DRAFT for Client Review

Site Investigation Report

La Crosse Marsh Gun Club

BRRTS # 02-32-576301

DNR Facility ID # 632138980

November 1, 2017

Prepared for

City of La Crosse, Wisconsin

Board of Public Works

Prepared by

The OS Group, LLC

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Executive Summary

Coulee Environmental Solutions, a division of The OS Group, LLC (CES) was engaged by the Board of Public Works to complete the Site Investigation of the legacy lead in the La Crosse River Marsh, adjacent to Myrick Park.

Findings and Conclusion

Through the scope of work summarized below, CES found the following:

- Sediments, surface water and soils have been impacted by lead (Pb) and polynuclear aromatic hydrocarbons (PAHs)
- An estimated 22 tons of Pb shot remains within the marsh sediment, typically buried below 4 to 12 inches of organic rich silt. An estimated 22 acres exceed the WI DNR criteria of 130 mg/kg for probable effects on biota
- PAH sediment concentrations above WDNR guidelines were identified in samples collected nearest the shoreline in their respective transects. Some limited remedial action for sediments with the high PAH concentrations may be appropriate and may consist of hot spot sediment removal or placement of a barrier cap, should similar actions be required for the lead sediment contamination
- Only one sample collected by either UWL or the WDNR exceeded the WDNR's surface water quality criteria for Pb, and it is not believed that any remedial action is specifically required to address lead in surface water
- PAHs were detected in the surface water in both target and background samples above EPA guidelines. Urban stormwater runoff has likely contributed to the PAH levels observed
- No lead was detected in shallow soils (top 4 feet) in the study area above the EPA criteria of 400 mg/kg based on the dike and shoreline lead sample results presented in the UW-L report. Direct-contact human exposure risk from Pb is limited
- PAHs in soils above direct-contact soil residual contact levels, posing some direct-contact human exposure risk, was observed in samples collected along trails and at former shooting stations
- There were no detected impacts to groundwater from Pb or PAHs, and nil to minimal long-term threat to the underlying aquifer
- Mild impacts to the biota from Pb were identified by the UW-L study. Lead was observed in fish tissues samples collected from the study area; however, no Wisconsin or US standards, guidance or advisory levels exist for lead levels in fish. Few toxicologic effects in aquatic organisms were observed by the UW-L researchers. The toxicological report concluded:
  - No acute risk
  - Only "minor toxicity to developing embryos" that "is likely due to factors other than, or in addition to, Pb exposure"
  - No toxicity to invertebrates
  - Few malformation[s] in invertebrates with no correspondence with sediment Pb levels
- PAH impacts to the biota have not been studied
- Archeological resources including a prehistoric burial mound site and an uncatalogued burial site adjoin the contaminant site. No cultural material except for several clay pigeon fragments were observed. Additional investigation or remediation should not affect any prehistoric or historic archaeological resources

Recommendations

The largest threat that exists from the contamination is to the biota. Thus, CES recommends pursuing a monitoring program that demonstrates limited risks. A monitoring program would assess both impacts and risks to the wildlife and contaminant conditions. Toxicological studies of aquatic organisms show mild to no effect attributable to the lead contamination, and PAH impacts to the biota have not been studied. CES recommends engaging Christine Custer and Thomas Custer of the USGS Upper Midwest Environmental Sciences Center, La Crosse, WI, to conduct a tree swallow study to assess impacts and risks to the wildlife at a higher trophic (food-chain) level. Similar studies conducted at multiple sites by the Custers and others have successfully used tree swallows as a bioindicator or sentinel species for assessing the uptake of lead contamination into the food chain. Monitoring contaminant conditions would include continued groundwater and surface water monitoring.

Summary of Scope of Work

CES completed the following scope of work:

1. Reviewed the UW-L Reports;
2. Developed an Evaluation Position Paper, dated July 8, 2016, which summarized the UW-L Study and determined the adequacy of the UW-L Report to serve as a site investigation per ch. NR 716, Wisconsin Administrative Code;
3. Prepared a Site Investigation Workplan, dated October 6, 2016, which outlined the scope and methods of additional investigation work required at the site;
4. Archeological Investigation, performed by Mississippi Valley Archeology Center, to evaluate the potential presence of additional archeological resources in the study area.
5. Contaminant Sampling for Polynuclear Aromatic Hydrocarbons (PAH) in each of the following environmental media:
    a. Sediments
    b. Surface water
    c. Soil
    d. Groundwater
6. Contaminant Sampling for Lead in each of the following environmental media:
    a. Soil
    b. Groundwater
7. Sediment Investigation
    a. Twenty-five (25) sediment cores were collected for PAH analysis;
8. Surface Water Investigation
    a. Twenty-five (25) surface water samples were collected at the locations of each sediment core;
9. Soil Investigation
    a. Twenty-two (22) shallow (0 to 2 & 2 to 4 feet bgs) soil samples for PAH analysis were collected from eleven (11) locations along the trail and adjacent land and around the existing shooting station;
    b. Ten (10) soil samples at 5 locations for lead analysis;
10. Groundwater Investigation
    a. Piezometer Nest
        i. Installed and sampled, over three quarterly events, a nest of three piezometers at the water table, and at 15 and 30 feet below the water table;
        ii. Evaluated vertical gradients between the surface water and the underlying aquifer to examine the vertical migration potential of the lead groundwater plume;
11. Preparation of this Site Investigation Report.

Site Information

Site Name

La Crosse Marsh Gun Club (the Site)

Site Address

2020 Myrick Park Drive, La Crosse, Wisconsin 54601

Location

PLSS: NE 1/4 of the NW 1/4 of Sec 33, T16N, R07W

Latitude: 43°49'25" Longitude: 91°13'28"

WTM: X Coordinate (WTM91): 421538.999958251

Y Coordinate (WTM91): 372982.000126013

The Site is located in the La Crosse River Marsh in the City of La Crosse, adjacent to and north of the City's Myrick Park. The site's location is depicted in Figure 1, Site Location Map. A site layout is provided in Figure 2.

Contact Information

Name, Address and Contact for Responsible Party

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Site Background

The La Crosse River Marsh (LRM) is an urban wetland located within the City of La Crosse, La Crosse County, Wisconsin. From 1929 to 1963, the La Crosse Gun Club leased land in Myrick Park and the LRM from the City of La Crosse and conducted trap shooting from four (4) shooting stations over the LRM from the adjoining park. This activity deposited lead shot and clay target (i.e. clay pigeons) fragments in the LRM over an area of approximately 37 acres. Lead contamination in the Marsh was documented from an earlier study completed by the Wisconsin Department of Natural Resources and the University of Wisconsin – La Crosse River Studies Center (UWL)1. In addition, polynuclear aromatic hydrocarbons (PAHs) were a potential second type of contaminant at the site. PAHs are present in tars, oils, and petroleum and have been associated with clay targets that historically used an asphaltic binder. PAHs can also be present in urban stormwater runoff at levels that exceed surface water quality standards.

The previous lead contamination study, documented in the WDNR and UWL report[1], concluded in part that:

> An estimated 20,000 kg of Pb shot remains within the marsh sediment, typically buried below 10 -30 cm [4 to 12 inches] of organic rich silt. An estimated 3.8 hectares of the LRM contains surface sediment that exceeds the EPA criteria of 400 mg/kg for contaminated soils and 8.9 hectares exceed the WI DNR criteria of 130 mg/kg for probable effects on biota. Terrestrial sites in the study area where most human activity is focused (e.g. gravel pedestrian trail and Myrick Park) were not found to have soil Pb levels above the EPA criteria of 400 mg/kg.[1]

The previous lead contamination study, nor any other studies, did not include any investigation on PAHs present at the LRM site.

In addition to the trap shooting activities, one remedial activity was reportedly conducted at the LRM in response to the trap shooting activities. More specifically, "In 1952, Pb shot was salvaged from the LRM sediments, but few

[1] Belby CS, Gerrish G, King-Hieden T, Rolfhus K, Sullivan J, Giblin S (2016). Final Report: Monitoring and Assessment of Legacy Lead Contamination in the La Crosse River Marsh: U.S. EPA Urban Waters Grant UW00E01025 Final Report.

details regarding the salvage operation are available"[3]. No additional information has since been obtained regarding this salvage operation.

In response to the WDNR and UWL study, the WDNR issued the City of La Crosse a responsible party letter on November 2, 2015. The City of La Crosse subsequently retained Coulee Environmental Solutions, A division of the OS Group, LLC. (CES) to complete additional investigation activities at the Marsh. Upon review of the previous activities completed at the site, it was determined that additional investigation activities to determine the presence and extent of 1) potential PAH contamination in the LRM, 2) lead contamination in the immediate vicinity of the trap shooting stations and 3) groundwater contamination was required. CES prepared a Site Investigation Work Plan for additional activities at the site which was conditionally approved by the WDNR on October 31, 2016. This report summarizes the results of the prior investigation and additional investigation activities completed at the site.

Method of Investigation

Previous Investigation Activities

Since the conclusions in this report are also based upon the results from the previous investigations completed by the WDNR and UWL, a brief summary of the methods of investigation used by them is provided below. A more complete description of their actual methodologies is documented in their report[1].

Sediment Sampling Methods

UWL collected a total of 456 surficial sediment samples from the marsh using a Wildco hand core sediment sampler and 36 deeper cores collected using a modified Livingston (Bolivia) drive rod piston corer. Surficial soil samples were also collected from the terrestrial sites along the path bisecting the study area and the terrace surface adjacent to the former trap fields.

The WI DNR collected bed sediments at three (North, East, and West) LRM monitoring sites using a petite ponar with a fourth sample collected at Lizzy Pauls Pond to serve as a reference. Several sediment samples were collected at each location and mixed to obtain a composite sample. In addition, sediment traps were also deployed at the three LRM monitoring sites in the spring/early summer of 2012 and 2013 to evaluate suspended sediments. Both the sediment and suspended sediment samples were analyzed for total volatile solids (TVS), total organic carbon (TOC) and lead analysis. Small portion of the sediment samples were also analyzed for particle size.

Water Sampling Methods

UWL collected surface water and sediment pore water samples four times at five locations within the LMR during 2013-2015 with four of the locations adjacent to areas with high sediment lead concentrations and the fifth "control" location farthest from the trap shooting range. Samples were collected from a canoe with surface water samples collected from the midpoint of the water column and analyzed for total lead, dissolved lead, and hardness. Sediment pore water were collected by petite ponar with pore water extracted from the sediment slurries by centrifuging and analyzed for dissolved lead. Surface water quality measurements for dissolved oxygen, pH, conductivity, turbidity and temperature were also collected at the five locations over the three years using a Hydrolab Quanta.

The WDNR collected water chemistry (nutrients, metals, and chlorphyll a) samples at four locations in late July and early August 2012. Three of the locations (North, East and West) were in the LRM and the fourth location was Lizzy Pauls Pond which served as a reference. Water samples were also collected from the East site in the LRM over eight consecutive days in August 2013 and analyzed for total Pb to determine the average 4-day total Pb concentration. Surface water quality field measurements (DO, pH, conductivity, turbidity, and temperature) were collected 15cm below the water surface at biweekly to monthly intervals from April to September 2012 at the North, East, and West sites in the LRM. A continuous DO and temperature logger was also installed at the WDNR's LRM North site during July to September to document diurnal changes.

Methods for measuring toxicity in fishes

Standard sediment toxicity assays were performed using zebrafish to identify lethal and sublethal toxicity following exposure to LRM sediments with the findings compared to exposure to water soluble pb (Pb nitrate: 0, 0.1, 0.2 and 0.4 mg/L). Homogenized sediments containing an artificial, reference (10 mg/kg Pb), low (269 mg/kg), medium (4,463 mg/kg) and high (12,520 mg/kg) Pb concentration were mixed with buffered zebrafish water (pH 7) and placed in 24-cell well plates. After the sediments settled overnight, one zebra fish embryo was placed into each well (24 at each concentration with 3 replicates; N-72). Mortality was used as the measure of acute toxicity after one day with surviving fish moved to clean 24-cell well plates to assess sublethal toxicity.

Sublethal toxicity was evaluated for both neurological and morphological signs on a subset of larvae (8 representative fish from each assay; n=24) by administering a stimulus (touch) to larval fish to initiate a standard response. Following neurological assessment, fish were immobilized, lateral images taken and developmental toxicity assessed qualitatively. Lateral images were also used to quantify the number of visible gross abnormalities and to assess growth.

To determine whether observed toxicity following exposure to LRM sediments was due to Pb or something else in the sediments, UWL measured the relative expression of the gene ALA-D as a biomarker of Pb exposure. Fish were again exposed to Pb nitrate, synthetic, or LRM sediments of various concentrations (as described above) for 5 days. After the 5 days, fish were euthanized and tissues stored for analysis.

Methods for measuring Pb concentrations in aquatic vegetation

Duckweed was sampled from 19 locations across of a gradient of Pb levels within and outside the shot fall zone by UWL scientist on three separate occasions (July and August, 2012; and September 2013). In addition, the WDNR collected a duckweed sample from the LRM east site during August 2012 and from two additional sites outside of the LRM to serve as references. Sparganium eurycarpum (bur-reed) was also collected by UWL in August 2012 from sub-aerially exposed sites on the west side of the trail that bisects the study area. All samples were analyzed for Pb.

Methods of measuring Pb levels and malformation occurrence in LRM invertebrates

Invertebrates (Leptocerus americanus) were collected from 11 locations within the LRM and 2 background locations during the months of May and June 2012. All of the invertebrates collected from each location were aggregated, ground manually with a ceramic mortar and pestle, and the subsequent larval tissue analyzed for total Pb. Collection of larval L. americanus was repeated in May 2014 from sites at each level of contamination to analyze the portioning of Pb between the bodies and cases.

Emergence traps were set in five locations in the LRM in the summer of 2013 to collect emerging adult aquatic insects. The traps were placed in control, low Pb level, medium Pb level, and high Pb level (2) locations. Emerging adult aquatic insects, including L. americanus, were captured and processed for Pb analysis.

A macroinvertebrate assemblage was collected at the same larval (see above) sampling sites in May 2014. Three replicates were collected from the control medium and high Pb levels and two replicates from the low sediment Pb level. Once collected, the macroinvertebrates were preserved and identified to the level of family with some being identified to genus and species, to calculate diversity estimates at each site. Due to the high abundance, Leptocerus americanus were removed from the analysis to focus on the underlying diversity. In addition to identification, invertebrates were visually assessed for head, leg and abdomen malformations under a dissecting microscope.

Methods for measuring toxicity in Invertebrates

Standard sediment toxicity assays were performed using larval midges and juvenile amphipod crustaceans. Homogenized sediments were placed in test beakers and tap water added at a ratio of 1:1.75 and acclimated to test temperature. After the sediments settled overnight, ten (10) organisms were randomly added to the test beakers containing artificial, reference (11mg/kg Pb), and contaminated LRM sediments containing 59, 3820, and 5360 mg/kg Pb (8 replicates; N=80). After 10 days, with overlying water replaced twice daily, surviving organisms were recovered to determine mortality and ashed to asses for growth by determination of their dry weight.

Methods Fish Collection & Determination of Pb Content

Golden Shiners, Blugills, Black Bullhead and Northern Pike were collected from four areas based on Pb concentrations in the sediment including a reference, (0-200 mg/kg), low (400 – 1,000 mg/kg), medium (2,000-4,000 mg/kg) and high (4,000-8,000 mg/kg) Pb contamination areas. Fish tissues were stored frozen and processed to determine Pb content of the whole fish. Five additional fish including four northern pike and one bluegill of catch size were collected in July 2015 from the high Pb contamination area to test Pb concentrations in the fillet portion of the fish.

During August 2012, the WDNR used electrofishing to collect 21 fish, including 17 black bullhead and 4 bluegill, adjacent to the East site. Samples were composited based on species and size and include 5 composited bullhead samples with 3 to 4 fish in each and 2 composited bluegill samples with 2 fish in each. Samples were analyzed for Pb.

Additional Investigation Activities

Site investigation activities completed at the site following the WDNR's and UWL study included the following:

- Archeological investigation (November 2016 – February 2017);
- Installation of four Geoprobe borings on the uplands near the trap shooting stations for PAH and lead soil sampling (November 7, 2016);
- Installation of six Geoprobe borings along the trail for PAH soil sampling (November 7, 2016);
- Installation of a groundwater monitoring well/piezometer nest on the trail for dissolved lead and PAH groundwater monitoring (November 7 and 18, 2016);
- Monitoring well/piezometer development (December 20 and 22, 1016)
- Monitoring well/piezometer sampling (February 14, 20017);
- Surface water sampling for PAHs (February 16 – 18, 2017);
- Sediment PAH sampling (February 16 – 18, 2017); and
- Monitoring well/piezometer sampling (May 24, 2017).

A description of these activities is provided below.

Archeological Investigation

The Mississippi Valley Archaeology Center (MVAC) was retained by CES to conduct Archaeological Monitoring of soil borings and sediment sampling at the LRM. MVAC first confirmed that the proposed soil boring and sediment sampling locations would not disturb any previously recorded burial sites at or in the immediate vicinity of Myrick Park. Then, in November of 2016 and February of 2017, MVAC personnel observed soil borings and sediment sampling to inspect soil and sediment samples for any potential buried soil that may contain prehistoric material and to determine if the depth of any potentially proposed soil or sediment removal could have an adverse effect on any potential archaeological resources.

Soil Investigation

On November 7, 2016, twenty-two (22) shallow (0 to 2 & 2 to 4 feet bgs) soil samples for PAH analysis were collected from eleven (11) locations along the trail and adjacent land and around the existing shooting stations (Stations 3 and 4). (Note the trail is present on the 1927 USGS 7.5-minute quadrangle.) Two of the samples were from the piezometer borehole. Ten (10) Geoprobe borings (GP-1 through GP-10) were advanced to a depth of four (4) feet below ground surface (bgs). Six of the borings (GP-1 through GP-6) were advanced along the trail (GP-2 through GP-6); one on the uplands at the west edge of the lead shot/clay pigeon fall zone (GP-1); and four (4) Geoprobe borings (GP-7 through GP-10) on the uplands near the eastern former shooting stations (Station 3 and 4). See figure 3 for sampling locations. All samples were collected by Geoprobe with split-spoon sampler. Soil samples were classified according to the USCS. Two samples from each of borings GP-1 through GP-6 were submitted to a state-certified laboratory for PAH analysis. Two samples from each of borings GP-7 through GP-10 were submitted to a state-certified laboratory for PAH analysis by EPA Method 8270 and lead (Pb) analysis by EPA 6010 / 200.7.

Manual removal & count of lead pellets was not conducted in the field for lead soil samples as no pellets were observed.

Groundwater Investigation

Piezometer Nest

CES constructed a nest of one water table observation well and two piezometers along the dike trail adjacent to the sediment lead hot spot as shown on Figure 4. On November 7, 2016, monitoring well MW-1 and piezometer PZ-1 were constructed. On November 18, 2016, piezometer PZ-2 was constructed, and soil samples were collected with split-spoon sampler continuously to the bottom of the borehole and classified according to the USCS. Two soil samples from the top four (4) feet were submitted to a state-certified laboratory for PAH and Pb analyses. The observation well and piezometers were constructed by hollow-stem auger and finished as stick-ups with flush-threaded, 2-inch ID, schedule 40 PVC pipe and protective cover steel pipe, per Chapter NR 141, Wisconsin Administrative Code, and as described below:

Table1: Monitoring Well Depths and Screen Lengths

Well #	Depth of Screen Bottom (Feet bgs)	Screen Length (feet)
MW-1	12	10
PZ-1	27.5	2.5
PZ-2	42.5	2.5

During the installation of piezometer PZ-2, split-spoon soil samples were collected continuously during borehole advancement and classified according to the Unified Soil Classification System. The soil boring log for PZ-2 is provided in Attachment A. Monitoring Well Construction and Development Forms are provided in Attachment B.

After development of the monitoring wells per NR 141, groundwater samples were collected from the monitoring well and piezometers and field analyzed for pH, specific conductivity, dissolved oxygen and oxidation-reduction potential. Samples prepared for lead analysis were field filtered. Samples were submitted to a state-certified laboratory for PAH and dissolved Lead analyses. Two (2) quarterly sampling events were conducted. Piezometer top-of-casing elevations were surveyed to a local datum and the stage staff gage at the culvert beneath the trail, and water levels were measured during each sampling event and not less frequently than monthly during a range of hydrologic conditions, including spring high water, over a period of six (6) to eight (8) months.

Groundwater Monitoring

On December 20, 2016, the monitoring wells and piezometers top-of-casing were surveyed to an on-site datum established by the WDNR at the nearby box culvert. On December 20 and 22, 2017, the monitoring wells and piezometers were developed per Wisconsin Administrative Code, Chapter NR 141 requirements. Two hundred and seventy-five (275) gallons of development water was collected and stored in two 275-gallon totes. A water sample collected from the development water was submitted for PAH and total lead laboratory analyses which revealed no detectable concentrations. The development water was then discharged to the ground.

Depth to water was measured in the wells on December 22, 2016 and January 20, February 14, March 28, April 25, and May 24, 2017. Groundwater samples were collected from the monitoring nest on February 14 and May 24, 2017 and submitted to a state-certified laboratory for PAH and dissolved lead analysis.

Surface Water Investigation

From February 16 through 18, 2017, CES performed surface water sampling at twenty-five (25) locations within the site. Twenty-one (21) of the sampling locations were located with the lead shoot and clay pigeon fall zones and four (4) were located outside of the fall zone as background samples. Sampling locations were geolocated with a Trimble GeoExplorer GeoXH GPS unit. Surface water samples were collected through holes drilled through the ice with a gasoline-powered ice auger. The water sampling was conducted a minimum of two (2) hours up to one (1) day after the holes were drilled to allow for the water column to settle and stabilize. The depth of the water column was measured, and field measurements of temperature, specific conductance, dissolved oxygen, pH and oxidation reduction potential were collected with a YSI 556 meter. Surface water samples were collected using a peristaltic pump and weighted low-density polyethylene and silicone tubing while lowering through the water column, in order to obtain samples that were representative of the water column. Samples were field analyzed for pH, dissolved oxygen, specific conductivity and oxidation-reduction potential with a YSI 556 meter. one sample per location was prepared and shipped for laboratory analysis for PAH by a Wisconsin certified laboratory. Surface water sampling locations, which were in the same locations as the sediment core sampling locations discussed below, are depicted in Figure 5.

Sediment Investigation

In conjunction with the surface water sampling, February 16 through February 18, 2017, twenty-five (25) sediment cores were collected at the same locations as the surface water samples. Twenty-five (25) sediment cores were collected for PAH analysis; 21 within the lead shot fall zone to characterize PAH contamination and four (4) outside to characterize PAH background levels. Following the methods required by Section NR 347.06, Wisconsin Administrative Code, all cores were advanced to a depth of thirty-six (36) inches with a 36-inch, 2-inch-diameter, AMS, multi-stage, stainless-steel, core sampler, using plastic core sampler liners and plastic sediment catch baskets. No sediment samples were collected for lead. All sediment cores were collected after the surface water sampling to prevent disturbed sediments from affecting the water quality. Figure 5, Sediment Sampling Locations, depicts the locations of the sediment core and surface water sampling locations.

Core samples were visually inspected for structure, layering, grain size and color. A written description of each core was recorded. Two sediment samples from each core (50 samples total) were submitted to a state-certified laboratory for PAH analysis via EPA method 8270 SIM. In addition, ten (10) randomly selected samples were also analyzed for PAHs via EPA method 8270 Full Scan. After receipt of the results of the 50 PAH analyses by EPA method 8270 SIM, the eleven (11) samples with the highest PAH concentrations were analyzed for total organic carbon (TOC).

A summary of the soil, groundwater, surface water, and sediment investigation sampling plan is provided in table 2 below:

Table 2: Summary of Investigative Sampling Plan

Parameter / Analyte	Media	Number of samples	Depth	Objective of Sample Set	Analysis Method	Sample Collection Method
PAH	Sediment	50	0 to 36 inches, depending on penetration and recovery	• Define extent and degree of PAH in sediments	EPA 8270 SIM Soil & sediment extraction by sonication EPA 3550C	Core Sampler, hammer-driven
	Surface water	25	Integrated Water Column	• Assess degree of PAH impacts in surface waters.		Peristaltic Pump
	Soil	11	0 to 2 feet	• Assess PAH direct-contact risks at trail and on shore. • Evaluate correlation of shallow soil PAH levels to groundwater PAH levels. • Characterization of investigative waste soil cuttings.		Geoprobe or HSA with split-spoon sampler
		11	2 to 4 feet			
		1	5 to 7 feet	• Define vertical extent of PAH contamination in soils. • Characterization of investigative waste soil cuttings.		
		1	10 to 12 feet			
	Groundwater	3 per quarter; 2 quarters	WT WT+15 feet WT+30 feet	• Assess PAH contamination in groundwater. • Define vertical extent of PAH contamination in groundwater. • Evaluate seasonal variations in PAH levels in groundwater. • Define vertical extent of PAH contamination in groundwater.		Bailer
Lead	Soil	4	0 to 2 feet	• Additional assessment for potential terrestrial impacts from 1952 lead salvage activities. • Additional assessment of lead direct-contact risks at trailhead and on shore.	EPA 6010 / 200.7 Manual removal & count of lead shot in field for soil samples. Lead water samples will be field filtered.	Geoprobe with split-spoon sampler
		4	2 to 4 feet			
		1	5 to 7 feet	• Define vertical extent of lead contamination in soils.		
		1	10 to 12 feet			
	Groundwater	3 per quarter; 2 quarters	WT WT+15 feet WT+30 feet	• Assess lead contamination in groundwater. • Define vertical extent of lead contamination in groundwater. • Evaluate seasonal variations in lead levels in groundwater. • Define vertical extent of lead contamination in groundwater.		Bailer

Investigative Waste Management

Soil cuttings from HSA drilling, Geoprobe and sediment core sampling were drummed and stored in a secure area at the city-owned Myrick Pumping Station, adjacent to the site. Disposal of soil and sediment investigative waste (IW) will be determined during the Remedial Action Options Analysis as they may potentially be disposed with dredged sediments, should that serve as part of the remedial action. Monitoring well development and purge water was drummed. Based on analytical results below the NR140 Preventive Action Limits, the well development and purge water was discharged to the ground.

Results

Information Gathered from Other Sources

Scoping of this Site Investigation predominantly relied upon earlier work conducted by the Wisconsin Department of Natural Resources (WDNR) and the University of Wisconsin – La Crosse River Studies Center (UWL)[2,3,4,5]. While certain key points are summarized here, the reader is directed to the full reference documents.

History of the Site

> The La Crosse River Marsh (LRM) is an urban wetland located within the City of La Crosse, Wisconsin. The LRM has been recognized for its high level of biological diversity in an urban setting (WIDNR, 1990) and is part of the larger 435 ha (1,075 acres) La Crosse River Valley wetland complex, situated on the southwestern border of Wisconsin at the confluence of the Mississippi and La Crosse Rivers along the Mississippi Flyway.[6]

The 1937 completion of construction of Lock and Dam 8 on the Mississippi River at Genoa, Wisconsin, created the impoundment known as Pool 8[7] and increased the depth and frequency of inundation of the LRM.

Leasing land in Myrick Park and the LRM from the City of La Crosse, the La Crosse Gun Club conducted trap shooting over the LRM from the adjoining Myrick Park from 1929 to 1963. This activity deposited lead shot in the Marsh over an area of 37 acres.

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[1] Belby CS, Gerrish G, King-Hieden T, Rolfhus K, Sullivan J, Giblin S (2016). Final Report: Monitoring and Assessment of Legacy Lead Contamination in the La Crosse River Marsh: U.S. EPA Urban Waters Grant UW00E01025 Final Report. University of Wisconsin – La Crosse River Studies Center, Wisconsin Department of Natural Resources, La Crosse, WI

[2] Belby CS, et al (2016). P. 35.

[3]Perroy RL, Belby CS, Martin CJ (2014). Mapping and modeling three dimensional lead contamination in the wetland sediments of a former trap-shooting range. *Science for the Total Environment* 487: 72-81

[3] Sullivan J, Rasmussen K (2012). *Lead Contamination Investigations in the La Crosse River Marsh Project Update* – November 2012. Wisconsin Department of Natural Resources, La Crosse, WI.

[4] Perroy RL, Belby CS, Martin CJ (2014). Mapping and modeling three dimensional lead contamination in the wetland sediments of a former trap-shooting range. *Science for the Total Environment* 487: 72-81

[5] Wisconsin State Laboratory of Hygiene Environmental Toxicology Section (2012). Sediment Toxicity Tests, La Crosse Marsh Lead Study, Madison, WI.

[6] Belby CS, et al (2016). P. 2.

[7] USACE St. Paul District, http://www.mvp.usace.army.mil/Missions/Navigation/Locks-Dams/Lock-Dam-8/, accessed on July 29, 2016.

1952 Lead Shot Salvage Operation

In 1952, Pb shot was salvaged from the LRM sediments, but few details regarding the salvage operation are available. Trap-shooting continued for another decade with no additional recovery efforts documented.[8]

Knowledge of the type and amount of contamination

As provided in the Final Report regarding the University of Wisconsin – La Crosse River Studies Center and WDNR studies:

> The La Crosse Gun Club operated four trap fields overlooking a 15 ha [37 acres] section of the LRM from 1929 to 1963…. Large quantities of Pb shot were regularly discharged in the LRM until the City declined to renew the Club's lease in 1963. Work completed in conjunction with the WI DNR in the early 1990s found Pb shot densities as high as 41,600 pellets/m^2 [3,865 pellets/ft^2] (Fors, 1994) .[9]
>
> An estimated 20,000 kg of Pb shot remains within the marsh sediment, typically buried below 10 -30 cm [4 to 12 inches] of organic rich silt. An estimated 3.8 hectares of the LRM contains surface sediment that exceeds the EPA criteria of 400 mg/kg for contaminated soils and 8.9 hectares exceed the WI DNR criteria of 130 mg/kg for probable effects on biota. Terrestrial sites in the study area where most human activity is focused (e.g. gravel pedestrian trail and Myrick Park) were not found to have soil Pb levels above the EPA criteria of 400 mg/kg.[10]

Furthermore, The UW-L report states, "Work completed in conjunction with the WI DNR in the early 1990s found Pb shot densities as high as 41,600 pellets/m^2 [3,865 pellets/ft^2] (Fors, 1994)."[11]

See Figure 4, Surface Distribution of Lead in Sediments.

UW-L Data Discrepancies

CES noticed some discrepancies in data provided by Professor Colin Belby, UW-L, pertaining to the previous study of lead contamination at the site. Specifically, CES noted the following:

- The UW-L report stated 36 core samples were collected at the site. Only 35 samples locations were depicted, however, on the figures and the data provided to CES had data for only 30 cores;
- The report stated 456 surficial sediment samples were collected. Only 412 locations are depicted on the UW-L reports' figures, and data was provided for only 401 locations; and
- In the data provided by Professor Belby to CES, surficial sediment samples mm02 and mm03 had the same northing and easting coordinates.

To resolve these discrepancies, CES contacted Professor Belby, one of the authors of each of the UW-L reports. His response as provided in an email[12] and phone conversation[13] are summarized below:

- Regarding the data for core samples, there were 38 cores collected. Of the 38, 30 cores were analyzed at 2 cm intervals via XRF. Of those 30 cores, 2 were background cores collected outside of the shotfall zone (cores 28a and 28b). Only 28 cores were therefore included in the 3D model of lead concentrations in the shot fall zone found the Perroy et al. paper[14];
- Regarding the surficial samples, UW-L had collected a total of 456 surficial samples. This includes an initial 415 surficial samples collected in the marsh and in Myrick Park near the trap fields, 28 surficial samples

[8] Perroy RL, et al (2014). P. 72.
[9] Belby CS, et al (2016). P. 2.
[10] Belby CS, et al (2016). P. 35.
[11] Belby CS, et al (2016). P. 2.
[12] Belby, C (2017). Personal email to Steven Osesek. September 25, 2017. La Crosse, WI.
[13] Belby, C (2017). Personal conversation with Steven Osesek, September 15, 2017. La Crosse, W
[14] Perroy RL, et al (2014).

obtained from the top of the cores discussed above, and 13 surficial samples from the gravel trail that bisects the study area. Of these samples, it appears only 373 of the 415 initial surficial samples collected in the marsh and Myrick Park were used. Combing the 373 surficial samples, 28 surficial core samples, and 13 surficial samples from the gravel trail results in 414 total surficial samples included in the model used in the paper, 2 off of the 412 depicted on the map. Dr. Perroy complied the georeferenced samples into the Matlab model, and Belby was unsure why all 456 samples were not used but thought it was likely due to how Perroy constrained the area represented in the model;

- Dr. Belby was unsure why samples mm02 and mm03 had the same coordinates but believed it was likely an error that was unfortunately introduced while compiling the data.

Environmental media affected or potentially affected

Affected and potentially affected media include sediments, surface waters, soils, and groundwater. Additionally, lead has been introduced into the biota. The 2016 U.S. EPA Urban Waters Grant UW00E01025 Final Report, entitled Final Report: Monitoring and Assessment of Legacy Lead Contamination in the La Crosse River Marsh (2016 UW-L Report), concluded:[15]

> An estimated 20,000 kg of Pb shot remains within the marsh sediment, typically buried below 10 to30 cm of organic rich silt. An estimated 3.8 hectares (9.4 acres) of the LRM contains surface sediment that exceeds the EPA criteria of 400 mg/kg for contaminated soils and 8.9 hectares (22 acres) exceed the WI DNR criteria of 130 mg/kg for probable effects on biota. Terrestrial sites in the study area where most human activity is focused (e.g. gravel pedestrian trail and Myrick Park) were not found to have soil Pb levels above the EPA criteria of 400 mg/kg.
>
> Pb is transferring from the sediment to the water column, though the effects appear to be limited based on our data. The water had elevated levels of total and dissolved Pb relative to the control sites, with the highest levels generally found above the most Pb-contaminated sediments. Of the 28 surface water samples collected and analyzed for Pb, one exceeded the WI DNR's chronic criteria and none exceeded the acute criteria. None of the running average 4-day surface water Pb concentrations exceeded the WI DNR's chronic criteria. Low concentrations of dissolved Pb in the surface water indicates that most of the water column Pb is associated with suspended particulate matter. This is supported by the high Pb levels found in suspended sediment traps placed within the former shot fall zone and by the correlation between total Pb and turbidity.
>
> Duckweed in the LRM had elevated Pb levels relative to control sites, with the highest levels generally found above the most Pb-contaminated sediments. Research has shown that Pb levels in duckweed is dose dependent and in highly contaminated waters Pb bioconcentrates to levels several orders of magnitude above what was found in the LRM duckweed samples (Kaur et al, 2010; Debusk et al., 1996; Zayed et al., 1997). While we did not examine LRM duckweed for signs of toxicity, *research indicates Pb-induced toxicity occurs at dissolved Pb concentrations above that found in the LRM water column (emphasis added)* (Kaur et al, 2010; Sobrino et al., 2010; Saygideger et al., 2013)
>
> All invertebrate and fish samples from the marsh had measurable Pb. In fish, higher levels were generally found in whole fish samples than fillets. In 1995 the USGS sampled primarily carp and bass from river shorelines and backwaters within the Mississippi River Basin and they found a maximum concentration of 0.69179 µg/g out of the 159 whole fish composite samples analyzed (Schmitt, 2002). This concentration was exceeded in 3 of 7 composite fish samples collected from the LRM by the WI DNR and 5 of 49 individual whole fish samples collected by UWL. Unlike the USGS survey of the Mississippi River Basin, the LRM fish samples did not include carp or bass. Only a limited number of fillets (n=5) from LRM fish were analyzed, and the WI DNR and US EPA have no known consumption guidelines based on Pb concentrations in fillets.

[15] Belby CS, et al (2016). Pp. 35 - 36.

> *Our data suggests that Pb from contaminated LRM sediments do not pose a significant toxicological risk following acute exposure* [emphasis added]. We observed minor toxicity to developing zebrafish, and that toxicity is likely due to factors other than, or in addition to, Pb exposure. *Contaminated LRM sediments posed no toxicity to invertebrates* [emphasis added]. Few malformation *(sic)* were observed in invertebrates sampled from the LRM, and there was no correspondence with sediment Pb levels.

During the marsh study conducted by UW-L, "sediment pore water" samples were collected and analyzed for dissolved lead (i.e. water samples were passed through a 0.45 µm filter prior to analysis). These "sediment pore water" samples meet the Wisconsin regulatory definition of groundwater. Analysis of 15 samples collected from 4 locations detected dissolved lead concentrations ranging from 6.6 to 409 µg/L with all samples exceeding the 1.5 µg/L NR 140 preventive action limit and 12 of the 15 samples exceeding the NR 140 enforcement standard of 15 µg/L.

Physiographical & Geological Setting, Significant Hydrologic Features

The 2016 UW-L Report summarizes the setting thus:

> The La Crosse River Marsh (LRM) is an urban wetland located within the City of La Crosse, Wisconsin. The LRM has been recognized for its high level of biological diversity in an urban setting (WI DNR, 1990) and is part of the larger 435 ha [1075 acre] La Crosse River Valley wetland complex, situated on the southwestern border of Wisconsin at the confluence of the Mississippi and La Crosse Rivers along the Mississippi Flyway…. The LRM resides within the La Crosse River floodplain and is hydraulically connected to the La Crosse River and the Upper Mississippi River National Wildlife and Fish Refuge during periods of high water. During normal hydrologic conditions, the LRM study area is classified as a shallow to deep emergent marsh with open water and a few small islands, bordered to the south by a late-Wisconsin age sand and gravel glacial meltwater terrace escarpment (Knox, 1996[16]). The local wetland plant community includes submersed (Ceratophyllum demersum and Chara spp.), emergent (Sparganium eurycarpum), and free-floating (Lemnacea) vegetation. The interspersion of open water and marsh vegetation attracts a wide variety of migrating waterfowl and wading birds, and provides habitat for fish including pike (Esox lucius), bluegill (Lepomis macrochirus), and bullhead (Ameiurus melas). The area is traversed by raised gravel trails and is heavily used for outdoor education and recreational activities including running, fishing, trapping and wildlife viewing (Moyer, 1989).[17]

Adjacent Land Uses

As stated above, the Site is adjacent to and north of the City's Myrick Park. On the north, east and west of the site are marshlands. A residential neighborhood is located to the east and southeast of Myrick Park. The University of Wisconsin – La Crosse athletic fields and dormitories are located to the south and southwest of Myrick Park. To the west of Myrick Park are located a City of La Crosse Water Supply treatment facility, Oak Grove Cemetery and the UW-L Motor Pool and Facilities Maintenance complex.

Topography

> The elevation model of the study site shows distinct topographic differences between the east and west sides of the raised gravel path that bisects the study area. With the exception of the deeper cut immediately adjacent to the raised path, the west side of the study area tends to be characterized by shallow depths and emergent islands during typical water levels. Depth on the east side of the raised path generally increases with distance from the berm.[18]

[16] Knox JC (1996). Late Quaternary Upper Mississippi River alluvial episodes and their significance to the Lower Mississippi River system. Eng Geol 45(1–4):263–85.
[17] Belby CS, et al (2016). P. 2.
[18] Belby CS, et al (2016). P. 5.

Texture and Classification of Surficial Sediments

> Sediment in the shot fall zone is typical of a floodplain marsh. Surface sediment is characterized by flocculent silt with high organic matter content and low bulk density, transitioning to high bulk density silt and clay with lower organic matter content. Below this zone is a layer of sand, likely deposited during lateral migration of the La Crosse River. This general sequence is found throughout the study area, though intrusions showing abrupt changes in particle size and organic matter content were found in a number of the sediment cores. Sediment pH throughout the study area was generally acidic (mean = 5.6), ranging from 4.9 to 7.[19]

Geology

According to the information provided in the Natural Resources Conservation Service national soils database[20], soils beneath the Myrick Park portion of the site are classified as Urban land, valley train which are areas consisting of land mostly covered by streets, parking lots, building and other structures of urban areas and soil textures and colors and thickness vary greatly as a result of disturbance caused by urban development. Soils beneath the wetlands portion of the site located west of the raised trail running through the site are classified as a Palms muck with 0 to 1 percent slopes which has a typical profile of muck from 0 to 40 inches and silt loam from 40 to 60 inches. Soil to the east of the raised trail are classified as a Palms muck or simply as water. Based on CES's experience with the City of La Crosse, deeper soils beneath the site likely consist of a fine- to medium-grained sand which would exist beneath the shallower muck within the wetlands and fill or disturbed soil located near the surface at Myrick Park. The presence of gravel stringers within the fine- to medium-grained sand is possible. Bedrock is composed of sandstone of the Cambrian System with some dolomite and shale[21]) and is expected to be located at depths greater than 100 feet below ground surface.

Hydrology and Hydrogeology

Much of the site consists of freshwater pond and is submerged beneath up to four (4) feet of water under normal hydrologic conditions. The water table will be at zero (0) to five (5) feet below ground surface (bgs) in the uplands; forested and shrub wetland portions; and emergent wetland portions of the site.

Hydrologically the LRM lies in the Lower La Crosse River Water Shed, the Bad Axe-La Crosse DNR Water Management Unit and the Mississippi River DNR Major Basin,[22]. As cited above, the UW-L report describes the hydrology thus:

> The LRM resides within the La Crosse River floodplain and is hydraulically connected to the La Crosse River and the Upper Mississippi River National Wildlife and Fish Refuge during periods of high water. During normal hydrologic conditions, the LRM study area is classified as a shallow to deep emergent marsh with open water and a few small islands, bordered to the south by a late-Wisconsin age sand and gravel glacial meltwater terrace escarpment[23].

According to the City Engineer, during La Crosse River flood events, full and unimpeded hydraulic connectivity exists between the river and the marsh[24].

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[19] Belby CS, et al (2016). P. 5.
[20] Wisconsin Department of Natural Resources, online Surface Water Data Viewer (http://dnrmaps.wi.gov/sl/?Viewer=SWDV). Accessed by CES on August 18, 2016.
[21] Mudrey, Jr., MG, Brown, BA, and Greenberg, JK (1982). Bedrock Geologic Map of Wisconsin. University of Wisconsin – Extension – Geological and Natural History Survey. Madison.
[22] Wisconsin Department of Natural Resources, online Surface Water Data Viewer (http://dnrmaps.wi.gov/sl/?Viewer=SWDV). Accessed by CES on August 11, 2016
[23] Belby CS, et al (2016). P. 2.
[24] Turtenwald, R (2016). Personal conversation with John Storlie, July 27, 2016. La Crosse, WI.

Based on CES's 30-year experience in La Crosse, the LRM is a regional discharge area for the underlying bedrock aquifer. On a local scale, groundwater flow is heavily influenced by flood and drought conditions and local river stage in the nearby La Crosse, Black and Mississippi Rivers.

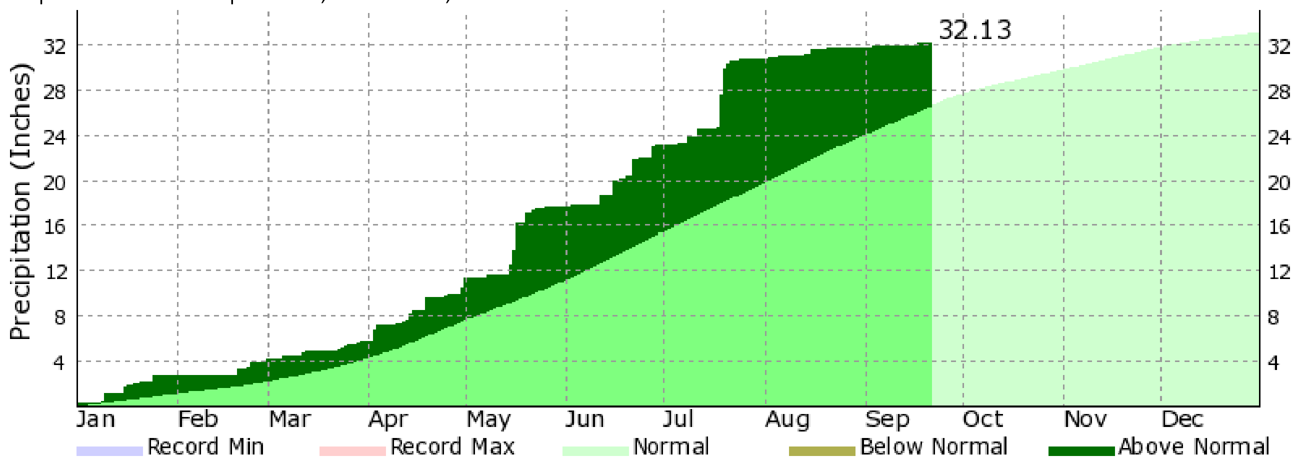
The Friends of the La Crosse Marsh published a report, titled Hydraulic Evaluations of the Southern Portion of the La Crosse Marsh; December 2015 – December 2016[25] It describes the surface water hydrology of the LRM in detail. A copy of the report is included as Attachment C. The legacy lead shot site is located in the east cell of the study area of this report, which notes, "Historically the southern portion of the La Crosse Marsh had less water. The construction of railroad and road embankments, Mississippi River navigation improvements (Lock & Dam 8) and wetland filling (loss in water storage) all contributed to the present hydraulic conditions in the La Crosse Marsh."[26] The report also states:

> The study [*the hydraulic evaluation*] was conducted during a period of high precipitation. As a result, the Mississippi and La Crosse Rivers were flowing at above average conditions and periodically contributed to large inflows and high water levels in the marsh during the study. The greatest period of water level change occurred in September 2016 when the area received about 3 inches of rainfall which resulted in very high flows in the La Crosse River (~3,000 cfs) and the inundation of the river's floodplain.[27]

The LRM legacy lead site investigation and the surface water, water table and piezometric surface elevations measured in 2017, were conducted in a period of above normal precipitation.[28] Graph 1 below depicts precipitation at the La Crosse Regional airport in calendar year 2017 and consistently above normal precipitation.

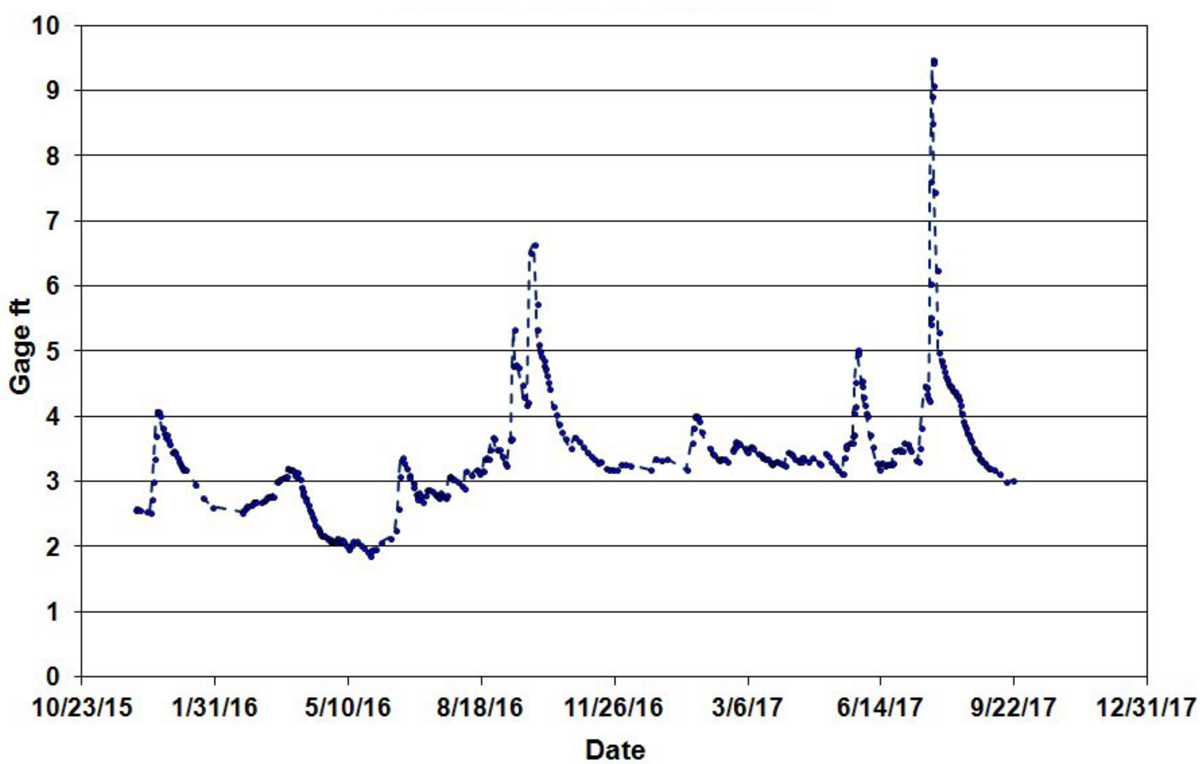
[25] Sullivan, John F (2017). *Hydraulic Evaluations of the Southern Portion of the La Crosse Marsh; December 2015 – December 2016,* September 2017. Friends of the La Crosse marsh Facebook Page https://lookaside.fbsbx.com/file/Hydrualic%20Study%20of%20the%20Southern%20Portion%20of%20the%20La%20Crosse%20River%20Marsh.pdf?token=AWyOuFguAbYJckizls4fSi_Tjikb6KY6KFIHhccYXXK38HK9zLeRBaXTgaqrUJRJ5qbovj6XXwtzvepG9Ix_NL4xVweWbxAlYLQvJALm0DyqnIP42pgNd1cUCOW9rJ6ynVt_tgsSXHRZrWFZAL3vrqm-uLEBbVSKYX4LOTbarg2YeEQcBvoZRBmEx8XZS6lHSJA4TJfEgCGSXlMI2BP1G07o. La Crosse, WI.
[26] Ibid. P. 37.
[27] Ibid. .P. 35.
[28] http://www.weather.gov/arx/climate, for 54601 as measured at the La Crosse Regional Airport. Accessed September 22, 2017.

Graph 1: 2017 Precipitation, La Crosse, WI 54601



In a September 20, 2017 email correspondence, John R. Sullivan, Friends of the La Crosse Marsh, shared the below graph of his records of the water levels in the East Cell as measured by him at the box culvert in the shot fall zone, under the east Marsh Loop Trail. Sullivan noted that comparing the east cell to the "middle cell and far west portions of the marsh, the water in the East Cell continues to remain noticeably higher. I think that has a lot to do with the blocked culverts near the dog park in combination with the higher than normal precip [*sic*]." [29]

Graph 2: Water Levels in the East Cell of the La Crosse Marsh, October 2015 to August 2017



[29] Sullivan, John R (2017). Personal email to authors. September 20, 2017. La Crosse, WI.

Sullivan's graph shows the water levels in the east cell of the marsh were consistently higher in the period of October 2016 through June 2017 than in the corresponding period beginning in October 2015. Moreover, three peak events occurred in the latest period. Of particular interest to the legacy lead study area is the flooding of July 19 to 26, 2017, which Sullivan described as "Record Flooding of the La Crosse River" in a document he prepared for the Friends of the La Crosse Marsh.[30] In it, Sullivan cites USGS River discharge data for the La Crosse River to note that the highest flow for the period of record, 1998 to 2017, occurred on July 21, 2017.

The consistently high water levels between October 2016 and June of 2017 in the east cell suggest that the consistent observations of downward vertical gradient in the water table/piezometer nest, as discussed below under Groundwater Investigation, was atypical. CES expects significant seasonal variation in vertical gradients with some upward flow during more typical hydrologic conditions.

Potential Hazardous Substance Migration Pathways

Dissolved Contaminants in Surface Water

Lead migration from the contaminated sediments appears to be occurring in through dissolved lead released as lead salts from corroded shot surfaces into the water column and as suspended solids of lead (presumably lead salts and carbonates) adsorbed to suspended particulate matter. Both dissolved lead in the water column and lead in the suspended sediments pose the potential for lateral migration of lead contamination in the marsh.

Dissolved Contaminants in Groundwater

No prior assessment has been conducted of the potential for dissolved lead migration from the surface water to the groundwater. Neither underlying groundwater quality nor vertical gradients between the surface water and the underlying aquifer, which could drive dissolved lead migration into the aquifer, have been previously assessed.

Anthropogenic Disturbance

In 1952, a lead salvage action was conducted, however no documentation of this activity exists and little is known about it. It is possible that some salvage activities were staged on the adjacent land in the park. Additional lead, as well as PAH, samples were collected from the shallow soils in the parking lot and other areas adjacent to the shooting stations to assess the potential movement and deposit of lead contamination into the park by the 1952 lead salvage. Results from the additional sampling are discussed below.

Current-driven Scouring and Transport of Contaminated Sediments

Current-driven scouring and transport, particularly during flood events, pose another potential mechanism for migration of dissolved, suspended and lead-shot contamination. As noted previously, the La Crosse Gun Club ceased its trap shooting operations more than 50 years ago in 1963. During the previous study conducted by UW-L and the WDNR, soil samples were collected in a grid pattern which adequately defined the extent of lead contamination. The pattern of lead deposition was typical of what would be expected from a trap shooting range with no indication of a prevailing or seasonal current transporting contaminated sediment beyond the boundaries of the site.

Scouring of sediments during high water events likely occurs at the box culvert, and this poses implications for remedial options selection. Specifically, placement of a cap or isolating layer of sand would be impracticable and ineffective in areas where sediment scouring occurs.

[30] Sullivan, JR (2017). Photo Documentation of Record Flooding of the La Crosse River and its Impact on the La Crosse Marsh - July 19-26, 2017. July 27, 2017. La Crosse, WI.

Receptors

Water Supply Wells

One active water supply well (Well 15, 713 Hillview Avenue) is located approximately 1,200 feet from the far south edge of the shot fall zone, in the southeast corner of Myrick Park. See Figure 2, Site Layout Map[31]. According to an August 25, 2016 phone conversation with La Crosse Water and Wastewater Utilities Director, Mark Johnson, Well 15 is only infrequently used, generally only during hydrant flushing events. Well 15 has significantly higher levels of the naturally occurring mineral manganese[32]. The high concentration of manganese indicates the well is drawing from a portion of the aquifer in which groundwater has an extremely long retention time, which in turn suggests a source provenance, or recharge zone, at large distance, and likely much greater than 1,200-foot, from the well.

Mr. Johnson also stated that he is unaware of any private wells within 1,200 feet of the site. He stated, "There is a small private well at Crowley Hall (1707 Pine Street) on the UWL campus but it's much further away than the 1,200 ft. criteria."[33]

CES reviewed a Summary of Inorganic Sampling Results (calendar year 2014) for City of La Crosse Municipal Wells, provided by Mr. Johnson.[34] No lead or PAH analyses have been performed.

Cultural Resources

Indian mounds are present in Myrick Park, and other archeological resources maybe present within the zone of contamination. While most of the land surface in the lead shot fall zone is currently submerged, the damming and creation of Pool 8 of the Mississippi River raised the water level possibly inundating archeological resources. The presence of archeological resources was completed by Ms. Vicki Twinde-Javner, Senior Research Archaeologist of the Mississippi Valley Archeology Center during the recent investigation activities completed at the site and the results are discussed in the archeological section below.

The Wetlands, Species, Habitat and Ecosystem

The UW-L study sought to determine whether "the high concentrations of Pb in the LRM sediments … pose[d] significant toxicological risk."

Invertebrates and Fishes Toxicity Assessment

The UW-L researchers used "several standard toxicity assays to determine risk to both invertebrates and vertebrates." [35] They found:

> Results for toxicity assessment in invertebrates and fishes: Toxicity assays utilizing amphipods were inconclusive due to high mortality in controls. LRM sediments were not toxic to larval midges, but did cause some mild toxicity in zebrafish larvae. ... While acute exposure of zebrafish embryos to LRM sediments caused no significant increase in mortality, we did observe signs of potential Pb toxicity in zebrafish larvae.[36]

Lead Levels in Aquatic Vegetation

The UW-L Study measured lead concentrations in the aquatic vegetation, commonly known as duckweed (including *Lemna trisulca*, *Wolffia* sp., and *Lemna minor*), small, fast-growing, floating, abundant aquatic plants found within the LRM. Duckweed was sampled at 19 locations across a range of lead concentrations, both inside and outside the lead shot fall zone. "*Sparganium eurycarpum* (bur-reed), an emergent wetland plant commonly found in the LRM, was also collected by

[31] City of La Crosse Information Technology Department (2016). August 22, 2016. La Crosse, WI.
[32] Johnson, M (2016). Personal conversation with John Storlie, August 25, 2016. La Crosse, WI.
[33] Johnson, M. (2016 a). e-mail to John Storlie, August 25, 2016, La Crosse, WI.
[34] Ibid.
[35] Belby CS, et al (2016). P. 17.
[36] Belby CS, et al (2016). P. 18.

UWL during August 2012 from sub-aerially exposed sites on the west side of the trail that bisects the study area. All samples were analyzed for lead…."[37]

The UW-L report described the findings of lead testing of aquatic vegetation:

> Duckweed collected by UWL ranged from <2 mg/kg at the control sites located outside of the potential shotfall zone to 268 mg/kg within the shotfall zone. Duckweed Pb levels generally increased with Pb concentration in the sediment. Variability in this relationship is likely explained by the movement of the duckweed during low to moderate winds.[38]

Pb levels and malformation occurrence in LRM invertebrates

The UW-L researchers collected samples of invertebrate organisms (predominantly Leptocerus americanus) from the LRM. The samples were analyzed for total lead. Larval and emerging adult aquatic insects were collected from the same sampling locations. "Invertebrates were visually assessed for head, leg and abdomen malformations under a dissecting microscope." They found "a significant positive relationship between the concentration of Pb in the sediment and the concentration of Pb in the whole larvae (bodies and cases) of L. americanus ($R2 = 0.696$, $p< 0.005$).[39] **A limited number of morphological anomalies (10 out of 1,477) were observed.**[40]

Pb Levels in Fish

Twelve (12) whole fish samples were collected by UW-L researchers and submitted to the State Lab of Hygiene (SLOH). At the lab the whole fish samples were composited by species and size before they were analyzed for total lead. All fish samples contained detectable concentrations of lead, which were highly variable with no significance between Pb in fish tissue and collection site ($P = 0.384$).[41] Similar lead levels were detected in samples collected by the WDNR: "Pb levels for the WI DNR composite samples ranged from 0.305 to 1.05 µg/g for black bullheads and from 0.176 to 0.826 µg/g for bluegill."[42]

Additional Investigation Results

Archeological Investigation

Myrick Park overlaps a prehistoric burial mound site, and the marsh contains an uncatalogued burial site near where the two existing walking trails in the marsh intersect to the northwest of the trap fall zone. The exact locations of the burial sites were not provided by MVAC due to restrictions imposed by the Wisconsin Historical Society. However, as previously noted, MVAC personnel confirmed prior to any on-site activities, that the proposed investigative activities did not encroach upon these burial sites. If necessary, MVAC can be contacted for the exact locations of the burial sites.

As stated in their report, MVAC personnel did not observe any cultural material in any of the sampling locations at the site except for several clay pigeon fragments found in several sediment samples. MVAC concluded that if soil or sediments containing contaminants is removed within the top 24 to 36 inches of the marsh, it should not affect any prehistoric or historic archaeological sites. A complete copy of MVACs Summary of Archaeological Monitoring of the soil borings is provided in Attachment D.

Soil Investigation

CES observed a range of soil characteristics at the site. Along the trail in borings GP-2 through GP-6, shallow soils were predominantly sand and gravel fill to a depth of approximately two feet below ground surface (bgs) underlain by silty sand or silt with occasional one- to two-inch sand seams. Soils near former shooting stations 3 and 4 in GP-8 through GP-10 consisted of approximately 6 inches of sandy silt, silt, or sand/gravel fill overlaying a well sorted fine- to medium-grained

[37] Belby CS, et al (2016). Pp. 21 - 22.
[38] Belby CS, et al (2016). P. 22.
[39] Belby CS, et al (2016). Pp. 24 - 25.
[40] Belby CS, et al (2016). P. 29.
[41] Belby CS, et al (2016). Pp. 30.
[42] Belby CS, et al (2016). Pp. 31.

sand. Soils observed at the piezometer nest were 12 inches of brown silt overlying a black silt to greyish black silty sand to a depth of 5 feet bgs. From 5 feet to 44 feet bgs, numerous layers ranging in thickness from 3 inches to 4 feet were encountered with the layers ranging from a grey, coarse sand to black silt to a grey clay.

Lead (Pb) concentrations in the upper four feet of soil near former shooting stations 3 and 4 ranged from 1.8 to 33.7 mg/kg. These concentrations are below the WDNR Background Threshold Value of 52 mg/kg and well below the NR720 non-industrial direct-contact standard of 400 mg/kg. Only one of the eight samples (GP-7 at 2 to 4 feet bgs) had a lead concentration that exceeded the 27-mg/kg, NR720, Residual Contaminant Level (RCL) Protective of Groundwater Quality for lead. Two lead samples from the upper four feet of soil at PZ-2 were analyzed. Lead concentrations at PZ-2 were 242 mg/kg at 0 to 2 feet bgs and 7.0 mg/kg at 2 to 4 feet bgs, both below the non-industrial direct-contact standard. The soil samples collected on the upland near the trailhead and shooting stations 3 and 4 (GP-7 through GP-10) contained lead concentrations ranging from 1.8 mg/kg to 33.7 mg/kg, all below the non-industrial direct-contact standard. Thus, CES observed no evidence of lead contamination in the park from the 1952 lead salvaging.

Soil PAH concentrations above applicable standards were observed in six of the ten Geoprobes borings (GP-1, GP-3, GP-4, GP-5, GP-6, and GP-7). GP-1 is located on the western shoreline near trap shooting station 1. GP-3 through GP-7 were located on the trail. All six of these Geoprobes had PAH compounds detected at concentrations above the NR720 non-industrial direct contact standards and groundwater protection standards in the upper 2 feet. Borings GP-5 and GP-7 contained PAHs in concentrations above the NR 720 industrial direct contact standards. While Benzo(a)pyrene was the most common contaminant detected above non-industrial direct contact standards in the samples collected along the trail (GP-3 through GP-7), other PAH compounds, including benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, Indeno(1,2,3-cd)pyrene and naphthalene, were also detected at concentrations exceeding the NR 720 non-industrial direct-contact standards in at least one location along the trail. However, according to the May 2017 WDNR draft guidance document RR-079 *Calculating Soil RCLS for PAHs*, a modified method for calculating alternative non-industrial direct contact RCLs for select PAHs is being considered.[43] Because the compounds detected above the standards, except naphthalene, are included in the draft document, CES compared the soil PAH results to the draft guidelines. Under the proposed method, soil PAH compounds along the trail would exceed the non-industrial direct contact standards in the shallow (0-2 feet) samples from Geoprobes GP-3, GP-6, and GP-7. In other words, following the draft guidance alternative method, borings GP-1, GP-4 and GP-5 do not exceed the non-industrial direct contact standards.

The shallow sample from GP-7, located near the beginning of the trail, had relatively high concentrations of 1- and 2-methylnaphthalene. These compounds were only detected in one sediment sample, C15, which is located approximately 130 feet east-northeast of GP-7. This anomaly suggests the potential of PAH source(s) other than the clay targets, such as stormwater runoff or contaminated fill at the trail. A summary of the soil lead and PAH concentrations is provided in Table 3. Soil PAH exceedences are depicted in Figure 6. Soil Laboratory Analytical Results are provided in Attachment E.

Groundwater Investigation

Depth to water was measured monthly in the monitoring well/piezometers between December 2016 and May 2017. Groundwater elevations were approximately 2 to 3 feet below ground surface (bgs). During all sampling events, a downward gradient of 0.02 to 0.03 ft/ft was observed between monitoring well MW-1 and the shallow piezometer PZ-1, and a downward gradient of 0.01 ft/ft was observed between shallow piezometer PZ-1 and the deeper piezometer PZ-2. Surface water elevations were approximately 0.1 to 0.2 feet below the water table elevation and 0.2 to 0.5 feet above the shallow piezometer potentiometric surface elevation during all sampling events. A horizontal flow direction could not be determined because only one water table monitoring well was installed. Groundwater and surface water elevations are summarized in Table 4.

Groundwater samples were collected from the monitoring wells and piezometers in February and May 2017 for PAH and dissolved lead analyses. During purging of the well water prior to sampling, field water quality measurements for dissolved

[43] Wisconsin Department of Natural Resources (2017). RR-079: Calculating Soil RCLs for PAHs. May, 2017.

oxygen, temperature, conductivity, pH and ORP were collected to establish that the wells were stabilized prior to sampling. Field water quality measurements indicated dissolved oxygen ranging from approximately 0.35 to 1.03 mg/l, temperature from 7.5 to 10.5°C, and pH from .66 to 7.27. A summary of the groundwater field water quality measurements is provided in Table 5.

Laboratory analysis detected no concentrations of dissolved lead in any of the samples. Several PAH constituents (benzo(b) fluoranthene; 2-methylnapthalene; and pyrene) were detected in at least one sample. All PAH detections, however, were well below the NR 140 preventive action limits. A summary of groundwater laboratory analytical results is provided in Table 6. Copies of the groundwater laboratory analytical results are provided in Attachment F.

Surface Water Investigation

John Sullivan, Friends of the La Crosse River Marsh provided CES a map of stormwater culverts discharging into the marsh[44]. He had identified 11 stormwater outfalls into the marsh in the study area. Locations of the stormwater outfalls are provided in Figure 2. Stormwater runoff from urban areas commonly contains significant levels of PAH concentrations, and the stormwater discharges into the marsh may be contributing to the PAH concentrations discovered in the surface water as discussed below.

Field parameters for surface water samples were highly variable. Temperatures ranged from 0.36 °C to 5.95 °C, specific conductance ranged from 0.04 to 1.225 mS/cm, and dissolved oxygen ranged from 0.53 to 18.41 mg/l. Lower dissolved oxygen readings were observed along the shoreline. A summary of the surface water field parameters is provided in Table 7. During the surface water sampling event, the ice was rapidly melting and this may have strongly affected observed field parameters.

At least one PAH compound was found in every surface water sample collected, including background samples far outside the shot and clay target fall zones. Between three (3) and sixteen (16) PAH compounds were detected in the samples collected within the lead shot fall zone. Between One (1) and fourteen (14) PAH compounds were detected in samples collected at background locations. Of the four (4) background surface water samples, the two northmost samples (C24 and C25) had least number and lowest concentrations of PAHs with only one or two PAH constituents detected. Background samples GP-22 and GP-23 contained eleven (11) and fourteen (14) PAH compounds, respectively.

Of the eighteen (18) PAH analytes, only one, fluoranthene, has a WDNR human threshold criteria, which is 4,300 ug/l for a non-public water supply, warm water community. Fluoranthene concentrations were well below that criteria in all surface water samples. The highest concentration was less than 0.2 µg/l. The EPA has developed human health ambient water quality criteria (AWQC), which represent levels of chemicals or conditions in a water body that are not expected to cause adverse effects to human health. The EPA human health AWQC contains criteria for twelve (12) of the eighteen (18) PAH analytes. Sixteen (16) of the twenty-five (25) samples had PAH compounds in concentrations above the EPA human health AWQC – fourteen (14) fall zone samples and two (2) background samples. The PAH compounds most commonly exceeding the EPA AWQC were benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene. Two (2) samples also had chrysene and/or dibenzo(a,h)anthracene above the AWQC. A summary of the surface water laboratory analytical results is provided in Table 8. Surface water laboratory analytical results are provided in Attachment G.

Surface water sampling was completed in February after drilling through the ice with a gasoline-powered auger. John Sullivan, formerly with the Wisconsin Department of Natural Resources, has indicated that in his past experience with the use of power ice augers, that augers may drip oil or spew oil-laden exhaust onto the blades or into the water thereby contributing to PAH concentrations observed in the surface water. Further, according to Sulivan, ice augering may disrupt the water column and contribute to sediment resuspension further impacting surface water PAH concentrations.[45] CES

[44] Sullivan, J. (2017). Email to John Storlie. May 30, 2017. La Crosse, WI.

[45] Sullivan, J. (2017). Email to authors, WDNR, and City of La Crosse. May 3, 2017.

minimized such impacts by drilling all of the sampling locations first and then allowing the locations to stabilize for approximately 8 hours (Cores 1 through 9) to greater than 24 hours (cores 9 through 25) before collecting surface water samples and field (ph, temp, conductivity, etc.) measurements.

Furthermore, comparison of the surface water PAH results to the sediment PAH results revealed that all of the surface water samples had low level concentrations of 1- and 2-methylnaphthalene. These compounds were observed in only one shallow sediment sample, C15, which is located adjacent to the shoreline east of the trail. Although low level, the presence of these compounds in the surface water compared to the absence of these compounds in the sediment samples could be evidence that the PAH concentrations detected in the surface water are not solely attributable to the former trap shooting operations and likely partially attributable to stormwater runoff entering the marsh via overland flow and the 11 stormwater outfalls in the study area.

Sediment Investigation

Sediments at the site typically consisted of approximately six (6) to eighteen (18) inches of a black organic muck overlying a grey or black organic clay. Typically, in most locations, a grey, medium-grained sand or sand seams were located beneath the clay. Sediment recovery was only 5 of 36 inches in core C2; CES is of the opinion that, based on the proximity of C2 to the fill slope with rip rap, in this core the core sampler was obstructed by and pushing rock. In the other cores recovery ranged from 11 inches in C23 to 30 inches in C3, typically 15 to 18 inches; CES attributes the recovery rates to compressibility of the organic sediments.

TOC analysis was completed on the eleven (11) samples containing the highest PAH compounds. TOC results at the site ranged from 600 to 159,000 mg/kg (0.06 to 15.9%) with the lowest TOC concentrations corresponding with sandy sediments.

PAH compounds were observed in thirteen (13) of the twenty-five (25) cores. In eight (8) of those cores, PAH concentrations (unadjusted for TOC) were above the WDNR threshold effect concentrations (recommended sediment quality guideline values)[46]. After normalizing to a 1% TOC per WDNR guidance[47], PAH were above the WDNR threshold effect concentrations in the shallow sample at five (5) cores (C5, C9, C12, C15 and C18) and in the deeper sample at two (2) cores (C2 and C12). When normalizing to a 1% TOC, CES took the conservative approach of using the detection limit as the value for individual PAH compounds when evaluating the total PAH concentrations. Additionally, following the recommendation of WDNR Water Resources Engineer, William Fitzpatrick[48], because very large and very small values of TOC cause a dramatic change in normalized PAH values, CES limited the range of TOC values used for normalization to 0.5 – 4.0% (i.e., if the TOC value was below 0.5%, it was adjusted up to 0.5%; and if above 4%, it was adjusted downwards). In cores C5, C9 and C12, clay pigeon fragments were observed in the upper half of the cores in layers ranging from ¼ to 1½ inch in thickness. These were the only locations where clay pigeon fragments were observed. PAH compounds were also detected at concentrations above the WDNR probable effect concentrations in cores C5, C12, and C18. Of the eighteen (18) PAH analytes, fifteen (15) were detected at concentrations above applicable standards except acenaphthylene, 1-methylnaphthalene and 2-methylnaphthalene. All four (4) cores with exceedences were located near the shoreline; clay pigeon fragments were observed in the upper half of the core in three of them – C5, C9 and C12. These were the only locations where clay pigeon fragments were observed. A copy of the raw PAH results is provided in Table 9. A summary of the PAH concentrations normalized to 1% TOC is provided in Table 10. Sediment PAH exceedences are depicted in Figure 7. Exceedences of soil lead, soil PAHs, and sediment PAHs is depicted in Figure 8. Sediment laboratory analytical reports are provided in Attachment H.

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[46] Wisconsin Department of natural Resources (2003). *Consensus-Based Sediment Quality Guidelines: Recommendations for Use & Application, Interim Guidance RR-088*. December 2003. Madison, WI.
[47] Ibid.
[48] Fitzpatrick, W. (2017). Email to Patrick Collins forwarded to John Storlie. May 3, 2017.

Conclusions

Impacts to Ecosystem

The UW-L report concluded:

> Our data suggests that Pb from contaminated LRM sediments do not pose a significant toxicological risk following acute exposure. We observed minor toxicity to developing zebrafish, and that toxicity is likely due to factors other than, or in addition to, Pb exposure. Contaminated LRM sediments posed no toxicity to invertebrates. Few malformation[s] were observed in invertebrates sampled from the LRM, and there was no correspondence with sediment Pb levels.[49]

Clearly, lead has entered the food chain. However, the toxicological assessment found:

- No acute risk
- Only "minor toxicity to developing embryos" that "is likely due to factors other than, or in addition to, Pb exposure"
- No toxicity to invertebrates
- Few malformation[s] in invertebrates with no correspondence with sediment Pb levels

No Wisconsin or US standards, guidance or advisory levels exist for lead levels in fish.

> The department's Integrated Sediment Team in conjunction with the Contaminated Sediment External Advisory Group are currently working on guidance for developing cleanup standards for sediments.

Direct-contact Human Exposure Risk

Lead

Direct-contact human exposure risk is limited based on the description of dike and shoreline lead sample results presented in the UW-L report. No lead was detected in shallow soils (less than 4 feet bgs) in the study area above the EPA criteria of 400 mg/kg.[50]

PAH

PAH samples collected along trails and at former shooting station (station 3 near the trailhead) contained PAHs above direct-contact soil residual contact levels. Some limited remedial action for direct-contact pathways may be appropriate and would likely consist of removal of shallow contaminated soils or their isolation by placement of a soil barrier cap. It is important to note, however, that the WDNR has issued proposed guidance (draft for comment) for PAH contamination in shallow soils that would raise the effective action level requiring remedial action. Thus, the need for and/or extent of remediation of PAH contamination to alleviate direct-contact threats may change before a final remedy for the overall site is selected.

Groundwater Pathway Threats

Lead

No lead was detected in the groundwater in any of the three monitoring wells, which were constructed near the two "hot spots" of highest lead sediment contamination. Thus, groundwater pathway threats from lead contamination are minimal, given:

- The absence of lead impacts to the groundwater in the area of highest lead levels in sediments, 50 to 90 years after the deposition of the lead
- The greater than 1,200-foot distance to active water supply wells

[49] Belby CS, et al (2016). Pp. 36.
[50] Belby CS, et al (2016). P. 35.

- The slow corrosion rate of lead in its elemental state and hence dissolution and migration of resulting lead salts, carbonates and oxides.

PAH

PAHs tend to be relatively immobile in the subsurface, because of their low aqueous solubility and strong adherence to organic compounds. While PAHs are commonly present in dissolved-phase petroleum plumes, such as diesel fuel, it is CES's experience that for non-liquid depositions of PAHs, such as from ash or coal dust, PAHs tend not to migrate in dissolved-phase. Finally, no PAHs were detected in the monitoring wells above the NR140 Preventive Action Limits.

Contaminated Sediments

Lead

The probable greatest threats and routes of both human and environmental exposure are for lead and via biological uptake in the wetland ecosystem, and impacts and risk pathways have been identified. The lead toxicity assays conducted by UWL showed only minor effects. Measurable lead was detected in all invertebrate and fish samples from the marsh; however, "in fish, higher levels were generally found in whole fish samples than fillets".[51]

PAH

The WDNR threshold effect concentrations and probable effect concentrations for PAH contamination in sediments are defined in the document, *Consensus-Based Sediment Quality Guidelines: Recommendations for Use & Application*[52]. It is important to note that document is guidance, not codified, and moreover interim guidance. In its Note to User, the document states:

> *The information in this guidance can be used for screening sediment quality data to help estimate the likelihood of toxicity.* DNR staff, responsible parties and consultants should evaluate available information in order to make case-by-case investigative, remediation and management decisions for each site.
>
> Any remedial action selected in accordance with Wis. Stats. 292 to address sediment contamination must comply with the Wis. Admin. Code ch. 700 through 754 rule series, in particular Wis. Admin. Code §§ 722.09 (2)(c) and (3).
>
> The values presented in the Consensus Based Sediment Quality Guidelines (RR-088) could be used as cleanup standards by responsible parties, with department approval, if they meet the provisions of Wis. Admin. Code ch. 700 – 754 rule series.
>
> In addition, *site-specific standard development and/or performance standards are potential options*, if the remedial actions would comply with Wis. Stat. ch. 292 and Wis. Admin. Code ch. 700 through 754 rule series.
>
> Risk assessments for sediment remediation are governed by Wis. Admin. Code NR § 722.11. In the case of sediments, a risk assessment for sediment is only allowable if the department determines that compliance with the applicable environmental standards listed in Wis. Admin. Code § NR 722.09(2) will not be protective of public health, safety, welfare, and the environment, and a more stringent standard is needed.

PAH sediment concentrations above the WDNR threshold effect concentrations adjusted to 1% TOC were identified in six (6) core samples and above the probable effect concentrations in three (3) cores, all of which were located nearest the shoreline in their respective transects. Some limited remedial action for sediments with the high PAH concentrations may

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[51] Belby CS, et al (2016). Pp. 35 - 36.
[52] Wisconsin Department of natural Resources (2003). *Consensus-Based Sediment Quality Guidelines: Recommendations for Use & Application, Interim Guidance RR-088*. December 2003. Madison, WI.

be appropriate and may consist of hot spot sediment removal or placement of a barrier cap, should similar actions be required for the lead sediment contamination.

Surface Water

Lead

Lead in surface water was previously investigated at the site and the findings are summarized in the UWL report. The report stated:

> UWL – Water results: Total Pb concentrations in surface waters varied from 0.530 to 10.6 ug/l at the sampling sites with the highest values generally found at sites with the highest sediment Pb levels (15, 19, 23, 24). Dissolved Pb in the surface water varied from 0.127 to 7.09 ug/L and was generally an order of magnitude lower than the total Pb measured at each site…Acute and chronic Pb criteria are based on the WDNR's surface water quality criteria guidelines, with harder samples having higher contamination thresholds. Because no hardness values are available for July 2013, the minimum hardness value sampled during three separate years by UWL and the WI DNR was used for this date to demine if samples exceeded the WI DNR's acute and chronic contamination criteria. Following this conservative approach, no one (N=17) of the total Pb concentrations from the surface water exceed the chronic criteria or the acute criteria.
>
> Wisconsin DNR water results: Total Pb concentrations in samples collected during July 2012 from the LRM ranged from 12.6 to 68.4 ug/L. The highest concentrations were present at the East and West sites, where bed and suspended sediments also revealed high Pb levels…the highest total Pb concentration (68 ug/l) reported at the East site exceeded the chronic toxicity criterion when factoring in the total hardness of this sample (137 ug/L).
>
> Total Pb ranged from 7.93 to 28.7 ug/L (mean = 12.3) during the 8-day sampling period in August 2013. None of the eight samples collected exceeded the chronic or the acute criteria based on the water harness measured over the same period.

As only one sample collected by either UWL or the WDNR exceeded the WDNR's surface water quality criteria, it is not believed that any remedial action is specifically required to address lead in surface water.

PAH

PAH concentrations above the EPA human health AWQC were observed in 16 of the 25 surface water samples collected including in two of the four background samples collected. However, the presence of 1- and 2-methylnaphthalene, observed in every water sample but in only one sediment sample, could be an indication that the source of PAHs in the surface water is at least partially attributable to a source other than the former shooting range. Stormwater runoff from the adjacent urban areas via the eleven stormwater outfalls in the immediate vicinity of the subject is likely at the least partially responsible for the observed PAH concentrations.

Vapor Pathway Threats

There is no risk of vapor intrusion into occupied buildings because the contaminants are not volatile and not mobile in soil gas.

Discussion of Potential Remedial Actions

Range of Remedial Action Options

The options for remedy to the sediment contamination range from no remedial action to, on the other extreme, dredging out one to two feet of sediment from 25 acres. The latter would be extremely complicated and expensive, clearly impracticable. Even just a cursory evaluation suggests that dredging would likely require:

1. Damming and draining dredging area to minimize dispersion of contamination.

2. Dewatering of dredged sediments.
3. Mechanical removal of recoverable lead shot.
4. Treatment or retention of marsh draining and dewatering effluent. WPDES permit to discharge back to surface water.
5. Some or all of sediment would need to be disposed as a hazardous waste at a hazardous waste landfill (all are out of state) or treated to fix lead before disposed in a regular landfill. Treatment would require a HW treatment license.
6. Significant footprint for operations.
7. Potential replacement of dredged soils and/or establishment of native wetland and aquatic vegetation

Likely Remedial Action Options

Per section NR 722.07(2), Wisconsin Administrative Code (WAC), CES has conducted an initial screening of remedial technologies to identify remedial action options for further evaluation which are reasonably likely to be feasible for a site or facility, based on the hazardous substances present, media contaminated and site characteristics, and to comply with the requirements of s. NR 722.09. The selected option will have to demonstrate compliance with the standards of WAC Chs. NR 726 (Case Closure), NR 140 (Groundwater Quality), NR 103 (Water Quality Standards for Wetlands), NR 720 (Soil Cleanup Standards), and related rules and guidance. The lead (Pb) contamination in the sediments will be the primary driver for remedial action requirements, although limited remedial action, such as capping or removal of PAH-contaminated soils on the shore or trail, may be required for PAH contamination in shallow soils that per the regulations pose a direct-contamination threat for human exposure. Practicable options for sediment lead contamination from least to most active include:

No Remediation

WDNR approval of a no-remediation option would require demonstration in the site closure request that the contaminants pose nil to minimal impacts and risks to human health and the environment. CES is of the opinion that insufficient data exist to demonstrate nil to minimal impacts and risks, in particular to wildlife.

Monitoring only

Under a monitoring-only option, monitoring of surface water quality and environmental impacts to flora and fauna to demonstrate that nil to minimal risks exist from the contamination. This would be accomplished by performance and risk-based standards.

Cap

Adding a layer of isolating fill an area of over all or some of the contamination. Groundwater monitoring performed during the site investigation indicates groundwater is not impacted by lead. The risk to wildlife would be ameliorated by capping the contaminated sediments to isolate them from the active biota. The feasibility and practicability of this option was enhanced by an observation related to the author by John Sullivan that removal of beaver-dam blockages of culverts under Lange Drive could lower the water level in the east cell by two feet or more during low flow conditions in the La Crosse River. Scouring of sediments at and near the box culvert during flood events, however, would rule out this option as a sole solution, should it be determined that active remediation is required.

Capping and Hot-Spot Dredging

Selective dredging and capping of hot spots of contamination. Dredging where sediment scouring is likely to occur coupled with capping contaminated sediments addresses the deficiencies of capping alone by removing contamination that would not be isolated by capping. Defining and selecting the areas and their extent to cap will require defining site-specific or performance-based standards.

Hot-Spot Dredging

Dredging hot spots only. Hot spot dredging is a feasible option. Defining and selecting the areas and their extent to dredge will require defining site-specific or performance-based standards.

Recommended Remedial Action Option

The largest threat that exists from the contamination is to the biota. Thus, CES recommends pursuing a monitoring program that demonstrates limited risks. A monitoring program would assess both impacts and risks to the wildlife and contaminant conditions. Toxicological studies of aquatic organisms show mild to no effect attributable to the lead contamination, and PAH impacts to the biota have not been studied. CES recommends engaging Christine Custer and Thomas Custer of the USGS Upper Midwest Environmental Sciences Center, La Crosse, WI, to conduct a tree swallow study to assess impacts and risks to the wildlife at a higher trophic (food-chain) level. Similar studies conducted at multiple sites by the Custers and others have successfully used tree swallows as a bioindicator or sentinel species for assessing the uptake of lead contamination into the food chain[53,54]. The contaminant uptake pathway is via tree swallow feeding on emergent aquatic insects, which mature in larval stages in the sediments. A tree swallow study would consist of establishing approximately 25 nesting boxes in the contaminated area and 25 in a comparable "clean" background area elsewhere in the marsh. Occupying tree swallows feed near their nest boxes, and contaminant concentrations in egg and nestling tissue correlates to the contaminant's uptake into the biota. A tree swallow study would take two to three (2 to 3) years, depending on whether the nest boxes are established before nesting season and the rate of nest box occupation in both the contaminated area and the background area.[55]

Monitoring contaminant conditions would include continued groundwater and surface water monitoring.

Certification

I, John C. Storlie, hereby certify that I am a hydrogeologist as that term is defined in s. NR 712.03(1), Wis. Adm. Code, am registered in accordance with the requirements of ch. GHSS 2, Wis. Adm. Code, or licensed in accordance with the requirements of ch. GHSS 3, Wis. Adm. Code, and that, to the best of my knowledge, all of the information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 700 to 726, Wis. Adm. Code.

Signature

____ October 27, 2017

Printed name and title **John C. Storlie, PG, Principal Hydrogeologist** Date

[53] Custer, CM, Custer TW, Archuleta, AS, Coppock, LC, Swartz, CD, and Bickham, JW. (2003). A Mining Impacted Stream: Exposure and Effects of Lead and Other Trace Elements on Tree Swallows (Tachycineta bicolor) Nesting in the Upper Arkansas River Basin, Colorado. In: Hoffman, DJ, Rattner, BA, Burton, GA, Cairns, J, editors. *Handbook of Ecotoxicology*, 2nd ed. Lewis Publishers. pp. 787 - 811.

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[55] Custer, Christine M., and Custer, Thomas W. (2017). Teleconference with the authors. October 6, 2017. La Crosse, WI.