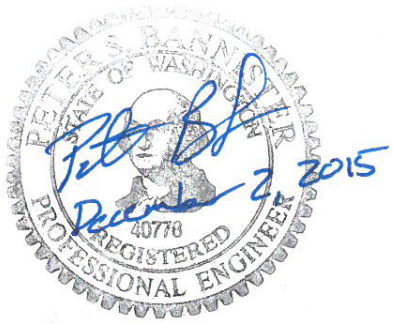
# MEMORANDUM

Project No.: 110125

December 2, 2015

**To:** Jessi Massingale, Floyd Snider

**From:**

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**Re:** **Lora Lake Pump Down/Pump-back Test Memorandum**

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This memorandum summarizes the Lora Lake pump down/pump-back test activities performed by Aspect Consulting, LLC (Aspect) and Port of Seattle (Port) representatives, and describes observed groundwater and surface water conditions in the vicinity of Lora Lake. This memorandum was revised to incorporate additional information provided by Port representatives.

The test was conducted at the request of Port representatives to support design efforts for implementing the Cleanup Action Plan for the Lora Lake parcel. The test objectives were to determine groundwater inflow to Lora Lake, which will be used to support pre-remediation and post-remediation groundwater level simulations, as well as construction planning. The test was proposed during a meeting with the project team and Port representatives on August 11, 2015. The proposed test was vetted with the Washington State Department of Ecology (Ecology), Washington State Department of Natural Resources, and the US Army Corps of Engineers (USACE), and approved in a joint agency letter from the USACE and Ecology dated September 10, 2015 (USACE and Ecology, 2015). The test was implemented in late September and early October 2015, and

results indicated a minimum groundwater inflow rate to Lora Lake of approximately 30 gallons per minute (gpm), and a storage capacity for the 518 Pond of approximately 1.2 million gallons (MG).

## Test Planning, Setup, and Operations

Aspect and Port representatives developed the test plan to pump surface water from Lora Lake, temporarily store the water in Port of Seattle stormwater Pond M, and finally pump the water back into the 518 Pond to infiltrate. The Site map on Figure 1 shows the location of Lora Lake, Pond M, and the 518 Pond. Groundwater and surface water levels were monitored before, during, and after the test. The test was conducted in phases, summarized in Table 1 below.

**Table 1 - Lora Lake Test Phase Dates and Durations**

| Phase | Start | End | Duration (days) |
|---|---|---|---|
| Pre-test Monitoring | 8/29/15 0:00 | 9/28/15 8:00 | 30.3 |
| Lora Lake Drawdown | 9/28/15 8:00 | 9/30/15 8:00 | 2.0 |
| Lora Lake Recovery | 9/30/15 8:00 | 10/5/15 8:20 | 5.0 |
| Pump-back to 518 Pond | 10/5/15 8:20 | 10/6/15 11:30 | 1.1 |
| Post-test Monitoring | 10/6/15 11:30 | 10/19/15 10:45 | 13.0 |

In consultation with the Department of Ecology, Port representatives determined that it was possible to have zero discharge to receiving waters by infiltrating all water from the drawdown phase into either Pond M or the 518 stormwater facility. Consistent with the Port's monitoring plan (Port of Seattle, 2015), water from the Lora Lake drawdown was settled prior to infiltration in accordance with Best Management Practice C241 -Temporary Sediment Pond (Ecology, 2014) and was monitored for water quality parameters while it was in Pond M.

### *Water Level Monitoring*

Prior to the test, Port representatives installed datalogging pressure transducers at selected monitoring locations to collect continuous water level data. Aspect and Port representatives also performed manual water level measurements at selected locations to supplement the continuous water level data. During the test, Port representatives moved transducers to optimize monitoring. The Site map on Figure 1 shows locations for monitoring wells, mini piezometers, and staff gages installed at the Site. Table 2 summarizes the selected pump down/pump-back monitoring locations, reference elevation source (i.e., survey versus LiDAR estimate), and monitoring frequency.

Due to the relatively shallow installation of staff gage SG-LL-1, Aspect representatives installed supplemental staff gages to monitor the Lora Lake stage during the drawdown phase. Thus, all data reported for SG-LL-1 accurately reflect Lora Lake stage.

Port representatives installed a staff gage in the 518 Pond (SG-518) to monitor water levels during the pump-back phase. SG-518 was installed near the low point of the pond, and the observed stage was converted to elevation based on ground surface elevation from LiDAR.

### *Miller Creek Monitoring*

Aspect and Port representatives measured flow in Miller Creek to supplement existing stage/discharge relationships. Flows at SG-MC-2 and SG-MC-3 were approximately 0.1 cubic foot

per second based on measurements using a Flowtracker instrument. These measurements appear consistent with the stage discharge rating curves developed in the *Lora Lake 2013-2014 Surface Water - Groundwater Baseline Monitoring Data Summary Memorandum* (Aspect, 2015).

Water quality monitoring was conducted by Port representatives to ensure the pumping operations did not impact Miller Creek or other receiving waters and wetlands. Water pumped to Pond M was monitored for pH, temperature and turbidity.

### *Pumps and Pipelines*

Port representatives installed, tested, and operated two temporary Godwin CD150M pumps (6-inch inlet and outlet; maximum pumping rate of 2,300 gpm with no suction or pressure head) and 6-inch conveyance pipelines. During the drawdown phase, pumps were set up in parallel and piping was set up to convey water from Lora Lake to Pond M. Port representatives selected the path for the suction pipe to minimize impacts to natural resources in the area. The suction pipe was placed predominantly outside of the restrictive covenant and crossed a minimal distance of shoreline. In addition, the suction pipe followed the access path for a previously approved groundwater monitoring well installed in June 2013, where invasive weeds had been cleared and vegetation had been trimmed.

The suction pipe intake in Lora Lake was set up to float offshore in water that was greater than six feet deep. To prevent fish passage, Port representatives constructed and attached a fish exclusion device to the pipe intake. To prevent disturbing lake sediment, the pipe intake was set at two feet below the lake surface, which was greater than four feet above sediment. During the drawdown phase, the device was monitored to ensure it was functioning properly and remained in place. As an additional check, a Port Biologist conducted a walkthrough of the Pond M site to ensure no fish were present.

During the pump-back phase, pumps were set up in parallel and piping was rearranged to convey water from Pond M to the 518 Pond. Aspect and the Port collaboratively monitored pump discharge via an analog flow meter. The Site map on Figure 1 shows the approximate location for the temporary pumps and the conveyance pipeline.

## Test Observations

The top graph on Figure 2 presents hydrographs of water level elevations and trends observed during the test, as well as the invert elevation of the culvert between Lora Lake and Miller Creek. The middle graph on Figure 2 shows the cumulative volume of water pumped during the drawdown and pump-back phases. The bottom graph on Figure 2 shows daily precipitation reported at the Seattle-Tacoma International Airport. Precipitation before the test was limited, and no precipitation or stormwater discharge to Lora Lake occurred during the drawdown, recovery, and pump-back phases.

### *Pre-Test Monitoring*

During pre-test monitoring, water levels were relatively consistent, including stages in Miller Creek. Several groundwater monitoring locations were found to be dry, including HPA1-3, HPA1-4, MW-8, and MW-10. Figure 3 shows the pre-test groundwater elevation contour map, and reflects lower water levels due to drier conditions than observed during baseline monitoring in 2013 and 2014 (Aspect, 2015).

### *Lora Lake Drawdown Phase*

The drawdown phase commenced on 9/28/2015 at 8:00 and ended 48 hours later on 9/30/2015 at 8:00. Aspect recommended a maximum Lora Lake drawdown of 2 feet (ft) during the drawdown phase. During the drawdown phase, pumping rates were relatively steady with an average of 580 gpm and a total of 1.68 MG of lake water was pumped into Pond M. There was no surface water discharge from Pond M into receiving waters. The water in Pond M had the following water quality parameters: the pH measured 8.77; the temperature was 16.02 degrees C; and the turbidity was 12.1 NTUs. As described below, approximately 0.4 MG of pumped water infiltrated at Pond M.

During the drawdown phase, the Lora Lake stage decreased steadily to about 1.84 ft below the initial stage, or about 1.48 ft below the culvert invert elevation. Groundwater levels decreased by less than 0.1 ft, except at wells MW-LL-1 and HC99-B31 which exhibited decreases of 0.61 ft and 0.47 ft, respectively. Miller Creek stages appeared relatively stable during the drawdown phase, and there were no notable changes in flow rates.

The lake buffer vegetation was observed during the drawdown phase. While water levels were drawn down during the two days of pumping, the soils in the area appeared to stay moist and there was no observed erosion or vegetation mortality associated with the test.

### *Lora Lake Recovery Phase*

The recovery phase commenced on 9/30/2015 at 8:00 and ended 5 days later on 10/5/2015 at 8:20. During the recovery phase, the Lora Lake stage increased approximately 0.22 ft, for a residual drawdown of 1.64 ft. Based on a comparison of the Lora Lake stage during drawdown and recovery, the average groundwater inflow during recovery was calculated at approximately 30 gpm. Groundwater levels continued to decrease during the recovery phase. Most groundwater levels decreased less than 0.5 ft from initial pre-drawdown levels, except at MW-LL-1 and HC99-B31 where decreases were measured at 0.95 ft and 0.70 ft, respectively. Miller Creek stages appeared relatively stable during the recovery phase, and there were no notable changes in flow rates.

### *Pump-Back to 518 Pond Phase*

The pump-back phase commenced on 10/5/2015 at 8:20 and ended 27 hours later on 10/6/2015 at 11:30. Aspect recommended a maximum stage height in the 518 Pond of 4 feet during the pump-back phase before shutting off the pumps to avoid overflowing the 518 Pond. During the pump-back phase, pumping rates were approximately 900 gpm, on average, and a total of 1.25 MG was transferred from Pond M back into the 518 Pond. Approximately 0.4 MG less water was pumped back to the 518 Pond than was pumped from Lora Lake, likely due to infiltration and evaporation at Pond M. A temporary pause in pumping occurred between 4:00 and 8:00 on 10/5/2015 because the discharge pipe inlet broke suction and had to be repositioned.

During the pump-back phase, the 518 Pond stage reached about 3.53 feet above the bottom of the pond before the temporary pause in pumping occurred. There was no surface water discharge from the 518 Pond into receiving waters. The maximum 518 Pond stage was about 22 feet above the initial groundwater level in the vicinity of the pond. The Lora Lake stage increased approximately 0.05 ft during the pump-back phase to the 518 Pond, for a residual drawdown of 1.59 ft. Based on a comparison of the Lora Lake stage during drawdown and pump-back, the average groundwater inflow during pump-back was calculated at 40 gpm. Groundwater levels continued to decrease during the pump-back phase, except at those wells located in close proximity to the 518 Pond

including HC00-B312 and MW-LL-1. Water levels in HC00-B312 and MW-LL-1 increased 2.5 ft and 0.45 ft, respectively, from minimum levels during the pump-back phase. The observed time lag in water level increases (see Figure 2) after the pump-back phase commenced reflects filling storage in the soil column beneath the 518 Pond. Miller Creek stages appeared relatively stable during the pump-back phase, and there were no notable changes in flow rates.

### *Post-Test Monitoring*

Post-test monitoring commenced on 10/6/2015 at 11:30. During post-test monitoring, the 518 Pond stage decreased to the pond bottom within 18 hours. Subsequent stages in the 518 Pond on and after 10/12/2015 are associated with stormwater input by Port representatives for airport stormwater management purposes. An estimated maximum infiltration rate of approximately 0.9 inch per hour was calculated for the 518 Pond based on the pump-back volume of 1.25 MG, the estimated 35,000-square-foot area of the 518 Pond, and the 63 hours required for infiltration. Figure 2 shows maximum water levels at HC00-B312 and MW-LL-1 occurred more than 24 hours after the pump-back phase ended. The extent of groundwater mounding was observed based on maximum water levels in HC00-B312, MW-LL-1, and MW-7. Figure 4 shows the maximum extent of groundwater mounding as a result of the pump-back phase.

Water levels observed during the post-test monitoring were influenced by precipitation. On 10/7/2015 and 10/10/2015, 0.4 inch and 1.1 inches respectively of precipitation increased the Lora Lake stage, groundwater levels, and Miller Creek gage stages. The precipitation event on 10/10/2015 alone resulted in about 40 percent total recovery of Lora Lake stage following the drawdown phase. The Lora Lake stage reached the culvert discharging to Miller Creek on 10/16/2015.

## Summary of Findings

The findings from the Lora Lake drawdown, recovery, and pump-back phases of this effort include the following:

- Lora Lake was drawn down below the discharge culvert invert elevation over a two-day period.
- The Lora Lake stage was slow to recover, indicating that groundwater recharge to Lora Lake is limited.
- During the pump-back phase, the observed infiltration rate, groundwater mounding, and limited connection with Lora Lake identified the 518 Pond as a potential infiltration facility during remediation efforts or for other Port stormwater management efforts.
- During implementation of the Cleanup Action Plan, pumping surface water from Lora Lake to the 518 Pond will provide an effective water management option. Pumping will control the Lora Lake stage during fill operations and prevent construction-related impacts to Miller Creek.

## Limitations

Work for this project was performed for Floyd Snider (Client), and this memorandum was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

All reports prepared by Aspect Consulting for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect Consulting. Aspect Consulting's original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

## References

Aspect Consulting LLC, 2015, Lora Lake 2013-2014 Surface Water – Groundwater Baseline Monitoring, Data Summary Memorandum.

Ecology, 2014, Stormwater Management Manual for Western Washington, December 2014.

Port of Seattle, 2015, Dewatering Monitoring Plan, Lora Lake Drawdown Test, September 2015.

U.S. Army Corps of Engineers (USACE) and Washington State Department of Ecology (Ecology), 2015, Letter correspondence between agencies and Port of Seattle, September 10, 2015.

## Attachments

Table 1—Lora Lake Test Phase Dates and Durations (*in text)*

Table 2—Hydrologic Monitoring Point Inventory

Figure 1—Site Map

Figure 2—Observed Hydrologic Conditions

Figure 3—Pre-Test Groundwater Elevation Contour Map

Figure 4—Maximum Groundwater Mound Resulting from Pump-Back Test

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# Table 2 - Hydrologic Monitoring Point Inventory

Project No. 110125, Lora Lake RI/FS Support
Burien, WA

| | Station Name | Reference Elevation Source[1] | Location | Monitoring | |
|---|---|---|---|---|---|
| | | | | Manual[2] | Datalogger[3] |
| Surface Water | SG-MC-2 | Survey | Miller Creek | X | X |
| | SG-MC-3 | Survey | Miller Creek | X | X |
| | SG-LL-1 | Survey | Lora Lake | X | X |
| | SG-LL-2 | Survey | Wetland | X | X |
| | SG-518[4] | LiDAR | 518 Pond | X | X |
| Groundwater | MW-8 | Survey | Des Moines Memorial Drive | X | |
| | MW-9 | Survey | Des Moines Memorial Drive | X | |
| | MW-10 | Survey | Des Moines Memorial Drive | X | |
| | MW-11 | Survey | Des Moines Memorial Drive | X | X |
| | HPA1-1 | Survey | Bank of Lora Lake | X | X |
| | HPA1-3 | Survey | Bank of Lora Lake | X | X |
| | HPA1-4 | Survey | Bank of Lora Lake | X | X |
| | HC99-B31 | Survey | Wetland | X | X |
| | HC00-B311 | LiDAR | East of Lora Lake | X | |
| | HC00-B312 | LiDAR | North of Lora Lake | X | X |
| | MW-LL-P1 | Survey | Wetland | X | X |
| | MW-LL-1 | Survey | North of Lora Lake | X | X |

**Notes:**

[1] All elevations referenced to vertical datum NAVD88.

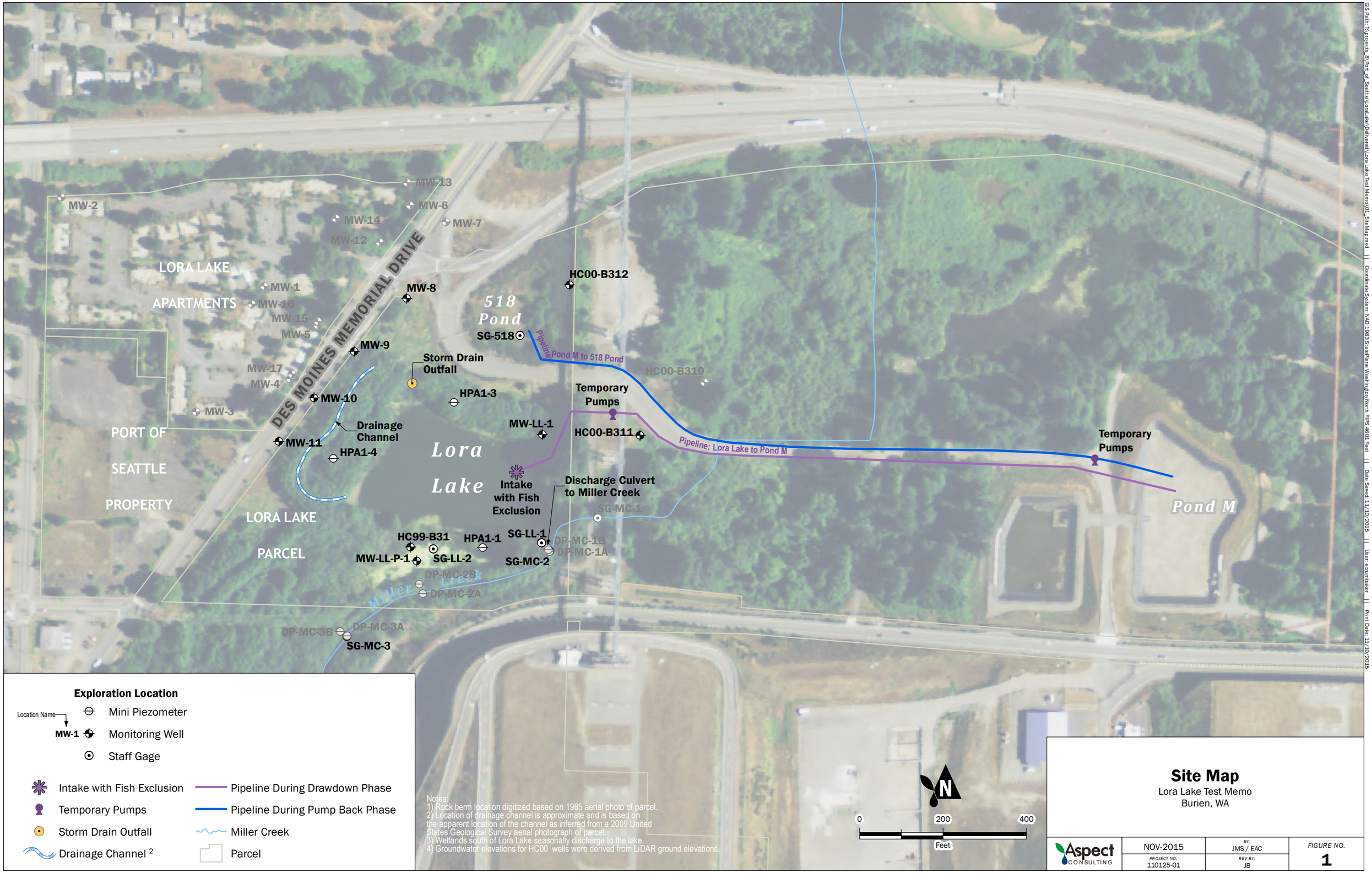
"Survey" indicates monitoring point reference elevation measured by professional surveyors.

"LiDAR" indicates monitoring point reference elevation based on 2007 LiDAR ground surface measurement and monitoring point dimensions (i.e. well stickup).

[2] Manual water level measurements were made periodically during test.

[3] Datalogger recorded pressure transducer water level measurements every 15 minutes.

[4] SG-518 was installed by Port representatives in the 518 Pond before the pump-back phase.

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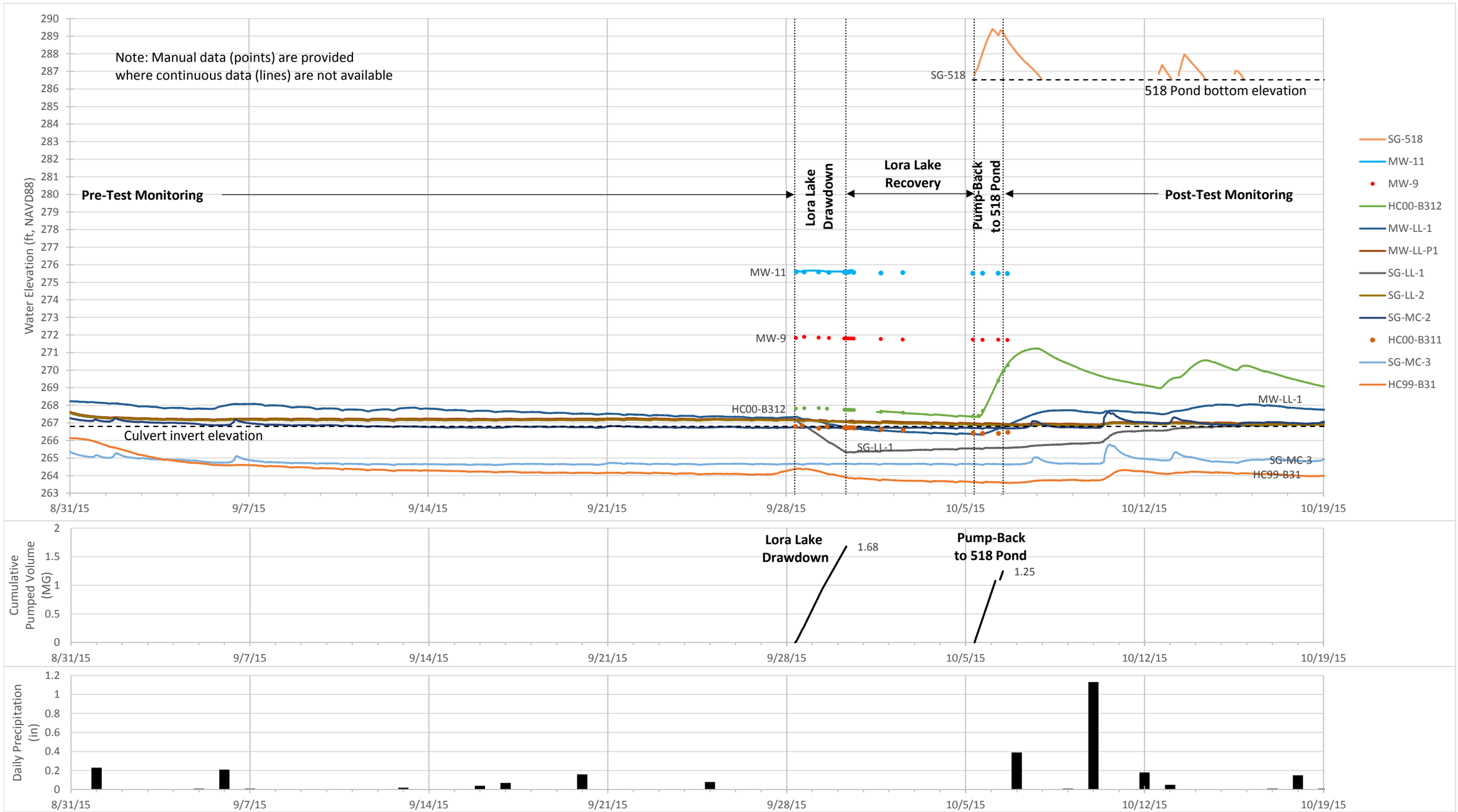
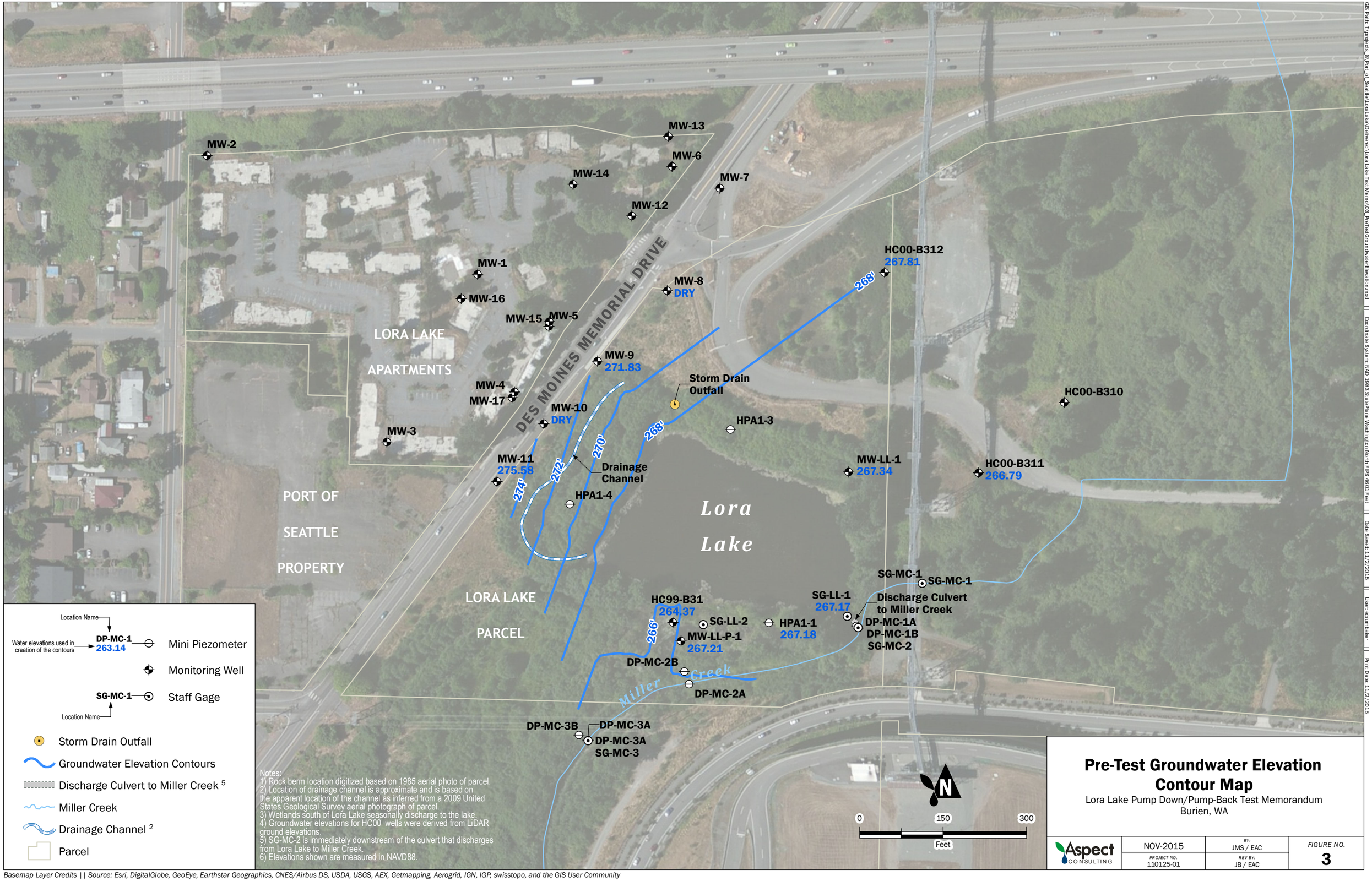



**Aspect Consulting**
10/30/2015
*\\biserver1.aspect.local\projects\Port of Seattle\Lora Lake\Lake Fill Baseline Data\Field data\Lake drawdown test\Lora Lake drawdown test - compiled data.xlsx*

**Figure 2**
**Observed Hydrologic Conditions**

Lora Lake Pump Down/Pump-BackTest Memorandum
Lora Lake RI-FS Support, Burien, WA




Location Name
DP-MC-1
263.14
Water elevations used in creation of the contours

- Mini Piezometer
- Monitoring Well
- SG-MC-1 (Location Name) — Staff Gage
- Storm Drain Outfall
- Groundwater Elevation Contours
- Discharge Culvert to Miller Creek [5]
- Miller Creek
- Drainage Channel [2]
- Parcel

Notes:
1) Rock berm location digitized based on 1985 aerial photo of parcel.
2) Location of drainage channel is approximate and is based on the apparent location of the channel as inferred from a 2009 United States Geological Survey aerial photograph of parcel.
3) Wetlands south of Lora Lake seasonally discharge to the lake.
4) Groundwater elevations for HC00 wells were derived from LiDAR ground elevations.
5) SG-MC-2 is immediately downstream of the culvert that discharges from Lora Lake to Miller Creek.
6) Elevations shown are measured in NAVD88.

# Pre-Test Groundwater Elevation Contour Map

Lora Lake Pump Down/Pump-Back Test Memorandum
Burien, WA

| Aspect Consulting | NOV-2015 | BY: JMS / EAC | FIGURE NO. 3 |
|---|---|---|---|
| | PROJECT NO. 110125-01 | REV BY: JB / EAC | |

*Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community*

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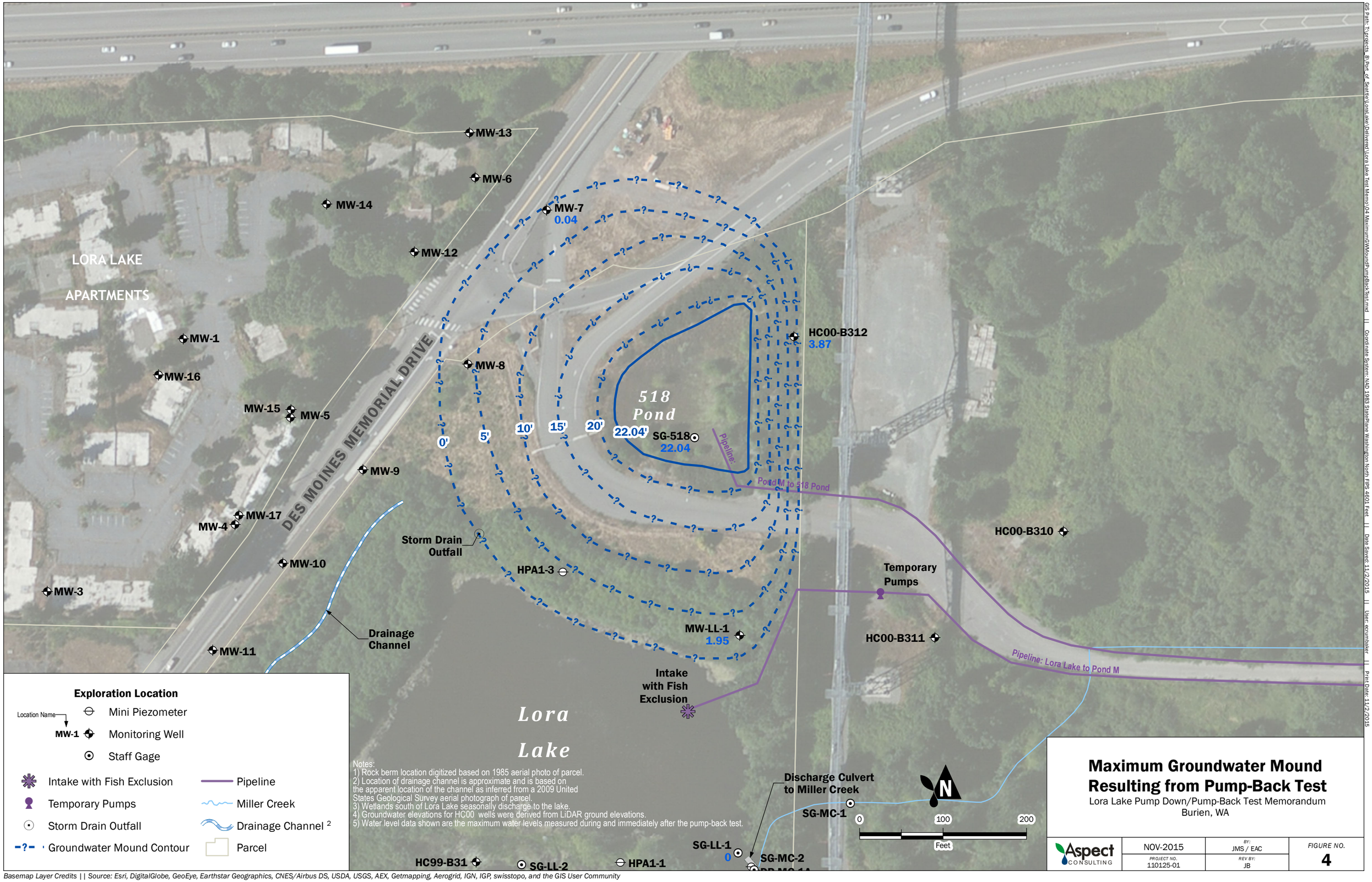


**Exploration Location**

Location Name → MW-1

- Mini Piezometer
- Monitoring Well
- Staff Gage
- Intake with Fish Exclusion
- Temporary Pumps
- Storm Drain Outfall
- Groundwater Mound Contour
- Pipeline
- Miller Creek
- Drainage Channel [2]
- Parcel

Notes:
1) Rock berm location digitized based on 1985 aerial photo of parcel.
2) Location of drainage channel is approximate and is based on the apparent location of the channel as inferred from a 2009 United States Geological Survey aerial photograph of parcel.
3) Wetlands south of Lora Lake seasonally discharge to the lake.
4) Groundwater elevations for HC00 wells were derived from LiDAR ground elevations.
5) Water level data shown are the maximum water levels measured during and immediately after the pump-back test.

# Maximum Groundwater Mound Resulting from Pump-Back Test

Lora Lake Pump Down/Pump-Back Test Memorandum
Burien, WA

| Aspect Consulting | NOV-2015 | BY: JMS / EAC | FIGURE NO. 4 |
|---|---|---|---|
| | PROJECT NO. 110125-01 | REV BY: JB | |

*Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community*

GIS Path: T:\projects_8\Port_of_Seattle\Lora Lake\Delivered\Lora Lake Test Memo\04 Maximum GW Mound\PumpBackTest.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 11/2/2015 || User: ecrumbaker || Print Date: 11/2/2015