Remedial Action Completion Report

Joint Base Lewis McChord

Logistics Center

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I. BACKGROUND

Joint Base Lewis-McChord (JBLM) is located about 10 miles south of Tacoma, Washington along Interstate 5, which bisects the installation (Figure 1). The installation occupies 90,837 acres in Pierce and Thurston Counties, Washington. JBLM was formally established as one of 12 joint bases worldwide on 1 October 2010. The merger of the former Fort Lewis (established 1917) and McChord Air Force Base (established 1947) was directed by the 2005 Base Realignment and Closure Commission. There are three cantonment areas of JBLM designated as: McChord Field (former McChord Air Force Base), Lewis-Main (former Fort Lewis) and Lewis-North (former North Fort Lewis). This Remedial Action Completion Report (RACR) addresses the Logistics Center NPL Site (Figure 2). The Logistics Center was listed on the NPL in December 1989 due to the release of chlorinated solvents found in the City of Tillicum's public water supply wells. This RACR addresses all the selected remedies for the Logistics Center.

The source of the Logistics Center groundwater plumes is the approximately 23-acre EGDY (i.e., Landfill 2) located immediately southeast of the Logistics Center on Lewis Main (Figure 2). This former industrial landfill was in operation between 1946 and the late 1960's or early 1970's. TCE (the primary degreaser used at the Logistics Center), mixed solvent/petroleum hydrocarbons, oil and lubricant wastes were disposed of at the EGDY. These wastes were transferred to the EGDY in drums and buried in trenches. It is unknown if the drums were crushed or left intact during operations. Some liquid wastes were poured directly into trenches and either used to burn woody debris or simply buried. A Record of Decision (ROD) was issued by EPA, Washington Department of Ecology, and the U.S. Army in September 1990 for the Logistics Center.

In 1983 the United States Environmental Protection Agency (EPA) and Tacoma – Pierce County Health Department (TPCHD) initiated studies of potential groundwater contamination north of Fort Lewis' Logistics Center in response to public concern. Studies confirmed the presence of TCE and DCE in domestic drinking water wells in the American Lake Garden Tract (ALGT) neighborhood. Seventeen monitoring wells were installed primarily east of ALGT and confirmed that an area located on McChord Air Force Base (currently McChord Field) was the source of TCE. In 1984 a second investigation was initiated by McChord Air Force Base's Installation Restoration Program (IRP) which included installing 26 more monitoring wells on the west side of ALGT. This investigation confirmed that another source of TCE was present in the area and most likely came from Fort Lewis' Logistics Center.

In 1984 to 1986 The United States Army Corps of Engineers (USACE) installed 47 monitoring wells throughout the Logistics Center. This investigation indicated that TCE was moving northwest under the Logistics Center. At the request of TPCHD Fort Lewis tested three domestic wells located in Tillicum, Washington north of the Logistics Center (Figure 2). All three wells were found to have low concentrations of both TCE and DCE in them. Ten more groundwater monitoring wells were installed in Tillicum to investigate the extent of the TCE plume north of the Logistics Center.

In 1986 to 1988 a Remedial Investigation (RI) was conducted for the Logistics Center by the Army. A total of 22 monitoring wells were completed in the Upper Vashon aquifer, three wells in the Lower Vashon aquifer and five wells in the Sea Level aquifer below the Vashon aquifer. Results from the RI indicated that groundwater in the Sea Level aquifer also had TCE in it.

In December 1989 the Fort Lewis Logistics Center was included on the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. An installation-wide Federal Facilities Agreement between the U.S. Army, the U.S. Environmental Protection Agency (EPA), and the State of Washington Department of Ecology (Ecology) became effective January 29, 1990. The agreement established the procedures for agency coordination and a schedule for all CERCLA activities at Fort Lewis.

The Record of Decision (ROD) for the Logistics Center was signed and implemented in September 1990 after a Remedial Investigation / Feasibility Study (RI/FS) was completed earlier that year. The selected remedy for groundwater cleanup in the upper aquifer (Vashon) at the Logistics Center was groundwater extraction and treatment by using two pump-and-treat facilities (US Army, 1990). The ROD also required an additional investigation in the Sea Level aquifer because of high concentrations of TCE (52µg/L to 143µg/L) detected in samples collected from monitoring well LC-41D during the RI.

In 1992 a Lower Aquifer (Sea Level aquifer) Study was conducted by the Army in response to the required investigation in the ROD. The objective of the study was to better define the extent of contamination present in the Sea Level aquifer (SLA) and to determine if LC-41D was the source of TCE in the SLA. It was suspected that LC-41D was allowing groundwater in the Vashon aquifer to seep along the annular space of the well into the SLA and transport TCE from the Vashon aquifer to the SLA. The study was conducted in two phases.

Phase one of the study included completion and sampling of six new SLA wells (LC-26D, LC-35D, LC-47D, LC-50D, LC-67D, and LC-68D) and sampling four existing SLA wells (LC-21c, LC-41D, LC-41e, and T-9e) for two rounds. Sampling events were conducted on 22 July and 20 November 1991.

During Phase 2 of this study two monitoring wells were completed in the SLA (LC-69D and LC-70D) and two monitoring wells in the Vashon aquifer (LC-41a and LC-41b). LC-69 was completed up gradient of LC-41D and LC-70D was completed down gradient of LC-41D. Monitoring wells LC-41a and LC-41b were completed within 50 feet of LC-41D. Sampling events were conducted on 03 and 23 December 1992.

TCE detected in samples collected from the two Vashon aquifer monitoring wells completed in Phase 2 of the study ranged from 110.92µg/L (LC-41b) to 154.66µg/L (LC-41a). TCE was detected above 5µg/L in samples collected from four monitoring wells completed in the SLA during this study (LC-41D, LC-67D, LC-69D, and LC-70D). Concentrations ranged from

16.6µg/L (LC-67D) to 220µg/L (LC-69D). Locations of these wells are presented on Figure 10. During advancement of monitoring well LC-69D it was noted that the formation did not contain a significant amount of silts or clays but instead was characterized by slightly silty, fine sand to course gravel. As noted in the report "a deposit like this could provide a permeable window through the Kitsap aquitard that could connect the upper (Vashon) and lower (Sea Level) aquifers.

It was concluded that LC-41D was not the source of TCE in the SLA because LC-69D, located up gradient of LC-41D had concentrations of TCE above 5µg/L also. In previous sampling events TCE was not detected in samples collected from other monitoring wells completed in the SLA up gradient of both LC-41D and LC-69D indicating that TCE must be entering the SLA up gradient and within the vicinity of LC-69D through a permeable "window" between the Vashon aquifer and the SLA up gradient of LC-69D.

Interim groundwater monitoring, prior to construction of the pump-and treat systems, began in March 1993 and continued until December 1994.

Construction of the two pump-and-treat systems began in December 1994. A system of six wells was constructed: Four in Landfill 2, formerly known as the East Gate Disposal Yard (EGDY), and two about 1500 feet down gradient (Figure 3). After groundwater has been treated by the Landfill 2 system it is re-introduced to the Vashon aquifer via infiltration galleries located southeast of the system. The I-5 pump and treat system, located south of Interstate 5 was constructed with 15 extraction wells configured in a straight line to intercept Vashon Aquifer groundwater before it flows off base (Figure 4). After treatment the water is infiltrated about 1000 feet down gradient of the extraction wells. The systems began operation in July 1995. The first quarter of data with the systems in operation was collected in December 1995. The Compliance Monitoring Plan and its related document, the Operations & Maintenance Plan were implemented in October, 1996.

In 1999 low-flow sampling procedures were first implemented for monitoring wells that did not have dedicated pumps. Monitoring wells were sampled using a non-dedicated submersible pump (Monitoring Well Table). However; it was noted in the fifth annual monitoring report for the Logistics Center that concentrations of TCE had decreased significantly in three Sea Level Aquifer monitoring wells (LC-40D, LC-66D, LC-73D) during the September 1999 and subsequent sampling events when compared to sampling events prior to September 1999. It was noted in the same report that TCE concentrations had decreased sharply from the December 1999 sampling event and the 2000 sampling events in monitoring wells LC-72D and LC-126. It was suspected in the 2000 annual report that the reason for the sudden drop in TCE concentrations in samples collected from these wells could be attributed to the change from purging three well volumes of water prior to sampling to low flow procedures. During purging of three well volumes, groundwater from the screened interval was drawn into the non-dedicated pump intake. During the low-flow purging method and sampling, the water drawn into the pump was not collected from the screened interval because the dedicated Hydrostar pumps' intakes were above the screens in these wells (URS, 2001). As a result, all data collected from monitoring wells LC-40D, LC-66D, LC-72D, and LC-73D from August 1999 to December 2000 were rejected as valid concentrations of TCE. Rejected data was not used to create the linear graphs presented in this report.

Beginning in December 1999 dedicated bladder pumps were installed in Sea Level aquifer monitoring wells and were sampled using low-flow procedures. By December 2000 all but three Sea Level aquifer monitoring wells (LC-21c, LC-69D, and LC-70D) had dedicated bladder pumps in them. Vashon aquifer monitoring wells were sampled with both dedicated and non-dedicated pumps until 2006 when almost all mechanical pumps were replaced with passive diffusion bags.

In 2001 an Explanation of Significant Difference (ESD) was issued for the Logistics Center. Described in the document was a requirement that innovative technologies be utilized to expedite remediation in Landfill 2, which was considered the source area of TCE (Figure 2). Source removal and thermal remediation were selected. Source removal was conducted in 2001. Approximately 2,272 containers, ranging in size from 5 gallons (the majority of containers) to 50 gallons were removed from Landfill 2. Approximately 580,000 pounds of Resource Conservation and Recovery Act (RCRA) waste, including the containers, impacted soil and liquids or sludge still in the containers were removed. Approximately 8,500 to 46,000 pounds of TCE was removed as part of the RCRA waste stream.

In 2002 a remedial action monitoring network optimization report was completed by the Corps of Engineers. Suggestions in the report resulted in changes to the remedial action monitoring sampling locations and frequency beginning in 2003 (Monitoring Well Tables).

In 2002 in-situ thermal treatment using electrical resistance heating (ERH) was performed by Thermal Remediation Services Inc. (TRS) of Longview, Washington. Three separate areas inside of Landfill 2 (NAPL Areas 1 through 3) were identified as candidates for ERH treatment.

In December 2003 TCE removal in NAPL Area 1 began and was completed in August 2004. The EGDY pump and treat system was shut down in fall 2004 to allow thermal remediation. An estimated 31,000 cubic yards of soil were treated and an estimated 2,500 kilograms (kg) of TCE were removed.

In November 2004, execution of the Logistics Center remedial action monitoring (LogRAM) program transferred from U. S. Army Corps of Engineers contractor, URS Corp to the Fort Lewis IRP. A revised *Fort Lewis Logistics Center Compliance Monitoring Plan* was also prepared. This plan implemented a number of changes to the original monitoring program and revised addendum management plan.

Also in 2004, 16 new Sea Level Aquifer wells were completed to determine the down gradient extent of the TCE plume in the Sea Level Aquifer. However, data collected in 2005 indicated that the down gradient extent of the plume was not completely characterized. Eight additional wells were installed in December 2005.

TCE removal in NAPL Area 2 began in February 2005 and was completed in August 2005. The Landfill 2 pump and treat system was shut down to allow the hydraulic grade to stabilize and to allow hydraulic control pumping in Area 2 for thermal remediation (February to August 2005). The purpose of the pumping was to flatten the hydraulic grade in Area 2 and thus keep groundwater from flowing out of the heating zone. An estimated 36,500 cubic yards of soil was treated and approximately 1,090 kg of TCE was removed.

In 2005 Fort Lewis IRP also evaluated the monitoring network to further optimize sampling efforts. Changes included, sampling frequency reduction for selected wells, elimination of several wells from the monitoring program, rescheduling of the annual monitoring event from March to August/September, and the installation of new wells to fill spatial data gaps. Additional monitoring wells were installed in 2006 and 2007 to address data gaps in the lower Vashon aquifer.

A bioremediation research project began in May 2005 in Area 3 and was completed in August, 2006. Approximately 3 tons of nutrients (whey) were injected into the up gradient groundwater. Down gradient groundwater was then extracted and analyzed. Results indicate a reduction in dissolved phase TCE, and elevated quantities of 1,2 cis-dichloroethene, and vinyl chloride. Sampling of down gradient wells indicated vinyl chloride concentrations were limited to the immediate treatment area.

In October 2005 construction began to upgrade and re-configure the Landfill 2 pump and treat system. Construction was completed in April 2006. The upgrade consisted of construction of new extraction wells and associated piping to better contain TCE in the source area. The effluent infiltration galleries were also re-configured. Details of the hydrogeological analysis and system design are contained in the *East Gate Disposal Yard Pump and Treat System Upgrade*. The upgraded system now contains eight production wells (PW-1 through PW-8) placed in an inverted "L" shape at the northwest edge of Landfill 2. The new infiltration galleries are located southwest of the original galleries and cross gradient of the system's new production wells (Figure 3). The south end of the system (wells PW-6 through PW-8) began operation in September 2006. The north end, however, was not operated until May 2007 to allow active thermal remediation in Area 3.

In 2005 a performance assessment of the thermal treatment was conducted which continued through 2007. The assessment included extensive sampling and aquifer testing in Landfill 2, especially in thermal Areas 2 and 3.

In fall, 2006 three I-5 system extraction wells were repaired. Repair included replacement of the vertical turbine pumps with submersible pumps. This improved the reliability and longevity of the system.

In 2006 most monitoring wells that were previously sampled using either dedicated, mechanical pumps or a non-dedicated submersible pump were sampled using disposable passive diffusion bags (PDBs) for the first time (Monitoring well table). Currently all monitoring wells scheduled for sampling are sampled using PDBs except where noted on Monitoring well table.

ERH began in NAPL Area 3 in October 2006 and continued until January 2007. Approximately 23,600 cubic yards of soil was treated. Approximately 850 kg of TCE was removed. Cool down monitoring was also conducted. Three hydraulic control wells were used to reduce flow across the thermal treatment area. Discharge from the wells was routed through the Landfill 2 air stripper and into the infiltration galleries).

In 2007 PNNL assessed the I-5 pump and treat system's effect on TCE capture in the Upper Vashon aquifer using a numerical model. A fate and transport model for the entire TCE plume under the Logistics Center had been calibrated by PNNL in 2006 and was the basis for this assessment. Model simulation suggested that the effective capture of the TCE plume could be maintained by the system even with two or possibly four of the outer most extractions wells turned off. Based on the simulation results of the model it was suggested to discontinue pumping in wells LX-1 and LX-15 located on either end of the system well line (Figure 4). Extraction wells LX-1 and LX-15 were turned off in July 2007. Water samples were collected in February 2008 from LX-1 and LX-15 and a sample was collected from LX-15 in August 2008. These samples were most likely collected in error.

In spring 2007 three additional Vashon Aquifer wells (LC-222 through LC-224) were installed in the Madigan Housing area. The purpose of these wells was to more accurately define the extent and concentrations of the TCE plume in this area.

In June and July 2007, a vapor intrusion study was conducted. Ninety-six indoor air samples were collected from 10 housing units located in the Madigan Family Housing area (MFHA) west of Landfill 2 (designated as MAMC on Figure 2). Ninety samples had no TCE detected in them, four samples had TCE detected in them ranging from 0.24J µg/m3 to 1.3J µg/m3 and two samples were rejected because it was suspected that the sampling equipment was contaminated prior to sample collection. The highest concentration of TCE detected in the indoor samples was below the no further action level of 5 $\mu g/m^3$ indicating that vapor intrusion into Madigan Family Housing units did not pose an unacceptable risk or hazard to human health.

To ensure MFHA safety, a groundwater threshold was calculated using the average concentration of TCE detected in five monitoring wells in the MFHA during the indoor air sampling event and the 1.3J µg/m3 value for indoor air:

Groundwater threshold = (average groundwater TCE concentration / indoor air) * NFA level

$$96.2\ \mu g/L\ \text{(rounded up to 100)} = (25\ \mu g/L\ /\ 1.3\ \mu g/m^3) * 5\ \mu g/m^3$$

This represents a conservative correlation value between TCE concentrations in groundwater and the 5 $\mu g/m^3$ indoor air no further action (NFA) value. No further investigation or action is necessary as long as TCE concentrations are not detected above the groundwater threshold of 100 µg/L in groundwater samples collected from monitoring wells located within or immediately adjacent to the MFHA. Subsequent to the MFHA Vapor Intrusion Study, EPA Region 10 issued a memorandum on December 13, 2012 regarding TCE toxicity. The revised indoor air concentration for protection from non-carcinogenic risks by residential exposure is 2.1 ug/m^3 for long term exposure and a two week exposure concentration of 8.4 ug/m^3. As of the writing of this report, TCE concentrations in MFHA monitoring wells have been declining and are below 100 µg/L (45 ug/L maximum in 2007 and currently 29 ug/L in 2015 at monitoring well LC-218).

The original ROD did not adequately address TCE in the Sea Level aquifer (SLA). At that time only six monitoring wells were completed in the SLA. TCE was detected in only one SLA monitoring well (LC-41D) at 113 µg/L in June 1990. From 1990 to 2005 additional investigation was conducted in which over 40 wells were completed in the SLA. Groundwater concentrations in many of these wells were above the cleanup level. In February 2007 a follow-on ESD was published for the Logistics Center describing remediation of the SLA component of the 1990 ROD. Construction of a Sea Level Aquifer pump and treat system (SLAPT) began in 2007 and was completed in October 2009. Six extraction wells (SLAP-1 through SLAP-6) and 11 monitoring wells (LC-96D through LC-103D) were constructed in the SLA.

An Environmental Strategic Technology Certification Program (ESTCP) project began in October 2008 and was completed in 2010. The project was designed to demonstrate the benefits of combining low-energy electrical resistance heating (ERH) with in-situ bioremediation (ISB) and iron-based reduction using zero valent iron (ZVI), for the remediation of dense NAPL source zones in Landfill 2. The objectives of the demonstration included:

- Assess the extent to which contaminant degradation is enhanced during heating compared to ambient temperatures;
- The relative contribution of biotic an abiotic contaminant degradation mechanisms at different temperatures, and
- The cost-benefit of applying low-energy heating with in situ treatments.

The demonstration was conducted in three phases to improve the accuracy of evaluating the effects of ERH on ISB and ZVI reduction and comparison between the two application techniques. The two application techniques were evaluated in test cells in the following three phases:

- Phase 1: Initial characterization and verification of the suitability of each test cell to meet project objectives and provide information for a "go/no-go" decision for subsequent phases.
- Phase 2: Field demonstration of ISB and ZVI without heating. This phase of the demonstration was intended to establish the reaction kinetics and mass balance factors at ambient temperature.
- Phase 3: Field demonstration of ISB and ZVI low energy heating. This phase of the demonstration was designed to establish reaction kinetics and mass balance factors at elevated temperatures of approximately 35^{o} C for the ISB cell and 55^{o}C for the ZVI cell. Results will be compared to Phase 2.

The ISB and ZVI test cells are located immediately northeast of the fence surrounding the Landfill 2 control building and treatment tower. Groundwater monitoring wells were installed and a sampling program was designed to allow for evaluation of contaminant concentration within the test cells. The study site is not located within the boundaries of NAPL areas 1 through 3 nor is located in an area that has been previously treated for NAPL using other processes or technology. As of the writing of this report JBLM has not received a report from the Pacific Northwest National Laboratory (PNNL) or ESTCP research teams in regards to this study.

In October 2009 the Sea Level Aquifer Pump and Treat (SLAPT) system was completed and began operation (Figure 5). IRP personnel are responsible for monthly inspections and influent and effluent sampling of the system. Madigan Army Medical Center (MAMC) personnel are responsible for the operation and maintenance of the system.

The pump and treat system intercepts the TCE plume in the Sea Level aquifer and treats TCE and DCE in the water using air stripping. Treated effluent is pumped to MAMC where it is used as cooling water for the hospital's HVAC system. The SLAPT system began operating in October 2009. Prior to construction of the pump and treat system groundwater was drawn from five production wells (MAMC – 1, 3, 4, 6, and 7), circulated through the hospital's HVAC system, discharged to a cooling pond east of the building and infiltrated in an adjacent basin. These production wells are still connected to the system and are used for back up during times when the HVAC system is being heavily used (i.e. summer months).

In April 2010 a Compliance Monitoring Plan (CMP) that updated the CMP from September 2006 was completed. This plan reflected changes in the monitoring network since 2006 including:

- Installation and sampling of monitoring wells completed in the Sea Level aquifer;
- Installation and sampling of monitoring wells completed in the Upper Vashon aquifer in the vicinity of Madigan Family Housing;
- Installation and sampling of monitoring wells completed in the Lower Vashon aquifer in Tillicum, Washington;
- Changes in monitoring frequency of monitoring wells completed in the Vashon aquifer; and
- Changes in monitoring frequency of monitoring wells completed in the Sea Level aquifer within the vicinity of the Sea Level Aquifer Pump and Treat (SLAPT) system.

In October 2010 as part of a Base Realignment and Closure (BRAC) action Fort Lewis and neighboring McChord Air Force Base merged to create Joint Base Lewis-McChord. All base services including the IRP are provided by the Army-led Joint Base.

In October 2010 the SLAPT stripper tower's water distribution system was reconfigured after unexpectedly high concentrations of TCE were detected in the system's effluent samples. The original SLAPT air stripper used a splash plate under a 10-inch inlet pipe to distribute water over the tower packing. Influent water poured out of the 10 inch pipe and then splashed from the splash plate to the distributor tray. The distributor tray spanned the 9.5 ft inside diameter of the tower. The distributor tray was perforated with 1.125 inch diameter holes allowing the water to pour into the stripper tower packing material. The splash plate and distributor tray were replaced with a series of PVC nozzles connected to the 10 inch pipe. The nozzles disperse the water across a wider area over the distributor tray than the splash plate did and reduced channeling of water through the packing material. Performance of the air stripper tower was greatly improved decreasing the annual average concentration of TCE in effluent samples from 4.1µg/L (before reconfiguration) to 0.62 µg/L (2011). The average concentration of TCE in effluent samples collected from the SLAPT system in 2013 was 0.56 µg/L.

In March 2012 contractors began clearing and grading the Regional Logistics Support Center (RLSC) construction site located north of the Logistics Center (Figure 2). The I-5 pump and treat system is located within the fenced area that defines the RLSC. In 2012 the I-5 system's effluent line was modified to supply treated water as a ground source heat supply for the HVAC system of two Tactical Equipment Maintenance Facilities (TEMFs) at the RLSC. Four gate valves were installed down gradient of the system's discharge pumps. Two valves will direct water through each building's HVAC system and then two valves will re-direct the water back to the I-5 system's effluent line. Water will then be returned back to the Vashon aquifer through the system's current infiltration galleries.

In September 2013 construction began on the TEMFs buildings mentioned above. Currently the buildings are under construction and the I-5 system is not connected to the TEMFs buildings' HVAC systems.

In March 2014 construction began on a water line connecting the Landfill 2 system effluent to an HVAC system that is part of an Army Readiness Center currently under construction. The center will be located northeast of Landfill 2 (Figure 2). This system will be similar to the RLSC system described above when completed.

The 1990 selected remedy for groundwater cleanup at the Logistics Center addresses the principal threats posed by the site by treating the groundwater and by flushing secondary source residual contamination. The remedy is designed to reduce exposure to the contaminated groundwater and to remediate the groundwater to levels that are protective of human health and the environment. The 1990 remedy included pump and treat systems at two locations. One pump and treatment system was installed near the EGDY, and the other was installed two miles away adjacent to I-5. The intent of the I-5 system was to contain impacted groundwater near the installation boundary. The intent of the EGDY system was to remove groundwater with higher concentrations near the source area. These initial P&T systems began operation in July 1995 to address the VOC plume in the Vashon Aquifer. Remediation Goals were established for three contaminants: Trichloroethylene, cis 1, 2 Dichloroethylene, and Tetrachloroethylene at their respective MCLs of 5 ug/L, 70 ug/L and 5 ug/L. The ROD established a surface water Remediation Goal for Trichloroethylene at 80 ug/L for surface water. At the time of the ROD the nature and extent of TCE contamination in the deeper Sea Level Aquifer was not well understood. The ROD specified that further investigation of the SLA would be performed and that a P&T system for SLA impacts would be implemented if needed.

An Explanation of Significant Difference (ESD) was issued in 1998 that included a requirement for innovative technologies to be utilized to expedite remediation of groundwater contaminants in the EGDY source area. A July 2000 Army Decision Document for a Removal Action selected removal of drummed and containerized wastes buried in the EGDY. A second Army Decision Document for a Non Time Critical Removal Action in August 2002 specified that thermal treatment would be applied to the EGDY source area. Thermal treatment was performed from December 2003 to January 2007, in three areas conceptually illustrated in Figure 3 (“NAPL Area 1”, “NAPL Area 2”, and “NAPL Area 3”).

A bioremediation research project was conducted from May 2005 to August 2006 in “Area 3” of the EGDY as part of an enhanced in-situ bioremediaton project. Approximately 3 tons of nutrients (whey) were injected into the groundwater. A larger scale bioremediation effort at EGDY is currently underway (discussed later).

The EGDY P&T system was turned off during thermal treatment in “Area 2” (February to August 2005), and the EGDY extraction system was subsequently reconstructed in a different Configuration in late 2005. The upgraded EGDY P&T system now contains eight wells (PW-1 Through PW-8) placed in an inverted “L” shape at the northwest edge of the former disposal area (Figure 3). Only a portion of the EGDY extraction wells operated during the “Area 3” thermal remediation that lasted into 2007. Thus, there was a period of several years where there was no extraction or limited extraction at the EGDY P&T system.

Additional monitoring wells were installed in the SLA from 2004 to 2007. An ESD in August 2007 describes the decision to implement a P&T system for the SLA. Construction of the SLA P&T system began in 2007 and was completed in October 2009. The SLA P&T system began intermittent operation in late 2009 and continuous operation in April 2010.

Currently all systems are meeting their design goals and are operational and functional.

II. CONSTRUCTION ACTIVITIES

There were multiple construction mobilizations at the Logistics Center. Table 2-1 depicts the major mobilizations.

The Logistics Center site has three P&T systems in operation to contain and remediate VOCs. These systems are known as the EGDY, I-5, and SLA systems.

• The current EGDY system (Figure 3) replaced an earlier source area P&T in the Vashon aquifer that operated from 1995 to 2004 and had 6 extraction wells (EWs) also illustrated on Figure 3. The current system has extraction wells on the southwest side of the landfill, whereas the previous system did not. The current system includes 8 extraction wells with submersible pumps equipped with variable frequency drives (VFDs), a packed tower air stripper with a 5.0 HP fan, and discharge by one of two 15 HP pump to two infiltration galleries (at revised discharge locations from the previous system). The EWs are configured in a reverse L-shape and are operated to provide hydraulic containment of the source area.

• The I-5 system (Figure 4) has been in operation since 1995 with the purpose of providing hydraulic containment near the downgradient edge of the Vashon Aquifer plume along the base boundary. This system includes 15 extraction wells (14 currently operating) with submersible pumps (non-VFDs), a packed tower air stripper with a 7.5 HP fan, and discharge downgradient by one of two 40 HP pumps with VFDs to four infiltration galleries. The EWs are oriented in a straight line perpendicular to the Vashon aquifer plume and are located approximately 0.25 miles upgradient of I-5. Recharge galleries are located downgradient from the extraction lines adjacent to I-5.

• The SLA system (Figure 5) began operation in late 2009, and began continuous operation in April 2010. The purpose is to prevent the existing 5 ug/L plume from significantly expanding. Initial treatment efficiency issues were overcome with water distribution improvements in the air stripper. There are six extraction wells with submersible pumps equipped with VFDs, a packed tower air stripper with 15 HP fan, and discharge by one of two 125 HP pumps to convey the treated water to the hospital for utilization as non-contact cooling water. Discharge from the SLA system is delivered to the Madigan Army Medical center (MAMC) for cooling needs (generally March to September) and the treated water is subsequently discharged to a water feature (a creek) in the atrium of the hospital, then to a lined pond on the northeast side of the hospital, and finally to an infiltration pond where it percolates into the shallow aquifer. Even during periods when cooling at the hospital is not needed, the discharge of treated water to the water feature/pond is maintained and is seen as a beneficial use (i.e., maintains flow in the creek). Table 2.1 provides a brief summary of all three systems.

Table 2.1 Brief Summary of Logistics Area Treatment Systems

Treatment System	No. of EWs	Submersible Pump HP	VFDs	Discharge Pump HP	Approximate Total Extraction Rate (gpm)	Air Stripper Fan HP

EGDY system	8	7.5	Extraction pumps only	(2) 15	700 - 800	5.0
I-5 system	15 (14 operating)	(10) 7.5HP, (2) 5, (1) 3	Discharge pumps only	(2) 40	1100 - 1500	7.5
SLA system	6	(3)20HP, (3)50	All pumps	(2) 125	1600 - 2250	15

Note: only one discharge pump is operated at a time.

Each of the treatment systems is relatively simple, consisting of only an air stripping tower and effluent distribution lines. In each case the extraction wells connect to a pipeline that conveys water to the top of the respective air stripper tower. Water flows over packing inside the tower. A blower forces air up through the flowing water resulting in mass transfer of volatiles from the water to the air. Air is discharged at the top of the tower while the water is collected at the base and routed to a sump for subsequent discharge. The blower horsepower ratings are listed in Table 2.1.

The following table provides Land Use Controls implemented by JBLM and selected in the 1990 ROD and subsequent Army Decision Documents:

Land Use Controls

Site Name	Document Requiring LUC	Applicable Area of Site	LUC Objective
Logistics Center	April 2006 DD	Landfill 2 (aka EGDY)	• Prevent residential land use • Prevent unplanned excavation of contaminated soil • Prevent training access
	September 1990 ROD	1000 feet buffer around site boundary and within	• Prevent new drinking water wells without EPA approved monitoring plan
		Off-post portion of Vashon Aquifer trichloroethylene (TCE)	• Remind Lakewood Water District that Logistics Center should remain listed as possible source of contamination in its Wellhead Protection Program
		Upper Vashon Aquifer TCE 100 ug/L iso-concentration contour	• Prevent residential land use

Land Use Controls are maintained and enforced through the February 2014 Installation Development Plan by JBLM command.

Monitoring:
All the remedies are monitored through the Logistics Center Remedial Action Monitoring Compliance Plan, which is reviewed and approved by EPA. Appendix A presents the results of the 2014 annual monitoring and shows the monitoring wells sampled. EPA and JBLM are currently optimizing the monitoring network for tracking long term trends in groundwater concentrations now that all remediation systems are operational and functional. There has never been an exceedance of the surface water remediation goal specified in the 1990 ROD of 80 ug/L for trichloroethylene.

The vast majority of monitoring wells are sampled with Passive Diffusion Bags (PDBs). This is appropriate given the contaminants of interest. The exceptions are five wells. Two wells are sampled with a dedicated bladder pump because those pumps are "stuck in the well", and three thin wells (1.25 inch diameter) that are sampled with a peristaltic pump. PDBs are low-density polyethylene bag that is filled with deionized water. The bag acts as a semi-permeable membrane and is hung in a monitoring well at the appropriate screen interval. VOCs in groundwater will diffuse across the bag material. Typically equilibrium between the outside and inside of the PDB samples is reached after 14 days.

Data are managed electronically via an Access database.

The monitoring program for the Logistics Center plumes has been subject to several optimization efforts over the past decade, and has been upgraded over time, particularly in the SLA. A review of the recommendations from the 2004 EPA-sponsored report on the application of two methods for monitoring program optimization indicates that many of the recommendations have been already adopted for the upper and Lower Vashon aquifer monitoring programs, with further improvements beyond those recommendations. JBLM began another optimization effort in 2015. Qualitative analysis appears warranted for the shallower aquifers. The monitoring programs are discussed below by aquifer, starting with the Upper Vashon.

Upper Vashon:

As of the 2014 Comprehensive Monitoring Plan, the monitoring network includes 112 monitoring wells (52 Upper Vashon wells, 14 Lower Vashon wells, and 46 Sea Level Aquifer Wells) that are sampled for VOCs and 23 additional wells measured for depth to water. There are an additional 8 production wells for Landfill 2, three production wells in the Lower Vashon and 14 production wells that are monitored for VOC concentrations. Three surface water locations (SW-MC-07, 08, and 09) are also monitored for VOCs (Figure 10). Monitoring is focused on the vicinities of the I-5, EGDY extraction systems, Sea Level Aquifer pump and treat, and along Murray Creek southwest of the EGDY. Relatively few wells are included in the interior or along the edges of the plume between the two extraction systems. The TCE plume within the Vashon Aquifer has migrated through a discontinuity in the aquitard separating the Vashon from the Sea Level Aquifer approximately two thirds the length of the plume. There is a TCE plume lobe that extend southwest of the EGDY toward a residential area. TCE concentrations in this lobe have been declining over the past three years and no significant surface water impacts have been observed in Murray Creek. A Vapor Intrusion study was conducted to evaluate the potential for this lobe to result in vapor intrusion in homes above the lobe and determined there was no unacceptable exposure. This lobe is diminishing because the EGDY extraction system is now capturing all the plume emanating from EGDY. Sampling frequency for the Upper Vashon aquifer wells is typically annual sampling except near the extraction systems where semi-annual sampling is conducted. Some quarterly sampling is conducted downgradient of the EGDY extraction, but these have been transitioning to semiannual. In 2015 an optimization evaluation was initiated to revise the monitoring network to focus on long term trend of the plumes, presumably as they decrease in size. Many wells are shifting to annual or every five years as the systems have stabilized and historic data indicate declining concentrations within the plumes. In 2014 TCE ranged from non-detect in multiple wells to 220 ug/L (LC-49) in the Upper Vashon aquifer. See Figure 7 for 2013 Upper Vashon water table contours and Figure 10 for Upper Vashon TCE concentrations for 2013. Figure 13 depicts the Upper Vashon Aquifer TCE Trends between 2004 and 2013. Table 4-1 show TCE concentrations in 2014.

Lower Vashon:

The monitoring network in the Lower Vashon aquifer is limited, and in places the relationship between the Lower Vashon and underlying the SLA is not entirely clear where there are discontinuities in the nonglacial aquitard. As noted above, the connection with the Upper Vashon is also not completely clear. The concentrations in LC-116b, a Lower Vashon monitoring well located along the I-5 well field, are increasing. This is believed to be because the I-5 system is pulling water up from the lower Vashon aquifer, and that contaminants are back-diffusing from the top of the underlying aquitard. The source of the relatively high concentrations of TCE in LC-219, located downgradient of LC-116b and the I-5 extraction system is not clear, but the concentrations there appear to be slowly declining. Few Lower Vashon monitoring wells are included in the network in the vicinity of the EGDY. Overall, the boundaries of the TCE plume (as defined as the 5 ug/l standard for TCE) are generally defined; with the exception of the area west of LC-217, which have had concentrations below 5 ug/L the past few years. The Lower Vashon network is generally sampled annually with the exception of several wells in Tillicum and LC-116b and LC-219 that are sampled semi-annually. In 2014 TCE ranged from non-detect in multiple wells to 69 ug/L (LC-41B) in Lower Vashon aquifer wells (Table 4-1). See Figure 11 for 2013 Lower Vashon TCE Plume map. Figure 14 depicts the Lower Vashon Aquifer TCE Trends between 2004 and 2013.

Sea Level Aquifer (SLA):

The monitoring network for the SLA is extensive in the vicinity and downgradient of the SLA extraction system, and includes a number of multi-depth monitoring well clusters. The network is much sparser in the vicinity of the main portion of the Logistics Center. In 2014 TCE ranged from non-detect to 120 ug/L (LC-69D) in the Sea Level aquifer (Table 4-1). Figure 8 shows the 2013 Sea Level Aquifer water table elevations and Figure 12 depicts the Sea Level Aquifer TCE Plume Map for 2013. Figure 15 depicts the Sea Level Aquifer TCE Trends between 2004 and 2013.

The low-concentration contour (5ug/L) TCE plume in the SLA is well defined for the most part; however, the extent is not fully defined to the 5 ug/l standard for TCE in the area north of LC-72d and LC-126, and north of the LC-86D cluster. These locations are all within the base boundary. In addition, American Lake is located north of these wells and is a recharge source for the SLA which would likely limit the plume migrating to the north. There are eight well clusters located up to 1.5 miles downgradient of the 5 ug/l TCE contour for the Sea-Level plume to show whether the plume is migrating downgradient versus contracting. See Figure 12 for the 2013 Sea Level TCE Plume Map.

The sampling frequency for wells in the SLA has been generally higher than for the shallower aquifers. This is due, in part, to the relatively recent installation of the extraction system and monitoring wells. The frequencies are being transitioned to ones similar to the shallower aquifers; annual except for wells near the extraction system that would be sampled semi-annually or on a five year frequency.

There were no major disruptions, deviations, or significant problems in implementing the remedies at the Logistics Center. Although there were multiple actions, these were planned events and in response to monitoring results and improvements in remediation technologies or JBLM needs (non-contact cooling water for air conditioning).

III. CHRONOLOGY OF EVENTS

Table 3: Chronology of Significant Milestones

Event	Date
Trichloroethylene (TCE) discovered in shallow groundwater beneath the Logistics Center	1985
Logistics Center NPL listing	1989
Federal Facility Agreement (FFA) signed	1990
Logistics Center Record of Decision (ROD) signed	1990
Construction of two Logistics Center pump-and-treat (P&T) systems in Vashon Aquifer begins	1992
Logistics Center Vashon Aquifer P&T systems begin operation	1995
Low-temperature thermal desorption at SRCPP conducted	1996 – 1997
Logistics Center Explanation of Significant Difference (ESD) signed	1998
Decision Document (DD) for Logistics Center source area drum removal action signed	2000
Drum removal action at Logistics Center source area conducted	2000 – 2001
DD for Logistics Center source area in-situ thermal treatment signed	2002
Logistics Center source area Vashon Aquifer P&T system re-configured (EGDY P&T)	2003 – 2006
In-situ thermal treatment at Logistics Center source area conducted	2003 – 2007

Land use controls at Logistics Center source area (Landfill 2 soil) signed	2006
Optimization of downgradient Vashon Aquifer P&T system (Interstate 5 P&T)	2006 - 2015
Logistics Center ESD for Sea Level Aquifer (SLA) signed	2007
Indoor air sampling conducted at Madigan Housing	2007
Existing land use controls formally documented in Land Use Control Plan	2007
Construction of Logistics Center P&T system in SLA begins	2007
SLA Pump and Treatment System Operational	2010

IV. PERFORMANCE STANDARDS AND CONRSTRUCTION QUALITY CONTROL

Cleanup standards were set in the 1990 Logistics Center Record of Decision for groundwater and surface water. Performance results for the three pump and treat systems and the ERH are provided in Appendix C. Summary of the effectiveness of the three pump and treatment systems are provided in Appendix A. All monitoring has been done under an EPA approved Quality Assurance Project Plan, which is updated periodically to address changes in monitoring wells, frequency of monitoring, and field and analytical techniques.

EGDY Pump and Treat

As previously discussed, the East Gate Disposal Yard treatment system was upgraded in 2004. For the EGDY system the effluent standards are 5 ug/l for TCE, 70 ug/L for cis 1, 2 Dichloroethylene, and 5 ug/L for Tetrachloroethylene. These have always been met, except for two events in 2007 (max effluent concentration 6.09 ug/l), and over the last 8 years the discharge has always been less than 5 ug/l. The pump and treat system treats between 250Mgal and 400 Mgal per year and removes between 0.25 pound and 1.0 pound of TCE per million gallons of water. The removal efficiency has ranged between 91% and 99%, with the vast majority of monthly removal efficiency above 99%. Over 7,000 pounds of TCE have been removed since 1995. (See Appendix B-LF2 Performance Tables)

EGDY:

There were no defined performance standards for the Electric Resistance Heating/In-situ Bioremediation. The target objectives for the ERH events at NAPL areas 1, 2, and 3 were to reach a specific operating temperature (100 c) in the saturated zone, and 90 C in the vadose zone for a set time. According to the NAPL area 1 completion report TRS accomplished the target heat and set time in about 80% of the area. TRS accomplished the target temperatures and set time in 100% of NAPL areas 2 and 3. Also, each area had a specific square foot area that was to be treated. However; no specific amount of hydrocarbons and VOCs to be removed were ever defined in either the management plan or completion reports. The goal of the study was to remove as much source material (NAPL) from the landfill as possible and evaluate the effectiveness of in-situ bioremediation (ISB) and iron-based reduction using zero-valent iron (ZVI).

NAPL Areas 1, 2, and 3 (see Figure 3) were identified as containing relatively high levels of residual contaminant mass, characterized by small zones of highly concentrated contamination present within the larger ”NAPL area”. Thermal treatment of these areas was initiated in December 2003 and completed in January 2007, and summarized as follows in the performance assessment:

1) Area 1: Treatment from 12/2003 to 8/2004 (231 days) with estimated mass removed of 2,990 kg
2) Area 2: Treatment from 2/2005 to 8/2005 (172 days) with estimated mass removed of 1,340 kg
3) Area 3: Treatment from 10/2006 to 1/2007 (107 days) with estimated mass removed of 1,120 kg

The performance assessment estimated that thermal treatment reduced the mass flux from the EGDY source area by 60-90%. Currently, ISB and ZVI are being conducted at EGDY. Approximately 3 tons of nutrients (whey) were injected into the upgradient groundwater. Down gradient groundwater was then extracted and analyzed. Results indicate a reduction in dissolved phase TCE, and elevated quantities of 1,2 cis-dichloroethene, and vinyl chloride. Sampling of downgradient wells indicated vinyl chloride concentrations were limited to the immediate treatment area. This project is ongoing.

+

I-5 Pump and Treat:

For the I-5 system the effluent standards are 5 ug/l for TCE, 70 ug/L for cis 1, 2 Dichloroethylene, and 5 ug/L for Tetrachloroethylene. These limits have always been met, and since April 2001 the discharge has always been less than 1 ug/l for TCE. There are currently 14 extraction wells in operation, with a combined extraction volume of 1,400 GPM (2014 average). The TCE removal efficiency ranged between 96% and 99% with one exception of a monthly removal efficiency of only 3.85 % due to a very low influent concentration of 0.52 ug/L of TCE in August 2007. (See Appendix C)

SLAPT:

The performance standards are the same as with the other systems, 5 ug/l for TCE, 70 ug/L for cis 1, 2 Dichloroethylene, and 5 ug/L for Tetrachloroethylene. The table below shows the initial results, but after modification of the air stripping manifold, the effluent limits have been below 1 ug/L since October 2010. The performance objectives for the SLA Pump and Treat system are: 1) document plume capture effectiveness, and 2) monitor natural attenuation progress in the downgradient uncaptured plume. Treatment effectiveness is monitored by measuring the reduction of TCE concentrations at the treatment plant and at the downgradient monitoring wells. Sentinel wells are monitored to confirm that the plume downgradient of the extraction wells is not expanding. Collected data is compared to historic concentrations to confirm that steady or downward trends are occurring.

Initial SLA Treatment System Performance:

Date	Influent TCE µg/l	Effluent TCE µg/l
11/18/2009	22	5.9
12/11/2009	21	3.9
1/21/2010	20	4.1
3/10/2010	20	4.2
4/19/2010	24	4.9

The system was designed to achieve 98% removal efficiency, which it was unable to achieve. In October 2010 the SLAPT stripper tower's water distribution system was reconfigured after unexpectedly high concentrations of TCE were detected in the system's effluent. The original

SLAPT air stripper used a splash plate under a 10-inch inlet pipe to distribute water over the tower packing. Influent water poured out of the 10 inch pipe and then splashed from the splash plate to the distributor tray. The distributor tray spanned the 9.5 ft inside diameter of the tower. The distributor tray was perforated with 1.125 inch diameter holes allowing the water to pour into the stripper tower packing material. The splash plate and distributor tray were replaced with a series of PVC nozzles connected to the 10 inch pipe. The nozzles disperse the water across a wider area over the distributor tray than the splash plate did and reduced channeling of water through the packing material. Performance of the air stripper tower was greatly improved decreasing the annual average concentration of TCE in effluent samples from 4.1µg/L (before reconfiguration) to 0.64µg/L, slightly less than 98% removal efficiency. See Appendix C for the history of efficiency of all the pump and treatment systems.

V. FINAL INSPECTION AND CERTIFICATIONS

The Final Inspection of selected Remedial Actions for the Logistics Center occurred on December 2, 2009. There were no punch list items identified during the inspection. There were no health and safety incidents that occurred during the implementation of the remedy for the Logistics Center. No significant deviations from plans occurred that required revisions to the remedy. The Army certified the Sea Level Aquifer Pump and Treatment system was operational and functional in March 2010.

VI. OPERATION AND MAINTENANCE

EGDY and I-5 Pump and Treat System:

The EGDY System and the Interstate 5 System have been operated by a JBLM Public Works contractor since December 2004. The contractor employs staff at the installation full-time to accomplish program management, operation, maintenance, monitoring, and reporting for remedial actions at JBLM. Routine operation and maintenance is performed in accordance with a *Final Management Plan* and the O&M Plan. O&M activities are reported annually. The O&M Plan requires weekly site visits for routine tasks. The system operator visits the treatment systems daily however, to closely monitor extraction well flow rates and make flow adjustments to avoid low water levels triggering on/off cycling of the extraction wells.

The EGDY and the I-5 systems have operated nearly continuously since the last five year review. Full system outages have been relatively short, having to do with planned maintenance and repairs or short term outages resulting from power fluctuations. Pumps in several extraction wells were replaced at various times through the past five years, resulting in extended downtime at some individual wells. Appendix A provides tabulated flow data for all extraction wells during 2007-2010. Figures 8 through 12 provide the same information graphically.

As part of a planned optimization program, several measures have been taken in the past five years to enhance performance of the I-5 system:

- ☐ Flow surge arrestors and flex piping installed at wellheads to control water hammer
- ☐ Variable frequency drives (VFDs) installed atsystem discharge pumps
- ☐ Transient voltage surge suppressor installed on system power supply
- ☐ Graphical user interface added to control system computer
- ☐ New magnetic flow meter installed on air stripper influent

In general, the O&M staff at JBLM regularly investigates opportunities to optimize all of the systems as a normal part of their work.
Several operation and maintenance issues beyond those normally expected were encountered over the past several years:

- ☐ Surges or fluctuations in the power supply may be the root cause of several extraction well or system shutdowns. The O&M staff has been evaluating surge protection for the extraction wells, though during the site visit it was noted that the power supply has been more stable recently.
- ☐ Extraction well maintenance has been a greater effort than expected. As an example, the system operator noted that in the past year there have been three extraction well pump replacements at the EGDY system. That re-configured system started continuous operation in May 2007, indicating that those wells failed in significantly less than five years. Well pump replacements have also been frequent at the Interstate 5 system. JBLM is now budgeting for two extraction well pump replacements per year.

- A heat wave in summer 2009 resulted in overheating and failure of the PLC at the EGDY system and also affected VFDs. The VFDs became unstable with temperature fluctuation. Controllers are being replaced and vents are being installed in VFD cabinets.

Bio-fouling has been present at isolated locations to a small extent, though not to the extent to lead to system failure. The system operator anticipates cleaning the air stripper packing at the EGDY system in 2012. At the I-5 system, extraction well LX-13 requires periodic cleaning to restore flow as a result of bio-fouling. There have been no difficulties with the groundwater recharge systems related to bio-fouling.

Extraction wells LX-1 and LX-15 have been off- line since June 2007 resulting from a groundwater flow modeling study showing they had limited pumping influence. LX-15 was restarted in 2012 due to an observed increasing trend in contaminant concentrations at nearby monitoring well LC-124.

JBLM is considering re-use of the effluent from the Interstate 5 system in the cooling system for a nearby motor pool.

Total annual cost for operation, maintenance, and monitoring for EGDY, Interstate 5, and SLA systems was developed from budget and cost information provided by JBLM, and is provided in Table 6 below.

Table 6 - Summary of Annual Costs Cost Category	**Estimated Annual Cost**
Project Management	$40,000
Operator	$136,000
Sampling/Data Management/Reporting	$91,000
Laboratory Analysis	$50,000
Equipment	$57,000
Power	$45,000

SLAPT

Operation and maintenance of the SLA P&T system is divided in three areas: Mechanical, electrical, and controls.

Mechanical equipment includes

- Pumps;
- pump motors;
- magnetic flow meters;
- variable frequency drives;
- valves;
- pipelines;
- treatment tower, and
- treatment power blower.

Electrical equipment includes:

- transformer;
- lights;
- panelboards;
- switchboards;
- circuit breakers, and
- motor starters.

Control equipment includes:

- water level (pressure) transducers;
- network circuitry and wiring;
- fiber optic cabling;
- Ethernet network;
- network hubs;
- fan sensors;
- hi&low level alarm sensors;
- computer, and
- proprietary software (Johnson Controls).

Operation and maintenance manuals for each service area are available from JBLM. Operation of the system will be the responsibility of Madigan Army Medical Center. System monitoring for environmental parameters is the responsibility of the JBLM environmental staff.

VII. CONTACT INFORMATION

The following personnel and contractors were used for construction of the SLA P&T system:

Extraction and monitoring well installation:

JBLM Project Manager: William Myers, Environmental Restoration Program Manager

Company Name: U.S. Army

Address: Public Works

Bldg 2012 Liggett Ave RM 313

Box 339500, MS-17

JBLM, WA 98433-9500

Phone: 253-477-3742

Email: william.w.myers@us.army.mil

Primary Contact Name and Title: Mike Truex, Project Manager

Company Name: Pacific Northwest National Laboratories

Address: Mail Stop K6-96

790 6th Street

Richland, WA 99352

Phone: 509- 371-7072

Pipeline, treatment plant, and controls:

Construction:

Primary Contact Name and Title: Chuck Parrish, Superintendent

Company Name: J&J Maintenance, Inc.

Address: P.O. Box 508

Dupont, WA 98327

Phone: 253-964-4046

Operation:

Primary Contact Name and Title: Bob Cody

Company Name: Facilities Management Division

Address: Madigan Army Medical Center

Tacoma, WA 98

Phone: 253-968-1491

The Project Manager for the Army:

Name: Ralph Strickland

Address: JBLM –Lewis Public Works

MS 17 Box 339500

Joint Base Lewis-McChord, WA 98433

Phone : 253-966-1748

e-mail: ralph.strickland@us.army.mil

The Project Manager for EPA:

Name: Chris Cora

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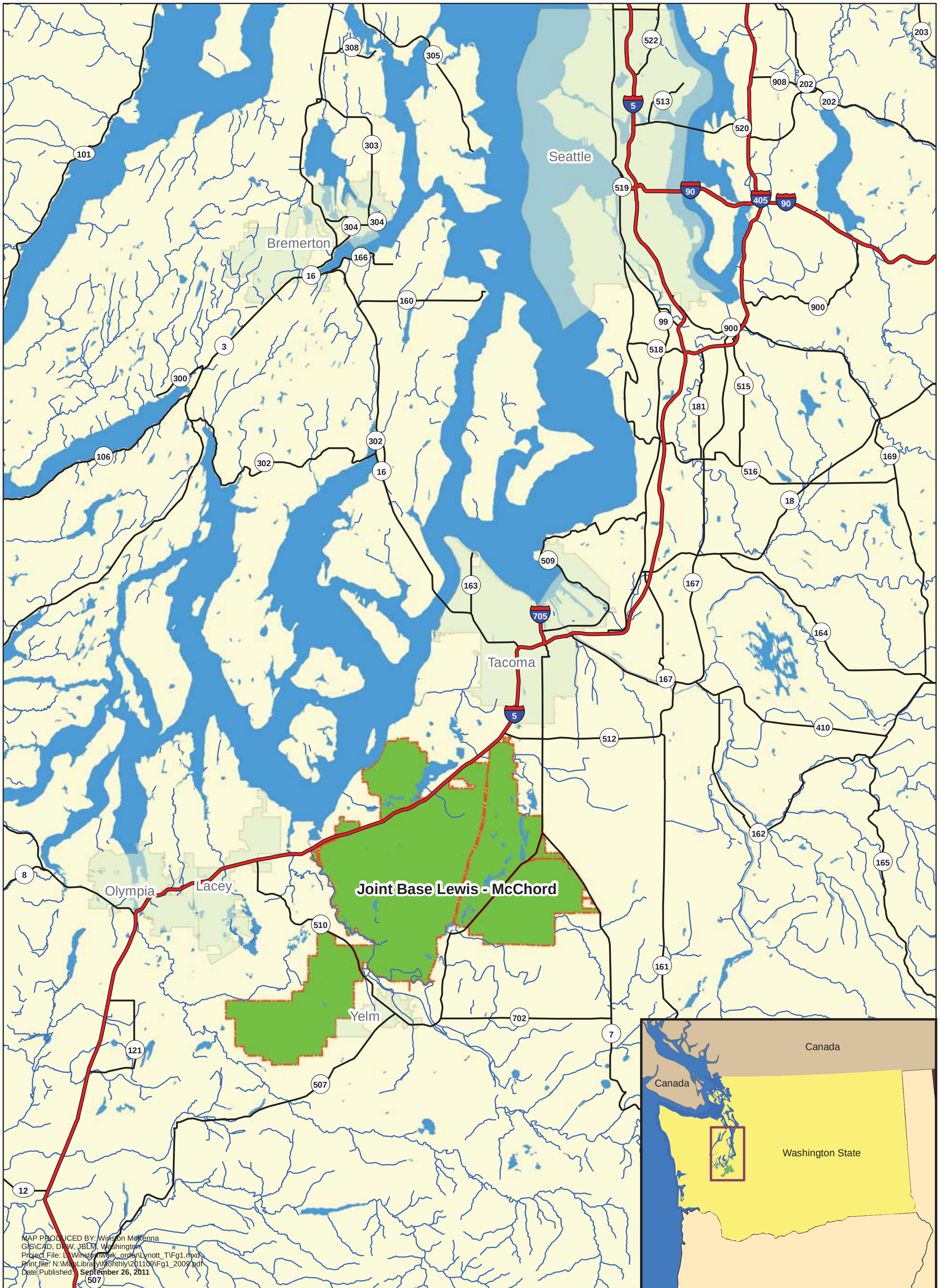
1200 Six Avenue, M/S: ECL-115

Seattle, WA 98101

Phone : 205-553-1478

e-mail : cora.christopher@epa.gov

VIII. APPENDIX



N

0 25,000 50,000 100,000
Feet

0 5 10 20
Miles

1 in = 5 miles

MAP DATA:
ELLIPSOID: GRS 80
COORDINATE SYSTEM: UTM, Zone 10
HORIZONTAL DATUM: WGS 84

Joint Base Lewis - McChord Location Map

Figure

1

Project Area - Extent of Monitoring Well Network
Landfill 2
MAMC HVAC cooling pond
JBLM Boundary
EGDY P&T System Wells
I-5 P&T System Wells
SLA P&T System Wells

N

0 2,500 5,000 10,000
Feet
0 0.3 0.6 1.2
Miles

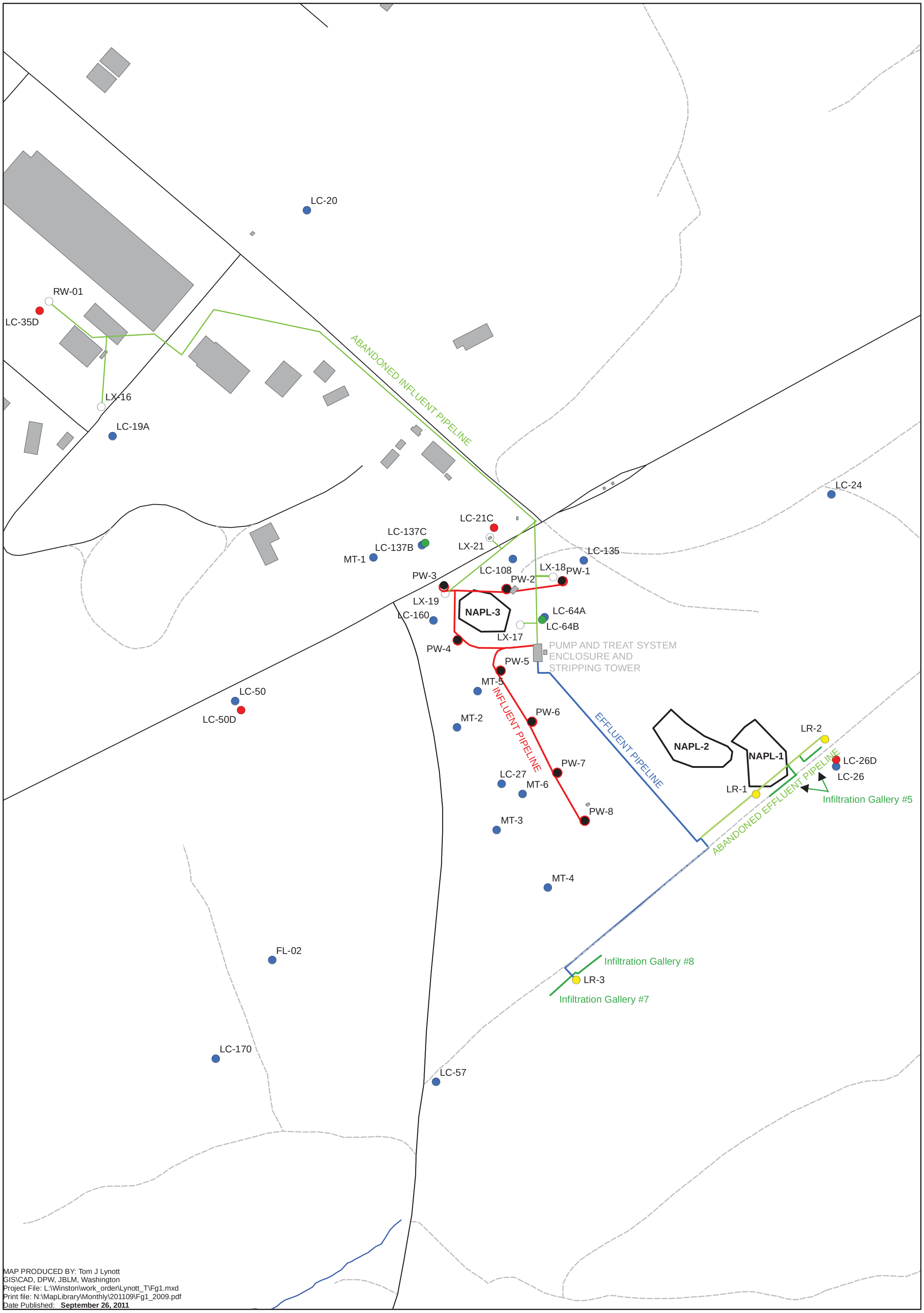
1 inch = 1,750 feet

MAP DATA:
ELLIPSOID: GRS 80
COORDINATE SYSTEM: UTM, Zone 10
HORIZONTAL DATUM: WGS 84

Project Location Map

Figure

2



Sample Location/ Identification

- ● Pump and Treat System Extraction Wells
- ● Upper Vashon Aquifer Monitoring Wells
- ● Lower Vashon Aquifer Monitoring Wells
- ● Sea Level Aquifer Monitoring Wells
- ● Injection Wells
- ○ Decommissioned Wells

Label ID

MT-3 - Well ID

N

0 290 580 1,160

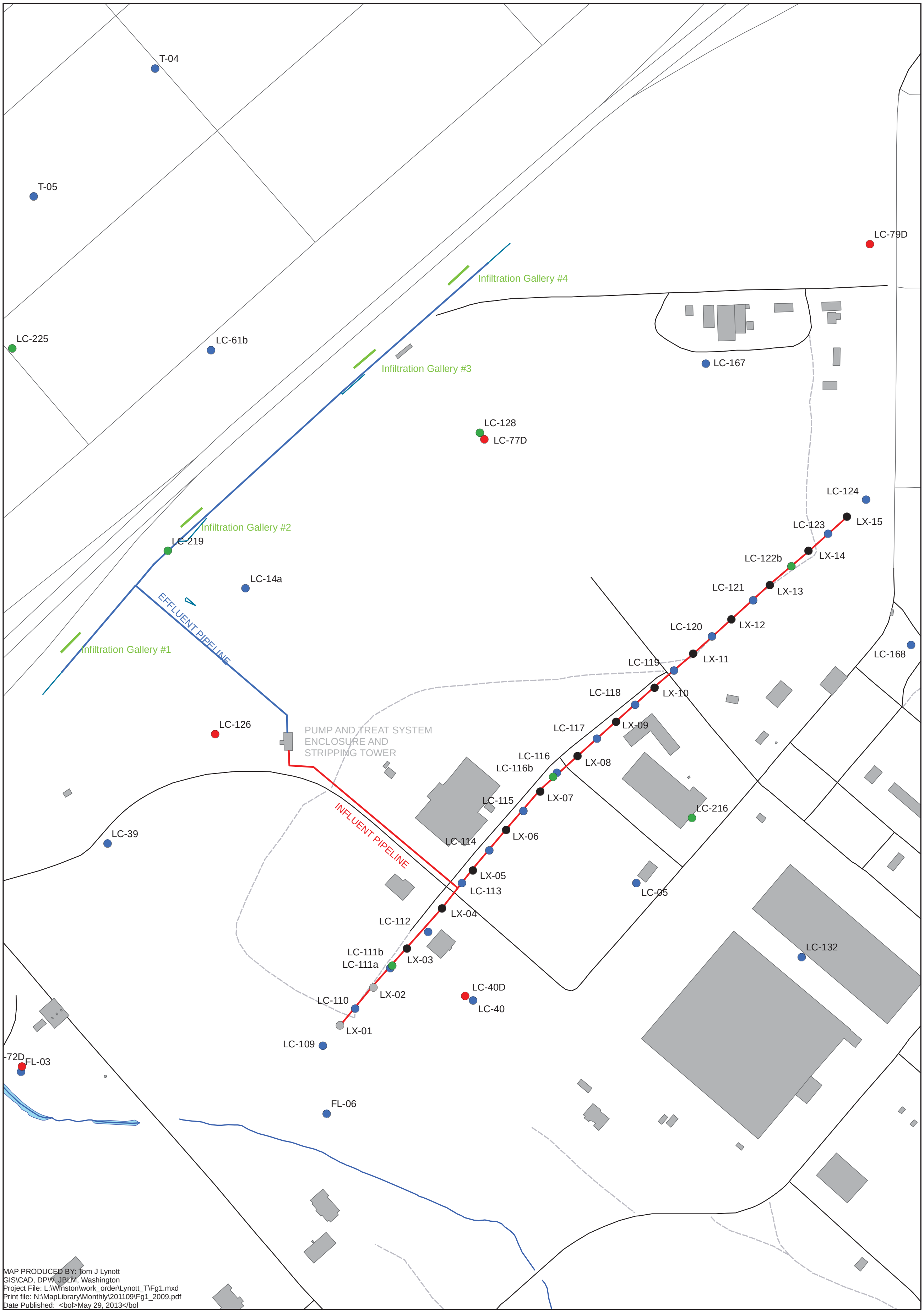
Feet

1 inch = 300 feet

MAP DATA:
ELLIPSOID: GRS 80
COORDINATE SYSTEM: UTM, Zone 10
HORIZONTAL DATUM: WGS 84

LANDFILL 2 PUMP & TREAT SYSTEM

Figure 3



Sample Location/ Identification — **Label ID**

- ● Pump and Treat System Extraction Wells — LC-39 - Well ID
- ● Upper Vashon Aquifer Monitoring Wells
- ● Lower Vashon Aquifer Monitoring Wells
- ● Sea Level Aquifer Monitoring Wells
- ● System Wells Off and not Sampled in 2012

N

0 | 290 | 580 | 1,160

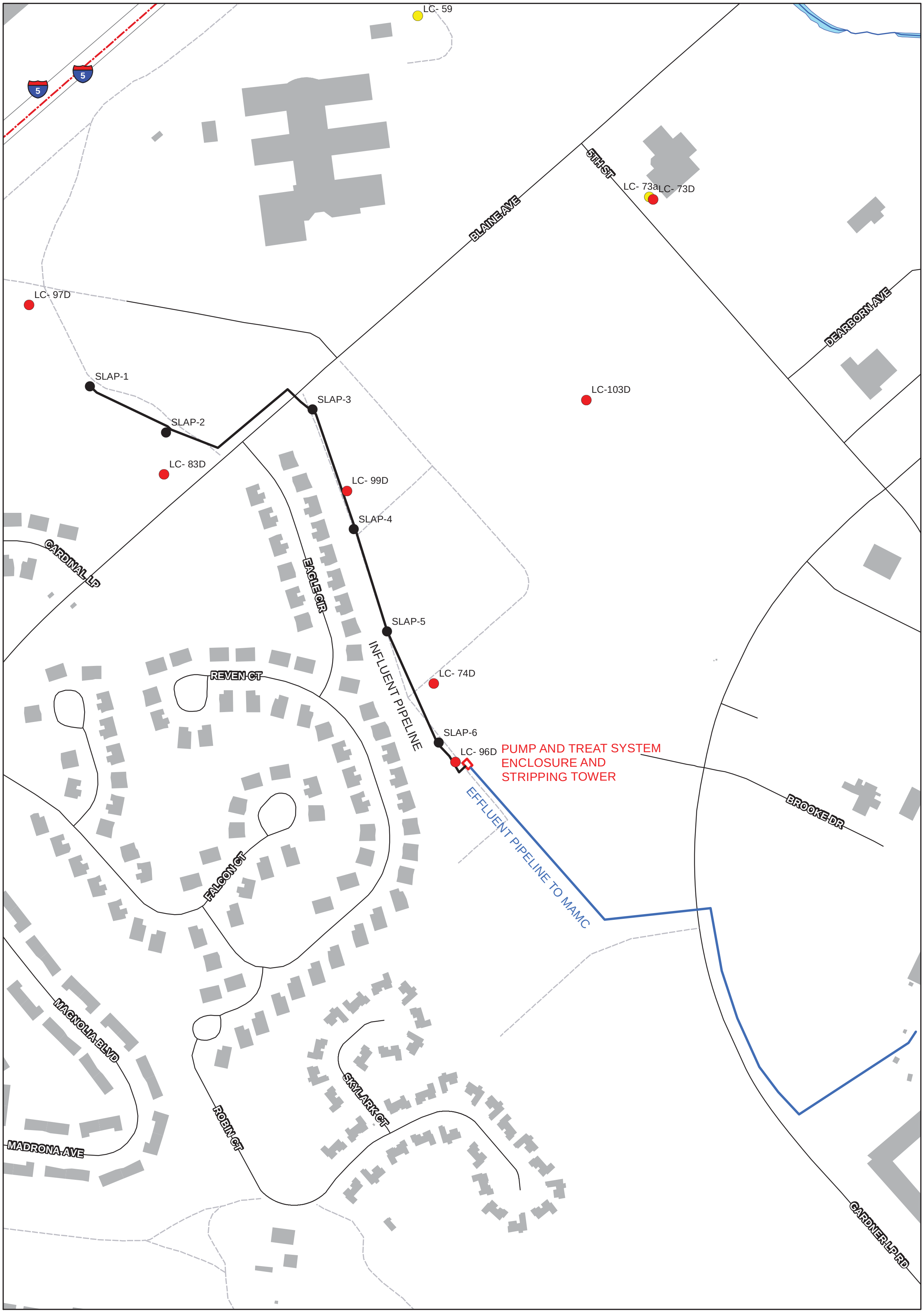
Feet

1 inch = 300 feet

MAP DATA:
ELLIPSOID: GRS 80
COORDINATE SYSTEM: UTM, Zone 10
HORIZONTAL DATUM: WGS 84

I-5 PUMP & TREAT SYSTEM

Figure 4



Monitoring Well Location and Identification

- Pump and Treat System Extraction Wells
- Vashon Aquifer Monitoring Wells
- Sea Level Aquifer Monitoring Wells

N

0 175 350 700

Feet

1 inch = 250 feet

MAP DATA:

ELLIPSOID: GRS 80

COORDINATE SYSTEM: UTM, Zone 10

HORIZONTAL DATUM: WGS 84

SEA LEVEL AQUIFER PUMP AND TREAT SYSTEM

Figure 5

Well Identification	Label ID
Decommissioned Wells	LCX-05 - Well ID
Existing Monitoring Wells	
Pump and Treat System Well	

N

West of Landfill 4 on Lewis North

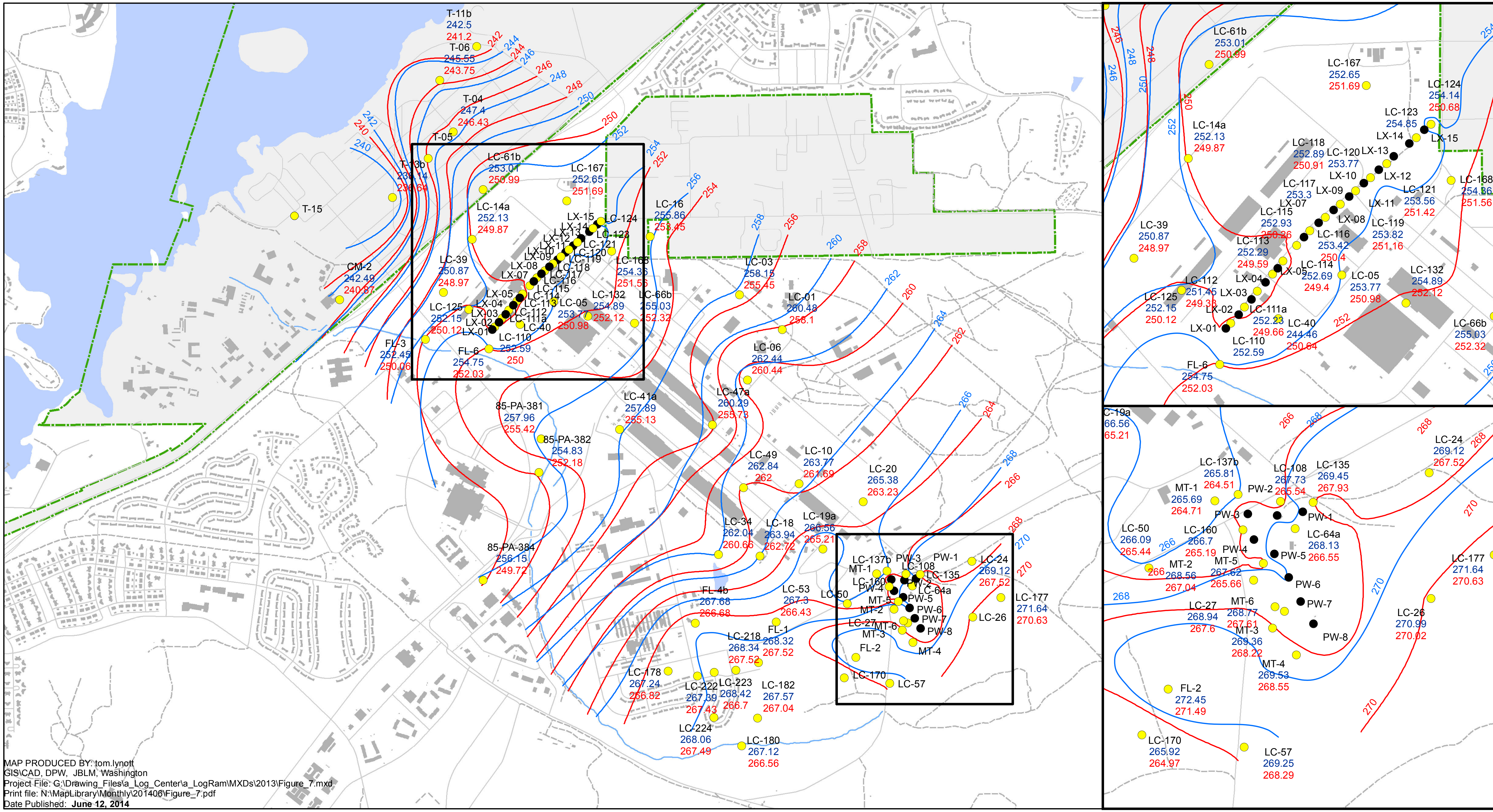
1 inch = 500 feet

MAP DATA:
ELLIPSOID: GRS 80
COORDINATE SYSTEM: UTM, Zone 10
HORIZONTAL DATUM: WGS 84

North of I-5 Pump and Treat System

DECOMMISSIONED WELLS LOCATION MAP **2013**

Figure 6



Contours
Wet Season
Dry Season

Label ID

Monitoring Well — LC-178 - Well ID

P&T System Extraction Well — 267.24 - Wet Season WL (ft AMSL)

266.82 - Dry Season WL (ft AMSL)

N

0 1,875 3,750 7,500

Feet

1 inch = 1,500 feet

MAP DATA:

ELLIPSOID: GRS 80

COORDINATE SYSTEM: UTM, Zone 10

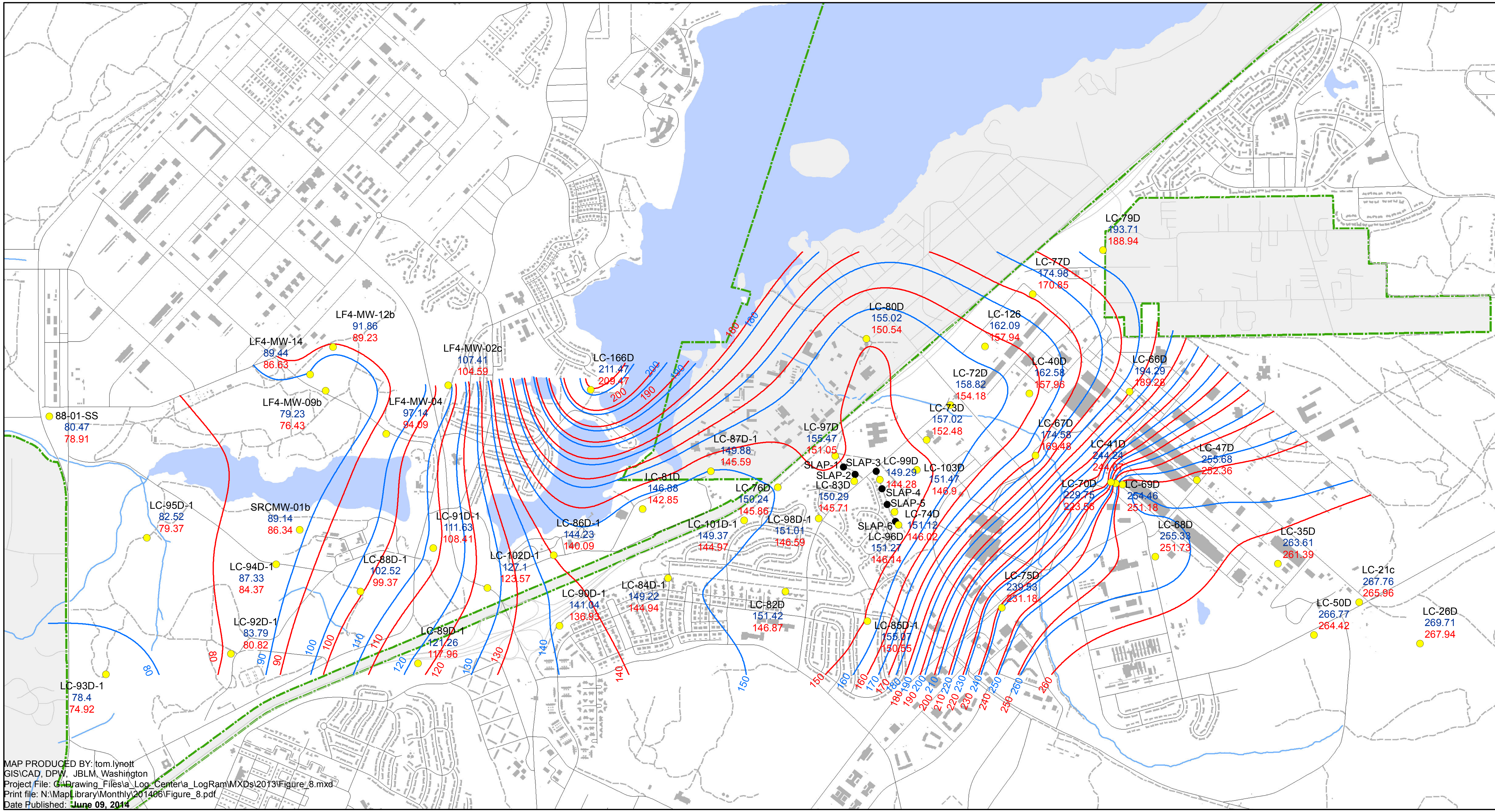
HORIZONTAL DATUM: WGS 84

WET/DRY SEASON UPPER VASHON AQUIFER WATER TABLE CONTOURS

2013

Figure

7



Contours

Wet Season

Dry Season

Label ID

Monitoring Well — LC-84D-1 - Well ID

P&T System Extraction Well — 149.22 - Wet Season WL (ft AMSL)

144.94 - Dry Season WL (ft AMSL)

N

0 2,200 4,400 8,800

Feet

1 inch = 1,750 feet

MAP DATA:

ELLIPSOID: GRS 80

COORDINATE SYSTEM: UTM, Zone 10

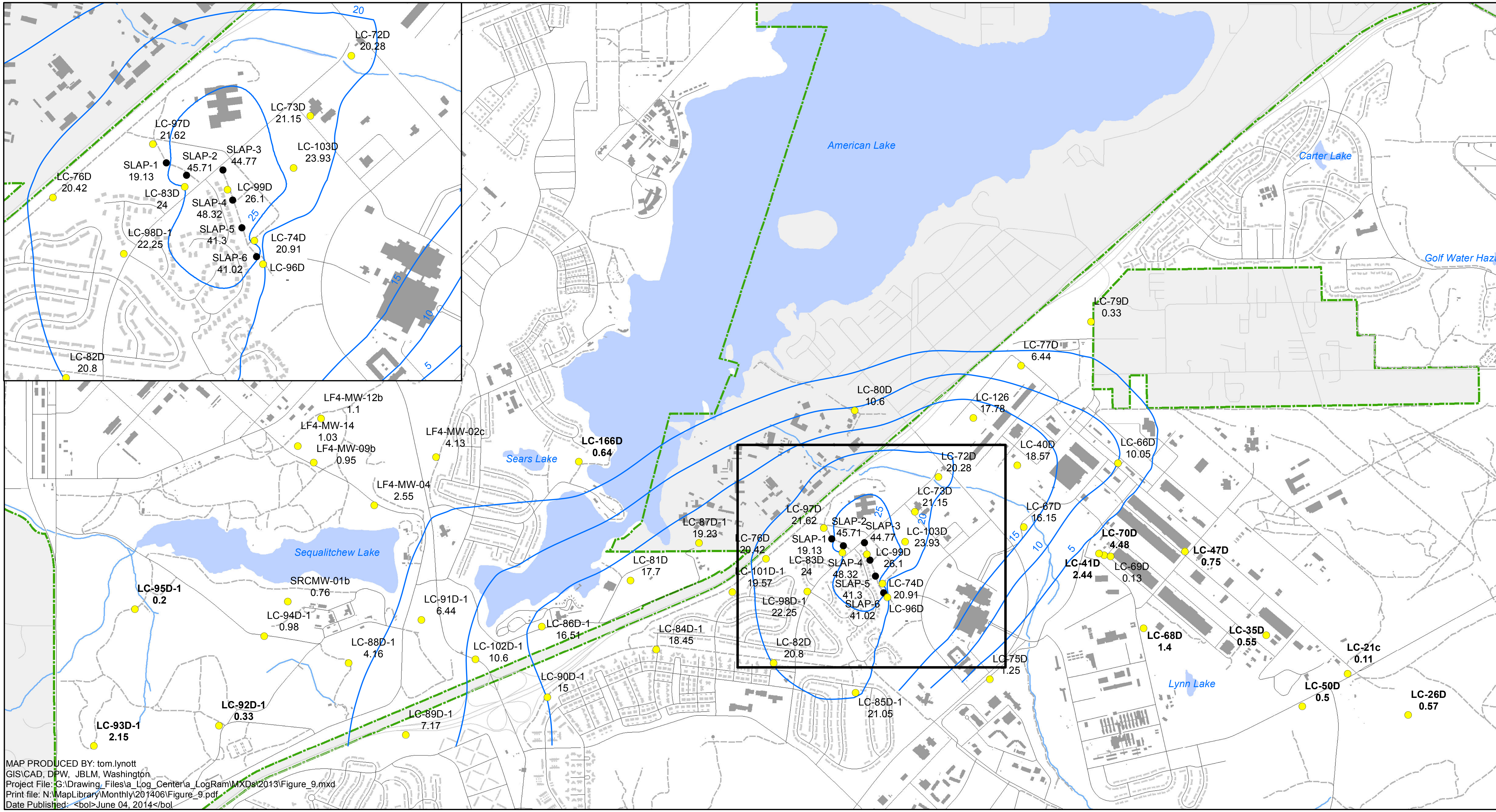
HORIZONTAL DATUM: WGS 84

WET/DRY SEASON SEA LEVEL AQUIFER WATER TABLE CONTOURS

2013

Figure

8



Contours

Dry Season Change in Elevation

Label ID

- Monitoring Well
- P&T System Extraction Well

LC-84D-1 - Well ID
18.45 - Dry Season WL Change (ft AMSL)
BOLD - WL higher in 2013 than 2009

N

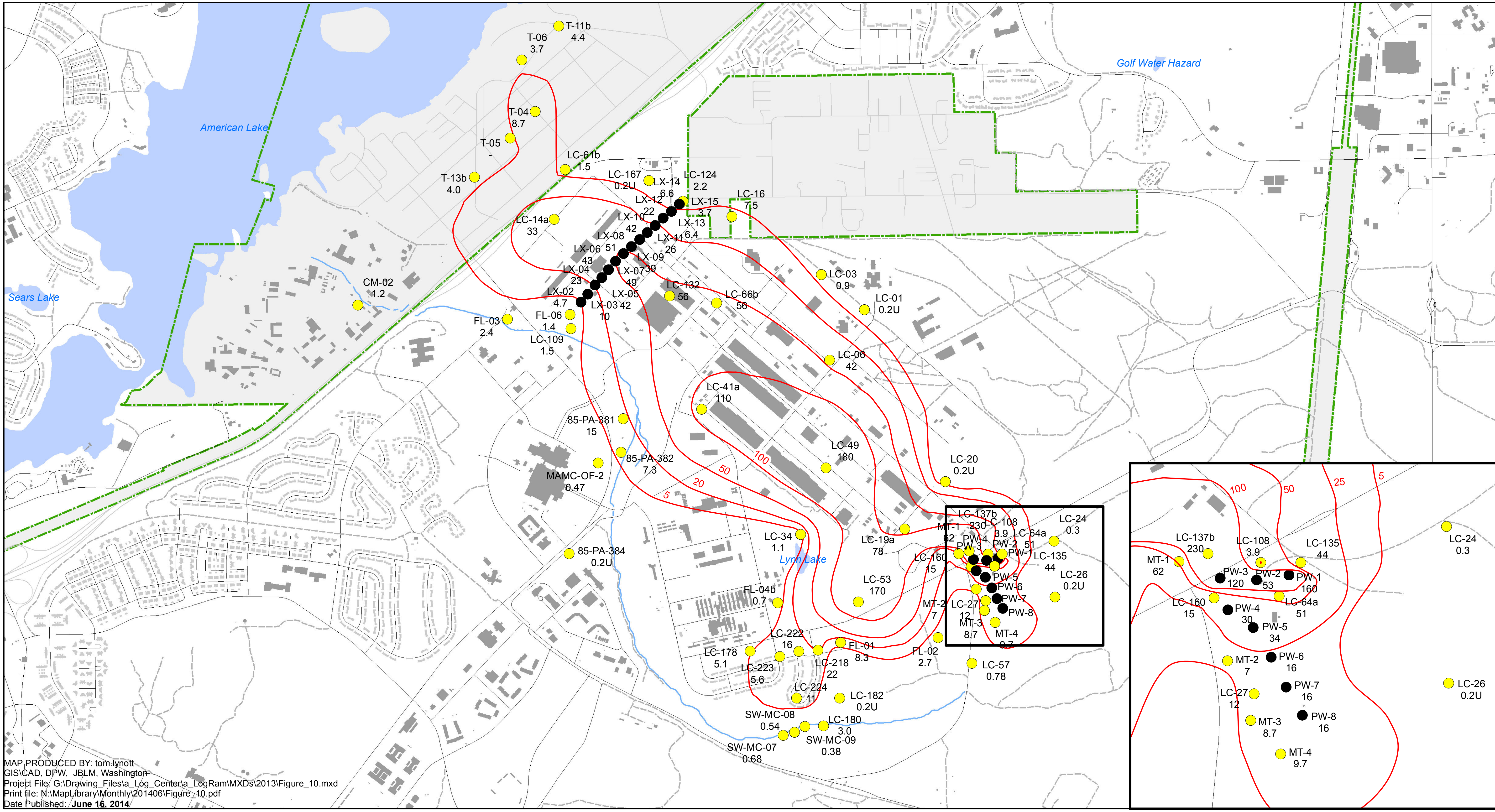
0 2,200 4,400 8,800
Feet

1 inch = 1,750 feet

MAP DATA:
ELLIPSOID: GRS 80
COORDINATE SYSTEM: UTM, Zone 10
HORIZONTAL DATUM: WGS 84

DIFFERENCES IN DRY SEASON SEA LEVEL AQUIFER WATER TABLE CONTOURS
2009 & 2013

Figure
9



TCE Concentration Contours

Sample Location/
Identification

Label ID

- Monitoring Well / Surface Sample Point
- P&T System Extraction Well

LC-178 - Well ID
5.1 - TCE (ug/L)
0.2U - TCE not detected above Lab PQL of 0.2 ug/L

N

0 1,875 3,750 7,500
Feet

1 inch = 1,500 feet

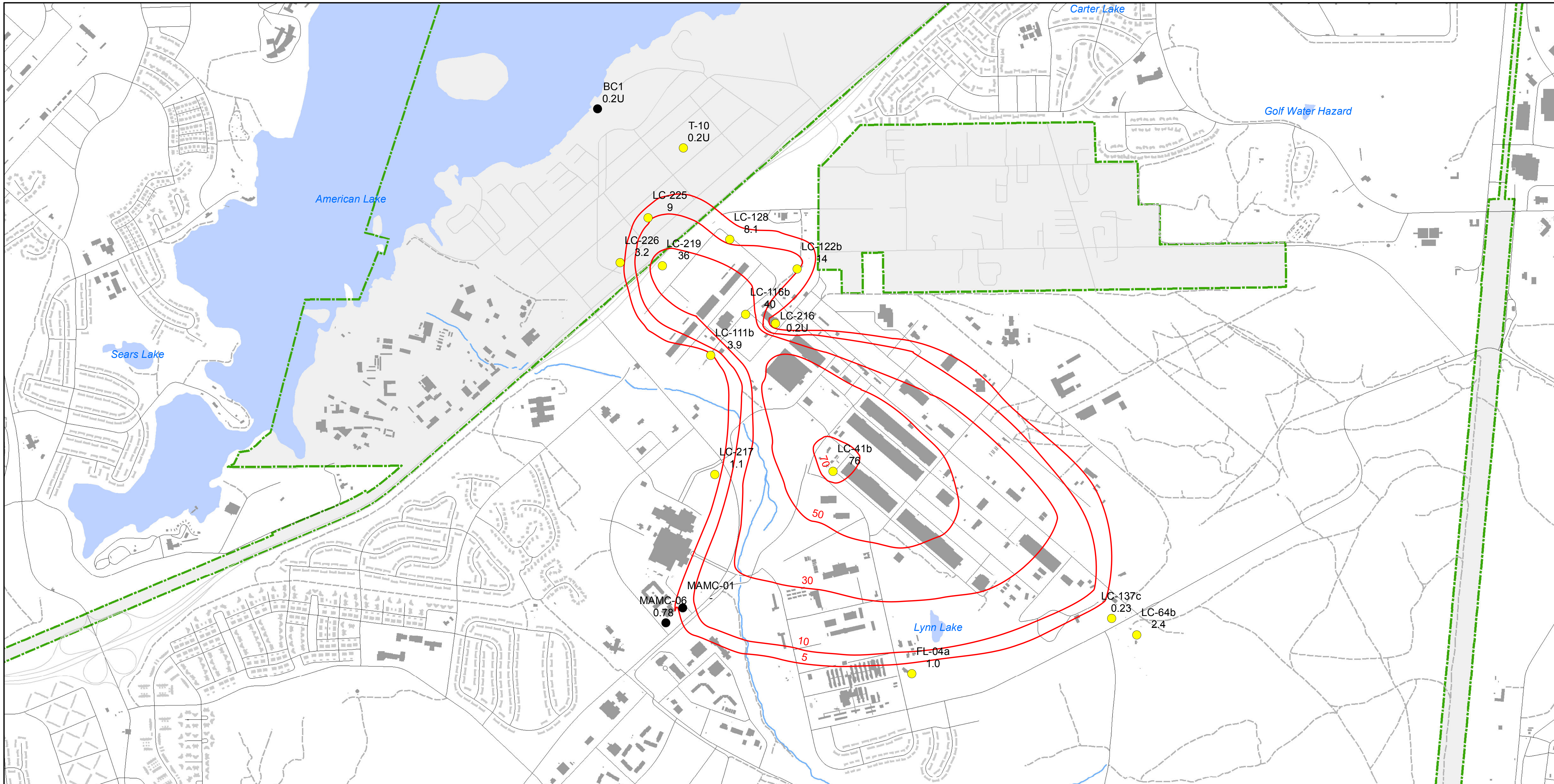
MAP DATA:
ELLIPSOID: GRS 80
COORDINATE SYSTEM: UTM, Zone 10
HORIZONTAL DATUM: WGS 84

UPPER VASHON AQUIFER TCE PLUME MAP

2013

Figure

10



MAP PRODUCED BY: tom.lynott
GIS\CAD, DPW, JBLM, Washington
Project File: G:\Drawing_Files\a_Log_Center\a_LogRam\MXDs\2013\Figure_11.mxd
Print file: N:\MapLibrary\Monthly\201406\Figure_11.pdf
Date Published: **June 04, 2014**

TCE Concentration Contours

Sample Location/ Identification

Label ID

Monitoring Well

Production Well

FL-04a - Well ID
1.0 - TCE (ug/L)
0.2U - TCE not detected above Lab PQL of 0.2 ug/L

N

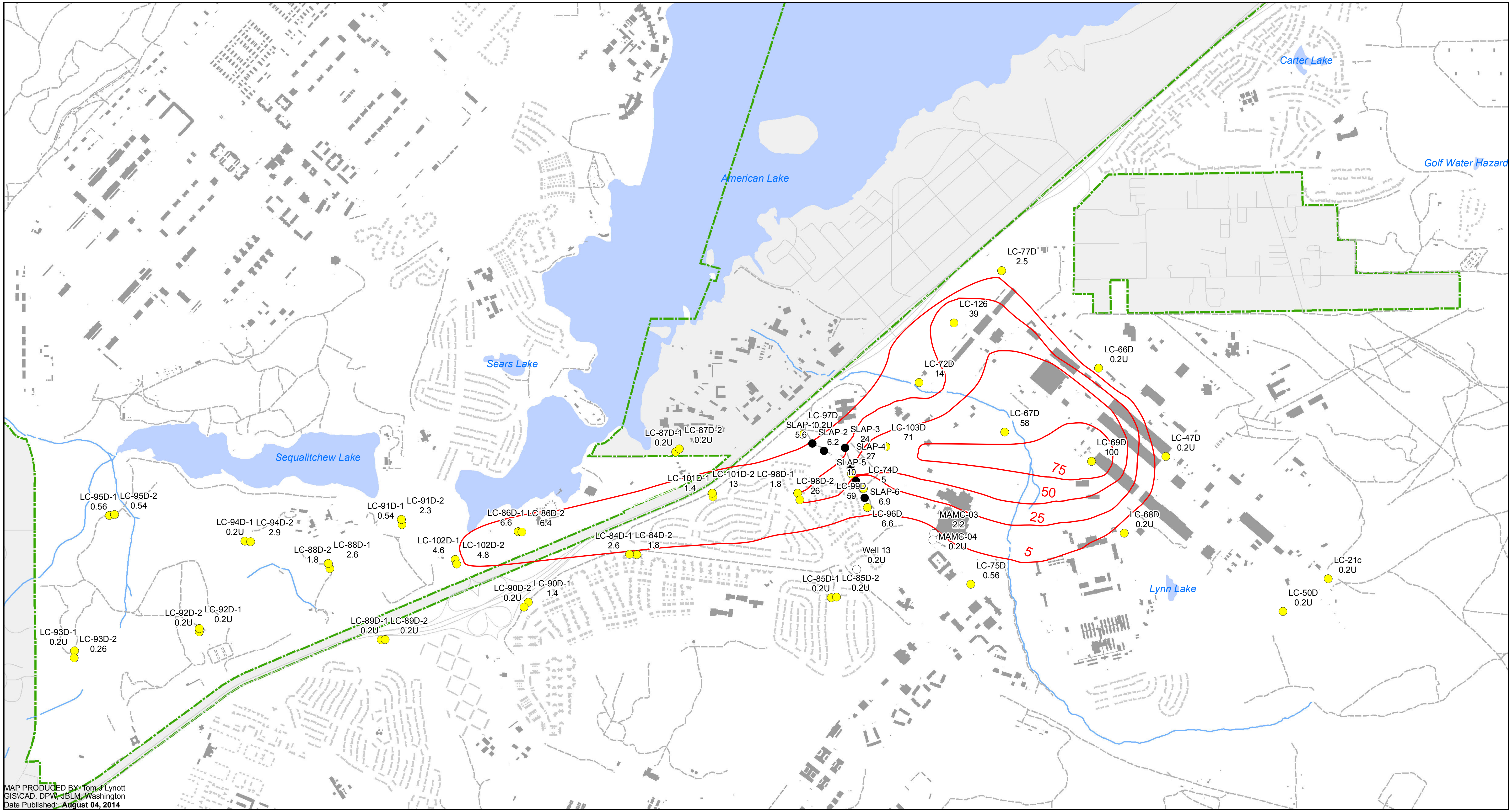
0 1,875 3,750 7,500
Feet

1 inch = 1,500 feet

MAP DATA:
ELLIPSOID: GRS 80
COORDINATE SYSTEM: UTM, Zone 10
HORIZONTAL DATUM: WGS 84

LOWER VASHON AQUIFER TCE PLUME MAP
2013

Figure
11



TCE Concentration Contours

Sample Location/ Identification

- Monitoring Well
- Production Well
- P&T System Extraction Well

Label ID

LC-84D-1 - Well ID

2.6 - TCE (ug/L)

0.2U - TCE not detected above Lab PQL of 0.2 ug/L

N

0 2,500 5,000 10,000

Feet

1 inch = 1,750 feet

MAP DATA:

ELLIPSOID: GRS 80

COORDINATE SYSTEM: UTM, Zone 10

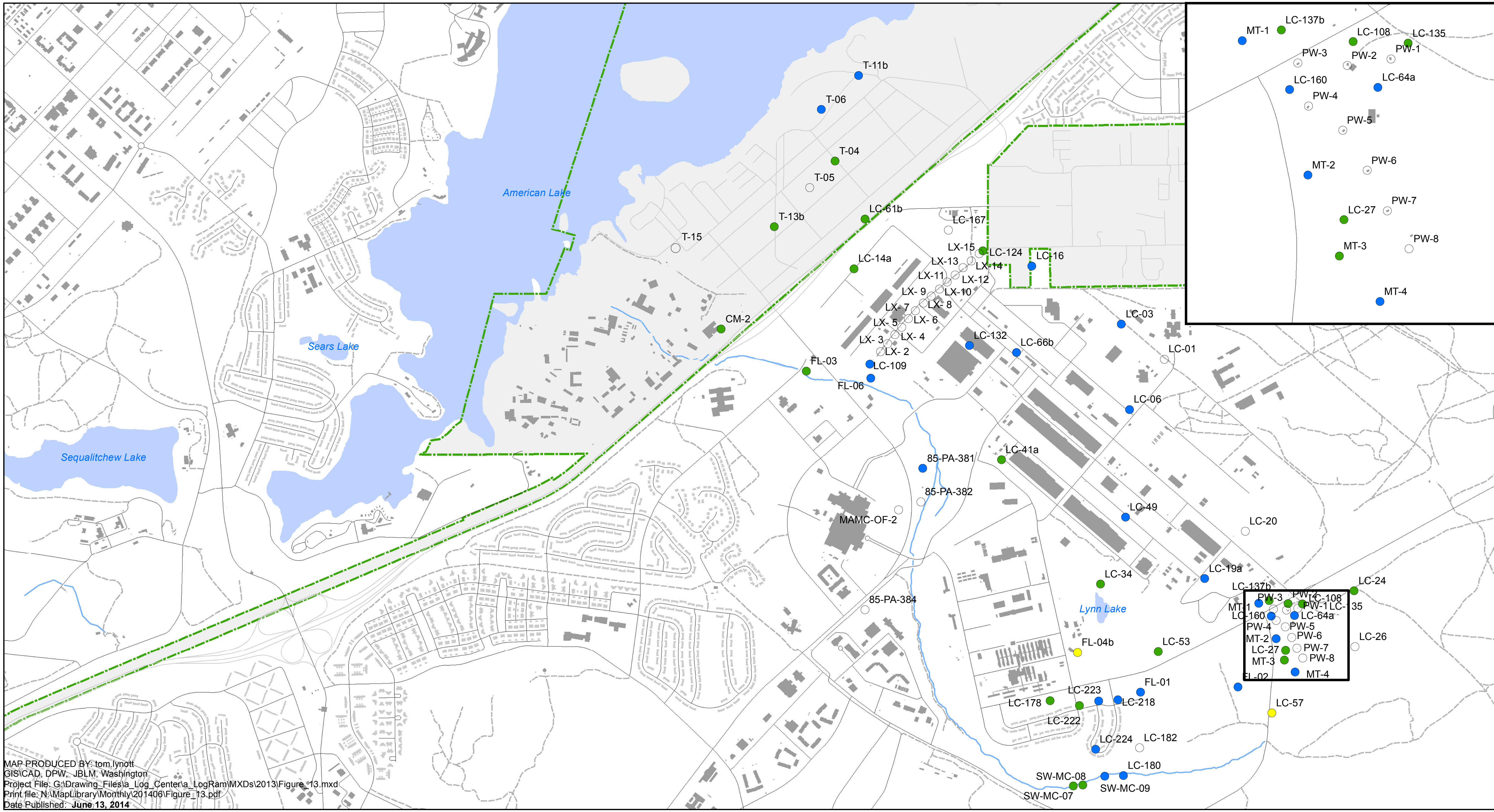
HORIZONTAL DATUM: WGS 84

SEA LEVEL AQUIFER TCE PLUME MAP

2013

Figure

12



Sample Location and Trend Statistics

- Statistically Significant Upward Trend
- Not Statistically Significant Upward Trend
- Not Statistically Significant Downward Trend
- Statistically Significant Downward Trend
- Data Not Analyzed

N

0 1,875 3,750 7,500
Feet

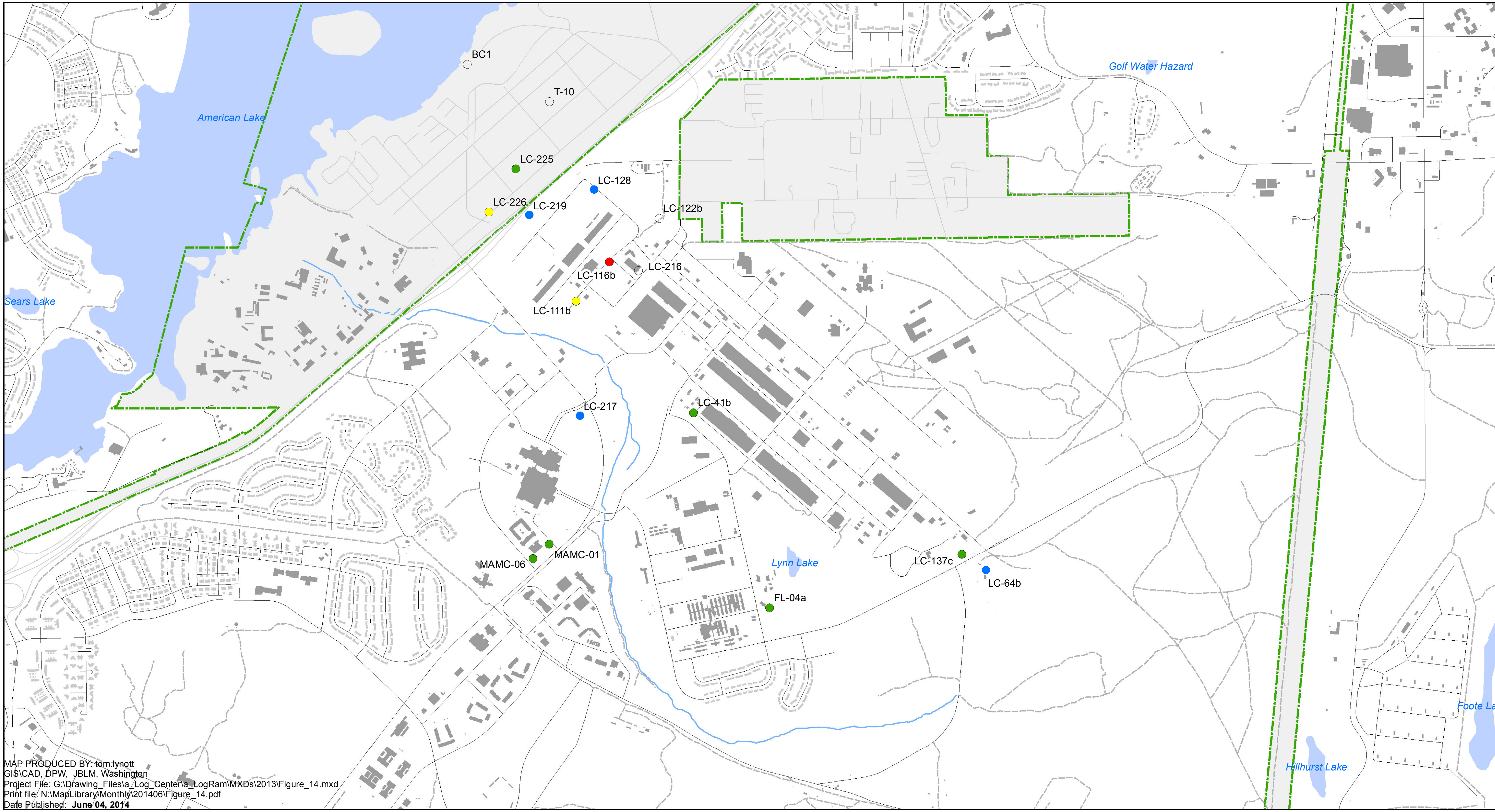
1 inch = 1,500 feet

MAP DATA:
ELLIPSOID: GRS 80
COORDINATE SYSTEM: UTM, Zone 10
HORIZONTAL DATUM: WGS 84

UPPER VASHON AQUIFER LINEAR REGRESSION MAP CURRENT TRENDS

2004 - 2013

Figure 13



Sample Location and Trend Statistics

- Statistically Significant Upward Trend
- Not Statistically Significant Upward Trend
- Not Statistically Significant Downward Trend
- Statistically Significant Downward Trend
- Data Not Analyzed

N

0 1,875 3,750 7,500

Feet

1 inch = 1,500 feet

MAP DATA:

ELLIPSOID: GRS 80

COORDINATE SYSTEM: UTM, Zone 10

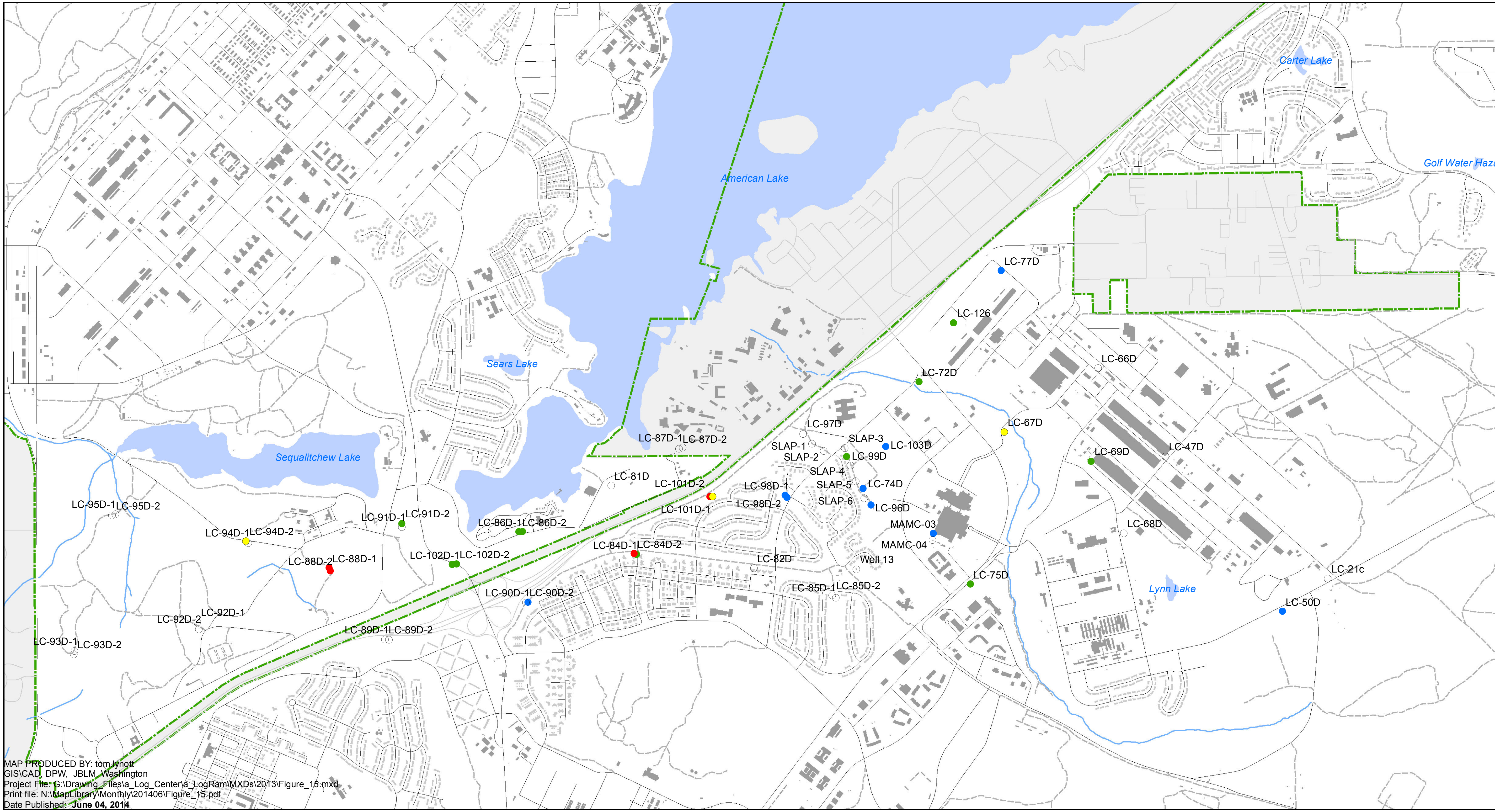
HORIZONTAL DATUM: WGS 84

LOWER VASHON AQUIFER LINEAR REGRESSION MAP CURRENT TRENDS

2004 - 2013

Figure

14



Sample Location and Trend Statistics

- Statistically Significant Upward Trend
- Not Statistically Significant Upward Trend
- Not Statistically Significant Downward Trend
- Statistically Significant Downward Trend
- Data Not Analyzed

N

0 2,200 4,400 8,800
Feet

1 inch = 1,750 feet

MAP DATA:
ELLIPSOID: GRS 80
COORDINATE SYSTEM: UTM, Zone 10
HORIZONTAL DATUM: WGS 84

SEA LEVEL AQUIFER LINEAR REGRESSION MAP CURRENT TRENDS
2004 - 2013

Figure 15