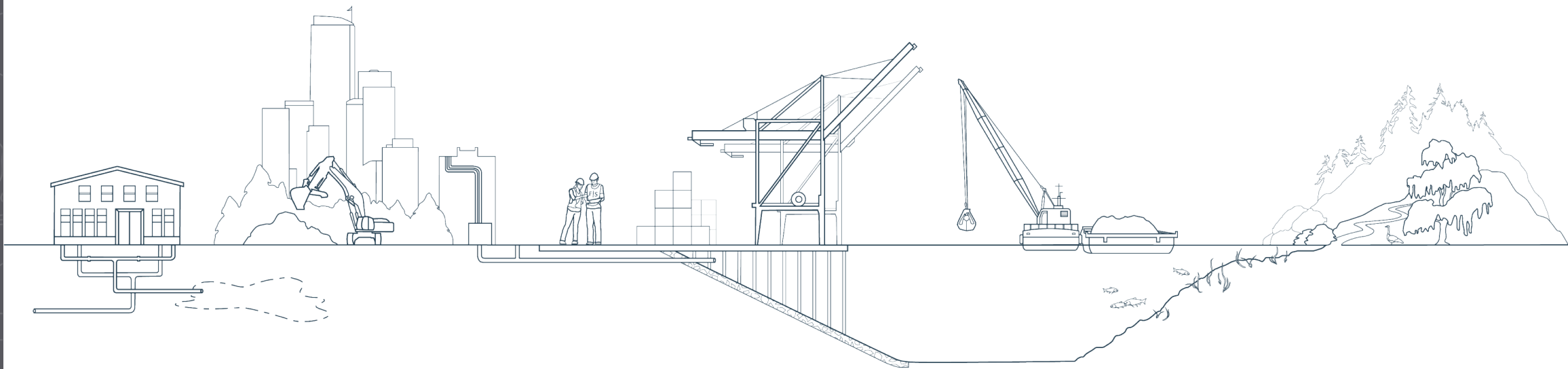


# Active Service Station Site: How a Better Understanding of the Hydrogeology Facilitated Successful Cleanup and Cost Settlement

Gabe Cisneros and Jessi Massingale



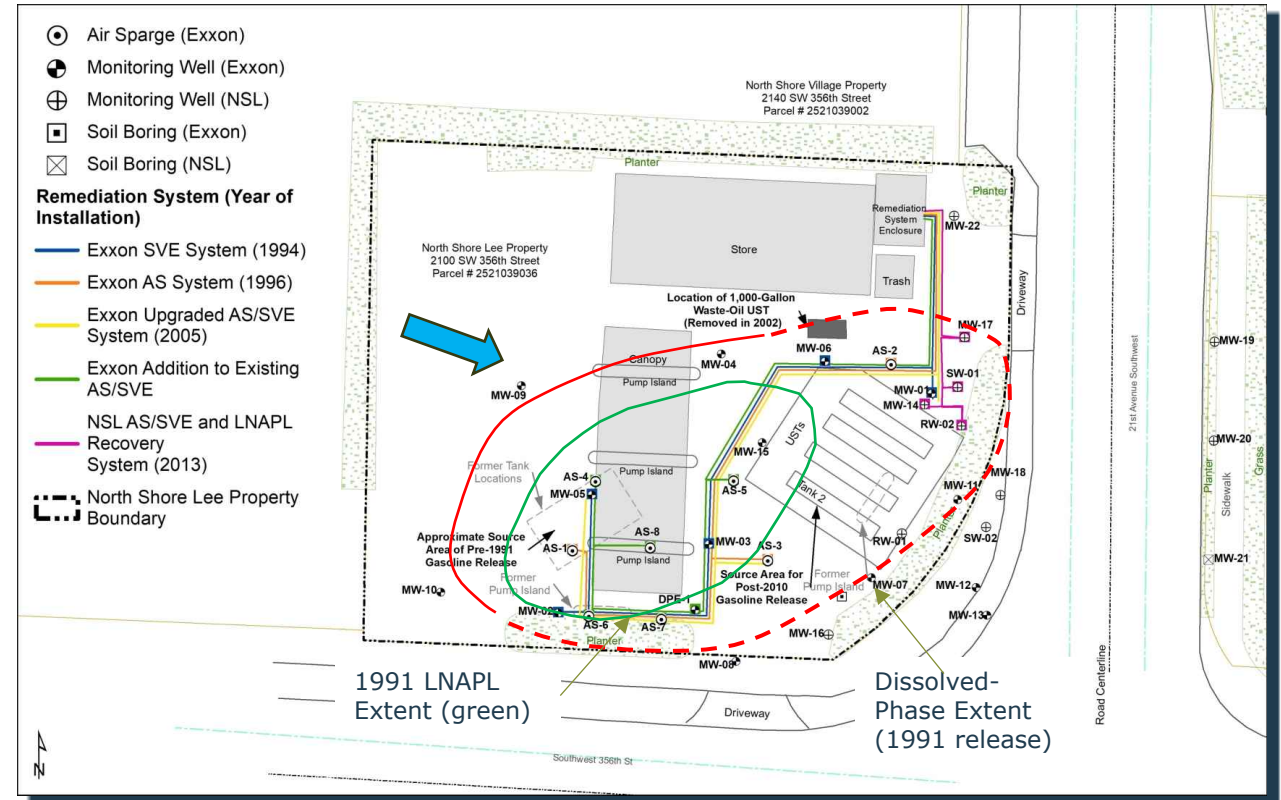
# Presentation Outline

- Site Background
  - Releases
  - Previous investigations and remedial actions
  - Cost Recovery Issues
- Development of CSM
- Cost Recovery Based on CSM
- Selected Remedial Action
- Post-Cleanup Groundwater Results



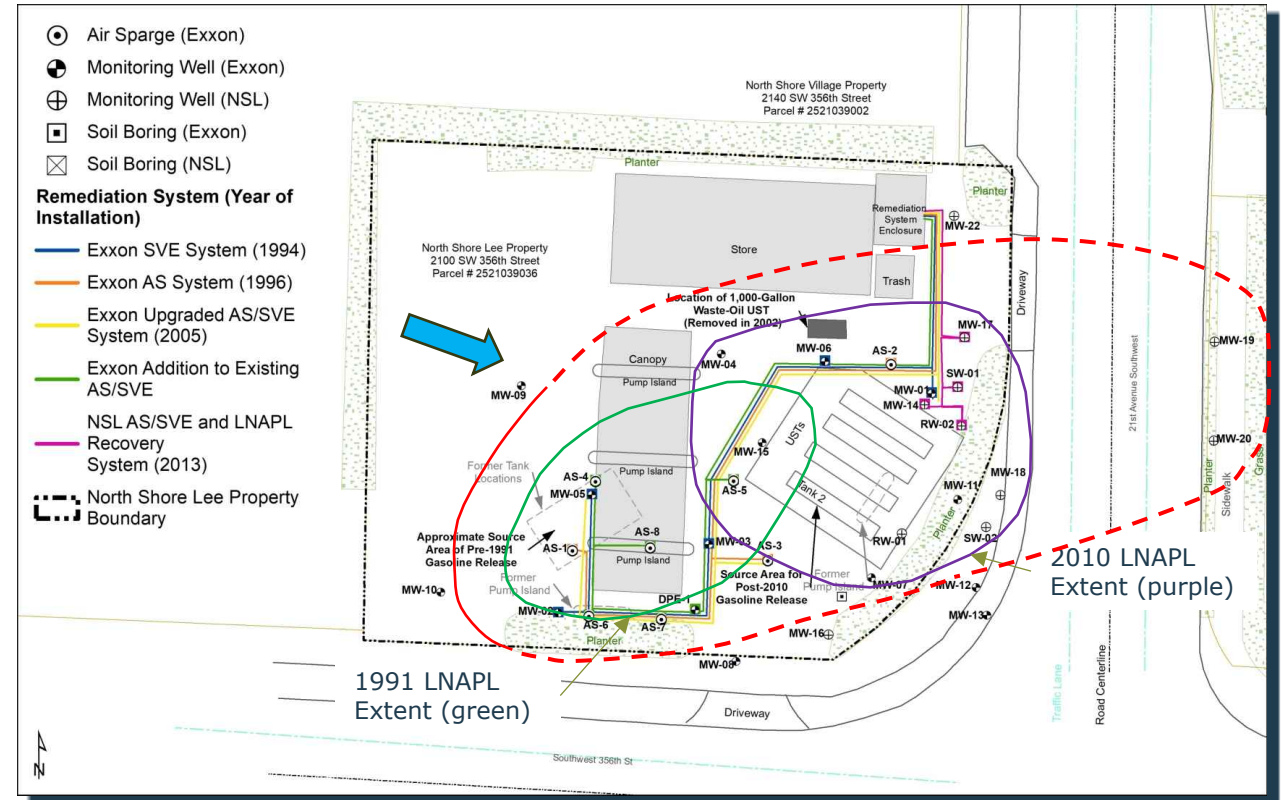
# Site Background

- Active Service Station since 1986 with historical gasoline releases
  - Pre-1991 Release and LNAPL Extent
- Various AS/SVE Systems operated between 1994 to 2010
  - Station sold in 2007
- Dissolved-Phase Extent in June 2010 prior to 2<sup>nd</sup> release



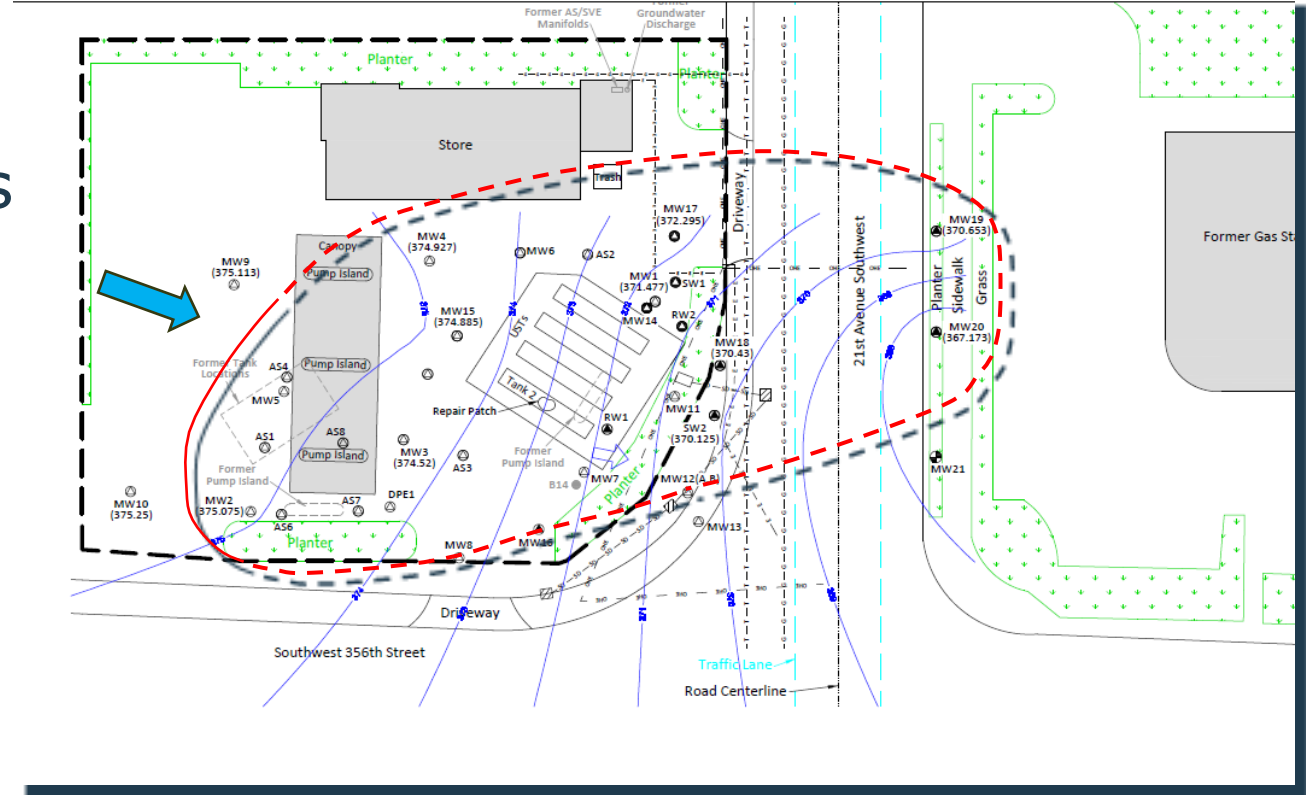
# Site Background

- Second release in Dec. 2010
  - System shut down and quarterly sampling stopped
- 2011 Interim Action Cleanup and System
  - LNAPL Recovery
  - AS/SVE
- 2011 Dissolved Phase Extent



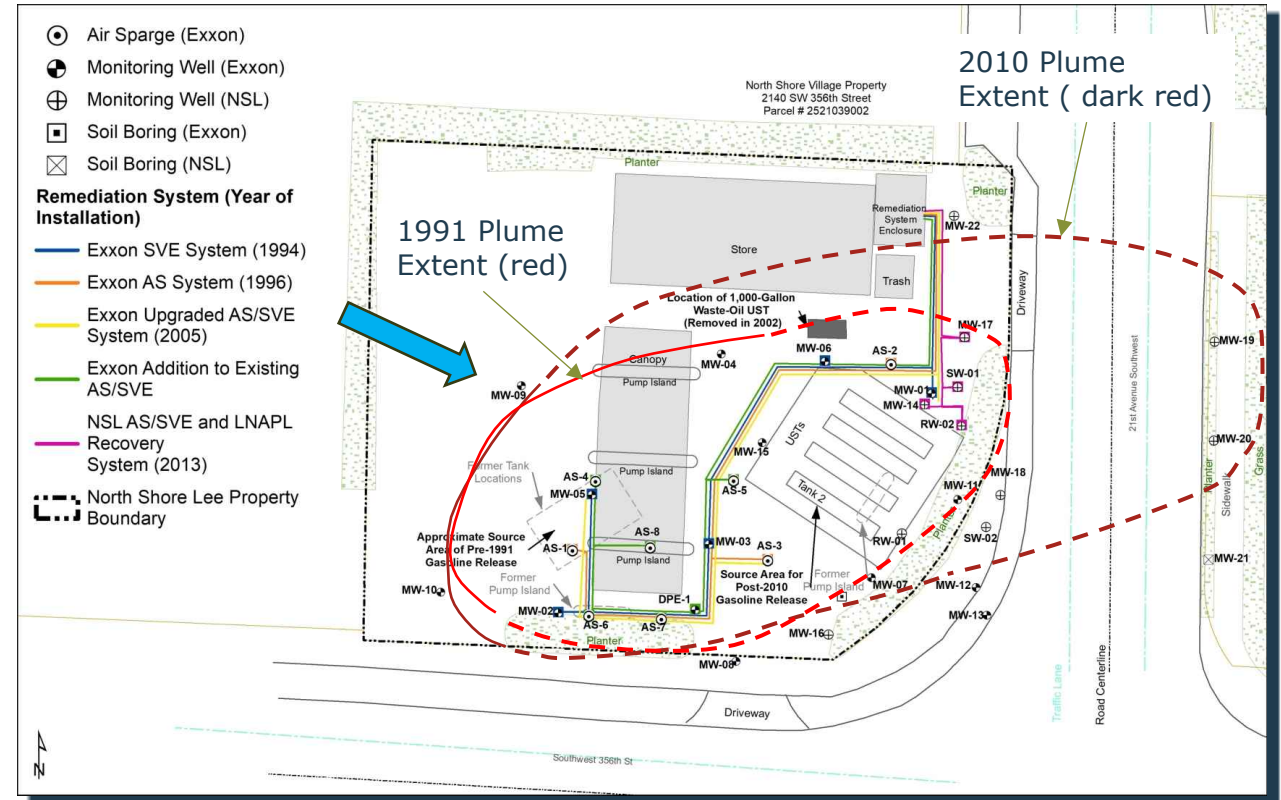
# Remediation Systems

- No remedial action was successful at reducing groundwater concentrations below cleanup levels (CULs)
  - Conceptual Site Model not sufficiently defined



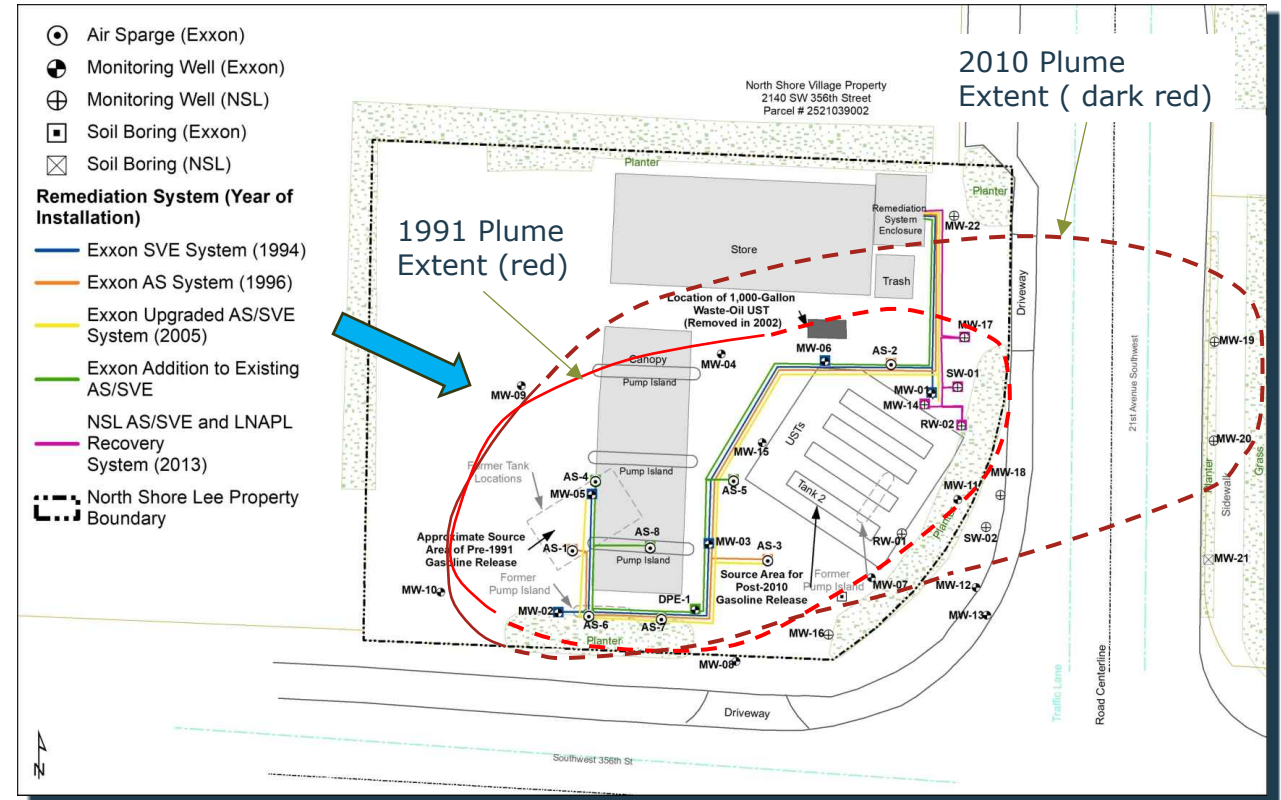
# Cost Recovery Support

- 60% of the insurance policy used by 2017 without fully delineating the plume or achieving CULs
- Cost recovery to support achieving CULs and NFA critical
- Remaining actions would address 1991 and 2010 releases
- Floyd|Snider assisted with cost recovery from the party assoc. with the 1991 release



# Approach to Cost Recovery

- Why the AS/SVE System did not work
  - The geology and hydrogeology not fully understood
  - The shape of the dissolved-phase plume not comparable to GW flow direction



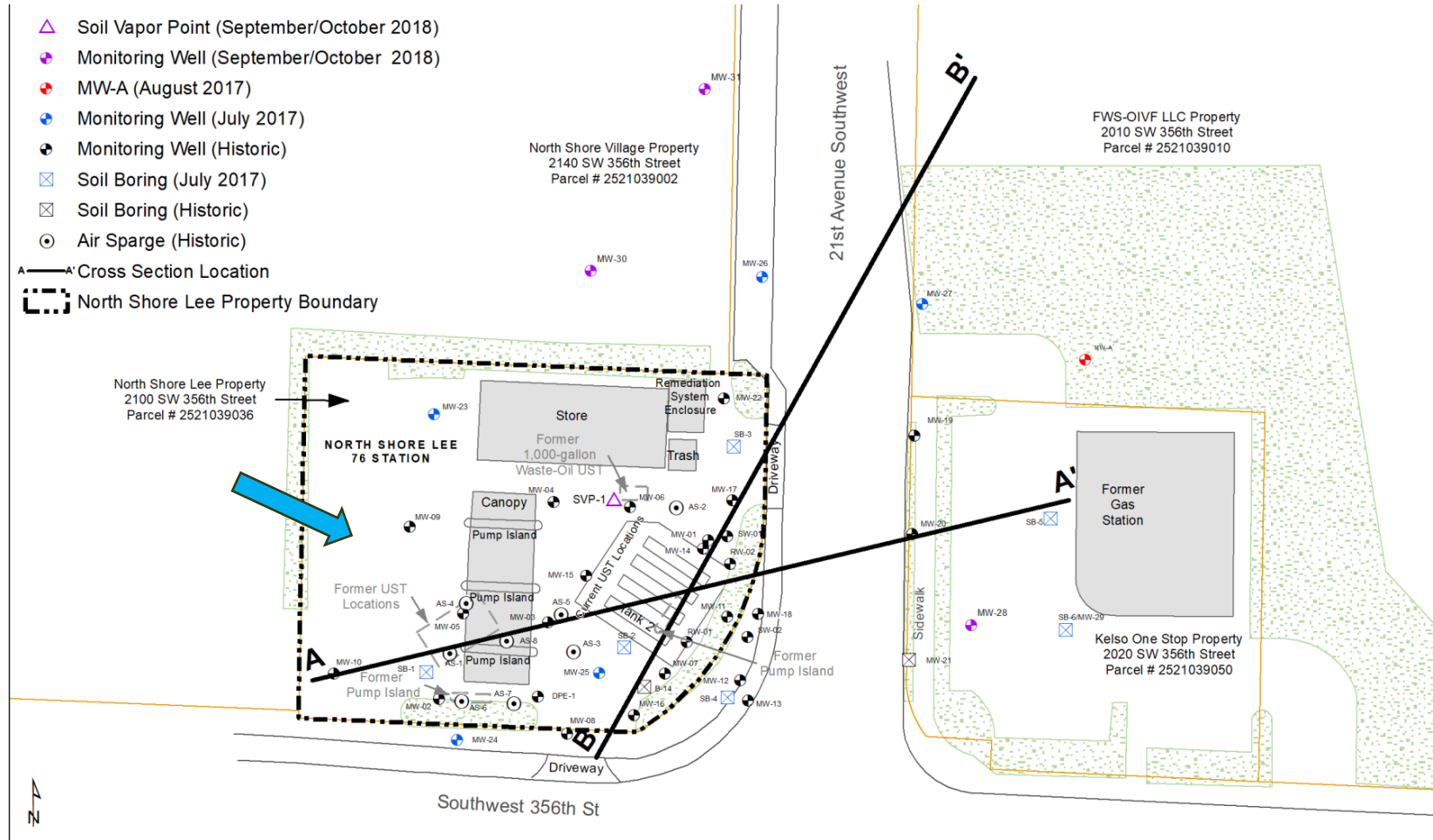
# Boring Logs – Hollow-Stem Auger Vs Sonic

- Site located on dense glacial drift material
- Poor recovery using a HSA drill rig
- Using a sonic rig provides a higher resolution of subsurface and a clearer picture of the hydrogeology
  - Sandy Gravel perched water bearing zone
  - Silt/Clay Aquitard

| Sample |     | Blow Count | Sample        |                | Depth Scale<br>1" = 4' | Descriptions of Materials and Conditions                                       | Depth (feet) | USCS Symbol | Soil Description and Observations<br>(color, texture, moisture, MAJOR CONSTITUENT, odor, staining, sheen, debris, etc.) | Drive/ Recovery |
|--------|-----|------------|---------------|----------------|------------------------|--------------------------------------------------------------------------------|--------------|-------------|-------------------------------------------------------------------------------------------------------------------------|-----------------|
| Type   | No. |            | Interval (ft) | Recovery (in.) |                        |                                                                                |              |             |                                                                                                                         |                 |
| CA     | 4   | 50+        | 23.5-24.0     | 10             | 24                     | SILTY SAND WITH GRAVEL; fine to coarse, poorly sorted, light brown, moist (SM) | 20           | SP          | Brown, very dense, gravelly, medium to coarse SAND with 30% gravels and cobbles; no odor; no sheen; moist.              |                 |
|        |     |            |               |                | 25                     |                                                                                | 21           | SM          | Brown, silty, gravelly, fine to medium SAND with 30% fine to large gravels and 15% silt; moist.                         |                 |
|        |     |            |               |                | 26                     |                                                                                | 22           | SP          | Brown, gravelly, medium to coarse SAND with 15% gravel; moist.                                                          |                 |
|        |     |            |               |                | 27                     |                                                                                | 23           |             |                                                                                                                         |                 |
|        |     |            |               |                | 28                     |                                                                                | 24           | SM          | Brown, silty, fine SAND with 40% silt and 10% fine gravel; no odor; no sheen; moist.                                    |                 |
| CA     | 5   | 50+        | 28.5-29.0     | 16             | 29                     | SILTY SAND; fine to medium grained, gray, wet at 29 ft. (SM)                   | 25           | SW          | Brown, gravelly, fine to coarse SAND with 30% gravel and trace silt; moist.                                             |                 |
|        |     |            |               |                | 30                     | SILTY CLAY; some gravel, light tan with some oxidation staining, damp (ML/CL)  | 26           | SP          | Brown, gravelly, medium to coarse SAND with 30% gravel; no odor; wet.                                                   |                 |
|        |     |            |               |                | 31                     |                                                                                | 27           | GW          | Gray, sandy, fine to large GRAVEL with 40% medium to coarse sand; no odor; no sheen; wet.                               |                 |
|        |     |            |               |                | 32                     |                                                                                | 28           |             |                                                                                                                         |                 |
|        |     |            |               |                | 33                     | SILTY SAND WITH GRAVEL; fine to coarse grained, light tan, dry (SM)            | 29           | SP          | Gray, fine to medium SAND; no odor; no sheen; wet.                                                                      |                 |
| CA     | 6   | 50+        | 33.5-34.0     | 7              | 34                     |                                                                                | 30           |             | Becomes brown.                                                                                                          |                 |
|        |     |            |               |                | 35                     |                                                                                | 31           |             | Olive-gray, very hard SILT with moderate plasticity; no odor; sheen.                                                    |                 |
|        |     |            |               |                | 36                     |                                                                                | 32           | ML          |                                                                                                                         |                 |
|        |     |            |               |                | 37                     |                                                                                | 33           |             |                                                                                                                         |                 |
|        |     |            |               |                | 38                     | Total depth at 38.5 ft.                                                        | 34           |             |                                                                                                                         |                 |
|        |     |            |               |                | 39                     |                                                                                | 35           |             | Bottom of boring = 35 ft. bgs.                                                                                          |                 |
|        |     |            |               |                | 40                     |                                                                                | 36           |             |                                                                                                                         |                 |
|        |     |            |               |                | 41                     |                                                                                | 37           |             |                                                                                                                         |                 |
|        |     |            |               |                | 42                     |                                                                                | 38           |             |                                                                                                                         |                 |
|        |     |            |               |                | 43                     |                                                                                |              |             |                                                                                                                         |                 |
|        |     |            |               |                | 44                     |                                                                                |              |             |                                                                                                                         |                 |
|        |     |            |               |                | 45                     |                                                                                |              |             |                                                                                                                         |                 |
|        |     |            |               |                | 46                     |                                                                                |              |             |                                                                                                                         |                 |
|        |     |            |               |                | 47                     |                                                                                |              |             |                                                                                                                         |                 |

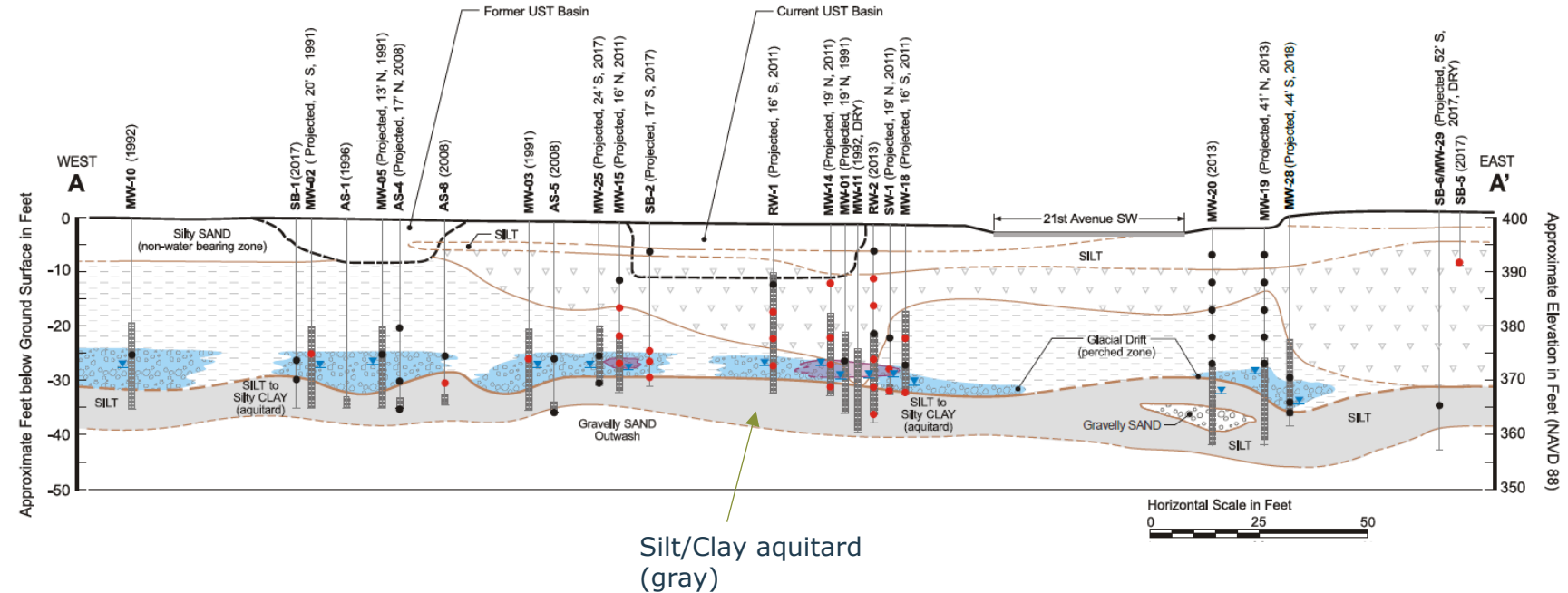
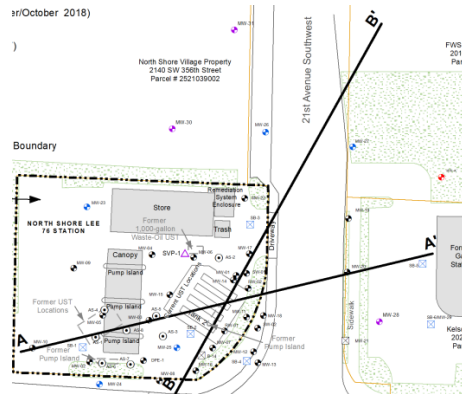
# Site Map and Boring Locations

- Aquitard: present at higher elevations in the southeast and to the east of the Site
- Perched water bearing zone: not present to the southeast and east, but thickened to the northeast
- Subsurface investigations to the north-northeast were deemed necessary



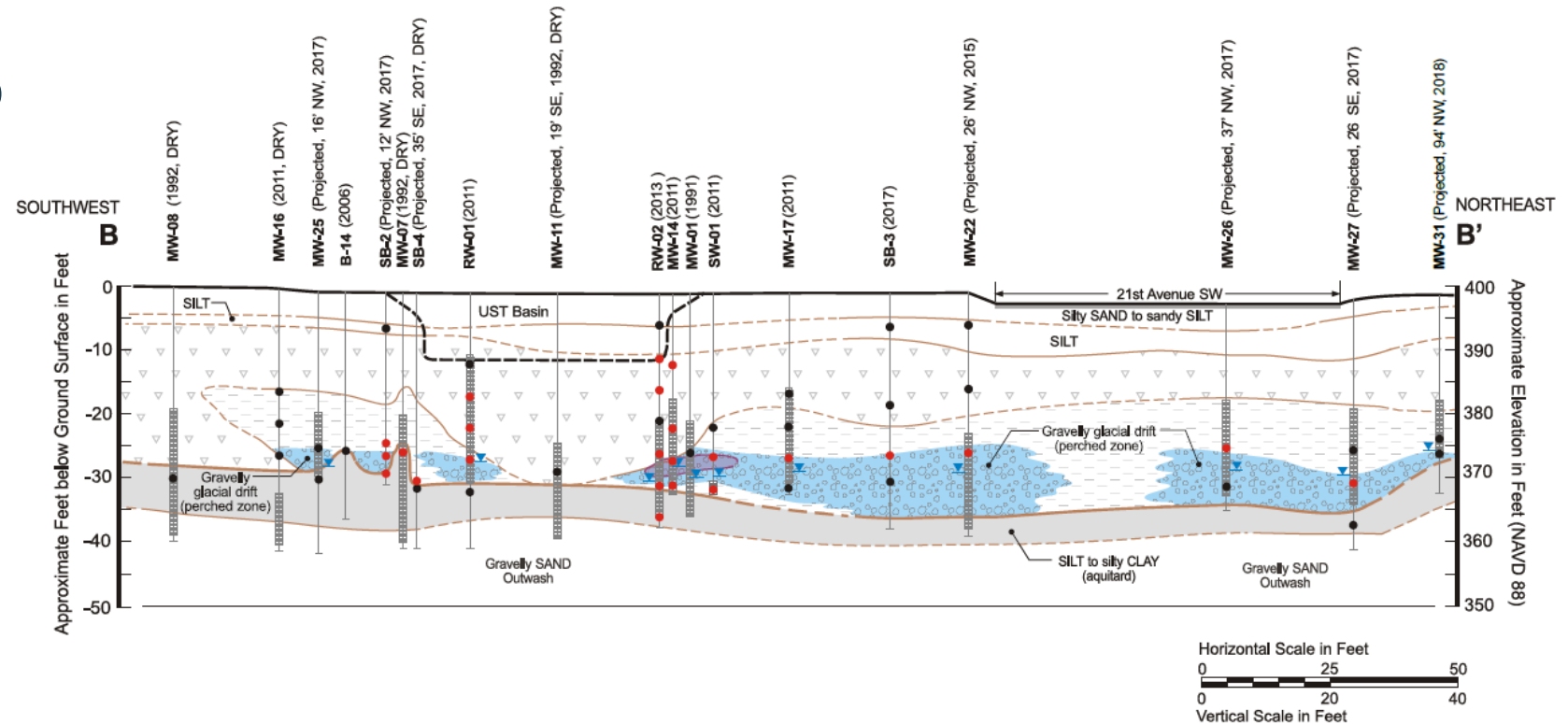
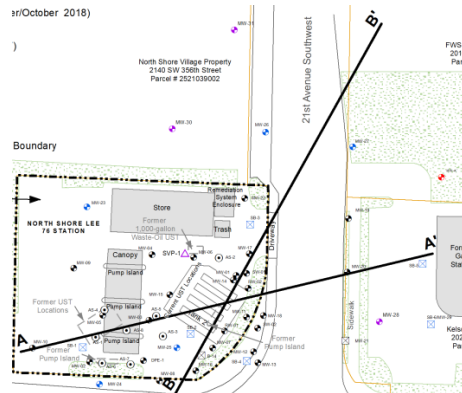
# CSM - Cross Section A-A'

- AS/SVE system not effective due to:
  - Screened within the aquitard or
  - Screened in areas with thin water bearing zones



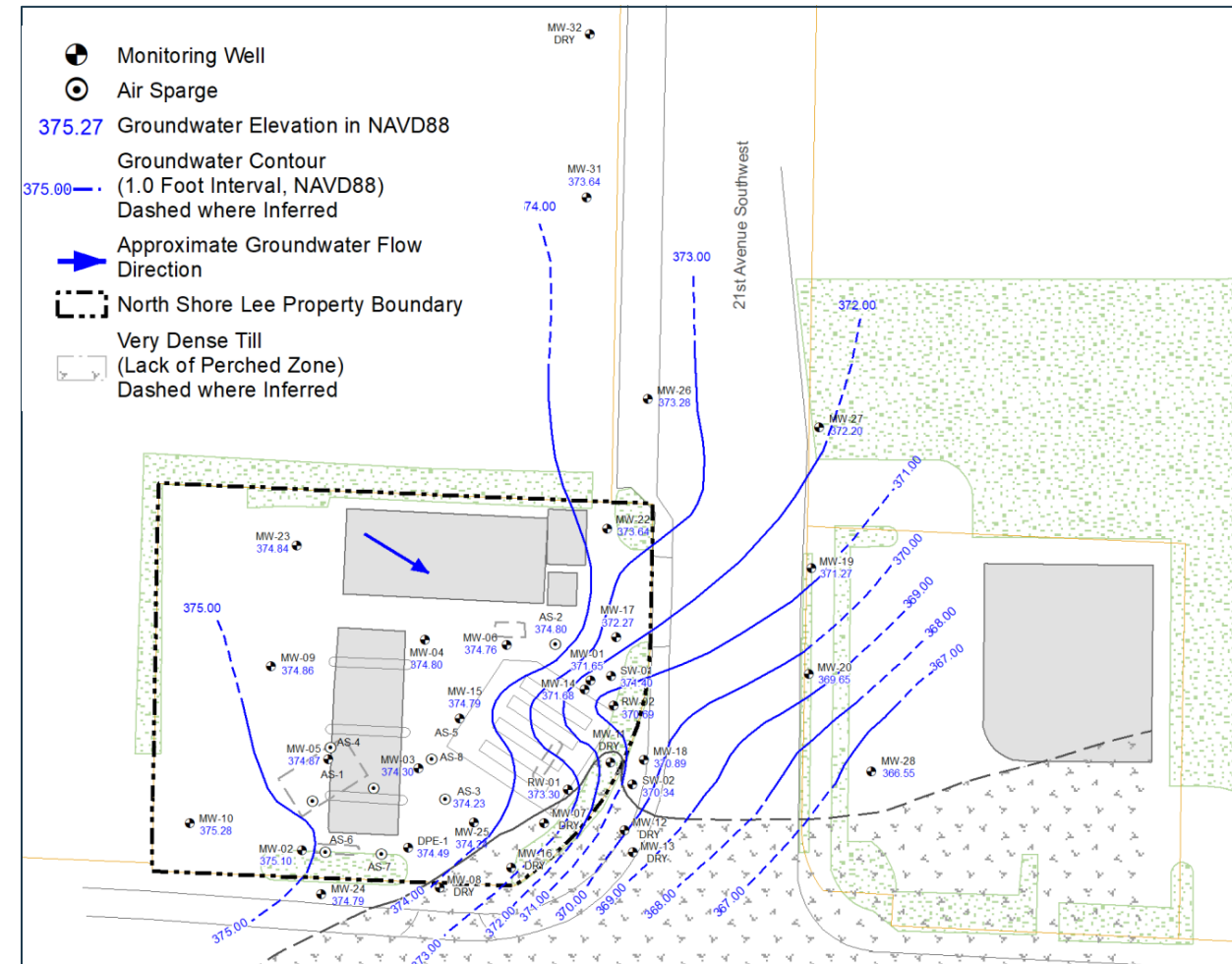
# CSM - Cross Section B-B'

- Contaminant flow direction to the NE, despite GW flow to the SE-E



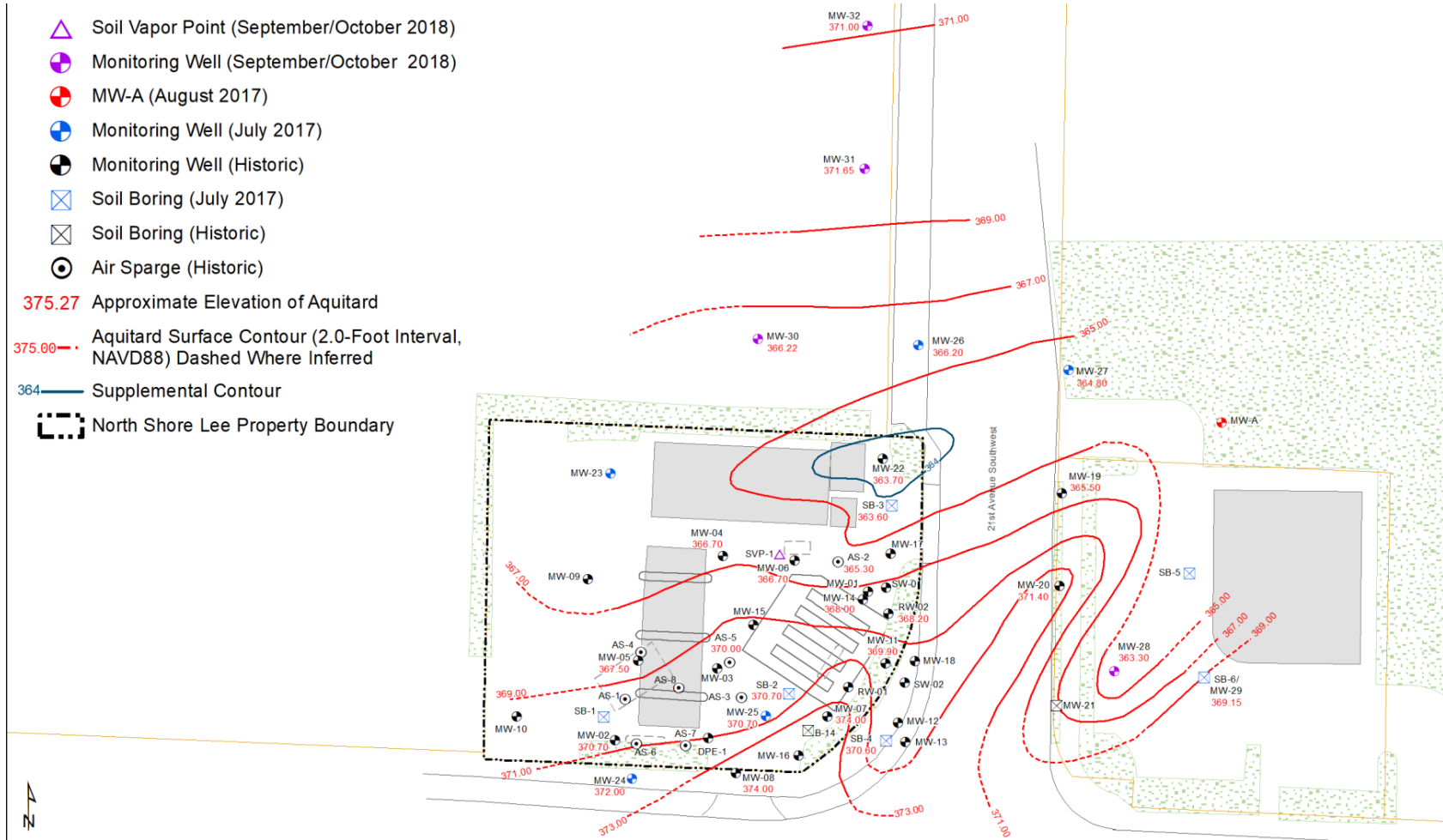
# CSM - Groundwater Flow Direction

- Flow to the SE
- Dry wells to the south and southeast and up north
- Dry wells associated with areas lacking the gravel water bearing zone and where the aquitard was encountered at shallower depths



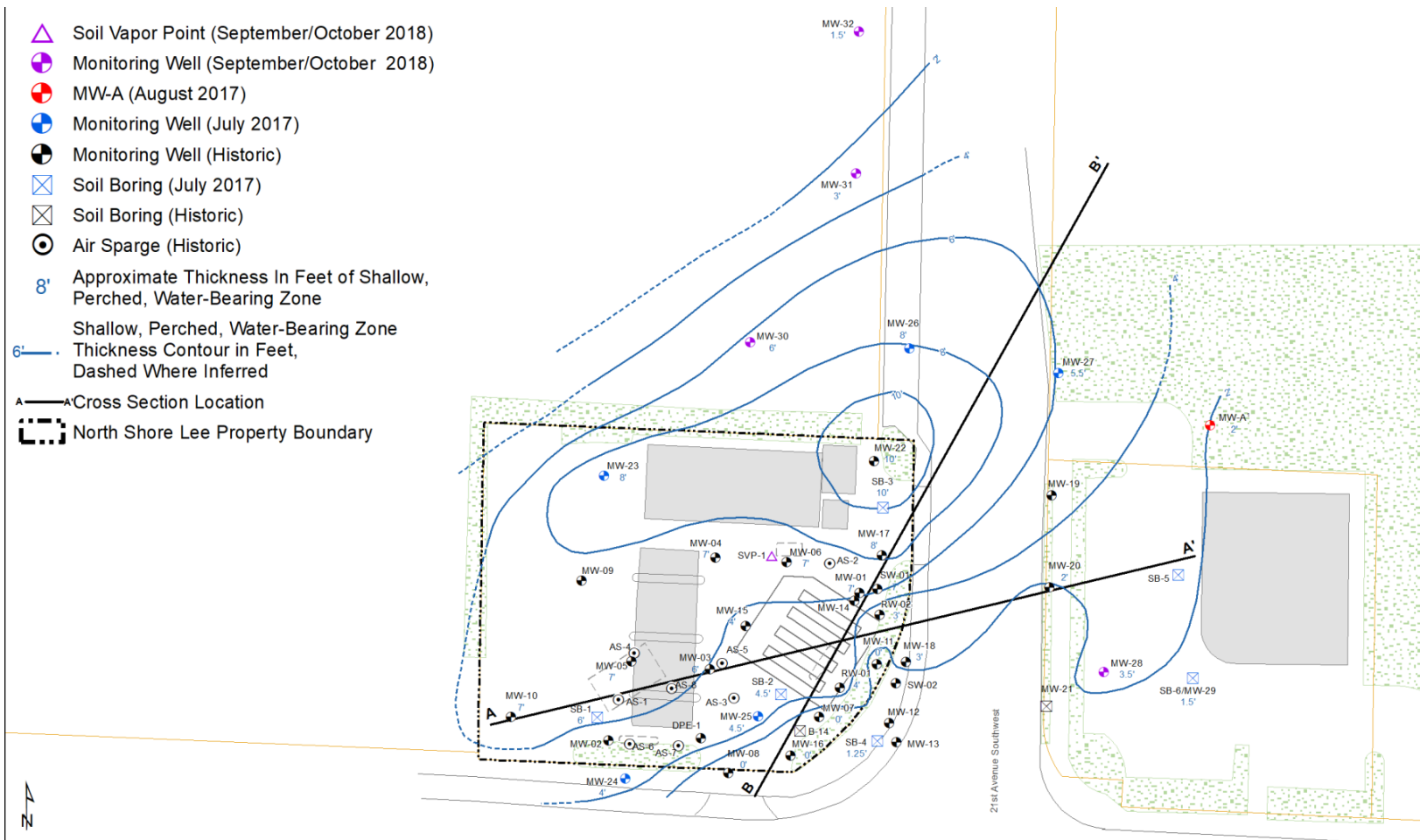
# CSM - Aquitard Surface

- Present at shallower elevations in south and east
- Deepest in NE corner of property

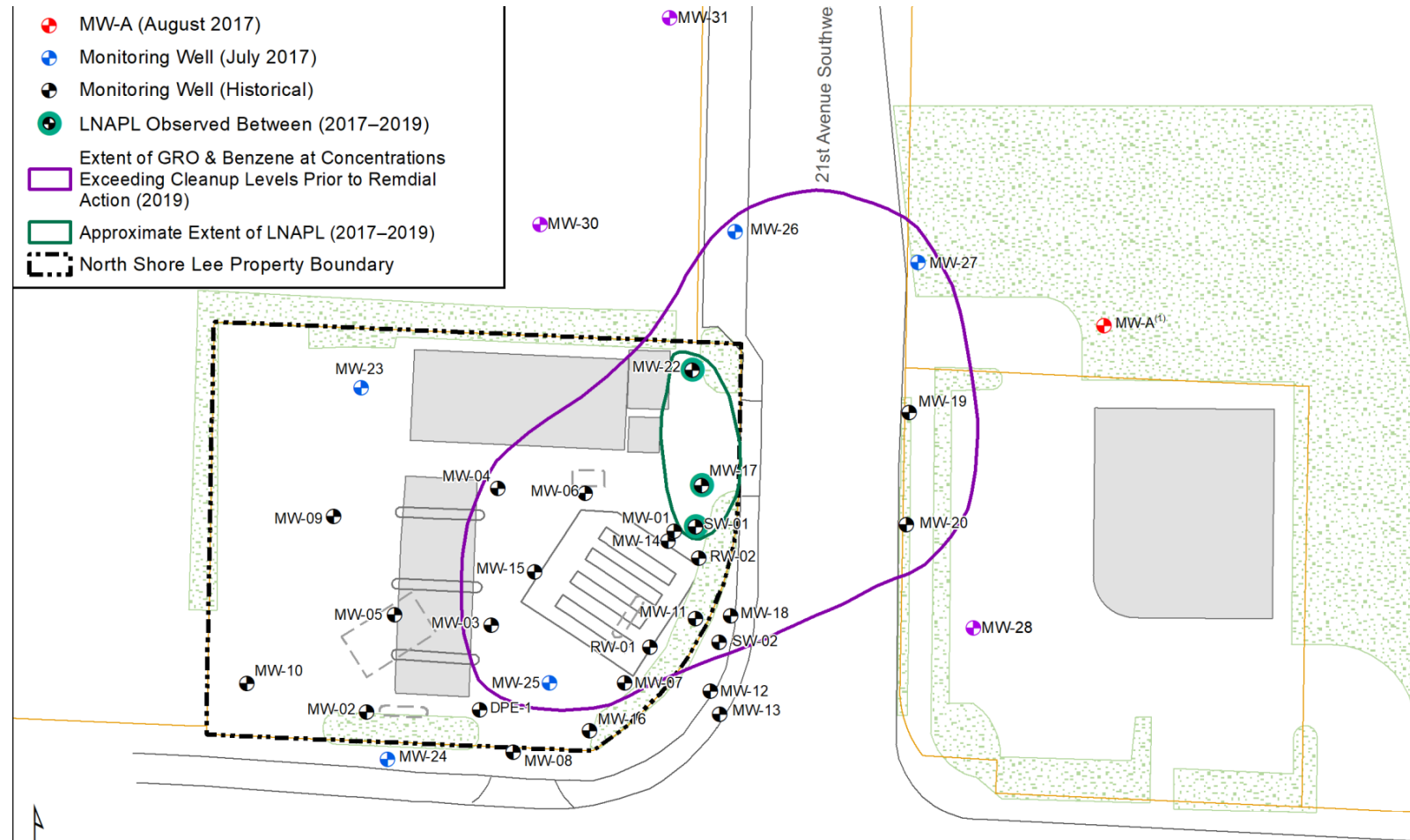


# CSM - Water Bearing Zone Thickness

- Not present or very thin to the southeast and east
- Thickest in northeast corner of the property
- CSM Explained:
  - Why wells were dry
  - Why some wells purged dry quickly with slow recovery
  - Contaminant migration pathway to the NE



# 2019 Extent of TPH-Impacted Groundwater



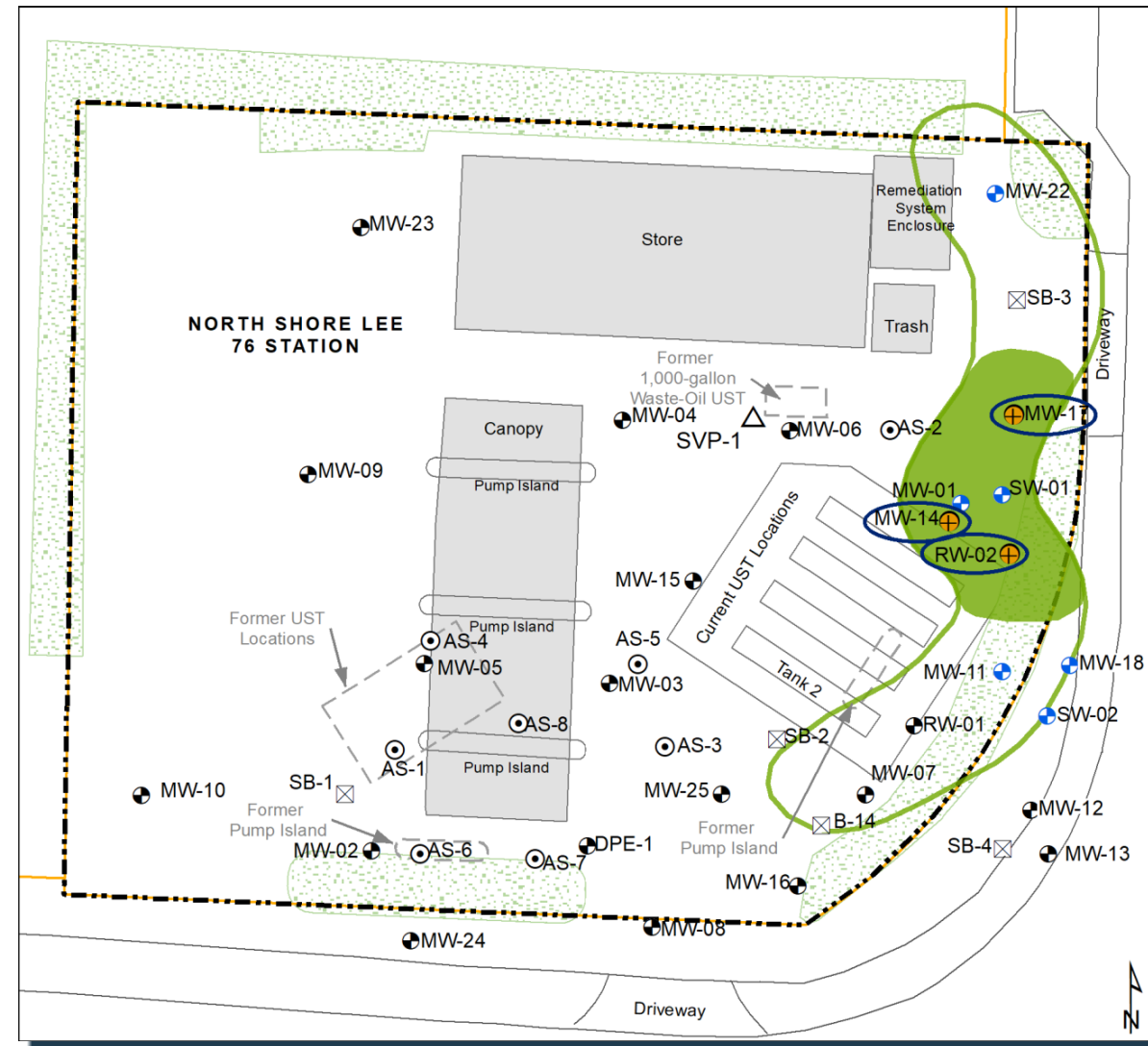
# Cost Settlement Efforts

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- The party associated with the 1991 was reluctant to contribute to investigation and cleanup costs
- Site activities and associated costs were reasonable and necessary to:
  - Define N&E of both plumes
  - Develop a CSM
  - Determine an effective cleanup
- Entering the Site under a regulatory process with a WA State cleanup agency benefits all parties and is the most efficient and cost-effective approach for regulatory agency approval
  - Allocation approach using respective party plumes to allocate field activities and analytical costs
  - Settlement results were sufficient to add to remaining insurance policy and avoid the current owner paying high costs out of pocket

# Selected Action and Pilot Study

- Four Alternatives were evaluated
- Surfactant and Targeted ISCO Injections was selected
- Pilot Study – Aug 2019 to determination of radius of influence and affectability
  - Surfactant injection and extraction
  - PersulfOx injection event
  - Followed by GW sampling



# Pilot Study – LNAPL and GRO Concentrations

- LNAPL was present in SW-01 & MW-22
  - Resulting in no LNAPL
- Most wells within 25 feet had reductions between 40 and 80%
- More than 80% reduction in downgradient well SW-01
- Little reduction in wells greater than 30 feet away from injections, except in MW-22



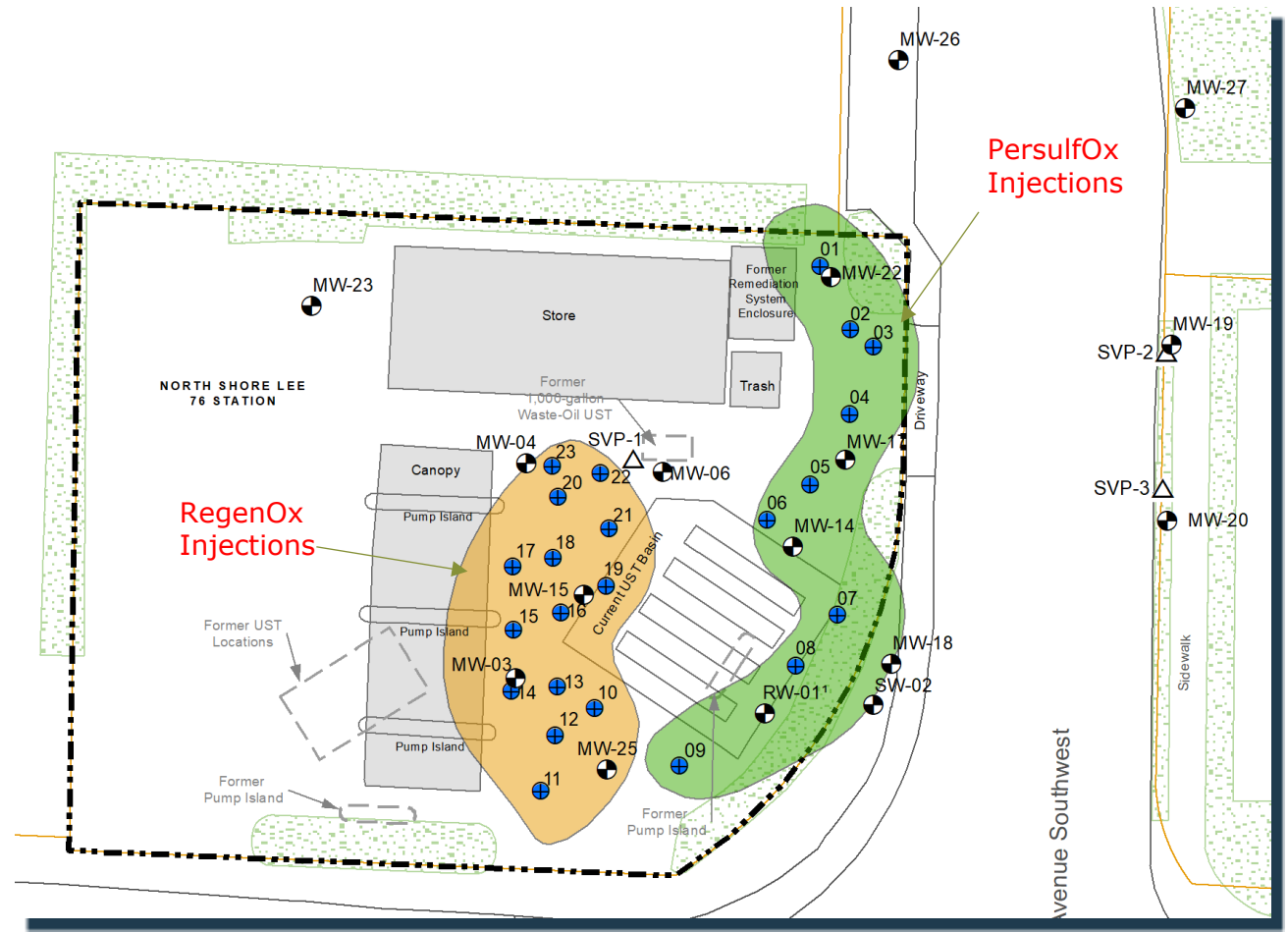
# Pilot Study – Total BTEX Concentrations

- Between 40 to 80% reduction in majority of wells within 25 feet downgradient and/or cross-gradient within injection points
- More than 80% reduction in downgradient wells SW-01 and MW-18



# Cleanup Action – Permanent Injection Wells

- Based on Pilot Study results, 23 new injection wells installed with 5-foot screens set across water bearing zone
- Eliminated surfactant injections/extractions



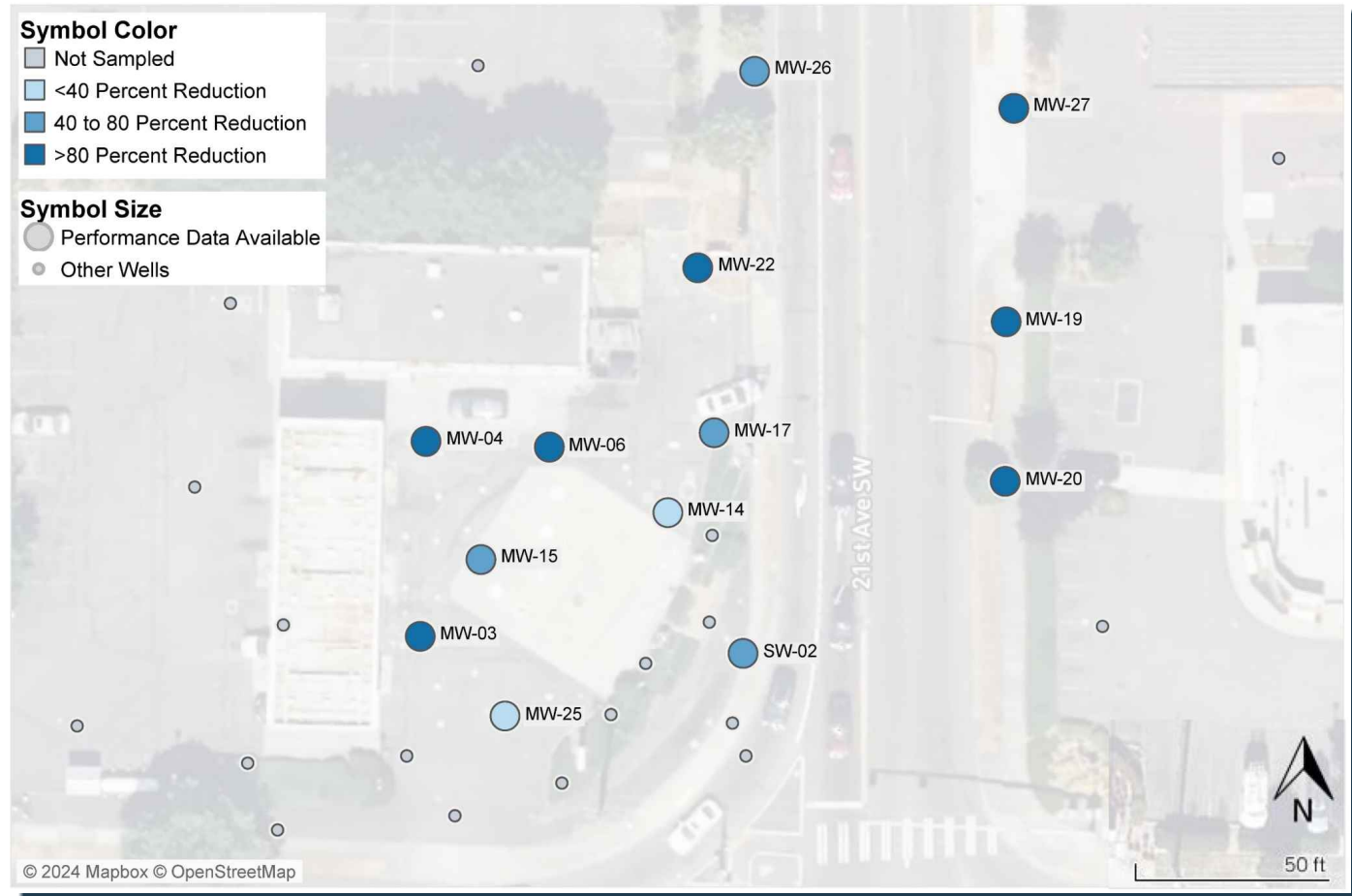
# Cleanup Action – ISCO Injections Feb-Jun 2022

- Three rounds of ISCO injections conducted without closing down service station. Each event took 2 days.
- Injections took longer during wet season
- Pressure monitored to prevent daylighting



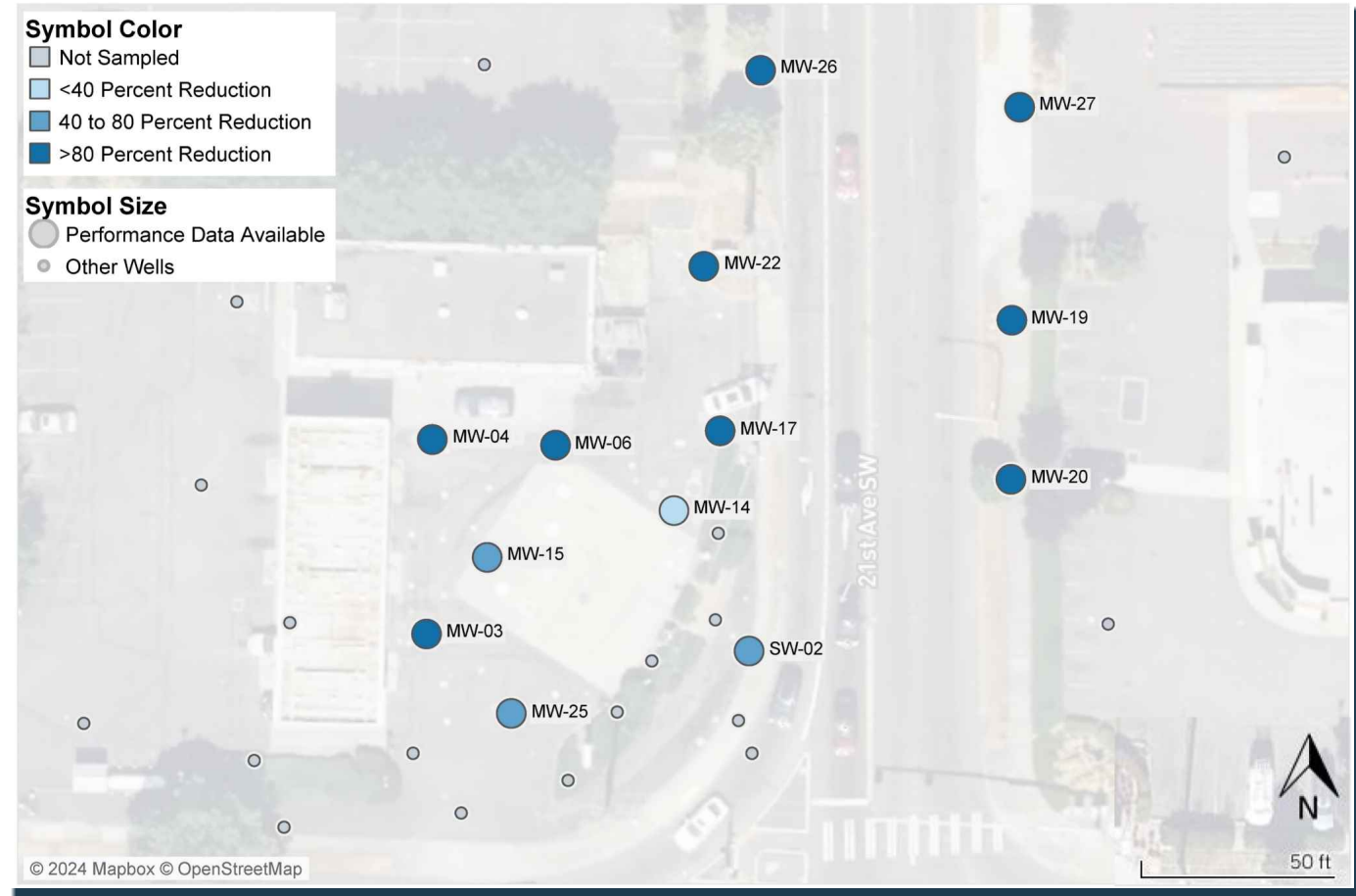
# April 2024 GRO Results

- LNAPL in key wells now meet GRO CULs
- GRO concentrations reduced from greater than 100,000 micrograms per liter ( $\mu\text{g/L}$ ) to near or less than the CUL of 800  $\mu\text{g/L}$ 
  - Dark blue = >80% reduction



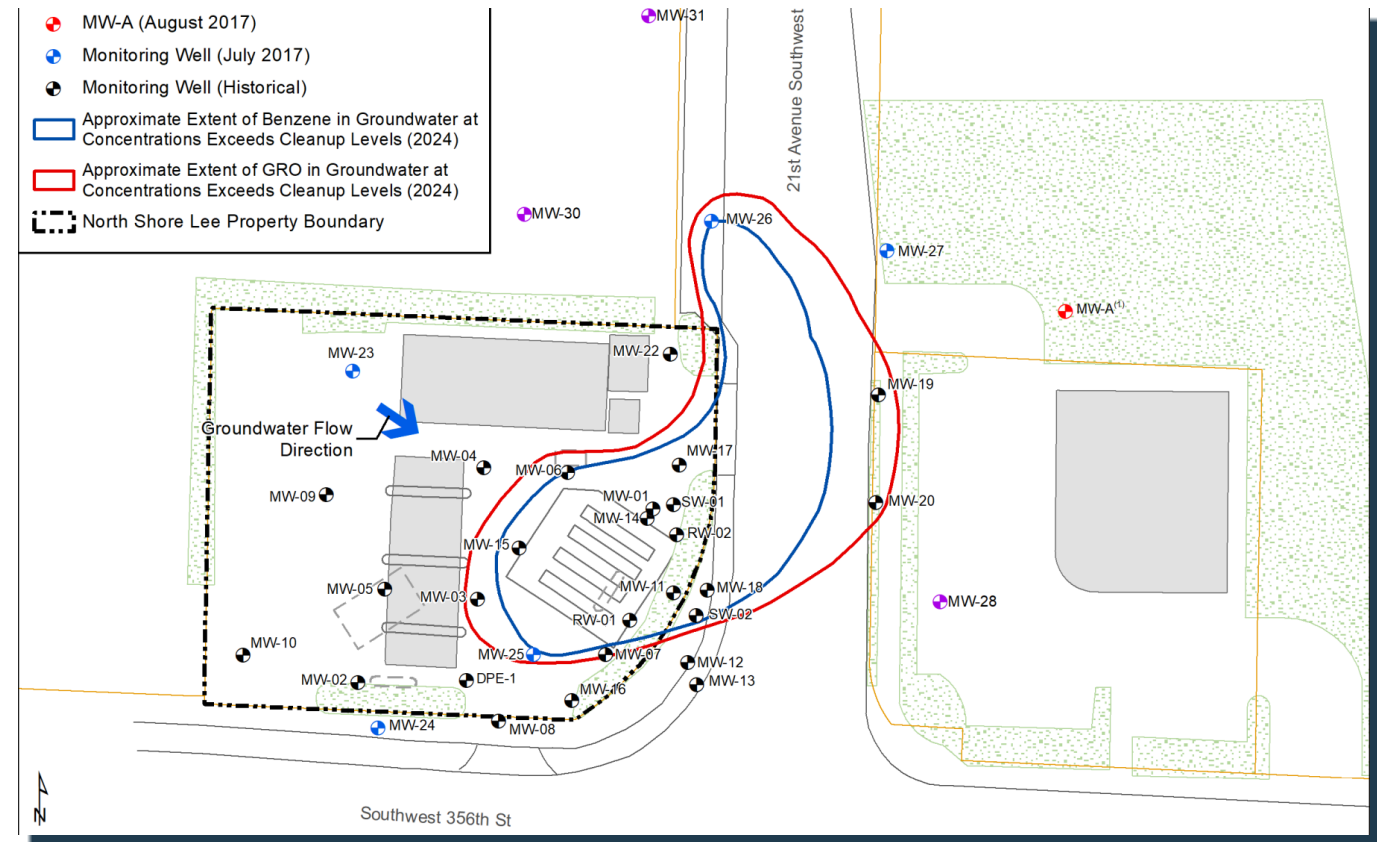
# April 2024 Total BTEX Results

- Benzene concentrations decreased from thousands of  $\mu\text{g/L}$  to slightly greater than the CUL in some wells and to less than the CUL in other wells such as MW-22.
  - Dark blue = >80% reduction



# 2024 GRO and Benzene Extent

- Dissolved-phase extent reduced
- Off-property results slightly greater than CULs
- Agency PM agreed to
  - Annual monitoring every 15 months until CULs are met
  - Followed by four consecutive quarterly events



# Thank you and Questions?

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- Thank you to Cascadia Law for bringing us interesting projects.
- Thanks to Regenesys for their assistance in developing the remedial action.

