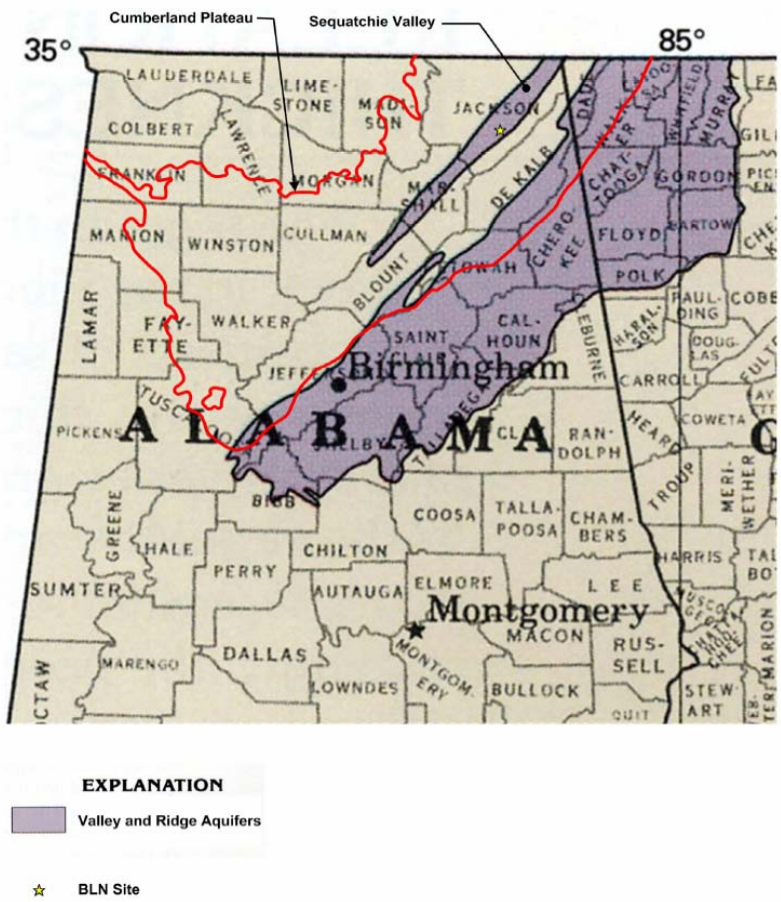
Groundwater Evaluation

BLN Units 3 and 4

Regional Groundwater

- Area of the BLN is part of the Sequatchie Valley Aquifer system.
- Principal water bearing strata regionally is Cambrian and Ordovician age dolomite and limestone.



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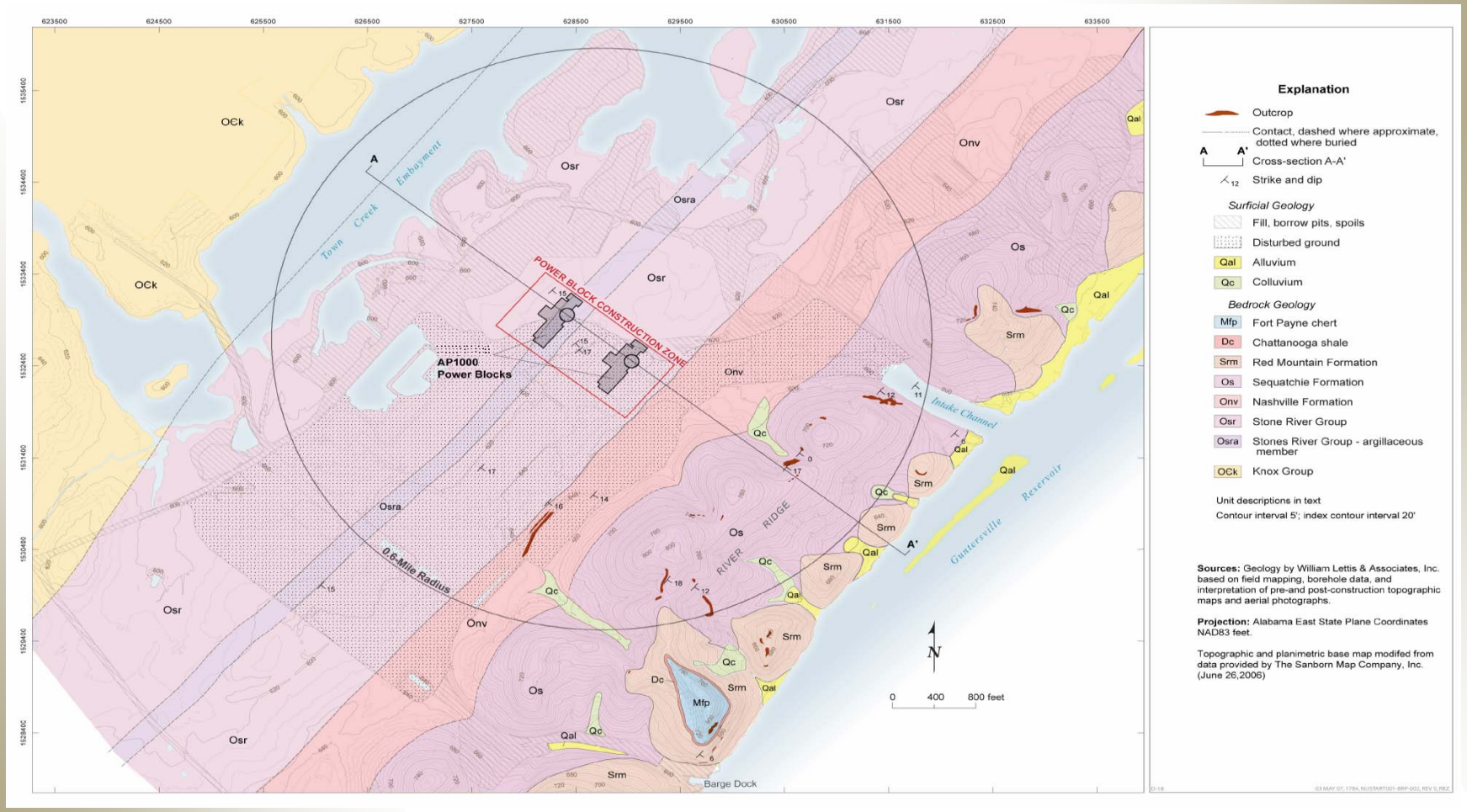
Site Geologic Map



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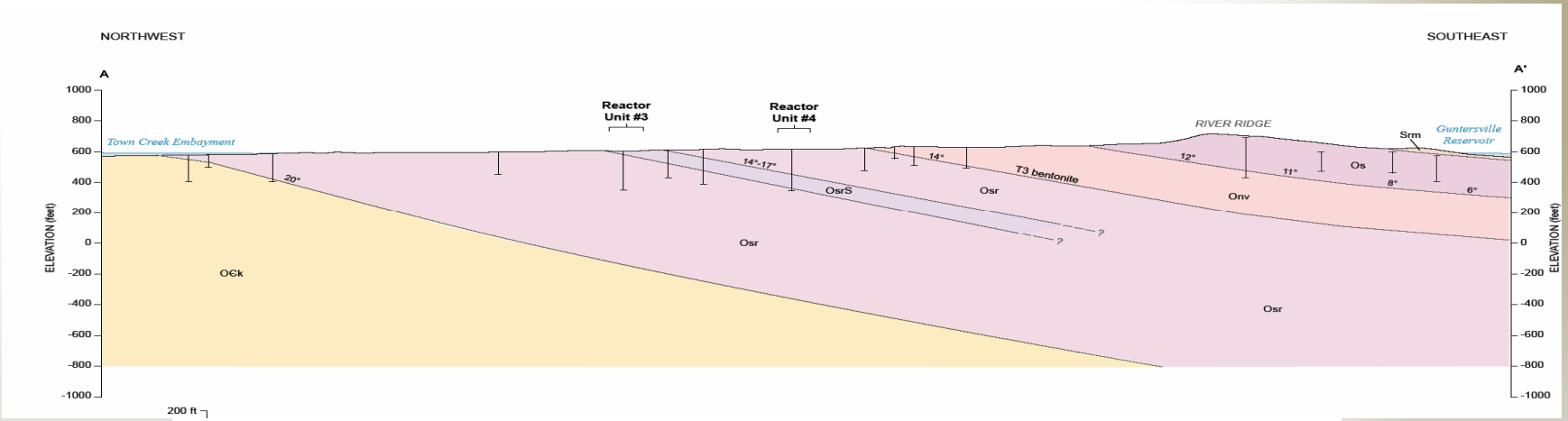
Site Geologic Cross Section



- Seen in cross section, bedding dips from northwest to southeast across the site.
- The principal water bearing strata in the area, Knox Dolomite, is at significant depth below the site.

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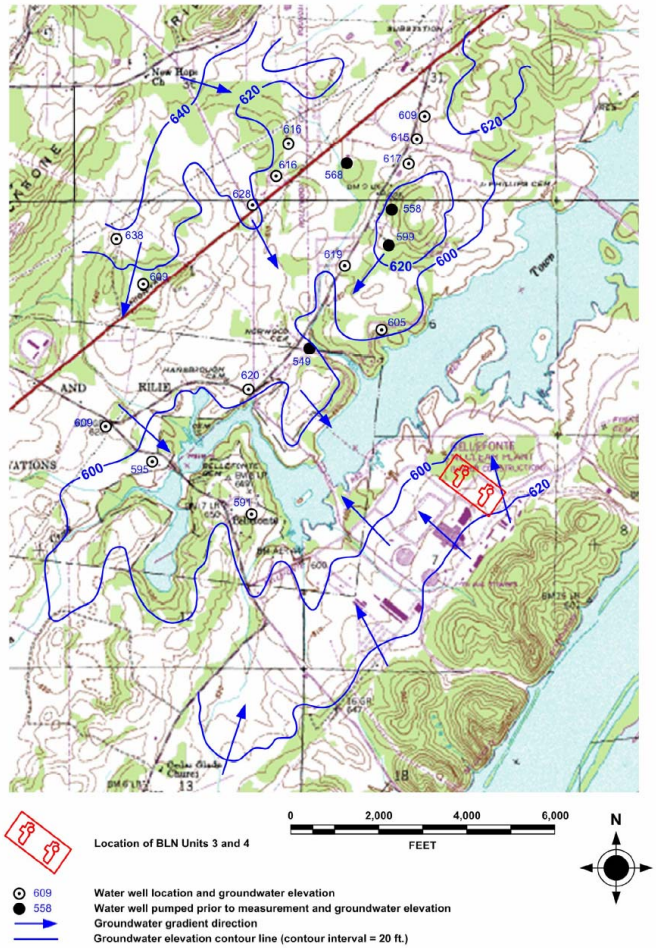
Previous Groundwater Investigation

- Bellefonte Units 1 and 2.
- 2005 Geotechnical, Geological, and Seismological Evaluation.
- Various environmentally-related investigations (localized assessments).

1961 Groundwater Levels

- Reported from Bellefonte Units 1 and 2 FSAR.
- 6 open bore groundwater wells installed on the BLN property.
- Measurements of private water supply wells on northwest side of Town Creek.



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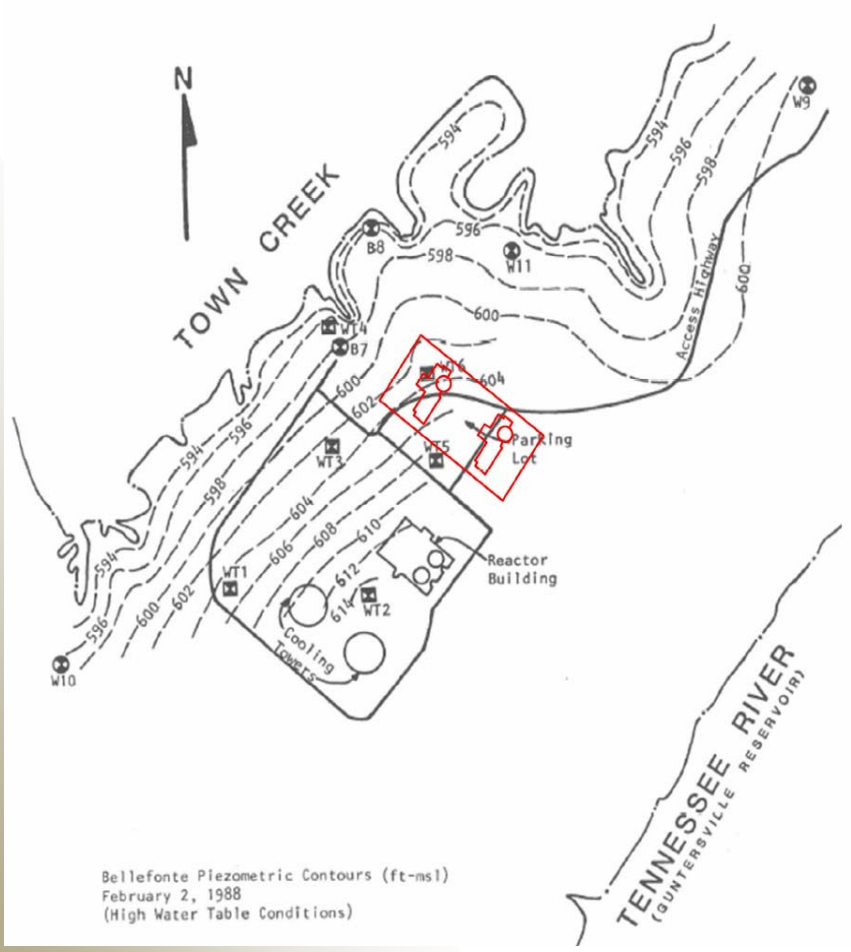
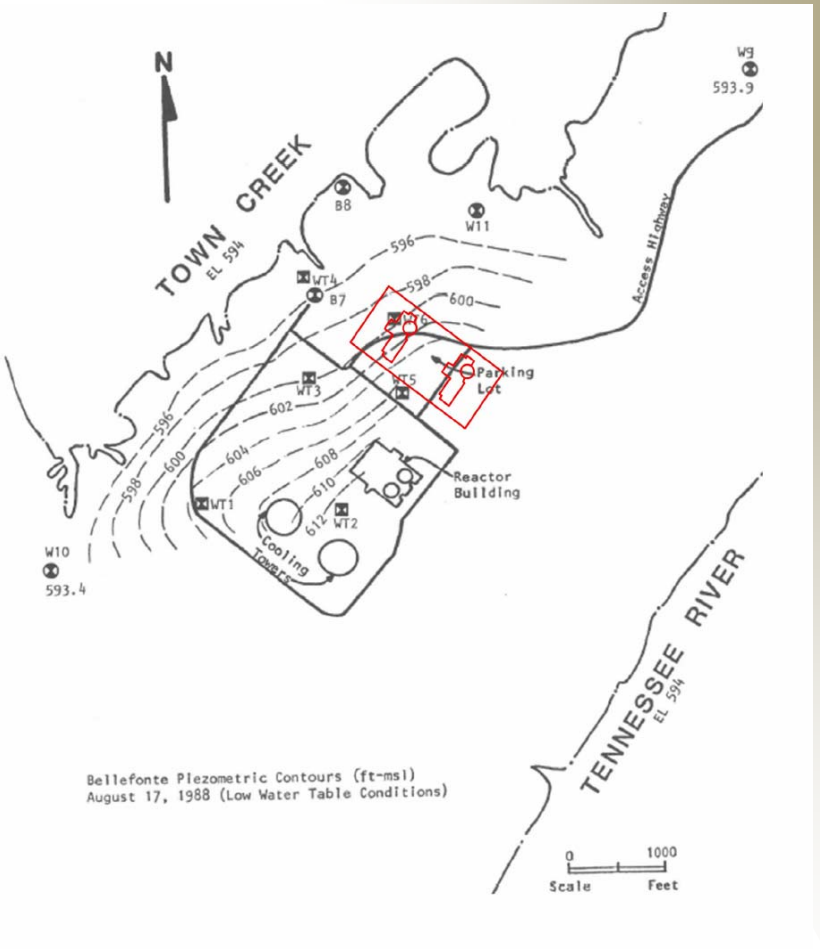
1988 Groundwater Levels

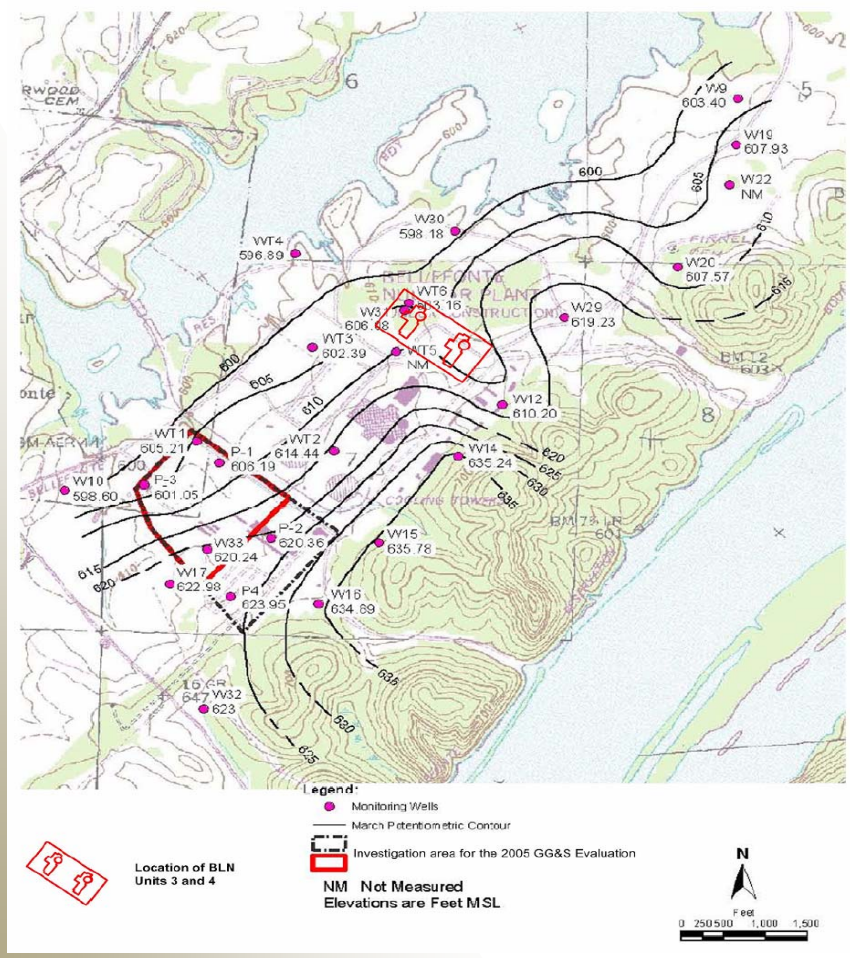


February 1988

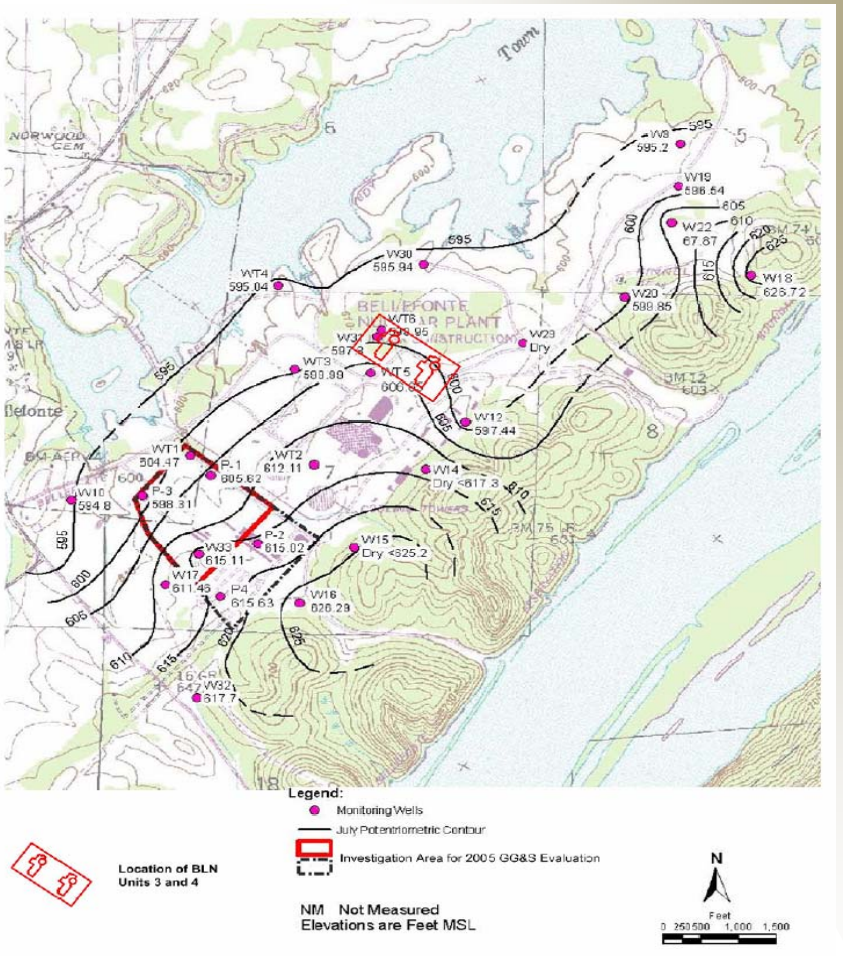


August 1988

2005 Groundwater Levels



March 2005



July 2005

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Previous Investigation Results

- Historic groundwater data reported unconfined aquifer conditions with water movement towards the Town Creek Embayment.

- Historic data also reports the groundwater movement is within the saturated portion of the overburden and within fractures in the top 30 feet of the bedrock.

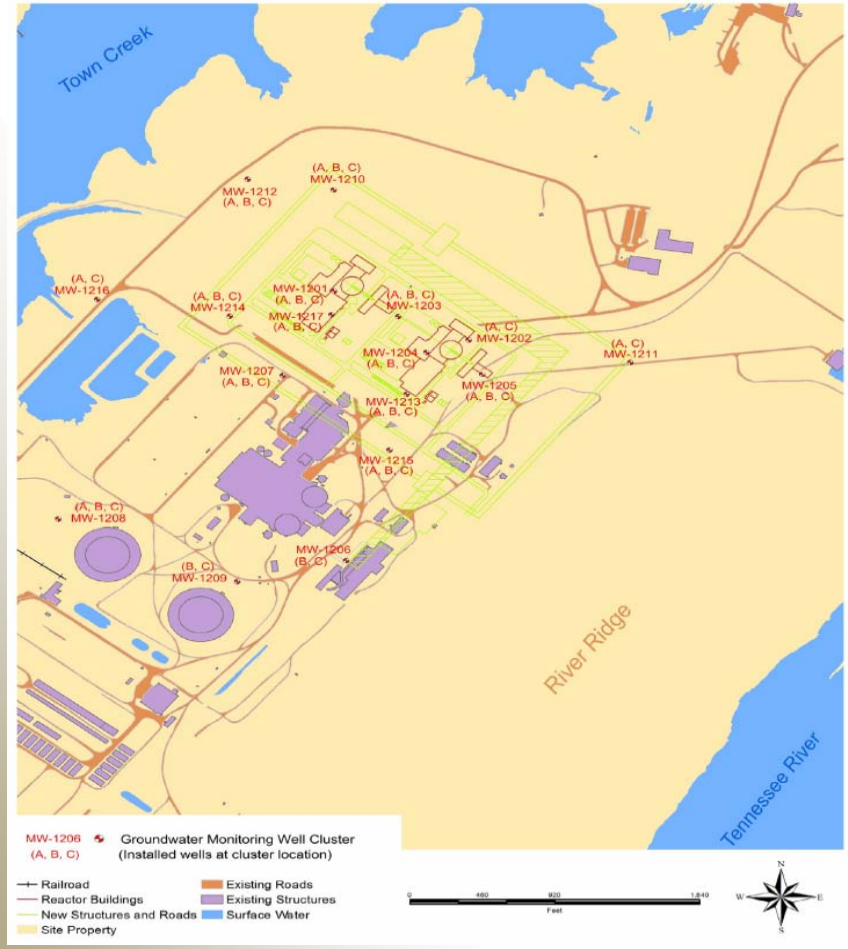
2006-2007 Groundwater Investigation

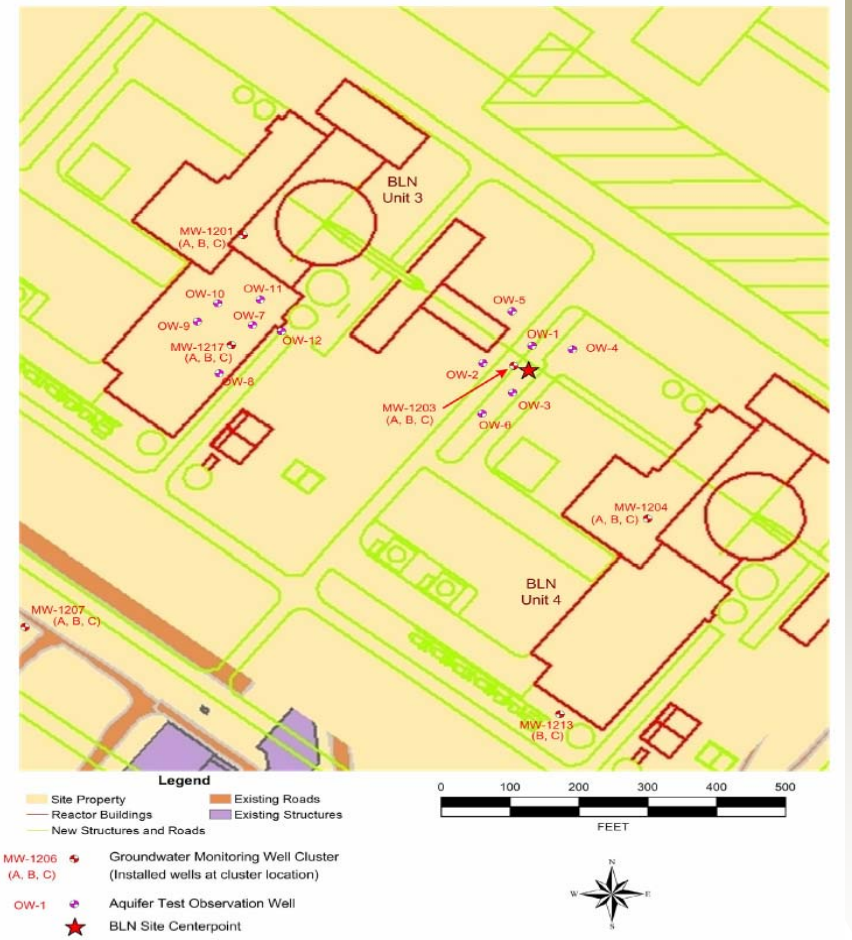
Monitoring Well Installations

- Monitoring wells were installed between May 8, 2006 and June 9, 2006.
- Each well cluster was installed adjacent to a geotechnical boring to provide geologic information for setting the well screen.

- 17 monitoring well clusters and 12 aquifer testing observation wells were installed.

Groundwater Monitoring Well Locations





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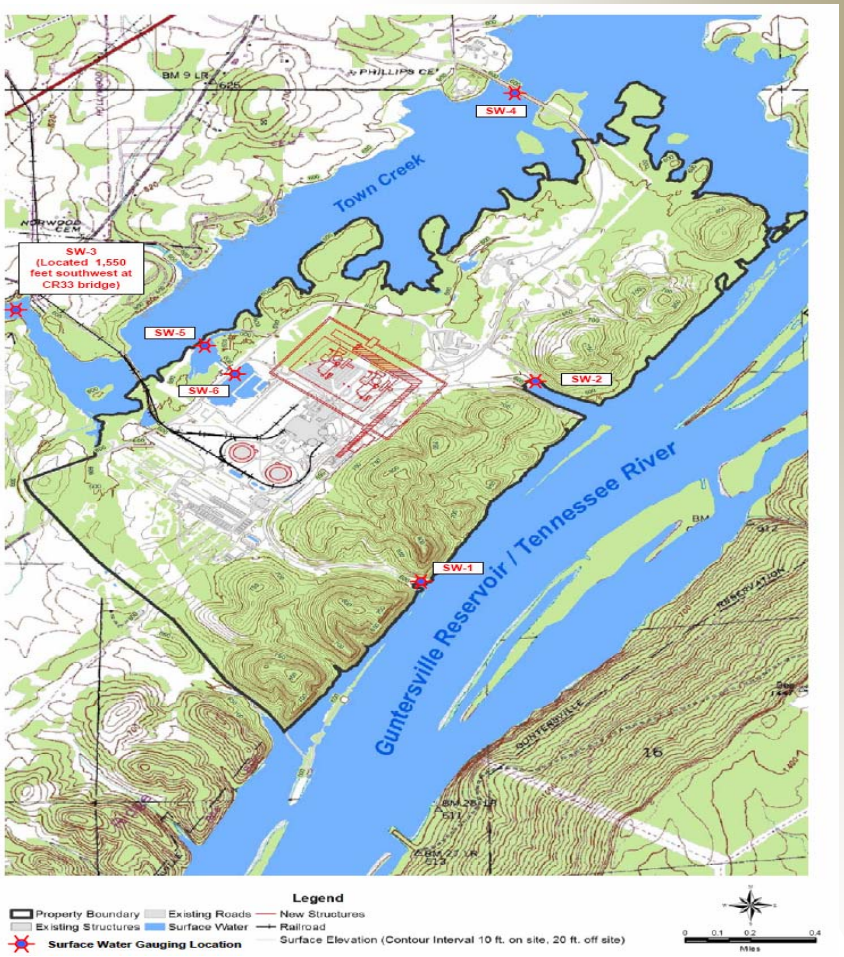
- Following installation, all wells were developed and 10 wells were sampled for groundwater quality parameters.

- All groundwater monitoring wells were gauged monthly for depth to water to obtain groundwater depth and gradient information.

Surface Water Gauging Locations

- 6 surface water locations were gauged at the same time as groundwater wells for comparison.



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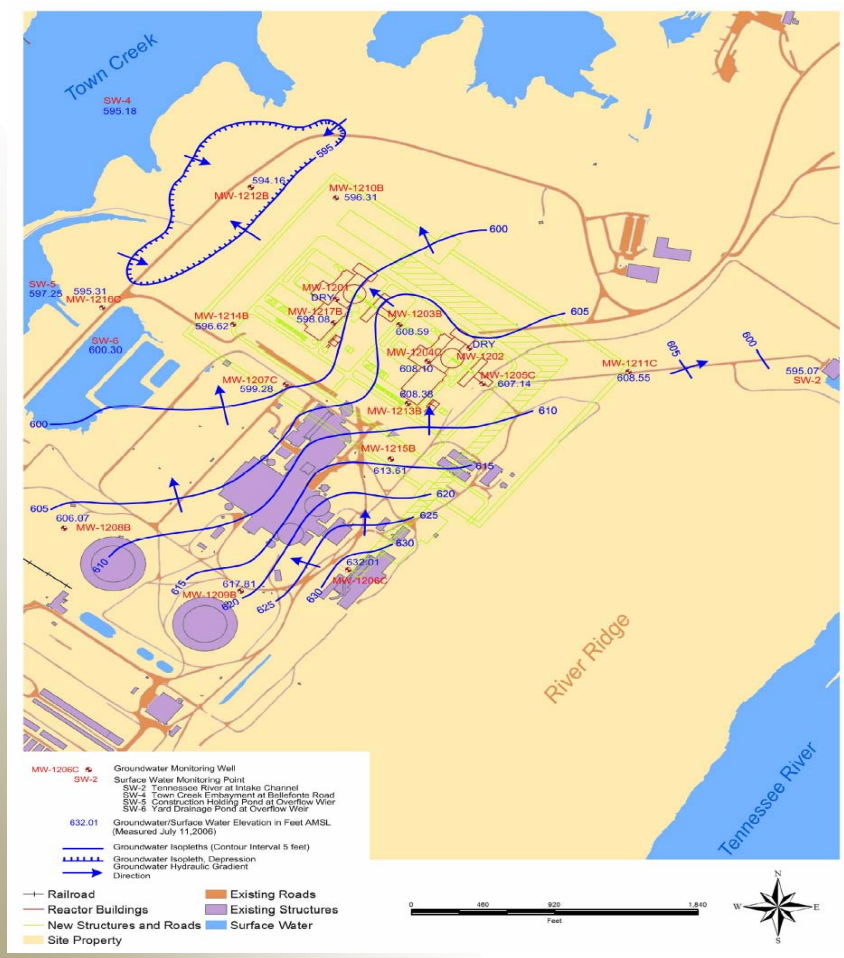
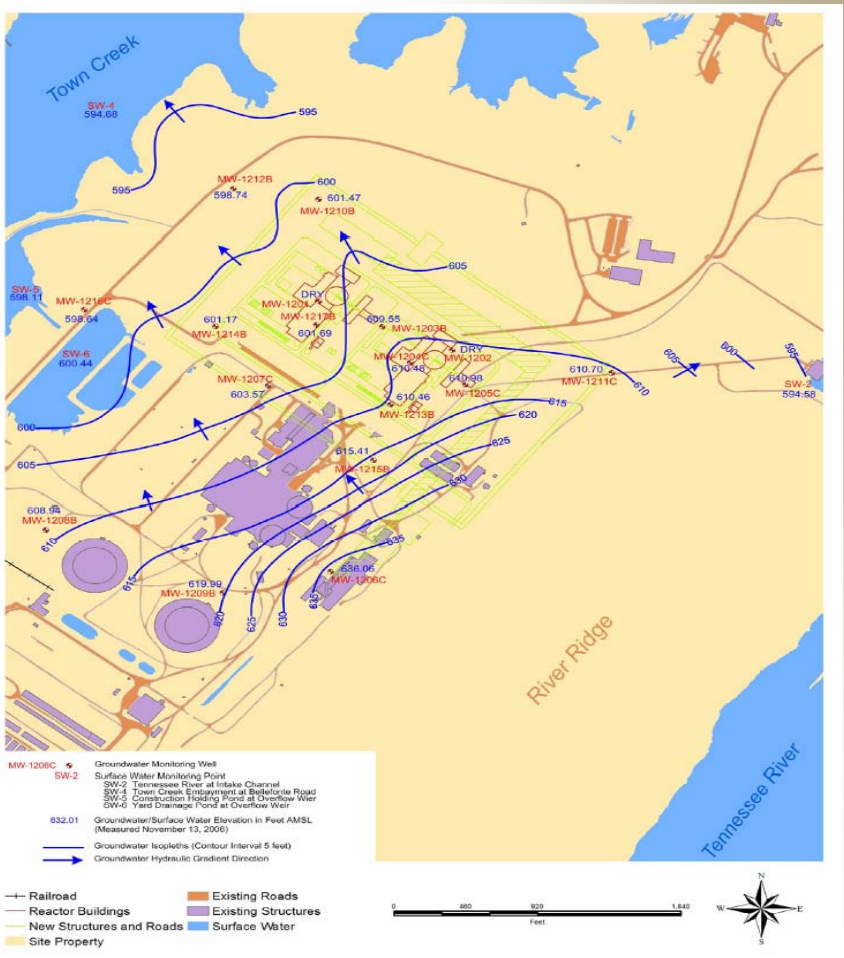
July and November 2006 Groundwater Levels





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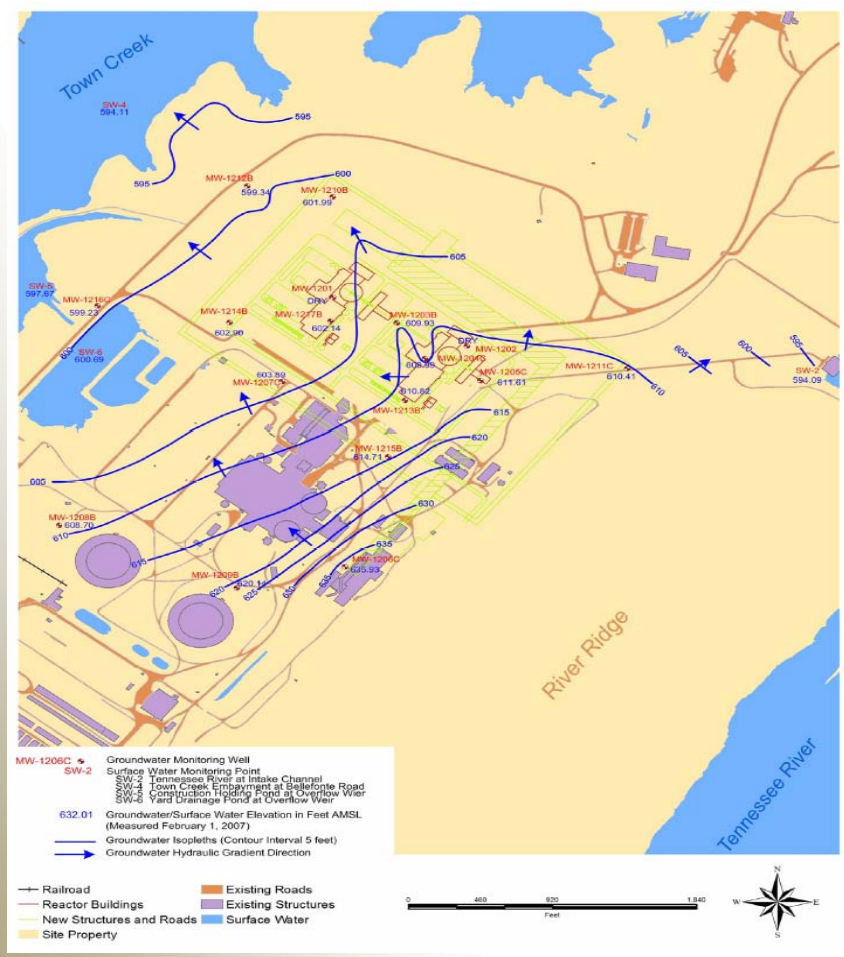
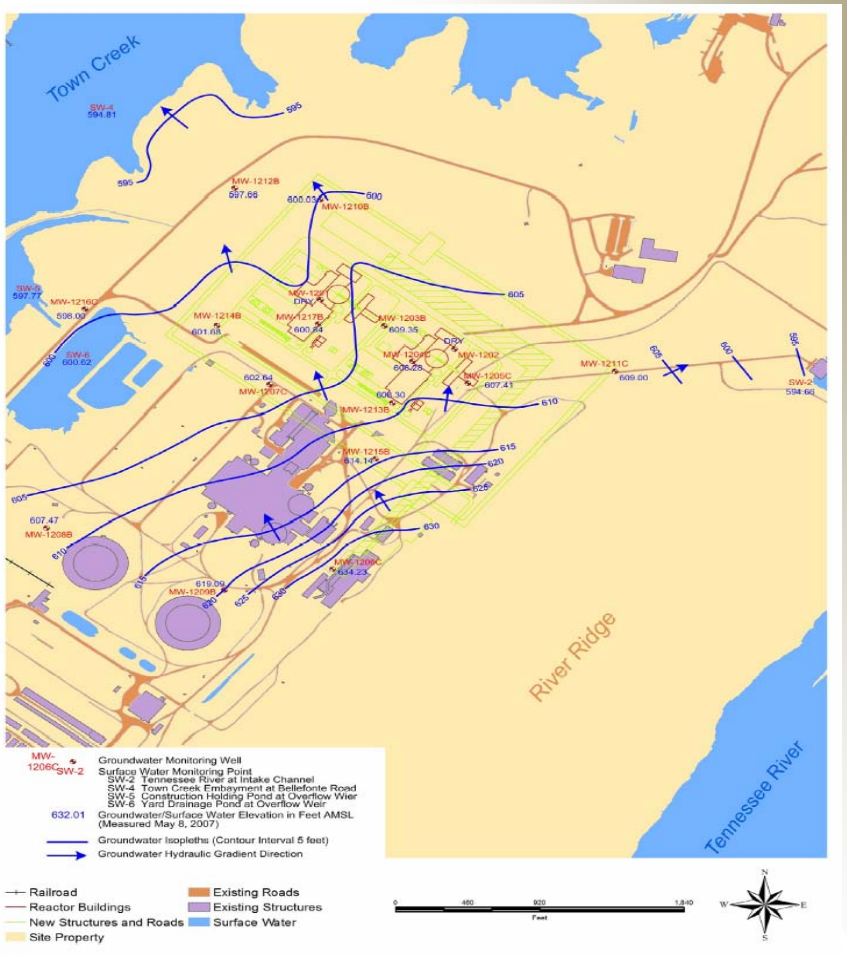
February and May 2007 Groundwater Levels





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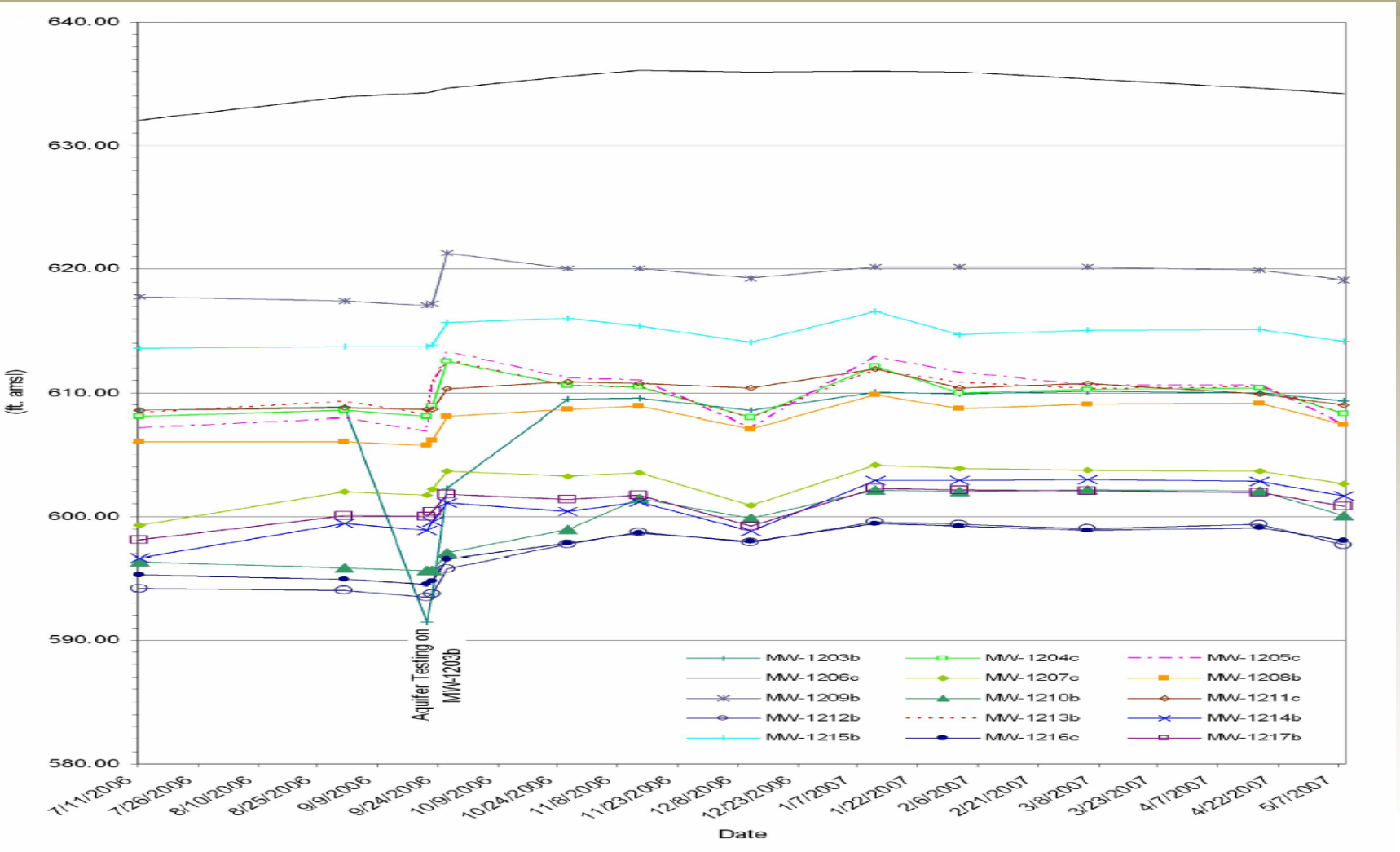
Groundwater Levels over Time



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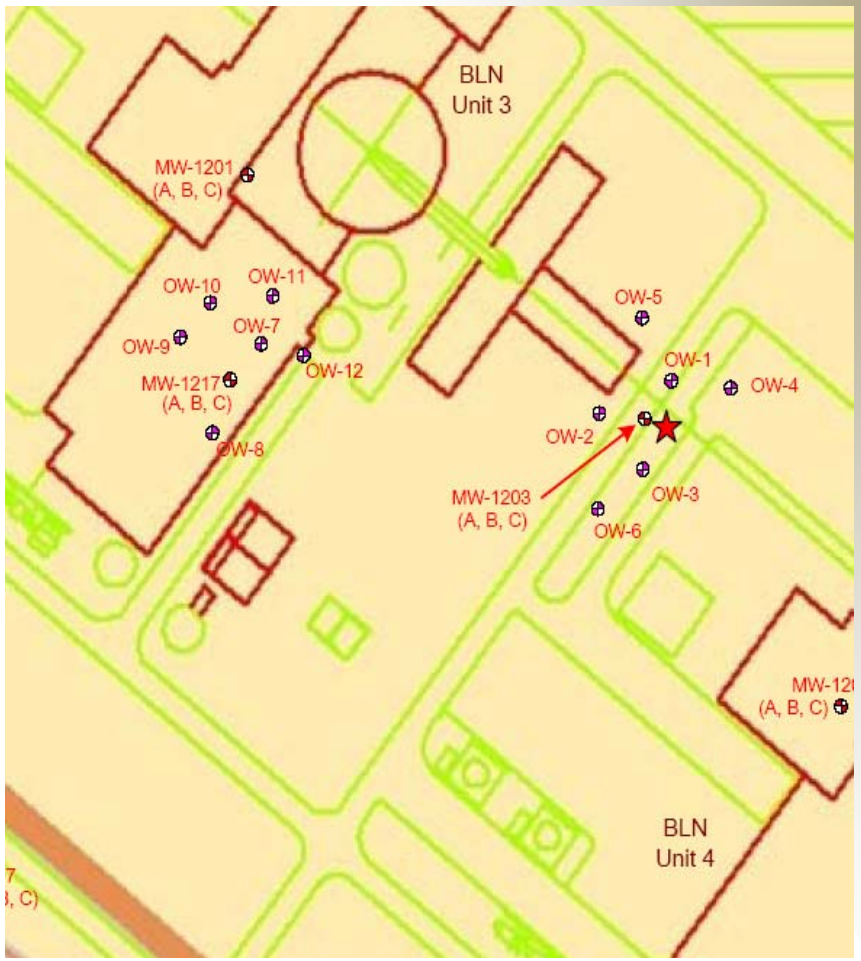
Aquifer Testing

MW-1217 Pumping Test

- Location chosen due to high loss of circulation at 24 feet bgs during drilling of B-1006.
- Pumping test preformed on MW-1217 and associated observation wells OW-7 through OW-12.
- Pump installed in MW-1217b.

MW-1217 Pumping Test

- MW-1217b, OW-10, OW-11, and OW-12 completed at approximately 30 feet bgs.
- MW-1217c, OW-7, OW-8, and OW-9 completed at approximately 50 feet bgs.



MW-1217 Pumping Test

- Due to low water availability, required constant drawdown method.
- At start of test, pumping rate was above 3 gpm.
- After 24 hours pumping rate dropped to approximately 1 gpm.
- After 24 hours, drawdown noted in OW-8, OW-11, and OW-12 only.

MW-1217 Pumping Test

- Maximum hydraulic conductivity calculated from OW-12 : 3.95×10^{-3} cm/sec.

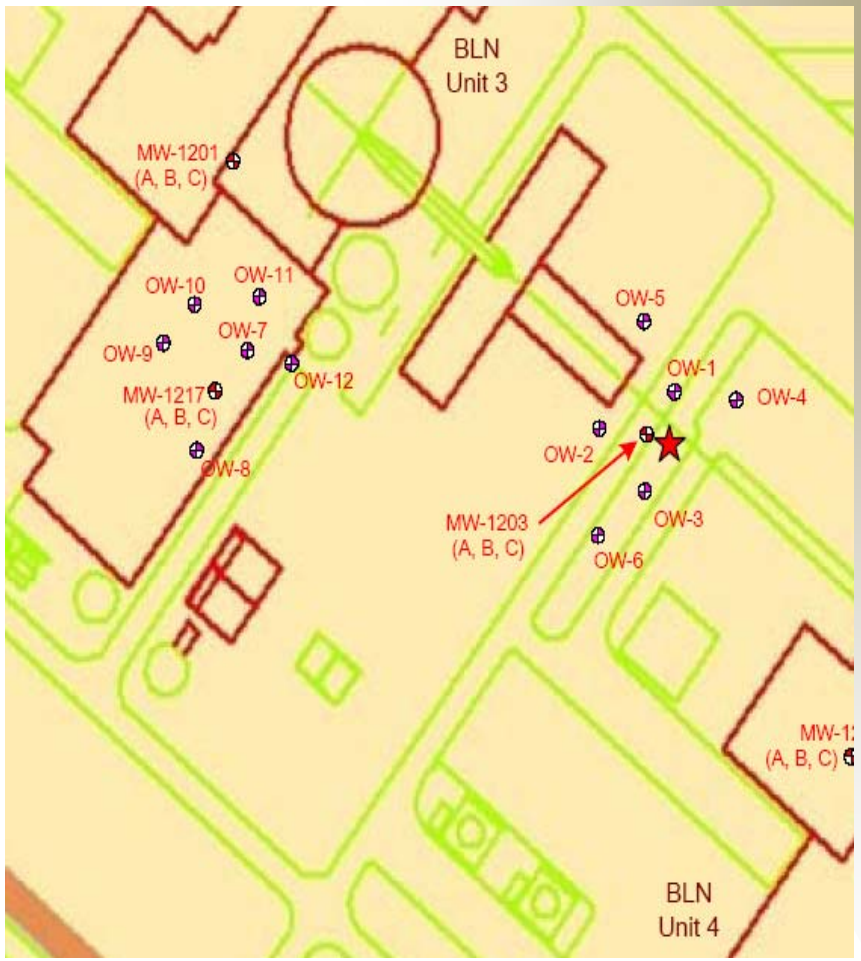
- Represents the highest hydraulic conductivity measured to date on the BLN site.

MW-1203 Baildown Test

- Location chosen due to proximity to reactor centers.
- Pumping test attempted on MW-1203 and associated observation wells OW-1 through OW-6.
- Pump installed in MW-1203b; however, the well purged dry immediately with very slow recovery.

MW-1203 Baildown Test

- MW-1203b completed at approximately 30 feet bgs.
- MW-1203c, OW-1, OW-2, and OW-3 completed between 80 and 110 feet bgs.
- MW-1203a, OW-4, OW-5, and OW-6 completed approximately 10 feet bgs in the soil.



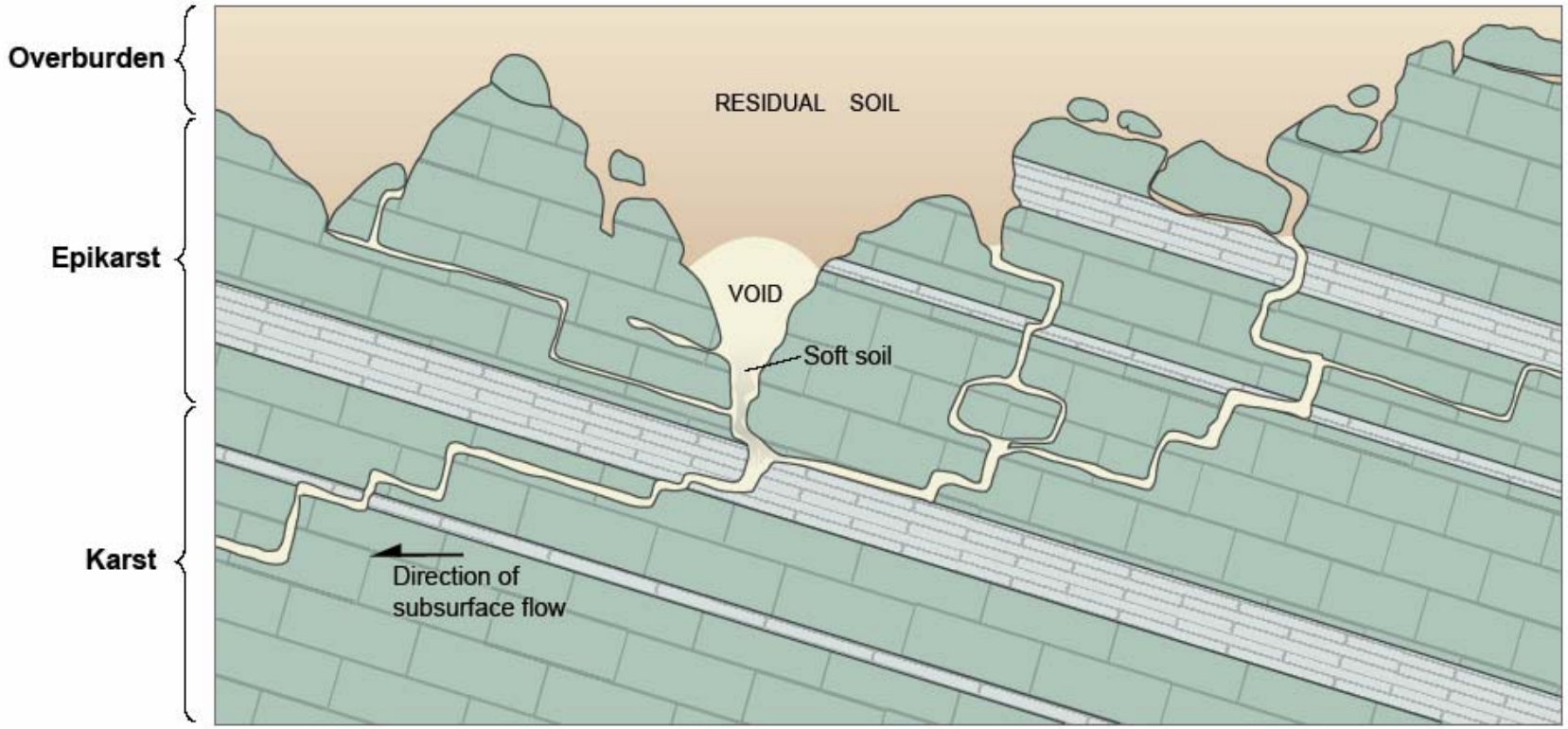
MW-1203 Baildown Test

- All soil wells with the exception of OW-6 were dry or exhibited very slow recharge.
- Deep wells MW-1203c, OW-1, OW-2, and OW-3 were also dry or exhibited very slow recharge.
- A 2-hour baildown test (well maintained dry by bailing) was conducted on MW-1203b and recovery measured.
- No effect was observed in any surrounding well.

MW-1203 Baildown Test

- Hydraulic conductivity calculated from MW-1203b : 6.11×10^{-7} cm/sec.

Groundwater Model



- Water transport in fractures within the limestone with varying degrees of flow and interconnections, both vertical and horizontal.

Aquifer Type

- Due to the poor development and lack of observed conduits and large voids, the underlying groundwater is best represented by a "diffuse" type aquifer system.

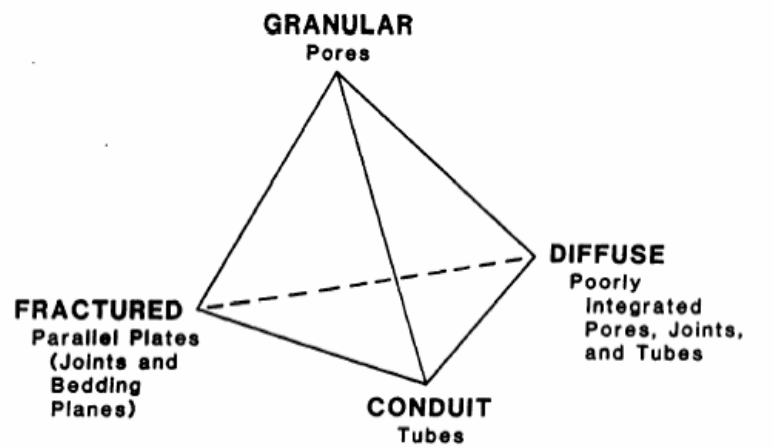


Figure 1. Relation between four major types of aquifers and the dominant porosity geometry in each. This is a tetrahedral continuum. (after Quinlan & Ewers, 1985)

Conceptual Model Development

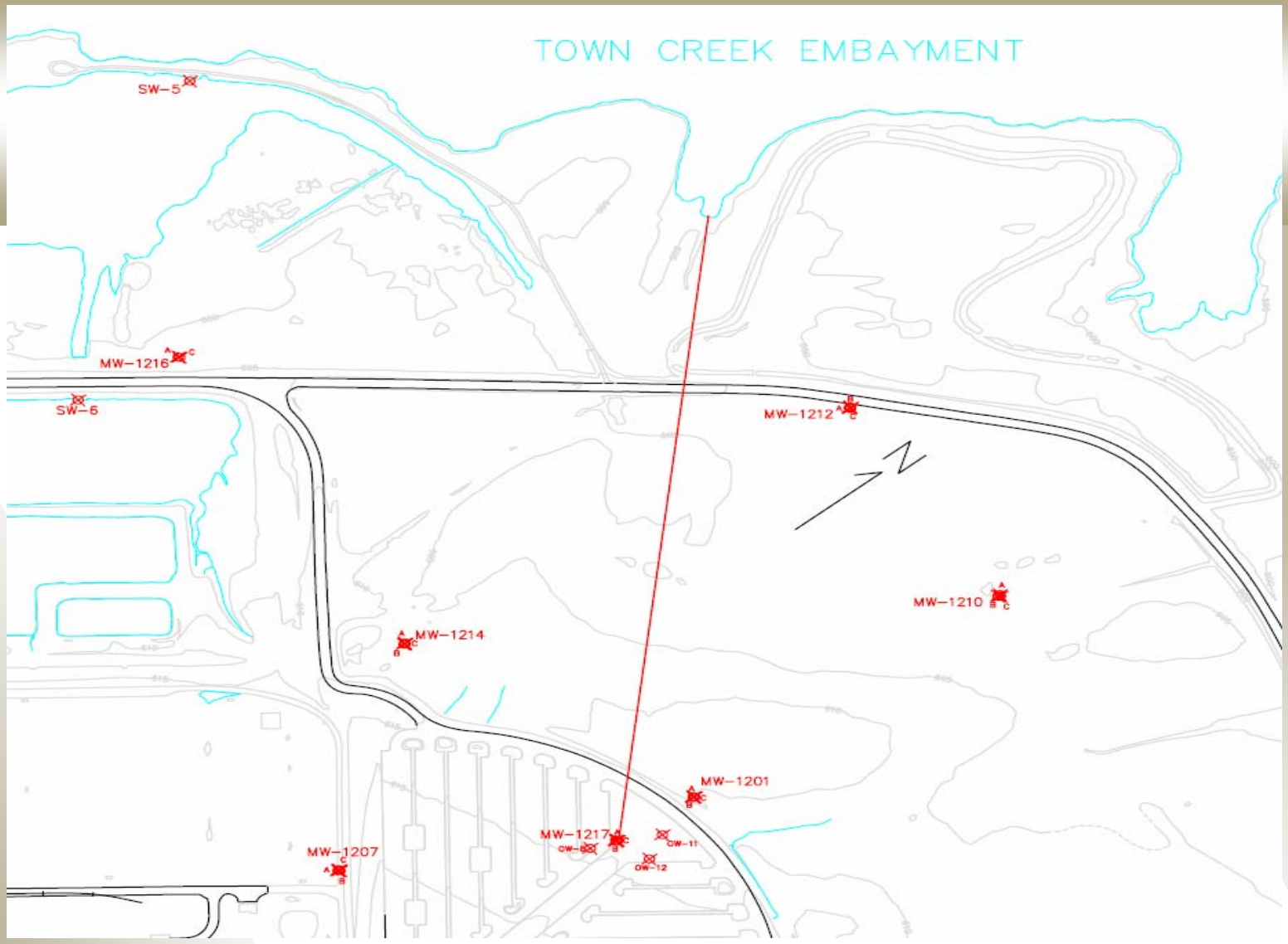
- Actual groundwater flow path determination hampered by poor karst development.
- Due to “hit-or-miss” nature of the water bearing fractures/conduits, additional monitoring well installation was not considered effective.
- Due to lack of springs (groundwater discharge points) on or near the site, dye trace studies were also not considered effective.

Conceptual Model Development

- A conservative "worst-case" approach was developed to characterize groundwater flow.
- All groundwater flow was modeled as existing in a theorized straight line fracture from the reactor area to the nearest hydraulically down gradient water body.
- Actual groundwater flow pathways would be longer and more tortuous than a straight line.

Conceptual Model Development

- Groundwater velocities were then calculated using the highest recorded hydraulic conductivity.



Unit 3 to Town Creek

Due to the unknown nature of karstic flow pathways, groundwater flow conservatively modeled as a single fracture with the highest measured hydraulic conductivity.

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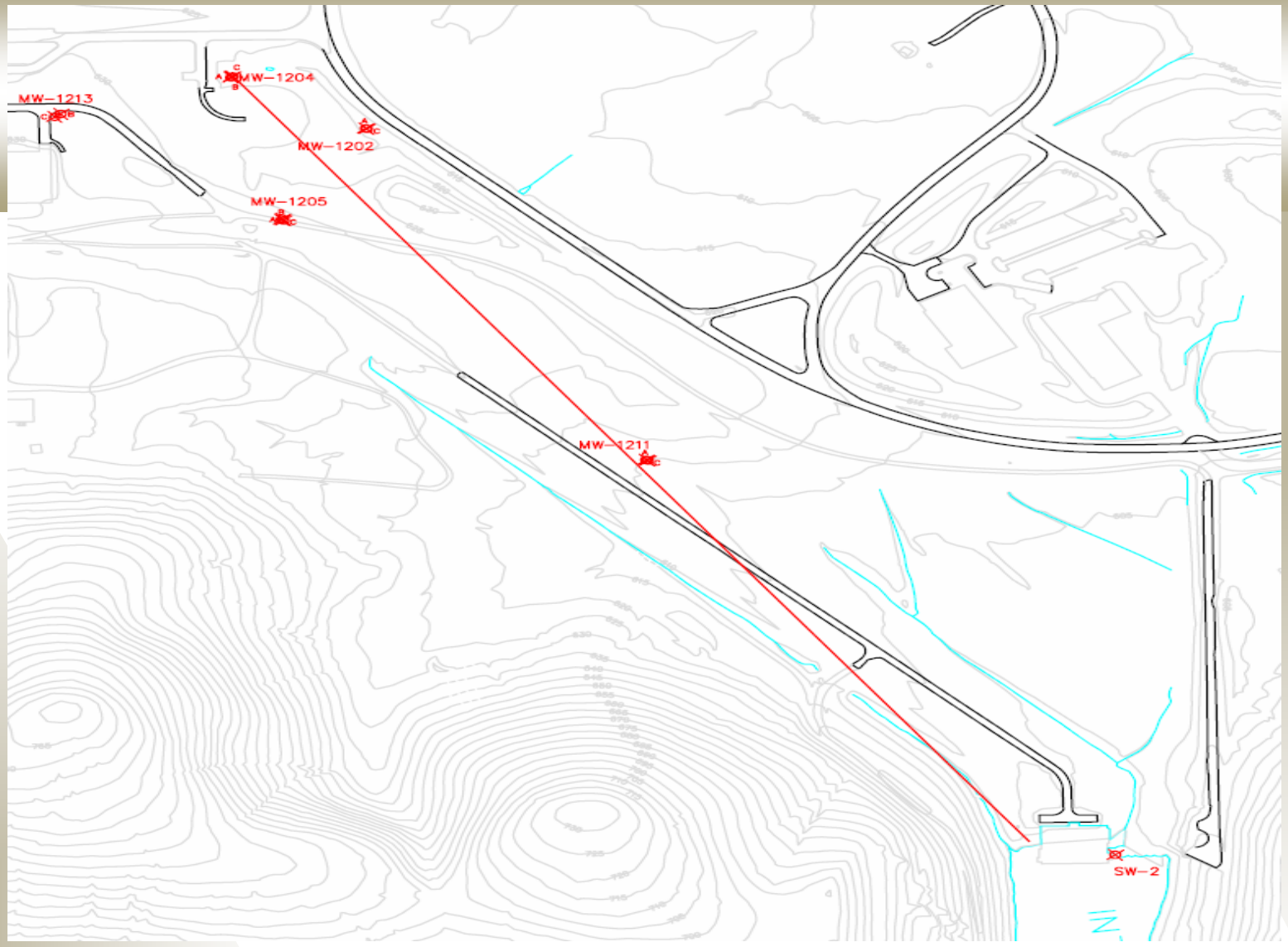

Unit 4 to Intake Structure

Due to the unknown nature of karstic flow pathways, groundwater flow conservatively modeled as a single fracture with the highest measured hydraulic conductivity.

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Conclusions

Geology and Groundwater Movement

- The BLN site is underlain by limestone with poorly developed karst in the upper 30 feet of bedrock.
- Groundwater is of limited availability due to the system of poorly connected water bearing fractures and solutional features.
- General groundwater movement in the area of the BLN Units 3 and 4 is northwest towards Town Creek.

Groundwater Movement

- Due to the complex nature of groundwater transport pathways in karstic systems, groundwater was conservatively modeled as a direct fracture from the unit to the nearest surface water body.

- Conservative values used to determine groundwater velocities and travel times.