

Site Remediation Status and Path Forward

Former Union Oil/PacifiCorp Astoria Site

November 2023

Agenda

Status of PacifiCorp/Unocal's August 19, 2022, Request to DEQ for a Conditional No Further Action (NFA)

Review of Completed Site Remediation

- Overview of 2023 LNAPL Assessment

Path Forward

- Issuance of Conditional NFA
- Continued Annual Site Operation and Maintenance Events
- Anticipated Change in Project Manager at DEQ



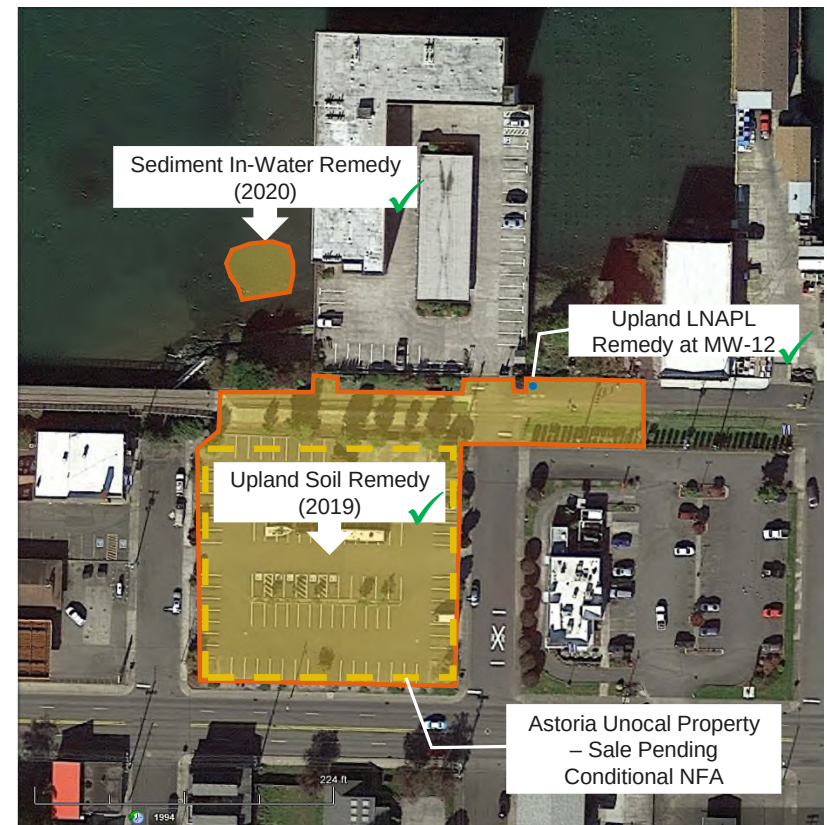
Review of Completed Remediation

Site-Wide Remedial Action Objectives Have Been Met

- The following remedial action objectives (RAOs) were established in the Amended Record of Decision (Amended Record of Decision (AROD); Oregon Department of Environmental Quality [DEQ] 2012):
 - *RAO #1.* Protect current and future occupational workers, construction workers, and excavation workers at the site from unacceptable risk posed through incidental ingestion, dermal contact, and inhalation exposure to soil, LNAPL, or groundwater containing constituents of concern (COCs) at concentrations exceeding DEQ generic risk-based concentrations (RBCs).
 - *RAO #2.* Protect potential future occupational workers at the site from unacceptable risk posed by inhalation of COCs in indoor air exceeding DEQ generic RBCs.
 - *RAO #3.* Remediate sediment posing significant toxicity to aquatic organisms.
 - *RAO #4.* Minimize the release of LNAPL from site soil and groundwater to the Columbia River sediment and surface water.
 - *RAO #5.* Remediate LNAPL hot spots of contamination to the extent feasible.

Site Remediation Status

- Upland Soil Remedy (**DEQ Approved**)
 - ✓ Upland caps: 1) City of Astoria-owned; 2) paved parking area; 3) railroad, Astoria Riverwalk, and utility corridor.
 - ✓ EES, CMMP, and Upland OMMP
- Sediment In-Water Remedy (**DEQ Approved**)
 - ✓ Intertidal sediment cap
 - ✓ Easement and lease from the ODSL and Columbia House Condominium Complex
 - ✓ In-water OMMP
- Upland LNAPL Remedy at MW-12 (**Under Review**)
 - ✓ Adaptive management remedy implemented from 2015 through 2019
 - ✓ Remedy effectiveness monitoring began in January 2021
 - ✓ Completed LNAPL Assessment in May 2023
 - ✓ Limited volume recovered over last 20 years.



Notes: Easement and Equitable Servitude (ESS), Contaminated Media Management Plan (CMMP), and Upland Operations Maintenance and Monitoring Plan (OMMP), Oregon Department of State Lands (ODSL)

Upland LNAPL Gauging Status



- LNAPL was historically measurable in MW-7, MW-11, MW-12, and MW-13
- LNAPL currently measurable in MW-11 and MW-12
 - MW-12 thickness is variable; correlates with water table elevation
 - MW-11 thickness peaked in late summer then declined; currently 0.02 feet
- LNAPL sheen seeps on shoreline no longer observed

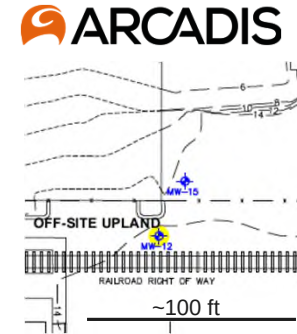
RAOs Met for Upland LNAPL Remedy at MW-12

- RAO #4 - Minimize the release of LNAPL from site soil and groundwater to the Columbia River sediment and surface water.
 - ✓ Site LNAPL and soil properties indicate that outward migration is not feasible
 - ✓ Sentinel well (MW-15) and shoreline monitoring confirmed that no LNAPL or sheen was observed during the active remediation phase or during 14 months of remedy effectiveness monitoring
- RAO #5 - Remediate LNAPL hot spots of contamination to the extent feasible.
 - ✓ Active LNAPL removal from MW-12, optimized based on pilot test results, did not remove LNAPL at a faster rate than any previous efforts
 - ✓ Low residual saturation, high viscosity and highly degraded LNAPL, and low porosity soil make active LNAPL removal impracticable

2023 LNAPL Assessment Overview

- Objective: Resolve remaining data gaps and complete further evaluation of the following:
 - LNAPL Plume Stability
 - Occurrence of Natural Source Zone Depletion (NSZD)
 - Potential Dissolved-Phase Constituents from LNAPL
- Deliverable/Correspondence Timeline:
 - LNAPL Assessment Work Plan – January 2023
 - Oregon DEQ Comments/Arcadis Response – March and April 2023
 - LNAPL Assessment Completed – May 2023
 - LNAPL Report Submitted to DEQ – August 2023

2023 LNAPL Assessment - NSZD



- **Process:** Fixed Gas and VOC measurements collected at MW-12
- **Results:**
 - Volatilization within LNAPL mass and rapid biodegradation occurring.
 - Depleted oxygen content supports diffusive and advective transport of soil-gas facilitating further degradation and attenuation.
 - Bio-oxidation of methane resulting in depleted oxygen as an indicator. Carbon dioxide as an end product of methanogenesis and aerobic methane oxidation.
- **Conclusion:** NSZD is likely occurring at MW-12 through a combination of biodegradation in the saturated zone, and volatilization and biodegradation in the unsaturated zone facilitating on-going degradation of LNAPL.

Location	Methane (ppm)	Carbon Dioxide (volume percent)	Oxygen (volume percent)	VOCs (ppm)
Ambient Air ¹	1.7	0.035	20.9	--
MW-12	2,000	4.2	13.2	48.8
Implication of Well Condition Finding	Elevated methane indicates anerobic biodegradation in the LNAPL source zone is occurring.	Elevated carbon dioxide in the source zone indicates methane is being degraded via aerobic processes in the vadose zone.	Depleted oxygen confirms the carbon dioxide observed is the result of aerobic biodegradation which uses subsurface oxygen.	Presence of VOCs indicate a phase change is occurring within the LNAPL to a readily degradable state.

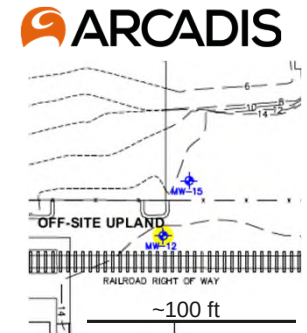
Notes:

ppm = part per million

-- = not available

¹ 2023. National Oceanic Atmospheric Administration. The Atmosphere. Accessed at: <https://www.noaa.gov/elstream/atmosphere>. July 28.

2023 LNAPL Assessment - Transmissivity



- **Process:** LNAPL Baildown Testing at MW-12
- **Results:**
 - Transmissivity is 0.09 ft²/day (consistent with results in 2014 which was 0.01 to 0.04 ft²/day)
 - Results below lower-bound of ITRC range considered practicable for hydraulic LNAPL recovery (0.1 to 0.8 ft²/day)
 - ~7 feet of LNAPL accumulation over 18-months.
 - Very slow recharge...
- **Conclusion:** LNAPL is not practicably recoverable via conventional hydraulic methods due to low LNAPL transmissivity and is very slow to recharge following LNAPL removal.

Theim Equation Solution for Upper-Bound Estimation of LNAPL Transmissivity (Unconfined Conditions)

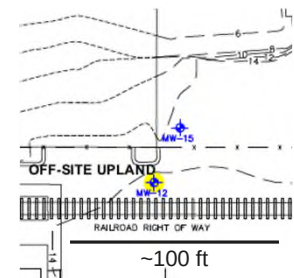
Well Designation:	MW-12
Date:	30-May-23
Initial LNAPL thickness in well, b_i (ft):	3.03
LNAPL-water density ratio, ρ_r :	0.97
Initial LNAPL thickness observed during test (ft):	0.40
Initial theoretical skimming drawdown, s_i (ft):	0.079
Final LNAPL thickness observed during test (ft):	0.42
Final theoretical skimming drawdown, s_f (ft):	0.078
Geometric mean of theoretical LNAPL drawdowns, s_n (ft):	0.079
Time between initial and final thickness observations (min):	65
Well casing diameter (in):	2
Observed LNAPL recharge rate, Q_r (ft ³ /d):	9.67E-03
$\ln(R_{oi}/r_w)$ (assumption per ASTM E-2856):	4.6
LNAPL Transmissivity, T_n (ft²/d):	0.09

$$T_n = \frac{Q_n \ln\left(\frac{R_{oi}}{r_w}\right)}{2\pi s_n}$$

$$s_{n_unconfined} = b_n(1 - \rho_r)$$

2023 LNAPL Assessment – Physical Properties

- **Process:** LNAPL Sampling at MW-12.
- **Conclusion:** LNAPL density, viscosity and interfacial tension results have not changed significantly from the values measured in 2014.



Date	LNAPL Density (g/cm ³)	LNAPL Viscosity ¹ (cSt)	LNAPL Interfacial Tension (dynes/cm)
May 7, 2014	0.968	660	32.6
May 30, 2023	0.968	419.8	30.1

Notes:

¹ LNAPL viscosity was measured at 90 °F during 2014 analysis (Arcadis 2014) and 104 °F during 2023 analysis.

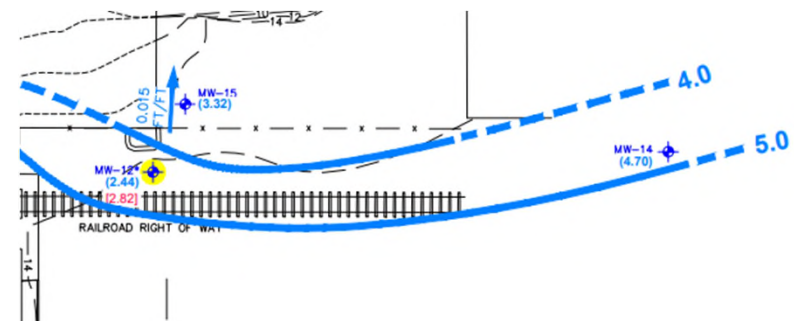
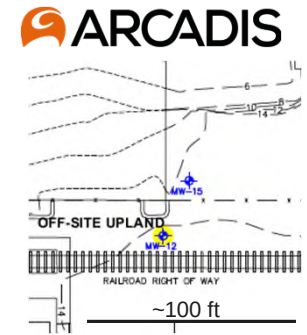
g/cm³ = gram per cubic centimeter

cSt = centistokes

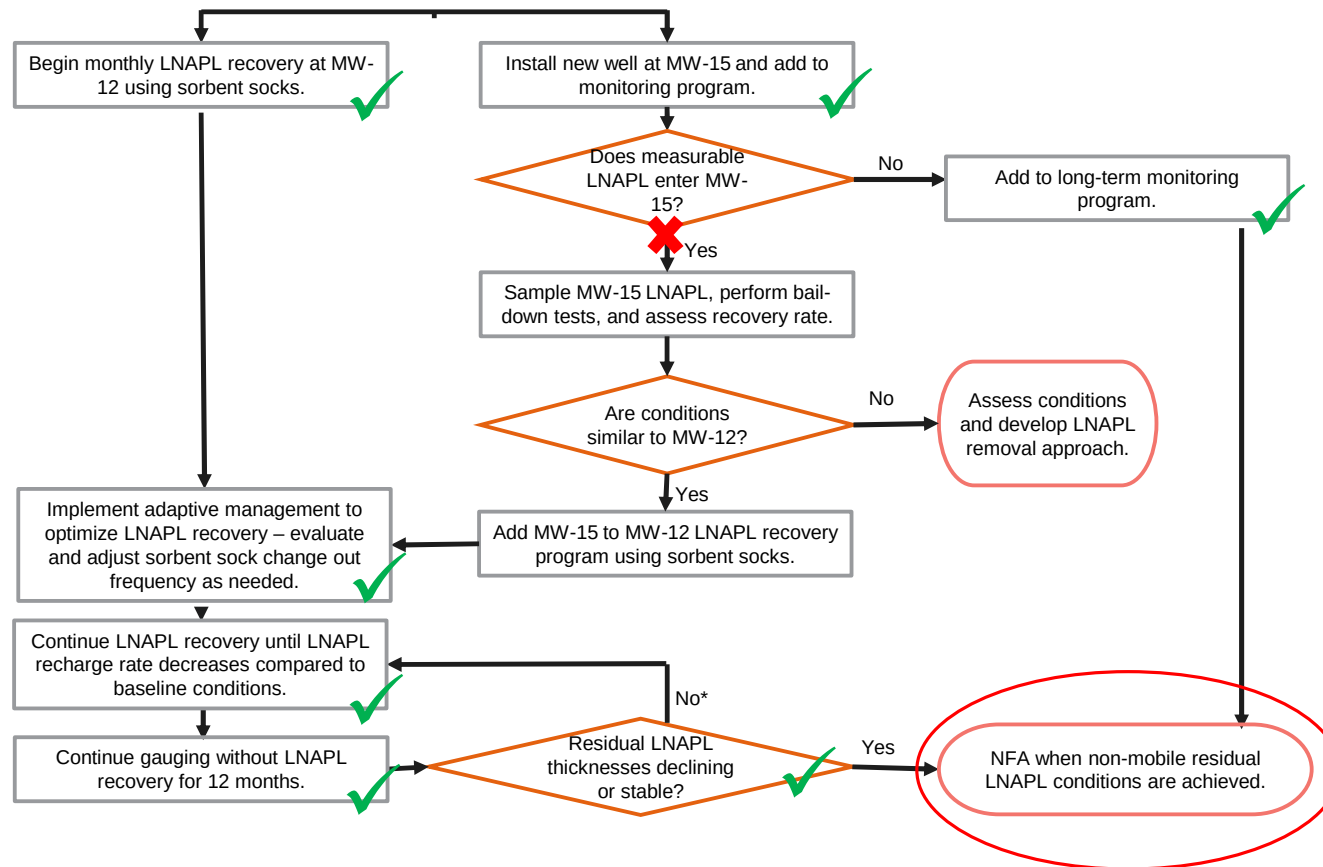
dynes/cm = dynes per centimeter

2023 LNAPL Assessment – LNAPL and Groundwater Sampling

- **Process:** LNAPL and groundwater sample collection at MW-12 (LNAPL) and MW-15 (Groundwater).
- **Results:**
 - MW-12 LNAPL detections of VOCs, SVOCs and PAHs.
 - MW-15 groundwater analytical results compared to RBCs (Construction and Excavation Workers) and SLVs (Ecological Risk for Aquatic Receptors in Fresh Surface Water) – No exceedances.
- **Conclusion:** Dissolved phase chemicals of concern potentially migrating from LNAPL near MW-12 upgradient of MW-15 are not present at concentrations that exceed human health RBCs and ecological SLVs.



Upland LNAPL Adaptive Management



Path Forward

Site-Wide Conditional No Further Action

- Regulatory requirements to support CFNA?
- CNFA Conditions:
 - Continued Annual Cap Inspections, Shoreline Inspections and MW-11 and MW-12 LNAPL Removal Events
 - Abandonment of Monitoring Wells: MW-4, MW-5, MW-6, MW-7, MW-9R, MW-10, MW-13 and MW-14
 - MW-11, MW-12 and MW-15 Remain for Gauging and LNAPL Removal
 - Discontinued Semi-Annual Reporting; Proceed with Annual Reporting Schedule
 - Ongoing evaluation of remedy effectiveness in 5-Year Reviews
- Timing for receipt of Site-Wide CNFA?
- Update on DEQ PM transition?



