LaManna Geosciences Inc.

2611 40th Avenue West
Seattle, WA 98199
206-352-8534
johnl@lamannageosciences.com

REMEDIAL INVESTIGATION and FEASIBILITY STUDY REPORT

SUNNYDELL DRYKE SHOOTING RANGE

292 DRYKE ROAD
SEQUIM, CLALLAM COUNTY, WASHINGTON, 98382

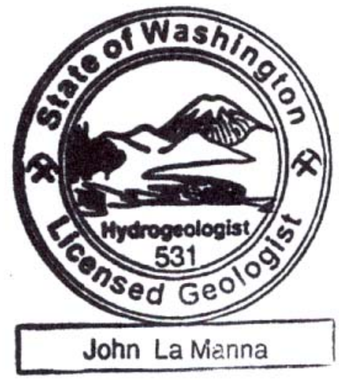
Final

Prepared for
Sunnydell Kennels & Shooting Range LLC

Prepared By
LaManna Geosciences Inc.

June 22, 2012

THIS REPORT HAS BEEN PREPARED UNDER THE RESPONSIBLE CHARGE OF A STATE OF WASHINGTON LICENSED HYDROGEOLOGIST



JOHN LAMANNA

LAMANNA GEOSCIENCES INC.

2611 – 40TH AVENUE WEST

SEATTLE, WA 98199

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

List of Abbreviations and Acronyms

Abbreviation/Acronym	Definition
AO	Agreed Order
ARAR	Applicable or Relevant and Appropriate Requirement
bgs	Below ground surface
BMP	Best management practice
CCHHS	Clallam County Department of Health and Human Services
COC	Contaminant of concern
cPAH	Carcinogenic polycyclic aromatic hydrocarbon
CUL	Cleanup Level
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESA	Environmental Services Associates, Inc.
MTCA	Washington State Model Toxics Control Act
NRCS	National Resources Conservation Service
RI/FS	Remedial Investigation/Feasibility Study
Site	Sunnydell Shooting Range
TEE	Terrestrial Ecological Evaluation

1.0 INTRODUCTION

This Remedial Investigation/Feasibility Study (RI/FS) was developed in accordance with the requirements of Agreed Order (AO) No. DE6551 between the Washington State Department of Ecology (Ecology) and Mr. Chuck Dryke and Ms. Rosemary Knotek, the former owners of the Sunnydell Kennels & Shooting Grounds LLC (Site).

Environmental samples collected by the Clallam County Department of Health and Human Services (CCHHS) in 2004 indicated the presence of lead in pond sediment and pond water at the Site (ESA, 2010b). CCHHS collected additional samples from soil near shooting areas and found high levels of lead. Ecology was notified of these results and requested the Sunnydell property owner enter into an AO (Ecology Agreed Order No. DE6551). The AO was signed on August 10, 2009 and required Sunnydell to conduct a RI/FS of the Site and prepare a draft Cleanup Action Plan. Subsequently, environmental investigations to characterize site conditions were conducted by Environmental Services Associates, Inc. (ESA) (ESA, 2010a and 2010b) and LaManna Geosciences Inc. (LGI, 2011b).

This report contains the following information:

- A summary of past, current, and expected future land use at the Site.
- A summary of environmental testing at the Site.
- A summary of published information on geology and hydrogeology.
- A conceptual model of the Site's geology and hydrogeology.
- A summary of lead and carcinogenic polycyclic aromatic hydrocarbon (cPAH) concentrations in soil and sediment.
- A summary of lead and cPAH concentrations in surface and groundwater.
- A description of contaminants of concern (COCs) and environmental pathways.
- Identification of appropriate clean up levels (CULs) for each COC.
- Identification of remedial alternatives and a preferred alternative that includes best management practices (BMPs) for future use of the Site as an active shooting range.

2.0 SITE DESCRIPTION AND HISTORY

The Site is located at 292 Dryke Road, Sequim, Clallam County, Washington 98382. The Public Land Survey coordinates are: NW¼, SE¼, Section 17, Township 30 North, Range 4 West (Willamette Meridian). The Site is located approximately 5 miles west of Sequim, Washington (Figure 1).

The Site opened in 1967 and has been used since then as a shotgun shooting range and a dog training facility. Currently, there are multiple sporting clay shotgun shooting stations and a small caliber (.22) range on the Site. The small caliber range is infrequently used. COCs associated with shooting ranges in general are lead (from bullets and shotgun shot) and cPAHs (from clay targets).

However, it is important to note that there are no national or state bans on the use of lead shot or clay targets on private land, including shooting ranges. Lead shot is banned in waterfowl hunting nationwide and is banned at certain upland public hunting sites owned by the

Washington State Department of Fish and Wildlife. Lead shot was banned from waterfowl hunting nationally because of concerns of toxicity to waterfowl from ingesting spent lead shot. Waterfowl hunting does not occur at the Site.

The Site currently occupies approximately 40 acres (Ac) of wooded and open areas, and contains three ponds (Upper Pond, Middle Pond and Lower Pond), a creek, a main residence, a second residence, and some small structures (i.e., Club House, kennels, gun repair shop) associated with the shooting range (Figure 2). There are two septic systems and one water-supply well. The Site is surrounded by single family dwellings with variable lot sizes. The dwelling density is highest at the trailer park that lies south (and upgradient) from the Site.

A 1937 aerial photograph shows the Site and surrounding areas were forested and there were no ponds at the Site (p6, ESA, 2010a). The Site was logged of second growth timber in 1946. A 1956 aerial photograph shows the Site and surrounding areas were forested and the Upper Pond was present (p6, ESA, 2010a). According to ESA, the Site was used to raise chickens, goats, horses, and ducks prior to its use as a shooting range (p14, 2010a). From 1960 to 1967, Mr. Dryke (recently deceased) trained dogs and operated a dog kennel at the Site. The northern portion of the Site, in the vicinity of the Lower Pond, was reportedly used by the public for hunting (Dryke, 2012). In 1967, Mr. Dryke opened the Sunnydell Gun Club, which has become internationally recognized for trap and skeet shooting, training shooters, and training dogs. In 1967, a small lead reclamation project took place in the vicinity of the trap field (p14; ESA, 2010a).

The Lower Pond was excavated in 2000 at the location of a swamp in the northeastern portion of the Site according to anecdotal evidence collected by ESA (p14, 2010a). Soil from excavating the Lower Pond reportedly was used for fill material on the adjacent Miller Property with their consent (p14, ESA, 2010a).[1] The Lower Pond was used for target practice and waterfowl hunting for a short period of time, but has exclusively been used for dog training since about 2002 (p17, ESA, 2010a).

ESA concluded that lead shot was deposited downrange of shooting areas but was not dispersed onto the land surrounding the main residence, bird pens, dog kennels, and Club House. The areas of concern identified by ESA for lead deposition are (obviously) the active or former shooting areas, including the Upper Pond, Lower Pond, Weeping Willow[2], and Rabbit Run (Figure 2). ESA estimated the amount of lead shot dispersed over the Upper Pond in 43 years was about 100 tons, and that another 100 tons was dispersed throughout the other shooting ranges at the Site (p.1; ESA, 2010b).[3]

LGI understands that the current owners plan to continue using the Site as a shooting range into the foreseeable future. As part of the management of the shooting range, the owners are currently reclaiming lead from the active shooting ranges. Lead reclamation is done at most ranges periodically, as lead shot is an easily recyclable material and provides the range owner a source of income. Currently, lead reclamation of Upper Pond sediment and nearby soil is underway. This activity is expected to continue for most of 2012.

[1] The fill was placed on the Miller property north of the Lower Pond.

[2] The Weeping Willow area has also been referred to as the Partridge Trap.

[3] ESA's estimate may be incorrect. Refer to Appendix D.

The Site consists of a 38.89-Ac property that is in the process of being subdivided into two properties, Lot 1 (9.03 Ac) and Lot 2 (29.86 Ac, refer to Figure 16).[4] The former owners of the Site, Mr. Chuck Dryke and Ms. Rosemary Knotek, started working with Clallam County in 2010 to perform a Large Lot Subdivision. Mr. Dryke's ownership passed to his daughter Ellen Dryke after he died in February 2012. The Site is currently owned by Ms. Dryke and Ms. Knotek.

3.0 SITE SETTING, GEOLOGY, AND HYDROGEOLOGY

3.1 Topography, Improvements, Surface Water, Cuts, and Fills

The Site is located on 38.89 Acs of low-gradient topography that slopes mainly to the northeast (Figure 3). Some areas of the Site are forested with a second and third growth mixed conifer-deciduous forest. LGI estimates that the forest cover is about 50%, based on Figure 2. LGI identified four surface water bodies at the Site: the Upper Pond, the Lower Pond, a small creek located in the northwestern portion of the Site (referred to in this report as the West Creek), and a very small pond that discharges to the Lower Pond (referred to in this report as the Middle Pond; Figure 3).

LGI did not observe evidence of significant surface water runoff from the Site to adjacent properties.[5] Such evidence would consist of ditches, cross drains, water bars, ditch-outs, gully erosion, or sediment deposits. Given the unpaved condition of much of the Site, runoff infiltrates into soil located near the roads and buildings.

The Site improvements include roads, two residences, a Club House, dog kennels, bird pens, target launchers, and shooting platforms. There is also a water-supply well and two septic systems. The water-supply well and one septic system is located near the main residence located in the southeastern, or upgradient portion of the Site. The other septic system is located by the Club House.

Runoff from US Highway 101, located approximately 1,600-ft south of the Site, flows into a ditch that flows to the ditch located on the east side of Dryke Road, which reportedly discharges into the Upper Pond (p.8; ESA, 2010b). In addition, the ditch on Dryke Road is sometimes used to convey water from a local irrigation agency into the Upper Pond. Hence, highway runoff (and any contaminants within) is one of the water sources for the Upper Pond (p. 13; ESA, 2010a).

LGI understands that the Upper Pond is an artificial pond whose water level is maintained by water pumped from the Lower Pond, groundwater seepage from upgradient areas, natural precipitation, and an off-site ditch system. A float valve in the Lower Pond reportedly controls the pump. Groundwater seepage into the Upper Pond likely has increased as a result of development of upland property (i.e., the trailer court). The Middle Pond appears to be diked (and possibly created by the adjacent road prism). Water flows through an overflow structure from the Middle Pond into the Lower Pond. Sometimes water from the irrigation agency, via the ditch system, is used to maintain the water level in the Upper Pond. In addition, an unknown amount of inflow consists of runoff from US Highway 101 that flows into the Upper Pond via the ditch system.

---

[4] 38.89 represents the NET or taxable acres; 39.80 represents the GROSS acres, which includes easements and right-of-ways.

[5] West Creek flows off-site. However, there is no obvious source of surface water runoff from the Site into West Creek.

The West Creek appears to be a natural channel that begins in a swale located in the northwestern portion of the Site. The creek flows northwest and exits the Site near the northwest property corner. LGI did not determine whether the West Creek connects to a larger creek or infiltrates into the soil and terminates north of the Site.

The cuts and fills LGI identified are summarized in Table 3-1.

Table 3-1. Summary of Cuts and Fills Identified by LGI at the Site

Location	Description
Upper Pond	The Upper Pond reportedly constructed by excavating peat to hardpan. By 1955, the Upper Pond was approximately the same size at it currently is (p.13; ESA, 2010a).
Lower Pond	The Lower Pond was constructed by excavating swampy ground (p.14; ESA, 2010a). The waste soil was deposited on the Miller Property (i.e., north of pond).
Miller Property north of Lower Pond	Waste soil from the Lower Pond was deposited on the Miller Property north of the Lower Pond. The east-west roads located on both sides of the property line appear to be situated on some of this fill.
Rabbit Run	The steep banks that stop the shot appear to have been excavated into the hillside.
Weeping Willow	A soil bank was reportedly constructed to stop stray shot (p.15; ESA, 2010a).
Between Middle Pond and Lower Pond	The Middle Pond appears to have been formed or made deeper by a road prism constructed between it and the Lower Pond.

3.2 Soils

The Site is situated on three soil units according to the National Resources Conservation Service (NRCS; Figure 4). These are Cassolary fine sandy loam, 0 to 8% slopes (unit 9); Clallam gravelly sandy loam, 0 to 15% slopes (unit 12); and Hoypus gravelly sandy loam, 0 to 15% slopes (unit 23). According to the NRCS, Cassolary fine sandy loam forms on hillslopes in glacial drift and glaciomarine deposits. Clallam gravelly sandy loam forms on hillslopes in glacial till. Hoypus gravelly sandy loam forms on outwash terraces in glacial outwash.[6]

3.3 Geology

Geologic mapping by Schasse and Wegmann (2000) shows that the Site is situated on Pleistocene deposits of undifferentiated drift related to the Fraser glaciation (unit Qgd). Qgd consists of “random mixtures of sand and gravel, lodgment till, sandy ablation (?) till, and lacustrine (?) silts.” They believe the deposit varies from 50- to 150-feet (ft) thick, based on water well data. The Qgd grades southward into lodgment till that veneers underlying bedrock; northward Qgd is overlapped by alluvial fan deposits.

[6] Soil information was obtained from the following NRCS website: http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

LGI observed glacial deposits at the Site that are generally consistent with the description in Schasse and Wegmann. At locations MW1, MW2, and MW3, surface soils are dense and appear to be a glacially overridden sandy till (Figure 5a). The till overlies a very stiff silt at MW3 that is about 9-ft thick and that is probably an overridden glaciolacustrine deposit. A water-bearing, poorly graded fine sand is present at all boring locations; this sand may be an advance outwash deposit or other deposit. Sample recoveries were generally not good at boring MW5 (Appendix A; LGI, 2011b).

3.4 Hydrogeology

Observations of surface water in many locations at the Site, wet soils in the northern study area, and shallow groundwater at the Site suggest that there is a continuous and steep groundwater table under the Site. Based on this assumption, LGI prepared a hydrogeologic cross section (Figures 5a and 5b). The cross section lumps the soils at the Site into two categories: the more permeable soils were placed into a higher hydraulic conductivity or Higher K unit and the less permeable soils into a Lower K unit. Groundwater flow occurs mainly in the Higher K unit. LGI prepared this cross section using the November 2010 Geoprobe data and driller's Water Well Report for the Miller well located about 730-ft north of the property line (LGI, 2011b). LGI was unable to locate a Water Well Report for the Dryke well, which is also shown on Figures 5a and 5b.

A Water Well Report for a different Miller's well located at 434 Pinnel Road is included in Appendix B of this report. LGI understands that this well, which was constructed in 1981, supplies water to the Miller house, which is located on the north side of Pinnel Road. LGI estimates that the elevation of the ground surface at the location of this well is about 202 ft (based on LiDAR-derived topography). The well log indicates the well screen is located between 144- and 195-ft bgs, which corresponds with elevations between approximately 7 and 58 ft. Because Figure 5b shows the strata dip gently to the north, LGI infers the Miller water-supply well screen is located in the lower of the two "Higher K" stratigraphic units shown on Figure 5b.

Groundwater measurements were made on November 11, 2010 and June 29, 2011 (Figure 6). The 220-ft contour was extended from the Lower Pond to the West Creek assuming a continuous groundwater table exists and the surface water elevation of West Creek, which LGI inferred from LiDAR-derived topography, is correct. Measurements on both dates show groundwater flow toward the north and confirm that the monitoring wells are correctly positioned downgradient from the ponds. Water level measurements and survey data are presented in Appendix B in LGI (2011b).

The available data suggest groundwater may seasonally discharge to the flatter and lower ground surface in the northern portion of the Site and the southern portion of the Miller Property, and this condition causes the wet, swampy soils observed in this area. The wet soils are present at this location because the Lower K unit or fill (e.g., from a road prism) does not cap the Higher K unit. In these locations, the Lower K unit was not deposited or it eroded away.

In summary, groundwater occurs at shallow depths under the Site and flows northward in a continuous water table aquifer that is in hydraulic contact with the Upper Pond, Lower Pond, Middle Pond, and West Creek. The aquifer that the Dryke's well and nearby wells, such as the Miller's wells, draw water from is a much deeper regional aquifer that does not appear to be hydraulically connected with the water table aquifer at the Site.

4.0 PREVIOUS INVESTIGATIONS AT THE SITE

Investigations at the Site and the north adjacent Miller Property are summarized in Table 4-1. Some of the early investigations were not well documented.

Table 4-1. Summary of Environmental Investigations

Date	Investigator	Summary of Sample Testing
Sep. 8, 2004	CCHHS	CCHHS collected one composite sediment and one water sample from the Upper Pond and one composite sediment sample and two water samples from the Lower Pond. The samples were tested for lead. Refer to Appendices A and B for the laboratory report and sample locations.
Jul. 29, 2005	CCHHS	CCHHS collected one soil sample at the Rabbit Run (also referred to as the gun testing area), one soil sample at the Bird Box, and one soil sample at the Weeping Willow areas. All samples were tested for lead and PAHs. Refer to Appendices A and B for the laboratory report and sample locations.
Aug. 2, 2005	CCHHS	CCHHS collected four sediment samples at the water line of the Upper Pond at the Dog Jump, Dog Beach, Wishing Well, and Cattail areas. All samples were tested for lead. Refer to Appendices A and B for the laboratory report and sample locations.
Jan. 22, 2009	CCHHS	CCHHS collected three soil and three surface water samples at the Miller Property north of the Lower Pond and tested them for lead (ESA, 2010b). Refer to Appendices A and B for the laboratory report and sample locations.
Jul. 13, 2010	Ecology	Ecology collected one water sample from the water-supply well for the Miller residence located at 434 Pinnell Road. The sample was tested for lead and PAHs. Refer to Appendices A and B for summary test results and the laboratory report.
July 2010	ESA	ESA collected soil samples at the Rabbit Run and Weeping Willow areas; sediment samples from the Upper Pond and Lower Pond; soil samples from the Miller Property (referred to as the Adjacent Property); and surface water samples from the Upper Pond and Lower Pond. Selected samples were tested for lead and PAHs (ESA, 2010b). Refer to Appendices A and B for the test results and sample locations.
Nov. 2010	LGI	LGI installed monitoring wells; measured water levels; collected limited soil samples from selected boring locations; collected groundwater samples from selected wells; and collected surface water samples from the Upper Pond, the Lower Pond, and the West Creek. Selected samples were tested for lead and cPAHs (LGI, 2010). Refer to Appendices A and B for the test results and sample locations.
June 2011	LGI	LGI measured water levels; collected soil samples at the Miller Property at the approximate location of the ESA samples; collected groundwater samples from selected wells; and collected surface water samples from the Upper Pond, the Lower Pond, and the West Creek. Soil samples were tested for lead; selected groundwater and surface water samples were tested for lead and cPAHs. Water samples for lead analysis were field filtered (LGI, 2011a, b). Refer to Appendices A and B for the test results and sample locations.

5.0 IDENTIFICATION OF CHEMICALS OF CONCERN AND CLEANUP LEVEL SELECTION

5.1 Chemicals of Concern

The use of the Site has resulted in accumulation of lead shot in certain areas due to target practice. Target practice deposited lead shot, lead bullets, and fragments from "clay targets" on the ground surface and in the ponds. The U.S. Environmental Protection Agency (EPA) states that lead shot contains primarily lead (97%), antimony (2%), arsenic (0.5%), and sometimes nickel (0.5%) (EPA, 2003). Painted clay targets contain approximately ⅔ dolomitic sandstone and ⅓ pitch (which contains PAHs) and approximately 1% fluorescent paint. Testing of soil, surface water, and groundwater samples collected by CCHHS, ESA, and LGI (summarized in Table 4-1 and Appendix A) identified high levels of lead and PAHs in areas at the Site where shooting occurs, a not surprising finding. As mentioned previously, lead reclamation occurs at most shooting ranges nationally primarily for the economic return to range operators and also to reduce lead concentrations in soil.

5.2 Cleanup Level Determination

Table 5-1 lists various applicable environmental criteria for evaluating the concentrations of lead and PAHs at the environmental media of concern at the Site (groundwater, surface water, soil, and sediment). The most conservative of these values for each medium was chosen as the CUL.

Three surrogates were used to evaluate PAH toxicity with respect to different regulatory criteria. Benzo-a-pyrene was selected as one of the surrogates because it is a cPAH with the highest toxicity, is frequently detected at the Site, and has specific cleanup criteria. Other PAHs detected in soil and sediment samples include (* indicates cPAH) acenaphthlene, benzo(a)anthracene*, benzo(b)fluoranthene*, benzo(k)fluor-anthene*, chrysene*, fluoranthene, phenanthrene, pyrene, and others. Refer to Appendix A for a complete list of PAH compounds detected.

The second surrogate used to evaluate PAH toxicity is the benzo-a-pyrene Toxicity Equivalence (TEQ). The TEQ is a concentration that represents the sum of all the detected cPAHs normalized to the toxicity of benzo-a-pyrene. This number represents the toxicity of all the cPAHs as if the toxicity was due to benzo-a-pyrene alone.

The third surrogate used to evaluate PAH toxicity is total PAHs. The total PAHs consist of the sum of all detected PAH compounds. Appendix A summarizes all PAHs detected in all soil and sediment samples and shows the TEQ concentrations calculated for each sample.

Table 5-1. Summary of Applicable Environmental Criteria for COCs at the Site

Parameter	Medium	Concentration	Comments
Lead	Freshwater Sediment	360 mg/Kg (proposed)	Sediment Quality Standard/Screening Level 1 (Table ES-1; Ecology, 2011).
Lead	Soil	250 mg/Kg	Model Toxics Control Act (MTCA) Method A for unrestricted land use (WAC173-340-900, Table 740-1).

Parameter	Medium	Concentration	Comments
Lead	Soil	220 mg/Kg	MTCA Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified Terrestrial Ecological Evaluation Procedure (WAC173-340-900, Table 749-2 for unrestricted land use).
Lead	Groundwater	15 µg/L	MTCA Method A (WAC173-340-900, Table 720-1).
Lead[1]	Drinking Water	50 µg/L	WAC 173-200-040, Table 1.
Lead	Fresh Surface Water	2.3 µg/L	Assumes a hardness of 100 mg/L $CaCO_3$ (WAC 173-201A).
Benzo-a-pyrene	Soil	30 mg/Kg	MTCA Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified Terrestrial Ecological Evaluation Procedure (WAC173-340-900, Table 749-2 for unrestricted land use).
Benzo-a-pyrene	Soil	0.1 mg/Kg	MTCA Method A for unrestricted land use (WAC173-340-900, Table 740-1).
cPAH TEQ	Soil	0.1 mg/Kg	MTCA Method A for unrestricted land use (WAC173-340-900, Table 740-1).
Total PAHs	Freshwater Sediment	17 mg/Kg	Proposed Sediment Quality Standard/Screening Level 1 (Table ES-1; Ecology, 2011). This criterion may not be applicable to the Upper Pond because it is an active shooting range.
Benzo-a-pyrene	Groundwater	0.1 µg/L	MTCA Method A Cleanup Levels for Groundwater (WAC 173-340-900, Table 720-1).
cPAH TEQ	Groundwater	0.1 µg/L	MTCA Method A Cleanup Levels for Groundwater (WAC 173-340-900, Table 720-1).
Benzo-a-pyrene	Drinking Water	0.008 µg/L	WAC 173-200-040, Table 1. Note: 0.008 µg/L criterion is below the laboratory reporting limit. In this situation it is customary to substitute the reporting limit. For water samples collected June 2011 and analyzed by Fremont Analytical, the reporting limit was 0.1 µg/L for individual PAHs including benzo-a-pyrene.

Note:

1. Measured as total metals.

The CUL of 220 mg/Kg for lead was selected for soil and sediment for two reasons. First, the 220 mg/Kg MTCA Ecological Cleanup Level is more conservative than the 250 mg/Kg MTCA Method A Cleanup Level for unrestricted land use. Second, because the Site is relatively large, mostly undeveloped, and has forest and shrub habitat, a terrestrial ecological criterion would be more appropriate as it is more conservative than the MTCA unrestricted land use criterion. The term “sediment” does not apply well to the ponds because they are man-made, relatively young, and most of the samples were collected along the shoreline where the “sediment” is the thinnest and mixed with upland soil. However, Ecology’s recently proposed sediment criteria are presented in Table 5-1 to help evaluate pond “sediment”.

The drinking water criterion of 15 µg/L lead was selected for the groundwater CUL because domestic water-supply wells are used in this area.

The freshwater criterion of 2.3 µg/L lead was selected for the surface water CUL based on water quality standards for the protection of fish, which for metals are hardness-dependent because the ability of fish gills to adsorb metals is limited by hardness. LGI tested three surface water samples for hardness in June 2011 and the hardness values ranged close to 100 mg/L. Based on a conservative estimate of measured hardness of 100 mg/L (as $CaCO_3$), the CUL for lead is 2.3 µg/L. There are no fresh surface water criteria for PAHs (i.e., PAHs are not toxic to fish).

A CUL of 0.1 mg/Kg TEQ was selected for soil PAHs for two reasons. TEQ concentrations were selected over benzo-a-pyrene because the same MTCA CUL criteria can apply to both the TEQ and benzo-a-pyrene. Yet, the TEQ is more conservative than benzo-a-pyrene because the TEQ concentration is composed of seven cPAHs, including benzo-a-pyrene.

A CUL of 17 mg/Kg for Total PAHs was selected for sediment as a sediment surrogate based on the recently proposed freshwater sediment quality standards. As indicated above, most sediment samples were collected along the shorelines of the ponds where sediment is thinnest and likely mixed with upland soil. However, this criterion provides a useful reference point for evaluating potential toxic effects on freshwater organisms.

The laboratory reporting limit of 0.1 µg/L TEQ was selected for the groundwater CUL for PAHs in lieu of the risk-based drinking water criterion for benzo-a-pyrene, which is below the laboratory reporting limit (Table 5-2). As stated above, the TEQ is more conservative than benzo-a-pyrene because the TEQ concentration is composed of seven cPAHs including benzo-a-pyrene.

Table 5-2. Summary of Site-specific CULs

Parameter	Medium	CUL Concentration	Comments
Lead	Soil/Sediment	220 mg/Kg	Most restrictive of the soil and sediment criteria listed in Table 5-1. Soil and sediment may be hard to distinguish in the shoreline area of the ponds.
Lead	Groundwater	15 µg/L	Most restrictive of the groundwater and drinking water criteria listed in Table 5-1.
Lead	Fresh Surface Water	2.3 µg/L	Assumes a hardness of 100 mg/L $CaCO_3$., which is higher than the harnesses measured at the Site.
Total PAHs	Fresh water sediment	17 mg/Kg	This proposed sediment quality standard may not apply to the Upper Pond because it is an active shooting range whose habitat quality is significantly limited.
TEQ[1]	Soil	0.1 mg/Kg	MTCA Method A for unrestricted land use (WAC173-340-900, Table 740-1).
TEQ[1]	Groundwater	0.1 µg/L	MTCA Method A for Ground Water (WAC173-340-900, Table 720-1). This CUL is based on the laboratory instrument reporting limits.

Note:
1. TEQ (Toxicity Equivalence) is explained in Section 5.2.

5.3 Chemicals of Concern in Upper Pond Sediment

Sediment samples were collected from the Upper Pond by CCHHS and ESA. CCHHS reported that their samples were collected along the shoreline and so, in fact, may be "soil". All sample locations and test results for CCHHS samples are summarized in Appendix A. Test results in terms of both TEQ and total PAHs are given below because, lacking descriptions of each sample, it is unclear which samples were actually soil or sediment or a mixture of both.

Many Upper Pond sediment samples contained concentrations of lead, TEQ, and total PAHs that exceed the site-specific CULs. These results are not unexpected given that the Upper Pond is an active shooting range and lead shot and target fragments fall directly into the pond and on the shore. From a total of 40 samples collected by ESA in July 2010, 34 exceeded the 220 mg/Kg lead CUL, with 190,000 mg/Kg (i.e., 19% by weight) being the highest sample concentration. From a total of 40 samples, 23 equaled or exceeded the 0.1 mg/Kg TEQ CUL, with 89.01 mg/Kg being the highest sample concentration. In contrast, from a total of 40 samples collected by ESA in July 2010, only six exceeded the 17 mg/Kg total PAHs CUL. Concentrations of lead and PAHs this high indicate pieces of lead shot and target fragments were present in many of the samples analyzed. The lead, TEQ, and total PAHs test results are summarized in Table 5-3. Lead and TEQ test results are summarized on Figures 7 and 8.

Each of the total PAHs exceedances coincided with a TEQ exceedance. However, the much higher number of TEQ exceedances (23) in comparison with total PAHs exceedances (7) suggests that the volume of the sediment potentially toxic to humans is significantly larger than the volume of sediment potentially toxic to freshwater aquatic organisms.

Table 5-3. Selected Test Results for Sediment Samples Collected in Upper Pond

Date (sampler)	Sample ID	Lead (mg/Kg)	cPAH TEQ (mg/Kg)	Total PAHs (mg/Kg)	Comments
9/8/2004 (CCHHS)	Upper Pond	**77,800**	(not tested)	(not tested)	Composite sample from four shallow locations around the pond. GPS position is available for one of the four locations.
8/2/2005 (CCHHS)	Dryke 4 (dog jump)	**46,200**	(not tested)	(not tested)	GPS position available. Depth unknown but probably surface grab.
8/2/2005 (CCHHS)	Dryke 5 (dog beach)	6.3	(not tested)	(not tested)	GPS position available. Depth unknown but probably surface grab.
8/2/2005 (CCHHS)	Dryke 6 (wishing well)	27.9	(not tested)	(not tested)	GPS position available. Depth unknown but probably surface grab.
8/2/2005 (CCHHS)	Dryke 7 (cat tails)	**5,210**	(not tested)	(not tested)	GPS position available. Depth unknown but probably surface grab.
7/12/2010 (ESA)	Q1-1-1	**1,800**	**0.30**	2.9	Surface sample. Position approximate.
7/12/2010 (ESA)	Q1-1-3	**820**	**0.83**	7.2	3- inches (in) deep. Position approximate.
7/12/2010 (ESA)	Q1-1-6	**100,000**	**0.18**	1.6	6-in deep. Position approximate.
7/12/2010 (ESA)	Q1-2-1	**6,200**	nd	nd	Surface sample. Position approximate.
7/12/2010 (ESA)	Q1-2-3	**4,300**	nd	nd	3-in deep. Position approximate.

Date (sampler)	Sample ID	Lead (mg/Kg)	cPAH TEQ (mg/Kg)	Total PAHs (mg/Kg)	Comments
7/12/2010 (ESA)	Q1-2-6	**6,100**	nd	nd	6-in deep. Position approximate.
7/12/2010 (ESA)	Q1-3-1	**160,000**	**0.32**	3.4	Surface sample. Position approximate.
7/12/2010 (ESA)	Q1-3-3	**440**	**0.12**	0.8	3-in deep. Position approximate.
7/12/2010 (ESA)	Q1-3-6	**2,000**	nd	nd	6-in deep. Position approximate.
7/12/2010 (ESA)	Q2-1-1	**2,800**	nd	0.4	Surface sample. Position approximate.
7/12/2010 (ESA)	Q2-1-3	**120,000**	0.03	2.3	3-in deep. Position approximate.
7/12/2010 (ESA)	Q2-1-6	**140,000**	**1.18**	9.4	6-in deep. Position approximate.
7/12/2010 (ESA)	Q2-2-1	**660**	0.02	2.2	Surface sample. Position approximate.
7/12/2010 (ESA)	Q2-2-3	80	nd	0.2	3-in deep. Position approximate.
7/12/2010 (ESA)	Q2-2-6	33	nd	0.02	6-in deep. Position approximate.
7/12/2010 (ESA)	Q2-3-1	**750**	**0.12**	0.9	Surface sample. Position approximate.
7/12/2010 (ESA)	Q2-3-3	**610**	**8.33**	**79.5**	3-in deep. Position approximate.
7/12/2010 (ESA)	Q2-3-6	**290**	**1.16**	8.2	6-in deep. Position approximate.
7/12/2010 (ESA)	Q3-1-1	160	nd	0.2	Surface sample. Position approximate.
7/12/2010 (ESA)	Q3-1-3	180	**0.67**	6.5	3-in deep. Position approximate.
7/12/2010 (ESA)	Q3-1-3 Dup	130	(not tested)	(not tested)	Duplicate of Q3-1-3.
7/12/2010 (ESA)	Q3-1-6	130	**89.01**	**511**	6-in deep. Position approximate.
7/12/2010 (ESA)	Q3-2-1	**750**	nd	0.2	Surface sample. Position approximate.
7/12/2010 (ESA)	Q3-2-3	**710**	**0.22**	0.6	3-in deep. Position approximate.
7/12/2010 (ESA)	Q3-2-6	22	nd	0.2	6-in deep. Position approximate.
7/12/2010 (ESA)	Q3-3-1	**560**	nd	0.2	Surface sample. Position approximate.
7/12/2010 (ESA)	Q3-3-3	**500**	nd	0.3	3-in deep. Position approximate.
7/12/2010 (ESA)	Q3-3-6	32	**1.10**	12.8	6-in deep. Position approximate.
7/12/2010 (ESA)	Q4-1-1	**490**	**0.24**	1.9	Surface sample. Position approximate.
7/12/2010 (ESA)	Q4-1-3	**160,000**	**3.88**	**31.8**	3-in deep. Position approximate.
7/12/2010 (ESA)	Q4-1-6	**530**	**0.30**	2.3	6-in deep. Position approximate.
7/12/2010 (ESA)	Q4-1-6 Dup	**420**	(not tested)	(not tested)	Duplicate of Q4-1-6.
7/12/2010 (ESA)	Q4-2-1	**1,100**	**10.85**	**87.5**	Surface sample. Position approximate.
7/12/2010 (ESA)	Q4-2-3	**19,000**	**0.86**	7.1	3-in deep. Position approximate.
7/12/2010 (ESA)	Q4-2-6	**920**	**3.17**	**22.9**	6-in deep. Position approximate.

Date (sampler)	Sample ID	Lead (mg/Kg)	cPAH TEQ (mg/Kg)	Total PAHs (mg/Kg)	Comments
7/12/2010 (ESA)	Q4-3-1	**3,100**	**5.42**	**27.9**	Surface sample. Position approximate.
7/12/2010 (ESA)	Q4-3-3	**67,000**	**0.55**	3.4	3-in deep. Position approximate.
7/12/2010 (ESA)	Q4-3-6	110	nd	nd	6-in deep. Position approximate.
7/12/2010 (ESA)	UPSED-1	**460**	nd	nd	Top 2-in of sediment under 8-ft water. Position approximate.
7/12/2010 (ESA)	UPSED-2	**360**	nd	nd	Top 2-in of sediment under 8-ft water. Position approximate.
7/12/2010 (ESA)	UPSED-3	**230**	**0.20**	0.5	Top 2-in of sediment under 8-ft water. Position approximate.
7/12/2010 (ESA)	UPSED-4	**450**	**0.20**	1.6	Top 2-in of sediment under 8-ft water. Position approximate.
7/12/2010 (ESA)	UPSED-4 Dup	**550**	(not tested)	(not tested)	Duplicate of LPSED-4.

Notes:
Bold = Exceedance of proposed fresh water sediment criteria.
nd = PAHs were not detected and a TEQ concentration could not be calculated.

It is important to understand that the deepest sediment samples collected by ESA around the pond perimeter were relatively shallow; less than 6-in (0.5-ft) below the sediment surface along the shore and less than 2-in (0.17-ft) below the sediment-water interface in the pond interior. ESA's samples did not identify the full vertical and lateral extent of the elevated lead and PAH concentrations because (a) the deepest samples were not collected deep enough and (b) the samples were not collected upland of the pond (which is an active shooting range). However, it is expected that elevated lead and cPAH concentrations occur in soil downrange of Active Shooting Areas, and the concentrations of COCs in Active Shooting Areas will always be in flux because lead is constantly being added to the surface soil and periodically removed by reclamation.

The Upper Pond was reportedly created by excavating a peat bog 5-ft down to hardpan in the 1950s (pp.6 and 13; ESA Associates, 2010a). The gun club opened in 1967. This information suggests that (a) lead shot and clay targets are probably present throughout the entire thickness of sediment that has accumulated in the Upper Pond since the excavation, (b) lead shot and clay targets are entrained in the sediment and not in the underlying hard pan, and (c) most of the lead in the sediment should be recoverable by excavating or dredging the soft sediment down to the underlying hardpan.

To demonstrate that the lead shot in the soils sampled by ESA is limited to the upper 12-in or so of surface soil, LGI collected soil samples at the locations of MW1 and MW2 at 1-foot bgs during the November 2010 monitoring well installation (LGI, 2011b). Lead was not detected in these samples (reporting limit was 5 mg/Kg). These samples were not tested for PAHs. At least in these two locations (50- and 82-ft from the pond, respectively), lead contamination is not present 1-foot below grade. These results were expected given that pure metallic lead shot is insoluble in soil unless exposed to acidic environmental conditions. Lead shot, does, however, after deposition, tend to migrate down into soft soil due to lead's high density and soil movement (wet-dry, freeze-thaw, plant, animal, and human activity).

The Site Characterization Report (LGI, 2011b) concluded that the high concentrations of lead and PAHs in the Upper Pond sediment do not warrant further investigation at this time because the Site is an active shooting range, and lead and PAHs can be expected to occur everywhere throughout the sediment column overlying the hardpan pond bottom.

5.4 Chemicals of Concern in Lower Pond Sediment

Sediment samples were collected from the Lower Pond by ESA and by CCHHS. ESA's sample locations and test results are presented in ESA (2010b). A few of ESA's samples contained elevated concentrations of lead and PAHs. From a total of 28 sediment samples, only three exceeded the 220 mg/Kg lead CUL, with 700 mg/Kg being the highest sample concentration. Similarly, from a total of 28 sediment samples, only two exceeded the 0.1 mg/Kg TEQ CUL, with 2.0 mg/Kg being the highest sample concentration and only one exceeded the 17 mg/Kg total PAHs criterion with 24.4 mg/Kg being the highest. The total PAHs exceedance coincided with the higher of the two TEQ exceedances. Both the TEQ and total PAHs exceedances were limited to one sample location (i.e., the location of samples LPQ-1-2-1, LPQ-1-2-2, and LPQ-1-2-3 on Figure A5 in Appendix A). Lead, TEQ, and total PAHs results are summarized in Table 5-4. Lead and TEQ results are summarized on Figures 9 and 10.

It is important to understand that the deepest sediment samples collected by ESA around the pond perimeter were relatively shallow, less than 6-in (0.5-ft) below the sediment surface and less than 2-in (0.17-ft) below the sediment-water interface in the pond interior. ESA's work shows that the extent of lead and PAH contamination at the Lower Pond is limited. These data are consistent with anecdotal information that indicates limited historical use of the Lower Pond for shooting. Consequently, significant accumulations of lead shot or target fragments would not be expected in this area.

Table 5-4. Selected Test Results for Sediment Samples Collected in Lower Pond

Date (sampler)	Sample ID	Lead (mg/Kg)	TEQ (mg/Kg)	Total PAHs (mg/kg)	Comments
9/8/2004 (CCHHS)	Lower Pond	100	(not tested)	(not tested)	Composite sample from four shallow locations around pond. GPS positions are available for two of the four locations.
7/13/2010 (ESA)	LPQ-1-1-1	8.0	nd	0.1	Surface sample. Position approximate.
7/13/2010 (ESA)	LPQ-1-1-3	120	nd	0.04	3-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-1-1-6	5.2	0.02	0.1	6-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-1-2-1	170	**0.34**	3.4	Surface sample. Position approximate.
7/13/2010 (ESA)	LPQ-1-2-3	8.1	nd	0.02	3-in deep .Position approximate.
7/13/2010 (ESA)	LPQ-1-2-6	13	**3.25**	**24.4**	6-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-2-1-1	25	nd	nd	Surface sample. Position approximate.

Date (sampler)	Sample ID	Lead (mg/Kg)	TEQ (mg/Kg)	Total PAHs (mg/kg)	Comments
7/13/2010 (ESA)	LPQ-2-1-3	47	nd	nd	3-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-2-1-6	32	nd	nd	6-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-2-2-1	24	nd	0.03	Surface sample. Position approximate.
7/13/2010 (ESA)	LPQ-2-2-1 Dup	31	(not tested)	(not tested)	Duplicate of LPQ-2-2-1.
7/13/2010 (ESA)	LPQ-2-2-3	52	nd	0.03	3-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-2-2-6	100	nd	nd	6-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-3-1-1	200	nd	0.1	Surface sample. Position approximate.
7/13/2010 (ESA)	LPQ-3-1-3	210	0.001	0.1	3-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-3-1-6	210	nd	nd	6-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-3-2-1	**700**	nd	0.2	Surface sample. Position approximate.
7/13/2010 (ESA)	LPQ-3-2-3	**690**	nd	nd	3-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-3-2-6	**660**	nd	nd	6-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-4-1-1	30	nd	nd	Surface sample. Position approximate.
7/13/2010 (ESA)	LPQ-4-1-3	8.3	nd	nd	3-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-4-1-3 Dup	12	(not tested)	(not tested)	Duplicate of LPQ 4-1-3.
7/13/2010 (ESA)	LPQ-4-1-6	7	nd	nd	6-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-4-2-1	15	nd	nd	Surface sample. Position approximate.
7/13/2010 (ESA)	LPQ-4-2-3	8.9	nd	nd	3-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-4-2-6	5.7	nd	nd	6-in deep. Position approximate.
7/13/2010 (ESA)	LPQ-4-2-6 Dup	6.2	(not tested)	(not tested)	Duplicate of LPQ-4-2-6.
7/13/2010 (ESA)	LPSED-1	34	nd	nd	Top 2-in of sediment under 8-ft water. Position approximate.
7/13/2010 (ESA)	LPSED-2	73	nd	nd	Top 2-in of sediment under 8-ft water. Position approximate.
7/13/2010 (ESA)	LPSED-3	5.0	nd	nd	Top 2-in of sediment under 8-ft water. Position approximate.
7/13/2010 (ESA)	LPSED-4	53	nd	nd	Top 2-in of sediment under 8-ft water. Position approximate.
7/13/2010 (ESA)	LPSED-4 Dup	78	(not tested)	(not tested)	Duplicate of LPSED-4.

Date (sampler)	Sample ID	Lead (mg/Kg)	TEQ (mg/Kg)	Total PAHs (mg/kg)	Comments

Notes:
Bold = Exceedance
nd = PAHs were not detected and a TEQ concentration could not be calculated.

LGI collected one soil sample at the location of MW5 at 1-foot bgs during the November 2010 monitoring well installation (LGI, 2011b). Lead was detected at 12 mg/Kg in this sample, which is a level consistent with natural background. This sample was not tested for PAHs. At least in this location (13-ft from the pond), lead contamination does not appear to be present at this depth. This soil sample likely represents soil removed during excavation of the Lower Pond and placed as fill at this location.

The Site Characterization Report (LGI, 2011b) concluded that the limited number of high concentrations of lead and PAHs detected in the Lower Pond sediment did not warrant further investigation.

5.5 Chemicals of Concern in Rabbit Run Soil

CCHHS collected one soil sample in a ground-level target simulation area referred to as the “Rabbit Run”. This sample contained 618 mg/Kg lead and 9.66 mg/Kg TEQ. Appendix A summarizes test results and shows the sample locations.

ESA collected soil samples at five locations representing an area of approximately 800 square ft (ESA, 2010b). Samples were collected at depths of 1-inch and either 6-in or 12-in bgs at each location. The results for lead and TEQ are summarized in Table 5-5 below; ESA’s sample locations and test results from the Rabbit Run area are shown on Figures 11 and 12 and summarized in Appendix A.

Table 5-5. Selected Test Results for Samples Collected in the Rabbit Run Area

Date (sampler)	Sample ID	Lead (mg/Kg)	TEQ (mg/Kg)	Comments
7/29/2005 (CCHHS)	Dryke1RR	**618**	**9.66**	GPS position available. Probably surface grab.
7/15/2010 (ESA)	RR-1-1	**66,000**	**105.68**	1-in deep. Position uncertain.
7/15/2010 (ESA)	RR-1-2	**3,100**	**44.88**	6-in deep. Position uncertain.
7/15/2010 (ESA)	RR-2-1	**180,000**	**255.72**	1-in deep. Position uncertain.
7/15/2010 (ESA)	RR-2-2	**290**	**21.80**	12-in deep. Position uncertain.
7/15/2010 (ESA)	RR-3-1	**100,000**	**85.78**	1-in deep. Position uncertain.
7/15/2010 (ESA)	RR-3-2	38	**1.09**	12-in deep. Position uncertain.
7/15/2010 (ESA)	RR-4-1	**52,000**	**101.98**	1-in deep. Position uncertain.
7/15/2010 (ESA)	RR-4-2	180	**2.71**	12-in deep. Position uncertain.
7/15/2010 (ESA)	RR-5-1	**63,000**	**140.31**	1-in deep. Position uncertain.
7/15/2010 (ESA)	RR-5-2	82	**6.61**	12-in deep. Position uncertain.

Date (sampler)	Sample ID	Lead (mg/Kg)	TEQ (mg/Kg)	Comments
7/15/2010 (ESA)	RR-5-2 Dup	76	(not tested)	Duplicate of RR-5-2.

Note:

Bold = Exceedance

From a total of ten ESA soil samples, seven exceeded the 220 mg/Kg lead CUL, with 180,000 mg/Kg being the highest sample concentration. From a total of ten soil samples, all ten exceeded the 0.1 mg/Kg TEQ CUL, with 255.72 mg/Kg being the highest sample concentration. However, lead and TEQ concentrations in soil decreased with depth. Only one sample, collected at a depth of 12-in bgs, contained lead that exceeded 220 mg/Kg (sample RR-2-2, 290 mg/Kg at 1-foot bgs), although all deeper samples exceeded the TEQ CUL.

The Rabbit Run area will always have COCs in surface soils at high concentrations that change with time as long as this remains an active target range.

5.6 Chemicals of Concern in Weeping Willow Soil

CCHHS collected two soil samples in a trap and skeet shooting area referred to as the “Weeping Willow” area (ESA, 2010a). Presumably these were surface grab samples. These samples contained 71.3 mg/Kg lead and 261.5 mg/Kg TEQ. Appendix A summarizes test results and shows the sample locations.

ESA collected soil samples at five locations across approximately 1,554 square ft of the Weeping Willow area (ESA, 2010b). Samples were collected at depths of 1-inch and 12-in bgs at each location. Test results for lead and TEQ are summarized in Table 5-6 and shown on Figures 13 and 14.

Table 5-6. Selected Test Results for Samples Collected in the Weeping Willow Area

Date (sampler)	Sample ID	Lead (mg/Kg)	TEQ (mg/Kg)	Comments
7/29/2005 (CCHHS)	Dryke2BB	12.5	(not tested)	GPS position available. Probably surface grab.
7/29/2005 (CCHHS)	Dryke2WW	71.3	**261.50**	GPS position available. Probably surface grab.
7/15/2010 (ESA)	WW-1-1	**300**	**10.26**	1-in deep. Position uncertain.
7/15/2010 (ESA)	WW-1-2	18	**1.84**	12-in deep. Position uncertain.
7/15/2010 (ESA)	WW-2-1	**73,000**	**74.43**	1-in deep. Position uncertain.
7/15/2010 (ESA)	WW-2-2	**15,000**	**28.61**	12-in deep. Position uncertain.
7/15/2010 (ESA)	WW-3-1	**21,000**	**81.76**	1-in deep. Position uncertain.
7/15/2010 (ESA)	WW-3-2	200	**5.38**	12-in deep. Position uncertain.
7/15/2010 (ESA)	WW-4-1	**570**	**58.29**	1-in deep. Position uncertain.
7/15/2010 (ESA)	WW-4-2	**290**	**25.81**	12-in deep. Position uncertain.
7/15/2010 (ESA)	WW-5-1	**5,000**	**52.57**	1-in deep. Position uncertain.

Date (sampler)	Sample ID	Lead (mg/Kg)	TEQ (mg/Kg)	Comments
7/15/2010 (ESA)	WW-5-2	89	**3.33**	12-in deep. Position uncertain.
7/15/2010 (ESA)	WW-5-2 Dup	65	(not tested)	Duplicate of WW-5-2.

Note:
Bold = Exceedance

From a total of 11 ESA soil samples, seven exceeded the 220 mg/Kg lead CUL, with 73,000 mg/Kg being the highest sample concentration. From a total of ten soil samples, all ten exceeded the 0.1 mg/Kg TEQ CUL, with 81.76 mg/Kg being the highest sample concentration.

The lead and TEQ concentrations decrease with depth. Only two of the five samples collected at 12-in bgs contained lead that exceeded the 220 mg/Kg CUL (sample WW-2-2, 15,000 mg/Kg; WW-4-2, 290 mg/Kg), although all deeper samples exceeded the TEQ of 0.1 mg/Kg CUL. In the Site Characterization Report (LGI, 2011b), LGI concluded the data from the Weeping Willow area show that contaminant concentrations decrease with depth and the lead CUL exceedances below 1-foot bgs are not widespread. The Weeping Willow area is an active target range where contaminant levels are expected to change over time, as previously discussed.

5.7 Chemicals of Concern in Miller Property Soil

Soil samples were collected on the Miller Property by CCHHS, ESA and LGI. Test results and sample locations are summarized in Appendix A.[7]

Investigations on the Miller Property were focused on an area located north of the Lower Pond. This area is characterized by an east-west vegetated access road located on the north side of the fence. LGI understands this fence coincides with the property line. The elevation of the road surface on the Miller Property is about 220-ft (North American Vertical Datum of 88). It appears that at least some of this road is composed of fill soil. A slight depression with elevations around 216-ft characterized by wet soils is located north of this road.[8] Portions of this depression contain wet organic soils.

The test results for lead are summarized in Table 5-7 and Figure 15. The CCHHS sample locations are approximate based on CCHHS's schematic drawing and the sample identifications, which indicate that the samples were collected an area with wet soils.[9] ESA's sample locations are also uncertain because ESA's map (Figure 7 in ESA 2010b) was not drawn to scale and lacks sufficient reference points. LGI's sample locations are accurate because each location is based on a professional survey (Appendix B; LGI, 2011b).

[7] ESA (2010b) refers to the Miller Property as the "Adjacent Property".

[8] These wet soils were probably the "Wetland" samples referred collected by CCHHS in January 2009.

[9] It is uncertain that the areas of wet soil at the Site meet the legal definition of a "wetland" because these areas have not been delineated by a wetland specialist.

Table 5-7. Summary of Soil Samples Collected On and Near the Miller Property

Date (sampler)	Sample ID	Lead (mg/Kg)	Comments
1/22/2009 (CCHHS)	Wetland 4	212	Probably a surface grab. Position approximate.
1/22/2009 (CCHHS)	Wetland 5	91	Probably a surface grab. Position approximate.
1/22/2009 (CCHHS)	Wetland 6	209	Probably a surface grab. Position approximate.
7/14/2010 (ESA)	AP 1-1	130	1-in deep. Position approximate.
7/14/2010 (ESA)	AP 1-2	130	12-in deep. Position approximate.
7/14/2010 (ESA)	AP 2-1	**15,000**	1-in deep. Position approximate.
7/14/2010 (ESA)	AP 2-2	130	36-in deep. Position approximate.
7/14/2010 (ESA)	AP 3-1	**390**	1-in deep. Position approximate.
7/14/2010 (ESA)	AP 3-2	180	36-in deep. Position uncertain.
11/18/2010 (LGI)	MW5-1.0	12	12-in (1-ft) deep. Position approximate.
6/29/2011 (LGI)	S2-0.2	90.7	2.4-in (0.2-ft) deep. Position approximate.
6/29/2011 (LGI)	S3-0.1	39.2	1.2-in (0.1-ft) deep. Position approximate.
6/29/2011 (LGI)	S4-0.1	16.4	1.2-in (0.1-ft) deep. Position approximate.
6/29/2011 (LGI)	S4-0.1D	28.3	Duplicate of sample S4-0.1
6/29/2011 (LGI)	S7-0.1	6.02	1.2-in (0.1-ft) deep. Position approximate.

Note:
Bold = Exceedance

Only two of the 14 samples collected on the Miller Property exceed the 220 mg/Kg lead CUL. The lead concentration in ESA's Sample AP 2-1 appears anomalously high. With a concentration of 15,000 mg/Kg, LGI speculates that this sample, which was collected at the surface, contained metallic lead from a random pellet.

Figure 9 shows lead data from samples collected in 2010 by ESA. The samples collected in the northern portion of the Lower Pond have lead concentrations below the lead CUL. Taken together, the lead data from both sides of the property line do not show significant lead contamination.

In LGI's opinion, the data associated with the Miller Property indicate that significant lead contamination in soil is not present in the area sampled and that the single anomalously high concentration sample collected by ESA represents a soil sample containing a lead pellet or pellet fragment. This opinion is consistent with LGI's understanding that the Lower Pond Area, including the Miller Property, was open to public hunting prior to the opening of the Site.

5.8 Chemicals of Concern in Surface Water at the Site and Miller Property

Surface water was tested by CCHHS, ESA, and LGI. The data are summarized in Appendix A. Only those samples collected by LGI were field filtered prior to lead analysis (0.45 µm filter). The test results for lead and TEQ are summarized in Table 5-8.

Table 5-8. Summary of Surface Water Samples Collected at the Site and Miller Property

Location	Date (sampler)	Sample ID	Lead (µg/L)	TEQ (µg/L)	Comment
Upper Pond	9/8/2004 (CCHHS)	Upper Pond A	**30**	(not tested)	Unfiltered sample.
Upper Pond	7/12/2010 (ESA)	UPWS-1	**11**	nd	Unfiltered sample.
Upper Pond	7/12/2010 (ESA)	UPWS-2	**31**	nd	Unfiltered sample.
Upper Pond	7/12/2010 (ESA)	UPWS-3	**8.1**	nd	Unfiltered sample.
Upper Pond	7/12/2010 (ESA)	UPWS-4	**27**	nd	Unfiltered sample.
Upper Pond	11/18/2010 (LGI)	UP1	1.9	(not tested)	Filtered sample.
Upper Pond	6/28/2011 (LGI)	UP	**11.2**	(not tested)	Filtered sample. Hardness = 96.7 mg/L CaCO3.
Lower Pond	9/8/2004 (CCHHS)	Lower Pond A	**10**	(not tested)	Unfiltered sample.
Lower Pond	9/8/2004 (CCHHS)	Lower Pond C	<2	(not tested)	Unfiltered sample.
Lower Pond	7/13/2010 (ESA)	LPWS-1	**3.9**	nd	Unfiltered sample.
Lower Pond	7/13/2010 (ESA)	LPWS-2	**3.0**	nd	Unfiltered sample.
Lower Pond	7/13/2010 (ESA)	LPWS-3	**2.7**	nd	Unfiltered sample.
Lower Pond	7/13/2010 (ESA)	LPWS-4	**2.8**	nd	Unfiltered sample.
Lower Pond	7/13/2010 (ESA)	LPWS-4 Dup	2.3	(not tested)	Duplicate of LPWS-4.
Lower Pond	11/18/2010 (LGI)	LP1	<1.0	(not tested)	Filtered sample.
Lower Pond	6/28/2011 (LGI)	LP	<1.0	(not tested)	Filtered sample. Hardness = 111 mg CaCO3.
West Creek	11/18/2010 (LGI)	WC1	1.3	(not tested)	Filtered sample.
West Creek	6/28/2011 (LGI)	WC	1.64	(not tested)	Filtered sample. Hardness = 148 mg/L CaCO3.
Miller Property	1/22/2009 (CCHHS)	Wetland 1	**14.6**	(not tested)	Unfiltered sample.
Miller Property	1/22/2009 (CCHHS)	Wetland 2	**101**	(not tested)	Unfiltered sample.
Miller Property	1/22/2009 (CCHHS)	Wetland 3	**101**	(not tested)	Unfiltered sample.

Notes:
Bold =exceedance.
nd = PAHs were not detected and a TEQ concentration could not be calculated.

Almost all unfiltered water samples exceeded the 2.3 µg/L lead CUL, with 101 µg/L being the highest exceedance. These samples were collected in the Upper Pond, the Lower Pond, and the wet soils on the Miller Property. The highest concentrations were detected in two of the three samples collected from the wet soils from the Miller Property.

One of the two filtered water samples from the Upper Pond exceeded the 2.3 µg/L lead CUL. This sample, which contained 11.2 µg/L lead, was collected at the same time that lead reclamation activities were taking place and disturbing the sediment in the Upper Pond which may have released some lead from particles into a dissolved state. The November 2010 sample from the Upper Pond, collected before lead reclamation activities began, only had 1.9 µg/L lead. Water from the Upper Pond did not contain detectable PAHs; hence, TEQ concentrations were also not detectable.

The two filtered water samples from the Lower Pond were below the lead CUL. Water from the Lower Pond did not contain detectable PAHs.

The two filtered water samples from West Creek were below the lead CUL. The West Creek samples were not analyzed for PAHs.

The hardness of the surface water varied from a low of 96.7 mg/L $CaCO_3$ (Upper Pond) to a maximum of 148 mg/L $CaCO_3$ (West Creek). A conservative value for hardness of 100 was used to calculate the 2.3 µg/L chronic water quality standard protective of fish toxicity.

5.9 Chemicals of Concern in Groundwater

The site-specific groundwater CULs are 15 µg/L lead and 0.1 µg/L TEQ. One groundwater sample was collected from the water-supply well to the Miller Residence in July 2010. Groundwater samples were collected by LGI from Monitoring Wells MW1, MW2, and MW5 in November 2010 and June 2011. Data for lead and PAHs are summarized in Table 5-9. All water test results and sample locations are summarized in Appendix A.

Table 5-9. Summary of Groundwater Analyses

Date (sampler)	Location	Sample ID	Lead (µg/L)	TEQ (µg/L)	Comment
7/13/2010 (Ecology)	Miller Well (Pinnell Road dwelling)	MILLER #1	1.40	nd	Unfiltered sample.
11/2010 (LGI)	MW1	MW1	<1.0	nd	Filtered lead sample.
11/2010 (LGI)	MW1	MW1D	<1.0	(not tested)	Duplicate sample of MW1.
6/2011 (LGI)	MW1	MW1	<1.0	nd	Filtered lead sample.
11/2010 (LGI)	MW2	MW2	<1.0	nd	Filtered lead sample.
6/2011 (LGI)	MW2	MW2	<1.0	nd	Filtered lead sample.
11/2010 (LGI)	MW5	MW5	<1.0	nd	Filtered lead sample.
6/2011 (LGI)	MW5	MW5	<1.0	nd	Filtered lead sample.
6/2011 (LGI)	MW5	MW5D	<1.0	(not tested)	Duplicate sample of MW-5.

Note:
nd = PAHs were not detected and a TEQ concentration could not be calculated.

The unfiltered sample from the Miller water-supply well contained 1.4 µg/L lead and no detectable TEQ. The detected lead concentration was much less than the 15 µg/L CUL. This low concentration may be due to a naturally occurring background lead concentration or possibly lead from plumbing solder located between the pump and the sampling point.

The monitoring well data from the two sampling events consistently show no detectable concentrations of lead and PAHs in groundwater. Because the monitoring wells are located downgradient from the ponds, LGI concludes that there is no detectable migration of lead and PAHs from the ponds into groundwater and therefore no risk exists to potable groundwater aquifers used by nearby residences.

5.10 Points of Compliance

A point of compliance is defined in MTCA as the point or points on a site where CULs must be met. MTCA defines a standard point of compliance as throughout the site and, unless a site qualifies for a conditional point of compliance, CULs must be met in all media at the standard point of compliance or throughout the site.

The standard point of compliance for groundwater is defined by WAC 173-340-720(8)(b) as "throughout the site from the uppermost level of the saturated zone extending vertically to the lowest most depth which could potentially be affected by the site," meaning any groundwater at the site that exceeds the cleanup standard, at any depth. At this Site, shallow groundwater and deep well water was tested during the site characterization groundwater sampling events. Because COCs were not detected above CULs in shallow groundwater sampled at relatively short distances downgradient from the Upper and Lower Ponds or in deep well water, COCs do not appear to be sufficiently mobile in this environment to threaten groundwater.

Soil for protection of indoor air is not a pathway of concern at the Site because the COCs are not volatile. The remaining applicable standard points of compliance for soil include the following:

- Protection of groundwater, with a point of compliance established as soils throughout the Site.
- Human exposure via direct contact, with a point of compliance established as soils throughout the Site from the ground surface to 15-ft bgs. This point of compliance represents a reasonable estimate of the depth of soil that could be excavated and distributed at the soil surface as a result of site development activities. However, based on the site soil data, soil contamination is mainly limited to the upper foot of soil.

6.0 NATURE AND EXTENT OF CHEMICALS OF CONCERN

Lead from shot and cPAHs (which are used to calculate TEQ) in clay targets made from pitch, are present in soil and sediment at concentrations that exceed site-specific CULs at the Active Shooting Areas of the Site. This conclusion is obvious and was expected.

The extent of soil contamination is limited to areas downrange of shooting stations; this is also obvious and expected. The concentrations of these contaminants in the Active Shooting Areas are always changing with time in response to ongoing target practice (which deposits lead) and reclamation activities (which remove lead and disturb soil). Based on the ballistic properties of size 7½ lead shot, which is the largest size shot that has been allowed to be used at the Site, it is possible that lead shot occurs in shallow soils up to a maximum of 700-ft downrange of all of the shooting areas. Most shot, however, will fall within 200 yards or so of a shooting station. At the Site, due the forested nature of some of the downrange areas, some lead shot will be stopped by the tree canopy before shot travels a significant distance downrange.

The 15,000 mg/Kg lead concentration detected in a surface soil sample collected on the Miller Property in July 2010 was poorly documented and was not reproducible by LGI's more detailed 2011 study (LGI, 2011b). In this later study, of the five soil samples collected on the Miller Property and analyzed, only one other sample exceeded the site-specific lead CUL of 220 mg/Kg. This surface sample contained 390 mg/Kg lead. The lead data from both sides of the property line are consistent and do not indicate significant lead contamination is present on the Miller Property north of the Lower Pond. As stated above, the lead detected in this area may have resulted from historical hunting that occurred here.

Nearly all of the elevated lead concentrations are present in the upper 1 foot or so of soil at the Site. There is no evidence of lead leaching from surface soils to deeper underlying soil or groundwater. One foot is the approximate depth of soil that is currently being excavated for lead reclamation.

Metallic lead and PAHs are very insoluble compounds and because of this, it is not surprising to find that they have not migrated to groundwater and are not present in surface water at levels of concern. However, dissolved lead did exceed the site-specific lead CUL of 2.3 µg/L in one of the samples collected from the Upper Pond. This concentration is expected to fall back to levels below the CUL following the cessation of lead reclamation activities in the pond. A confirmation water sample will be collected from the Upper Pond after lead reclamation has ended and the water has been allowed to settle to verify lead concentrations are below the CUL.

7.0 CONCEPTUAL SITE MODEL

The following paragraphs present a conceptual site model of site conditions based on significant findings from the RI.

7.1 Historical Contaminant Use

Lead shot and target fragments have been deposited downrange of the former and active shooting ranges. The available data indicate that historical contaminant use consisted of releases of shotgun pellets (lead shot), lead bullets at the .22 range, and clay target fragments containing cPAHs.

The shooting stations where lead shot, bullets, and targets accumulate in soil or pond sediment are shown on Figure 16. The remaining areas and surrounding property (referred to in this report as "non-shooting areas") were not used for target shooting. However, recreational waterfowl hunting reportedly occurred in the Lower Pond Area and a limited amount of shot may have been dispersed onto surrounding properties. In contrast, clay target fragments and significant accumulations of lead shot are limited to known target shooting areas.

LGI understands there are five active shooting ranges and no abandoned (i.e., no longer active) shooting ranges at the Site. The locations of the shooting ranges are shown on Figure 16. Table 7-1 summarizes information on how these ranges are used.

Table 7-1. Selected information on Active Shooting Ranges at the Site

Map ID	Use Description	Shot Size[10]	Comments
1	Woodland target practice.	#7½ –8	Target flies toward shooter. Referred to as "Bus Stop" area.
2	Trap shooting and partridge simulation.	#7½ –8	Target flies away from shooter. This area was referred to as "Weeping Willow" and "Bird Box" during sampling events.
3A	Skeet shooting.	#8–9	Target released from shooter's left and right sides.
3B	Quail simulation target practice.	#8 and #9	Target flies away from shooter.
4	Over water target practice area.	#7½ –8	Referred to as "Upper Pond" area. Targets fly in many directions relative to shooter's line of sight.
5A	Ground level target simulation area.	#7½ –8	Target moves close to ground and from right to left at approximately 90° from shooter's line of sight. This area referred to as "Rabbit Run" during sampling events.
5B	Ground level target simulation area. Gun testing area.	Varies, but mostly #8; some .22 bullets	Bullets impact steep soil slope. Shotguns, small caliber (.22) rifles and pistols are tested within covered containment trench. This area referred to as "Rabbit Run" during sampling events.

The most commonly used shot sizes are currently #8 and smaller. Prior to 1997, #7½ shot was commonly used at all shooting ranges except skeet (3A in Table 7-1).

Sunnydell uses the following practices to control the distance shot fall area:

- Shot sold at the Site is no larger than #8.
- Strategic placement of target launchers.
- Limiting the height the targets fly.
- Target launch direction and shooting directions are designed so lead shot and target fragments accumulate in limited areas to facilitate lead reclamation and lead shot will not stray off-site.

7.2 Release Mechanisms and Site Operations

The Site operations consist of activities that cause COC concentrations to change with time. Target practice adds lead shot and target fragments to soil and sediment in the shooting ranges. Gun repair and testing adds bullets to the soil by the gun repair shop (Figure 2). Periodic lead reclamation reduces the amount of lead shot and disturbs soil and sediment. Human activity (e.g., excavations, grading, fills), erosion, plant and animal activity, and wet-dry/freeze-thaw

[10] Larger shot sizes have smaller numbers. LGI understands that Sunnydell does not sell shot larger than #8 and most shooters use #8; however, shooters sometimes use #7½. Shot sizes larger than #7½ are never used.

processes disturb the soil and potentially can change COC distributions. COC concentrations in the shooting ranges are therefore not static.

7.3 Transport Pathways and Impacted Media

The lead and PAH contaminants have the potential to migrate along the following pathways:[11]

- Leaching of contaminants in the unsaturated zone and their migration to the saturated zone where they can enter groundwater. However, testing of groundwater found that this pathway was not of concern due to the low solubility of lead and clay targets at the Site.
- Transport of contaminated soil by erosion and site grading activities. These processes can bury contaminated soil or move it to a new location. Transport was a concern at the off-site Miller Property but further study did not indicate deposition of lead-containing soil at significant concentrations off-site.
- Leaching of contaminants in pond sediment (i.e., wet soil) into surface water. This condition was found to occur in the Upper Pond at levels of concern only after pond waters were disturbed by nearby lead reclamation activities.
- Downward infiltration of contaminated surface water into the groundwater. Testing of site groundwater found that this pathway was not of concern.
- Migration of contaminated groundwater to water-supply wells. Testing of residential well water found that this pathway was not of concern.

7.4 Exposure Routes

The following list summarizes and evaluates potential exposure routes:

- **Direct contact with COCs in surface soil and sediment.** This likely exposure route applies to humans if they enter into downrange areas and do not wash their hands after coming in contact with soil and is probably most significant with children, because they are more likely to touch the ground, touch their mouths, and not wash their hands. However, range rules prohibit site visitors from entering downrange areas, so this pathway is not currently realistic but may apply in the future if site use changes. This route currently does apply to animals that have intimate contact with shallow soil and sediment such as burrowing animals, pets, and dabbling ducks.
- **Direct contact with COCs in surface water.** This is an unlikely exposure route. The ponds and the West Creek area are unsuitable for bathing. Further, testing did not detect high quantities of lead and cPAHs in surface waters.
- **Ingestion of COCs in groundwater.** This is an unlikely exposure route. Although, a domestic water-supply well is located downgradient from the Site (i.e., the Miller well at 434 Pinnel Road) the data indicate there is no groundwater transport of COCs at the Site. In addition, the water sample collected from the Miller water-supply well by Ecology contained lead below the drinking water criterion and no detectable PAHs.

[11] Vapor phase migration is assumed insignificant for lead and PAHs.

- **Ingestion of contaminated fish.** This exposure route is not likely to be significant. Fish do not live in the Upper or Lower Ponds. The lead concentration in the West Creek is below the freshwater criterion. West Creek is not known to have fish or to connect to a fish-bearing stream.

In summary, of the four exposure routes identified, the only one likely to be currently significant is direct exposure by animals to contaminated soil or sediment.

7.5 Terrestrial Ecological Evaluation

The Site is located in a lightly developed suburban area, which provides habitat to wildlife, including raccoons, deer, opossum, coyote, muskrat, rodents, hawks, ravens, and other mammalian and avian species associated with the Olympic Peninsula. Amphibians also have been noted in and near the ponds, and the Lower Pond is occasionally used by waterfowl during migratory periods. It has been reported that Mr. Dryke once stocked the Upper Pond with bluegills and/or largemouth bass for recreational fishing purposes (i.e., not consumption). LGI understands there are currently no fish in any of the ponds at the Site.

According to the MTCA, a terrestrial ecological evaluation (TEE) is required of each site. The Site does not qualify for an exclusion from a TEE because it is too large, relatively undeveloped, and used by wildlife. Therefore, a simplified terrestrial ecological evaluation was performed by completion of Table 749-1 of the MTCA (refer to Appendix C). This evaluation indicates that the Site is likely to attract wildlife. Wildlife exposure may be likely because soil lead concentrations exceed 220 mg/Kg and benzo-a-pyrene concentrations exceed 30 mg/Kg, the reference concentrations given in Table 749-2 for unrestricted land use.

Therefore, 220 mg/Kg lead and 0.1 mg/Kg TEQ are appropriate CULs for soil because 220 mg/Kg is more conservative than the MTCA A CUL for human protection of 250 mg/Kg and 0.1 mg/Kg TEQ is more conservative than 30 mg/Kg benzo-a-pyrene.

8.0 FEASIBILITY STUDY

The following section of the report identifies and evaluates appropriate cleanup alternatives for the Site. However, a typical “MTCA cleanup” that involves removal of lead-contaminated soil to reach soil at or below CULs may not be appropriate for the Site, with its active shooting ranges, because more lead shot will immediately reaccumulate. Therefore, BMPs and specific remedial actions should be considered at the Site to ensure that spent lead shot and targets are managed in a manner to avoid threats to human health and the environment while the range remains active.

8.1 Remedial Action Objectives

The remedial goals for the Site are site-specific objectives that can be used to compare the effectiveness of BMPs and cleanup actions while limiting their potential future impact on the economic operation of the Site as an active shooting range. Within this context, the remedial active objectives for the Site include the following:

- Protect human health and the environment.
- Prevent migration of COCs away from active shooting ranges.
- Address contamination present at the Lower Pond Area that exceeds CULs.

8.2 Threshold Requirements for Remedial Action Alternatives

Remedial action alternatives must meet the following threshold requirements under WAC 173-340-360(2):

- **Protect human health and the environment.** Protection of human health and the environment shall be achieved through implementation of the selected remedial alternative. As previously discussed, determination of site-specific COCs and the existing and potential exposure pathways led to the development of remedial action objectives for site remediation.
- **Comply with cleanup standards.** Cleanup standards, as defined by MTCA, include CULs for hazardous substances present at the Site, the location or point of compliance where the CULs must be met, and any regulatory requirements that may apply to the Site because of the type of action being implemented, or the location of the Site.
- **Comply with applicable state and federal laws**. Section 173-340-710 of the WAC states that cleanup standards shall comply with applicable state and federal laws, as Applicable or Relevant and Appropriate Requirements (ARARs) for the Site.
- **Provide for compliance monitoring**: MTCA requires that all selected cleanup alternatives provide for compliance monitoring as described in Section 173-340-410 of the WAC. Compliance monitoring consists of three different types of monitoring, including the following:
    - *Protection Monitoring* during remedial implementation to monitor short-term risks and confirm protection of human health and the environment during construction activities.
    - *Performance Monitoring* to confirm compliance with site CULs immediately following remedial implementation.
    - *Confirmational Monitoring* to evaluate long-term effectiveness of the remedial action following attainment of the cleanup standards.

8.3 Other Model Toxics Control Act Requirements

Cleanup alternatives that meet the threshold requirements must also fulfill the requirements described in WAC 173-340-360(2)(b). These additional requirements are as follows:

- **Use permanent solutions to the maximum extent practicable**. The use of permanent solutions to the maximum extent practicable for a cleanup action is analyzed according to the procedure described in WAC 173-340-360(3). Preference is given to alternatives that implement permanent solutions, defined in MTCA as actions that can meet cleanup standards "without further action being required at the site being cleaned up or any other site involved with the cleanup action, other than the approved disposal of any residue from the treatment of hazardous substances (WAC 173-340-200)."

- **Provide for a reasonable restoration time frame.** Under MTCA preference is given to alternatives that, when compared to other alternatives for effectiveness, can be implemented in a shorter restoration time frame.
- **Consideration of public concerns.** Public involvement must be initiated according to the requirements set forth in WAC 173-340-600. Public comments raised during the RI/FS review process will be evaluated and addressed as appropriate and in consultation with Ecology. A Public Participation Plan for the Site was also prepared and provided to the public for review and comment during the AO/RI/FS 2008 public comment period.

9.0 IDENTIFICATION OF REMEDIAL ACTION ALTERNATIVES

The remedial action alternatives listed below for the Site meet the MTCA requirements listed above:

1. **No action**. This is the baseline alternative and is listed here only for comparison sake. Alternative 1 is judged not acceptable because (a) this alternative does not address potential exposures to humans and wildlife, which is a threshold requirement; (b) this alternative does not reduce the potential for Site operations from spreading COCs; and (c) this alternative does not include institutional controls to ensure protection if land use changes in the future.
2. **Develop and implement BMPs, specific remedial actions, and institutional controls for continued operation of the active shooting ranges**. Alternative 2 is judged to be a practical alternative that reclaims lead and also limits spreading of lead shot from Active Shooting Areas.
3. **Excavate shallow soil, recover lead shot, consolidate contaminated soil on-site, and cap with clean soil.** Alternative 3 is not practical because the Site is an active shooting range. If soil was remediated to below CULs, future target practice would cause COC concentrations to increase and exceed CULs.
4. **Excavate shallow soil (and sediment), recover lead shot, and dispose of off-site**. Alternative 4 is permanent and more protective and expensive than Alternative 3. Like Alternative 3, Alternative 4 is not practical because the Site is an active shooting range.

Alternative 2 is identified as the most practical remedial action that can be implemented given the current use of the Site.

9.1 Detailed Description of the Preferred Alternative

The Site was divided into Management Areas based on historical site use using information provided by the owners. These areas are (a) Active Shooting Ranges, (b) Lower Pond Area, and (c) Non-Shooting Areas (Figure 16). Active Shooting Ranges are locations where target shooting currently takes place. LGI understands the owners of the Site do not plan on expanding the Active Shooting Ranges or creating new ones. COC concentrations in Active Shooting Ranges are generally high and vary with time, as discussed above. BMPs for Active Shooting Ranges are needed to prevent human or environmental exposures and to prevent COCs from migrating out of these areas.

The Lower Pond Area is not a shooting range; however, it has two limited areas ("hot spots") of sediment where lead, TEQ, and total PAHs exceed site-specific CULs. Hence, a specific remedial action is needed for the Lower Pond Area to prevent human or environmental exposures and to prevent COCs from migrating out of the Lower Pond's hot spots to Non-Shooting Areas.

Non-Shooting Areas are locations where target shooting has not occurred in the past. These are the forested and residential areas that were not characterized during the RI/FS as they were considered unlikely to have COCs that exceed CULs based on historical land use. BMPs are needed to prevent COCs from migrating into the Non-Shooting Areas from the Active Shooting Ranges and the Lower Pond Area.

Active Shooting Range Management Areas

The four Active Shooting Range Management Areas are shown on Figure 16. These will be operated in accordance with the following BMPs:[12]

- Lead reclamation will be conducted in a manner that does not spread COCs (shot, target fragments, post-reclamation soil, muddy water, etc.) beyond the area that is undergoing reclamation. Boundary limits will be established for lead reclamation operations to prevent releases onto Non-Shooting Areas.
- Recovered lead shot destined for recycling will be temporarily stored on-site in sealed containers that are not subject to rainfall infiltration and rodent damage.
- Movement of soil within Active Shooting Areas will be minimized to limit potential environmental impacts.
- Records should be kept of lead shot reclamation and the tonnage of reclaimed lead received by recyclers or reused for on-site reloading. These records will demonstrate that recycling has been taking place. LGI recommends that only reputable recyclers be used.
- Soil from Active Shooting Ranges (including waste soil from lead recovery operations) will not be deposited in Non-Shooting Areas.
- Biodegradable targets are preferred over targets made with pitch and will be used if economically and practically feasible.
- Target fragments and debris recovered during reclamation will be sent off-site as solid waste.
- Shooting platforms and target launchers will be positioned to keep shot falling within the already established boundaries of the Active Shooting Ranges.
- Shot size will be restricted to #8 or smaller to limit the shot fall areas. Signs will be placed in all shooting ranges to notify shooters of this restriction in shot size.
- Post-reclamation areas of bare soil will be planted with vegetation, mulched, or covered to prevent erosion and direct contact with potentially contaminated soil. Vegetation should be properly chosen because excessive vegetation may hinder reclamation efforts and vegetation typically must be removed prior to reclamation.

[12] Some of these BMPs were taken from EPA 2005 and the National Shooting Sports Foundation.

Children will not be allowed to play with or sit on the ground (i.e., the soil), sediment, or water in Active Shooting Ranges.

- Livestock will not be allowed to graze on plants growing in Active Shooting Ranges.
- The Upper Pond will be poisoned to make sure fish are not present. Fish will not be placed in the Upper Pond. This will prevent potentially contaminated fish being ingested by humans or animals.
- Hunting will not be allowed. This restriction will prevent the spread of shot or bullets beyond the boundaries of the Active Shooting Ranges. Killing of nuisance animals will be allowed if done lawfully.
- Compliance monitoring will consist of record keeping. Records will be kept of soil excavations, soil fills, lead reclamation, and target composition.

A confirmation water sample will be collected from the Upper Pond after lead reclamation has ended and the water has been allowed to settle. This sample will be field filtered and analyzed for lead. The test results will be used to verify that lead concentrations have fallen below the CUL of 2.3 µg/L.

Lower Pond Management Area

The Lower Pond Area is shown on Figure 16. The following specific mitigation and BMPs will be implemented.

- Soil from two locations of the Lower Pond contains lead and PAHs that exceed CULs (refer to LPQ-1-2-1 and LPQ-3-2-1 on Figure A5 in Appendix A). The soil in these two areas will be mitigated by excavating the upper 1-foot of soil and relocating this soil to the soil berm at the Rabbit Run and/or one of the other Active Shooting Ranges. The soil remaining after the excavation is complete, where located above the water level, will be allowed to vegetate to prevent erosion. Clean soil fill can be brought in to restore site grades if desired.
- Target practice and hunting will not be allowed. These restrictions will prevent further addition of shot or bullets onto shallow soil surfaces. Killing of nuisance animals will be allowed if done lawfully.
- Children will not be allowed to play or sit on the ground (soil), sediment, or water in the Lower Pond Area until after the hot spots are remediated.
- Records will be kept of soil excavations, soil fills, and lead reclamation (if any).

Non-Shooting Management Areas

Non-Shooting Areas are shown on Figure 16. The Non-Shooting Areas will be operated with the following BMPs:

- Soil from the Active Shooting Ranges and the Lower Pond Area will not be brought onto Non-Shooting Areas.
- Lead reclamation activity (i.e., processing contaminated soil or sediment) will not take place on Non-Shooting Areas. Potentially contaminated soil or sediment will not

be transported across the Non-Shooting Areas unless the soil, and any entrained water, is contained.

- Target practice and hunting will not take place on Non-Shooting Areas. This will prevent the deposition of lead shot and target fragments in an area not suspected of shooting operations.

9.2 Institutional Control

The current owners of the 38.89-Ac Site intend to subdivide the Site into two properties, Lot 1 (9.03 Ac) and Lot 2 (29.86 Ac, refer to Figure 17; David Cummins and Associates, 2010). Lot 1 will be excluded from the BMPs and the Institutional Control because it was never a shooting range. A covenant will be placed in the deed of Lot 2 that will alert future owners that this property was used as a commercial target range and potential contamination from lead shot and target fragments may be present.

10.0 LIMITATIONS

LGI has prepared this report for the Sunnydell Shooting Range for the purposes described and is based on conditions that existed at the time the study was performed. Within the limitations of information provided, scope, schedule, and budget, LGI's services have been executed in accordance with generally accepted practices in this location at the time this report was prepared. No warranty, expressed or implied, is made. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the Site, or by natural events. LGI's interpretations of subsurface conditions are based on widely-spaced borings, published mapping, and LGI's judgment. Actual subsurface conditions may differ, possibly significantly, than those indicated in this report.

11.0 REFERENCES

Dryke, Ellen. 2012. Personal communications with John LaManna regarding historic site use.

David Cummins and Associates, PS. 2010. Sunnydell Large Lot Subdivision of a Portion of N.W.1/4,S.E.1/4,Sec.17,T.30N.,R.4W.,W.M., Clallam County, Washington for Chuck Dryke and Rosemary Knotek. Job No. 2-17-30-4-4975LLS. April 15 – August 17.

Environmental Protection Agency (EPA). 2005. Best Management Practices for Lead at Outdoor Shooting Ranges. EPA-902-B-01-001. June.

_____. 2003. TRW Recommendations for Performing Human Health Risk Analysis on Small Arms Shooting Ranges. U.S. EPA Office of Solid Waste and Emergency Response #9285.7-37. March: http://www.epa.gov/superfund/lead/products/firing.pdf

Environmental Services Associates, Inc. (ESA). 2010a. Scoping Phase Report, Sunnydell Dryke Shooting Range, 292 Dryke Road, Sequim, WA 98382. Prepared for Chuck Dryke and Rosemary Knotek. July 5.

_____. 2010b. Site Characterization, Sunnydell Dryke Shooting Range, 292 Dryke Road, Sequim, WA 98382. Prepared for Chuck Dryke and Rosemary Knotek. August 18.

LaManna Geosciences Inc. (LGI). 2010. Sampling and Analysis Plan, June 2011 Groundwater and Soil Investigation, Sunnydell Dryke Shooting Range, Sequim, Clallam County Washington. Prepared for Sunnydell Dryke Shooting Range. November 12.

_____. 2011a. Sampling and Analysis Plan, November 2011 Groundwater Investigation, Sunnydell Dryke Shooting Range, Sequim, Clallam County Washington. Prepared for Sunnydell Dryke Shooting Range. June 5.

_____. 2011b. Site Characterization Report, Sunnydell Shooting Range, 292 Dryke Road, Sequim, Washington, 98382. Prepared for Sunnydell Shooting Range. October 1.

National Shooting Sports Foundation. (undated). Environmental Aspects of Construction and Management of Outdoor Shooting Ranges. Facility Development Series Number 2.

Schasse, H.W. and K.W. Wegmann. 2000. Geologic Map of the Carlsborg 7.5-minute Quadrangle, Clallam County, Washington. Washington Division of Geology and Earth Resources Open File Report 2000-7.

Washington State Department of Ecology (Ecology). 2011. Development of Benthic SQVs for Freshwater Sediments in Washington, Oregon, and Idaho. Publication No. 11-09-054. November.

Figures

Figure 1. Map showing the approximate location of the Site (red circle) relative to the town of Sequim, Washington. The project is located in Clallam County, Washington. The blue area in the northern portion of this map is the Strait of Juan De Fuca.

Figure 2. 2009 orthophoto showing locations of the Upper Pond (UP), Lower Pond (LP), Middle Pond (MP), Rabbit Run (RR), Weeping Willow (WW), West Creek (WC), and selected improvements. The approximate site property lines are shown in red. The highest density developments are located to the south and west of the Site.

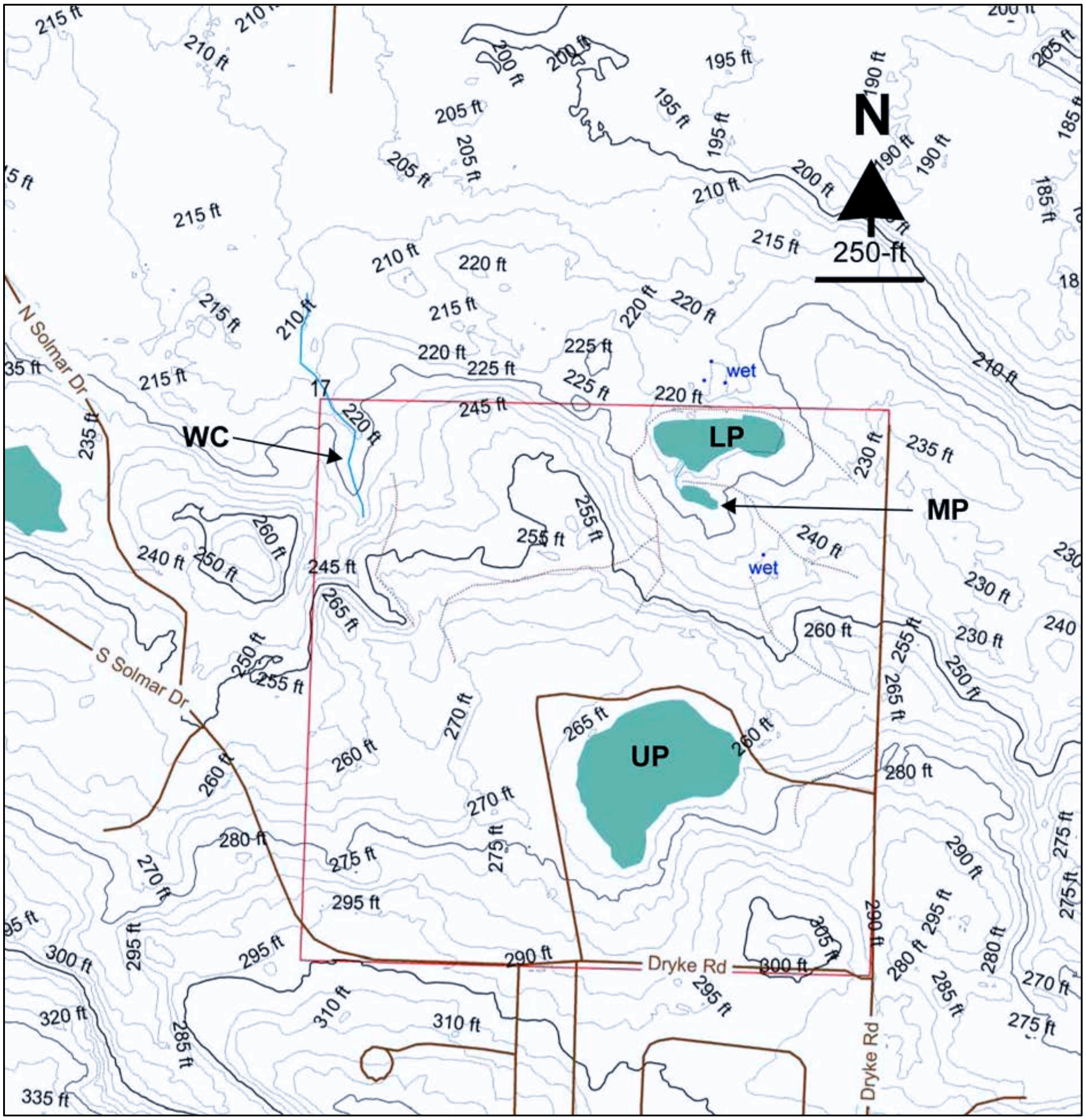


Figure 3. Map showing the topography (5-ft contours), Upper Pond (UP), Lower Pond (LP), Middle Pond (MP), West Creek (WC), and areas of wet soil (blue dots).

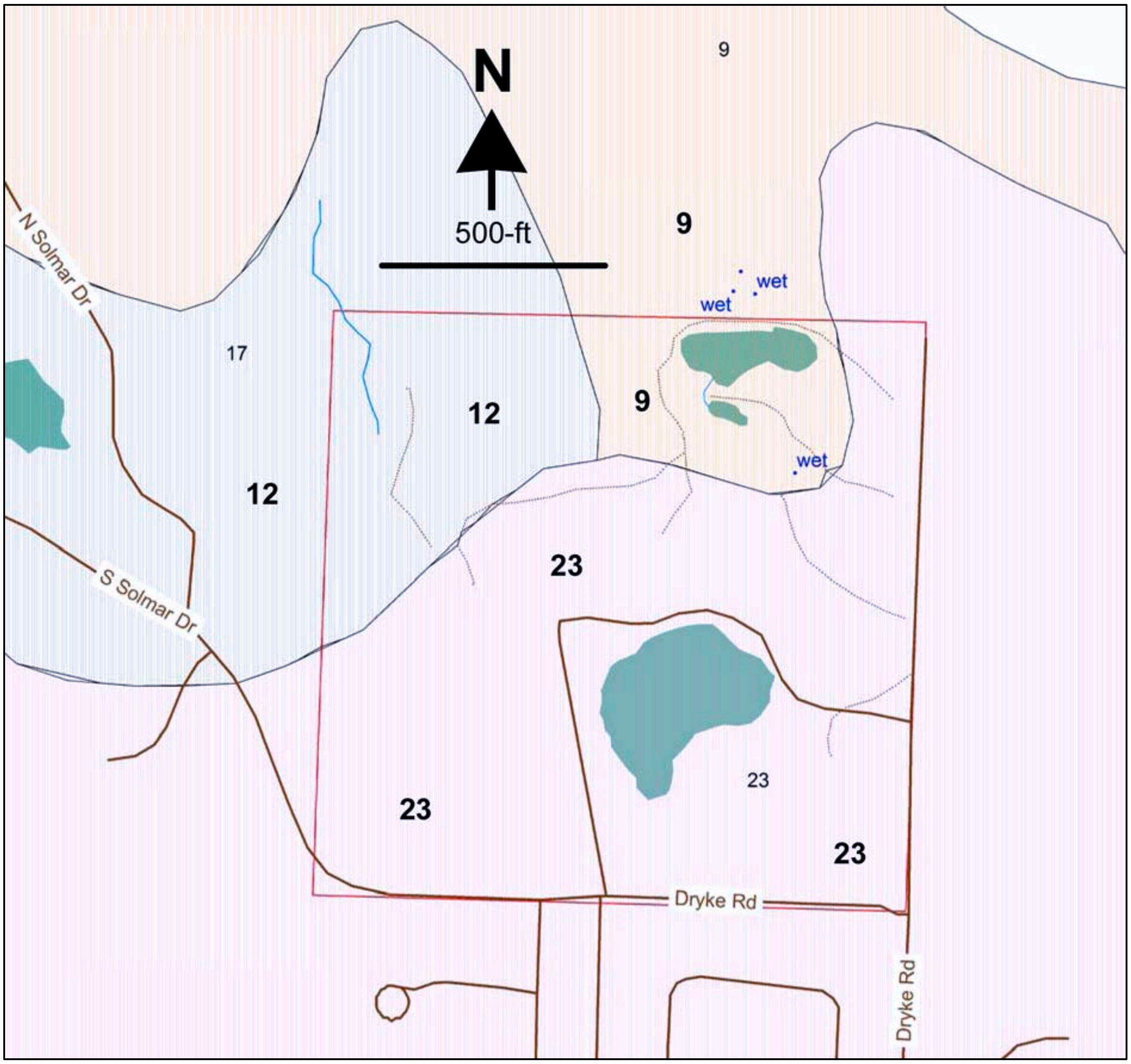


Figure 4. Map showing soil units (9, 12, and 23). The Site is delineated in red. Also displayed are roads, surface water bodies, and observed areas of wet soil. Refer to text for descriptions of soil units.

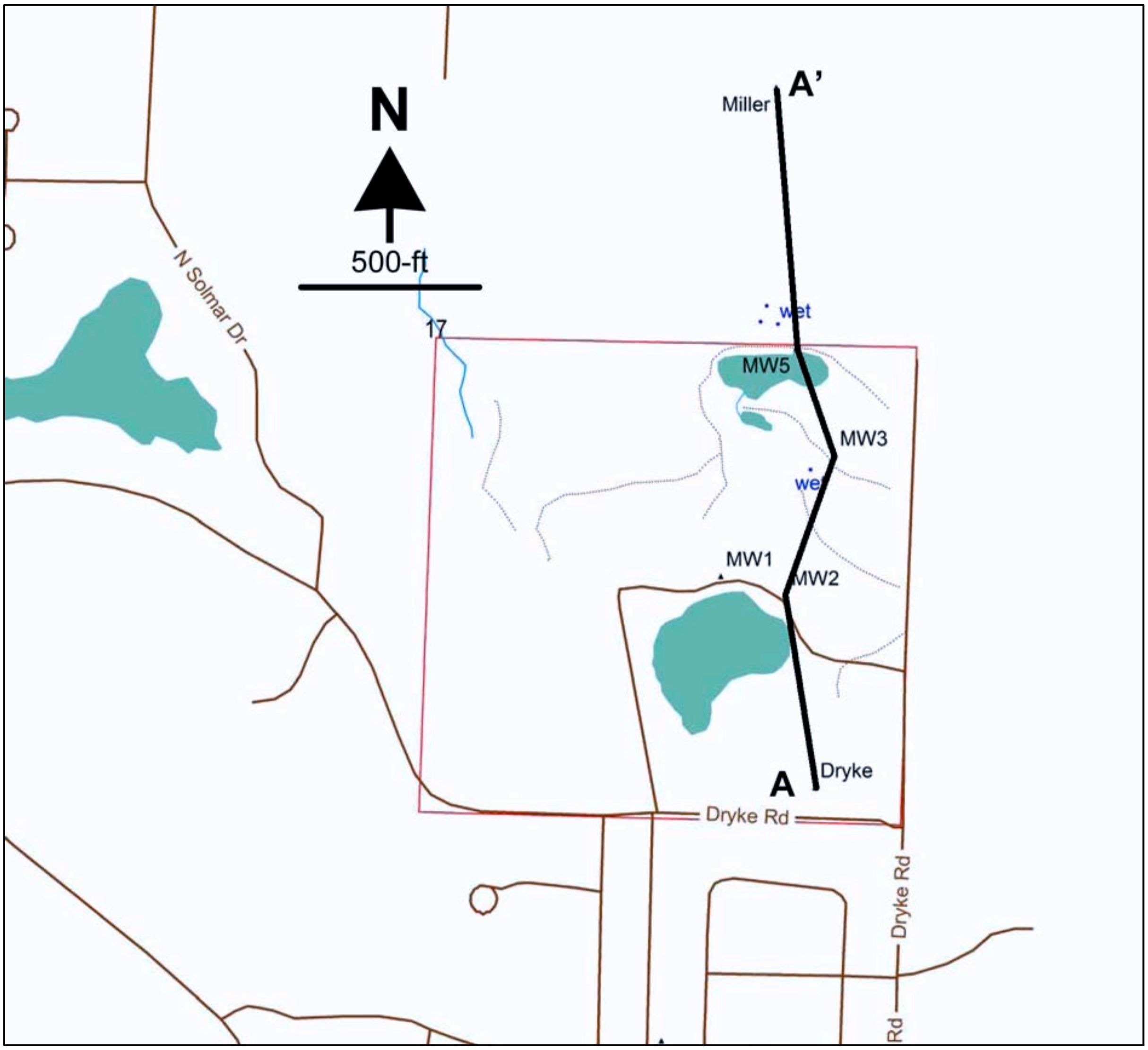


Figure 5a. Location of hydrogeologic cross section.

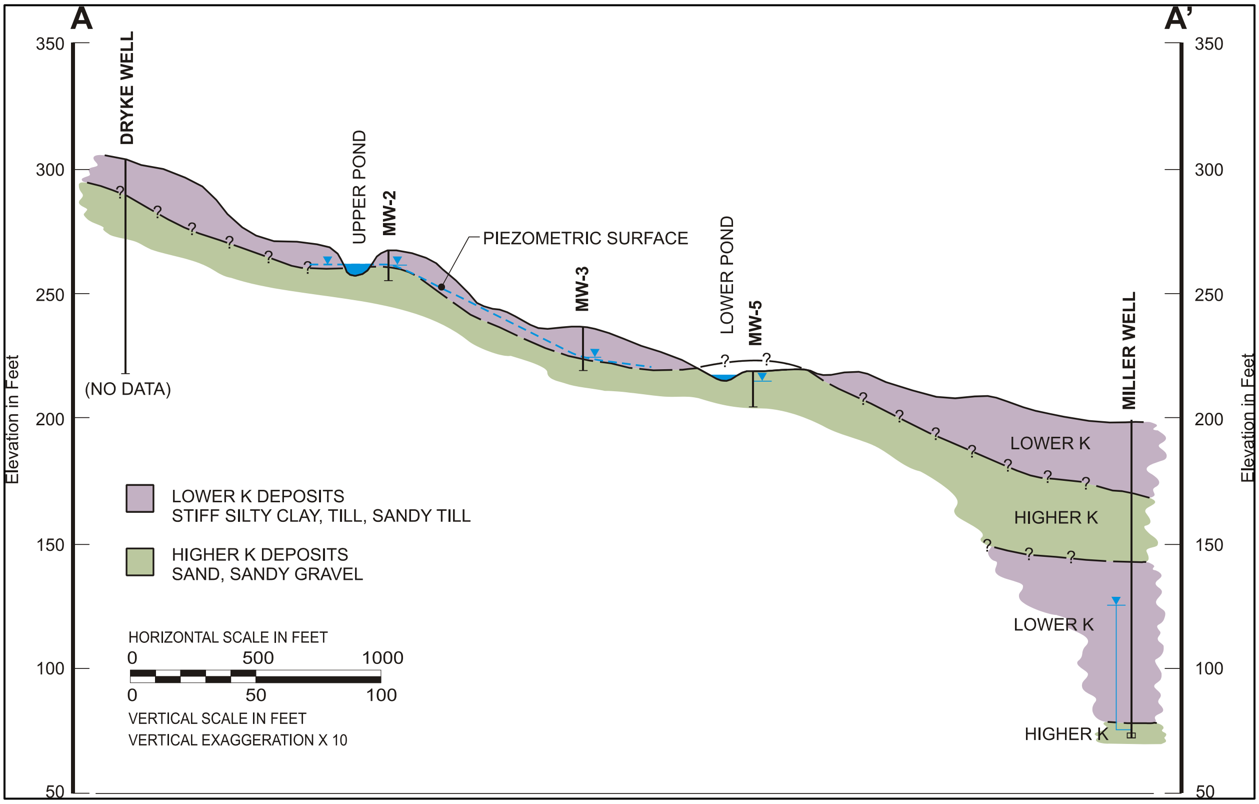


Figure 5b. Hydrogeologic cross section A-A'. This representation assumes a continuous water table exists beneath the Site that is in hydraulic contact with the surface water bodies. The strata appear to dip gently to the north, which is to the right. Boring logs for the monitoring wells and the Miller well are located in Appendix A of LGI (2011b).

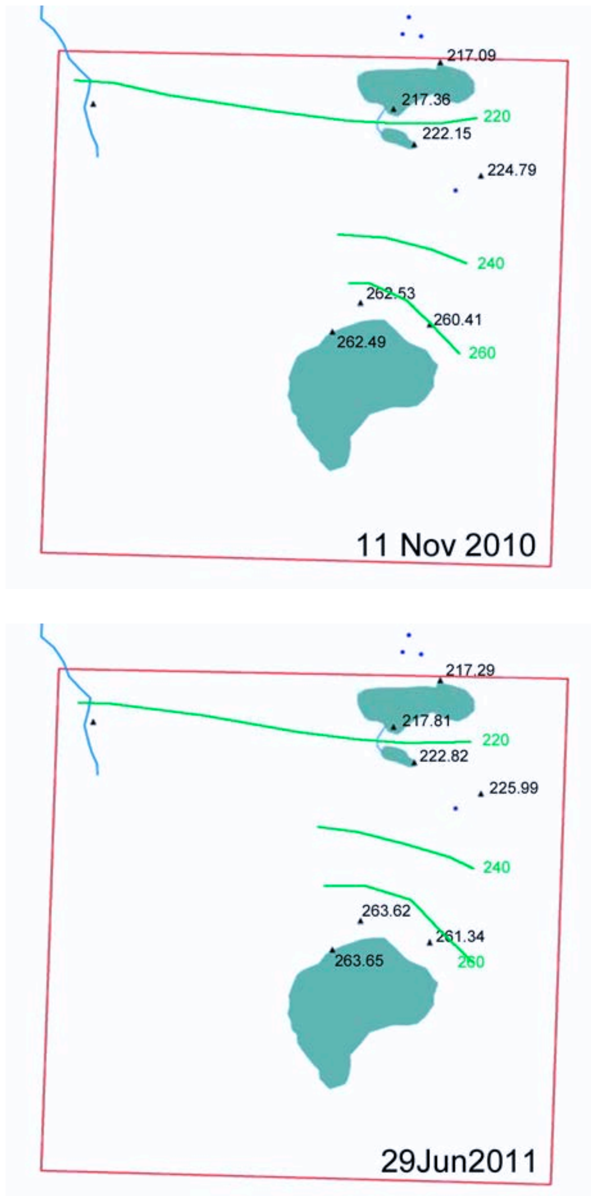


Figure 6. Maps showing inferred water table configurations in November 2010 and June 2011 based on hand-contoured data. At both times the groundwater flow was to the north. These representations assume a continuous water table exists beneath the Site that is in hydraulic contact with the surface water bodies. The contour interval is 20-ft. The Site is delineated in red.

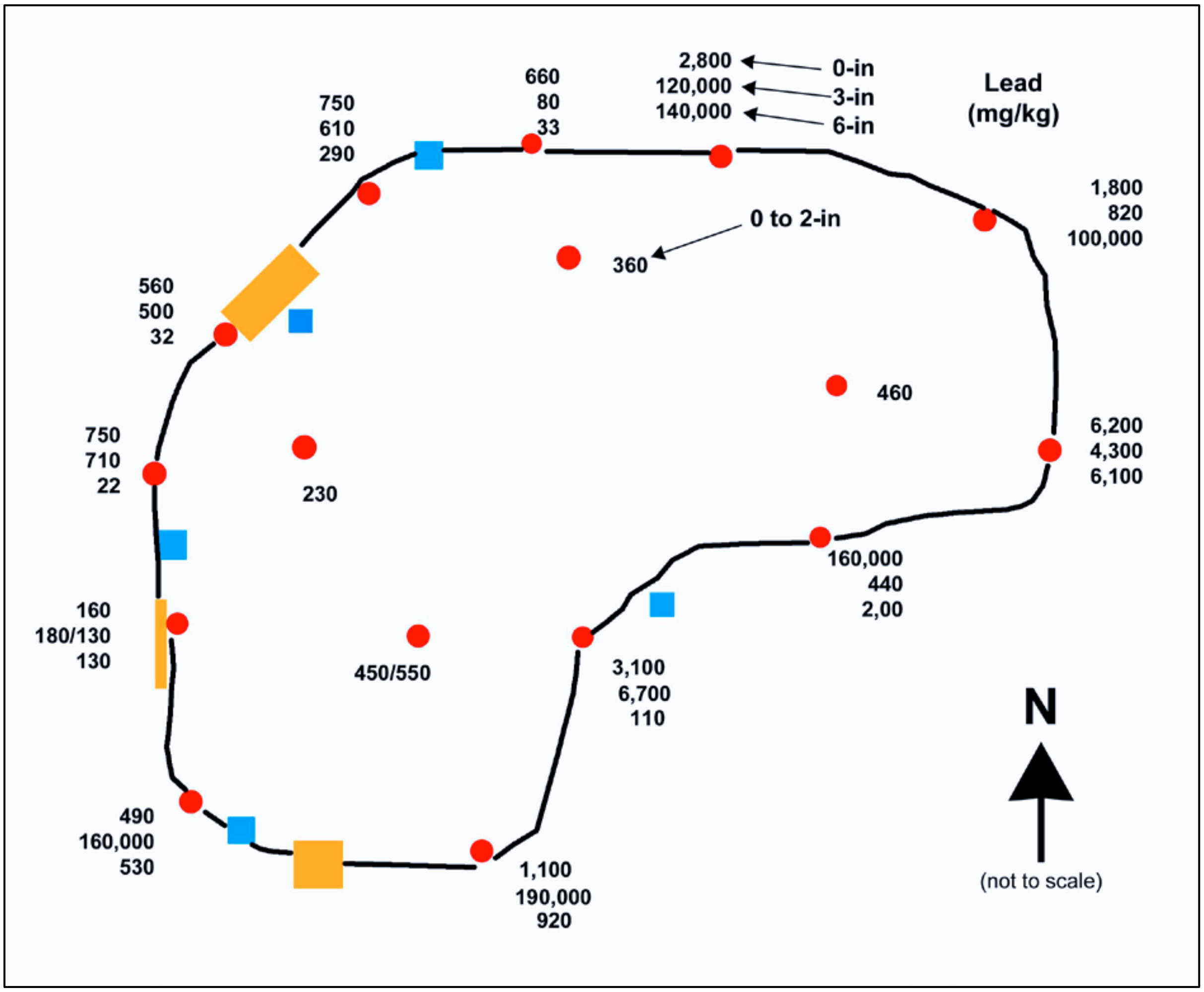


Figure 7. Schematic drawing of Upper Pond showing lead concentrations in sediment in July 2010. Samples along the perimeter were collected at depths of 0-in, 3-in, and 6-in. Samples in the pond interior were collected from the top 2-in. This drawing is based on Figure 3 in ESA (2010b). Shown are sample locations (red circles), target release stations (blue squares), and shooting stations (yellow rectangles).

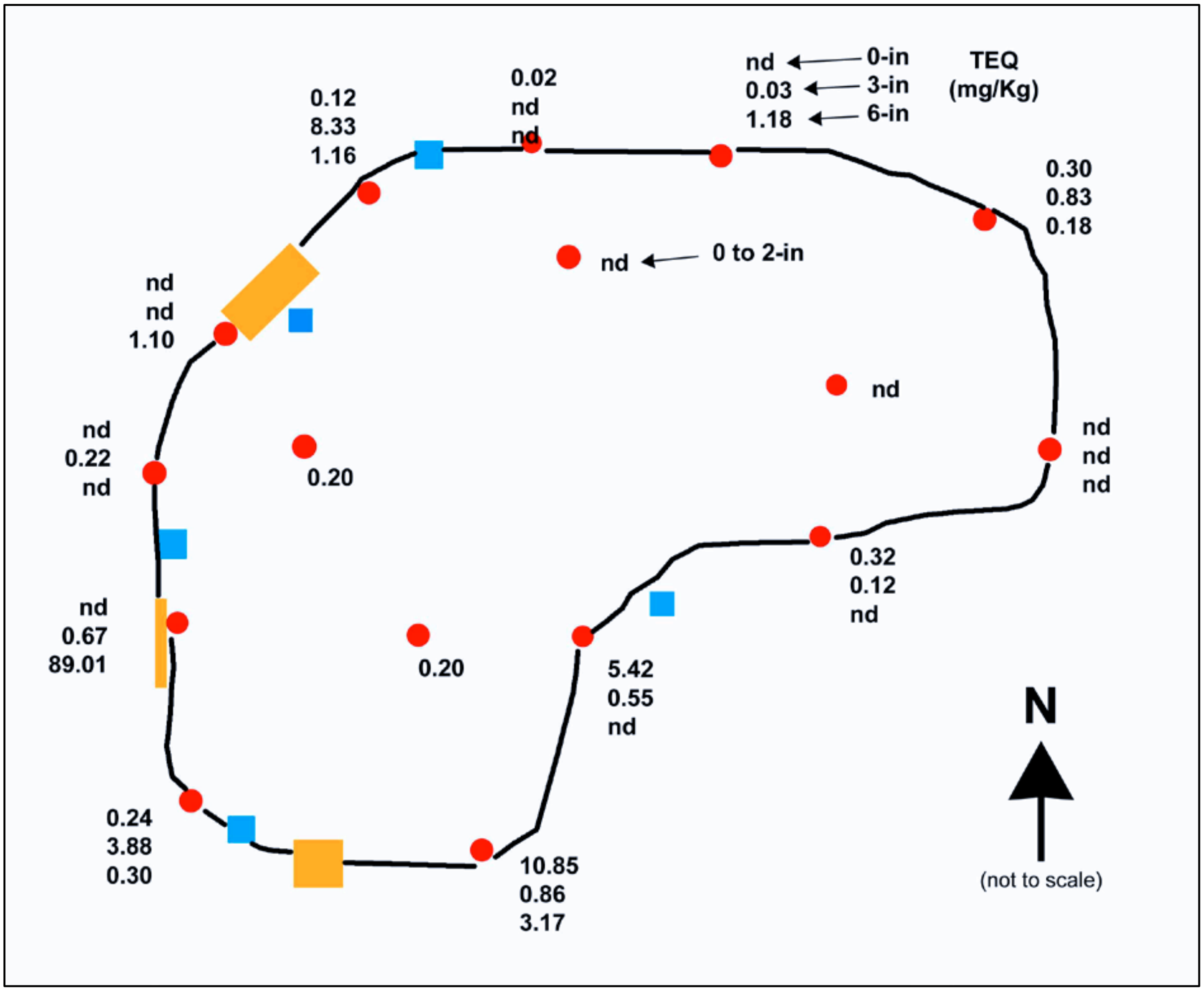


Figure 8. Schematic drawing of Upper Pond showing TEQ concentrations in sediment in July 2010. Samples along the perimeter were collected at depths of 0-in, 3-in, and 6-in. Samples in the pond interior were collected from the top 2-in. An “nd” means PAHs were not detected and TEQ concentrations could not be calculated. This drawing is based on Figure 3 in ESA (2010b). Shown are sample locations (red circles), target release stations (blue squares), and shooting stations (yellow rectangles).

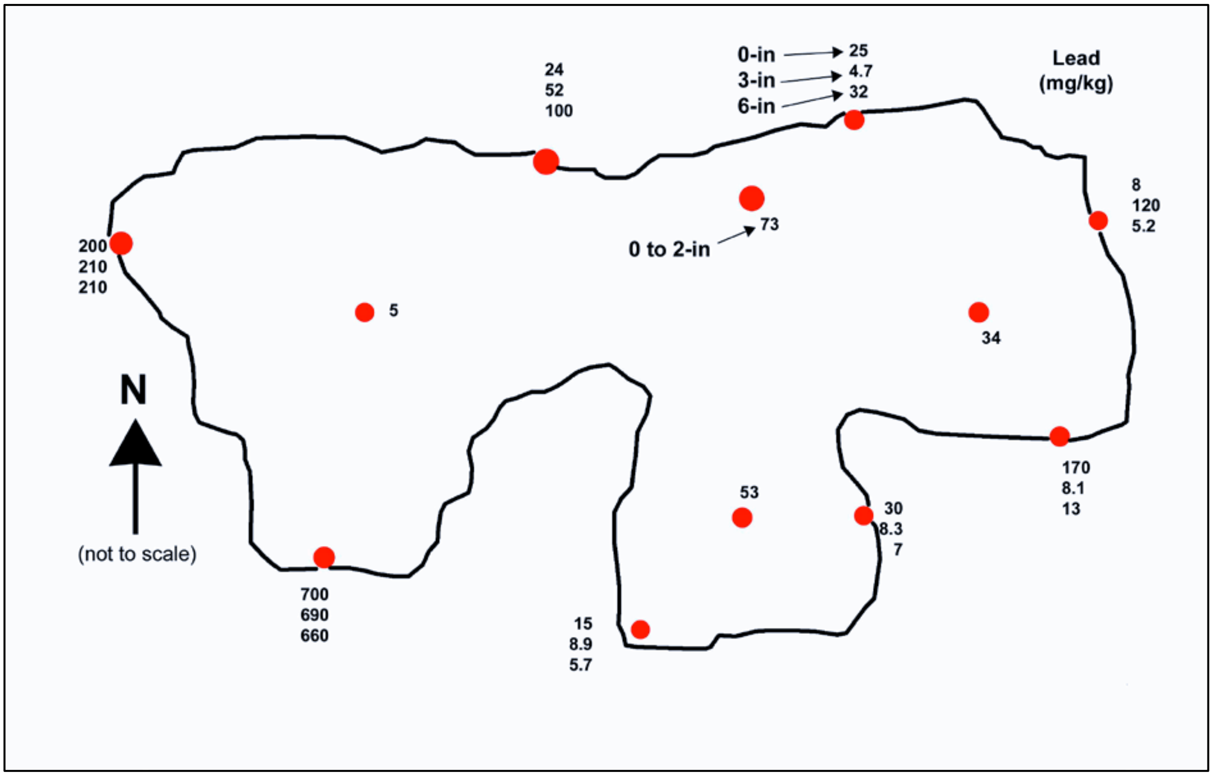


Figure 9. Schematic drawing of Lower Pond showing lead concentrations in sediment in July 2010. Samples along the perimeter were collected at depths of 0-in, 3-in, and 6-in. Samples in the pond interior were collected from the top 2-in. This drawing was copied from Figure 4 in ESA (2010b).

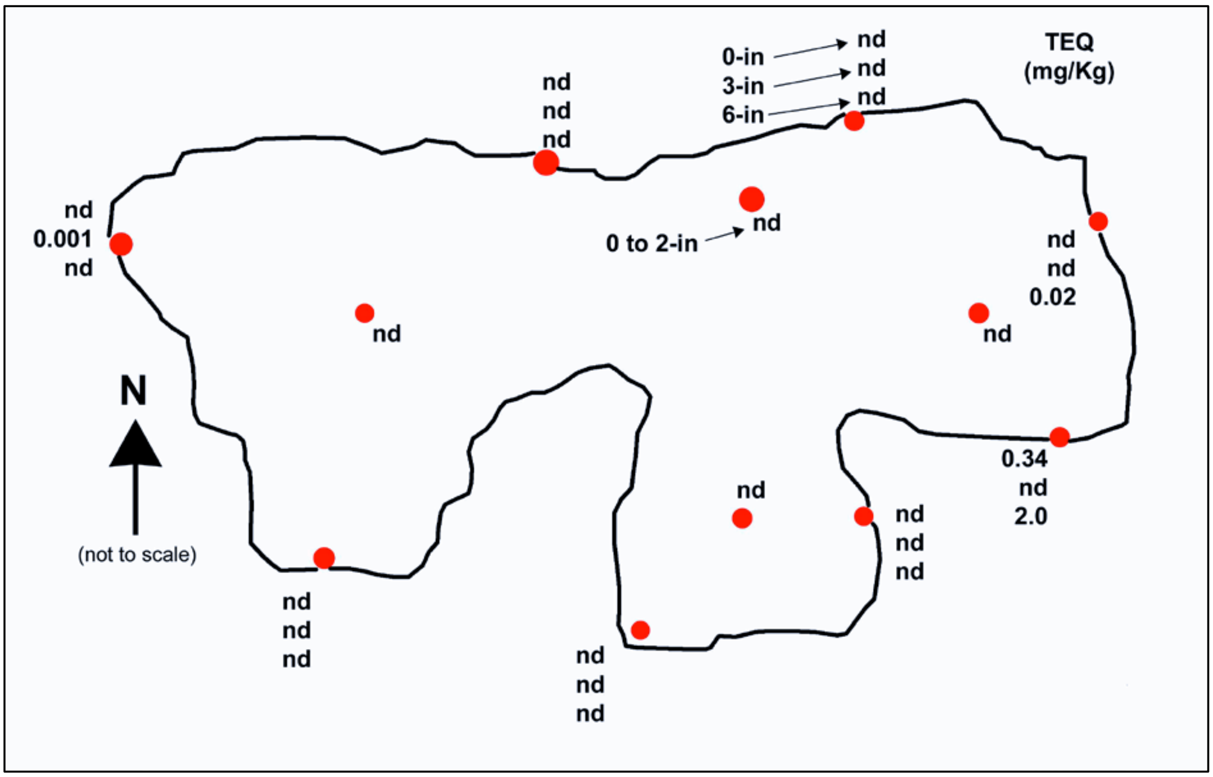


Figure 10. Schematic drawing of Lower Pond showing TEQ concentrations in sediment in July 2010. Samples along the perimeter were collected at depths of 0-in, 3-in, and 6-in. Samples in the pond interior were collected from the top 2-in. An "nd" means PAHs were not detected and TEQ concentrations could not be calculated. This drawing was based on Figure 4 in ESA (2010b).

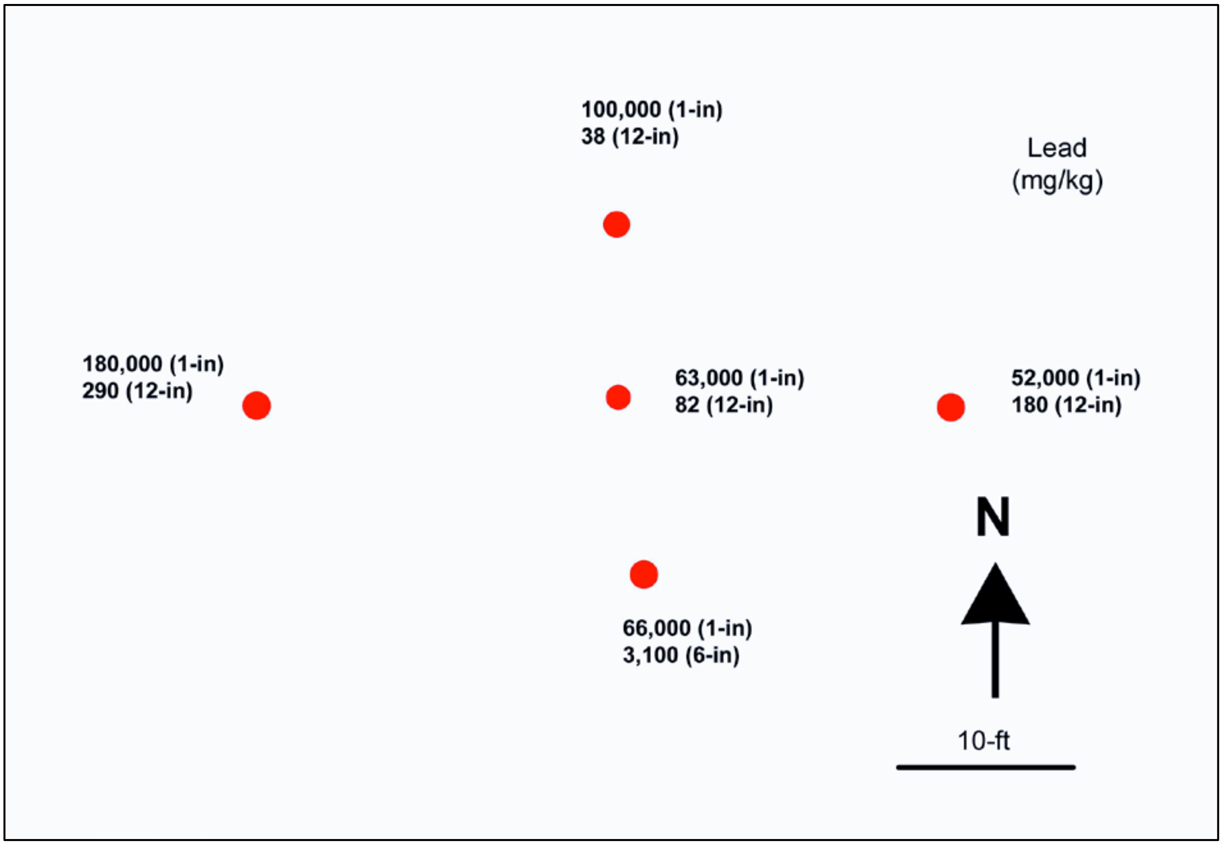


Figure 11. Schematic drawing showing ESA's lead concentrations in the Rabbit Run area in July 2010. Samples were collected at two depths at each location. This drawing was based on Figure 5 in ESA (2010b). ESA's report does not show where these samples were collected relative to site features.

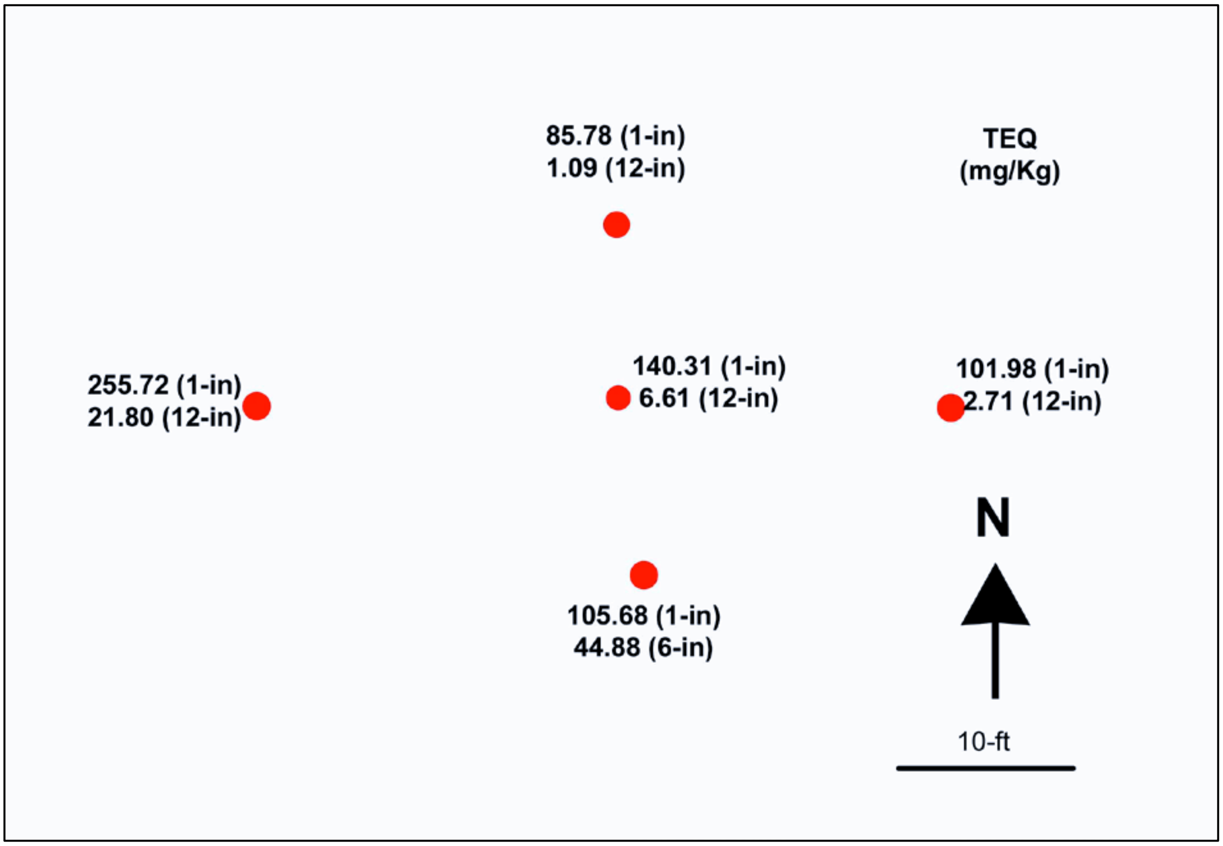


Figure 12. Schematic drawing showing ESA's TEQ concentrations in the Rabbit Run area in July 2010. Samples were collected at two depths at each location. This drawing was based on Figure 5 in ESA (2010b). ESA's report does not show where these samples were collected relative to site features.

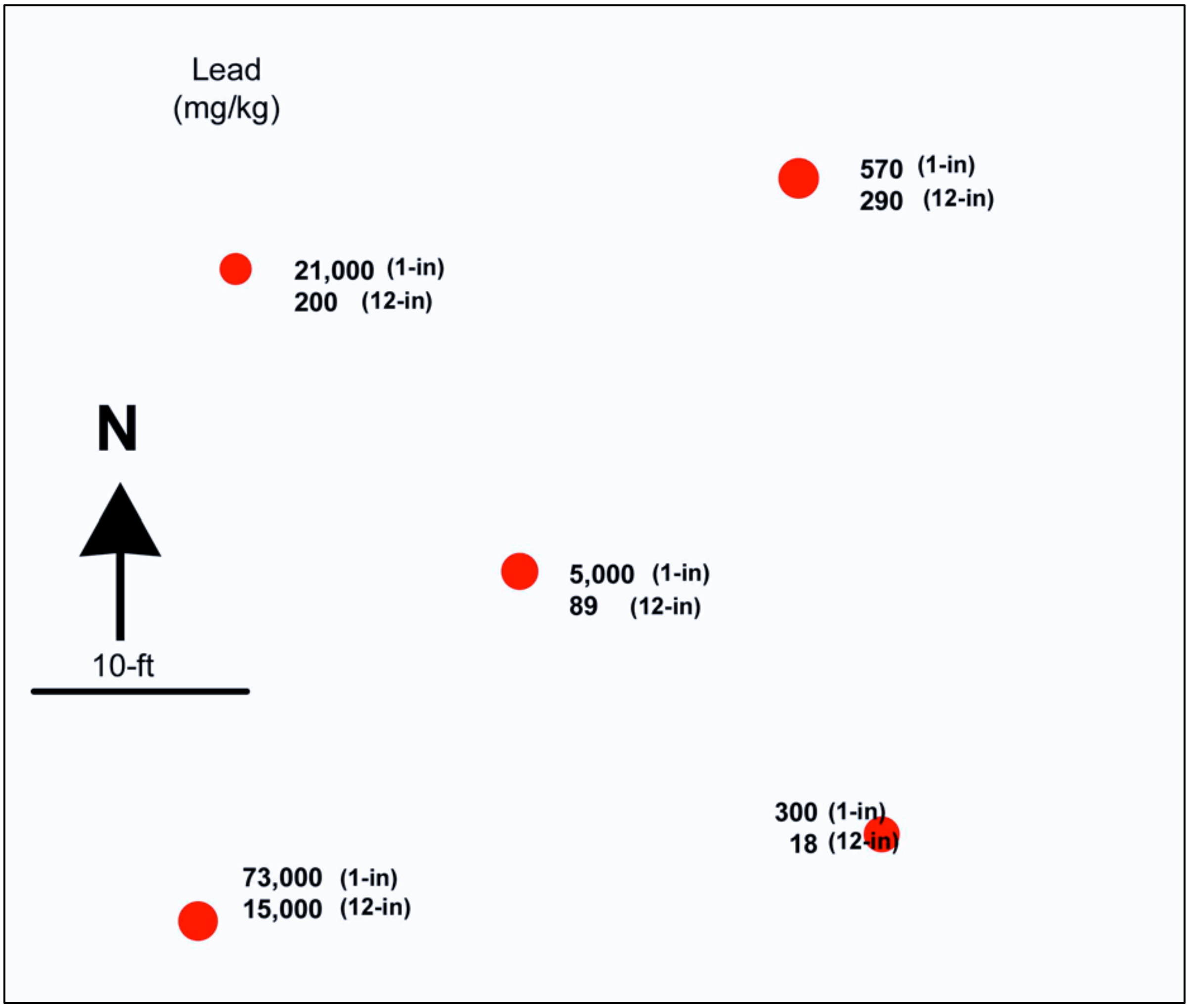


Figure 13. Schematic drawing showing ESA's lead concentrations in the Weeping Willow area in July 2010. Samples were collected at 1-in and 12-in depths at each location. This drawing was based on Figure 6 in ESA (2010b). ESA's report does not show where these samples were collected relative to site features.

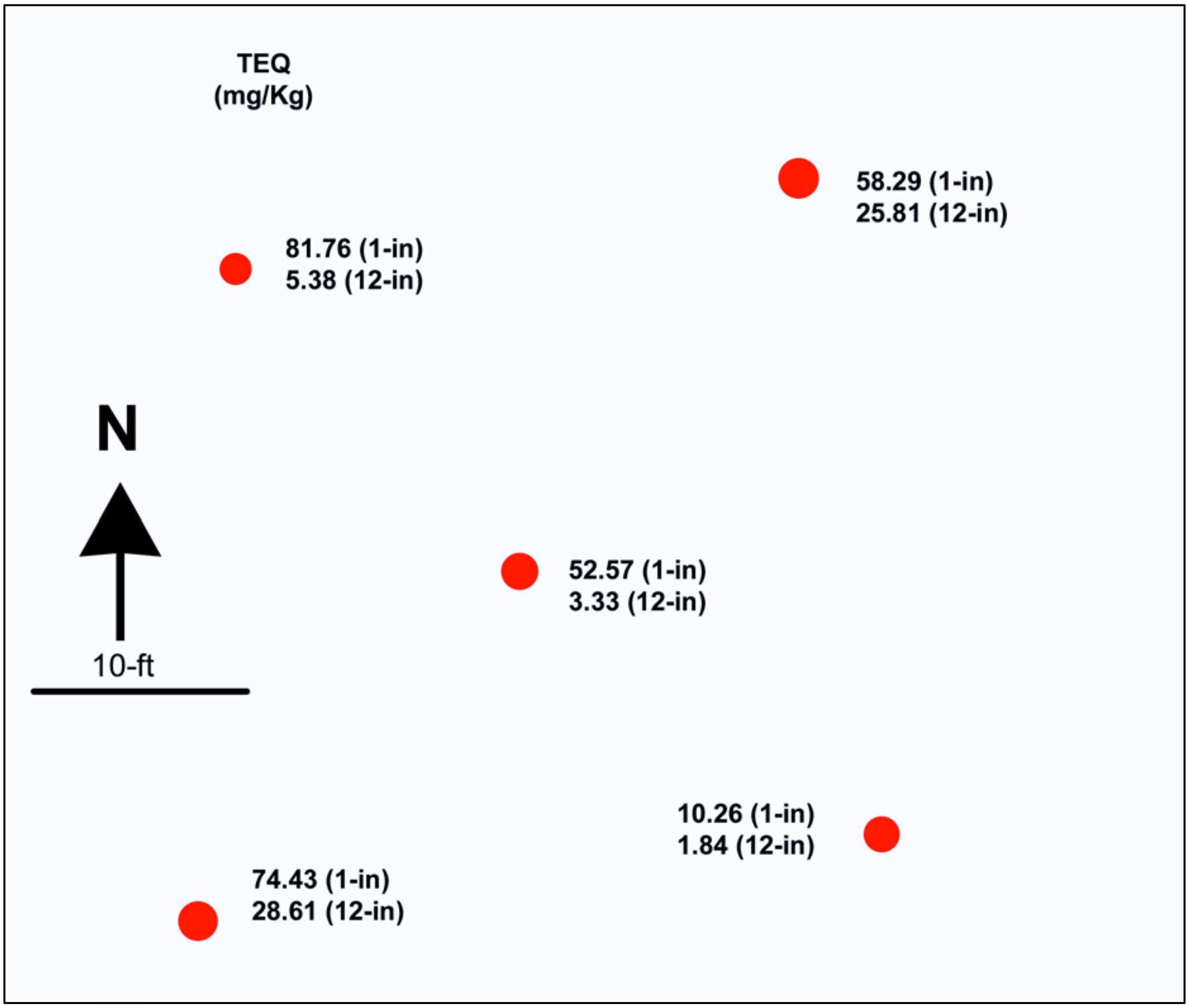


Figure 14. Schematic drawing showing TEQ concentrations from ESA's soil samples collected in the Weeping Willow area in July 2010. Samples were collected at 1-in and 12-in depths at each location. This drawing was based on Figure 6 in ESA (2010b). ESA's report does not show where these samples were collected relative to site features.

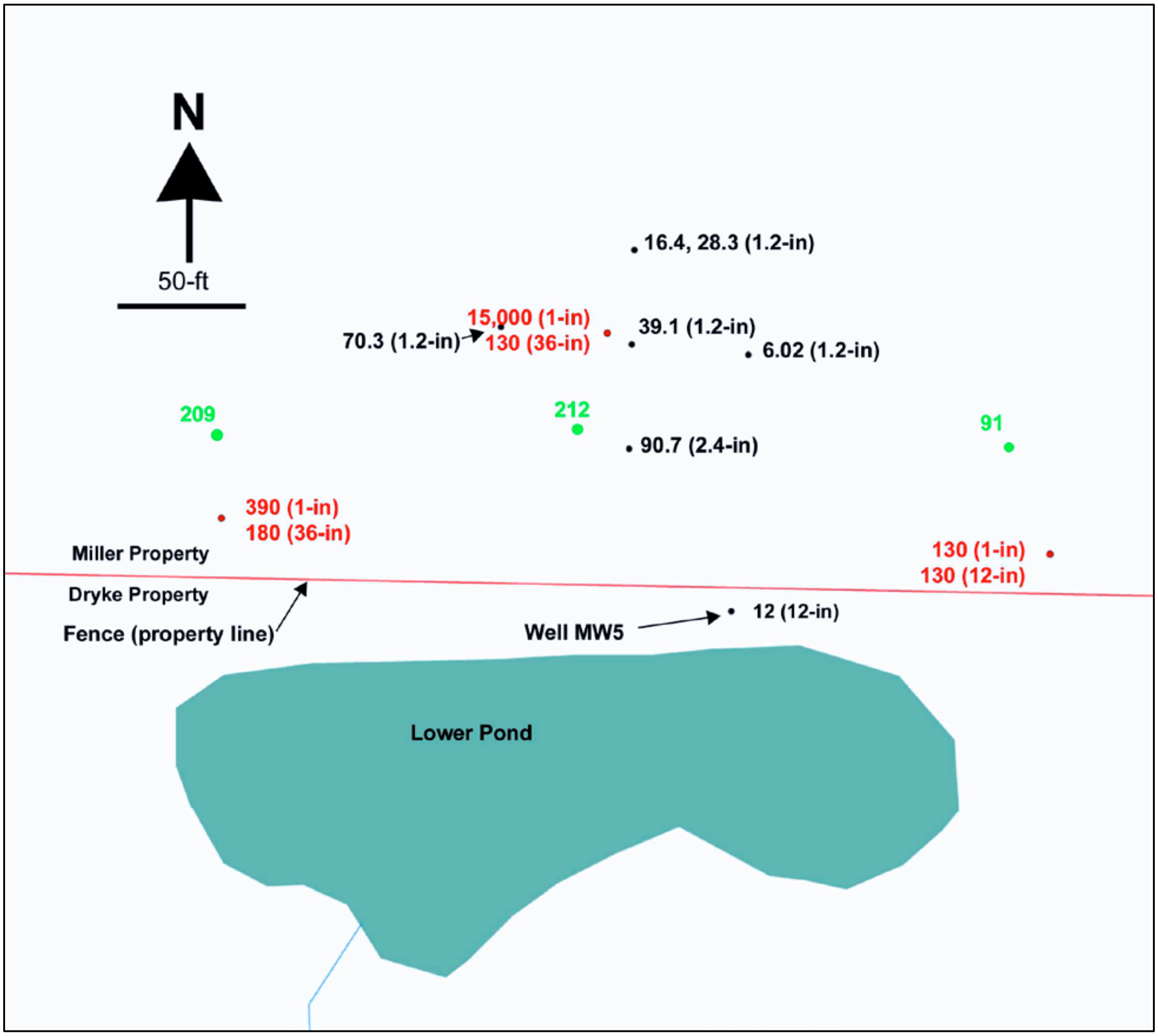


Figure 15. Schematic drawing showing soil samples collected on and near the Miller Property. Shown for each sample location are the lead concentrations in mg/Kg and the approximate sample depth in inches bgs (in parentheses) if known. The CCHHS samples are probably surface grab samples collected less than 3-in deep. LGI estimated the locations of the CCHHS samples (shown in green) and ESA samples (shown in red) from unscaled drawings. LGI samples are shown in black. The lead concentrations shown on this figure are consistent with concentrations detected in the northern portion of the Lower Pond (Figure 9).

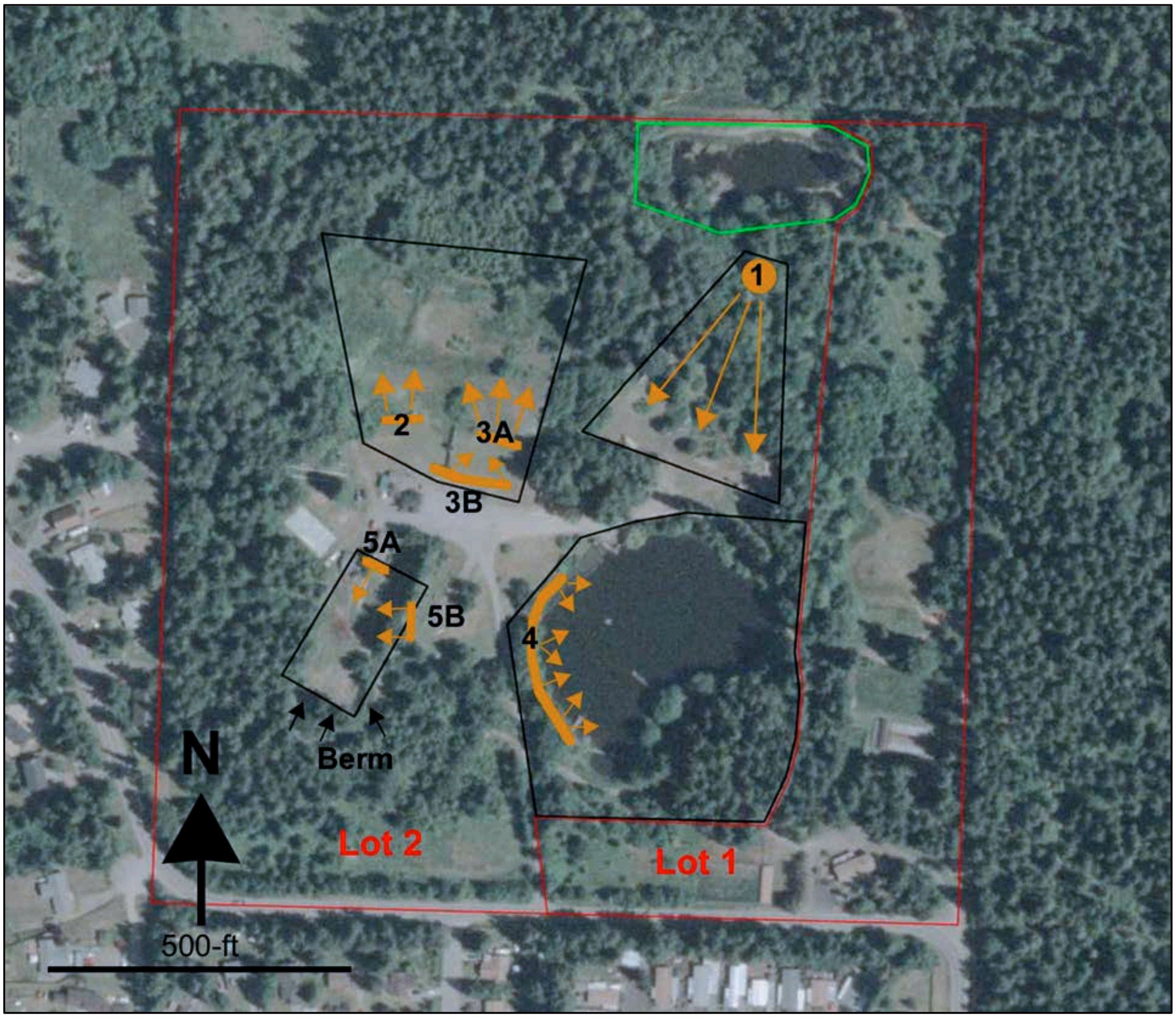


Figure 16. Map showing locations of proposed Active Shooting Range Management Areas (4 black polygons); shooting locations (1, 2, 3A, 3B, 4, 5A, 5B); shooting directions (orange arrows); Lower Pond Management Area (green polygon), and Lots 1 and 2 (red polygons). There are berms located at the south and southeast sides of Management Area 5. These berms prevent stray shot and bullets. The area outside of the black and green polygons in Lot 2 comprise the Non-Shooting Management Areas. The text describes BMPs and an institutional control for these management areas. Lot 1 will be managed separately and is excluded from these BMPs and institutional control.