STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Northwest Region Office
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April 25, 2023

Alexis McKinnon
Closed Landfill Program Analyst
Kitsap County Public Works Solid Waste Division
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Re: Opinion on the Remedial Action Status Report, Revision 2 (March 29, 2023) for the following Contaminated Site:

- **Site Name:** Olalla Landfill
- **Site Address:** 2850 SE Burley Olalla Road, Olalla, Washington 98359
- **Public Landfill Survey System:** NE/4 of NE/4 of Section 1, Township 22 North, Range 2 East, Willamette Meridian
- **Cleanup Site ID:** 2220
- **Facility/Site ID:** 7057711

Dear Ms. McKinnon:

Kitsap County Public Works (KCPW) is the owner and operator of the closed Olalla Landfill. Kitsap Public Health District (KPHD) is the jurisdictional health department that permits the landfill under Chapter 173-304 of the Washington Administrative Code (WAC). The Washington State Department of Ecology's (Ecology)'s Solid Waste Management Program provides technical support to KPHD and oversight of the landfill under WAC 173-304, but has primacy when there is a release of hazardous substances from the landfill that is subject to the Model Toxics Control Act (MTCA), Chapter 70A.305 of the Revised Code of Washington, and WAC 173-340. KCPW is performing an independent cleanup of the landfill under MTCA. Ecology is providing an opinion of the cleanup of the permitted landfill.

Review of Cleanup Documents and Prior Opinions

Cleanup activities began at the landfill because the concentrations of natural-occurring metals (i.e., arsenic, iron, and manganese) and vinyl chloride exceeded groundwater quality criteria in the upper aquifer downgradient (west) of the landfill.

KCPW prepared a Remedial Investigation/Feasibility Study (RI/FS) in May 2014 and an independent Cleanup Action Plan (CAP) in December 2014. The RI/FS and CAP reviewed analytical results through June 2011.

The RI/FS and CAP define the following groundwater cleanup levels for the identified chemicals of concern:

- 1.29 micrograms per liter (µg/L) of dissolved arsenic, based on natural background concentrations as allowed under WAC 173-340-720(7)(c).
- 300 µg/L of dissolved iron based on the secondary maximum contaminant level (MCL) for drinking water.
- 50 µg/L of dissolved manganese based on the secondary MCL for drinking water.
- 0.29 µg/L of vinyl chloride, based on a 1E-5 cancer risk as allowed under WAC 173-340-720(7)(b).

The CAP selected Cleanup Alternative 1: Monitored Natural Attenuation (MNA) and Land Use Controls, which includes:

- Quarterly monitoring of upgradient well MW-1 and downgradient wells MW-3, MW-6, MW-8, and MW-10, annual monitoring of cross-gradient wells MW-5A and MW-7, and annual monitoring surface water in the stormwater detention pond (SW-2), with quarterly reporting.
- Inspection, maintenance, and repair of the landfill closure systems, including the cap, drainage ditches, and the landfill gas system.
- Quarterly monitoring, maintenance, and operation of the landfill gas system.
- Preparation of a Restrictive Covenant, Land Use Control Implementation Plan, and Notice of Conveyance or Other Transfer of an Interest in the Property upon property transfer. The Restrictive Covenant will also be put in place when the cleanup action is complete or when the facility no longer operates under a post-closure permit.

The CAP (December 2014) stated that the effectiveness of cleanup action would be evaluated at 5-year intervals, and that no later than 10 years after initiating Cleanup Alternative 1, KCPW would thoroughly re-evaluate all performance data and reconsider viable alternatives versus monitored natural attenuation.

Ecology provided opinions on the RI/FS on September 5, 2014, and on the independent draft CAP on December 2, 2014. Ecology determined that:

- The cleanup standards meet the substantive requirements of MTCA.
- A conditional point of compliance is allowed because waste removal is not practicable. Groundwater compliance can be evaluated at the Site monitoring wells, which cannot be placed at the refuse boundary because of the topography.
- The Site is defined by the nature and extent of arsenic, iron, manganese, and vinyl chloride in groundwater and arsenic in surface water.
- The Site likely extends beyond the Olalla Landfill property boundary to the adjacent property west of the landfill, where the property owner restricted access. Sampling of

nearby off-site water wells during the RI and twice in earlier years, however, provides some characterization of off-site downgradient groundwater conditions.

- Cleanup Alternative 1 meets the minimum requirements and will not exacerbate conditions or preclude reasonable cleanup alternatives elsewhere on the Site.
- Post-closure care will continue to be performed in accordance with the facility's Post-Closure Plan and WAC 173-304-407.
- The effectiveness of the cleanup action will be evaluated at 5-year intervals and the other viable alternatives will be reconsidered after 10 years.
- If further remedial action is necessary elsewhere at the Site, Alternative 1 would constitute only an "interim action" for the Site as a whole.

KCPW submitted the Remedial Action Status Report (RASR), Revision 2, on March 29, 2023. This report updates the draft RASR, dated March 3, 2021, after a two-year interactive review process with Ecology and KPHD.

Opinions on Remedial Action Status Report, Revision 2

Ecology provides the following opinions on the Remedial Action Status Report

1. Site boundary

The Olalla Landfill Site boundary is defined by the landfill (i.e., the source of contamination) and the extent to which the chemicals of concerns in groundwater exceed the cleanup levels. The landfill impacts groundwater within the shallow advanced outwash (Qva) sand formation, and impacted groundwater extends west-northwest from the landfill. The Site is bound by upgradient well MW-1 to the east, cross-gradient well MW-5A to the north, and cross-gradient well MW-7 to the southwest. The downgradient extent of the Site is defined by the concentrations of manganese. Manganese exceeds the cleanup level in downgradient wells MW-3, MW-6, MW-8, and MW-10, which are located on the landfill property west of the landfill. The Site boundary likely extends west of the landfill property.

The RASR provides further evaluation of the off-site wells and seeps, including identifying new off-site wells and well logs, preparing extended geological cross-sections through most of these off-site wells, and sampling the off-site wells and seeps as allowable. The advanced outwash sand formation contains the uppermost aquifer west of the landfill. Four water wells west of the landfill are completed in the advanced outwash formation—OW-2 to the northwest, the G.A. Pierson well to the west-northwest, and OW-9 and OW-10 to west-southwest. Additionally, surface water seep OS-1 was sampled between the landfill and well OW-10. Two additional off-site spring/seeps (surface representation of the upper aquifer) were sampled between the landfill and OS-1 in 1985.[1]

RASR Figure 3 shows the locations of the wells and seep OS-1 and the surface expressions of the geological cross-sections. Figure 3 and cross-section A-A' show that the site topography

[1] See Figure 2.11 of the June 1988 Olalla Landfill Final Closure Plan.

drops off to a ravine southwest of the landfill property, and advanced outwash wells OW-9 and OW-10 are located on the opposing side of the surface water seep (the 1985 seep/spring locations also align closely with A-A'). Cross-section D-D', which extends west from the northern portion of landfill parcel to intersect the deeper wells, intersects advanced outwash wells OW-1, OW-2, and the G.A. Pierson well.

RASR Table 4 summarizes historical sampling of the offsite wells, including recent sampling performed in July 2020, September 2021, and December 2021. The concentrations of arsenic, iron, manganese, and vinyl chloride were below the Site cleanup levels in advanced outwash wells OW-1, OW-2, OW-9, OW-10, and the G.A. Pierson well, and in surface water seep OS-1. The western Site boundary is bound by advanced outwash wells OW-2, the G.A. Pierson well, OW-9, and OW-10, which are located northwest to west-southwest of the landfill. These wells have not been accessible for routine sampling.

2. Deep water wells protected by Lawton Clay Formation aquitard.

The RASR identifies four deep off-site water wells—OW-3, OW-4, OW-5, and Well #4—west of the landfill that are completed in the Olympia Beds formation. The deep water wells are shown in RASR Figure 3 and cross-section D-D'. Cross-section D-D' depicts at least 100 feet of the Lawton Clay formation between the advanced outwash formation and the Olympia Beds formation.

RASR Attachment G provides three additional deep well logs that were not reported in the RI/FS. These three wells are located, but not depicted, in the northwest corner of RASR Figure 3 on opposing sides of Olympic Drive SE, north and west of OW-5. The well logs record more than 130 feet of clay between the advance outwash sand formation and the Olympia Beds formation. The wells are:

- Well ID BLH648 (Parcel No. 012201-2-032-2006, 13082 Olympic Drive SE):
  Gray silty clay from 95 to 229 feet deep, with interbedded gray silt and some fine sand from 185 to 188 feet deep (131 feet of clay).
- Well ID BME039 (Parcel No. 012201-2-031-2007, 13024 Olympic Drive SE):
  Gray fine sand soft clay from 88 to 128 feet deep, gray sand with some water from 128 to 131 feet deep, and gray clay from 131 to 246 feet deep (155 feet of clay).
- Well ID BIJ937 (Parcel No. 012201-1-031-2009, 2420 SE Burley Olalla Road):
  Gray clay from 103 to 262 feet deep, with interbedded gray fine sand from 132 to 147 feet deep (144 feet of clay).

Ecology concurs that the Lawton Clay formation provides a competent aquitard between the advanced outwash formation and the Olympia Beds formation. The aquitard forms a protective hydraulic barrier beneath the landfill and its impacts to shallow groundwater in the advanced outwash formation.

RASR Table 4 summarizes the water quality analysis results from Olympia Bed wells OW-3, OW-4, OW-5, and Well #4. The concentrations of arsenic were below the 8 µg/L Puget Sound

Basin background concentration[2] and the 10 µg/L MCL for drinking water in the four deep wells. The maximum concentrations of manganese in OW-3 and OW-4 were 59 and 52 µg/L, respectively, which slightly exceed the 50 µg/L secondary MCL based on aesthetic drinking water criteria. The concentrations of iron are below the 300 µg/L secondary MCL based on aesthetic drinking water criteria, except for an anomalous high concentration of 572 µg/L in well OW-3 in 2011. The metals concentrations are consistent with natural groundwater quality.

3. Groundwater monitoring requirements

The monitored natural attenuation described in Section 4.2 of the CAP closely resembles landfill post-closure groundwater monitoring requirements in WAC 173-304-490(2)(d) and WAC 173-350-500(4)(h), which include field, geochemical indicator, and leachate indicator parameters. The landfill is regulated under WAC 173-304, not WAC 173-350, and KPHD can grant variances from these monitoring requirements where appropriate.

Biological reactions consume oxygen, creating anaerobic conditions. Anaerobic leachate and landfill gas typically impact shallow groundwater beneath landfills constructed before 1985, before landfill liners were required. Geochemical indicator parameters are collected to evaluate the impact of methanogenic conditions from waste degradation to the groundwater quality. Anaerobic conditions can reduce naturally occurring dissolved oxygen, nitrate, manganese, ferric iron, sulfate, and carbon dioxide. The concentrations of iron and manganese increase in groundwater because the reduced divalent manganese and ferrous iron species are more soluble than the more oxidized manganese and ferric iron species. Arsenic is also more mobile under anaerobic conditions.

The Olalla Landfill creates anaerobic conditions in the shallow advanced outwash formation, as evidenced by depressed concentrations of dissolved oxygen and oxidation-reduction potential and elevated concentrations of manganese, iron, and arsenic observed in MW-3, MW-6, MW-8, and MW-10. As reported in Table 6 of the 2022 Annual Report, depressed concentrations of nitrate are also observed in MW-3, MW-6, MW-8, and MW-10, with elevated concentrations of the reduced nitrite and/or ammonia species in MW-6 and MW-10 downgradient of the stormwater detention pond. The presence of nitrite in the stormwater detention pond, along with nitrite and ammonia in downgradient wells MW-6 and MW-10 may indicate that leachate infiltrates into the pond, and that the pond is under anaerobic conditions. Limited iron-reducing conditions are only observed in MW-6 and MW-8 downgradient of the stormwater detention pond. Sulfate-reducing conditions are not observed.

MTCA requires that unfiltered groundwater samples be compared with cleanup levels in WAC 173-340-720(9)(b), but states that filtering will generally be acceptable for iron and manganese and other naturally occurring inorganic substances. The landfill regulations (WAC 173-304-490(2), WAC 173-350-500(4), and WAC 173-351, Appendix II) require the collection of dissolved manganese and dissolved iron as geochemical indicators, although both total and

[2] Natural Background Groundwater Arsenic Concentrations in Washington State, Ecology Publication No. 14-09-044, January 2022.

dissolved iron and manganese are required in WAC 173-350. Calcium, magnesium, potassium, and sodium should also be analyzed as dissolved species, which is more suitable for geochemical analysis.

Dissolved arsenic and dissolved barium are included in the CAP, but these are not listed parameters in WAC 173-304-490(2) or WAC 173-350-500(4). The analysis of total arsenic and total barium is appropriate for these metals; however, further sampling for arsenic and barium is not warranted. Barium was not identified as a chemical of concern and the concentrations of arsenic are representative of background conditions (see discussion below).

4. Stormwater Detention Pond

The RASR discusses surface water and the stormwater detention pond in Section 2.4.2. The stormwater detention pond reportedly receives stormwater from the landfill surface and stormwater that is diverted around the landfill. KCPW samples surface water in the pond (as sample SW-2) annually, and analyzes the water for nitrate, nitrite, ammonia, fecal coliform, and field parameters. The presence of reduced nitrite and ammonia are indicators of leachate. The 2022 Annual Report documents the presence of nitrate, nitrite, and fecal coliform in surface water sample SW-2, nitrite in downgradient well MW-6, and ammonia in downgradient wells MW-6 and MW-10 (including a recent spike since early 2022).

Ecology recommends that KCPW coordinate with Ecology's Water Quality Program to review potential permitting requirements for the stormwater detention pond.

5. Arsenic

The cleanup level for arsenic is defined based on a background concentration described in an August 13, 2012, memorandum from Parametrix, provided in the RI/FS, Appendix H. The background was calculated in accordance with WAC 173-340-720(3) using analytical results from upgradient well MW-1 and cross-gradient well MW-5A from 2009 to 2012 and analytical results from downgradient wells OW-1, OW-2, OW-4, and OW-9 from 2010 and 2011. The background concentration was calculated from spatially-averaged well data using dissolved arsenic concentrations.

RI/FS Appendix H references several regional studies that found higher background concentrations of arsenic. Ecology historically applied the 5 µg/L Method A groundwater cleanup level as the background concentration of arsenic based on a footnote in WAC 173-340-900, Table 720-1. Ecology finalized Publication No. 14-09-044 in January 2022, which establishes a background concentration of 8 µg/L of arsenic for the Puget Sound Basin. These background concentrations are below the 10 µg/L MCL for drinking water.

Table 4 of the RASR presents the 95% upper confidence limits (UCL) of arsenic using five years of quarterly analytical results from the Site monitoring wells. The highest concentrations of arsenic were detected in MW-8 and MW-10 downgradient of the landfill, where the 95% UCLs of arsenic were 1.92 and 1.96 µg/L, which are well below the 8 µg/L regional background concentration for the Puget Sound Basin.

Ecology recommends the removal of arsenic as a chemical of concern for the landfill.

6. Manganese

The 50 µg/L groundwater cleanup level for manganese is based on the secondary MCL. As identified in Table 4 of the CAP, the non-carcinogenic Method B groundwater cleanup level of manganese was 2,200 µg/L at the time. As referenced in Section 6.1 of the RASR, Ecology lowered the non-carcinogenic Method B groundwater cleanup level of manganese to 750 µg/L in 2020. The 50 µg/L secondary MCL is based on aesthetic considerations, whereas the 750 µg/L Method B cleanup level is based on health effects. Secondary MCLs are based on aesthetic considerations, such as taste, color, or odor.

As shown in RASR Appendix C, the concentrations of manganese were consistently below the 2,200 µg/L Method B CUL in MW-3 during the preparation of the RI/FS (532 to 1,330 µg/L). The concentrations of manganese have significantly increased in MW-3 since the CAP was completed in 2014. As shown in RASR Table 2, the 95% lower confidence limit (LCL) and 95% UCL of manganese were 5,367 and 6,448 µg/L in MW-3 using the most recent five years of data, which exceed the current, health-based 750 µg/L Method B cleanup level by nearly an order-of-magnitude.

The concentrations of manganese in downgradient wells MW-8 and MW-10 were approximately 2 to 3 times the 2,200 µg/L Method B cleanup level during preparation of the RI/FS and CAP. Although declining trends are observed in MW-8 and MW-10, the 95% UCLs of manganese are 2,791 and 4,658 µg/L, which significantly exceed the current 750 µg/L Method B cleanup level. The 95% UCL of manganese was 705 µg/L in downgradient well MW-6, which is below the current 750 µg/L Method B cleanup level.

The concentrations of manganese pose potential health-based risks to downgradient water well users if not mitigated. **Ecology recommends that KCPW:**

- **Delineate the extent of manganese contamination in the advance outwash and surface seeps on adjoining Parcel No. 012201-1-015-2009, as allowable.**
- **Request access to sample advance outwash wells OW-2, OW-9, OW-10, and the G.A. Pierson well, and observed seeps every five years to assess potential impacts from the landfill.**
- **Sample additional private water wells near the landfill if requested by the property owners.**

7. Iron

The highest concentrations of iron are observed MW-6 and MW-8 downgradient of the landfill and stormwater detention pond. As shown in RASR Appendix C, the concentrations of iron exhibit a decreasing trend since completion of the 2014 CAP. As shown in RASR Table 2, the 95% UCLs of dissolved iron were 848 and 706 µg/L in MW-6 and MW-8 based on the most recent five years of data. The 95% UCLs of dissolved iron in the remaining Site wells are below the 300 µg/L secondary MCL. The 95% UCLs of dissolved iron are below the 1,000 µg/L aquatic life-protective cleanup level and below the 11,000 µg/L health-based Method B cleanup level. Although the concentrations of iron are not compliant with the groundwater cleanup level based on aesthetic drinking water criteria, the concentrations of iron do not pose environmental or health risks.

8. Vinyl chloride

The concentrations of vinyl chloride have generally declined to below the 0.02 µg/L method detection limit. When detected, the concentrations of vinyl chloride have ranged from 0.02 to 0.1 µg/L since preparation of the RI/FS and CAP. Vinyl chloride was detected only once during quarterly sampling since the fall of 2019, where vinyl chloride was detected at 0.04 µg/L in MW-8 in the fall of 2021. The concentrations of vinyl chloride have exceeded the unadjusted cleanup level of 0.029 µg/L based on a 1E-6 cancer risk, but have not been detected above the adjusted cleanup level of 0.29 µg/L based on a 1E-5 cancer risk since 2001. Continued surveillance monitoring of vinyl chloride is warranted since vinyl chloride is periodically detected above the unadjusted cleanup level of 0.029 µg/L.

9. Potential impacts of sludge disposal from the Phase II area

The 2014 RI/FS reviews the operational history of the landfill in Section 1.3. Waste disposal started in the late 1950s or early 1960s, and continued through 1985, when the waste transfer station was constructed at the northern portion of the landfill parcel. The landfill received mixed municipal solid waste, construction and demolition materials, and septic tank sludge.[3] Refuse burning was performed through the early 1970s, consistent with practices at the time. The RI/FS does not distinguish the disposal dates or waste characteristics of the Phase I and II Areas. The southern Phase I Area was closed with a 2-foot thick, low-permeable, 6%-bentonite-amended soil cover and landfill gas recovery system, whereas the northern Phase II Area was closed with only a soil cover. Phase I closure was completed in 1988, while Phase II closure was delayed a year, pending an evaluation of groundwater monitoring.

The highest concentrations of manganese are observed in MW-3, which is downgradient of the Phase II Area. The disposal of septic tank sludge or biodegradable waste within the Phase II Area could contribute to the manganese-reducing conditions observed in MW-3. Ecology requested that KCPW perform a bar hole survey for landfill gas to evaluate the potential for biodegradable waste disposal in the Phase II Area. KCPW performed the bar hole survey of the Phase II Area and the perimeter of the landfill in January 2022. The landfill gas bar hole survey is described in RASR Section 2.4.3, Table 1, and Figure 6. Methane was not detected in any of the 5-foot-deep bar holes.

[3] The Olalla Landfill Final Closure Plan (1988) reports that the Bremerton-Kitsap County Health Department authorized the disposal of 300,000 gallons of septic tank sludge at the landfill in 1978. This volume equates to 0.9 acre-feet of sludge in a 12-acre landfill.

The absence of methane does not rule out the disposal of septic tank sludge in the Phase II Area. The expected methane generating potential of the septic sludge would be low four decades after its disposal; and depending on the handling practices, may have been low when disposed in the landfill. Nevertheless, the septic tank sludge provides a long-term source of carbon that would enhance biological reactions in water that leaches through the sludge, creating anaerobic leachate. The Phase II Area was closed by grading the soil cover to a 2 percent slope, which neither promotes surface water runoff nor impedes infiltration.

As shown in RACR Attachment B, the manganese concentrations increase sharply in MW-3 after 2013, or 35 years of the authorized disposal of the septic tank sludge. A delayed response is expected based on groundwater hydrology. As shown in cross-section B-B' in RASR Figure 3 and Attachment A, the unlined landfill is underlain by unsaturated soil and potentially till, which retard leachate flow to the underlying groundwater. The seepage velocity of the impacted groundwater can be estimated. As shown in RASR Figure 4, the hydraulic gradient between MW-1 and MW-3 is about 15 feet of head per 1,200 feet of distance. Assuming hydraulic conductivity of 0.001 centimeters/second in the advanced outwash sand and 30 percent porosity, the groundwater seepage velocity is about 40 feet/year. Based hydraulic gradient and capture zone of MW-3 depicted in RASR Figure 4, the delayed increase in manganese concentrations is entirely consistent with water infiltrating through the septic sludge.

10. Recitation of cleanup alternatives

The RASR reiterates the three cleanup alternatives considered in the RI/FS.

- Alternative 1 essentially defaults to prescriptive landfill post-closure care.

- Alternative 2 adds new cap construction, including the following options:
    - Alternative 2A - a low-permeability soil cap of the Phase II Area, and
    - Alternative 2B – a geomembrane cap of both the Phase I and Phase II Areas.

- Alternative 3 consists of Alternative 2A plus the identical remediation measures beyond the landfill that were considered in the RI/FS.

The landfill containment and remediation technologies are addressed individually below.

11. Landfill cap opinion

The 2014 RI/FS provides a review of the 1988-89 landfill closure activities in Section 1.4. The Phase I Area was closed with a low-permeability soil cap in 1988, consistent with the landfill closure requirements in WAC 173-304-460(3)(c). Phase II Area closure was delayed a year to allow Ecology to determine, based on groundwater monitoring, whether the low-permeability cap should be extended over the Phase II Area. In the absence of a record of Ecology's subsequent determination, the low permeability cover was not extended over the Phase II Area.

The Phase II Area was closed with a vegetated soil cover, consistent with the inert waste and demolition waste closure requirements in WAC 173-304-461(6).

The landfill closure requirements include a minimum 2-foot, low-permeability (1E-6 cm/sec or less) cover, a minimum 6-inch vegetated soil layer, and greater than 2 percent surface slopes to drain surface water. In contrast, the inert wase landfill closure standards only require one foot of soil, leveling the waste to the extent practicable, and filling in voids.

Ecology believes that reactive waste, likely septic tank sludge, was disposed in the Phase II Area. The inert waste landfill closure standards were not appropriate at the time, and the evaluation of groundwater monitoring would not have been predictive of reactive waste 10 years after the disposal of the septic tank sludge. The decision to not extend the prescriptive landfill cover over the Phase II Area was made at-risk. **Ecology recommends that KCPW construct a low-permeability landfill cover on the Phase II Area that meets the prescriptive requirements in WAC 173-304-460(3)(c).**

The RI/FS reviews the 1997 landfill settlement survey and the 2000 and 2003 restoration of the Phase II cap in Section 1.5. The RASR does not evaluate landfill settlement or the landfill cap's continued effectiveness to drain surface water. Ecology recommends that landfill cap settlement be monitored as part of the ending post-closure care criteria in Ecology Publication No. 11-07-006 and its 2013 addendum. **Ecology also recommends continued inspection of surface water drainage from, and possible retention on the landfill cap.** If warranted, Phase I cap restoration can be performed during construction of the prescriptive Phase II cover.

12. Metal Remediation Compound opinion

Alternative 3 includes both the injection of a metals remediation compound and active air sparging. Regenesis' Metals Remediation Compound® (MRC) is an inappropriate technology that would exacerbate the problems at the landfill. MRC is designed to remediate oxidized compounds, specifically hexavalent chromium, along with chlorinated hydrocarbons. An organosulfur compound in the MRC reduces soluble hexavalent chromium to insoluble trivalent chromium. There are no sources of hexavalent chromium at the Site. If applied downgradient of the landfill, the concentrations of manganese and iron would increase. Air sparging would be needed to counteract the adverse effects of MRC.

13. Air sparging and bioventing opinions

Alternative 3 includes a conceptual air sparging component, which includes air sparging through ten wells along the downgradient landfill boundary, for thirty years, with an 83 percent operating time. This is an unrealistic assumption that hinders the evaluation of aeration technologies.

Air sparging is differentiated from bioventing by objective and scale. Air sparging is performed to strip volatile organic compounds from groundwater, which are typically removed from the vadose zone using a soil vapor extraction system. Bioventing is performed to provide oxygen for biological and geochemical oxidation reactions. Bioventing can be performed actively or passively. Although active bioventing can resemble air sparging, bioventing involves the periodic injection of air at low pressures to promote mixing and to minimize the channeling of air through preferential flow paths. Active bioventing can be performed as a treatment wall or to a treatment grid. Passive bioventing can be performed by periodically injecting proprietary extended oxygen releasing compounds or by placing oxygen releasing compounds in treatment wells and periodically replenishing them.

Aeration may also be performed using a surface water aerator placed in the stormwater detention pond, and then discharging the aerated stormwater to groundwater using leach field or injection wells.

Ecology recommends that bioventing technologies be retained for further consideration if the concentrations of manganese persist. Landfill containment technologies should be prioritized.

14. Request for sampling variance request

Ecology recommends optimizing the landfill monitoring plan and redirecting resources to improving the Phase II landfill cover and delineating the extent of manganese contamination beyond the landfill property, as allowable.

Ecology recommends that KCPW prepare a variance request Technical Memorandum (TM) and submit it to KPHD and Ecology for review. The TM should include a table with the current and proposed sample locations, analytes, and sampling/reporting frequency, time-series graphs, statistical trend analysis, and a rationale for the variance or analyte reduction requested. Landfill gas trend analyses should be included to support the recommended landfill gas sampling frequency. The proposed sampling locations, analytes, and frequency shall be protective of human health and the environment. The proposal should request variances from specific groundwater monitoring requirements in WAC 173-304-490 as warranted.

The sampling and analysis plan should be revised following regulatory acceptance of the proposed variance request TM.

15. Environment covenant

Consistent with the independent Cleanup Action Plan, Ecology recommends that KCPW use the *Environmental Covenant for Municipal Solid Waste and Limited Purpose Landfills* template (Ecology Publication No. 070-534, Revised October 2021) when the cleanup action is complete or when the facility no longer operates under a post-closure permit.

In summary, Ecology recommends:

- Construct a prescriptive landfill cover on the Phase II Area.
- Continue to inspect surface water drainage from, and possible retention on landfill cap.

- Monitor landfill cap settlement as part of the ending post-closure care criteria in Ecology Publication No. 11-07-006 and its 2013 addendum.
- Coordinate with Ecology's Water Quality Program to review potential permitting requirements for the stormwater detention pond.
- Remove arsenic as a chemical of concern for the landfill and discontinue further sampling of arsenic and barium.
- Submit a groundwater and landfill gas Variance Request Technical Memorandum to optimize sampling and reporting costs.
- Delineate the extent of manganese contamination in the advance outwash and surface seeps on adjoining Parcel No. 012201-1-015-2009, as allowable.
- Request access to sample advance outwash wells OW-2, OW-9, OW-10, and the G.A. Pierson well, and observed seeps every five years to assess potential impacts from the landfill.
- Sample private water wells near the landfill if requested by the property owners.
- Retain bioventing cleanup technologies for further consideration if the concentrations of permanganate persist.
- Use the *Environmental Covenant for Municipal Solid Waste and Limited Purpose Landfills* template (Ecology Publication No. 070-534, Revised October 2021) when the cleanup action is complete or when the facility no longer operates under a post-closure permit.

Thank you for your continued post-closure care and cleanup of the Site. Please contact Tim O'Connor, at 425-389-2695 or tim.oconnor@ecy.wa.gov or Alan Noell, at 425-213-4803 or alan.noell@ecy.wa.gov with questions.

Sincerely,

Alan Noell, PhD, PE
Solid Waste Management Program

cc: Christopher Piercy, KCPW, Solid Waste Program Supervisor
Steve Brown, KPHD, Solid & Hazardous Waste Program Manager
Jakob Hughes, KPHD, Environmental Health Specialist
Steven Williams, Ecology, Solid Waste Management, Section Manager
Tim O'Connor, Ecology, Solid Waste Management, Hydrogeologist