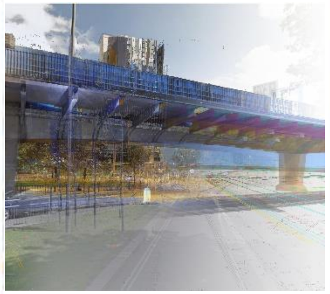






Introduction to Bentley Subsurface Utility Engineering (SUE) and StormCAD

Ernst van Baar

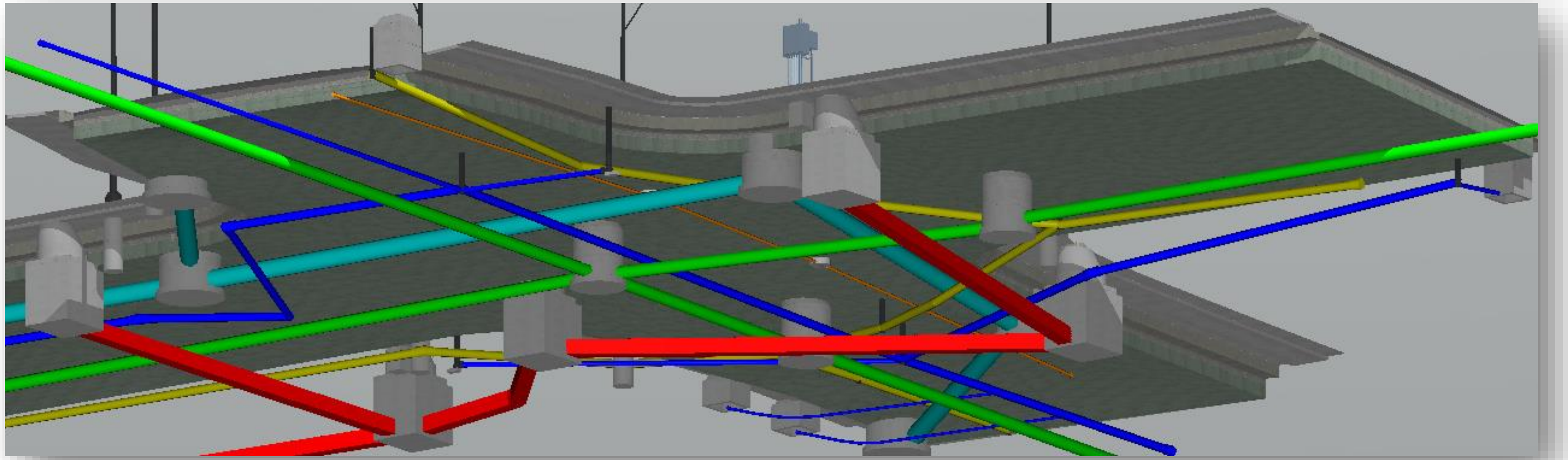
Lecture Topics

- Introduction to SUE (NOW)
- Introduction to StormCAD in OpenRoads (Drainage Design) (LATER)
- Want a copy of presentations?
  - learn.bentley.com – Bentley LEARN Server (Will also have recordings of all Lectures)
  - Bring a USB drive up front after the Lecture
  - Send an email to Ernst.Vanbaar@Bentley.com

Why 3D Utility Models?

3D Utility Models

- 2 - 3D modeling in transportation construction is a mature technology that serves as the building block for the modern-day digital jobsite. The technology allows for faster, more accurate and more efficient planning and construction.
- Every Day Counts 3 effort focuses on three practices: using the raw data from which the model is created for roadway inventory and asset management purposes, incorporating schedule (4D) and cost (5D) information into models, and using post-construction survey data to correct the design model and create an accurate as-built record drawing



Bentley Subsurface Utility Engineering

Subsurface Utility Design and Analysis (SUDA)

Subsurface Utility Engineering

StormCAD Hydraulic Analysis/Design Engine

- Conflict Management
- SUE Attribution

↔

- 3D Modeling of all underground
- Integrated with OpenRoads

↔

- Storm/Sanitary Hydraulic Analysis and Design
- Hydrology

SUE and StormCAD Licensing

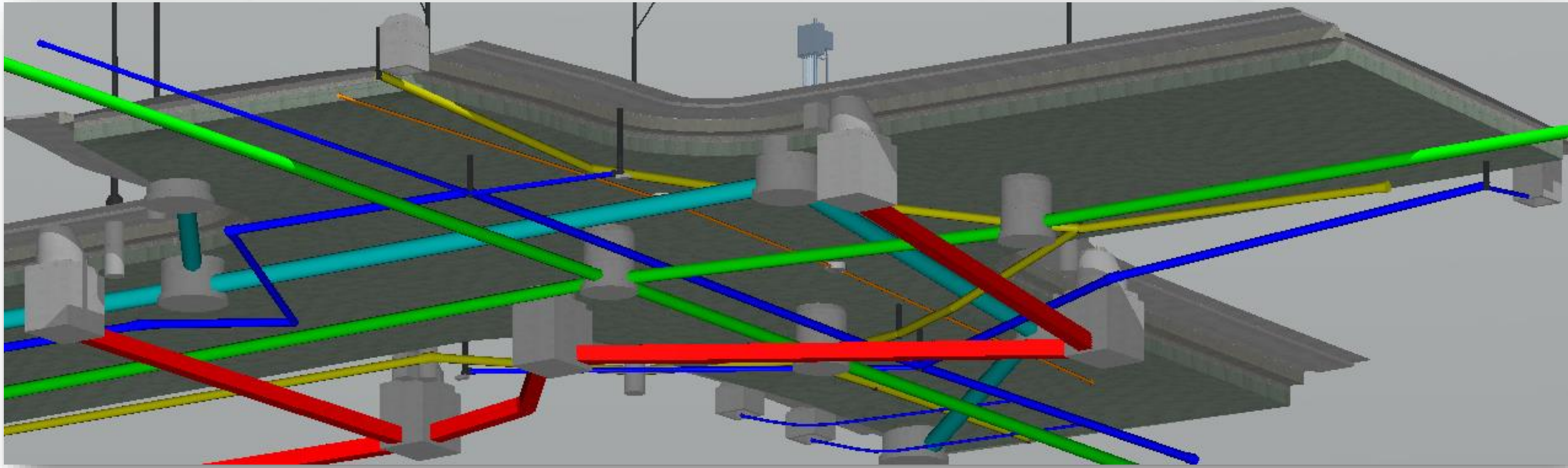
<table>
<tr><th>If you own this license</th><th>It will include these drainage functions:</th><th>SUE functionality</th></tr>
<tr><td>Any OpenRoads product which includes GEOPAK Drainage, InRoads S&S or MX Drainage</td><td>Storm water peak flow design and analysis
Max 100 Inlets in any single drainage model
Storm/Sanitary attributes</td><td>Utilities can be modeled in 3D
No SUE attributes
No Utility Conflict Tools</td></tr>
<tr><td>Any of the above plus either:
StormCAD Unlimited
SewerCAD
CivilStorm
SewerGEMS</td><td>Unlocks additional hydraulics calculations capabilities according to which enhanced license is activated.</td><td>Utilities can be modeled in 3D
No SUE attributes
No Utility Conflict Tools</td></tr>
<tr><td>Any of above plus SUE license</td><td>Same hydraulic capabilities as above according to which hydraulics license is active.</td><td>Unlocks SUE attributes
Unlocks Utility Conflict Tools</td></tr>
</table>

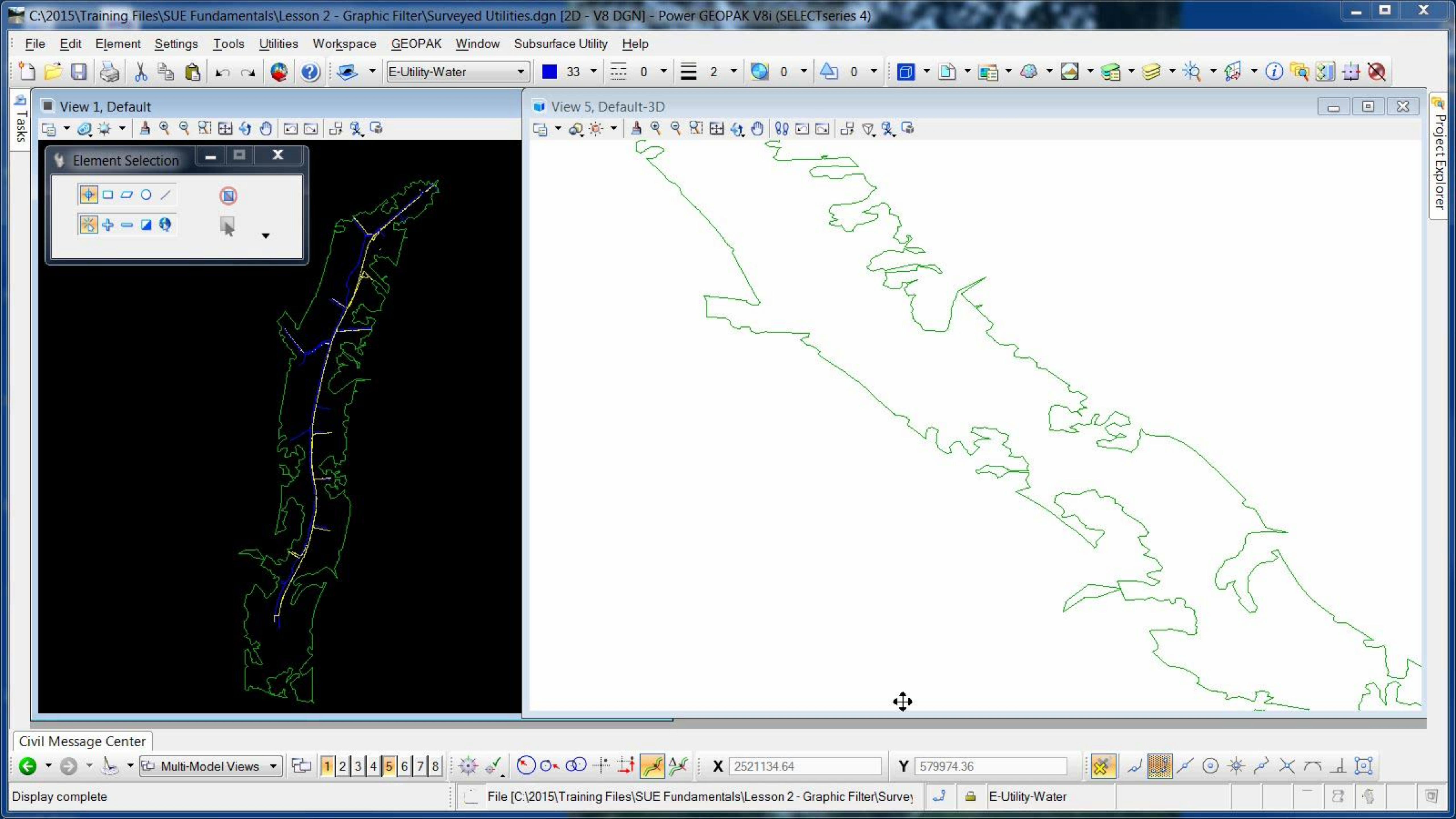
Note: Open Access Licensing in All the Above

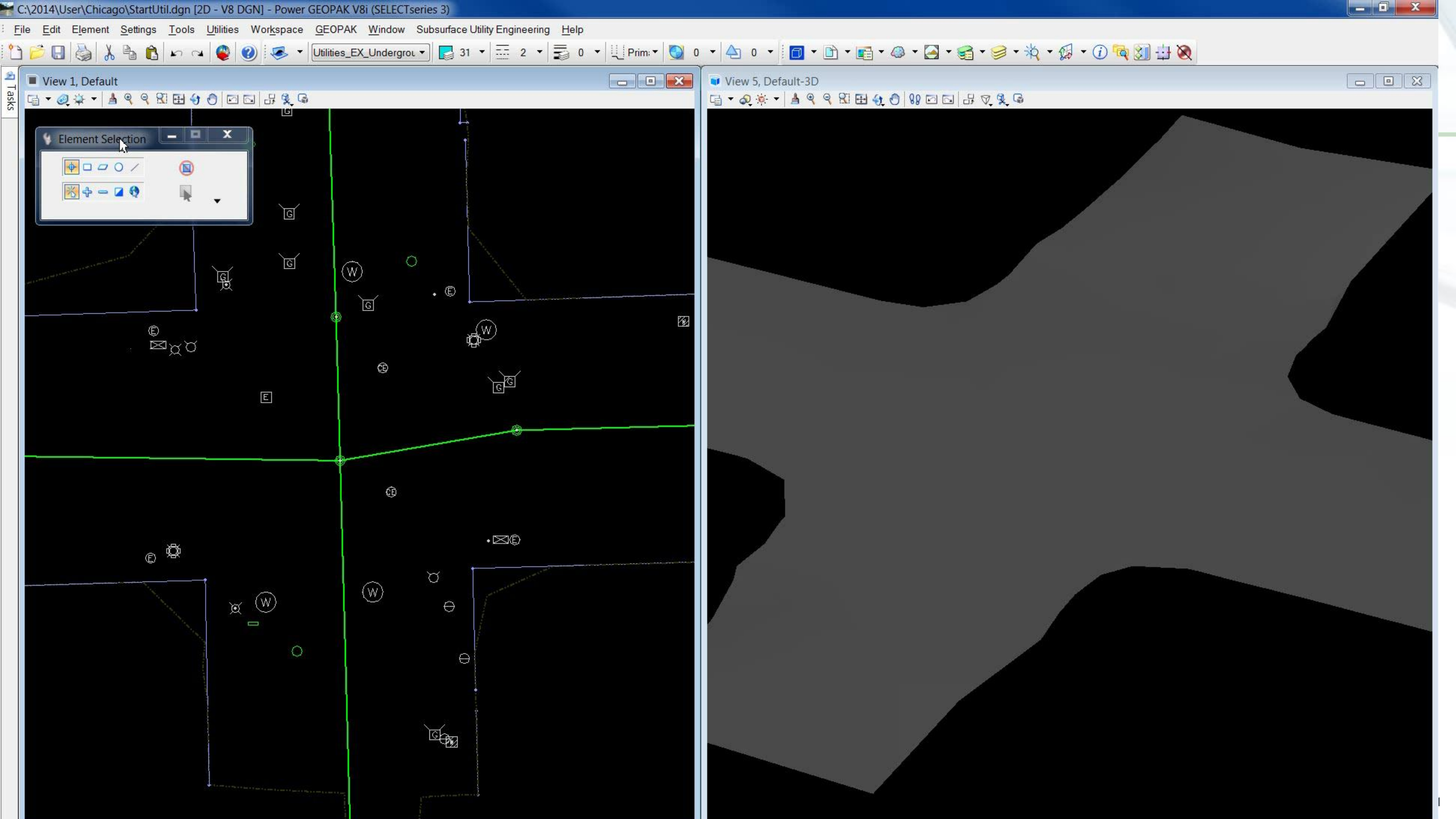
Existing Utilities From Survey

Model Existing Utilities From Survey

- Create 3D utility models, including drainage and wastewater features
  - Pipes, cables, ducts of all sorts
  - Virtually everything underground
- Elevations from the 3D survey features or from terrain.

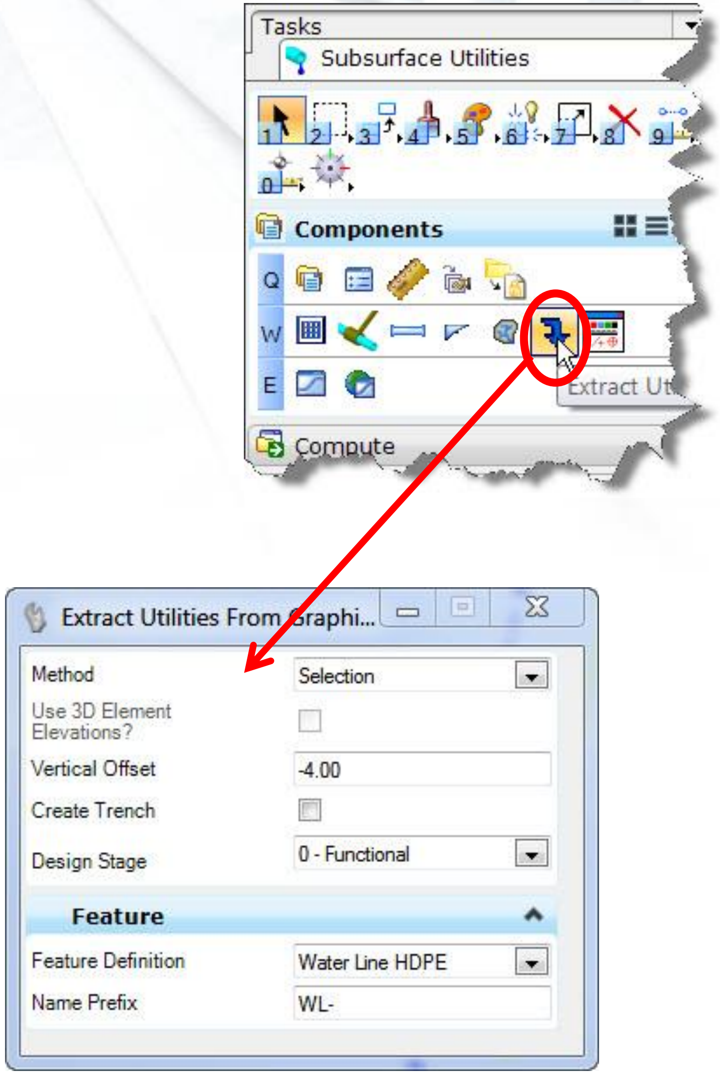



C:\2015\Training Files\SUE Fundamentals\Lesson 2 - Graphic Filter\Surveyed Utilities.dgn [2D - V8 DGN] - Power GEOPAK V8i (SELECTseries 4)
File
Edit
Element
Settings
Tools
Utilities
Workspace
GEOPAK
Window
Subsurface Utility
Help
E-Utility-Water
33
0
2
0
0
Tasks
View 1, Default
Element Selection
View 5, Default-3D
Project Explorer
Civil Message Center
Multi-Model Views
1
2
3
4
5
6
7
8
X
2521134.64
Y
579974.36
Display complete
File [C:\2015\Training Files\SUE Fundamentals\Lesson 2 - Graphic Filter\Survey
E-Utility-Water


C:\2014\User\Chicago\StartUtil.dgn [2D - V8 DGN] - Power GEOPAK V8i (SELECTseries 3)
File Edit Element Settings Tools Utilities Workspace GEOPAK Window Subsurface Utility Engineering Help
Utilities_EX_Undergrou
View 1, Default
Element Selection
View 5, Default-3D
Tasks

Extract Utility From Graphics Command

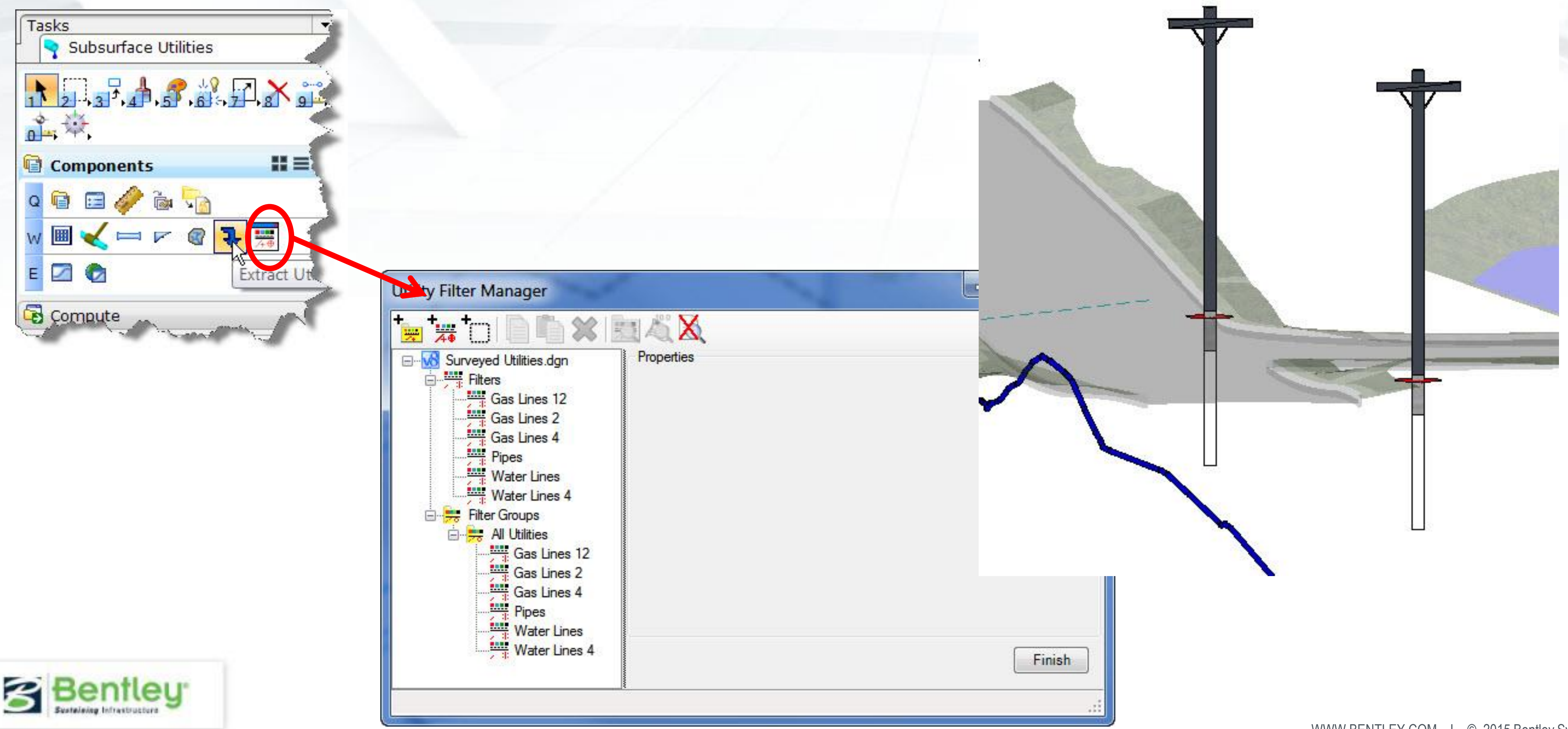
- Modeled after the Terrain Model from Graphics command.
- Uses graphics from any source.
- Elevations from terrain model or from 3D element.
  - Terrain Model – graphic is draped at specified depth
  - Element – if the graphic is 3D then user has option of using the elevations of the graphic vertices plus optional vertical offset.
- Use selection set or pick during command prompts



Bentley
Sustaining Infrastructure

Utility Filter Manager

- New Utility Filter type similar to Terrain Filters.

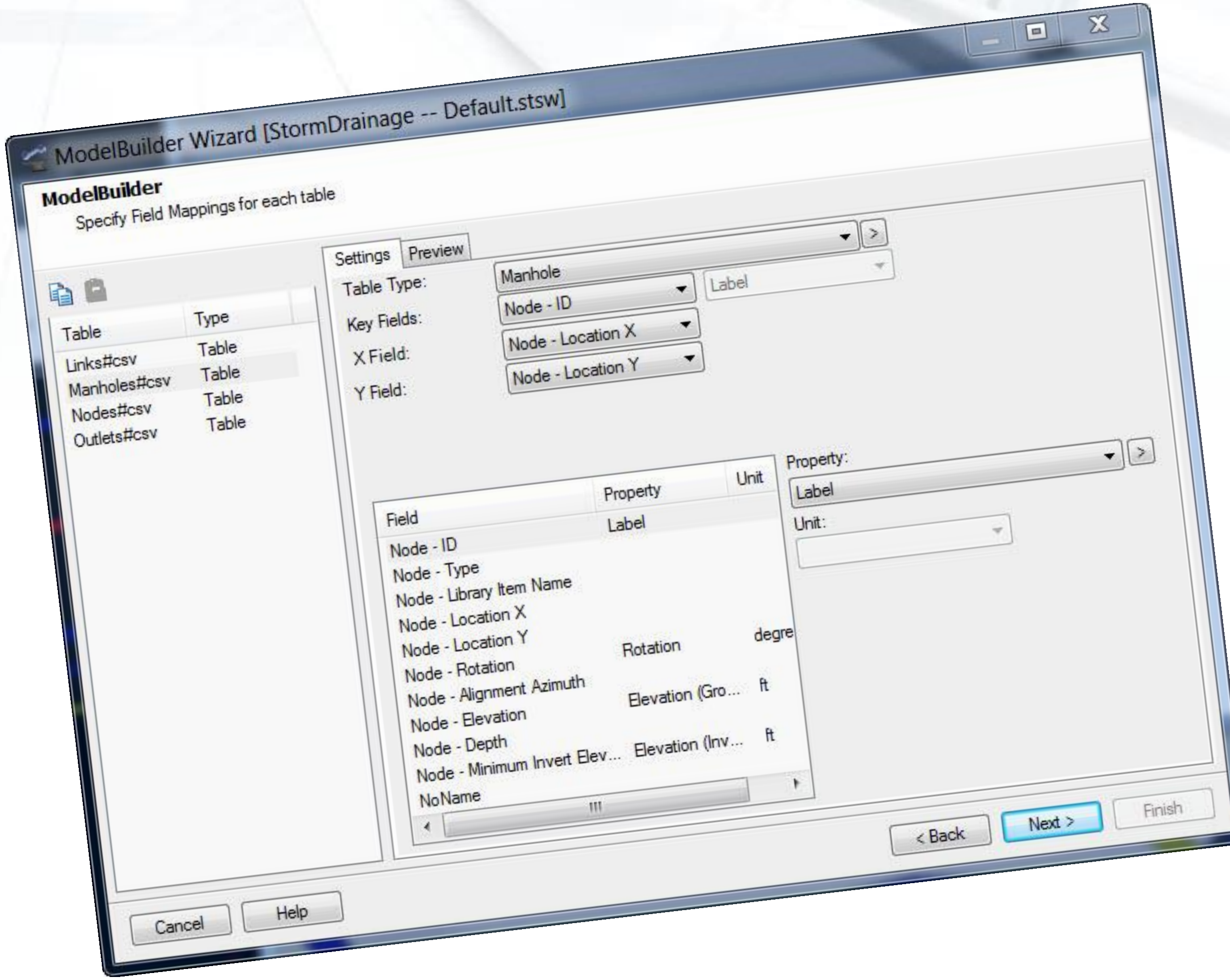


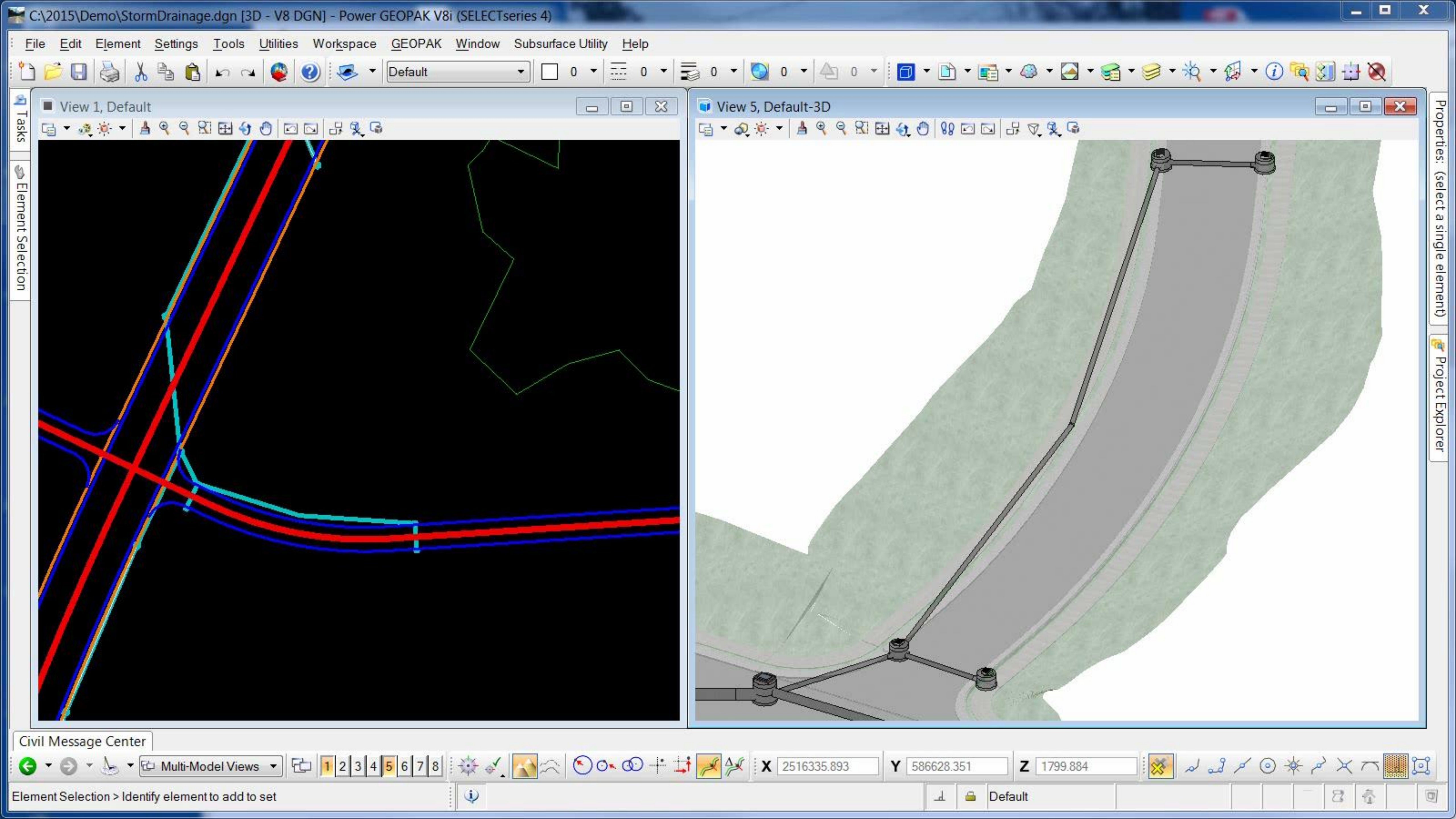
Existing Utilities From GIS

Create Models of Existing Utilities From GIS Data

- Model Builder tool provides two way link from virtually all database formats including:
  - Oracle Spatial
  - SQL Spatial (by way of Bentley Map)
  - ESRI spatial databases (requires ESRI Connector)
  - SHP

- Model Builder maps the tables and fields in the database with tables and fields in the CADD file.

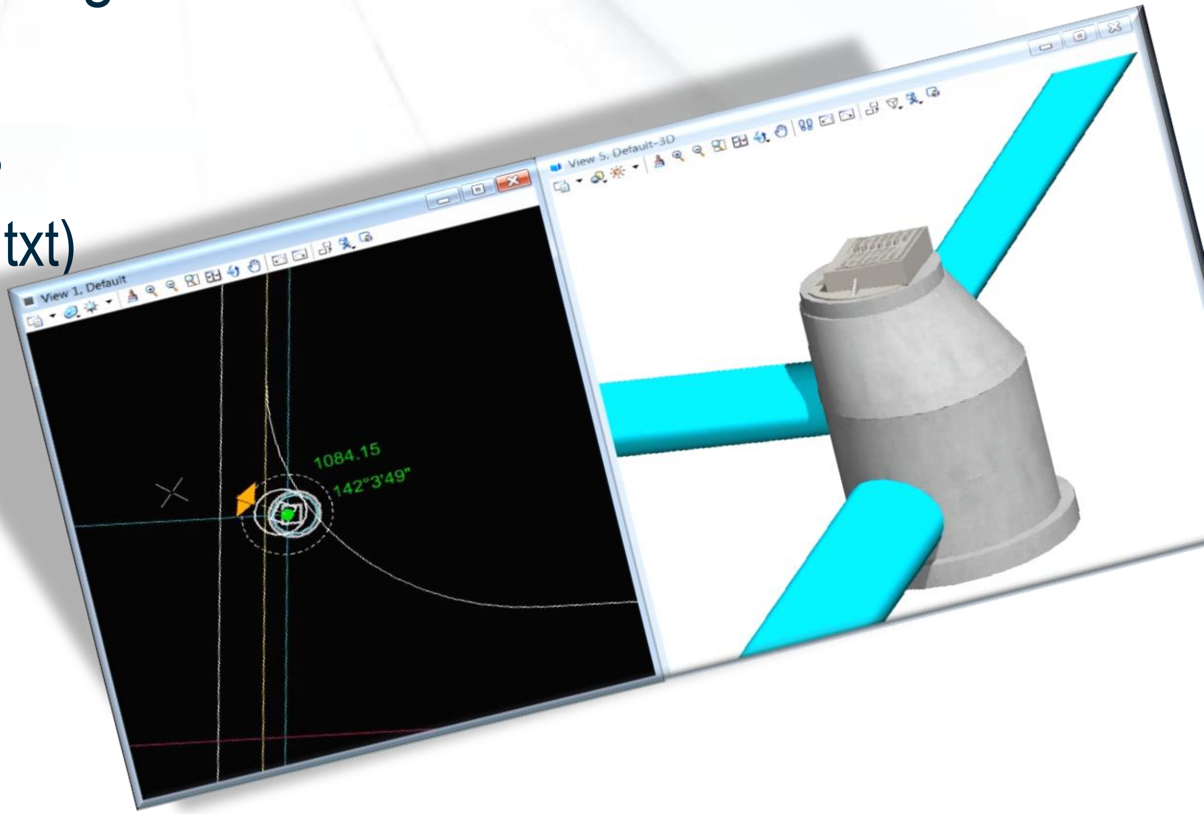


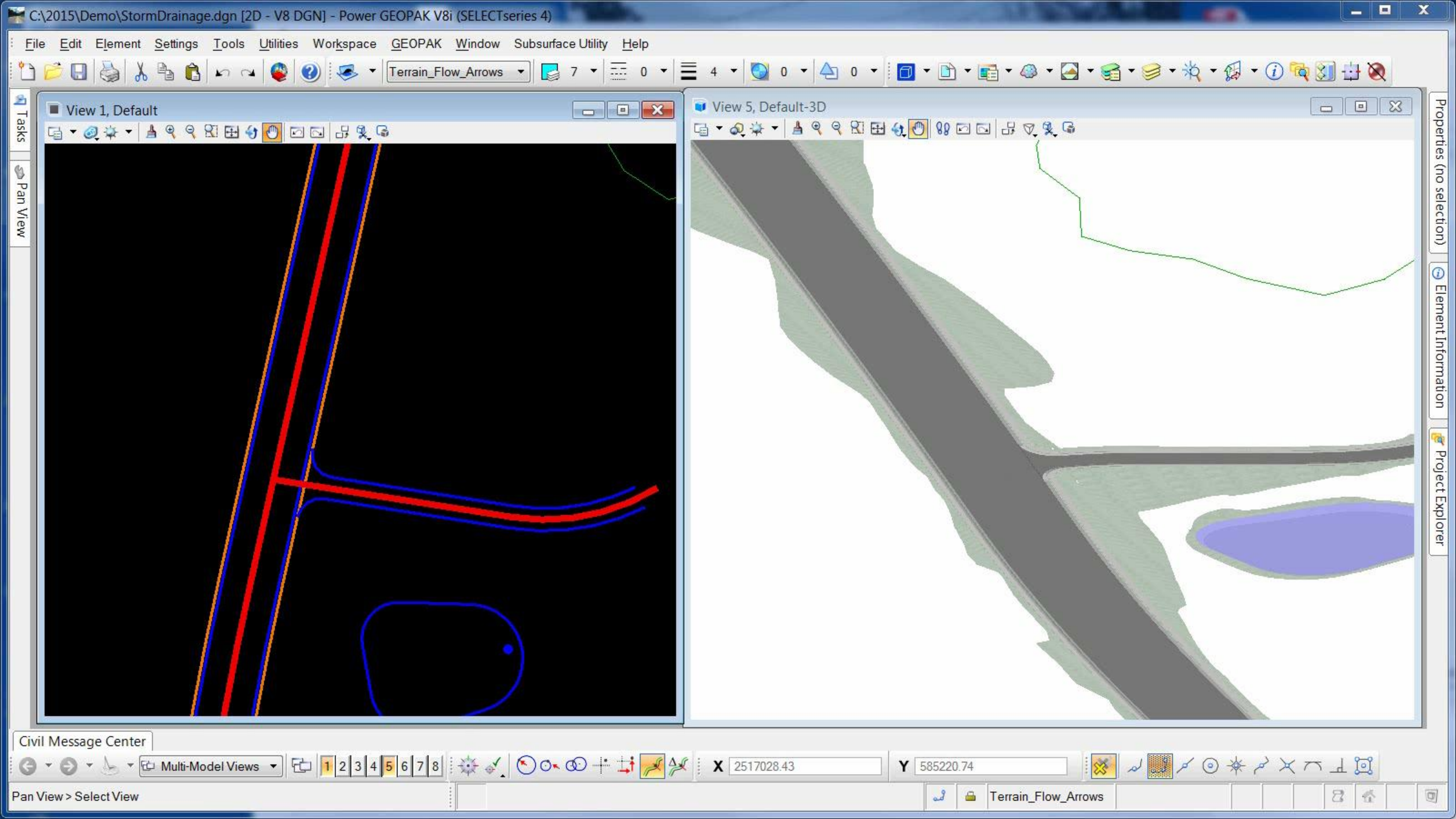

C:\2015\Demo\StormDrainage.dgn [3D - V8 DGN] - Power GEOPAK V8i (SELECTseries 4)
File Edit Element Settings Tools Utilities Workspace GEOPAK Window Subsurface Utility Help
Default
View 1, Default
View 5, Default-3D
Tasks
Element Selection
Properties: (select a single element)
Project Explorer
Civil Message Center
Multi-Model Views
1 2 3 4 5 6 7 8
X 2516335.893
Y 586628.351
Z 1799.884
Element Selection > Identify element to add to set
Default

Drainage Models From Legacy Sources

Build Models from Legacy Sources

- Direct Import from:
  - StormCAD, CivilStorm, SewerCAD SewerGEMS (.stsw)
  - SWMM V5
  - LandXML
  - MicroDrainage
  - GEOPAK Drainage
  - InRoads S&S
  - MX Drainage
- Using Model Builder link/import from virtually any data source including:
  - Microsoft Excel
  - Microsoft Access
  - Text Files (.csv, .txt)
  - ESRI (.shp)
  - Bentley Map

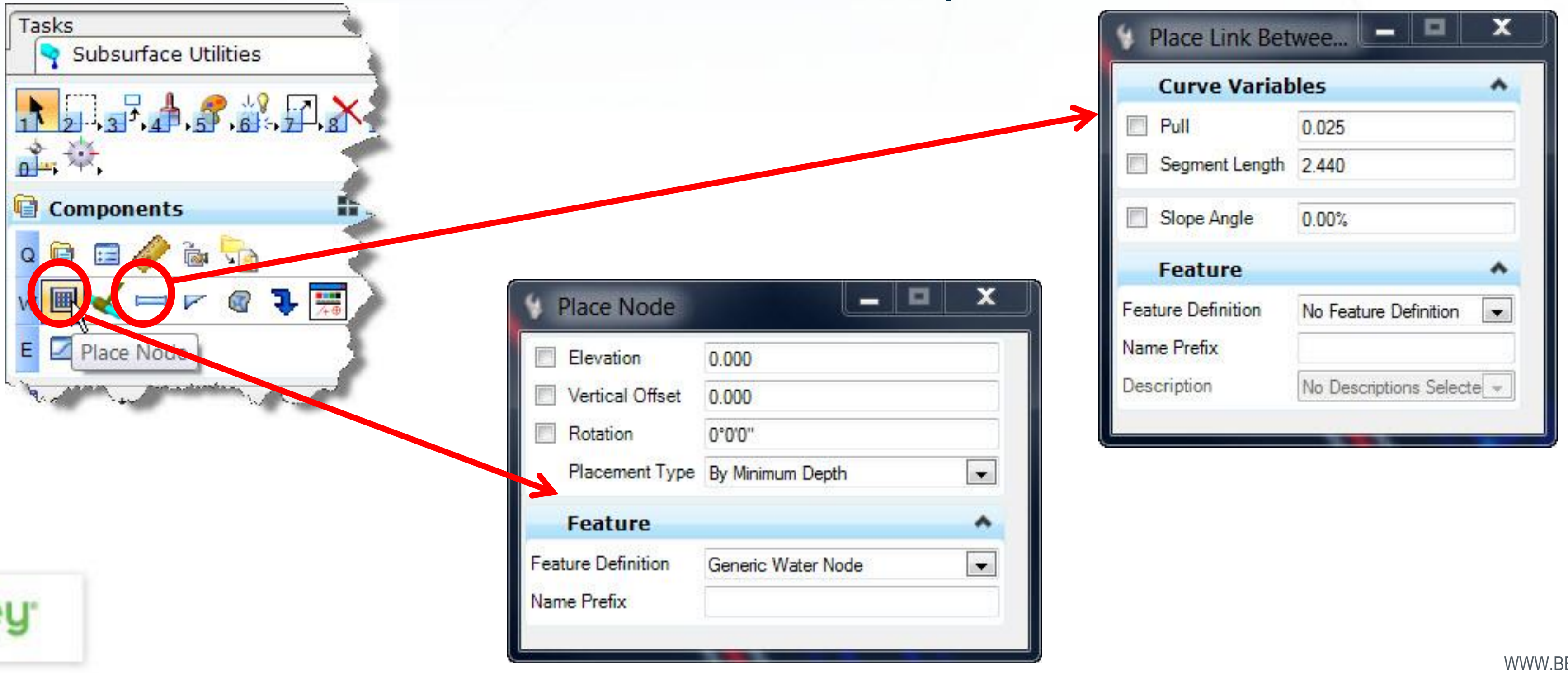


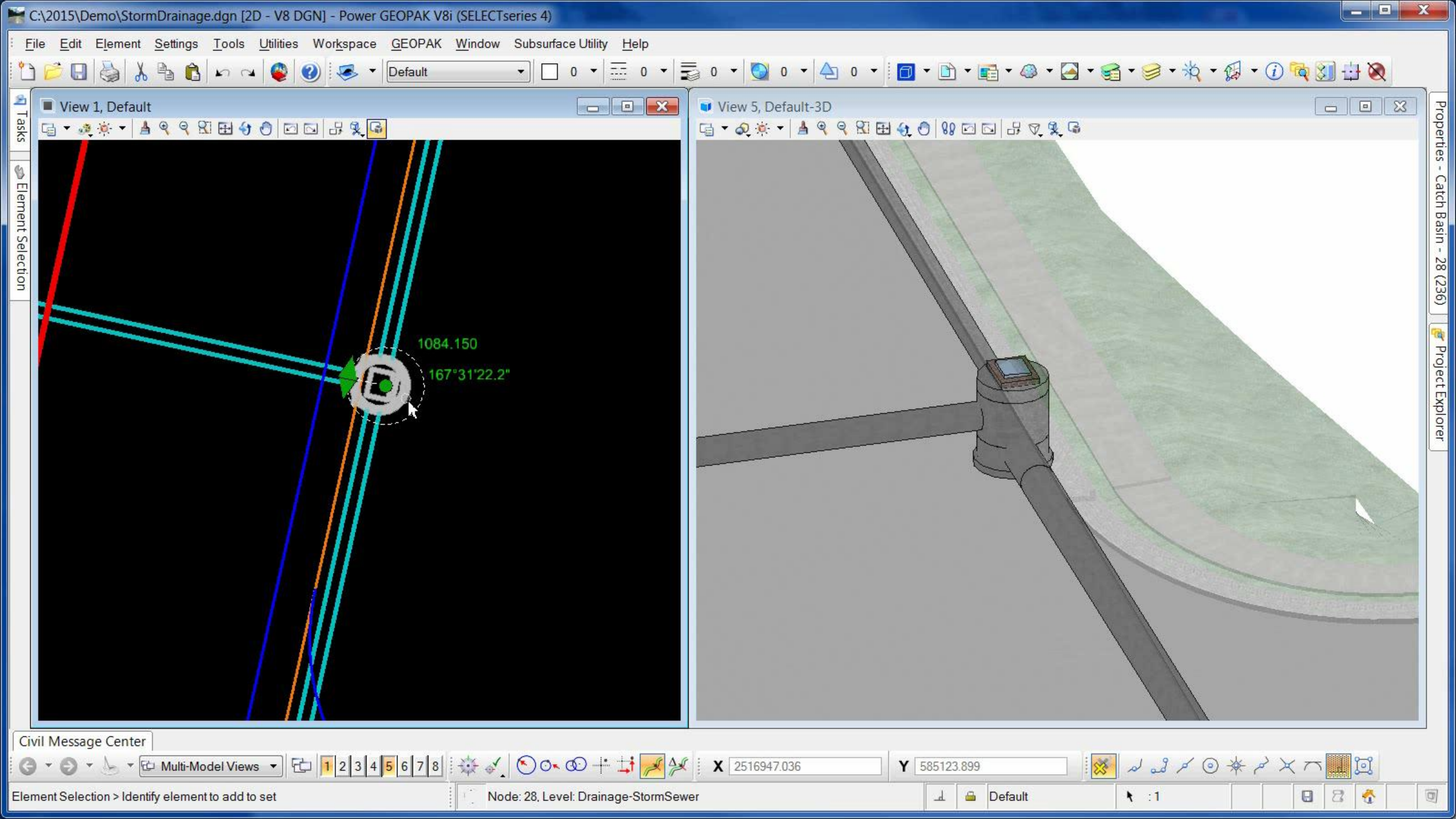

C:\2015\Demo\StormDrainage.dgn [2D - V8 DGN] - Power GEOPAK V8i (SELECTseries 4)
File Edit Element Settings Tools Utilities Workspace GEOPAK Window Subsurface Utility Help
Terrain_Flow_Arrows
View 1, Default
View 5, Default-3D
Tasks
Pan View
Properties (no selection)
Element Information
Project Explorer
Civil Message Center
Multi-Model Views
X 2517028.43
Y 585220.74
Pan View > Select View
Terrain_Flow_Arrows

Drainage Layout

Place Node and Place Link

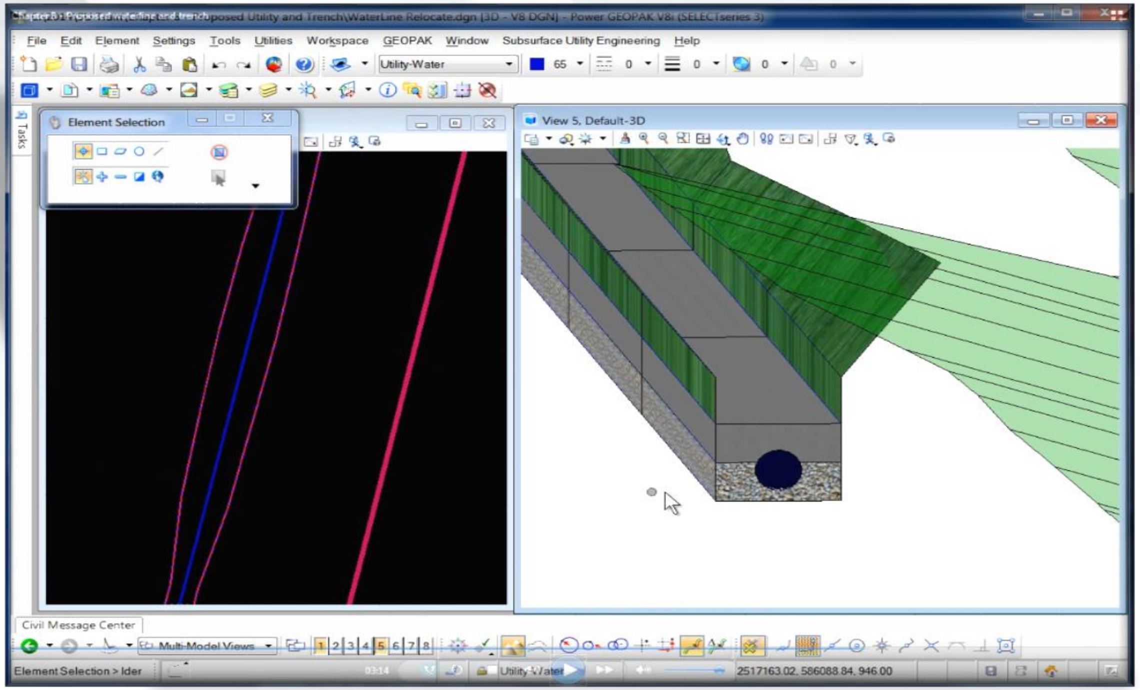
- Place Node command allows creation of new nodes
- Place Link command creates conduits between nodes
- Feature Definition to describe presentation and function.



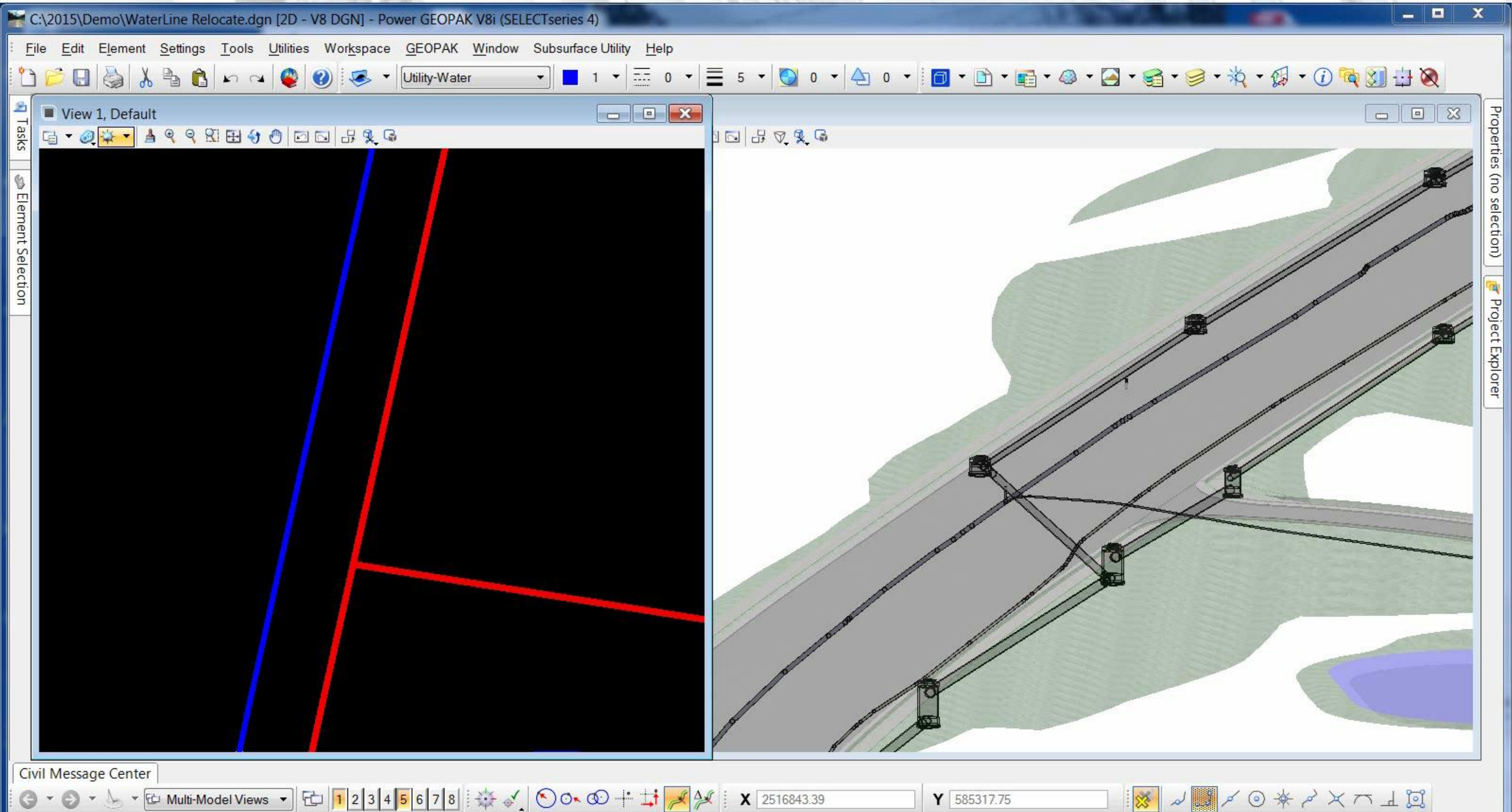

C:\2015\Demo\StormDrainage.dgn [2D - V8 DGN] - Power GEOPAK V8i (SELECTseries 4)
File Edit Element Settings Tools Utilities Workspace GEOPAK Window Subsurface Utility Help
Default
View 1, Default
View 5, Default-3D
1084.150
167°31'22.2"
Tasks
Element Selection
Properties - Catch Basin - 28 (236)
Project Explorer
Civil Message Center
Multi-Model Views
X 2516947.036
Y 585123.899
Element Selection > Identify element to add to set
Node: 28, Level: Drainage-StormSewer
Default
:1

Proposed Utilities

Design Non-Drainage Utilities for Extension or Relocation

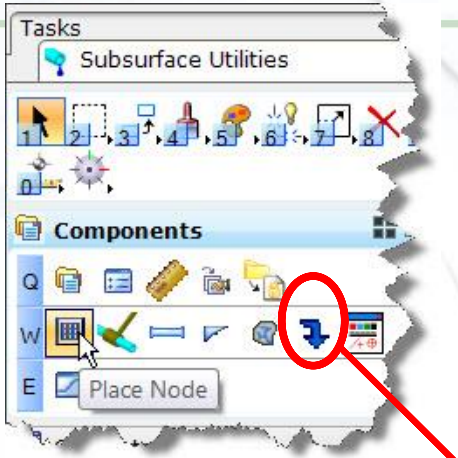


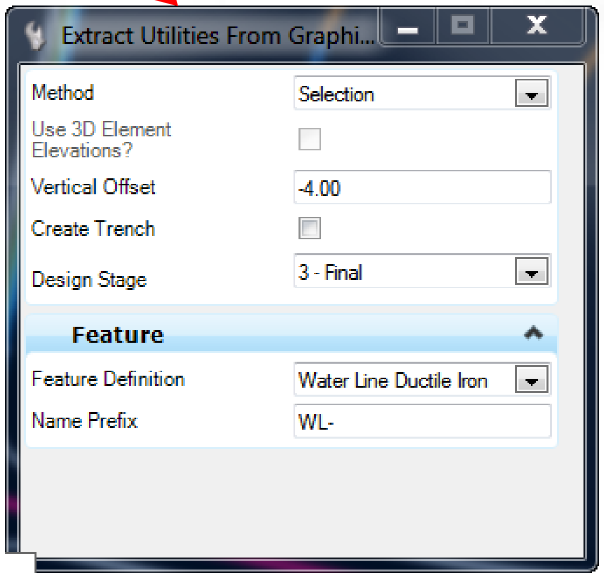
- Physical Design Only for Pressure Conduits
  - No Hydraulic design for water, gas etc.
  - No analytics for comms, electrical, etc.
- Integrated with Openroads Horizontal and Vertical Geometry
- Design Trenches along with the conduit.
- Trenches can be used to define the soft clash envelope


C:\2015\Demo\WaterLine Relocate.dgn [2D - V8 DGN] - Power GEOPAK V8i (SELECTseries 4)
File Edit Element Settings Tools Utilities Workspace GEOPAK Window Subsurface Utility Help
Utility-Water
View 1, Default
Tasks
Element Selection
Properties (no selection)
Project Explorer
Civil Message Center
Multi-Model Views
1 2 3 4 5 6 7 8
X 2516843.39
Y 585317.75

Utility with Trench

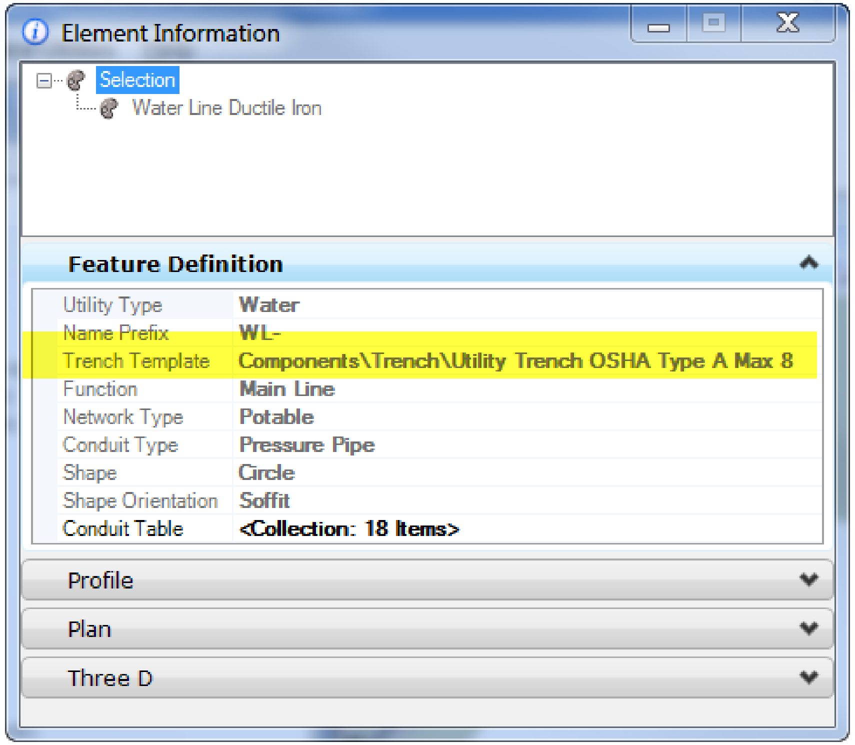
- Common use cases:
  - Relocation of utilities.
  - Modeling of pipe trench for quantities.
  - Define a soft clash envelope
- Use selection or filter method





Trench Template in the Feature Definition

- Conduit Feature Definitions include a property for trench template.
- Which is an OpenRoads corridor design template



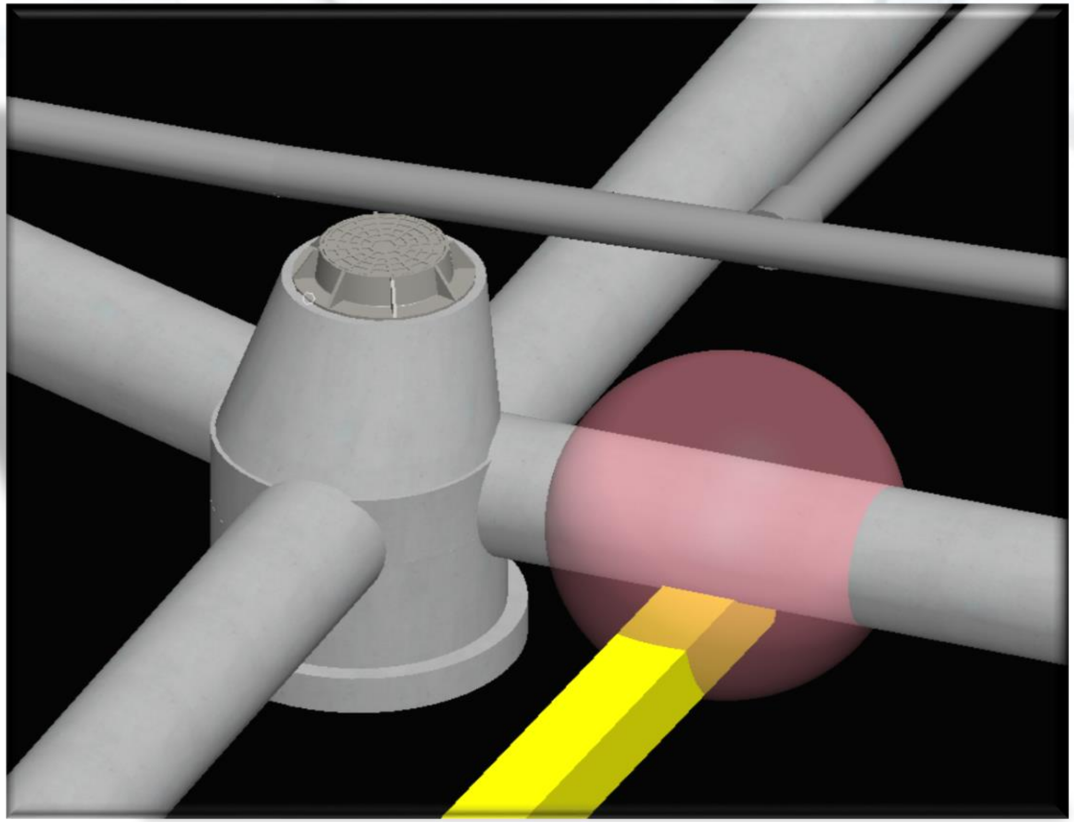
Conflict Detection

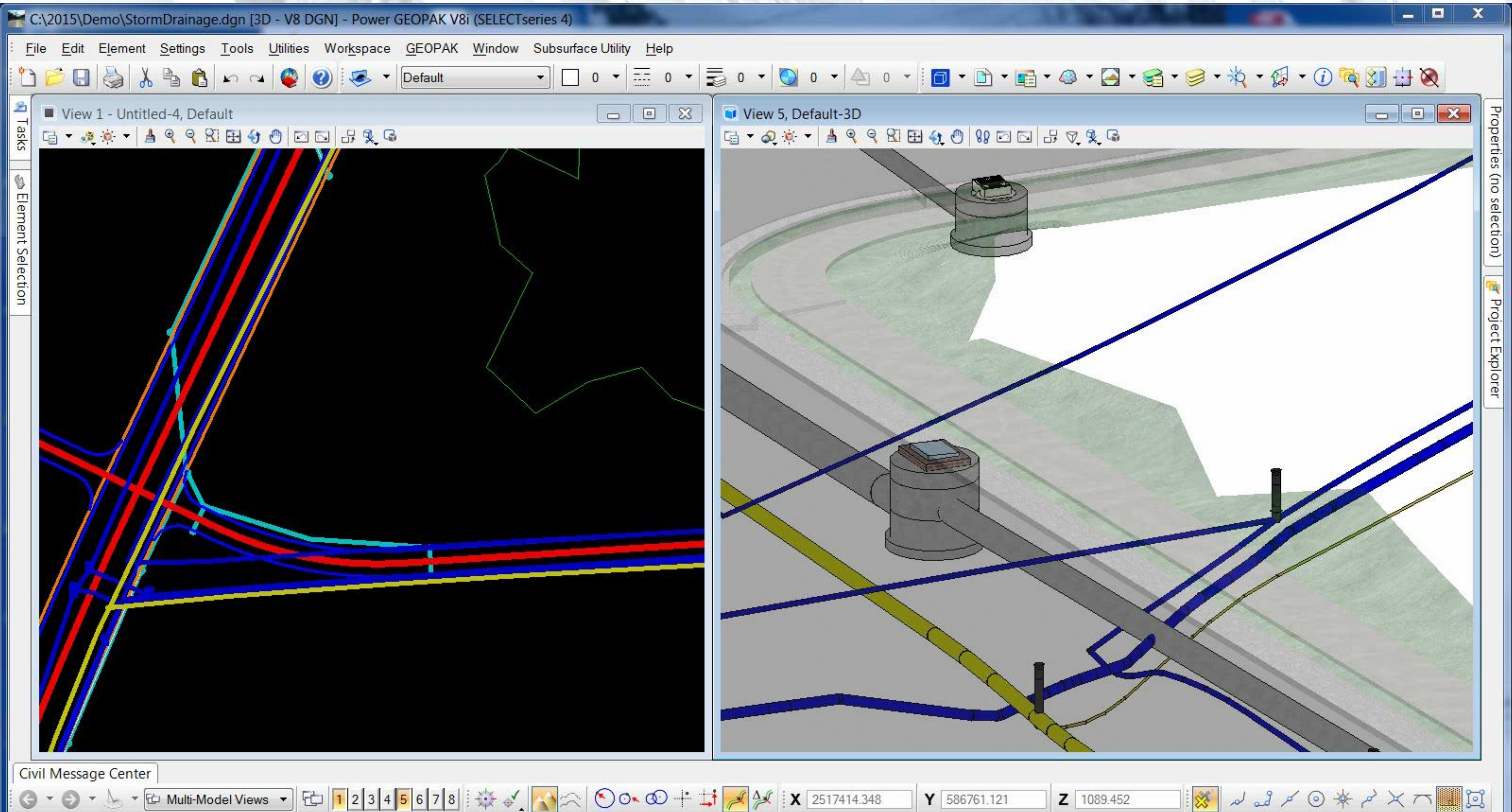
Conflict Detection

- Perform conflict detection using:
  - Feature Definitions for search criteria
  - Or use Levels for search criteria
  - Any 3D features whether utility features or road/bridge, or anything else

- Detected conflicts are marked with a 3D Conflict Node.

- Conflict Nodes are stored in database so they can be queried and reported.




C:\2015\Demo\StormDrainage.dgn [3D - V8 DGN] - Power GEOPAK V8i (SELECTseries 4)
File
Edit
Element
Settings
Tools
Utilities
Workspace
GEOPAK
Window
Subsurface Utility
Help
Default
View 1 - Untitled-4, Default
View 5, Default-3D
Tasks
Element Selection
Properties (no selection)
Project Explorer
Civil Message Center
Multi-Model Views
X 2517414.348
Y 586761.121
Z 1089.452

Lecture Topics

- Introduction to SUE (JUST FINISHED)
- Introduction to StormCAD in OpenRoads (Drainage Design) (NOW)
- Want a copy of presentations?
  - learn.bentley.com – Bentley LEARN Server (Will also have recordings of all Lectures)
  - Bring a USB drive up front after the Lecture
  - Send an email to alvie.griffith@bentley.com

Drainage Design

Subsurface Utility Design and Analysis (SUDA)

Subsurface Utility Engineering

- Conflict Management
- SUE Attribution

StormCAD Hydraulic Analysis/Design Engine

- 3D Modeling of all underground
- Integrated with OpenRoads

- Storm/Sanitary Hydraulic Analysis and Design
- Hydrology

SUE and StormCAD Licensing

If you own this license	It will include these drainage functions:	SUE functionality
• Any OpenRoads product which includes GEOPAK Drainage, InRoads S&S or MX Drainage	• Storm water peak flow design and analysis • Max 100 Inlets in any single drainage model • Storm/Sanitary attributes	• Utilities can be modeled in 3D • No SUE attributes • No Utility Conflict Tools

• Any of the above plus either:
  • StormCAD Unlimited
  • SewerCAD
  • CivilStorm
  • SewerGEMS
	• Unlocks additional hydraulics calculations capabilities according to which enhanced license is activated.	• Utilities can be modeled in 3D
		• No SUE attributes
		• No Utility Conflict Tools

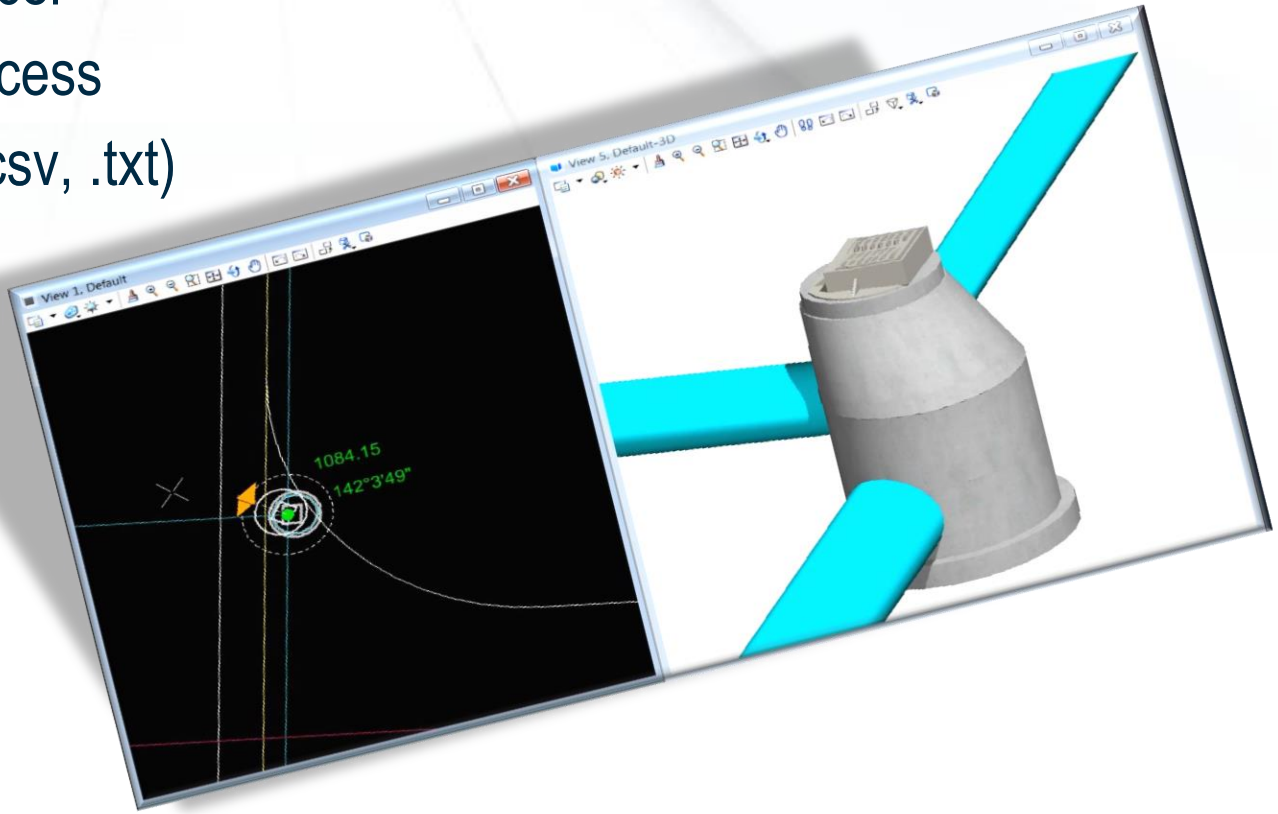
• **Any of above plus SUE license**	• **Same hydraulic capabilities as above according to which hydraulics license is active.**	• **Unlocks SUE attributes** • **Unlocks Utility Conflict Tools**

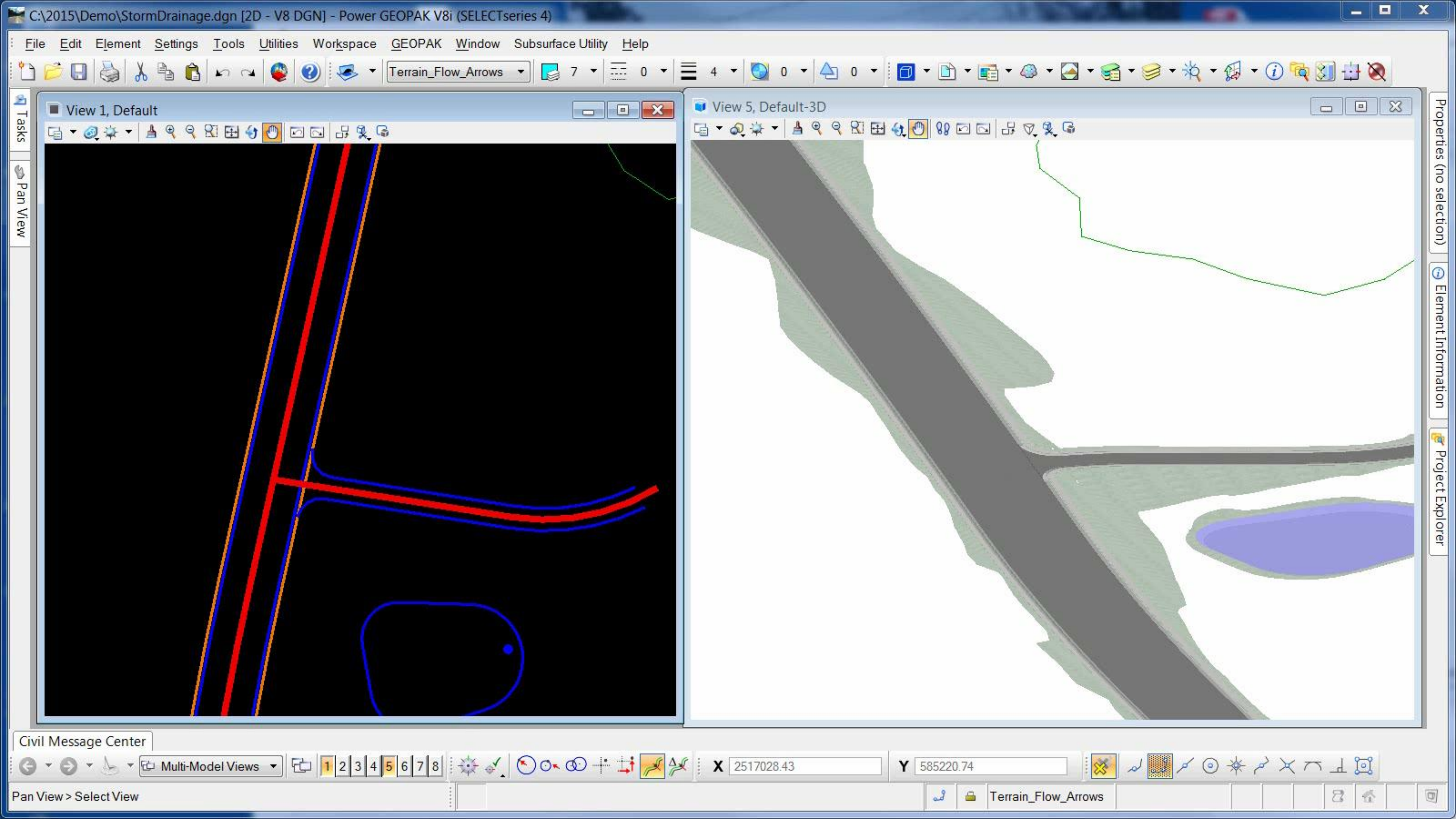
Note: Open Access Licensing in All the Above

Drainage Models From Legacy Sources

Build Hydraulic and 3D Models from Legacy Sources

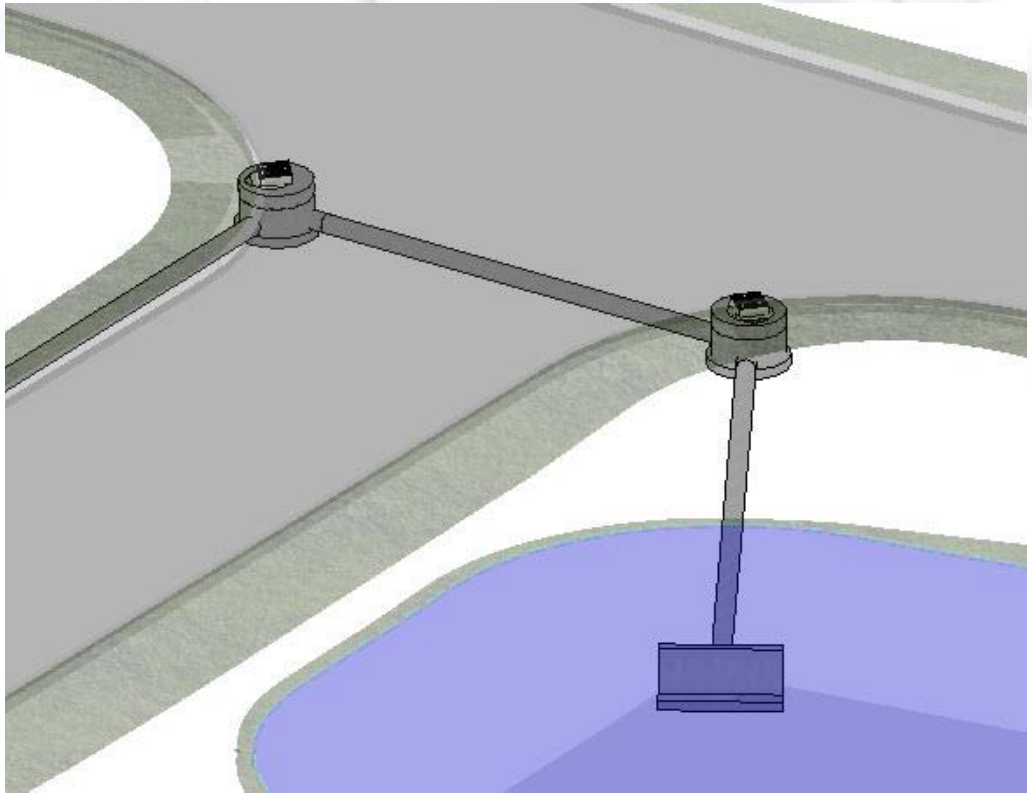
- Direct Import from:
  - StormCAD, CivilStorm, SewerCAD SewerGEMS (.stsw)
  - SWMM V5
  - LandXML
  - MicroDrainage
  - GEOPAK Drainage
  - InRoads S&S
  - MX Drainage
- Using Model Builder link/import from:
  - Microsoft Excel
  - Microsoft Access
  - Text Files (.csv, .txt)
  - ESRI (.shp)
  - Bentley Map




C:\2015\Demo\StormDrainage.dgn [2D - V8 DGN] - Power GEOPAK V8i (SELECTseries 4)
File Edit Element Settings Tools Utilities Workspace GEOPAK Window Subsurface Utility Help
Terrain_Flow_Arrows
View 1, Default
View 5, Default-3D
Tasks
Pan View
Properties (no selection)
Element Information
Project Explorer
Civil Message Center
Multi-Model Views
X 2517028.43
Y 585220.74
Pan View > Select View
Terrain_Flow_Arrows

Best Practice

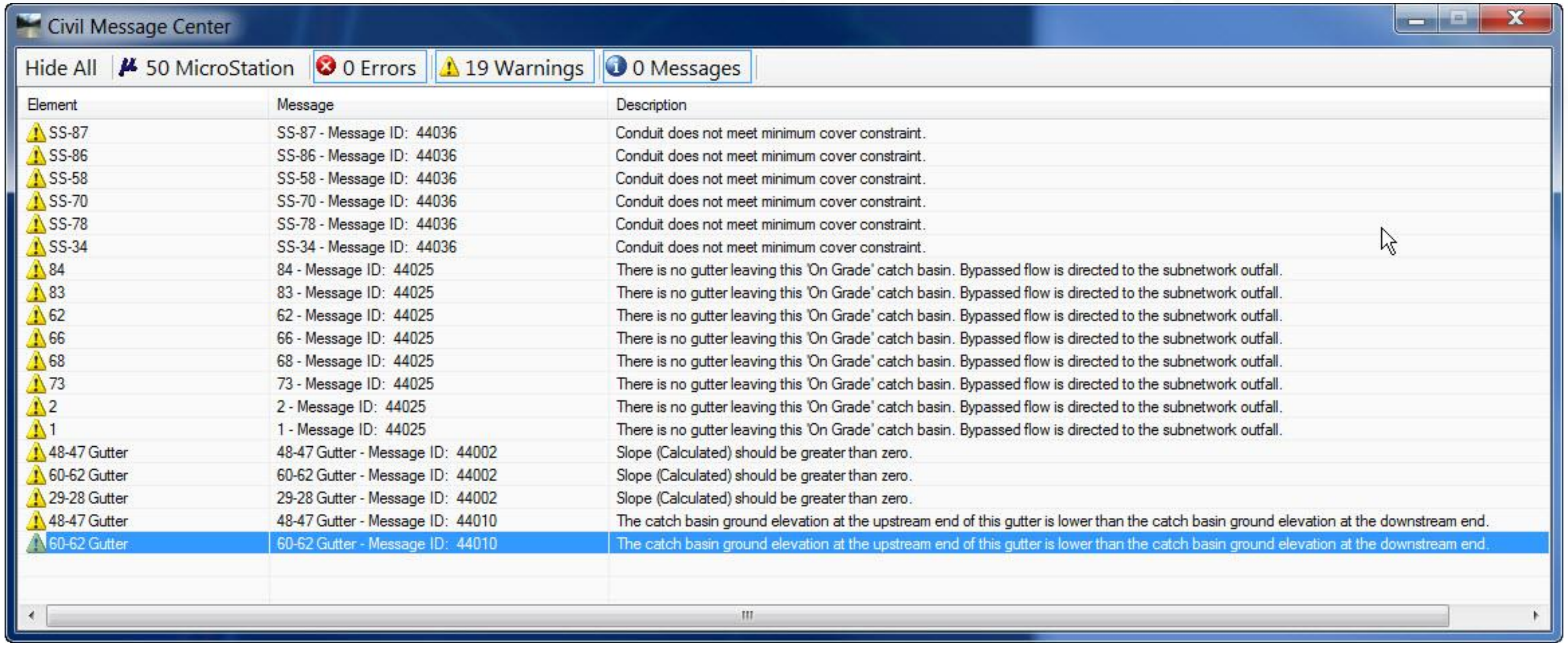
- Click any subsurface utility command before import to trigger creation of utility project and setting up of seed storms and etc.
- For commonly used nodes, make the feature definition name match the GEOPAK/InRoads library item name.
  - Thus the proper 3D model will be created on import
- For pipe feature definitions, make no attempt to match feature definitions.
  - If you do, you must maintain a Feature Definition for every pipe size
  - It is very easy after import to mass select and change all Feature Definition at once.
- Validate model and review any error reports



Best Practices

- Run Validate immediately after import to check for differences or incompatibilities between StormCAD and source data.

- Any errors found can be tidied up using the subsurface utility tools or properties.

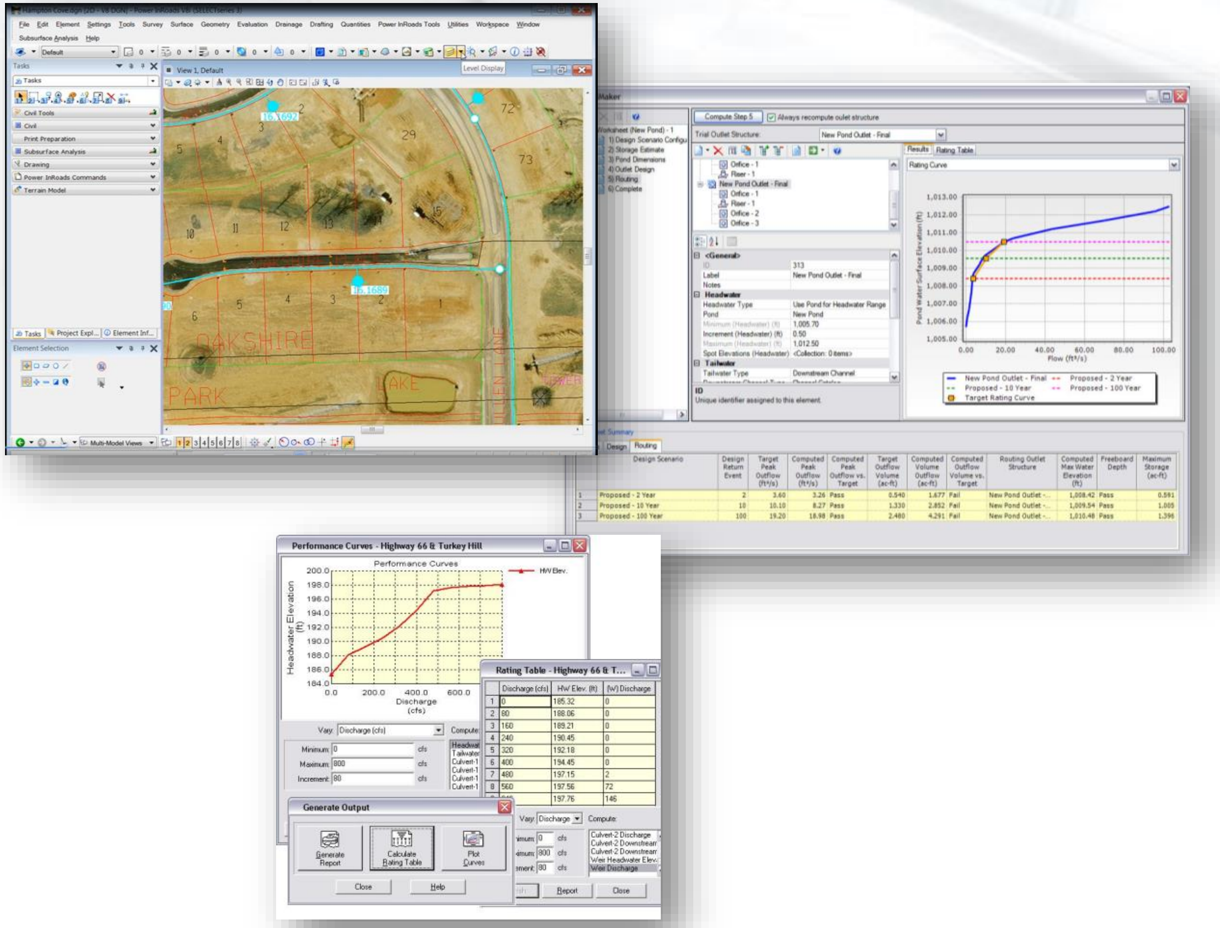


Element	Message	Description
SS-87	SS-87 - Message ID: 44036	Conduit does not meet minimum cover constraint.
SS-86	SS-86 - Message ID: 44036	Conduit does not meet minimum cover constraint.
SS-58	SS-58 - Message ID: 44036	Conduit does not meet minimum cover constraint.
SS-70	SS-70 - Message ID: 44036	Conduit does not meet minimum cover constraint.
SS-78	SS-78 - Message ID: 44036	Conduit does not meet minimum cover constraint.
SS-34	SS-34 - Message ID: 44036	Conduit does not meet minimum cover constraint.
84	84 - Message ID: 44025	There is no gutter leaving this 'On Grade' catch basin. Bypassed flow is directed to the subnetwork outfall.
83	83 - Message ID: 44025	There is no gutter leaving this 'On Grade' catch basin. Bypassed flow is directed to the subnetwork outfall.
62	62 - Message ID: 44025	There is no gutter leaving this 'On Grade' catch basin. Bypassed flow is directed to the subnetwork outfall.
66	66 - Message ID: 44025	There is no gutter leaving this 'On Grade' catch basin. Bypassed flow is directed to the subnetwork outfall.
68	68 - Message ID: 44025	There is no gutter leaving this 'On Grade' catch basin. Bypassed flow is directed to the subnetwork outfall.
73	73 - Message ID: 44025	There is no gutter leaving this 'On Grade' catch basin. Bypassed flow is directed to the subnetwork outfall.
2	2 - Message ID: 44025	There is no gutter leaving this 'On Grade' catch basin. Bypassed flow is directed to the subnetwork outfall.
1	1 - Message ID: 44025	There is no gutter leaving this 'On Grade' catch basin. Bypassed flow is directed to the subnetwork outfall.
48-47 Gutter	48-47 Gutter - Message ID: 44002	Slope (Calculated) should be greater than zero.
60-62 Gutter	60-62 Gutter - Message ID: 44002	Slope (Calculated) should be greater than zero.
29-28 Gutter	29-28 Gutter - Message ID: 44002	Slope (Calculated) should be greater than zero.
48-47 Gutter	48-47 Gutter - Message ID: 44010	The catch basin ground elevation at the upstream end of this gutter is lower than the catch basin ground elevation at the downstream end.
60-62 Gutter	60-62 Gutter - Message ID: 44010	The catch basin ground elevation at the upstream end of this gutter is lower than the catch basin ground elevation at the downstream end.

Hydraulic Design Engines

Drainage Design and Analysis

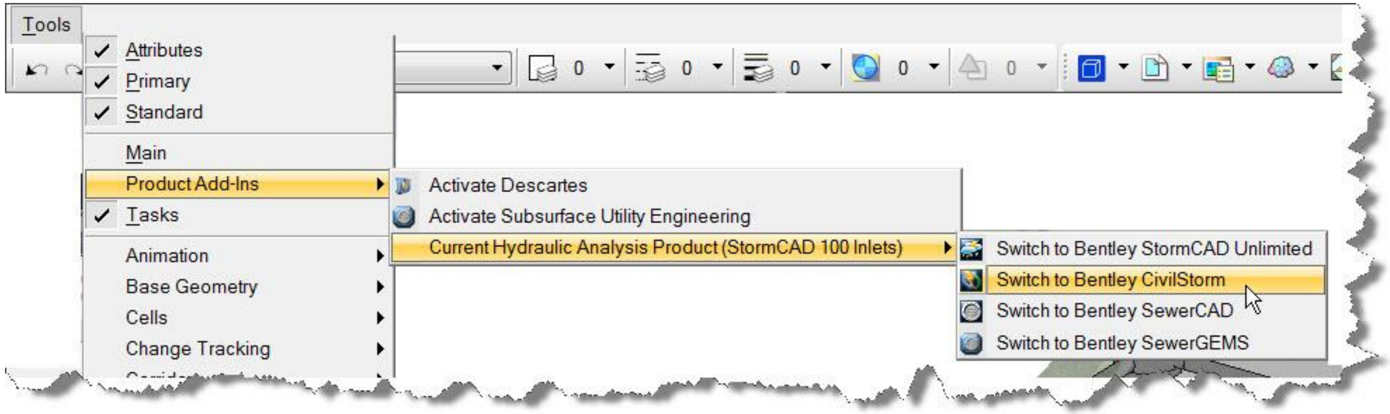
- Industry standard analytics with more than 25 years maturity behind the hydraulic simulation engines
- Integrated with OpenRoads
- Conventional Peak Flow design plus advanced dynamic wave and transient analysis.
- Customizable and extensible
- Enterprise data exchange built-in



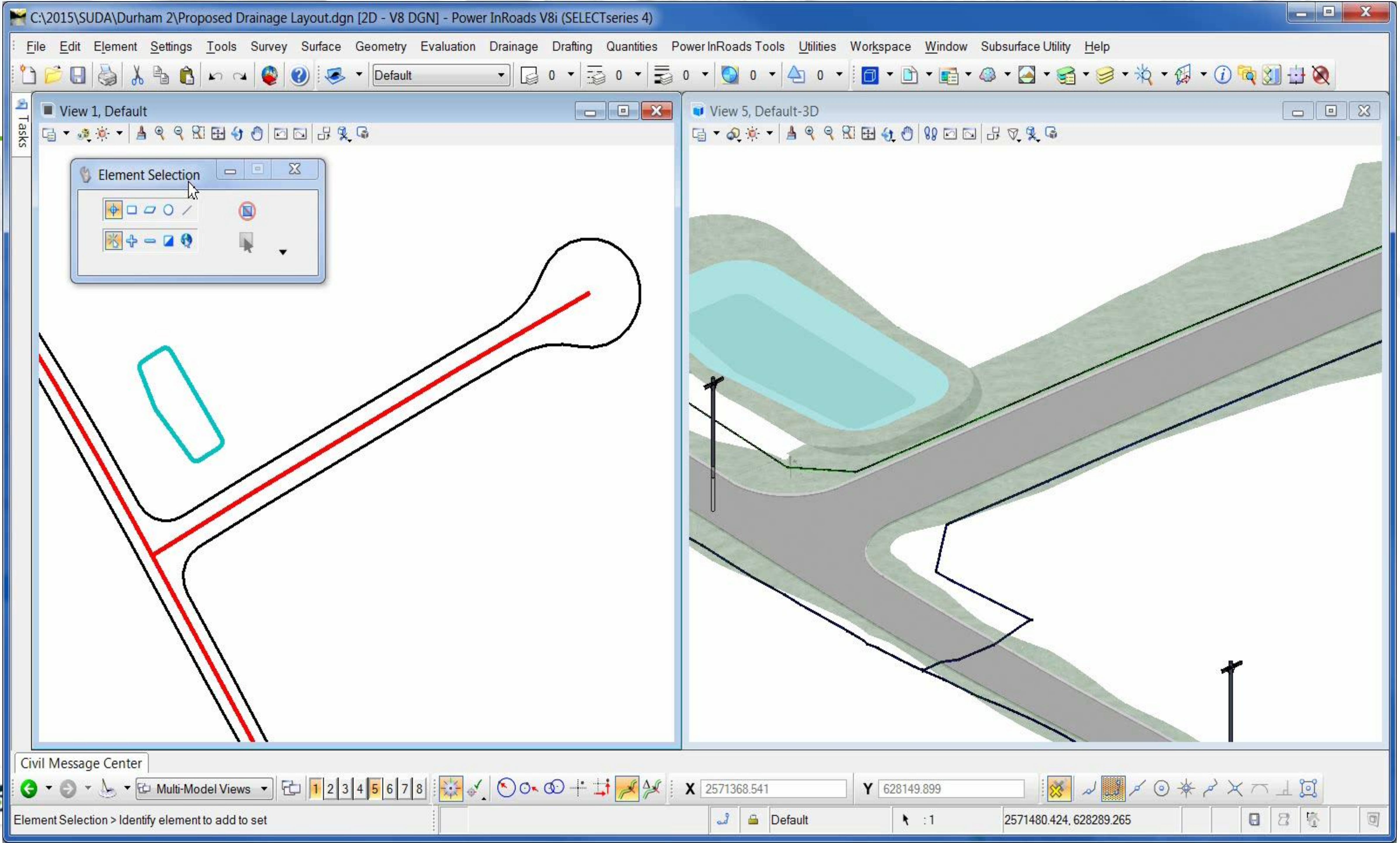
Bentley Sustaining Infrastructure

Storm/Sanitary Product Functions

- StormCAD – Rational Method storm water design and analysis (HEC 22)
- SewerCAD – Gradually varied flow sanitary sewer design and analysis package
- CivilStorm – Storm water management and dynamic modeling
- SewerGEMS – Complete storm and sanitary sewer modeling analysis and design package with geospatial integration. Superset of SewerCAD, CivilStorm and StormCAD.



Drainage Layout


C:\2015\SUDA\Durham 2\Proposed Drainage Layout.dgn [2D - V8 DGN] - Power InRoads V8i (SELECTseries 4)
File Edit Element Settings Tools Survey Surface Geometry Evaluation Drainage Drafting Quantities Power InRoads Tools Utilities Workspace Window Subsurface Utility Help
Default
View 1, Default
View 5, Default-3D
Tasks
Element Selection
Civil Message Center
Multi-Model Views
X 2571368.541
Y 628149.899
Element Selection > Identify element to add to set
Default
2571480.424, 628289.265

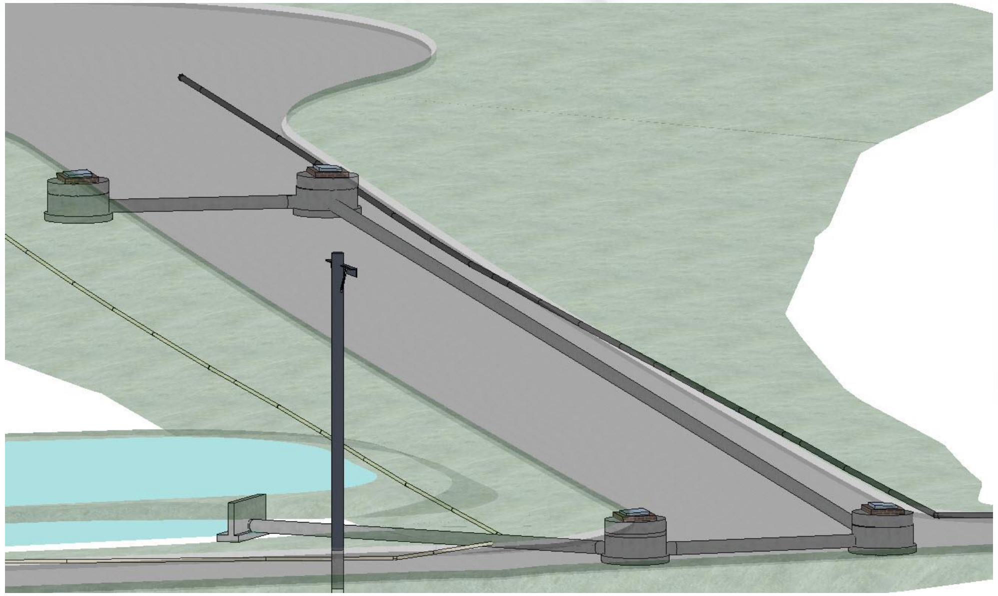
Modeling Storm and Sanitary Networks

- Inlets, headwalls and catch basins ruled to OpenRoads geometry and surfaces.

- Pipes ruled to the nodes.

- Multi-pipe profile runs

- Hydraulic properties linked into feature definitions.

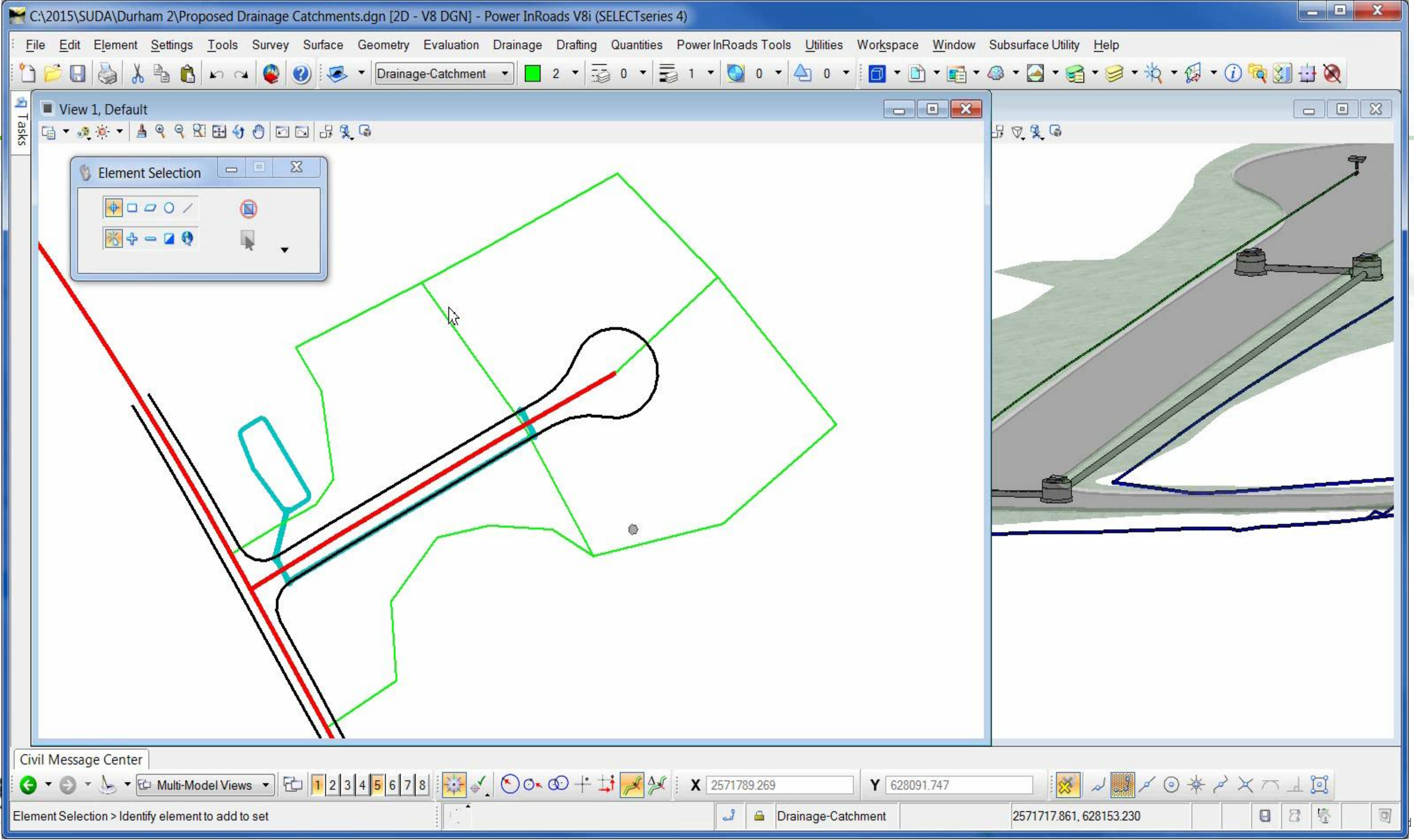


Best Practices - Layout

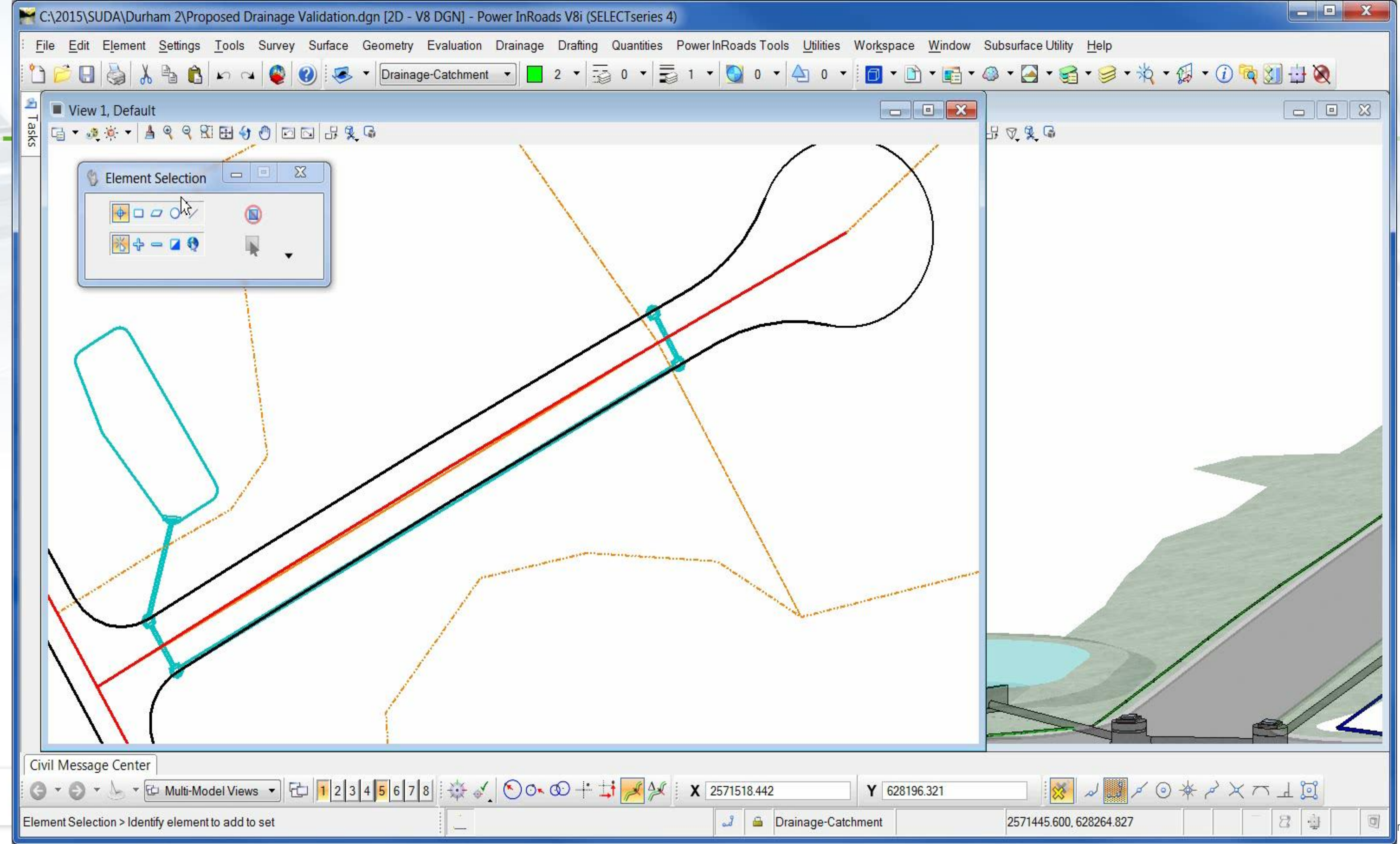
- If you don’t know how to use Civil Accudraw, then learn. It will make your life easier and OpenRoads more powerful

- When connecting pipes to headwalls, remember that the direction determines whether the headwall is an inlet or an outlet.

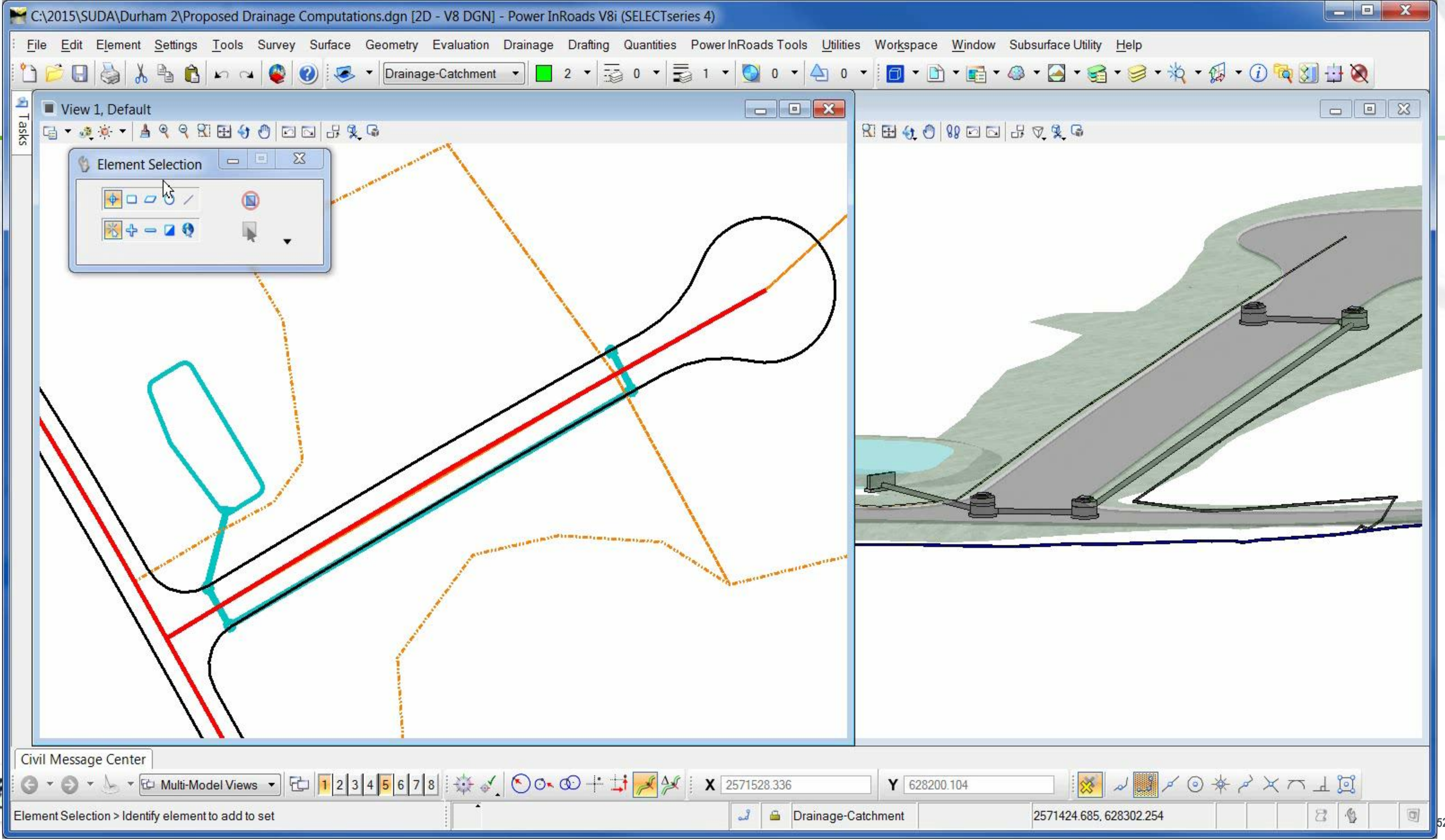
Catchments


C:\2015\SUDA\Durham 2\Proposed Drainage Catchments.dgn [2D - V8 DGN] - Power InRoads V8i (SELECTseries 4)
File Edit Element Settings Tools Survey Surface Geometry Evaluation Drainage Drafting Quantities Power InRoads Tools Utilities Workspace Window Subsurface Utility Help
Drainage-Catchment
View 1, Default
Tasks
Element Selection
Civil Message Center
Multi-Model Views
X 2571789.269
Y 628091.747
Element Selection > Identify element to add to set
Drainage-Catchment
2571717.861, 628153.230

Validate Drainage Layout


C:\2015\SUDA\Durham 2\Proposed Drainage Validation.dgn [2D - V8 DGN] - Power InRoads V8i (SELECTseries 4)
File Edit Element Settings Tools Survey Surface Geometry Evaluation Drainage Drafting Quantities Power InRoads Tools Utilities Workspace Window Subsurface Utility Help
Drainage-Catchment
View 1, Default
Element Selection
Tasks
Civil Message Center
Multi-Model Views
X 2571518.442
Y 628196.321
Element Selection > Identify element to add to set
Drainage-Catchment
2571445.600, 628264.827

Peak Flow Design Calculations


C:\2015\SUDA\Durham 2\Proposed Drainage Computations.dgn [2D - V8 DGN] - Power InRoads V8i (SELECTseries 4)
File Edit Element Settings Tools Survey Surface Geometry Evaluation Drainage Drafting Quantities Power InRoads Tools Utilities Workspace Window Subsurface Utility Help
Drainage-Catchment
Tasks
View 1, Default
Element Selection
Civil Message Center
Multi-Model Views
X 2571528.336
Y 628200.104
Element Selection > Identify element to add to set
Drainage-Catchment
2571424.685, 628302.254

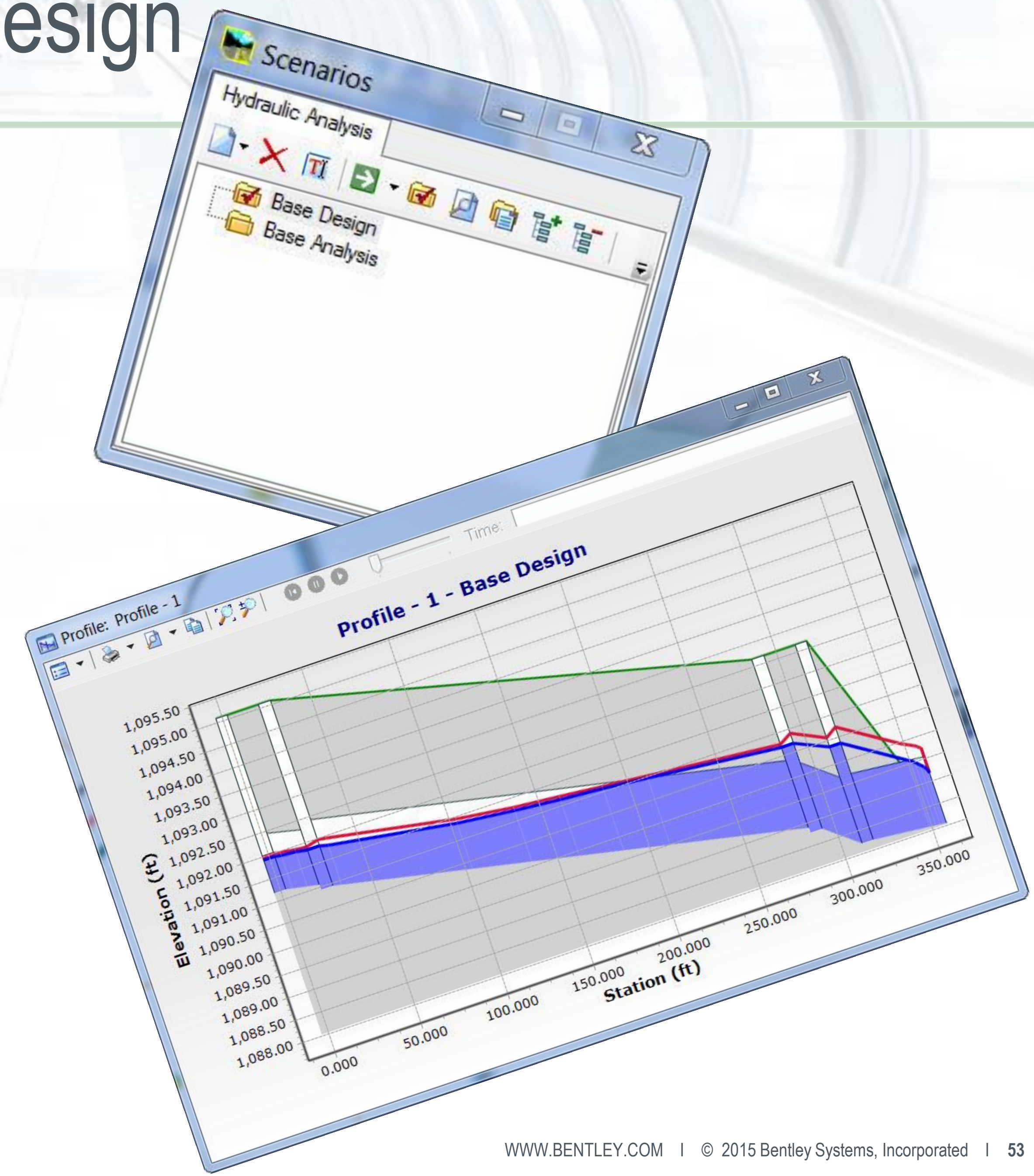
Peak Flow Hydraulic Analysis/Design

- Included with OpenRoads - drainage networks up to 100 inlets.

- StormCAD GVF calculations engine.

- 3D Model updates with design changes.

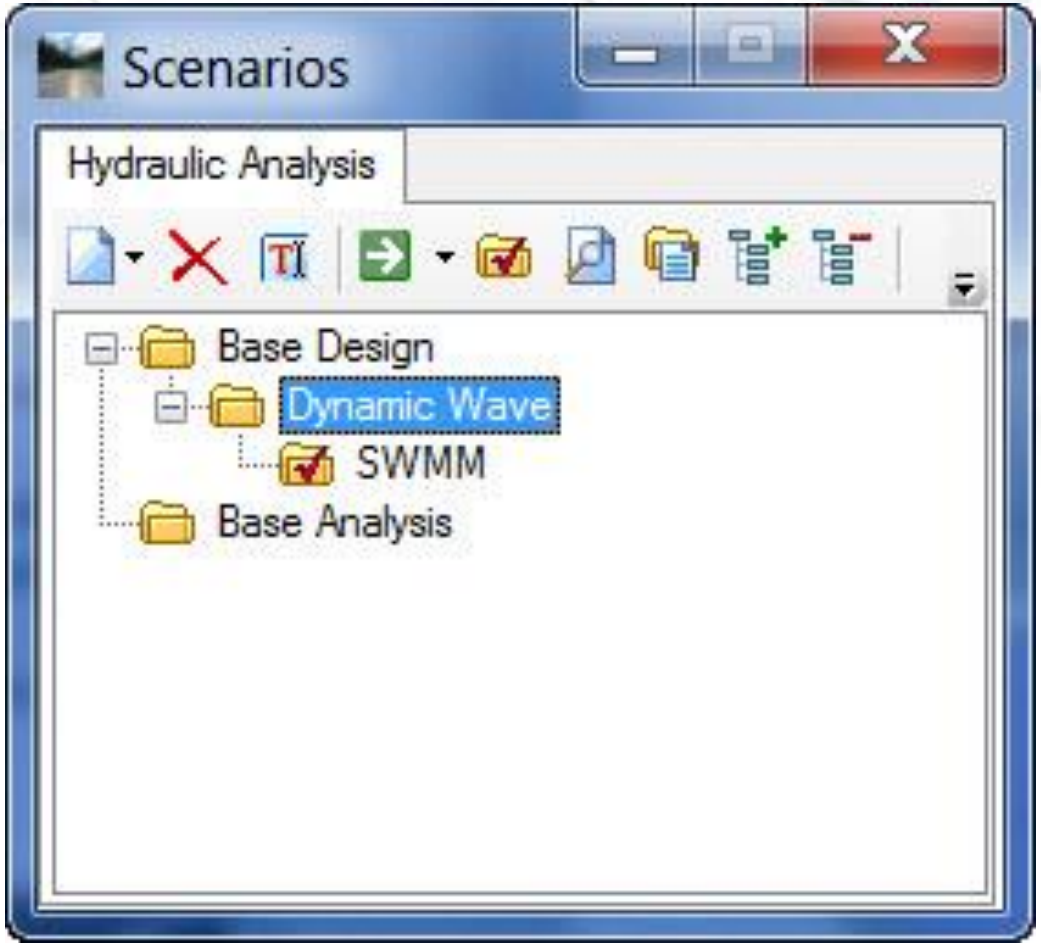
- Includes latest HEC-22 methods.

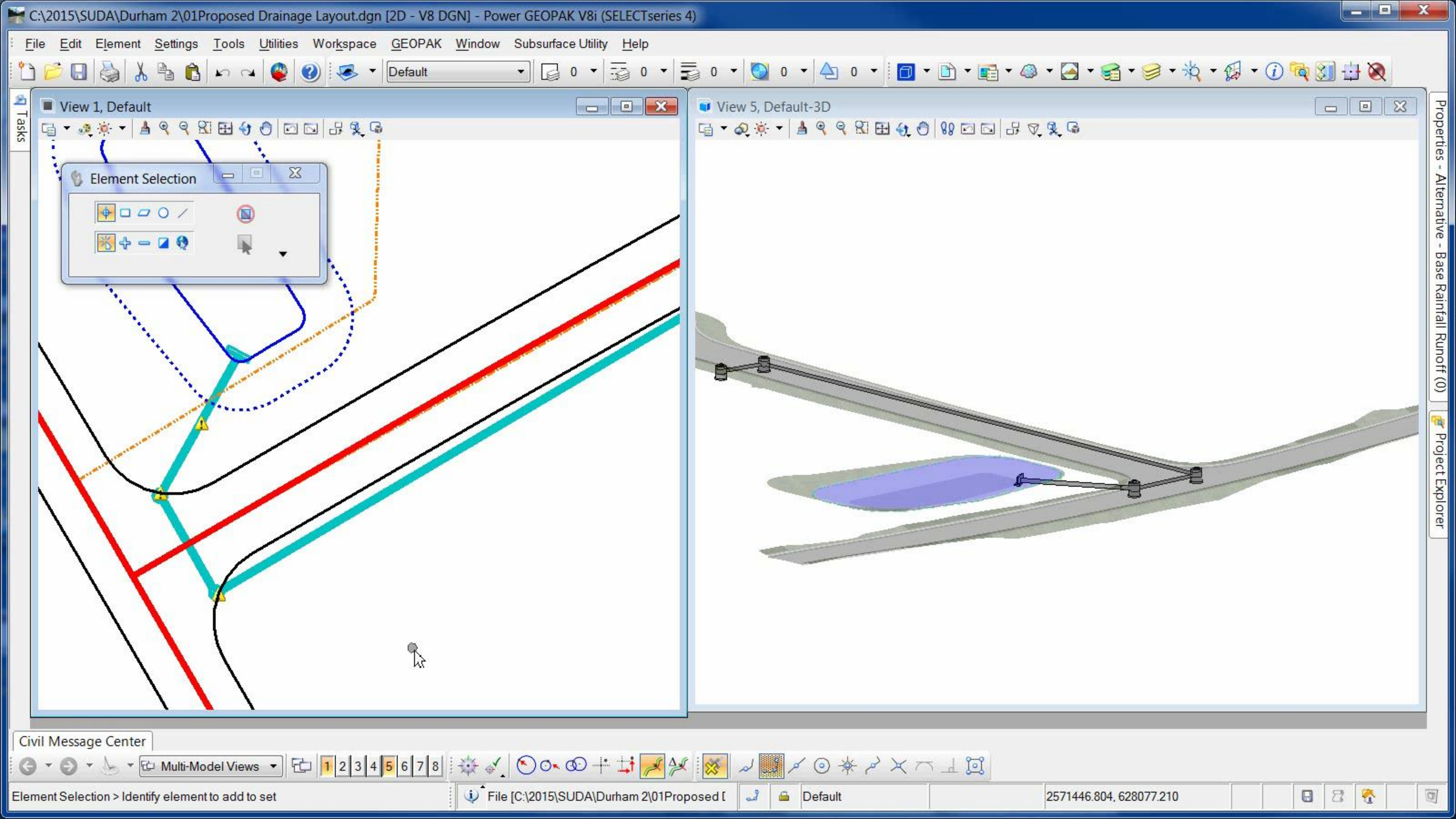


Scenario Manager

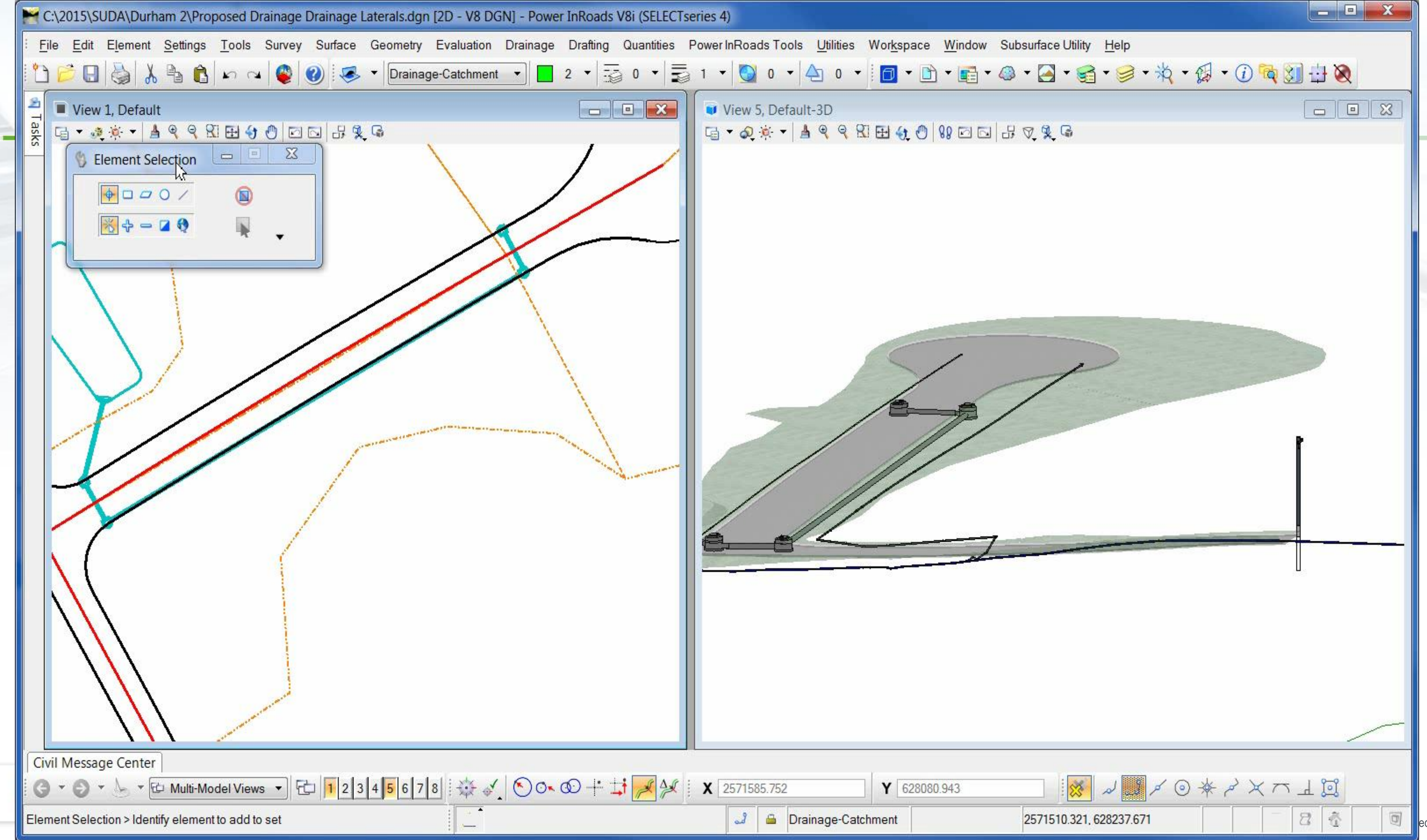
Scenario Manager

- Scenario Manager provides unlimited variation of design parameters with complete confidence that known good alternatives can be recalled at any time.



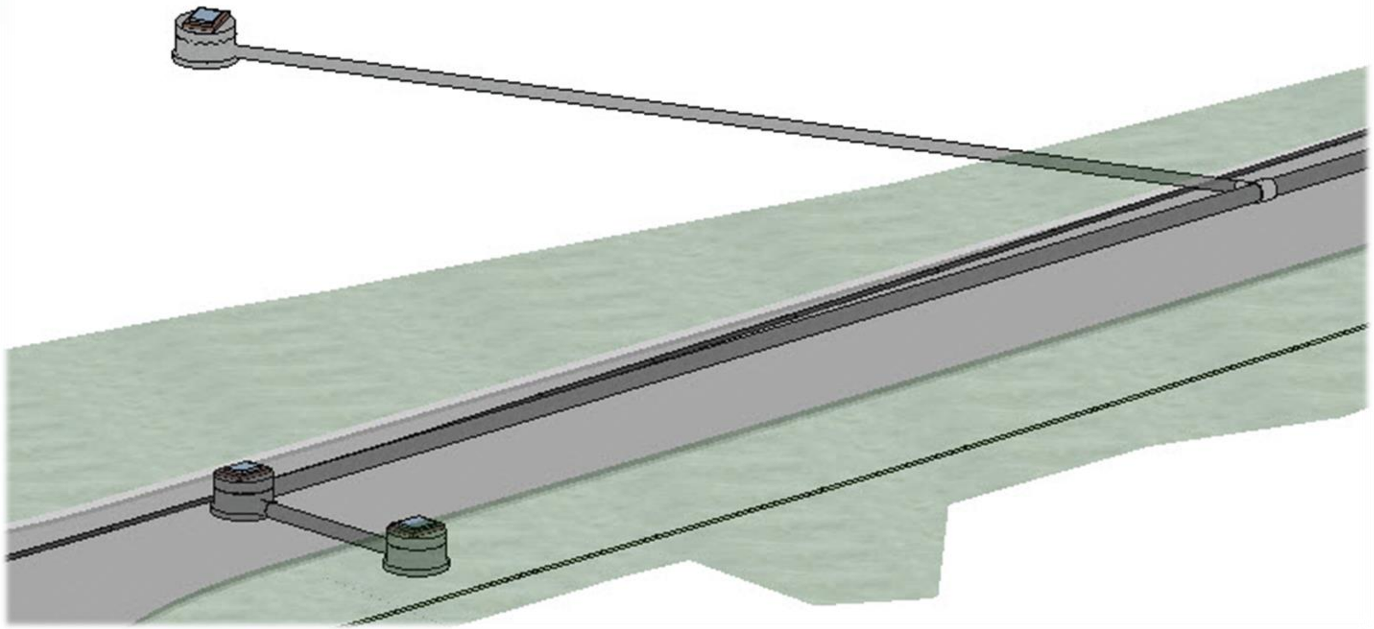

C:\2015\SUDA\Durham 2\01Proposed Drainage Layout.dgn [2D - V8 DGN] - Power GEOPAK V8i (SELECTseries 4)
File Edit Element Settings Tools Utilities Workspace GEOPAK Window Subsurface Utility Help
Default
View 1, Default
View 5, Default-3D
Element Selection
Tasks
Properties - Alternative - Base Rainfall Runoff (0)
Project Explorer
Civil Message Center
Multi-Model Views
1 2 3 4 5 6 7 8
Element Selection > Identify element to add to set
File [C:\2015\SUDA\Durham 2\01Proposed I
Default
2571446.804, 628077.210

Laterals


C:\2015\SUDA\Durham 2\Proposed Drainage Drainage Laterals.dgn [2D - V8 DGN] - Power InRoads V8i (SELECTseries 4)
File Edit Element Settings Tools Survey Surface Geometry Evaluation Drainage Drafting Quantities Power InRoads Tools Utilities Workspace Window Subsurface Utility Help
Drainage-Catchment
View 1, Default
View 5, Default-3D
Element Selection
Tasks
Civil Message Center
Multi-Model Views
X 2571585.752
Y 628080.943
Element Selection > Identify element to add to set
Drainage-Catchment
2571510.321, 628237.671

Drainage Laterals

- Flows thru the terminal inlet are computed and inlet can be designed.
- Flows from inlet are passed thru lateral pipe but lateral pipe is not designed.
- Lateral connects to trunk line but does not split in two.
- All lateral flows are accumulated and applied at upstream end of trunk.



Configuration Variables

Configuration Variables

- SU_3D_Bends_Detail =
  - Low – (default value) – bends in the 3D models of conduits have a lower resolution, which provides better performance in larger datasets.
  - High – bends in the 3D models of conduits are modeled to resemble fittings.
- SU_3D_Structure_ExtrudeMethod =
  - Up – (default value) – when making nodes the bottom cell is extruded upward using a slice from top of vault.
  - Down – extrude a slice off the bottom of top cell downwards.
- SUDA_SEED_FILE = points to the dgnlib file which contains the hydraulic seed data
- SUDA_SEED_MODEL = the model within above seed which contains the hydraulic seed data

Configuration Variables common with OpenRoads

- CIVIL_CIVILTMDGNLIBLIST – except in SUDA used to point to Utility Filters
- CIVIL_CONTENTMANAGEMENTDGNLIBLIST – points to SUDA feature definitions
- MS_DGNLIBLIST – points to element templates used in SUDA feature defntions.
- MS_CELL, MS_CELLLIST – be sure to include the SUDA 3D cell libraries

Best Practices

- Include conduit and node feature definitions in the same DGNLIB
- Also, include hydraulic seed information in the same DGNLIB
- Element Templates in same or separate DGNLIB. Maintenance is easier if use same file.
- Utility Filters wherever you wish. Maintenance might be easier if use same DGNLIB as above.

More Information!

Questions?

Alvie F. Griffith; PSM, P.E.

Senior Consultant, Bentley Systems Inc.

alvie.griffith@bentley.com