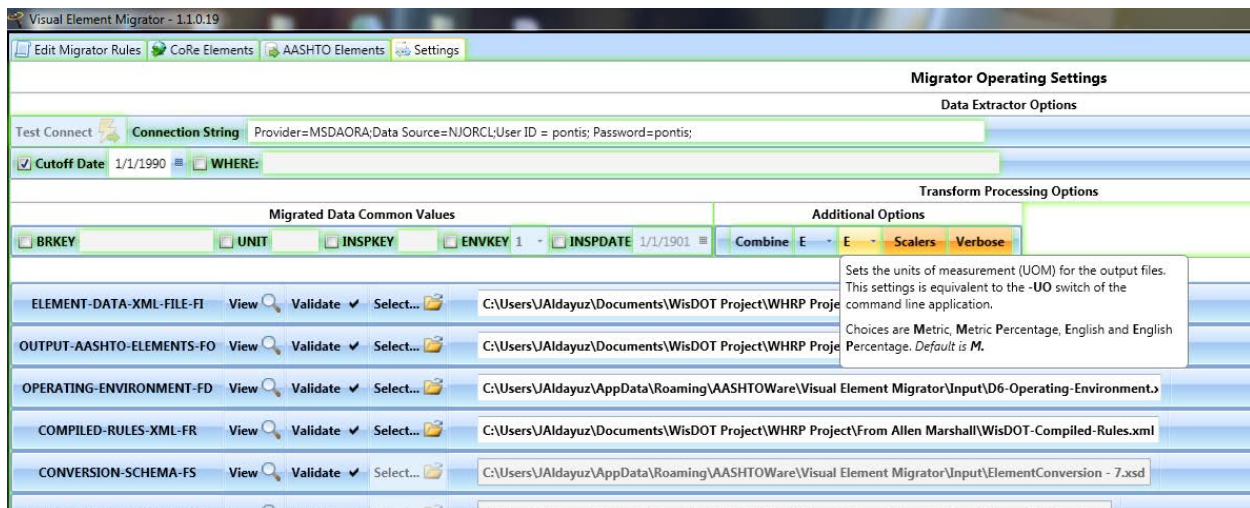
In accordance with the Work Plan, to verify compliance with AASHTO standards, the Migrator files were tested using the following iterative process:

- Applied transformation rules to generate output XML files
- Reviewed results with the POC and corrected some rules as requested
- Imported XML selected bridge inspections to test BrM/Pontis 5.1.3 database
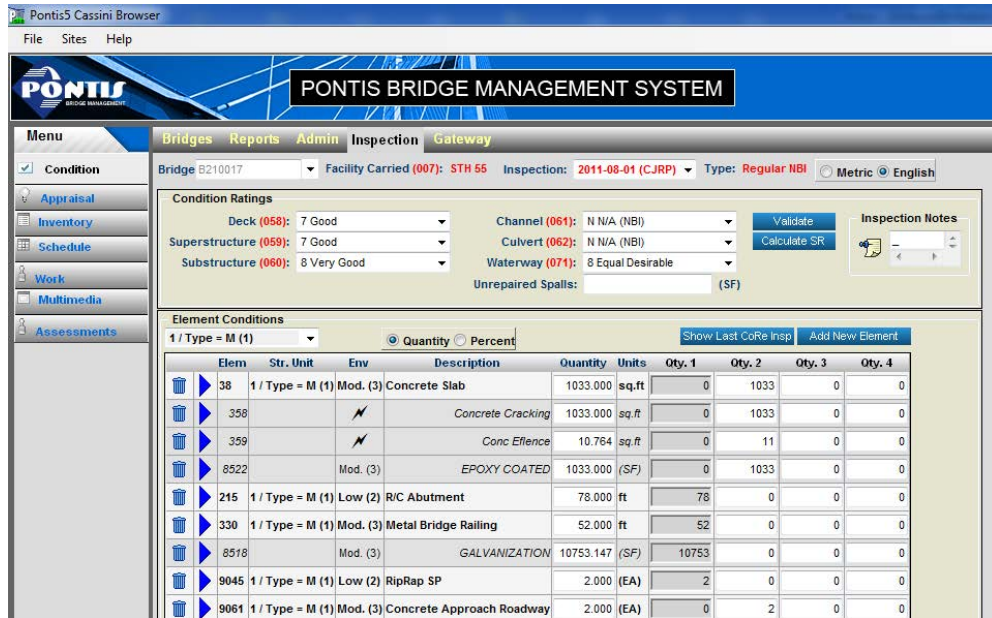
Deliverable: Migration Rules File, XML Element Definition File, and XML Migrated Data File delivered on August 26, 28, and 29, 2013, respectively.

WisDOT-Compiled-Rules-2013-08-28.xml	8/30/2013 9:32 AM	XML Document
WISDOT-Element-Specifications-20130826.xml	8/30/2013 9:33 AM	XML Document
WisDOT-Rules-Input-2013-08-28.txt	8/30/2013 9:33 AM	Text Document

Script_Create_Materialized_View_ELEMINSP.sql
Transfer_ELEMINSP_20130829.sql.zip
WISDOT-All Districts - CoreElementData -Latest R or INI Inspections 20130829.xml
WisDOT-All Districts-Migrated-AASHTOElementData-Latest Inspections Only - 20130829 ENGLISH UOM.xml
WisDOT-All Districts-Migrated-AASHTOElementData-Latest Inspections Only - 20130829 METRIC UOM.xml

New HSI Migrated Data Import Process

This section describes the process used to import the two Migrator XML files to a new HSI Oracle database modified by WisDOT to accommodate BrM/Pontis 5.1.3 conventions. The current and new HSI databases were reviewed in order to identify their differences in terms of the tables relevant to bridge inspection information.
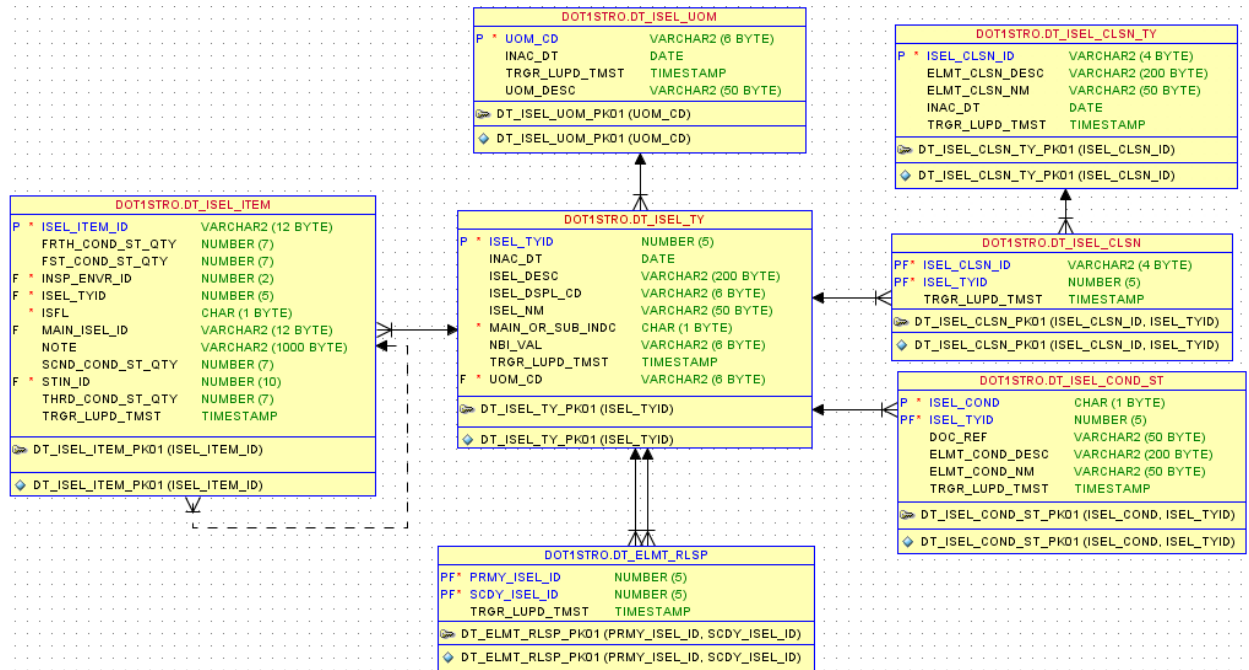
The following entity-relationship diagram shows the current HSI database tables where the CoRe bridge element inspection data is stored.
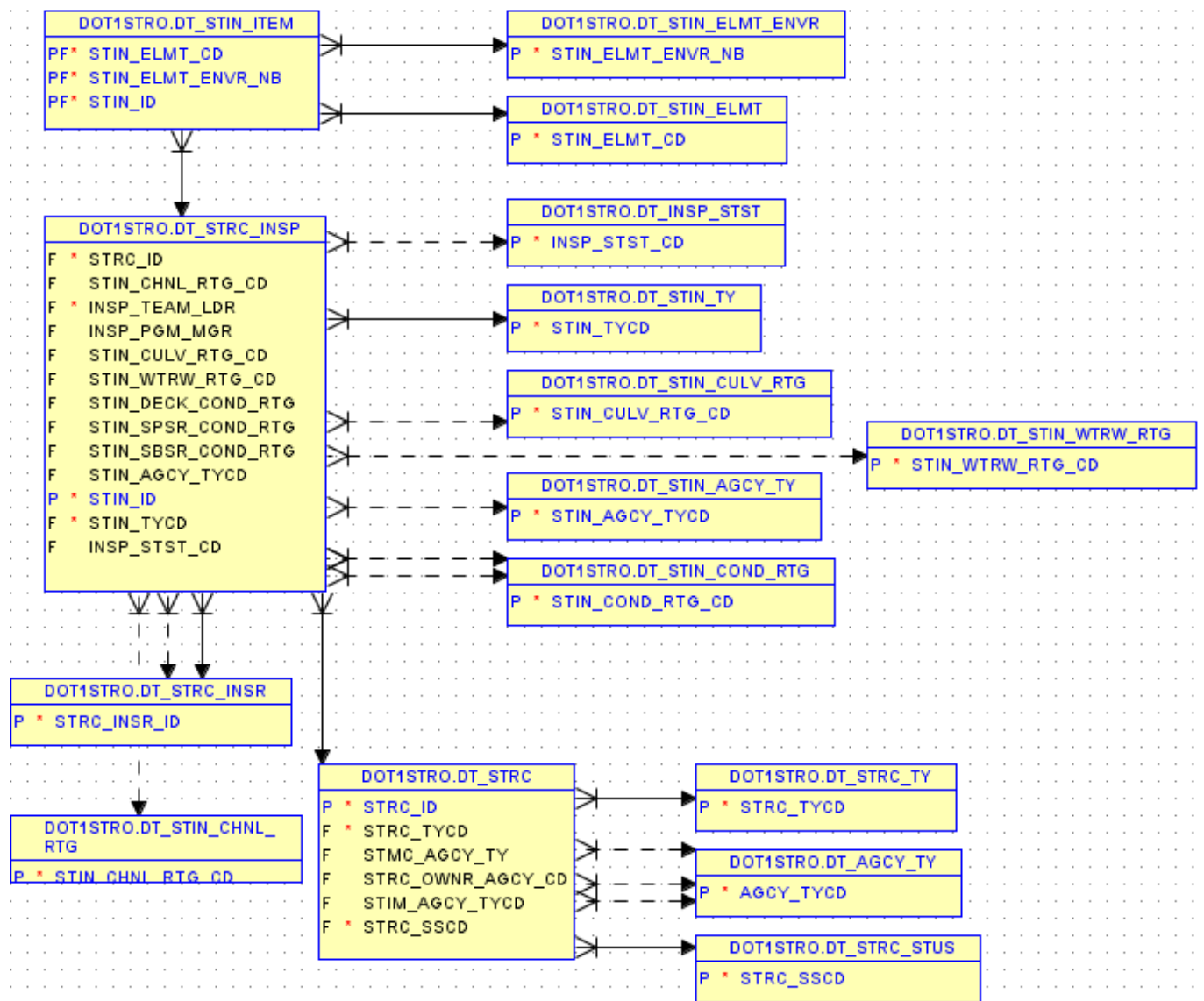
The next entity-relationship diagram shows the new HSI database structure where the converted CoRe element data based on the XML element specification from the Migrator will be stored. The new tables have their names shown in red font.
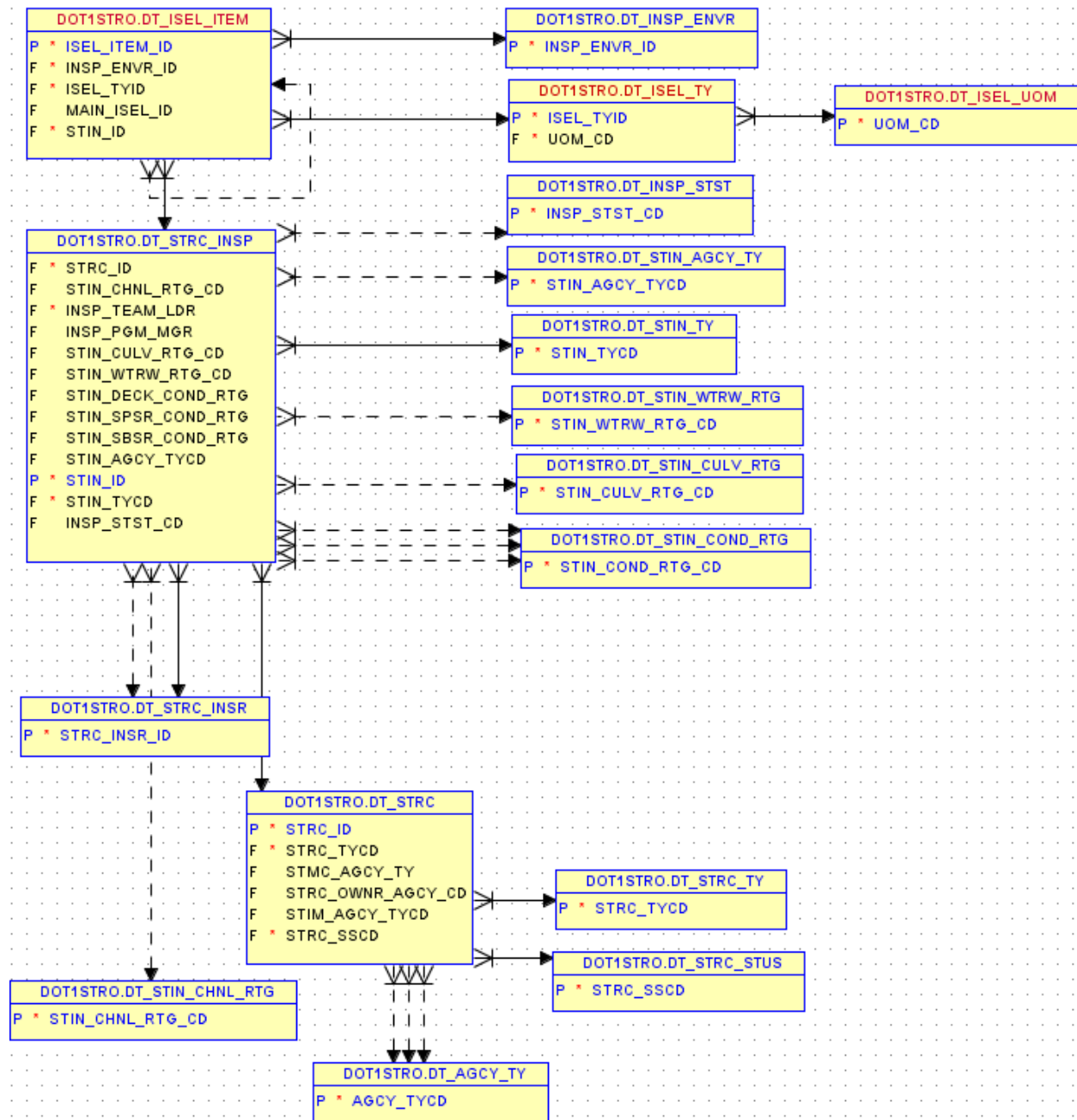
The following figure shows an expanded entity-relationship between the new tables to be added to the production HSI database.

DOT1STRO.DT_ISEL_UOM

P	* UOM_CD	VARCHAR2 (6 BYTE)
	INAC_DT	DATE
	TRGR_LUPD_TMST	TIMESTAMP
	UOM_DESC	VARCHAR2 (50 BYTE)

- DT_ISEL_UOM_PK01 (UOM_CD)
- DT_ISEL_UOM_PK01 (UOM_CD)

DOT1STRO.DT_ISEL_CLSN_TY

P	* ISEL_CLSN_ID	VARCHAR2 (4 BYTE)
	ELMT_CLSN_DESC	VARCHAR2 (200 BYTE)
	ELMT_CLSN_NM	VARCHAR2 (50 BYTE)
	INAC_DT	DATE
	TRGR_LUPD_TMST	TIMESTAMP

- DT_ISEL_CLSN_TY_PK01 (ISEL_CLSN_ID)
- DT_ISEL_CLSN_TY_PK01 (ISEL_CLSN_ID)

DOT1STRO.DT_ISEL_ITEM

P	* ISEL_ITEM_ID	VARCHAR2 (12 BYTE)
	FRTH_COND_ST_QTY	NUMBER (7)
	FST_COND_ST_QTY	NUMBER (7)
F	* INSP_ENVR_ID	NUMBER (2)
F	* ISEL_TYID	NUMBER (5)
	* ISFL	CHAR (1 BYTE)
F	MAIN_ISEL_ID	VARCHAR2 (12 BYTE)
	NOTE	VARCHAR2 (1000 BYTE)
	SCND_COND_ST_QTY	NUMBER (7)
F	* STIN_ID	NUMBER (10)
	THRD_COND_ST_QTY	NUMBER (7)
	TRGR_LUPD_TMST	TIMESTAMP

- DT_ISEL_ITEM_PK01 (ISEL_ITEM_ID)
- DT_ISEL_ITEM_PK01 (ISEL_ITEM_ID)

DOT1STRO.DT_ISEL_TY

P	* ISEL_TYID	NUMBER (5)
	INAC_DT	DATE
	ISEL_DESC	VARCHAR2 (200 BYTE)
	ISEL_DSPL_CD	VARCHAR2 (6 BYTE)
	ISEL_NM	VARCHAR2 (50 BYTE)
	* MAIN_OR_SUB_INDC	CHAR (1 BYTE)
	NBI_VAL	VARCHAR2 (6 BYTE)
	TRGR_LUPD_TMST	TIMESTAMP
F	* UOM_CD	VARCHAR2 (6 BYTE)

- DT_ISEL_TY_PK01 (ISEL_TYID)
- DT_ISEL_TY_PK01 (ISEL_TYID)

DOT1STRO.DT_ISEL_CLSN

PF	* ISEL_CLSN_ID	VARCHAR2 (4 BYTE)
PF	* ISEL_TYID	NUMBER (5)
	TRGR_LUPD_TMST	TIMESTAMP

- DT_ISEL_CLSN_PK01 (ISEL_CLSN_ID, ISEL_TYID)
- DT_ISEL_CLSN_PK01 (ISEL_CLSN_ID, ISEL_TYID)

DOT1STRO.DT_ISEL_COND_ST

P	* ISEL_COND	CHAR (1 BYTE)
PF	* ISEL_TYID	NUMBER (5)
	DOC_REF	VARCHAR2 (50 BYTE)
	ELMT_COND_DESC	VARCHAR2 (200 BYTE)
	ELMT_COND_NM	VARCHAR2 (50 BYTE)
	TRGR_LUPD_TMST	TIMESTAMP

- DT_ISEL_COND_ST_PK01 (ISEL_COND, ISEL_TYID)
- DT_ISEL_COND_ST_PK01 (ISEL_COND, ISEL_TYID)

DOT1STRO.DT_ELMT_RLSP

PF	* PRMY_ISEL_ID	NUMBER (5)
PF	* SCDY_ISEL_ID	NUMBER (5)
	TRGR_LUPD_TMST	TIMESTAMP

- DT_ELMT_RLSP_PK01 (PRMY_ISEL_ID, SCDY_ISEL_ID)
- DT_ELMT_RLSP_PK01 (PRMY_ISEL_ID, SCDY_ISEL_ID)

After reviewing the HSI databases, a map for the data transfer was developed by quantifying and qualifying the data in both Migrator XML output files. The table below shows the migrated element inspection fields in the XML that will be imported into the new HSI Oracle database.

	Migrated XML Fields	Column Type	Sample Data
1	brkey	varchar (15)	"B190001"
2	inspkey	varchar (4)	"DWIU"
3	inspdate	datetime	8/21/2012
4	strunitkey	numeric (4,0)	1
5	elemkey	numeric (3,0)	12
6	envkey	numeric (1,0)	3
7	quantity	float	183.1119
8	scale-factor	float	1
9	paircode	numeric (2,0)	57
10	num-core-origins		1
11	core-parent-number	number (3,0)	26
12	Qty 1	float	173.9563
13	Qty 2	float	9.1556
14	Qty 3	float	0
15	Qty 4	float	0
16	linked-to-element-number	numeric (3,0)	

Mapping of Migrated Element Data to New HSI Database

The following figure shows how the migrated element data will be mapped to the new HSI database.

	Migrated XML Fields	Column Type	Sample Data	HSI Table Name	HSI Column Name	HSI Column Type
1	brkey	varchar (15)	"B190001"	DT_STRC_INSP	STRC_ID	Varchar2(11 Byte)
2	inspkey	varchar (4)	"DWIU"			
3	inspdate	datetime	8/21/2012	DT_STRC_INSP	STIN_DT	Date
4	strunitkey	numeric (4,0)	1			
5	elemkey	numeric (3,0)	12	DT_ISEL_ITEM	ISEL_TYID	Number (5,0)
6	envkey	numeric (1,0)	3	DT_ISEL_ITEM	INSP_ENVR_ID	Number (2,0)
7	quantity	float	183.1119	DT_STRC_ELMT	STD_ELMT_QTY	Number (12,3)
8	scale-factor	float	1			
9	paircode	numeric (2,0)	57			
10	num-core-origins		1			
11	core-parent-number	number (3,0)	26			
12	Qty 1	float	173.9563	DT_ISEL_ITEM	FST_COND_ST_QTY	Number (7,0)
13	Qty 2	float	9.1556	DT_ISEL_ITEM	SCND_COND_ST_QTY	Number (7,0)
14	Qty 3	float	0	DT_ISEL_ITEM	THRD_COND_ST_QTY	Number (7,0)
15	Qty 4	float	0	DT_ISEL_ITEM	FRTH_COND_ST_QTY	Number (7,0)
16	linked-to-element-number	numeric (3,0)				

Mapping Description

Item 1: brkey to DT_STRC_INSP/STRC_ID

This item is a foreign key in the DT_STRC_INSP table. The import rule established for this item is that when an inspection will be copied, it will be copied to a new inspection row.

Item 2: inspkey to DT_STRC_INSP/STIN_ID

The inspkey data field, along with the brkey and inspdate data fields for each record in the XML file, is used to obtain the STIN_TYCD field from the "cloaked" linking table named INSPEVNT. Once the STIN_TYCD is obtained, it is combined with the inspdate and brkey to obtain the DT_STIN_ID field from the DT_STRC_INSP table.

These transformations are performed automatically during the last step within the .NET HSI importer utility. The DT_STIN_ID data field links the new HSI element inspection records to the corresponding main inspection record in the DT_STRC_INSP table.

Item 3: inspdate to DT_STRC_INSP/STIN_DT

This item will get copied to a new inspection from the original inspection row, keeping the date as is.

Item 4: strunitkey

This field is not imported; WisDOT does not use structure units for the inspection.

Item 5: elemkey to DT_ISEL_ITEM/ISEL_TYID

The elemkey field will be used as a part of the primary key for the new row inserted to the DT_ISEL_ITEM table. This data field will reside in the ISEL_TYID column of the DT_ISEL_ITEM table.

Item 6: envkey to DT_ISEL_ITEM/INSP_EVNR_ID

Item 6 will be used as a part of the primary key for the new row inserted to the DT_ISEL_ITEM table. In order to transfer the envkey field from the new migrated element inspections in the XML file, the DT_INSP_ENVR table is first populated during one of the steps within the .NET HIS XML importer utility. The current process only requires that the DT_INSP_ENVR table has four environments populated with the INSP_ENVR_ID ranging from 1 through 4 representing the environment names Low, Moderate, Severe, and Benign, respectively.

The determination of any changes necessary to these environment definitions while still maintaining the validity of migrated element inspection data will be materialized during WisDOT internal review of new HSI element inspection data as a part of the pilot inspection process.

Item 7: quantity to DT_STRC_ELMT/STD_ELMT_QTY

This item will not be imported since the total quantity of an element does not change during the migration.

Item 8: scale-factor

This field will not be imported.

Item 9: paircode

This item will not be imported.

Item 10: num-core-origins

This item will not be imported.

Item 11: core-parent-number

This item will not be imported.

Item 12: Qty1 to DT_ISEL_ITEM/FST_COND_ST_QTY

Item 12 will be imported as part of the new element inspection row added to the DT_ISEL_ITEM table.

Item 13: Qty2 to DT_ISEL_ITEM/SCND_COND_ST_QTY

This data will be imported as part of the new element inspection row added to the DT_ISEL_ITEM table.

Item 14: Qty3 to DT_ISEL_ITEM/THRD_COND_ST_QTY

This data will be imported as part of the new element inspection row added to the DT_ISEL_ITEM table.

Item 15: Qty4 to DT_ISEL_ITEM/FRTH_COND_ST_QTY

This data will be imported as part of the new element inspection row added to the DT_ISEL_ITEM table.

Item 16: linked-to-element-number to DT_ISEL_ITEM/MAIN_ISEL_ID

This data will be used to locate the ISEL_ITEM_ID field of a parent HSI element inspection record in the DT_ISEL_ITEM table to populate the MAIN_ISEL_ID field of a new element inspection record being inserted.

Import Operation Implementation Plan

The following is a summary of the Import Operation Implementation Plan:

- The data import application will first load the Element Definitions and Migrated Inspections XML files.
- The connection to the new HSI database will be established.
- All new HSI database tables that are parent to the DT_ISEL_ITEM table will be read and populated as necessary, including the following:
  - The DT_ISEL_UOM table will be populated such that it is synchronized with unit of measures used by the migrated element inspection dataset.
  - The DT_ISEL_TY table will be populated by mapping element definitions used by the migrated element inspection dataset.
- For each element from the XML file, a corresponding main inspection record will be located in the DT_STRC_INSP table using the STRC_TYCD and STIN_DT fields to obtain the STIN_ID field.
- For each migrated element record in the XML file, a new row will be inserted into the DT_ISEL_ITEM table with the sequential number generated for the primary key column ISEL_ITEM_ID.
- The foreign key INS_ENVR_ID and ISEL_TYID in the DT_ISEL_ITEM table will be populated from the XML file data row. The STIN_ID field is populated as described in the fourth bullet of this section.
- The MAIN_ISEL_ID field will be populated with the ISEL_ITEM_ID field of the parent element inspection record in the DT_ISEL_ITEM table for child inspections.
- The DT_ISEL_ITEM inspection notes will be populated by migrating old HSI element inspection data to new HSI element inspection data.

XML Import Application Description

Prerequisites

1. The test or production HSI Oracle database instance must have new empty HSI tables created.
2. The client machine where the application is to be installed must have the Oracle 11g (32 bit) client software installed.
   - The database user account connection must have privileges to connect to the HSI database and perform create, read, update, and delete (CRUD) operations. Preferably, the connection user account should be the schema owner.
   - The client machine windows login must have privileges (preferably administrator) so that importer application can be installed.
   - The client machine and/or windows login account must have privileges to allow the installation of the NET 4.5 framework files. These are needed by the application.
   - The installer requires a Windows 7 operating system.

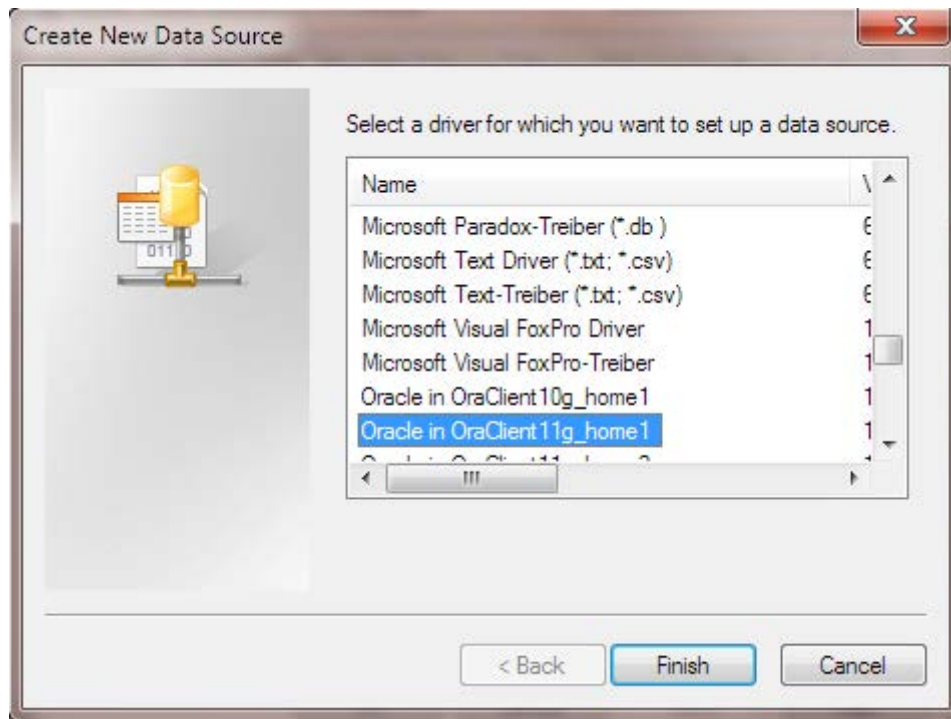**Pre-Installation Steps**

1. Create a TNS Profile for HSI Oracle Database on the client machine.
   - Open Oracle Net Manager from Oracle 11g (32 bit) client software.
   - Create Service Naming for HSI database.
   - Test the connection and save the configuration.
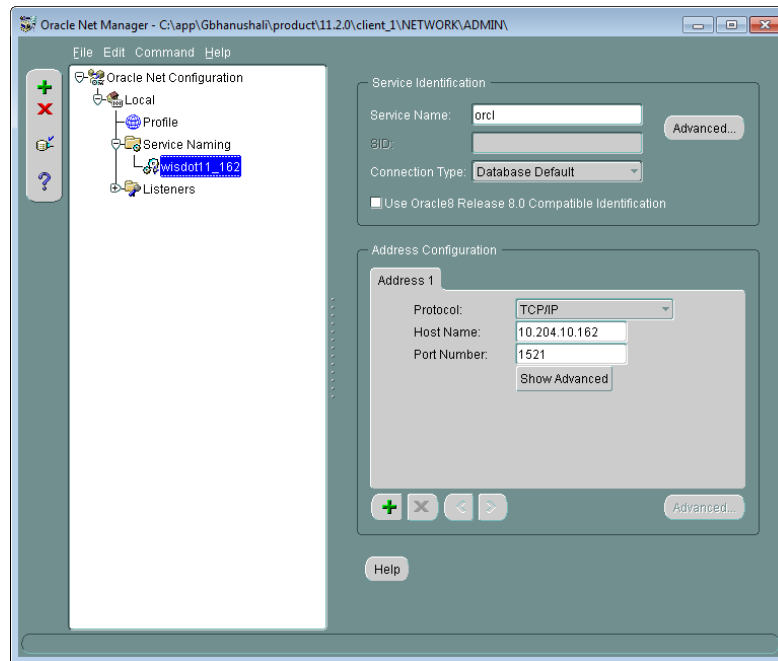

2. Create an ODBC profile for the HSI Oracle Database on the client machine.
   - Open the 32-bit ODBC Data Source Administrator. This executable can be found in the *C:\Windows\SysWOW64* folder.
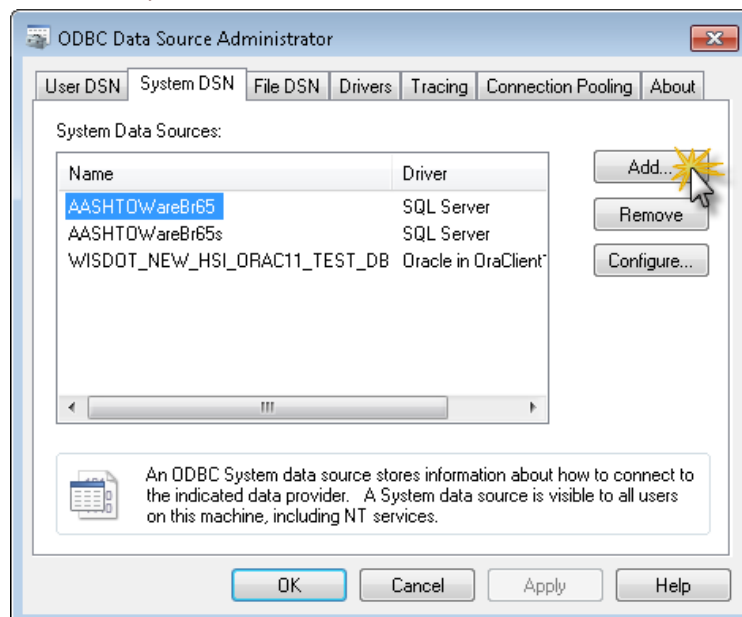
- Create a System DSN Profile for the HSI database using the Oracle Client 11g (32 bit) driver.

- Make sure that the ODBC profile name starts with "**WISDOT**".
- Test the connection with valid *User Name* and *Password*, and click the **OK** button to save the profile.
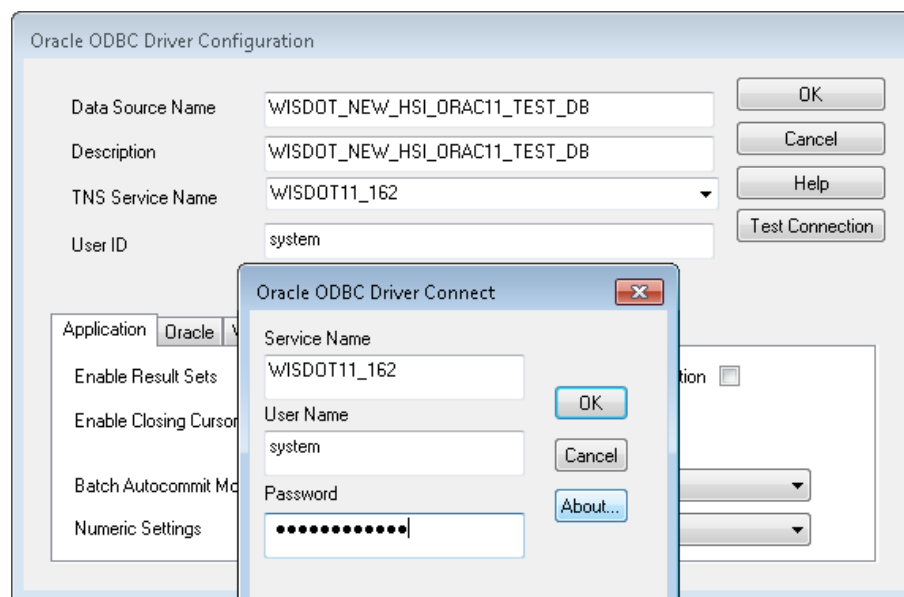
Installation

a. Save and unzip the *Install.zip* file on the client machine.
b. Locate and run *setup.exe* from the **Disk1** directory.
c. Follow the installation wizard to install the product.
d. Launch the application from the *Start Menu\Programs\Baker WisDOT BMS* folder.
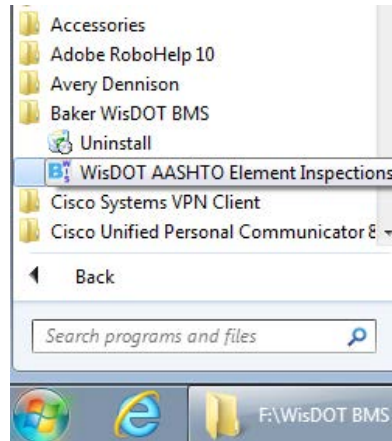
e. The default application installation directory is *C:\Program Files (x86)\Baker WisDOT BMS*.
f. The application can be uninstalled using the **Uninstall** link from the *Start Menu\Programs\Baker WisDOT BMS* folder.

Importing the Migrated Bridge Element Inspections

Step 1— Read Elem XML Tab

Use this tab to load the migrated element inspection XML data for the import process as follows:

a. Click the **Select XML File** button to open the select file dialog box.
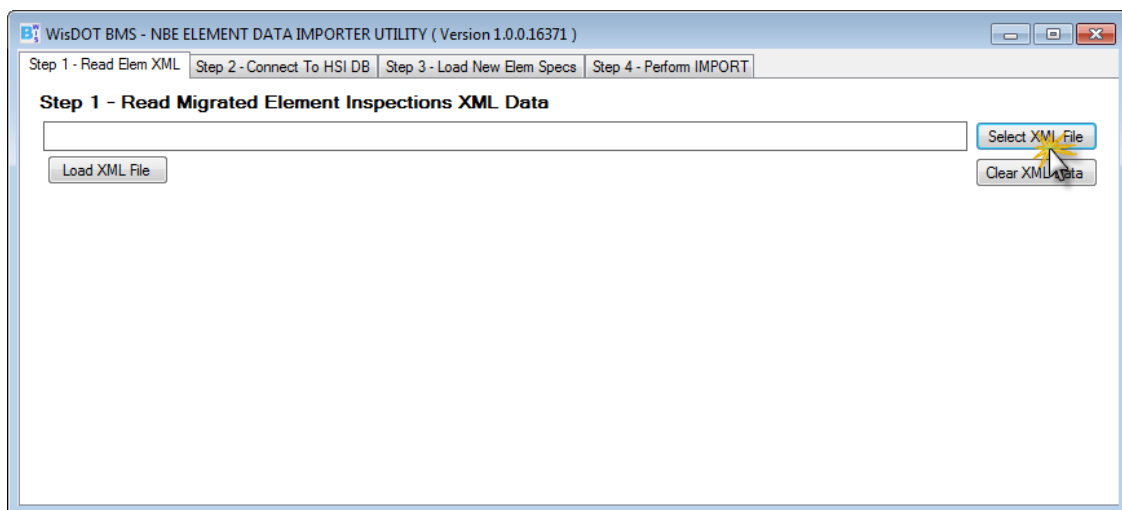
b. Navigate to the **Data** folder in the installation directory *C:\Program Files (x86)\Baker WisDOT BMS* folder.
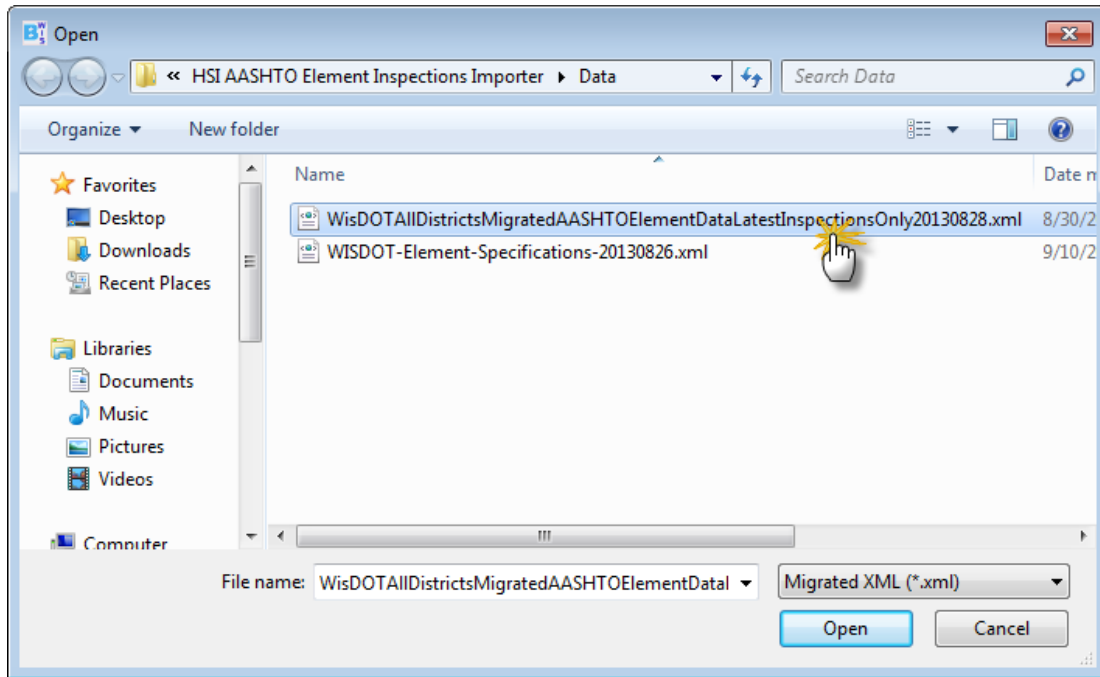
c. Select the migrated xml data file named

   WisDOTAllDistrictsMigratedAASHTOElementDataLatestInspectionsOnly20130828.xml

d. Click the **Load XML File** button.
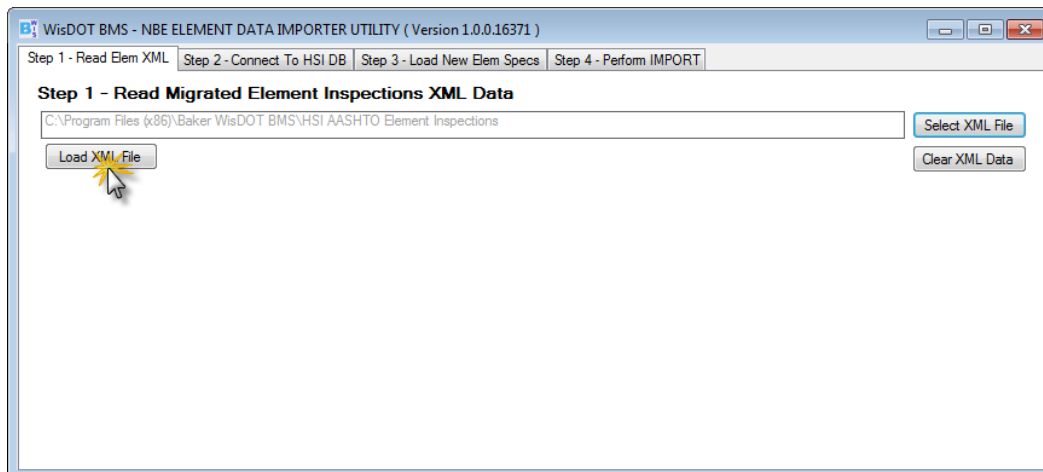
e. A message related to the successful loading of the xml file should be automatically displayed.
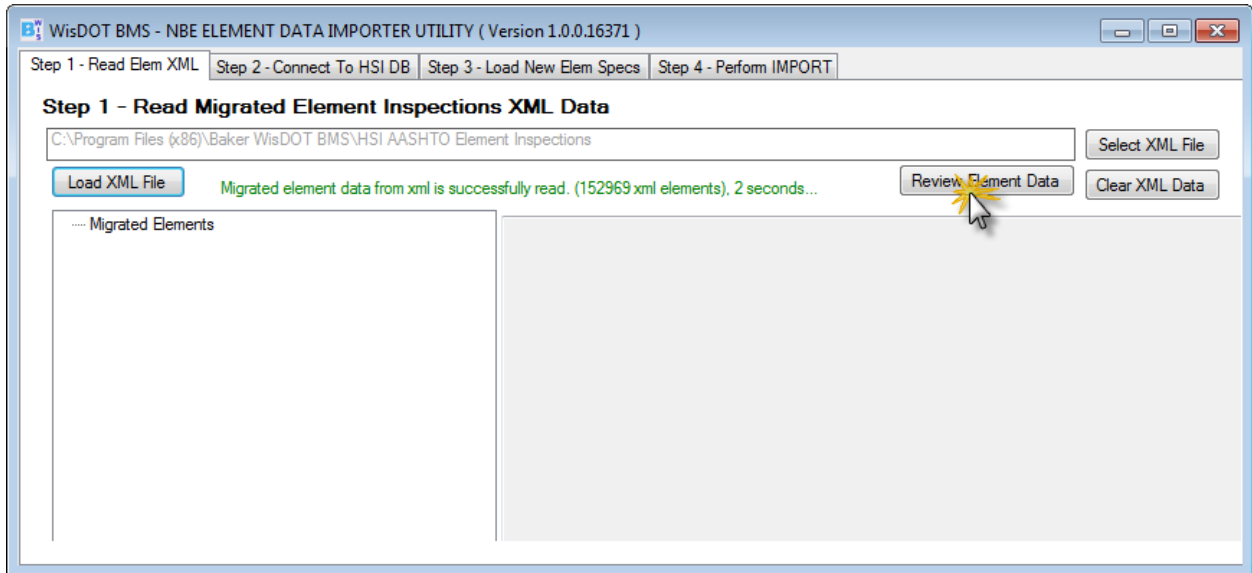
f. Click the **Review Element Data** button to load the data in the tree format organized by *bridge\inspection\element inspections* parent and children. Click the bridge node in the tree and drill down to the element inspections. Click each element inspection node to review individual migrated element inspection details in the right pane.
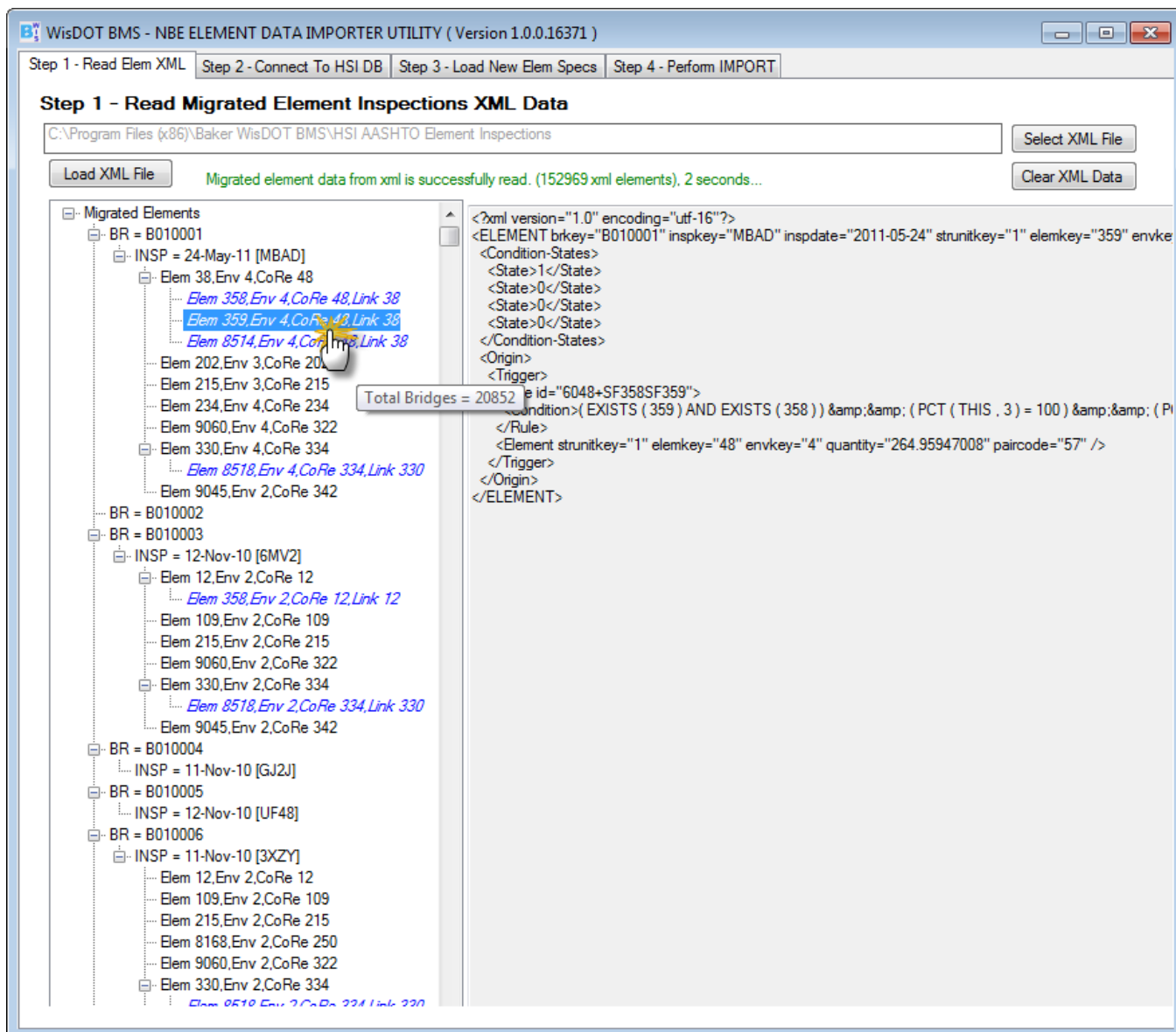
Step 2— Connect to HSI DB Tab

The HSI DB tab allows the user to connect to the HSI database using the application. Users should ensure that the correct credential and connection are being used, as verified via the ODBC Data Source Administrator (32 bit).

> **Caution:** For convenience, the application filters ODBC DSN profiles by **WISDOT** prefix to avoid populating numerous other DSN that are not relevant. Users must ensure that their ODBC DSN profile name starts with the **WISDOT** key word.

To connect to the HSI database, follow the steps below:

a. Establish the connection by clicking the **Connect** button. Once connected, the **Disconnect** button will be visible. The user may not disconnect until all the import steps are complete.

When closing the application using the **X** button on the top right corner of the window, the connection will also automatically close.
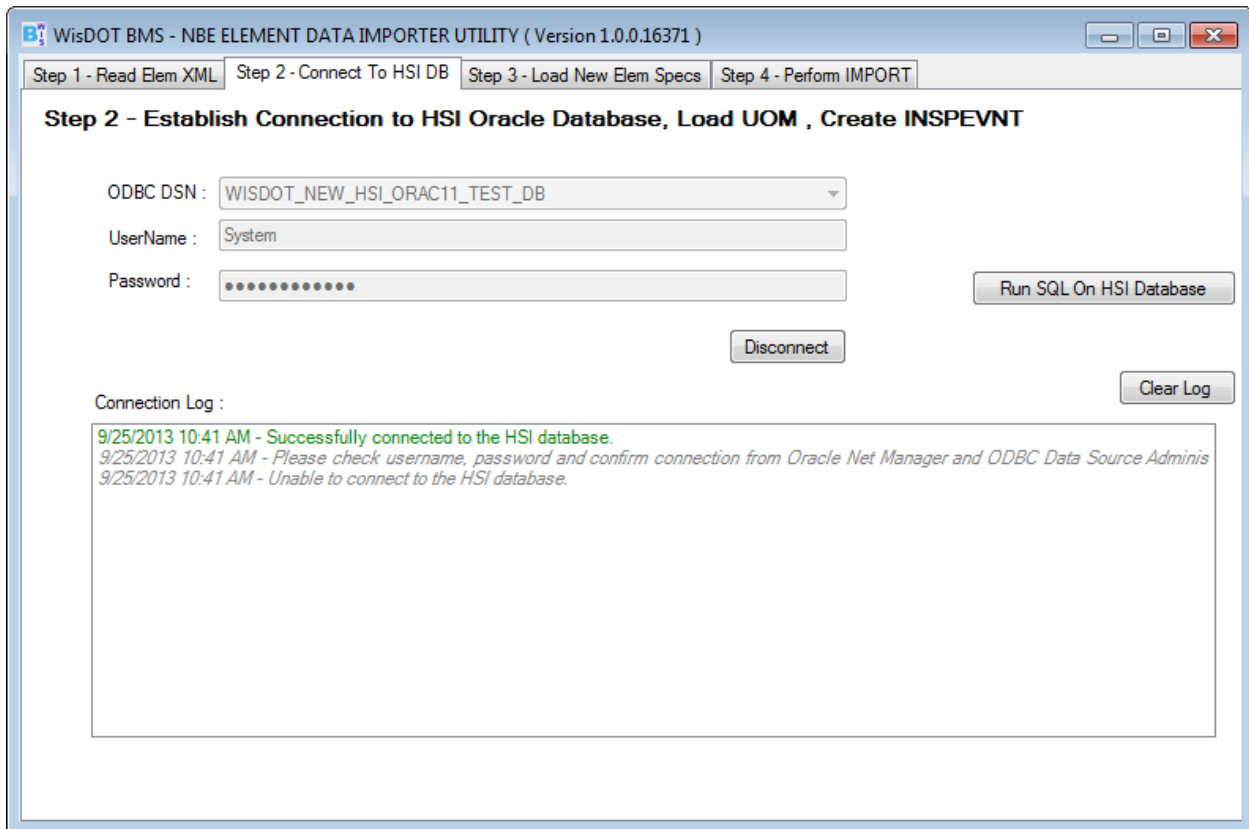

b. **The Run SQL on HSI Database** button is added for convenience and can be used to select, execute, and commit the pre-developed SQL files. At this time, users need to run two SQL files that are provided as a part of the installation package. These files are installed as part of the installation, and they reside under the **Data** folder in the installation directory.

   *a. Load_DT_ISEL_UOM.sql*
     b. Transfer_INSPEVNT.sql

Caution: Only SQL Meta command keywords such as **"- -"** for comments and **"prompt"** are supported in SQL files using the **Run SQL On HSI Database** button. If the SQL file includes other Meta command keywords, the SQL execution will fail. It will run SQL files outside of this application using the user's choice of Oracle tool and continue with the import process.
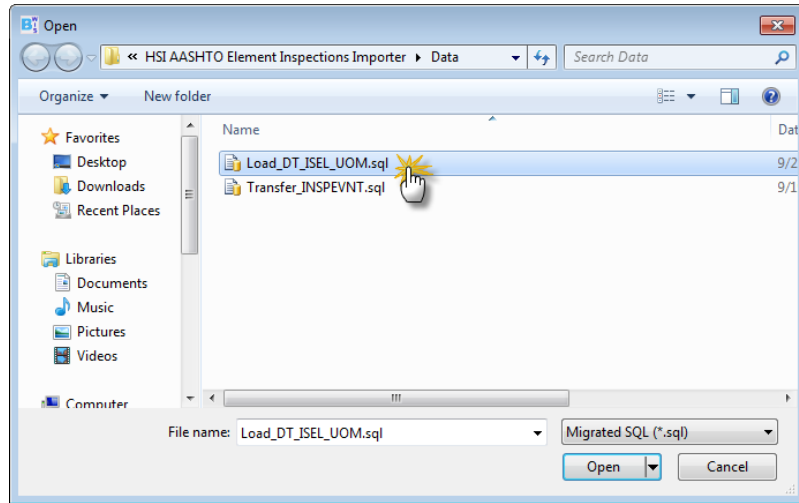
- Select the *Load_DT_ISEL_UOM.sql* file, and click the **Open** button. This will open a new window, as shown below. Click the **Execute** button to run the file on HSI database.
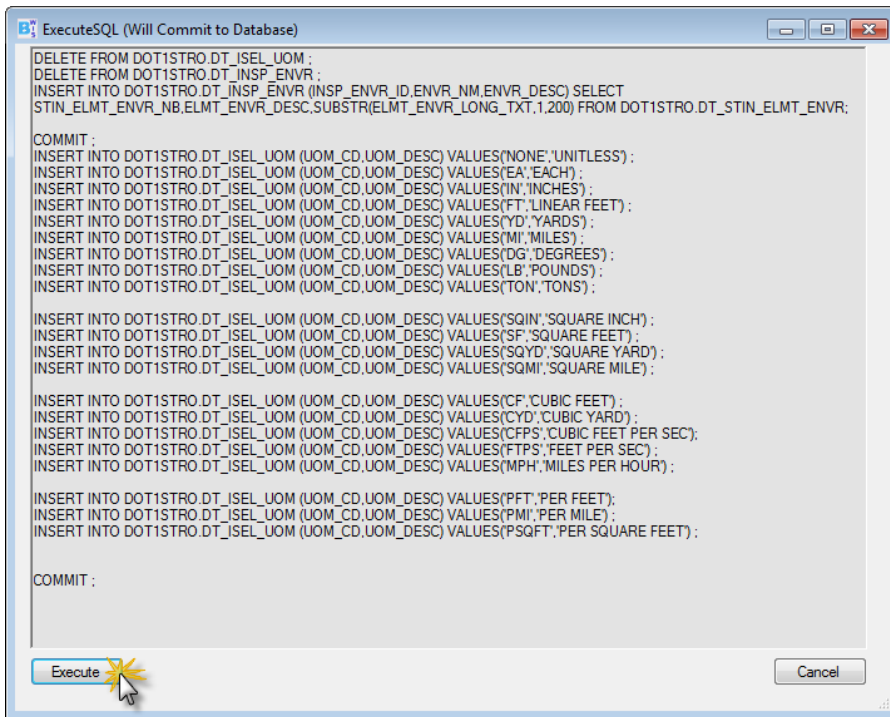
- The *Load_DT_ISEL_UOM.sql* file will populate the **DT_INSP_ENVR** and **DT_ISEL_UOM** tables for the import process to work. The U_OM entries are synchronized and compatible with the migrated elements of the xml data.
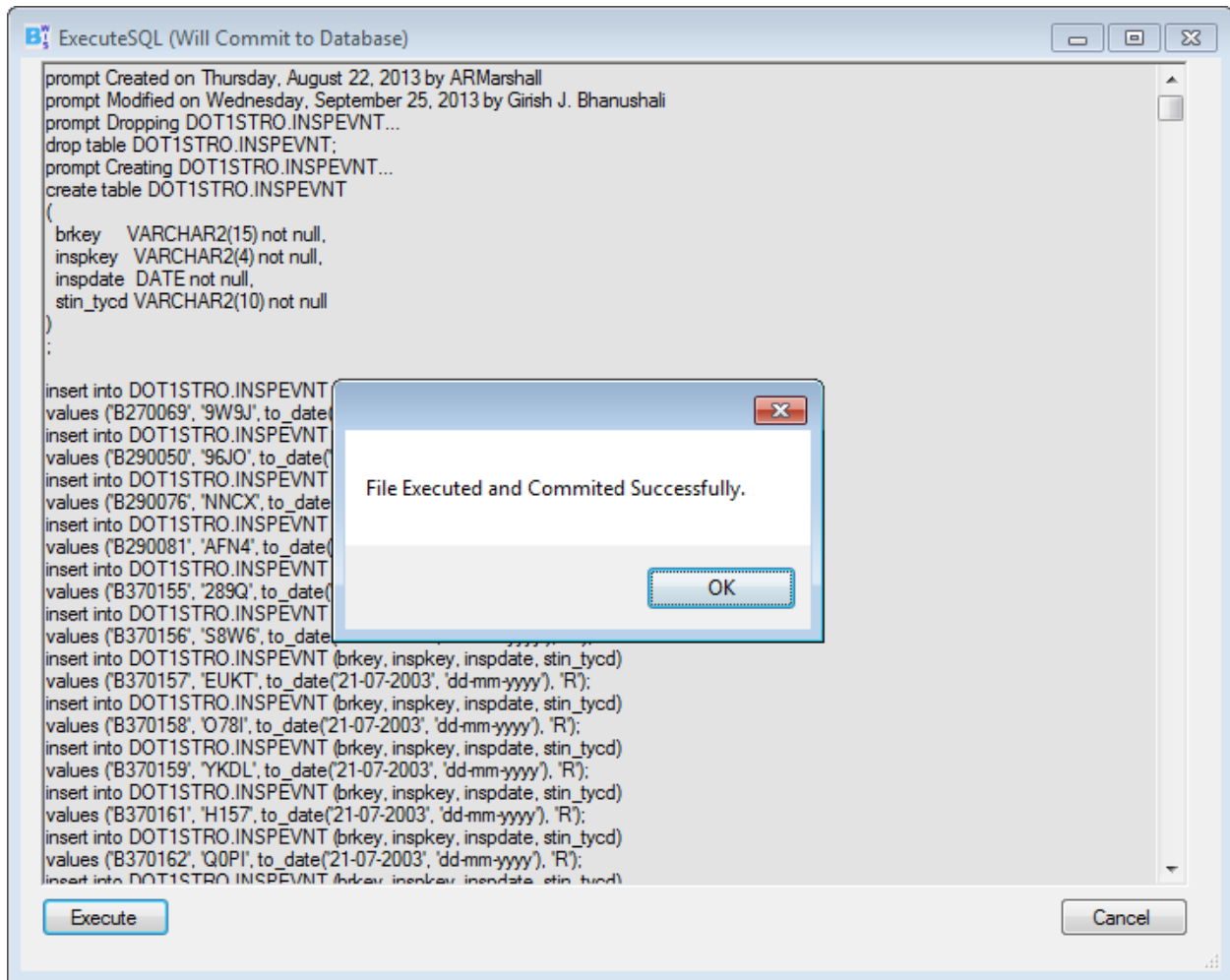- Upon successful execution, the following confirmation dialog will appear:
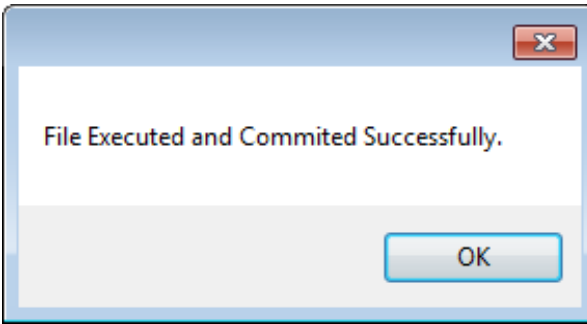
- The user may select and execute the *Transfer_INSPEVNT.sql* file the same way. This file creates a linking table name **INSPEVNT** under **DOT1STRO** schema. This table is crucial for the import process to work. The nature of this table is considered to be temporary and can eventually be dropped when it is no longer required. This table links the **BRKEY** and **INSPDATE** fields in the migrated elements xml data with the **STIN_TYCD** field. The application automatically maps these keys to the **DT_STRC_INSP** table to obtain **STIN_ID** as shown below for the import process to work.

BRKEY	STRC_ID
INSPDATE	STIN_DT
STIN_TYCD	STIN_TYCD

Recommendation: The *Transfer_INSPEVNT.sql* file is very large, and its execution will take several minutes. It is recommended that this file be run outside of this application using any standard tools provided with Oracle Client. These two SQL files are independent, and both can be run outside of this application. These files can be run only one time, and tables may not need to be cleaned in case the import process is run multiple times for testing or other trials.

- The following screen capture shows the successful execution of the *Transfer_INSPEVNT.sql* using this application.

ExecuteSQL (Will Commit to Database)

```
prompt Created on Thursday, August 22, 2013 by ARMarshall
prompt Modified on Wednesday, September 25, 2013 by Girish J. Bhanushali
prompt Dropping DOT1STRO.INSPEVNT...
drop table DOT1STRO.INSPEVNT;
prompt Creating DOT1STRO.INSPEVNT...
create table DOT1STRO.INSPEVNT
(
  brkey    VARCHAR2(15) not null,
  inspkey  VARCHAR2(4) not null,
  inspdate  DATE not null,
  stin_tycd VARCHAR2(10) not null
)
;

insert into DOT1STRO.INSPEVNT
values ('B270069', '9W9J', to_date(
insert into DOT1STRO.INSPEVNT
values ('B290050', '96JO', to_date(
insert into DOT1STRO.INSPEVNT
values ('B290076', 'NNCX', to_date
insert into DOT1STRO.INSPEVNT
values ('B290081', 'AFN4', to_date(
insert into DOT1STRO.INSPEVNT
values ('B370155', '289Q', to_date(
insert into DOT1STRO.INSPEVNT
values ('B370156', 'S8W6', to_date
insert into DOT1STRO.INSPEVNT (brkey, inspkey, inspdate, stin_tycd)
values ('B370157', 'EUKT', to_date('21-07-2003', 'dd-mm-yyyy'), 'R');
insert into DOT1STRO.INSPEVNT (brkey, inspkey, inspdate, stin_tycd)
values ('B370158', 'O78I', to_date('21-07-2003', 'dd-mm-yyyy'), 'R');
insert into DOT1STRO.INSPEVNT (brkey, inspkey, inspdate, stin_tycd)
values ('B370159', 'YKDL', to_date('21-07-2003', 'dd-mm-yyyy'), 'R');
insert into DOT1STRO.INSPEVNT (brkey, inspkey, inspdate, stin_tycd)
values ('B370161', 'H157', to_date('21-07-2003', 'dd-mm-yyyy'), 'R');
insert into DOT1STRO.INSPEVNT (brkey, inspkey, inspdate, stin_tycd)
values ('B370162', 'Q0PI', to_date('21-07-2003', 'dd-mm-yyyy'), 'R');
insert into DOT1STRO.INSPEVNT (brkey, inspkey, inspdate, stin_tycd)
```

> File Executed and Commited Successfully.
>
> OK

Execute   Cancel

Step 3— Load New XML Elem Spec File

This tab populates the HSI database with all the element specifications data necessary for the import process to work. The complete set of element inspections used in migrated element inspections data is mapped to populate the **DT_ISEL_TY** table. This is an essential step since the **DT_ISEL_ITEM** table has a foreign key to **DT_ISEL_TY**.

a. Click on the *WISDOT-Element-Specifications-20130826.xml* file from the data folder under the installation directory.
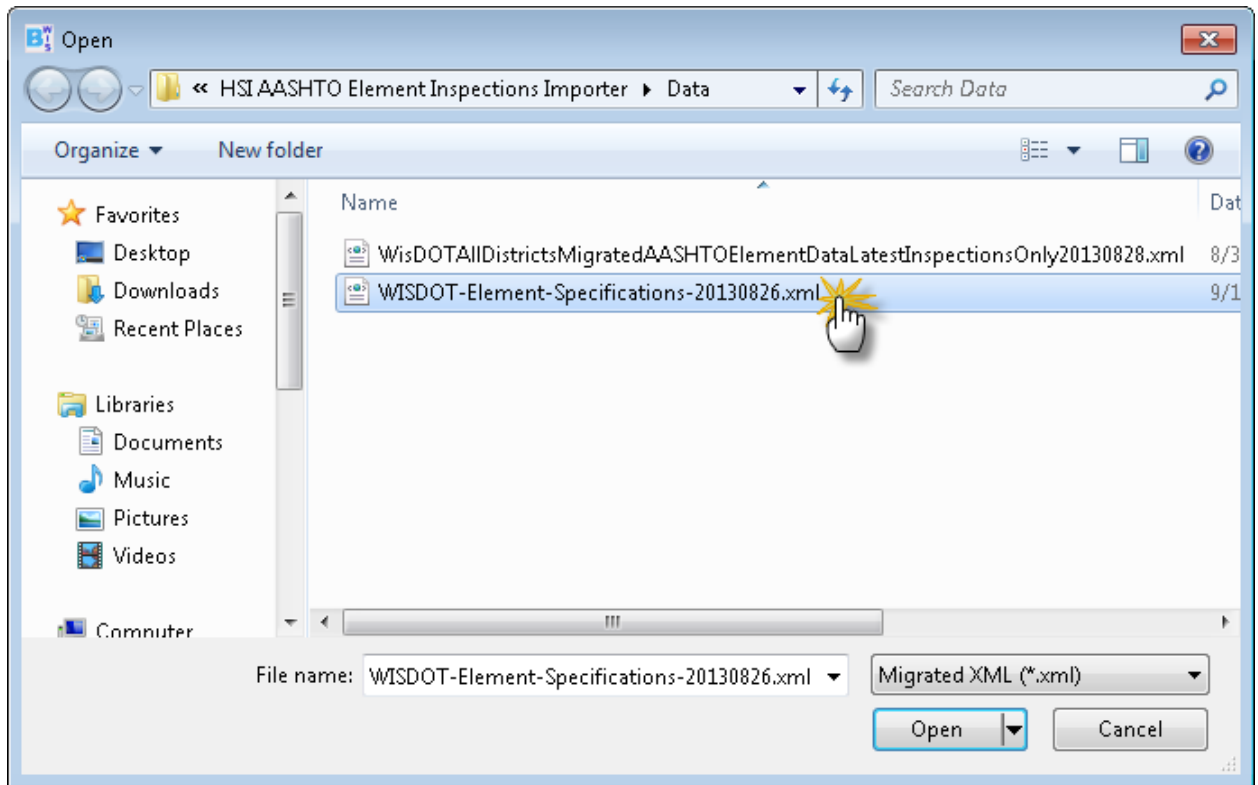
b. Click the **Load Elem Spec from XML To HSI** button to load element specification xml data in HSI format and review the data in the grid table format.
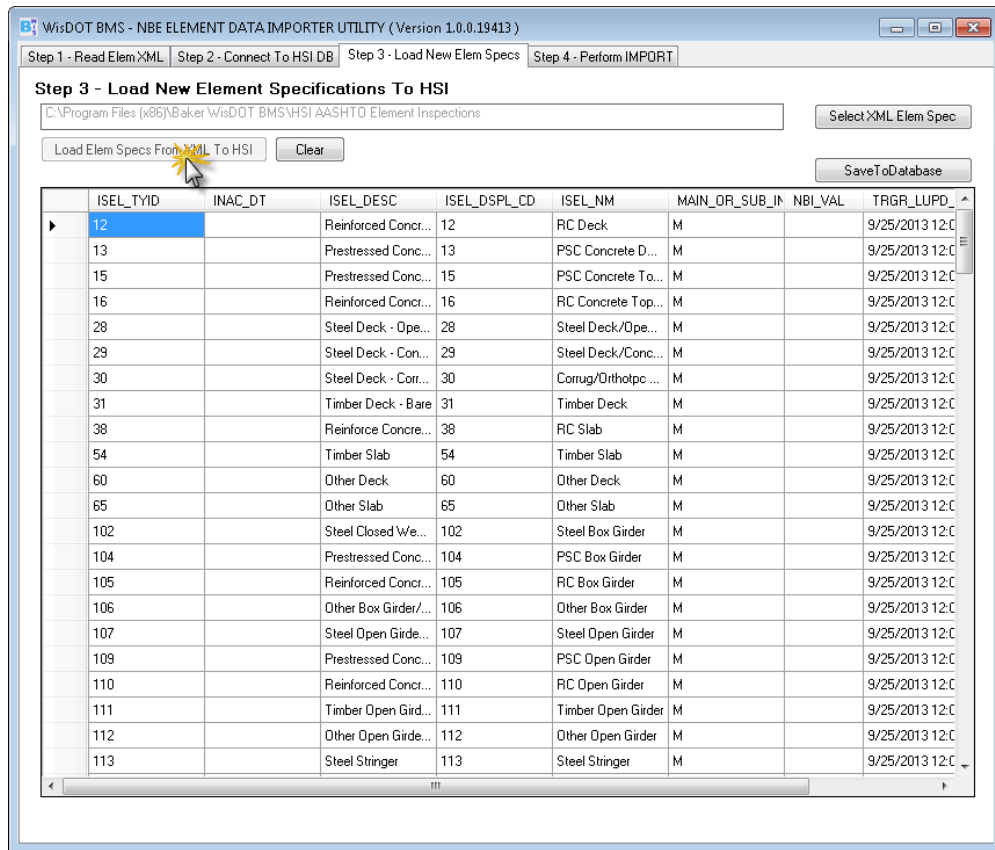
c. Click the **Save to Database** button to populate and commit data in the HSI database. Click the **OK** button on the confirmation dialog.
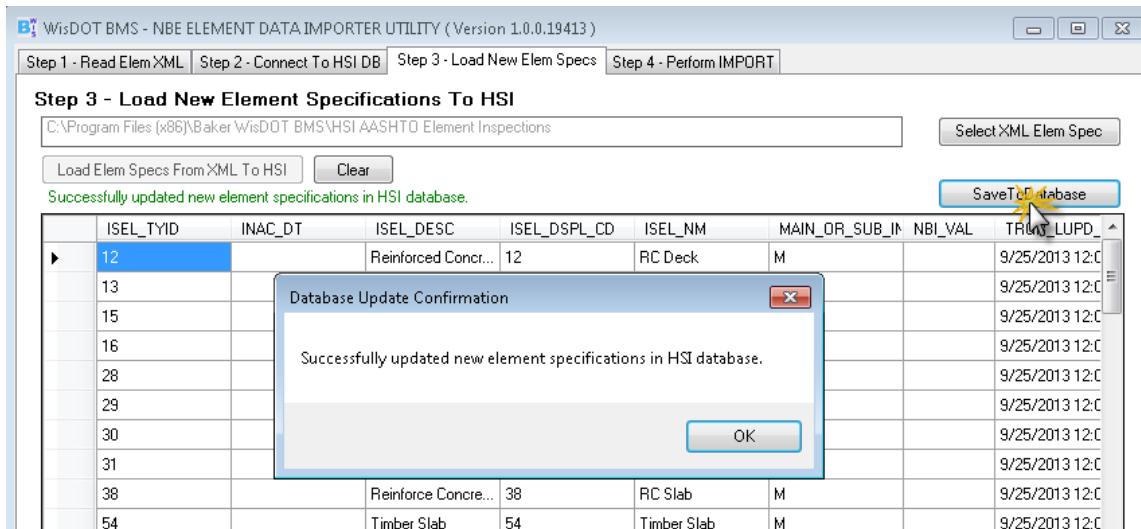
Step 4—Perform IMPORT Tab

This tab performs the last step of importing all the migrated element inspections to the **DT_ISEL_ITEM** table. This application is equipped with capabilities to perform operations asynchronously so that the user interface remains responsive and the application progress can be tracked. The window is intentionally disabled while the saving-to-the-database operation is running.

The import process from one of the test migrated xml files for all districts includes nearly 152,969 element data nodes that translate to processing the file with almost 2.5 million lines. The application uses the latest .NET technologies for XML processing considered fit for use and specific to the type of operations involved to achieve the best performance possible. The application is also equipped with transactions, rollback, and logging capabilities. In the test environment, the importing process on this step takes approximately one hour to complete. The operation to commit data to HSI database could take approximately four to five minutes.

    a.   Click the **Load Migrated Inspections to HSI** button to load process XML data for HSI.
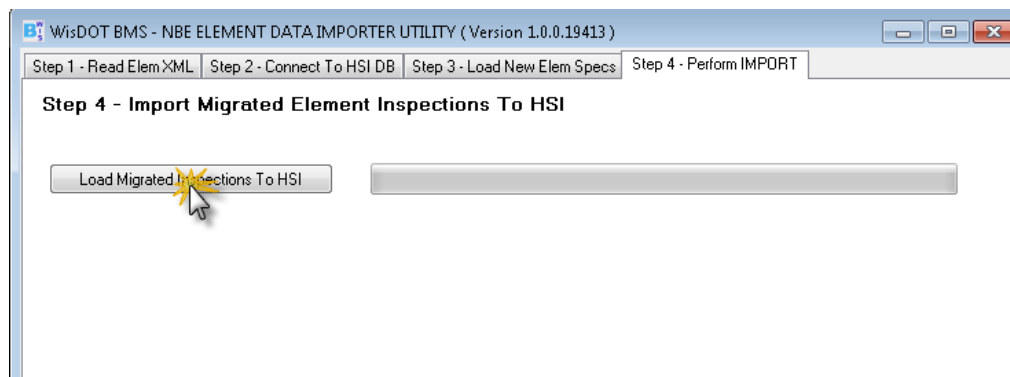
    b.   **The Cancel** button will abort processing the data for the import. The following screen capture shows the result of aborting the process. The process can be restarted by starting again from **Step (a),** but it should be avoided.
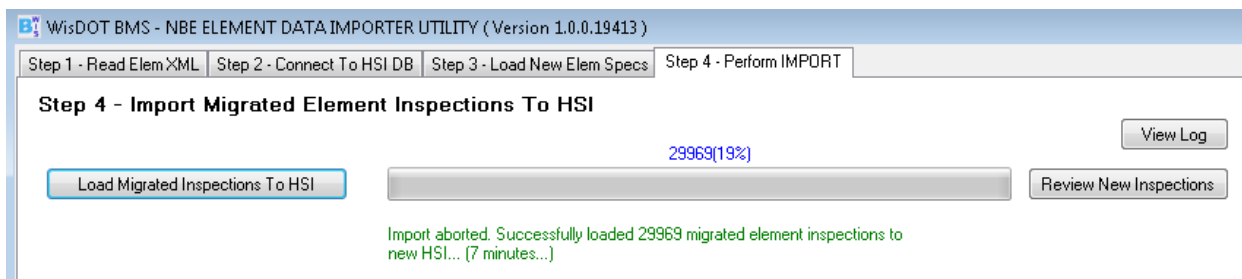

> **Recommendation:** Hitting the **Cancel** button will only process partial data which can be saved to the database. However, in the interest of time and data integrity, this should be avoided as much as possible. It is advisable to continue the import process until completion. Any records that cannot be imported will be skipped and logged during the saving operation.
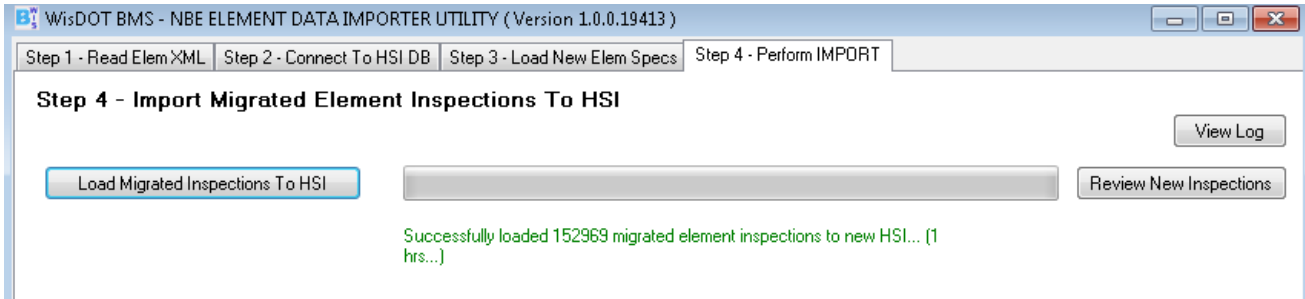
c. The following screen capture shows how the continuation of the import process is monitored.
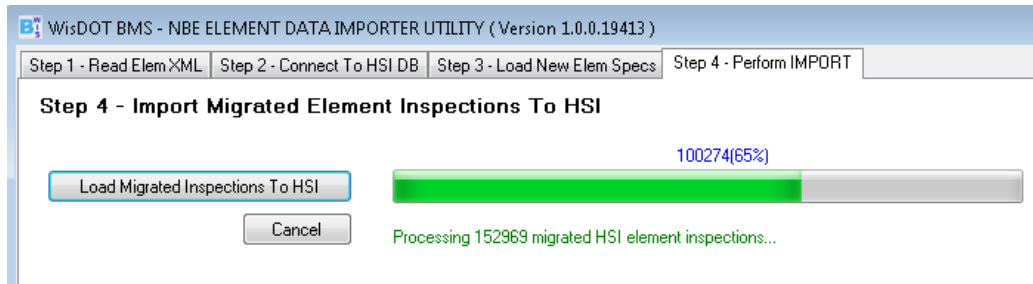
d. Click the **View Log** button to review any errors or omissions.
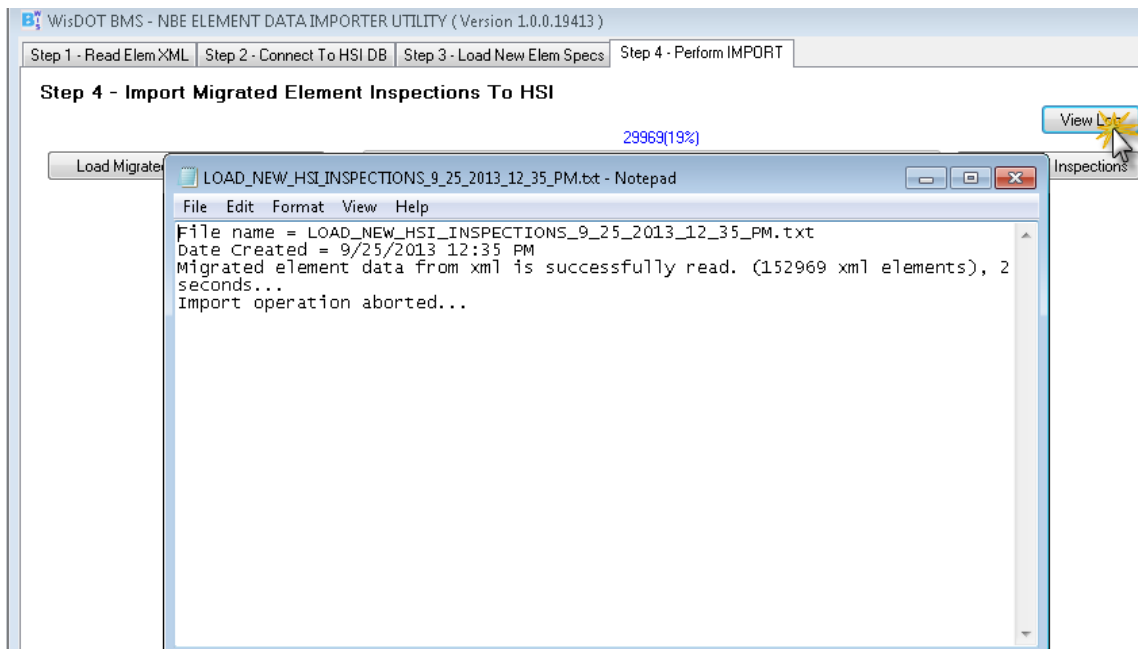
e. Upon 100% completion of the process, click the **Review New Inspections** button to view the new data in grid table format. The data will not be saved until the **Save to Database** button is clicked.

WisDOT BMS - NBE ELEMENT DATA IMPORTER UTILITY (Version 1.0.0.19413)

Step 1 - Read Elem XML | Step 2 - Connect To HSI DB | Step 3 - Load New Elem Specs | **Step 4 - Perform IMPORT**

Step 4 - Import Migrated Element Inspections To HSI

View Log

Load Migrated Inspections To HSI | Review New Inspections

Successfully loaded 152969 migrated element inspections to new HSI... (1 hrs...]

WisDOT BMS - NBE ELEMENT DATA IMPORTER UTILITY (Version 1.0.0.19413)

Step 1 - Read Elem XML | Step 2 - Connect To HSI DB | Step 3 - Load New Elem Specs | Step 4 - Perform IMPORT

Step 4 - Import Migrated Element Inspections To HSI

View Log

Load Migrated Inspections To HSI | Review New Inspections

Successfully loaded 152969 migrated element inspections to new HSI... (1 hrs...]

Save To Database

Total Inspection Records = 152969

ISEL_ITEM_ID	FRTH_COND_ST_QTY	FST_COND_ST_QTY	INSP_ENVR_ID	ISEL_TYID	ISFL	MAIN_ISEL_ID	NOTE	SCND_COND_ST_QTY	STIN_ID	THRD_COND_ST_QTY	TRGR_LUPD_TMST
1	0	219.9164	4	38	N		Auto Imp...	45.0431	336865	0	9/25/2013 12:42 PM
2	0	219.9164	4	358	N	1	Auto Imp...	45.0431	336865	0	9/25/2013 12:42 PM
3	0	1	4	359	N	1	Auto Imp...	0	336865	0	9/25/2013 12:42 PM
4	0	0	4	8514	N	1	Auto Imp...	264.9595	336865	0	9/25/2013 12:42 PM
5	0	0	3	202	N		Auto Imp...	12	336865	0	9/25/2013 12:42 PM
6	0	12.192	3	215	N		Auto Imp...	6.096	336865	0.3048	9/25/2013 12:42 PM
7	0	17.0688	4	234	N		Auto Imp...	0.9144	336865	0	9/25/2013 12:42 PM
8	0	2	4	9060	N		Auto Imp...	0	336865	0	9/25/2013 12:42 PM
9	0	55.7784	4	330	N		Auto Imp...	0	336865	0	9/25/2013 12:42 PM
10	0	999	4	8518	N	9	Auto Imp...	0	336865	0	9/25/2013 12:42 PM
11	0	2	2	9045	N		Auto Imp...	0	336865	0	9/25/2013 12:42 PM
12	0	124.968	2	109	N		Auto Imp...	0	323307	0	9/25/2013 12:42 PM
13	0	21.9456	2	215	N		Auto Imp...	0	323307	0	9/25/2013 12:42 PM
14	0	4	2	8168	N		Auto Imp...	0	323307	0	9/25/2013 12:42 PM
15	0	2	3	9060	N		Auto Imp...	0	323307	0	9/25/2013 12:42 PM
16	0	46.6344	3	330	N		Auto Imp...	4.2672	323307	0	9/25/2013 12:42 PM
17	0	999	3	8518	N	16	Auto Imp...	0	323307	0	9/25/2013 12:42 PM
18	0	2	2	9045	N		Auto Imp...	0	323307	0	9/25/2013 12:42 PM
19	0	1	4	7361	N		Auto Imp...	0	323307	0	9/25/2013 12:42 PM
20	0	0	2	12	N		Auto Imp...	228.9131	323291	0	9/25/2013 12:42 PM
21	0	0	2	358	N	20	Auto Imp...	228.9131	323291	0	9/25/2013 12:42 PM
22	0	106.9848	2	109	N		Auto Imp...	0	323291	0	9/25/2013 12:42 PM
23	0	15.8496	2	215	N		Auto Imp...	1.8288	323291	0	9/25/2013 12:42 PM
24	0	0	2	9060	N		Auto Imp...	2	323291	0	9/25/2013 12:42 PM
25	0	68.8848	2	330	N		Auto Imp...	0	323291	0	9/25/2013 12:42 PM
26	0	999	2	8518	N	25	Auto Imp...	0	323291	0	9/25/2013 12:42 PM
27	0	2	2	9045	N		Auto Imp...	0	323291	0	9/25/2013 12:42 PM
28	0	91.3237	2	38	N		Auto Imp...	0	323194	0	9/25/2013 12:42 PM
29	0	15.5448	2	215	N		Auto Imp...	0	323194	0	9/25/2013 12:42 PM
30	0	2	2	9060	N		Auto Imp...	0	323194	0	9/25/2013 12:42 PM
31	0	19.2024	2	330	N		Auto Imp...	5.7912	323194	0	9/25/2013 12:42 PM
32	0	999	2	8518	N	31	Auto Imp...	0	323194	0	9/25/2013 12:42 PM
33	0	0	2	9045	N		Auto Imp...	2	323194	0	9/25/2013 12:42 PM
34	0	0	2	12	N		Auto Imp...	100.8927	323285	0	9/25/2013 12:42 PM
35	0	0	2	358	N	34	Auto Imp...	100.8927	323285	0	9/25/2013 12:42 PM
36	0	0	2	359	N	34	Auto Imp...	1	323285	0	9/25/2013 12:42 PM
37	0	15.8496	2	215	N		Auto Imp...	0	323285	0	9/25/2013 12:42 PM
38	0	0	2	9060	N		Auto Imp...	2	323285	0	9/25/2013 12:42 PM
39	0	24.6888	2	330	N		Auto Imp...	6.096	323285	0	9/25/2013 12:42 PM
40	0	999	2	8518	N	39	Auto Imp...	0	323285	0	9/25/2013 12:42 PM
41	2	0	2	9045	N		Auto Imp...	0	323285	0	9/25/2013 12:42 PM
42	0	115.014	2	12	N		Auto Imp...	0	323108	0	9/25/2013 12:42 PM

f. Click the **Save to Database** button to save new imported element inspections data to the HSI database.

Step 4 - Import Migrated Element Inspections To HSI

Successfully imported new element inspections to HSI database.(0 Skipped) 5 minutes...

Database Update Confirmation

Successfully imported new element inspections to HSI database.(0 Skipped) 5 minutes...

OK

WisDOT BMS - NBE ELEMENT DATA IMPORTER UTILITY (Version 1.0.0.19413)

Step 1 - Read Elem XML | Step 2 - Connect To HSI DB | Step 3 - Load New Elem Specs | Step 4 - Perform IMPORT

Step 4 - Import Migrated Element Inspections To HSI
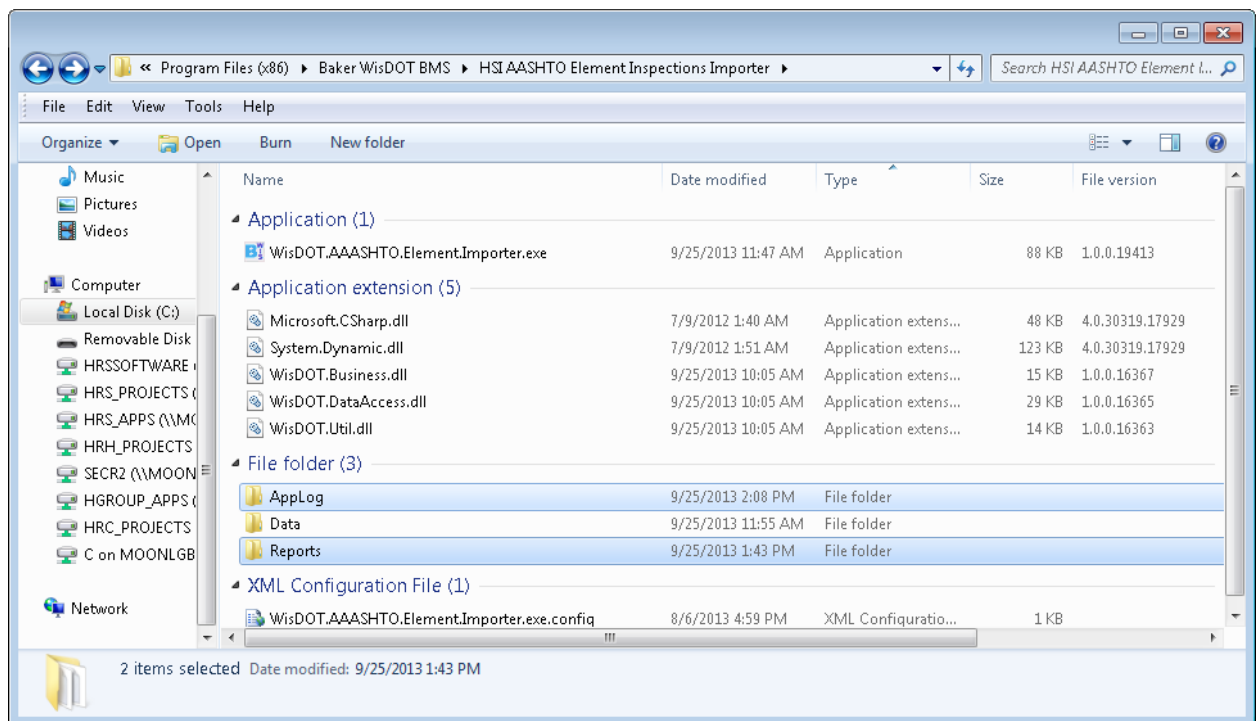
View Log

Load Migrated Inspections To HSI

Successfully imported new element inspections to HSI database.(0 Skipped) 5 minutes...

---

g. Close the application by clicking the **X** button in the top right corner of the window. Optionally, the user can go to the Step 2 tab and click the **Disconnect** button to close the database connection.
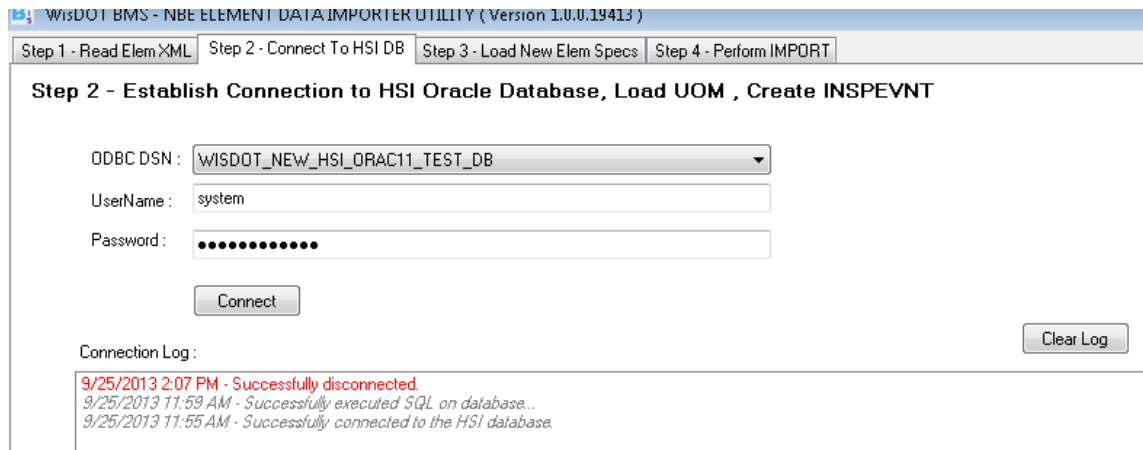
h. Navigate to the installation directory, and drill down to the folder with installation files. There are two folders created named **AppLog** and **Reports**. The user can review log files under these folders for error, warning, and information messages.

i. Confirm the imported new element inspections data under the **DT_ISEL_ITEM** table in the new HSI database using any standard Oracle Client tool.

j. This ends the Import Process.

BrM 5.2.X Future Database Changes

The processes previously described are only dependent on the HSI database structure. They will not need to be changed regardless of the future database structure of the BrM 5.2.X software. The project team has learned that changes to the BrM 5.2.X are being proposed.

The entity-relation diagrams below illustrate the original Pontis 5.2 database design and the proposed BrM 5.2.X database design.

V_ELEMINSP_PRESENTATATION

V_PON_ELEM_DEFS

BRIDGE
Bridge table. Only possible changes known are to LRFR factor storage...

Key Constraint	Columns
PK_BRIDGE	BRKEY
BRIDGE_BRIDGE_ID	BRIDGE_ID
BRIDGE_STRUCT_NUM	STRUCT_NUM
BRIDGE_DOCREFKEY	DOCREFKEY

has the elements
are located on

is inspected by
has inspection data for

is the bridge document primary ID
is a document instance for the bridge

PON_ELEM_INVENTORY
INVENTORY of bridge elements and quantity - time stamped historical database.. This table contains the latest total quantity/count of the element, AND inventory of bridge elements and PROTECTIVE SYSTEMS - time stamped historical database. This is accomplished with a self-referencing foreign key from 1:N protective system element to a protected element's record in this table

Key Constraint	Columns
PK_PON_ELEM_INVENTORY	ELEM_INVENTORY_KEY

is protected by
is replaced by
reflects the parent
replaces

is inspected by
has element inspection data for

METRIC_ENGLISH

Key Constraint	Columns
PK_METRIC_ENGLISH	PAIRCODE

INSPEVNT
Familiar inspection event table, reorganized with primary uniqueidentifier

Key Constraint	Columns
PK_INSPEVNT	INSPEVNT_KEY
INSPEVNT_DOCREFKEY	DOCREFKEY
UNQ_BRKEY_INSPKEY	BRKEY, INSPKEY

has element inspections
are performed as part of

PON_ELEM_INSP
Instances of inspections on the inventory elements. This is a record of every time the element and its protective systems has been inspected and automatically provides the latest element inspection by date.

Key Constraint	Columns
PK_PON_ELEM_INSP	ELEM_INSP_KEY

is the inspection event document primary ID
is a document instance for the inspection

Inspection for work recommendation
was generated on inspection

MULTIMEDIA
Register of documents related to individual

defines type of defect

defines element
is a model for

PON_ELEM_CLASS_DEFS
Class for the element such as NBE, BME, ADE

Key Constraint	Columns
PK_ELEMENT_CLASSES	ELEMENT_CLASS_KEY
UNQ_ELEM_CLASS_LABEL	ELEMENT_CLASS_LABEL
UNQ_ELEM_CLASS_ID	ELEMENT_CLASS_ID

design type for

Recommendations

As previously mentioned, the following recommendations are intended to place WisDOT in a strategic position to export HSI information to forecast bridge needs and prioritize bridge preservation and replacement work using the BrM 5.2.X software to be released in 2015.

Condition State Language

The Migrator does not include the capability of inserting the condition state language for the NBEs and BMEs. It is recommended to create a custom version of the database created for the 2013 AASHTO *Guide for Bridge Element Inspection* with the condition state language for the WisDOT ADEs condition state language and import the condition state language for all elements into the HSI database.

Export/Import to BrM 5.2.3

After the BrM 5.2.3 database is defined, an application similar to the one developed to import the XML data needs to be developed. The application would export the HSI data for analysis in BrM 5.2.3 and seamlessly import it into BrM 5.2.3 for analysis.

Annual Report to FHWA

After the FHWA publishes the XML schema for the annual report, the developed export/import application can be altered to include a plug-in to develop the future annual reports required by the FHWA.

Appendix A—Literature Review

Title	Author	Date	Source/URL
AASHTO Manual for Bridge Element Inspection	AASHTO	June 2013	AASHTO
Pontis 5.1.4 Database Design Changes	Bentley and Allen Marshall	June 2013	AASHTO
Pontis 5.1.3 Release Notes	Bentley	May 2013	AASHTO
HSI Schema	WisDOT	December 2012	Wisconsin DOT
Development of Element Repair Costs and Estimated Life Expectancy for Bridge Maintenance	CTC & Associates	October 2011	http://wisdotresearch.wi.gov/wp-content/uploads/tlselementrepaircosts-10-7-11_revised-2.pdf
AASHTO Guide Manual for Bridge Element Inspection	AASHTO	January 2011	AASHTO
Pontis 5.2 Design Document	Michael Baker Jr., Inc. and Paul Thompson	August 2010	AASHTO
Sensitivity Analysis of Bridge Health Index to Element Failure Costs and Conditions	Teresa M. Adams and Myungook Kang	November 2009	Midwest Regional Transportation Center – University of Wisconsin at Madison
Element Unit and Failure Costs and Functional Improvement Costs for Use in the MN/DOT Pontis Bridge Management System	Teresa M. Adams and Emil Juni	November 2003	Minnesota DOT
Bridge Life-Cycle Cost Analysis	Hugh Hawk	June 2003	NCHRP Report 483
WisDOT Bridge Inspection Pocket Manual	WisDOT	February 2002	Wisconsin DOT
Establishing MR&R Costs for a Network-Level Bridge Management System	Teresa M. Adams and Joseph F. Barut	January 1998	Transportation Research Record 1642
Sensitivity of Network-Level BMS MR&R Policies to Variations in Cost, Transition Probability, and Discount Factor	Teresa M. Adams and P. Robert Sianipar	January 1998	Transportation Research Record 1643