GIS Applications in a Civil Engineering Environment

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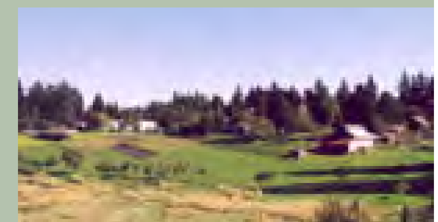
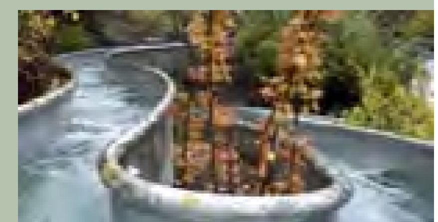
Philosophy

We find outstanding professionals, and give them the freedom and support to do what they do best.



Core Purpose

To improve the quality of life while demonstrating stewardship to the built and natural environments.



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Transportation

Airport MAX Light Rail Extension,
Portland, Oregon

Monroe Street Bridge Restoration
Spokane, Washington

- **Bridge Design, Engineering, and Construction**
- **Heavy Rail Engineering**
- **Highway/Roadway Design and Engineering**
- **Traffic Engineering**
- **Transit Planning and Engineering**
- **Transportation Design**
- **Transportation Planning**
- **Surveying**

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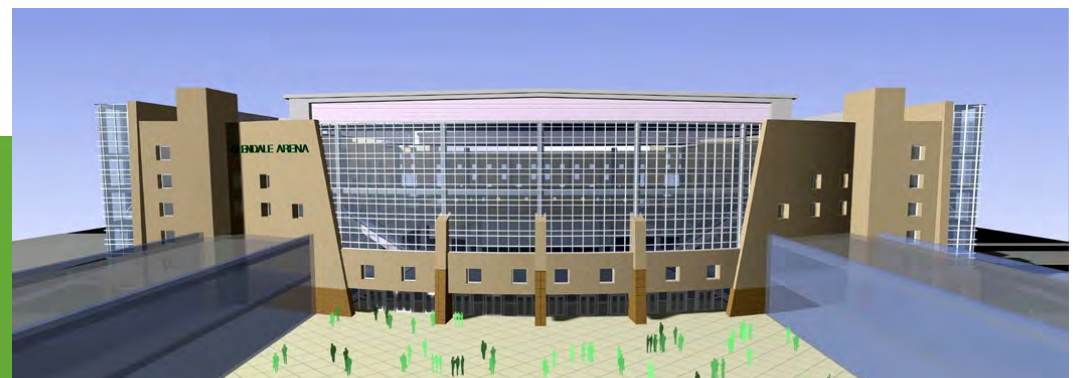
Land Development

Canyon Lakes Water System Design
Kennewick, Washington

Westgate – Coyotes Arena
City of Glendale, Arizona



- **Residential**
- **Master Planned Communities**
- **Golf Course Development**
- **Commercial and Industrial**
- **Retail and Entertainment**
- **Transit-oriented Development**

Water Resources

Shiloh Corridor Environmental Assessment, Billings, Montana

Tumalo Irrigation District System Design, Oregon

- Agricultural Water Services
- Endangered Species Act/Clean Water Act Compliance
- Environmental Planning and Documentation
- Marine Services
- Natural Resources Management
- Sanitary Sewer, Water, and Stormwater Engineering, Planning, and Treatment or Restoration
- Water Resources Appropriations, Reallocation, and Banking
- Wetlands and Stream Restoration

Energy

Schultz - Wautoma 500kV Transmission Line, Ellensburg, Washington

Wild Horse Wind Farm, Ellensburg, Washington

Hells Canyon Complex Aesthetic Resource Inventory and Evaluation, Idaho and Oregon

- Transmission Lines and Pipelines
- Gas- and Coal-fired Power Generation
- Hydropower Projects
- Windpower

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My Background

BS, Environmental Resource Management
Pennsylvania State University

10 years of experience with the US Forest Service supporting NEPA documentation for federal actions (forestry practices, development, new roads, culvert replacements).

6 years with DEA as a project biologist supporting projects through local, state and federal permitting on infrastructure projects.

Primary Clients

- **Puget Sound Energy**
- **Washington State Department of Transportation**
- **Land Development Clients**

What about GIS?

- First exposure to GIS was through ArcView 3.x in 1997 at PSU.
- At the National Park Service field crews used GPS to record the location of survey efforts or observations. ArcView 3.x was used to make maps.
- At the USFS we began to assign attributes to the surveys efforts and observations.

- After years of working on projects designed to identify prime habitats and document species presence using GIS, I moved to Seattle and enrolled in the UW GIS Certificate Program in 2004.
- Shortly after I was hired by DEA and since then I have been using GIS to inform engineers on the potential environmental impacts of their designs.

Main Points

- GIS is a precise analytical tool.
- Outputs are only as accurate as your input.
- Tough economic times require increased efficiencies to minimize rework and streamline the permitting and approval process.

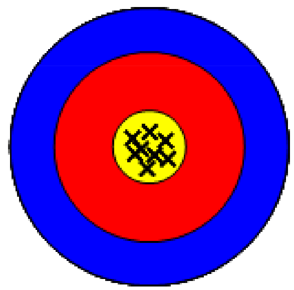
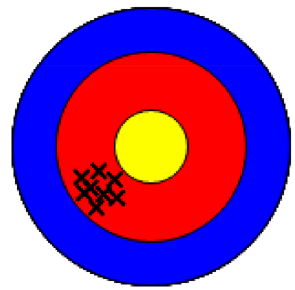
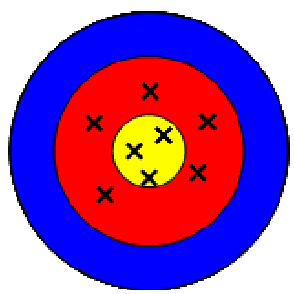
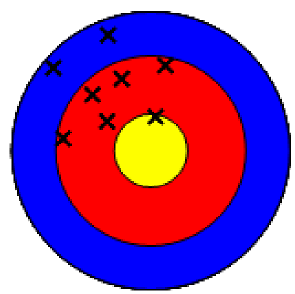
Accuracy in Question

Survey Grade Data

Undocumented Public Data

GIS at Double Precision

Manual Calculations (Human Error)

	Accurate	Inaccurate (systematic error)
Precise		
Imprecise (reproducibility error)		

Accuracy in Question

- Technology changes fast but institutional memory…not so fast.
- GIS does not stand for Get It Surveyed.
- Garbage in - Garbage out. Any data can be inaccurate regardless of format.
- Think of spatial data as something separate from CAD or GIS…is the spatial data any good? What about the metadata?

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Typical Environmental Issues

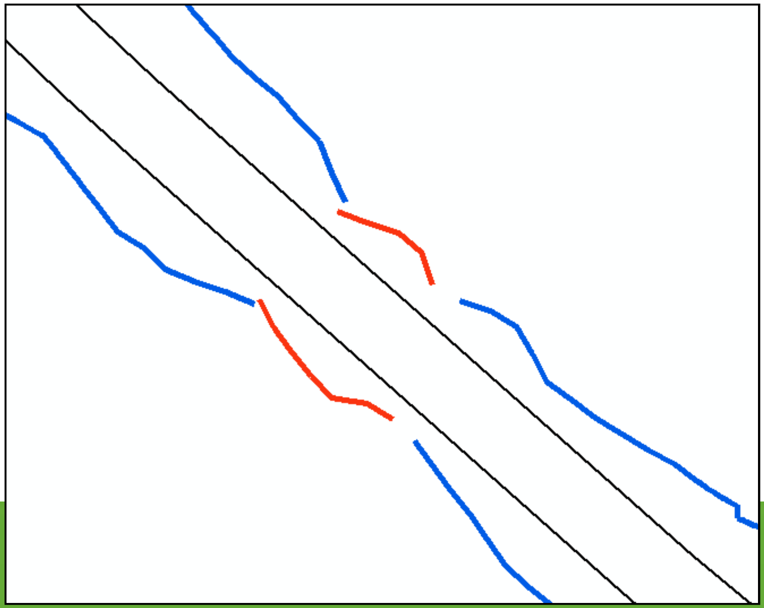
- Filling of wetlands
- Stream Crossings
- Threatened and Endangered Species
- Archeological and Historic resources
- Significant Tree Removals

ENV Impacts and Project Design

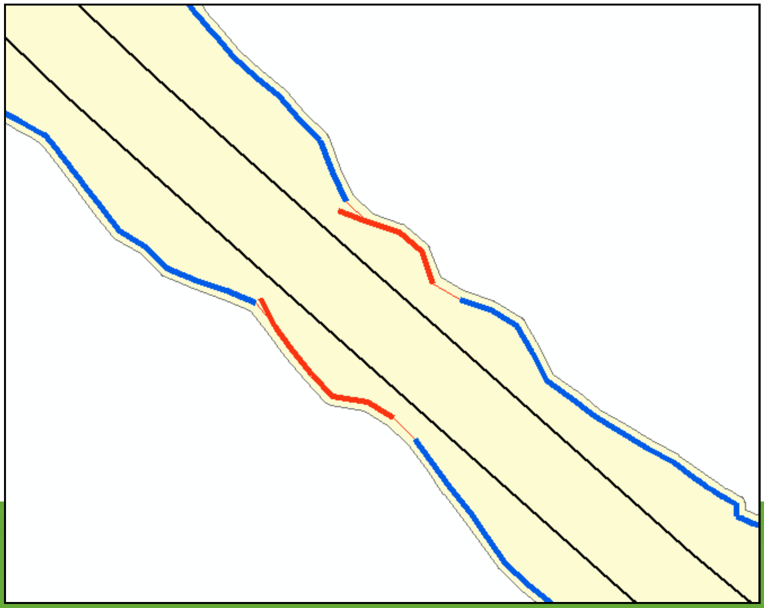
- Has the project AVOIDED impacts to the maximum extent practicable?
- Has the project MINIMIZED unavoidable impacts to the maximum extent practicable?
- Have the unavoidable impacts been COMPENSATED for?

GIS for Impact Analysis

CAD Design to GIS polygons

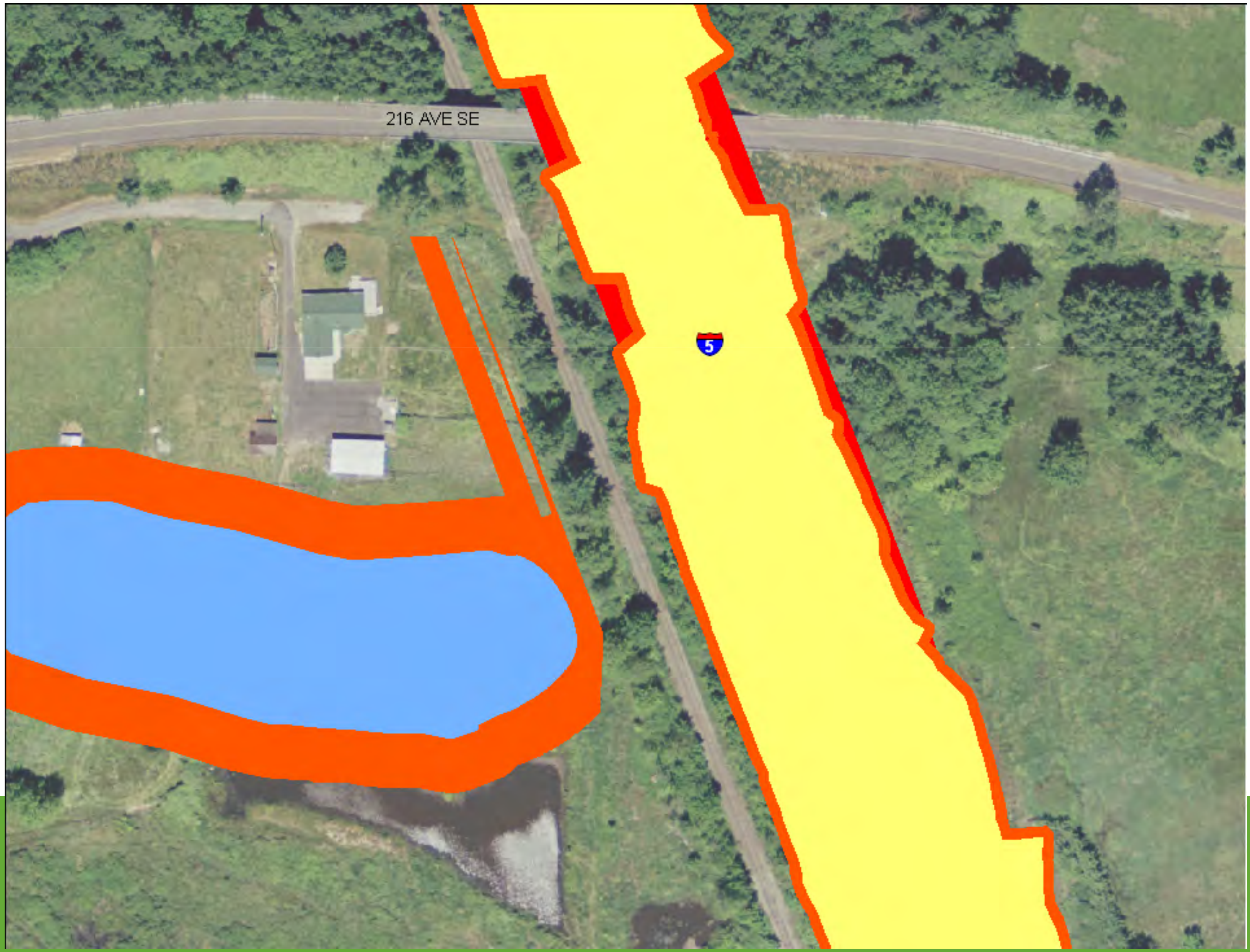


Cut/fill lines define the extent of project impacts

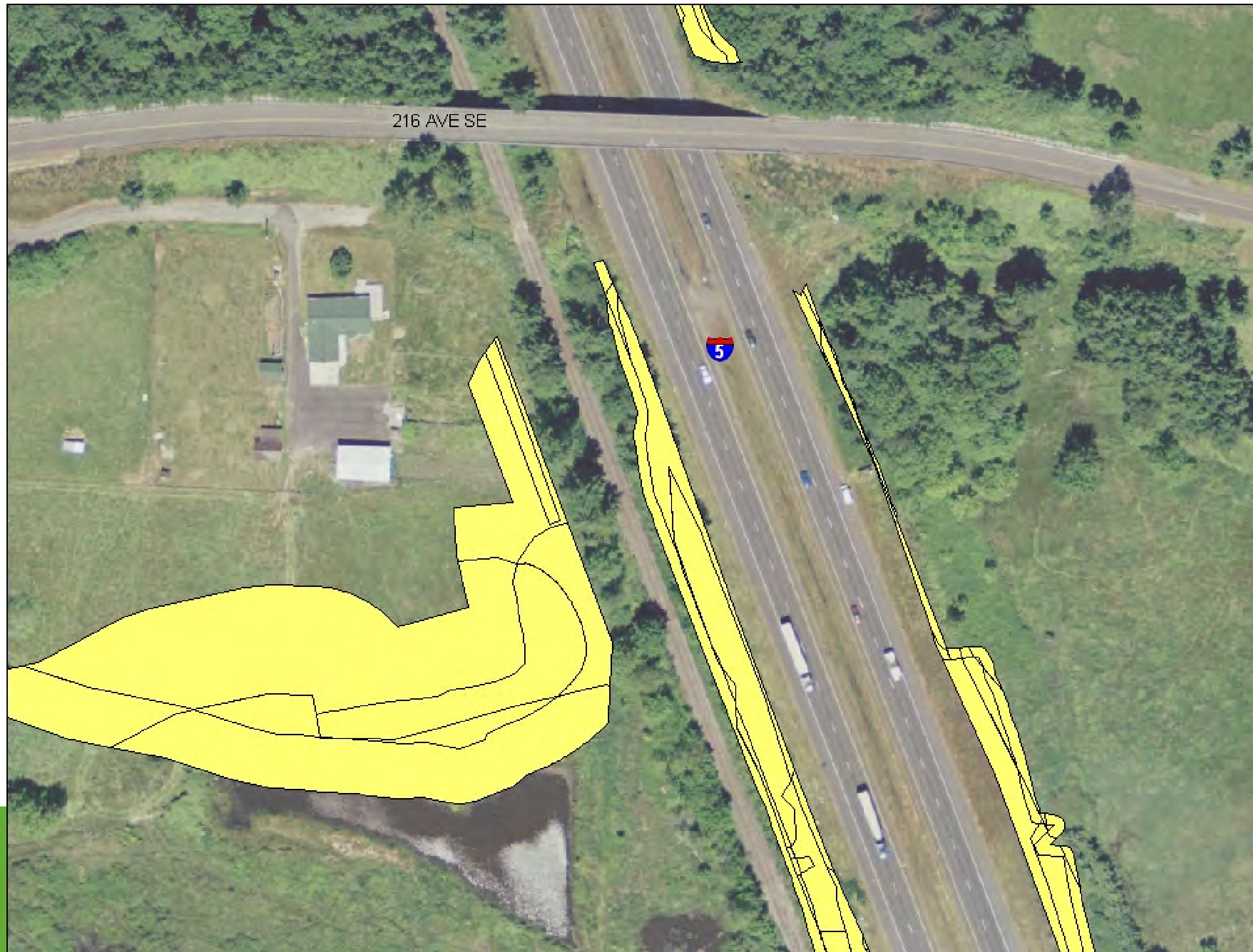


Impact analysis requires polygon features that represent the extent of impact

GIS for Impact Analysis



GIS for Impact Analysis



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GIS for Impact Analysis

I-5 Widening, Blakeslee Junction to Grand Mound

Project Impacts by County

Table 7. Direct Wetland Impacts and Compensatory Mitigation Calculations For Fill Placement In Wetlands by County

County	Ecology Category	Cowardin Classification	Fill Placement	NFN Ratio	Credits Required
Lewis	II	Emergent	0.03	1	0.034
		Forested	1.78	1	1.778
		Shrub-Scrub	0.31	1	0.313
	III	Emergent	0.09	0.85	0.075
		Forested	0.20	0.85	0.168
		Shrub-Scrub	0.07	0.85	0.055
Lewis County Total			**2.48**		**2.42**
Thurston	II	Emergent	0.02	1	0.019
		Forested	1.04	1	1.043
		Shrub-Scrub	0.50	1	0.497
	III	Emergent	0.00	0.85	0.000
		Forested	0.01	0.85	0.012
		Shrub-Scrub	0.01	0.85	0.005
Thurston County Total			**1.58**		**1.58**
		Grand Total	**4.05**		**4.00**

Table 8. Areas of Wetland Restoration For TDA 13 and TDA 11 Flow Control Facilities

TDA 13 facility (Category III)

Cowardin Classification	sq ft	acres
Emergent	246,379.00	5.66
Forested	2,006.00	0.05
Shrub-Scrub	756.20	0.02

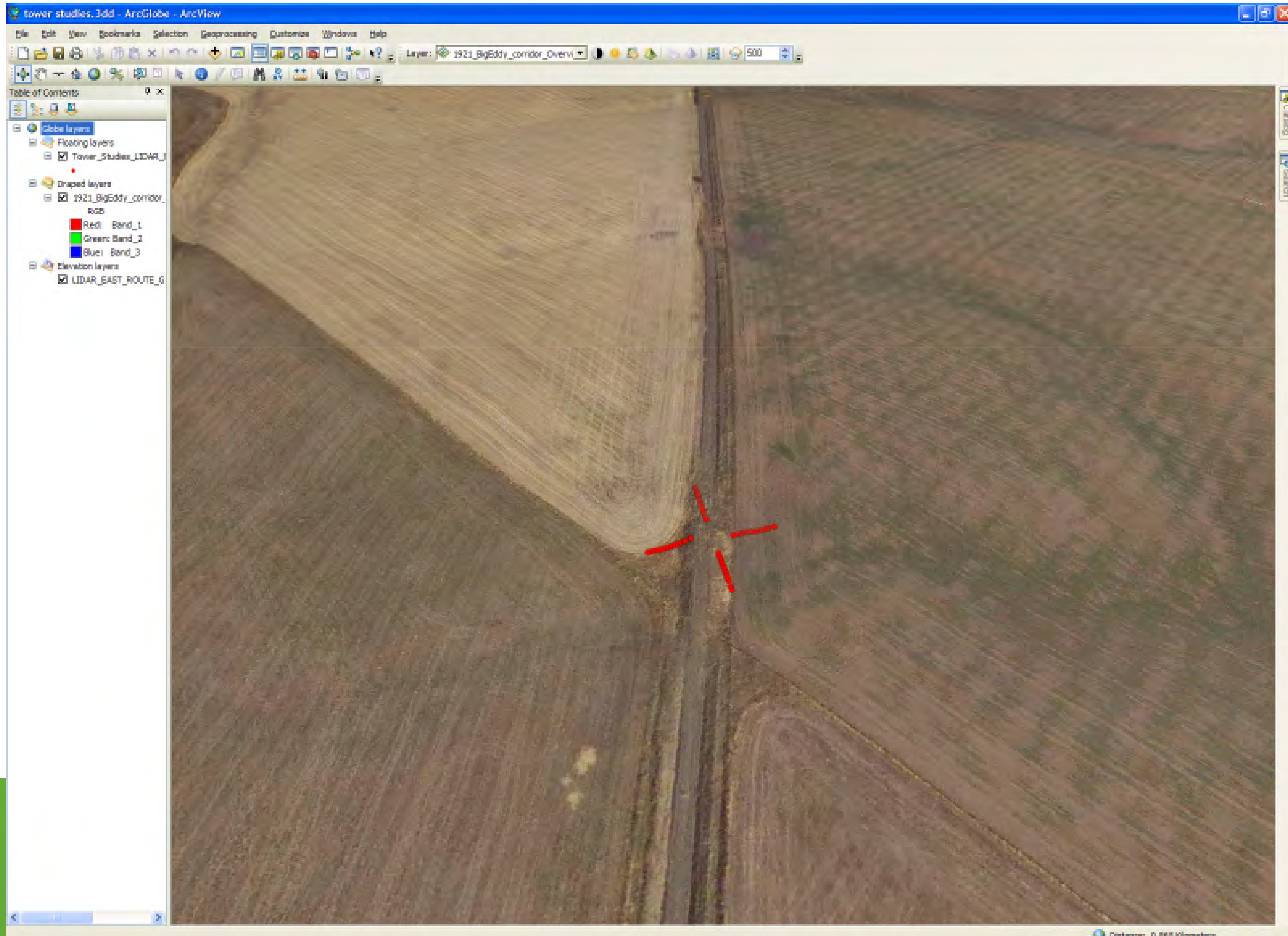
TDA 11 facility (Category II)

Cowardin Classification	sq ft	acres
Emergent	65,079.00	1.49
Forested	13,594.70	0.31
Shrub-Scrub	33,559.00	0.77

Intersection of Design and Survey Represents the Environmental Impact

- Cost effective, reasonably dynamic calculation of resource impacts.
- With survey grade data, analysis can be both accurate and precise.
- Environmental review and mitigation negotiations proceed during design, when adjustments can be made at a lower cost.

GIS for Locating Transmission Towers



GIS for Locating Transmission Towers

•Using GIS we analyzed LiDAR and field survey data for HDR Engineering and Bonneville Power Administration to check transmission crossing elevations and proposed tower location studies.

•100% of the tower study location points matched the LiDAR based DTM within 1 foot vertically, with 94% matching with 0.5ft, and 75% matching with 0.25ft.

•We were able to identify areas where the LiDAR DTM would fail the confidence check as embankments at the edges of roads and cultivated fields, as well as locations with steep cross slopes and heavy vegetation.

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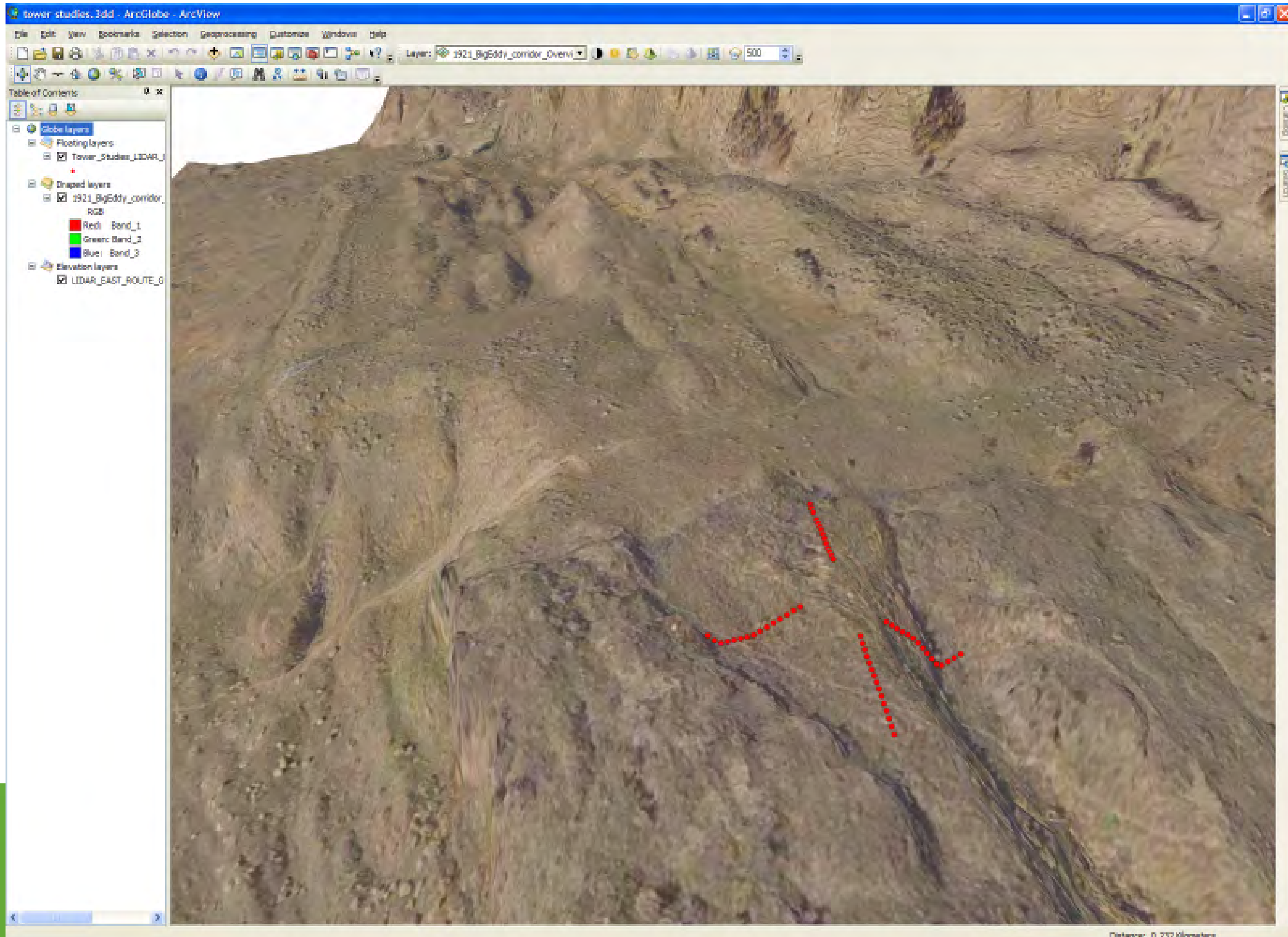
GIS for Locating Transmission Towers



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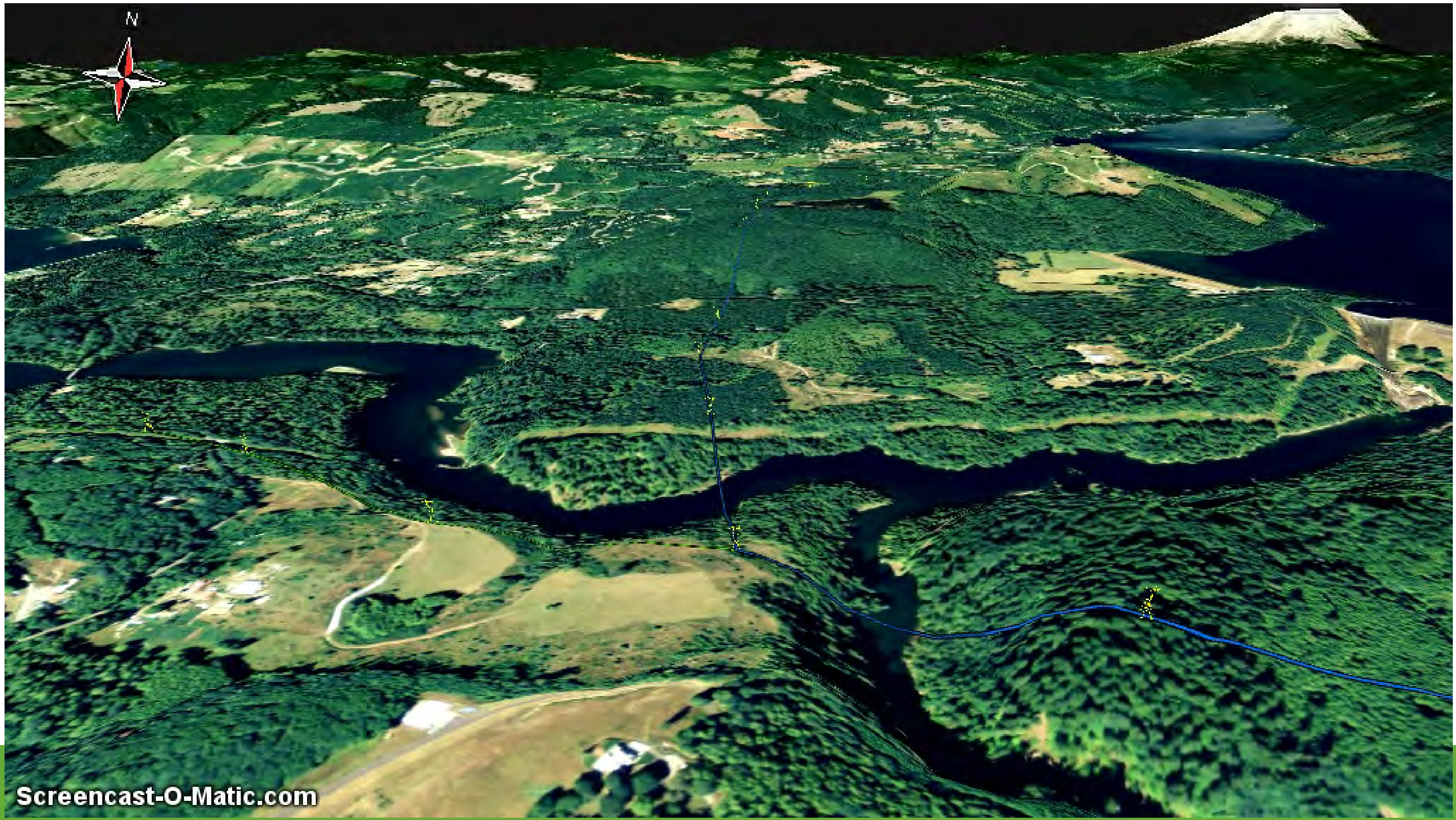
BPA Flyover



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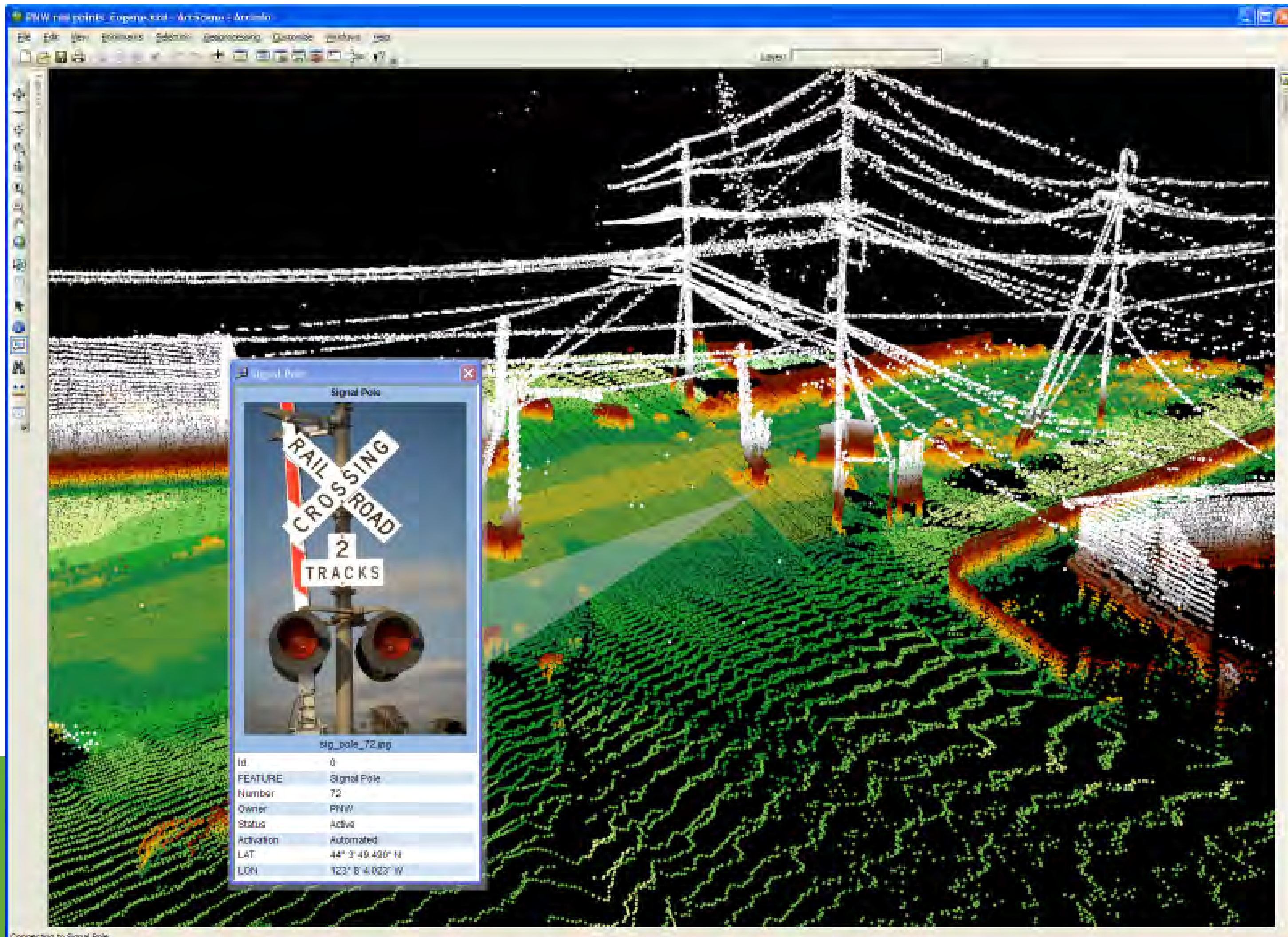
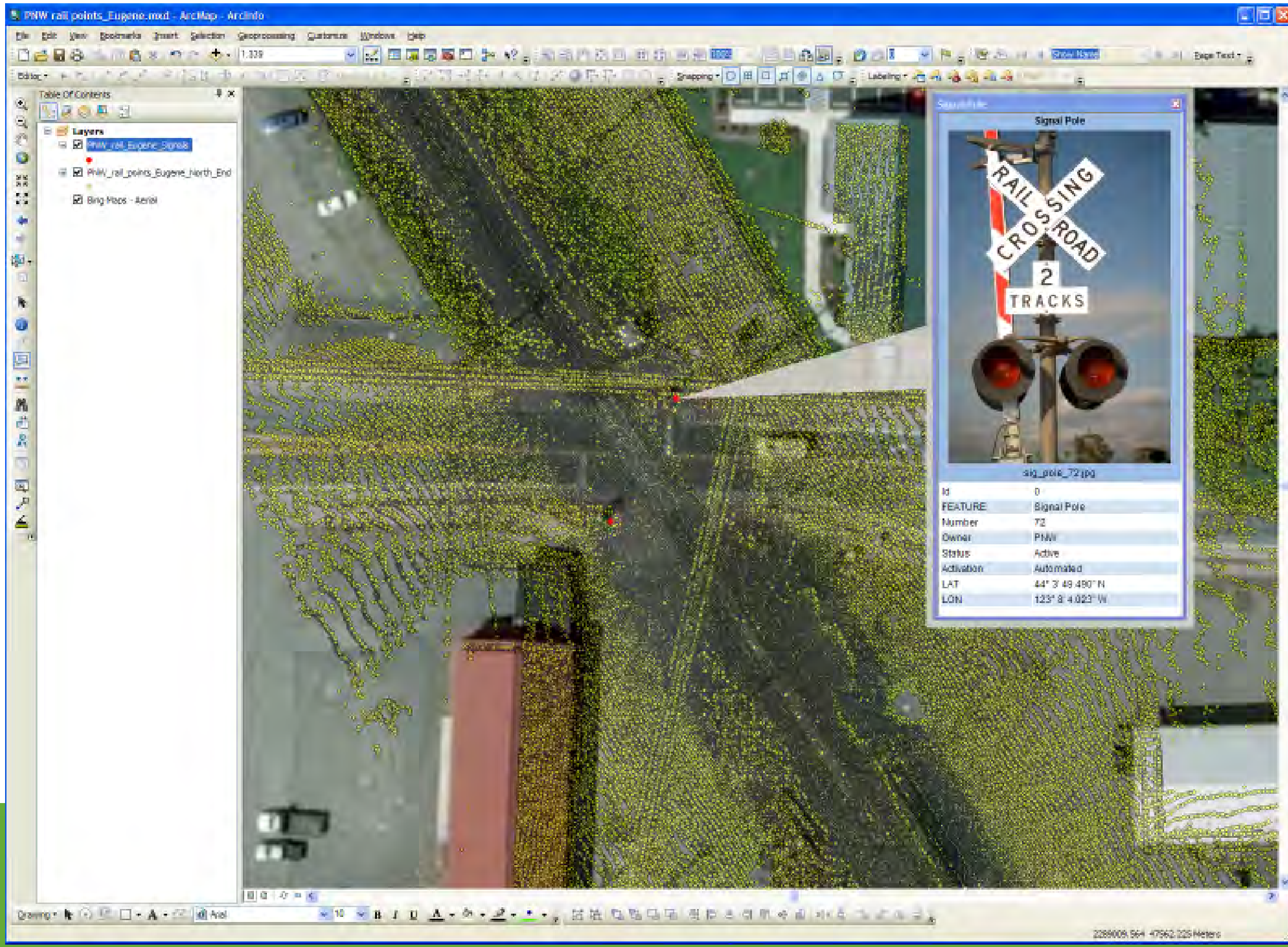
3D Scans – Point Cloud in ArcScene



3D Scan – Point Cloud in ArcGIS



GIS for Route Analysis

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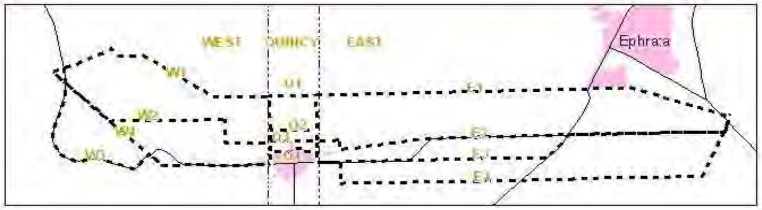
Summary Matrix Comparing Preliminary Route Segments

				West Segments				Quincy Segments				East Segments			
				W1	W2	W3	W4	Q1	Q2	Q3	Q4	E1	E2	E3	E4
Fatal Flaws		Meets purpose & need?		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Is construction feasible?		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economic Criteria	Engineering	Segment Length (miles)		10.3	11.4	14.4	11.1	6.7	2.0	2.5	3.8	18.4	18.9	18.8	20.6
		Points of Intersection[5] (number)		4	3	50+	1	2	0	1	6	2	4	3	3
		Transmission Line Crossings (Total incl. BPA lines)		4	0	11	1	3	1	1	2	2	4	3	3
		Transmission Line Crossings (number)	115 kV	0	0	3	1	3	1	1	2	2	1	0	0
			230 kV	2	0	6	0	0	0	0	0	0	2	2	2
			287 kV	1	0	1	0	0	0	0	0	0	0	0	0
			500 kV	1	0	1	0	0	0	0	0	0	1	1	1
	Right of Way	Miles by Ownership[6]	Private	9.3 / 9.7	10.9 / 9.8	11.4	9.8 / 9.0	6.4 / 6.5	2.0	2.3 / 2.0	3.2 / 2.7	15.1 / 15.2	14.9 / 12.8	15.2 / 15.4	16.7 / 16.2
			Government	0.7 / 0.9	0.2 / 1.2	1.2	0.7 / 1.2	0.2 / 0.0	0.0	0 / 0.5	0.3 / 0.7	2.9 / 3.0	2.9 / 3.2	2.2	2.9 / 3.2
		Number of Properties Crossed[6]	Private	26	40 / 36	64 / 52	52	28 / 21	8 / 9	16 / 14	57 / 58	78 / 68	76 / 54	101 / 85	73 / 60
			Federal	3	1	3	2	0	0	0	0	3 / 2	2 / 4	2	3
			State	0	1	2 / 6	1 / 4	0	0	0	0	3	4 / 2	5 / 2	3 / 5
			Local	1	0	0	0 / 1	0	0	0 / 1	7 / 9	3 / 4	2 / 1	0	0
		Railroad Crossings (number)		0	2	1	1	0	0	0	2	1	1	0	0
		Distance Within 200 Feet of Railroad (miles)		0	0.2	0.3	0.3	0	0	0	0.2	0.1	3.8	0	0
	Construction	Transmission Line Corridor within 200 Feet (miles)		10.3	3.4	1.2	6.4	4.1	0.1	0.1	0.9	18.4	0.5	0.5	2.3
		Primary GCPUD Distribution Overhead Lines within 200 ft (miles)		0.0	3.9	8.1	7.9	4.8	0.3	0.6	0.1	2.5	12.9	12.0	17.9
		Primary GCPUD Distribution Underground Lines within 200 Feet (miles)		0.1	0.6	0.5	0.5	0.4	0.2	0.1	2.7	0.3	0.8	0.4	1.4
		Distance with County Roads or Highways within 200 Feet (miles)		1.8	4.4	13.4	4.5	4.7	0.2	2.5	3.2	3.8	11.6	9.5	17.3
		Distance without Roads or Highways within 200 Feet (miles)		8.5	7.0	1.0	6.6	2.0	1.8	0.0	0.6	14.6	7.3	9.3	3.3

Notes:
1. Stream and canal crossings determined manually; intermittent/seasonal stream not counted.
2. No hydric soils crossed in Douglas County.
3. Only identified one block group with very high minority population and poverty level.
4. Archaeologically-sensitive landforms, ethographic sites, or historic features.
5. Does not include connection details around each substation.
6. Numbers reflect 150 ft offset on both sides of road, first# is Side 1 (usually south and west); second# is Side 2 (usually north and east).



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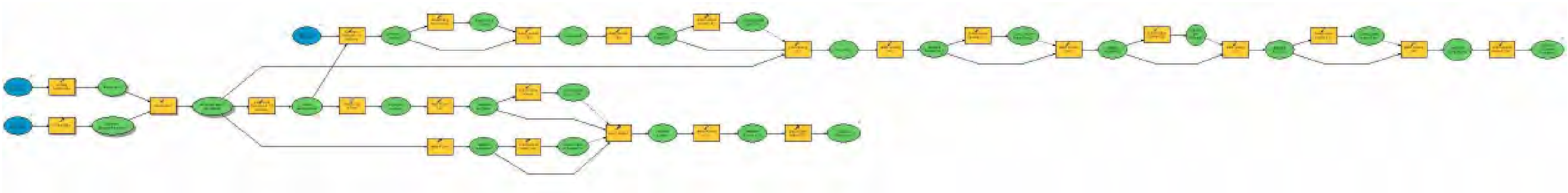
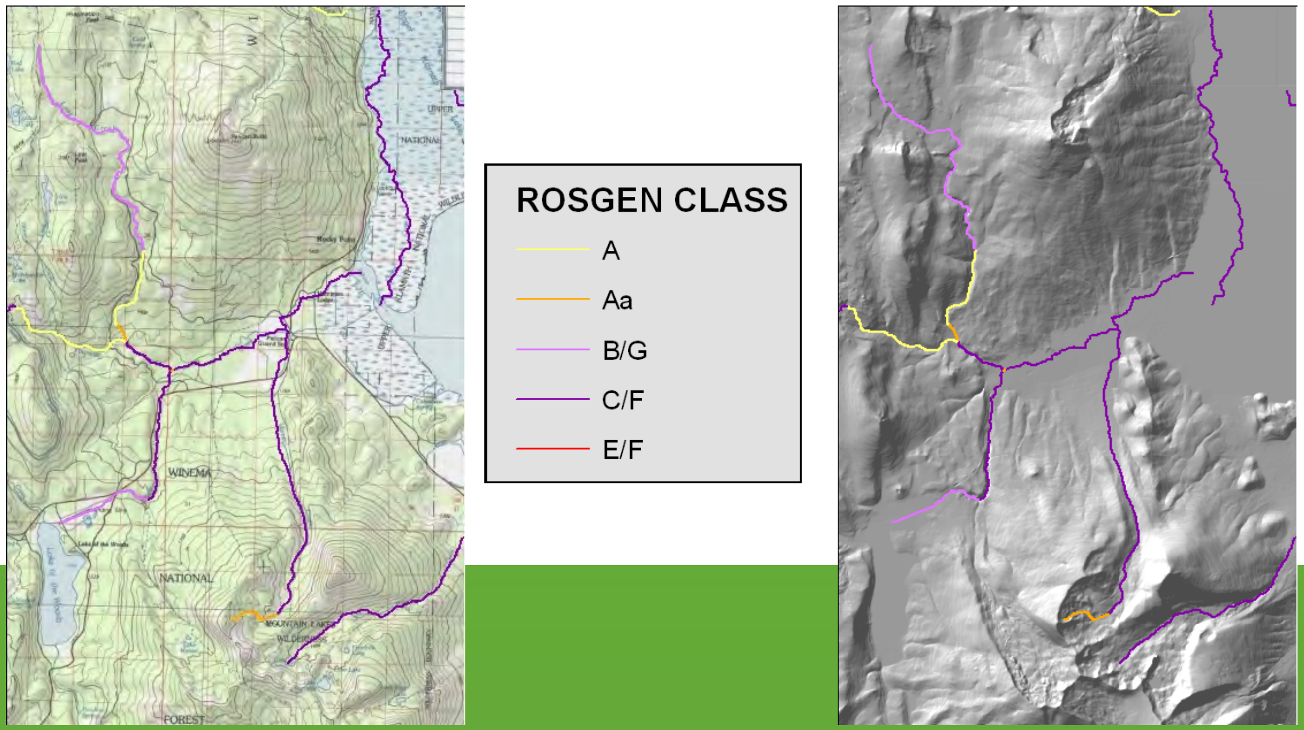
GIS for ROSGEN Analysis





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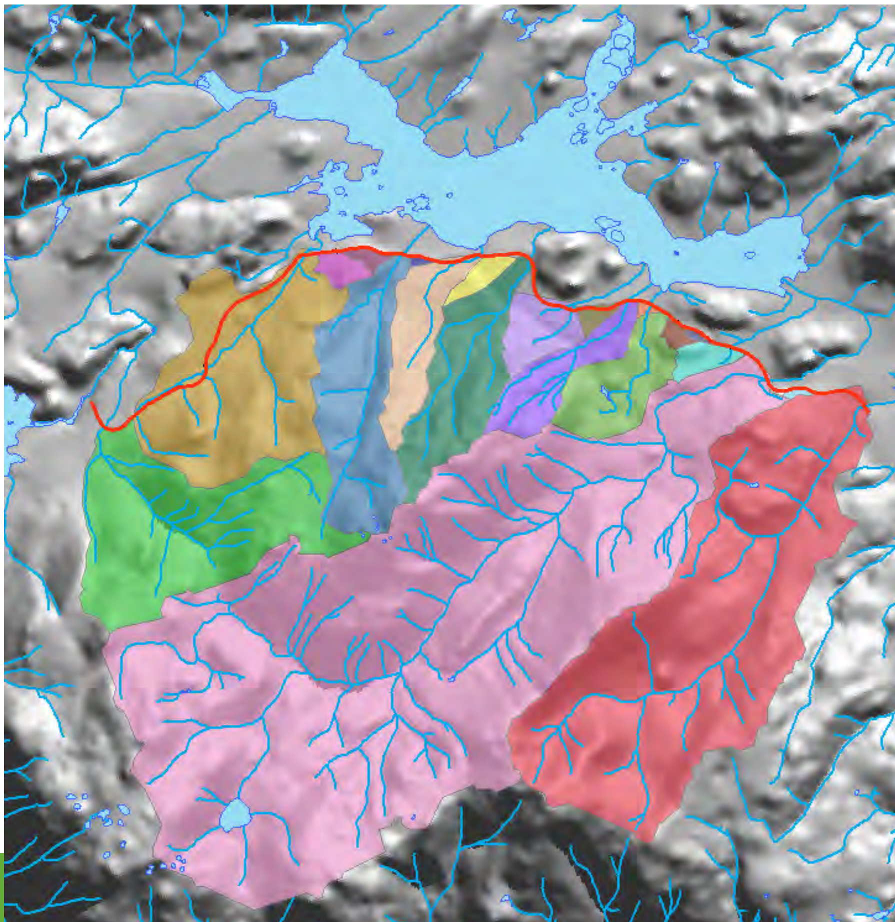
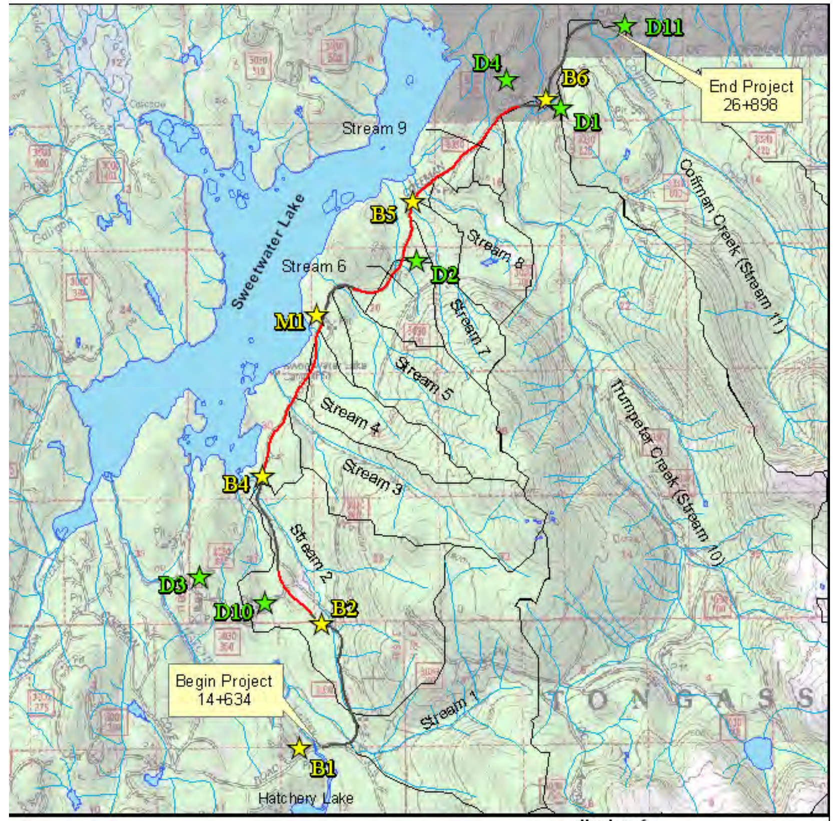
GIS for Drainage Analysis



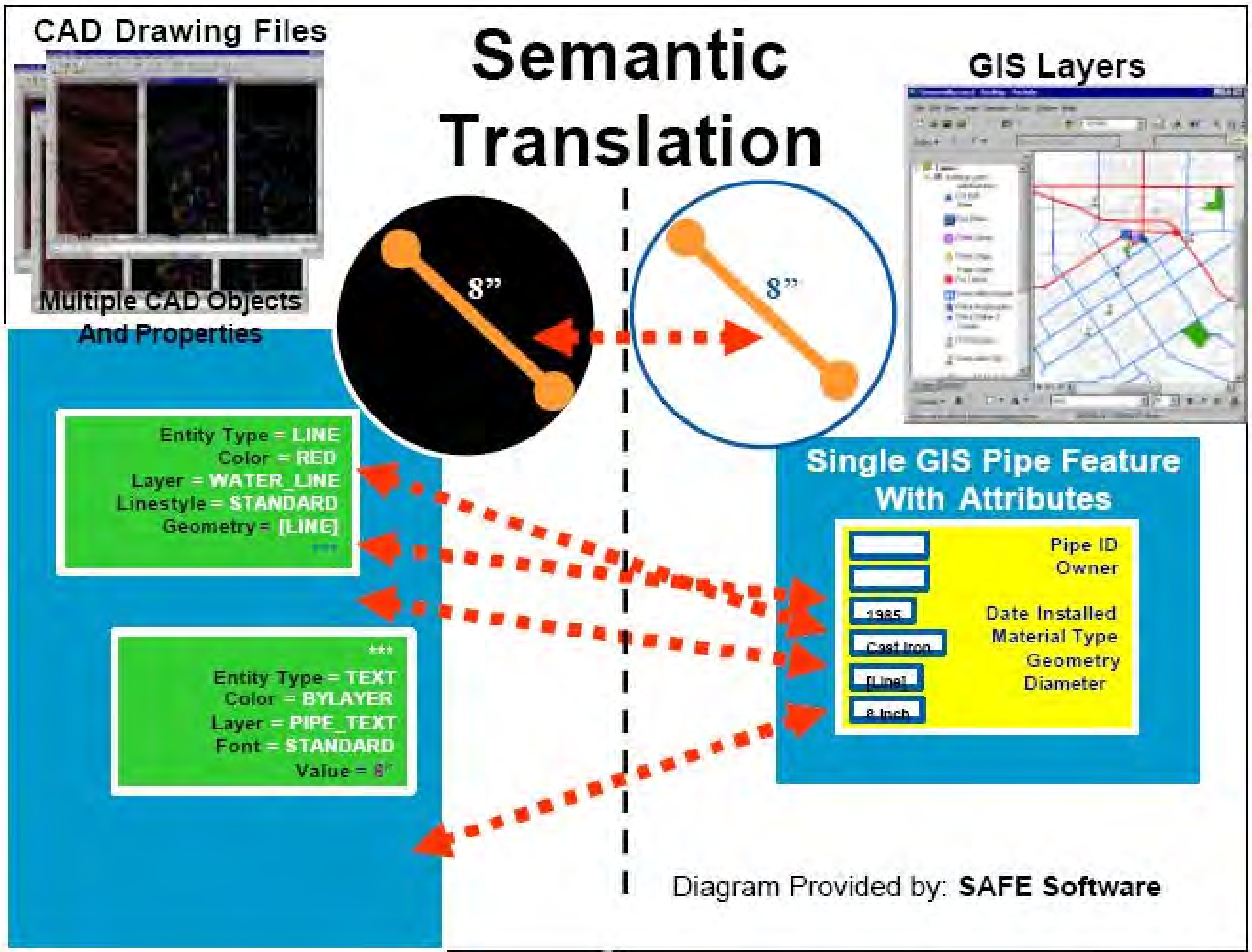


Watershed or Stream Number	AKF&G Fish Distribution Database Code	Stream Name	Crossing Type(s)	Number of Stations Sampled in Drainage	Principle Stream Culvert(s)
1	106-30-10670-2004-3031-4011	Hatchery Creek Trib.	Bridge	0	14+500
2	106-30-10670-2004-3029	n/a	Culverts (3)	1	16+364, 16+517, 18+544
3	106-30-10670-2004-3027	n/a	Culvert	2	19+887
4	106-30-10670-2004-3025	n/a	Culvert	0	20+852
5	106-30-10670-2004-3023	n/a	Culvert	1	21+519
6	106-30-10670-2004-3021	n/a	Culvert	5	22+391
7	n/a	n/a	Culvert	1	23+257
8	106-30-10670-2004-3019	n/a	Culvert	3	23+745
9	n/a	n/a	Culvert	0	24+701
10	106-30-10670-2004-3017	Trumpeter Creek	Bridge	1	25+375
11	106-30-10160	Coffman Creek	Bridge	1	26+850

GIS and CAD

- CAD is the drafting standard for survey and design.
- CAD becomes more GIS with every software update.
- Intelligent CAD data is becoming the norm as institutions begin to manage infrastructure through <u>enterprise systems with spatial components</u>.

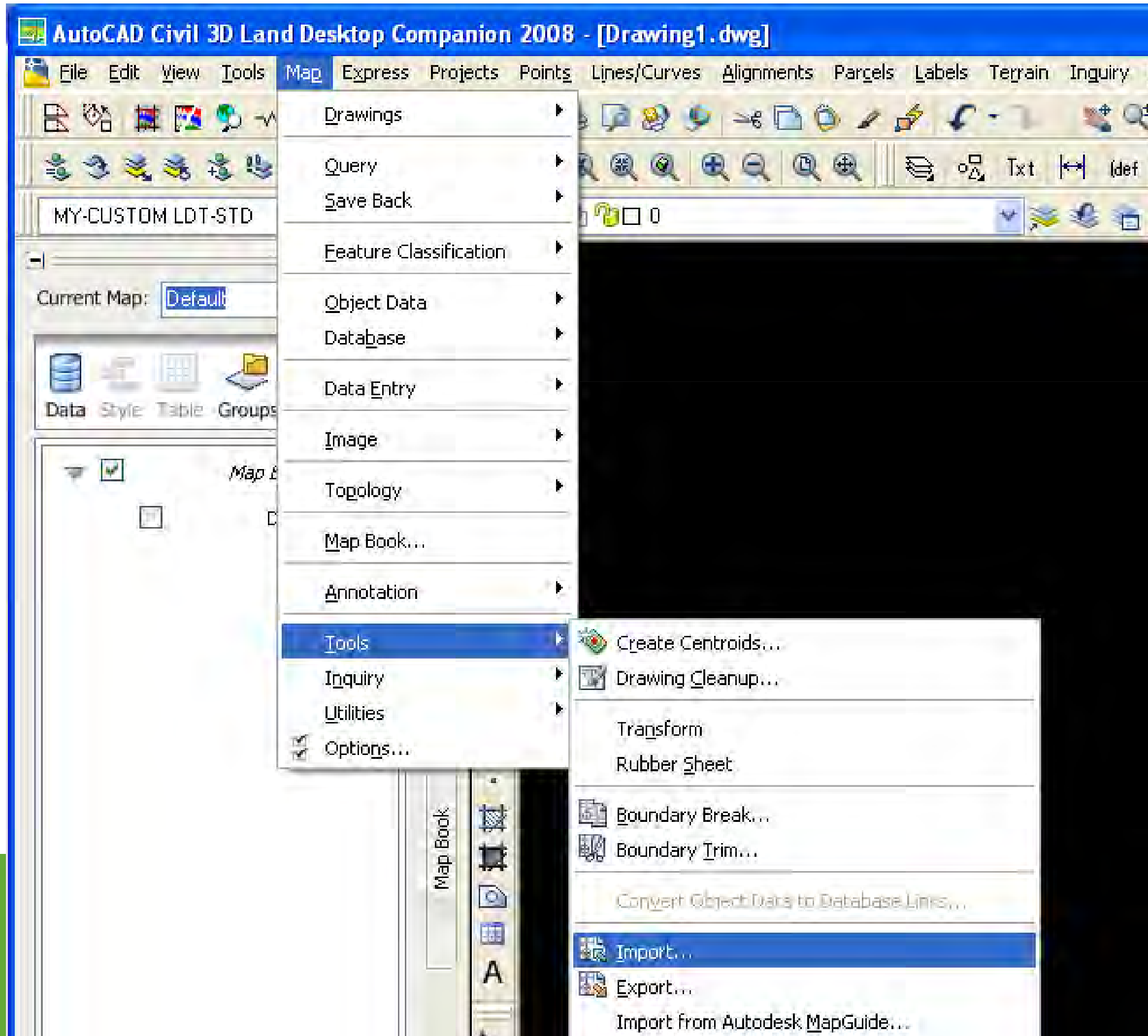
Challenges with converting CAD to GIS



Object Tables in AutoCAD Map 3D

- Object tables essentially are the attribute table of the AutoCAD world.
- Populating object tables during the site survey with new electronic tools provides attributed data that <u>can be</u> ready for GIS analysis.
- Running analysis in separate software programs brings up <u>enterprise issues</u>.

Importing GIS to AutoCAD Map 3D



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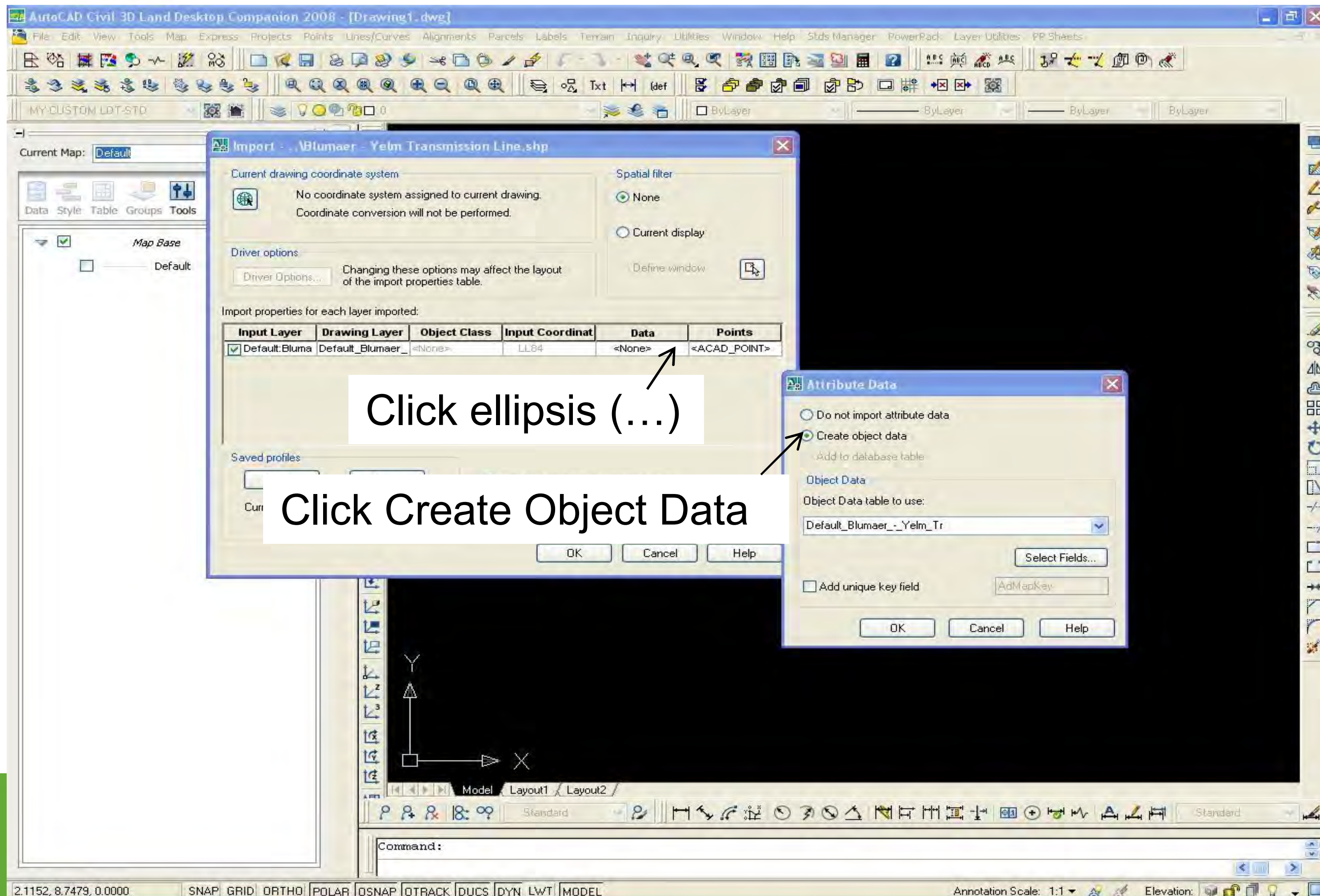
Importing GIS to AutoCAD Map 3D



What GIS Trends are Apparent?

- Attributed survey grade data from the field.
- Requests for on-line dynamic mapping deliverables
- New tools developed around remote sensing and mobile 3D scanning and lidar.

What's Going on in the Market?

- Design-build road and bridge projects are the new normal throughout the country.
- Power and gas transmission infrastructure is aging requires continual improvements and upgrades.
- Water resources and stormwater continue to be strong markets in the PNW due to increasingly restrictive environmental regulations.