



STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

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December 18, 2019

Shane DeGross
BNSF Railway Company
605 Puyallup Avenue
Tacoma, WA 98421

RE: Ecology comments on draft Uplands Remedial Investigation Report:

- **Site Name:** BNSF Track Switching Facility aka Wishram Railyard
- **Site Address:** 500 Main St., Wishram, Klickitat County
- **Facility Site ID No.:** 1625461
- **Cleanup Site ID No.:** 230
- **Agreed Order:** DE 12897

Dear Shane DeGross:

Thank you for the submittal of the above-referenced draft report in accordance with Agreed Order DE 12897. The Department of Ecology (Ecology) has included comments in the enclosure with this letter. Ecology expects its comments will be addressed in the next submittal.

If you have questions or need clarification, you can reach me at (509) 454-7836.

Sincerely,

John Mefford, LHG
Cleanup Project Manager
Toxics Cleanup Program
Central Regional Office

Enclosure: Ecology Comments on draft Uplands RI Report

cc: Allyson Bazan, AGO Ecology Division
Brooke Kuhl, BNSF Railway Company
Matt Wells, Tupper Mack Wells PLLC



General Comments

- Comment 1.** Please add the words, “Upland” or “Upland Operable Unit” to the RI Report title.
- Comment 2.** Comments that apply to particular sections should be reflected by corresponding changes in other sections. Please revise the content to ensure consistency throughout the report.
- Comment 3.** Certain portions of this report will remain premature until revised with new information from the ongoing inundated lands investigation. Please note this status in the document. Once collected, update this report with information on the assessment of the outfalls that cross the facility property.
- Comment 4.** Supplemental in-water investigation for evaluation of the sediments associated with the facility outfalls is pending. Polychlorinated biphenyls (PCBs), if found at those locations above area background, should remain as a potential contaminant of concern that will require further evaluation in the uplands where oil was released including process areas such as the repair and wash locations. Perform additional investigation if warranted by the findings, and note this in the document.
- Comment 5.** A formal Terrestrial Ecological Evaluation (TEE) is expected. The brief mention of ecological receptors in the Executive Summary and in Section 3.3.3 is not adequate.
- Comment 6.** Please ensure the report includes interpretation that compares analytical results at particular locations to assess for potential bias from the presence of non-dissolved fractions within the dissolved-phase sample.

The monitoring well locations that appear to show this potential bias based on SGC comparison data include the following: RMD-1, RMD-2, RMD-5, WMW-03, WMW-09, WMW-15, MWM-16, and MWM-17. RMD-2 provides a special case since it also has duplicate samples collected in April and August 2018. For the April samples, there is not much difference in the analytical results; however, in the August samples, there is a marked difference in the analysis after SGC.

Please note that a well screened across a smear zone with formation NAPL provides a potential source of the NAPL blebs, and that the presence of NAPL blebs demonstrates a point of compliance that does not meet MTCA criteria.

- Comment 7.** Please ensure the report contains the following elements:
- A complete description of human uses and exposed ecological receptors at the site, including a clear identification of reasonable maximum exposure scenarios.

- Identification of All Relevant and Applicable Requirements (ARARS), including treaty uses.
- Establishment of site boundaries based on potentially applicable cleanup standards and ARARs, and identification of areas where boundaries have not yet been determined.

Comment 8. Please provide the full results and interpretation from the laser-induced fluorescence (LIF) investigation, as it regards the integration of the lateral and vertical information pertaining to the NAPL bodies.

- Please provide more discussion of the vertical distribution of the submerged NAPL that in some cases is supplemented by formation matrix information provided by the electrical conductivity (EC) logs. This line of evidence has bearing on the contaminant fate and transport in association with the aquifer architecture that may consist of a dual domain of flux and storage zones. The aquifer has been treated simply as homogeneous whereas the totality of the information suggests otherwise for those areas that are impacted by contamination. This gap is significant since the information provided informs the proposed remedial alternatives.
- Please provide a more extensive data visualization of the various NAPL bodies versus showing the spatial distribution of the submerged NAPL as a single footprint that depicts the generalized lateral dimensions.
- Please provide a more extensive data visualization regarding the vertical dimension, instead of generalized cross sections. The water table NAPL is sparsely depicted, if at all. Likewise, the data visualization provided by subsurface mapping is significant since this information will inform the proposed remedial alternatives.

Ecology will require detail that is more complete prior to transitioning to the Feasibility Study.

Comment 9. Discuss the significance of the well length with regard to variation in groundwater data for those wells with screen intervals spanning 15 feet and greater. These wells include WMW-8 through WMW-18, RMD-1 through RMD-6, and OHM-1 through OHM-3. Does the data represent flow-averaged concentrations across the screened interval such that screening across clean portions of the aquifer dilute the concentration that one would expect compared to a well that primarily brackets the impacted interval? If this is the case, some of the monitoring wells have a screen length that may render the interpretation of the analyte concentration suspect, include the evaluation of the geochemical parameters.

What is the added effect of a vertical hydraulic gradient, which may fluctuate in direction over time? For example, at well pair, WMW-17 and RMD-3, the vertical hydraulic gradient is usually upwards.

At well pair, WMW-16 and RMD-2, the vertical hydraulic gradient is variable and does not appear consistently in one direction, either up or down. At well pair, WMW-15 and RMD-1, the vertical hydraulic gradient is typically upwards.

Discuss the interpretation of the groundwater flow patterns shown in Figure 31. Add the discussion of these issues into the report.

Comment 10. Verify that all of the figures with the circle icon have the correct coloration, as described by the legend, in the appropriate half of the “half-moon” portion. The left side refers to diesel range organics (DRO) results and the right side refers to the oil range organics (ORO) results. On Figure 37, I have counted at least 13 errors of improper coloration in comparison to the analytical results provided in the accompanying box. Revise as necessary.

Comment 11. Arsenic remains as a potential contaminant of concern (PCOC). Ecology requires a more detailed analysis and discussion of the geochemical conditions, including redox and pH, of the groundwater as a mechanism for potentially liberating arsenic from naturally occurring parent material. What is significant is the role played by the primary contaminant release of petroleum hydrocarbons and the degradation of that mass with the possible consequent secondary effect of arsenic mobilization that may potentially affect surface water receptors. Note that the designated use of the Columbia River in this area includes water supply and there may be a violation of the surface water standards for arsenic based on that usage type or under any of the other designated uses.

Specific Comments

Comment 12. Executive Summary, Soil Sample Results: The text states “*Benzene and lead were reported infrequently at concentrations above MTCA Method A CULs and are, therefore, not considered site-related constituents of concern.*”

Please remove this statement since Ecology does not concur. This statement is premature given the site’s history of the presence of gasoline tanks together with the relatively limited data collection for leaded gasoline and its constituents.

Comment 13. Executive Summary, RGW Sample Results: The text states: “*While arsenic, barium, cadmium, chromium, and lead were reported above their respective MTCA Method A CULs in RGW samples from 2004 and 2016, these metals are not of concern based on RGW results alone, as RGW sample results tend to be biased high in total metals.*”

Ecology does not concur with your interpretation of the findings. Remove this statement until sufficient empirical data has been collected to inform a proper interpretation of the groundwater contaminant load. Please provide a table to show pairs of data, total and dissolved of all metals, obtained from monitoring wells, and incorporate this information into the report. Include other information as appropriate.

Comment 14. Executive Summary, Transport and Fate: See comment #11 regarding arsenic as a PCOC.

Comment 15. Executive Summary, LNAPL Testing Results: The text states: “*LNAPL was not observed in the LIF borings south of the LNAPL body nor in the river bank monitoring wells, indicating that the LNAPL body is not migrating.*”

This statement depends on the cutoff values determined for the presence of NAPL as measured in percent of the reference emitter (%RE). There appear to be at least two distinct light non-aqueous phase liquid (LNAPL) bodies existing at different depths and that likely consist of different compositions. As such, Ecology does not accept your conclusion as a blanket statement, as it is not supported by the expression of residual NAPL in the LIF profiles in the CR transect. Please remove this statement until Ecology accepts this interpretation.

Please provide any chemical analyses performed on LNAPL samples from either MW-07 or MW-08. These locations have had LNAPL at the water table and presumably of a different nature from that represented by the submerged NAPL. If analyses were not performed, then collect and analyze LNAPL from the sedimentary interval that only brackets the vertical range of contemporary water table fluctuation (smear zone) to verify its petroleum composition. Collection of sufficient volume of this LNAPL may also allow the determination of its fluid properties. Also, the water table LNAPL in other areas of the uplands may consist of different composition with resultant differences in physical properties than of that characteristic of the submerged NAPL mass.

Comment 16. Executive Summary, Potential Exposure Pathways and Receptors: The text states: “*The vapor intrusion pathway is not a complete exposure pathway due to lack of VOCs reported in soil and groundwater.*”

Please remove this statement until sufficient evidence is collected to support this interpretation. Data gaps exist, and a proper assessment of petroleum vapor (PVI) intrusion has not been completed. Assess the PVI pathway as required.

Comment 17. Executive Summary, Conclusions and Recommendations: The text states: “*Based on the data and information collected and the analysis described herein, characterization of the nature and extent of impacts in the upland area of the site is complete.*”

This statement is premature. Please remove this statement. In addition, change the wording of Remedial Action Plan (RAP) to Draft Cleanup Action Plan (DCAP). Please apply this change throughout the document.

Comment 18. Executive Summary, Conclusions: The text states: “*GRO is present at locations near former gasoline tanks and does not pose risk to human health and the environment.*”

Remove this statement. Ecology considers all concentrations of hazardous substances above MTCA Method A cleanup levels to pose a potential risk to human health and the environment. The text states: *“The relative absence of VOCs and the lack of onsite buildings in or near impacted areas indicates vapor intrusion is an incomplete exposure pathway under current site conditions.”*

The presence of contaminants above MTCA Method A cleanup levels in soil and groundwater may pose a risk to human health and the environment. Remove this statement until Comment No. 15 is fully addressed and Ecology has approved any findings of no impact.

Comment 19. Same Section (also Sec. 4.1): The text states: *“...and increasing the pore entry pressure, thereby minimizing or eliminating the potential for the viscous LNAPL body to migrate.”*

This is not true in all cases regarding the onsite NAPL. The LNAPL near the water table may potentially migrate as sheen with short-term rapid changes in groundwater elevation consequent of fluctuating lake level (see Section 2.2.7.3). The mechanism for sheen transport from the uplands may be a function of the differences in the interfacial tension between air, NAPL and water. A sheen may form at the air-water interface and migrate along the capillary fringe to surface water. However, this mechanism may either be very minor or non-existing if the NAPL at the water table has a high viscosity. This determination of this distinction requires the evaluation of the fluid properties of the water table NAPL.

Another exception potentially exists with the submerged NAPL. There may be a situation where petroleum NAPL becomes a wetting fluid through biodegradation. This change in NAPL behavior can occur under certain conditions induced by microbially-mediated production of surfactants or by other microbial reactions that decrease the organic-water interfacial tension.

Comment 20. Section 2.1, Previous Environmental Investigations and Interim Remedial Actions, February/April 2004: The text states: *“RGW samples were collected from eight borings for analysis of DRO, ORO, GRO, BTEX, volatile organic compounds (VOCs, two samples), and RCRA 8 metals.”*

State that not all of these analyses were performed on these eight reconnaissance groundwater (RGW) samples.

2013: The text states: *“Soil samples were collected to qualitatively correlate the LIF signal response to laboratory soil analytical concentrations for petroleum hydrocarbons.” “Furthermore, the percent reference emitter (%RE) data were qualitatively evaluated with respect to field observations to assess whether the LIF responses were indicative of mobile LNAPL or residual total petroleum hydrocarbons (TPH) being potentially present.*

Evaluation of the above data suggests that an LIF response less than 20 %RE indicates residual TPH and/or LNAPL are not present..., an LIF response between 20 %RE and 60 %RE indicates that residual TPH is likely present..., and an LIF response above 60 %RE indicates a location where potentially mobile LNAPL is suspected to be present...”.

The residual saturation should vary, given what appears to be NAPL of at least two different compositions. Residual saturation will also vary with changes in grain size and water saturation so it may be best to describe as a range of values. Did you integrate the field observations with pore fluid saturation (PFS) and contaminant composition? With communication of sufficient aggregated data, Ecology will accept the cutoff values of %RE that you propose as indicative of NAPL and its mobility.

You reference Figure 8 and Table 4, which show TPH concentrations collected at a certain depth at LIF locations. The qualitative evaluation appears to consist of a comparison of TPH concentration to LIF %RE. However, there is no indication that this information was plotted. Show the correlation of %RE to TPH mass concentration and/or to pore fluid saturation (PFS) and/or to mole fraction for determination of the specific cutoff values. Provide a graph that supports your establishment of the cutoff values for NAPL and for NAPL mobility.

Also, in 2013, core samples were collected at D6, F2 and F6 for determination of matrix properties and of various properties of the in-situ NAPL including parameters such as pore fluid saturation, residual saturation, mobility and capillarity. However, the validity of the sample collected for TPH analysis at F2 is suspect upon review of the combined TPH analytical concentration in comparison to the LIF log at the depth of sample collection. The combined TPH value appears to be too low for the soil type. In addition, the parameters yielded by the core analysis at F2 are suspect since the collection interval coincides with that portion of the LIF log that shows little or no %RE response. Please explain this discrepancy and whether this discrepancy will invalidate the data from core sample F2.

Additional NAPL fluid and core samples were collected in 2016 and 2017. A comparison of the fluid properties of the sample from D4 and of a sample collected from OHM-1 in 2016 shows a substantial difference in viscosity even though these two locations are in close proximity. The difference in properties suggests that some of the volatile fraction may have evaporated from the fluid and caused a change in properties. Indeed, the chain of custody (CoC) shows that the NAPL sample collected at D4 was received warm (73° F) and the sample appears not to have been kept cool as required by sampling protocol given in API 4711 (*Methods for Determining Inputs to Environmental Petroleum Hydrocarbon Mobility and Recovery Models*). The CoC for NAPL fluid sample from OHM-2 also shows that a cool temperature was not maintained during shipment and handling.

The chains of custody for fluid samples from OHM-1 and OHM-3 do not indicate the temperature recorded upon receipt by the laboratory. Please address the handling protocol for the NAPL fluid samples.

Another issue is whether the ambient temperature of the NAPL at laboratory receipt was sufficiently different from the temperature of the fluid during sample collection and whether that ambient temperature was high enough for volatilization of the lighter fractions that may have been resident in the fluid. For example, gasoline has a flash point of about -49° F (-40° C) and that is the temperature at which the liquid vaporizes. The question of whether the NAPL sample has been altered such that it is no longer representative of the formation NAPL. Please address this issue.

Note that the API publication 4711 provides information regarding sample collection procedures to ensure the collection of representative samples. API states that in all cases, the in-situ temperature of the product should be determined however, it gives allowance for measurement of the temperature immediately after collection. Did you measure the NAPL temperature in the field? If so, provide that information. If not, state this in the report.

The NAPL core samples and the NAPL fluid samples were not collected under the 2017 RI Work Plan. Provide details on the sample collection performed in 2013 and 2016. This information should cover the collection and preservation of these samples for verification of the representativeness of these samples.

Comment 21. Section 2.1, Previous Environmental Investigations and Interim Remedial

Actions: The text (p. 12) states: *“As such, the %RE reference ranges developed for this site may not consistently indicate residual NAPL is mobile.”*

The cutoff value of %RE is expected to differ for a diesel-like product, for a “pure heavy” product, or for a blended mixture based on the composition that contains different types of polycyclic aromatic hydrocarbons (PAH) together with the relative amounts of the types.

The LIF response for TG-D06 is very similar to that shown in TG-D05. Dakota Technologies (Dakota) called out TG-D05 as an example of a distinctive pattern that differs from what appears to be a light to medium (or diesel-like) petroleum hydrocarbon as shown in TG-D00 or TG-E00. Dakota further differentiates what appears to be a more “pure heavy” material as opposed to what appears to be a blended mixture. The characteristic fluorescence signature for the “pure heavy” petroleum hydrocarbon is TG-E08. This pattern is also distinguished by shorter lifetimes (basal width of channel response), by more red shifting, and an axis line fitted through the point distribution on the classification plot is more strongly pulled to the right. Heavier petroleum hydrocarbon mixtures are “red-shifted” in the LIF response; however, weathering can also lead to red shifting and complicate attempts at rudimentary forensics.

Some attempt was made in the diagrams to depict the lateral distribution of diesel-like product versus a Bunker C mixture. However, the mapping of the spatial distribution of the three main product patterns as shown in the LIF profiles was not attempted. It may be revealing to depict the spatial distribution of the three product types in comparison to the locations of former storage tanks and distribution lines for the various petroleum mixtures. For example, see if the diesel-like signature and the “mixed” signature are near diesel tanks. If the pattern of inferred association does not hold then another mechanism to explain the distribution of mixed composition is likely. An alternative is that different product types were mixed to aid in mobility and/or other characteristics needed to enhance the mixture’s use as a fuel. Another alternative is that mixing was a consequence of using a relatively lighter molecular weight petroleum product as a solvent for cleaning heavy oil from metal parts or for mobilizing heavy oil for disposal from other surfaces.

The text (page 12) states: “...a grab sample of oil/Bunker C NAPL was collected from a temporary well installed in soil boring (and LIF) location TG-D4 (Figure 8) and submitted to PTS Laboratories (PTS) of California for analysis...”
“The NAPL sample from location TG-D4 had a reported density of 0.9672 grams per cubic centimeter (g/cc), which is less than that of water (1g/cc); therefore, the sample is classified as an LNAPL. The results from the LNAPL mobility testing indicate that LNAPL in TG-D6 is mobile under static conditions...”.

According to the chain of custody, this sample was not kept cool for transit and was received by the lab at a temperature of 73° F. The NAPL sample was also a composite sample according to the chain of custody. Therefore, the representativeness of the results listed in the parameters analysis may be suspect. Discuss the validity of the results obtained from this fluid sample in regard to the sample handling protocol.

The LIF callouts for logs, TG-D4 and TG-D6 suggest blended mixtures of petroleum hydrocarbons. In contrast, the callouts for the LIF profile at F2 suggests a mixture that appears to be more diesel-like. I note that a closer look at the LIF profiles of these logs as well as the remainder of all of the LIF logs does not reveal readily apparent vertical variations that might be expected due to density differences consequent of composition. Weathering of what might be termed an earlier release, deeper in the profile, is also not readily apparent. There does appear to be some variation in the presumed blended mixture composition as seen in changes in the fill color but this difference may be difficult to provide information useful in informing a potential remedy due to the difficulty of collecting appropriate co-located samples for chemical analysis. What is more apparent is the variation in the height of the blue channel which may be indicative of backscatter of the fluorescence signal caused by matrix properties usually being more fine-grained and/or by low PFS.

The text (pages 11-12) states: “LIF logs and data cluster plots...were reviewed by KJ, in consultation with Dakota Technologies, to qualitatively evaluate whether the LIF data presented no LNAPL impacts, diesel-like LNAPL, oil/Bunker C-like LNAPL, or a mixture of fuels. Furthermore, the percent reference emitter (%RE) data were qualitatively evaluated with respect to field observations to assess whether the LIF responses were indicative of mobile LNAPL or residual total petroleum hydrocarbons (TPH) being potentially present.” “Evaluation of the above data suggests that an LIF response less than 20 %RE indicates residual TPH and/or LNAPL are not present..., an LIF response between 20 %RE and 60 %RE indicates that residual TPH is likely present ..., and an LIF response of above 60 %RE indicates a location where potentially mobile LNAPL is suspected to be present...”

I disagree with the cutoff values for the reasons stated in various comments above. The major disagreement is using a single set of cutoff values under the assumption that the product composition is the similar enough throughout the site and the formation matrix is homogeneous. State that Ecology has not accepted the cutoff values without further review.

“Reference emitter responses and NAPL mobility vary based on multiple factors. Therefore, the %RE values are used as a guide for interpretation of relative NAPL quantities in the vicinity of the probe. As such, the %RE reference ranges developed for this site may not consistently indicate residual NAPL is mobile.”

The NAPL footprints should be depicted conservatively, i.e., larger, since the NAPL source zone serves as a source for dissolved-phase impacts depending on mixture composition and degree of weathering. In addition, depiction only of the NAPL footprint does not convey the spatial extent of the NAPL bodies which is reflective of the release location, geology, and the product characteristics including any product blending that may have occurred.

The text (page 12) states: “Additionally, three soil cores (D6-30/32, F2-34.3/36.3, and F6-28/30) were collected...and submitted to PTS for mobility analysis.” “The results of the analyses are included in Table 23 (LNAPL properties), Table 24 (mobility testing) and Appendix F.”

Table 23 shows fluid physical properties for NAPL collected at TG-D4, OHM-1, OHM-2 and OHM-3, not for locations D6, F2 and F6. Please correct this for clarification.

Comment 22. Same section: Please explain why pilot borings were drilled in the proposed locations of the OHM wells. Was it basically to supplement the LIF data and if so, in what way?

Also, in the appropriate subsection, add information about the underdrain and any outfalls from the facility and/or any outfalls from the town of Wishram that crossed through the facility grounds. The information to be included in the report about the underdrain should consist of its investigation and subsequent findings including any actions taken.

Comment 23. Section 2.2.3, Cultural Resource Monitoring: State that Ecology performed government-to-government consultation with the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Confederated Tribes of Warm Springs.

Comment 24. Section 2.2.4.1, Cleanup Levels: Previous reports compared the contaminant concentrations to the Method A soil cleanup levels for industrial properties. Precluding conditions may exist which will lead to Ecology's rejection of industrial soil cleanup levels. Decisions regarding this position will be made at Ecology's discretion as provided for under MTCA.

Establishment of the cleanup standards requires the evaluation of the reasonable maximum exposures. Add that cleanup standards (cleanup levels and points of compliance) will be determined during the Feasibility Study (FS) stage and stated in the FS report after the reasonable maximum exposures are established.

Comment 25. Section 2.2.5.1, Soil Sampling: The text states, "*The direct-push rig was also used to advance pilot holes for six deep monitoring wells...*"

What was the purpose of drilling pilot holes for the deep monitoring wells?

Comment 26. Section 2.2.5.2, Reconnaissance Groundwater Sampling: Groundwater samples collected from temporary wells are generally considered screening level quality and may not suffice for MTCA compliance purposes where groundwater contamination is detected. Ecology requires a properly constructed monitoring well to provide representative groundwater samples to evaluate the soil leaching to groundwater pathway.

Per WAC 173-340-720(9), "*Analyses shall be conducted on unfiltered ground water samples, unless it can be demonstrated that a filtered sample provides a more representative measure of ground water quality.*"

Filtering may be acceptable for naturally occurring inorganic substances if the conditions described in subsection 720(9) are met. For instance, when claiming contribution from natural background concentration of inorganic substances in the aquifer material, a monitoring well shall be constructed. Construct monitoring wells as required in those areas where existing monitoring well coverage is insufficient to sufficiently evaluate metals contamination. This includes the areas assessed by RGW that do not have monitoring wells sufficiently close in the vicinity.

RGW sample, B-16-10, had a total arsenic groundwater concentration of 151 ug/L while the MTCA Method A groundwater cleanup level is 5 ug/L. Vadose soil from this location also exceeded applicable Method A cleanup levels for cadmium, total chromium and barium. This is concerning since this location near the former repair shop and turntable is about 30 feet from the former water well #3. The indication that metals above MTCA compliance levels are present in the soil column at this location may present a risk and warrant further investigation. Petroleum hydrocarbons were not detected in soil from the sample depth above the water table. The reconnaissance groundwater (RGW) concentrations of combined DRO and ORO, as total petroleum hydrocarbons, yields a value of 619 ug/L. With the exception of lead and arsenic, the dissolved phase concentrations of the other metals in the RGW sample were not assessed.

RGW sample, B-18-17, had the highest detection of dissolved arsenic at 15.5 ug/L with the groundwater CUL at 5 ug/L. This location is near a former repair shop that was sampled to assess the oil drain line from the engine house to the oil/water separator. Again, we are within about 30 feet from a former water well, well #2. Soil samples collected at two different depths did not show any total petroleum hydrocarbons above the detection limit. The RGW sample exhibited a TPH concentration of 552 ug/L. With the exception of lead and arsenic, the dissolved phase concentrations of the other metals in the RGW sample were not assessed.

Groundwater sample, B-16-23, exhibited a high concentration of total lead at the former wash & locker room associated with the engine house. The concentration at 4530 ug/L is over two orders of magnitude (OoM) greater than the groundwater CUL. A soil sample obtained above the water table did not show any TPH above detection limits. The RGW sample showed a TPH concentration at 528 ug/L.

Soil samples were collected at location WSB-2; which is near the “boneyard” of the current maintenance building north of the mainline tracks. There were two depths of sampling, one within the vadose zone and the other from the saturated zone. The soil sample collected at 8 feet bgs exceeded for total lead at 387 mg/Kg. In that same sample, barium was found at 6,500 mg/kg, which is below the soil CUL but appears elevated. Total arsenic was found at a concentration below the soil CUL. Gasoline was not assessed at this location however the soil samples were analyzed for DRO and ORO. The combined TPH values ranged from 11,610 (8 ft bgs) to 26,200 mg/kg (20 ft bgs). Benzene was not detected in either soil sample but other VOCs were found. The soil sample collected within the saturated zone at 14 feet bgs had the highest reported concentration for naphthalene at 23.8 mg/kg. The combination of contaminants found at this location and their concentrations suggest that the metals may be associated with petroleum hydrocarbon releases such as diesel and leaded gasoline.

A vadose zone soil sample collected at 10 feet bgs at WSB-4-30 failed the TCLP waste profiling for barium. This sample exhibited detections of VOCs but TPH was below detection limits.

This location is between the former Caloil tank and the former powerhouse, and near the LIF borings, CR2 and CR3. Based on the above findings, the distribution of metals requires further evaluation.

Comment 27. Section 2.2.5.3, Monitoring Well Installation: The RI Work Plan called for the use of 4-inch diameter stainless steel casing and 0.040-inch machine-slotted screen for all of the oil head monitoring (OHM) wells. However, only OHM-4 was completed with stainless steel material. Heaving sand was given as the reason for the deviation; however, that condition would apply to either type of well construction material that exhibits the same slot size. I see no reason why you replaced the stainless steel with PVC. Typically, the driller mitigates heaving sand conditions by pouring clean water into the casing to weigh it down and keep it in place during removal of the drill casing. Presumably, the stainless steel would also have weighed more than the PVC material. State that the well construction with schedule 40 PVC is a deviation from the RI Work Plan.

Comment 28. Section 2.2.5.5, Groundwater and LNAPL Level Gauging: The text states: “A specific gravity of 0.85 was used for LNAPL detected in the Maintenance Shop area (vicinity of wells WMW-7 and WMW-8).”

State the rationale for using a value of 0.85. Is this a table value or is this value based on fluid properties determined from a NAPL sample obtained from any of these wells? If the latter, then list the values of the fluid properties obtained from the NAPL samples.

The text states: “*The reduction in apparent LNAPL thicknesses in these wells is attributable to the performance of the bioventing system in the vicinity of wells WMW-07 and WMW-08 and natural source zone depletion.*”

The effectiveness of bioventing is limited by mass transfer considerations in the vadose zone. Likewise, natural source zone depletion (NSZD), which is a function of volatilization and biodegradation, is likely influenced by mass transfer limitations. What empirical evidence exists to support your conclusion other than inference by anecdote? Have you modeled the depletion and/or degradation rate? If so, provide this information as a line of evidence to help support your conclusion.

There is a competing explanation under some cases in which depletion and/or degradation is not the main mode of action. Under an unconfined hydrologic condition, an apparent reduction in in-well NAPL thickness can be caused by an increase in water level and persistence of that high-water level. Conversely, an opposite effect is observed with in-well NAPL thickness in association with water level under a confined hydrologic condition. In this respect, the in-well NAPL information obtained from a monitoring well should be supplemented with additional lines of evidence to support depletion and/or degradation as the mode of action.

Comment 29. Section 2.2.5.7, LNAPL Properties and Mobility Sampling: Do you have information to show that there are differences in fluid properties between the in-situ submerged NAPL and the in-well LNAPL consequent of the submerged NAPL? If so, please provide this information. If you did not collect this information, what information do you have to support using these fluid NAPL values as acceptable to apply to the submerged NAPL as well as to all of the in-well LNAPL found throughout the site?

Per API 4711, *Methods for Determining Inputs to Environmental Petroleum Hydrocarbon Mobility and Recovery Models*, the density of site water should be measured. The density measurement of water is significant since capillary pressure is a function of the difference in density between water and the product. Dissolved compounds both organic and inorganic can affect the water density. According to the chains of custody, it appears that only one sample of formation water was collected for measurement of water density. I question whether this one sample is representative. I note that the CoC shows that the water sample was collected at 18 feet bgs while the NAPL samples were collected from a depth of 40 feet bgs. This likely invalidates the applicability of the measurements of the water for determining the capillary pressure. Was the water density of that single sample used in the calculations or was the default value for water used for all of the calculations involving capillary pressure? In either case, the results generated using LDRM may be questionable. Please discuss the representativeness of the water sample.

Comment 30. Section 2.2.5.10, Bank Inspection: In the monthly reports, low water level was recorded as a condition possibly associated with the sheen appearance. The RI report (page 34) states that the typical water level fluctuation ranges from one to two feet daily. Furthermore, you state in Section 2.2.7.3, that the transducer graphs indicate consistent, short time span fluctuations in the losing/gaining condition throughout the year. Did you correlate the measured water level from the transducer time-series data to the timing of the sheen observations? If so, provide this information in the report. If not, can you extract this level of detail from the transducer data set?

Comment 31. Section 2.2.6, Site Geology: The text states: “*Field observations suggest three separate fill episodes occurred at the site, the dates of which are unknown.*”

Stratigraphic/sedimentologic patterns are significant since these features exert real world control on contaminant distribution and transport.

For example, cross-bedding can enhance vertical transport. Within the native, in-situ soil/sediment, did you observe any stratigraphic/sedimentological patterns? For instance, was cross-bedding observed in the in situ fluvial deposits and eolian deposits? Which features in microscopy suggest eolian origin?

Some of the soil boring logs show a repeated pattern of depositional events characterized by sets of fining-upwards sequences.

The EC log information also suggests the interbedded nature of the stratigraphic sequence in portions of the uplands subsurface. Discuss the influence of depositional facies on contaminant fate and transport.

Comment 32. Section 2.2.7.4, Vertical Gradients Evaluation: You describe the trend in the vertical hydraulic head gradient. For instance, you state that the data from particular shoreline transect well pairs most frequently displayed upward gradients while another transect well pair displayed downward gradients more frequently than upward. What is the significance of this pattern to contaminant transport and fate?

What explanations would you provide that describe the temporal and spatial patterns of vertical gradient among the well network? For instance, observe the April and November events in 2017 and 2018. The direction of the vertical gradient has fluctuated at a given monitoring locations seasonally as well as annually among all of the well pairs along the shoreline transect. Have you compared the patterns in vertical hydraulic gradient for correlation to patterns of changes in lake level elevation and precipitation? If so, provide this information.

Comment 33. Section 2.2.8.1, Former Water Supply Wells: State that the presence of former water supply well #1 was known in 2005 (Section 4.4, Remediation Work Plan dated June 2005) and possibly as early as 1974 when the water right claim transferred from the Spokane, Portland and Seattle (SPS) Railway to BNSF Railway Company. The Ecology, Water Resources Section online tool, the Water Resources Explorer, shows records including the certificates of ground water right filed initially by SPS and the water right claims by BNSF. Figure 1 of the Remediation Work Plan (2005) also displays the location of the referenced water supply well. Per that work plan, the water well was to be decommissioned but no well log was filed with Ecology's Water Resources Section to verify that decommissioning occurred. Therefore, this well was likely destroyed or buried rather than properly decommissioned. Provide information that this well was properly decommissioned.

For the remaining former water supply wells, Ecology requires a determination from the Ecology well coordinator on whether these former water supply wells were suitably decommissioned. Did you communicate with the Water Resources well coordinator for Central Regional Office? If not, please seek an opinion on whether the former water supply wells were sufficiently decommissioned and provide confirmation of that determination in the report.

The text states: *“Based on these multiple unsuccessful attempts to locate former water supply well #1, it is assumed that the well casing for the former well is no longer present.”*

Since former water supply well #1 was never located, we cannot safely presume that the well was suitably decommissioned per WAC 173-160, Minimum Functional Standards for Construction and Maintenance of Wells.

Ecology is concerned since the original well casing had been damaged such that shallow contamination was reported to have entered the well. The portion of the damaged casing may have been as deep as 35 feet bgs. Note that the SPS company correspondence does not record any expenditure for neat cement, bentonite grout or other sealing material to be used to decommission the well. Despite their meticulous accounting, there is no line item for expenditure related to sealing materials to decommission this well. As such, former water supply well #1 remains a potential conduit for contamination of potable water in the basalt aquifer. State this information in the report.

The draft report also states that Well #3 appears to have be filled-in with sand and gravel, which are materials that are not suitable for properly decommissioning water supply wells. In any event, evidence of proper decommissioning is required due to the presence of contaminants found proximate to these two wells.

Comment 34. Section 2.2.8.1.3, Wellhead Protection Zones: The text states: *“However, the three onsite water supply wells are not included in the wellhead protection zones for PWS wells.”*

“However, available information for the former onsite water supply wells suggest that these three wells were completed as unscreened open holes at approximately the same elevation as the screened interval of the 2017 municipal water supply well. As such, the onsite water supply wells are likely completed in the same aquifer as the local municipal water supply.”

These two statements are concerning since the former water supply wells are preferential flow pathways for vertical entry into more permeable zones in the deeper strata and possibly provide access for lateral transport to receptors, especially given the presence of recalcitrant contaminants. The USGS Circular 1385, *Factors Affecting Public-Supply-Well Vulnerability to Contamination: Understanding Observed Water Quality and Anticipating Future Water Quality*, discusses the problem of how preferential flow pathways can influence drinking water quality. Abandoned wells, though non-pumping, can act as hydraulic short-circuits to allow water and contaminants to move across confining units that normally function to restrict flow.

Little or no evaluation was performed to demonstrate that the drinking water in the basalt aquifer is not impacted by the abandoned water supply wells. At a minimum, you must provide other lines of evidence if it cannot be shown that the former water supply wells were properly decommissioned.

Comment 35. Section 2.2.8.2, Inundated Lands Investigation: Ecology has commented on the draft Inundated Lands Investigation Report. These comments may affect the interpretation of the investigation results. Changes in the Inundated Lands report should be reflected in this section as well.

Comment 36. Section 2.3.2, Field Screening Observations: The text states: “...and in some cases, the LNAPL was qualitatively characterized as residual or drainable.”

Did you perform a sheen test in addition to the field observation of whether the LNAPL in the sample was described as residual or drainable?

Comment 37. Section 2.3.3.1, Soil Laboratory Results: Some relevant information is lost in the manner by which the results are summarized in the bullet points. For instance, the text states: “*The highest reported concentration in a sample prepared with SGC was 52,000 mg/kg (boring B-12-11 at 35 feet bgs).*”

The combined TPH result for sample, B-12-11, is 113,000 mg/Kg. This sample location is between the former wash rack area and the wrecker shed, near the heavy oil distribution line from the Bunker C above ground storage tank (AST) to the fueling track. This sample location is also between OHM-2 and OHM-3.

Show the combined TPH results in addition to the TPH results reported as two separate categories of diesel range organics (DRO) and oil range organics (ORO).

The text states: “*The highest reported concentration of ORO in a sample analyzed without SGC was 3,790 mg/kg (boring B-18-03 at 2.0 to 2.5 ft bgs).*”

The combined TPH soil concentration is 4,780 mg/kg. This is significant since the sample location is the engine house but the sample was collected from the air-knifed cuttings as shown on the boring log. At WMW-26 the nearest monitoring well to B-18-03, the aqueous phase combined TPH concentrations ranged from about 1900 to 2500 ug/L. The comparison of the analytical results with and without SGC suggests entrainment of NAPL in the groundwater sample. However, this interpretation is inconsistent with the soil-boring log, which does not show soil TPH at WMW-26. MW-26 is situated approximately 50 feet to the southeast of B-18-03. Sample B-18-03 also had the highest reported total chromium concentration in soil at 28.8 mg/kg compared to the MTCA Method A CUL at 19/2000 mg/kg, chromium VI and chromium III, respectively. Metal speciation of the total chromium was not performed on the soil sample. Groundwater analysis of chromium in the RGW sample at B-18-03 was also not performed nor was analysis performed to evaluate chromium concentration at WMW-26. These findings support the installation of a monitoring well required to define the boundary of the dissolved phase plume at the north end of the engine house.

Regarding detections of gasoline, location B-12-3 exhibited a GRO concentration of 1,300 mg/kg for soil sampled at the water table depth. This particular sample location is situated near a former gasoline storage tank close to the west side of the powerhouse. In contrast, a number of locations showed notable detections of gasoline apart from the areas near the former gasoline UST/ASTs. B-12-2 is at the former oil sump at southern end of NAPL body near the east side of the Powerhouse.

Gasoline was found above MTCA Method A soil CULs in samples collected at 12.0 feet bgs and 40.0 feet bgs. LIF log, F7, is adjacent to that location and the LIF signature suggests a blended mixture of NAPL. Other locations where gasoline concentrations above MTCA Method A soil CULs was found at depth include B-12-4 and B-12-11. At B-12-4, gasoline was found at 40 feet bgs, which is a location near LIF log, D6. The LIF profile of NAPL suggests a blended mixture at D6.

This location is significant since the total thickness of the NAPL is approximately 70 feet and the blended nature of the heavy oil mixture may account for vertical transport of the maximum reported depth of NAPL, approximately 45 feet beneath the pre-1957 water table. Location B-12-11 showed a gasoline concentration of 1,100 mg/kg in a soil sample collected at 35.0 feet bgs. Benzene also exceeded at 0.14 mg/kg (soil CUL = 0.03 mg/kg). The combined TPH value for that location is 114,100 mg/kg (GRO, DRO, ORO). This location is near LIF log, B6. These findings suggest that sampling for gasoline should continue or be resumed at monitoring wells in their vicinity to continue to evaluate whether surface water may be impacted.

Recall that benzene concentrations above the MTCA Method A groundwater CULs (17.4 ug/L) were found at the location of decommissioned well, WMW-2, which was situated near the northeast corner of the powerhouse and adjacent to WSB-5. What is concerning is that the monitoring well log for WMW-2 and its associated soil boring log provides information contrary to what is reported on page 3-10 the Remediation Documentation Report dated March 2007. This report states that this well's screen was installed within a mass of oily timbers. This statement appears misleading since the monitoring well log records that the screen interval was installed in a gray, fine to medium sand. See the well log provided in Appendix A of the Site Assessment Report (2004).

The findings above together with the presence of gasoline found deeper in the sedimentary sequence suggest that sampling for gasoline and VOCs should be initiated, continue or resume at monitoring points in the vicinity including the wells that assess the deeper intervals. Note also at well pair, RMD-3 and WMW-17, that there may be a gap in coverage with the given screened intervals. Well RMD-3 is screened from 40 to 60 feet bgs while WMW-17 is screened from 12 to 27 feet bgs. However, gasoline was found at deeper depths ranging from 35 to 40 feet bgs.

Comment 38. Section 2.3.3.1, Reconnaissance Groundwater (RGW) Sample Results:

Location B-18-24 exhibited the highest groundwater concentration of DRO without SGC at 38,900 ug/L. This location also yielded the highest reported ORO concentration without SGC at 9,270 ug/L. The combined TPH groundwater concentration was 48,170 ug/L. Sheen was also observed in the groundwater sample.

The groundwater concentrations are consistent with the soil concentration, which exceeded MTCA Method A CULs for DRO (9,070 mg/kg without SGC) and naphthalene (19.7 mg/kg). This soil sample was collected at or just below the water table. Groundwater comparison samples with and without SGC were not collected. The determination based on these results is that monitoring well should be installed at this location.

A grab groundwater sample collected at 35 feet bgs at MWD-1 exhibited the highest reported groundwater DRO concentration with SGC (22,000 ug/L). This location also showed the highest reported groundwater concentration of ORO without SGC (4,400 ug/L) with a sample collected at 20 feet bgs. The combined TPH groundwater concentration at 20 feet bgs was 13,300 ug/L and 33,800 ug/L at 35 feet bgs. Groundwater comparison samples to evaluate the presence of entrained separate phase blebs were not collected.

Monitoring well WMW-11 is situated adjacent to MWD-1. The groundwater analytical results from WMW-11 are somewhat higher than at MWD-1 even though the WMW-11 samples were prepared with SGC. However, no pairs of results with and without SGC were collected to evaluate the potential non-dissolved bias.

Note that the well installation for WMW-11 did not include soil sampling although field screening was performed (see Appendix A, Groundwater Report dated September 2012). The soil boring log for WMW-11 shows that the highest ORO impacts occur at 20 feet bgs while the highest DRO impacts are seen at 35 feet bgs. However, WMW-11 is screened over a fifteen-foot interval from 7.0 to 22.0 feet bgs even though the PID readings showed that the highest readings occurred at the bottom of the boring along with a strong sheen. The well should have been deeper based on the PID screening and other field observations. This observation that the well should have been screened deeper also corresponds with the findings at MWD-1 regarding depth of contamination. These findings show that WMW-11 is improperly screened for assessment of petroleum hydrocarbons based on the subsurface data, especially given the information provided from WMD-1. For the reason stated above, the groundwater results from WMW-11 are not representative of the depth intervals where the greatest contamination has been detected. State this in the report.

Comment 39. Section 2.3.3.3.2, Reconnaissance Groundwater Results Summary: Some of the RGW samples indicate that additional monitoring wells will need to be installed for collection of representative groundwater samples required to fully evaluate the metals in groundwater.

The text states: “*Dissolved arsenic is likely influenced by site geochemistry in areas where carbon sources from TPH or the presence of the former Septic Drainage Field contribute to reducing conditions.*”

What specific evidence, e.g., geochemical data, do you cite to support this statement? For instance, the expectation that arsenic may be mobilized by the dissolution of iron oxides is not supported by data as recorded in Section 2.3.3.3.7, Natural Attenuation Parameters Evaluation.

Does the spatial distribution of the groundwater arsenic exceedances support this statement? For instance, do all areas where TPH exists show an elevated groundwater arsenic concentration? Likewise, the assumption of the reducing conditions in the Septic Drainage Field is anecdotal without any measurement of one of the following: fraction of organic carbon, total organic carbon or dissolved organic carbon. Granted, there were detections of organics as TPH in the septic field area; however, the majority of the areas across the site with comparable levels of TPH do not show elevated groundwater arsenic at the levels seen here.

Comment 40. Section 2.3.3.3.5, 2012 to 2018 Groundwater Monitoring Results: The text states: *“In these samples, the DRO concentration reported without SGC was 1.7 times the concentration reported with SGC, on average. The ORO concentration reported without SGC was 2.8 times the concentration reported with SGC, on average.”*

You provide an interpretation that the DRO groundwater results appear to be comparable with and without SGC sample preparation. However, I contend that a point comparison should be performed on a sufficient number of samples from specific monitoring points with and without SGC otherwise; a site-wide comparison is spurious.

The ORO results are somewhat higher without SGC however; this may be due to the presence of polar organic compounds, not related to degradation, such as those product compounds containing sulfur and nitrogen in the heavy oil. Again, comparisons should be made between samples with and without SGC at specific monitoring points. Indeed, Ecology Publication ECY-97-602, Analytical Methods for Petroleum Hydrocarbons, points out in Method NWTPH-Dx: *“It has been noted that some petroleum products, i.e. heavy fuel oils...or Bunker C, may experience a concentration loss of between 10 and 20 percent when subjected to this cleanup technique. This loss appears to be primarily associated with the removal of petroleum compounds, which contain sulfur. To account for this loss when analyzing samples that have been subjected to the cleanup procedure...the analyst must use utilize [sic] standards which have undergone the cleanup technique to calibrate the GC.”* To my knowledge, this issue concerning how to evaluate the weathering of heavy oil and how to assess the presence of petroleum degradates versus non-degrade polar compounds remains unresolved.

The text states: *“...the average ratio of total arsenic to dissolved arsenic was 1.03, indicating that the values for total and dissolved arsenic are very similar to each other and that arsenic is predominantly in the dissolved phase.”*

The ratio is very close to one so that indicates that a difference is nearly non-existent. You state that this pattern is also holds for barium (average ratio of 1.00), chromium (average ratio of 1.03), and selenium (average ratio of 1.03). However, I do not interpret this comparison as sufficient to allow groundwater compliance based on dissolved metals rather, I see it as evidence against the case for evaluating solely based on the dissolved phase. Ecology will evaluate compliance based on total metals though you may continue to collect pairs of data for total and dissolved metals for submittal and future evaluation

“The highest concentrations of total and dissolved arsenic reported were 35.5 and 37 ug/L respectively, both reported in WMW-24 on 30 August 2018.”

This boring location is at the former wash rack near the engine house. Note that this monitoring well sample is unlike the RGW samples collected from temporary wells. Here, the comparison results do not show much difference between the total and dissolved metal concentrations. In contrast to the RGW samples, the monitoring well sample is considered representative of the groundwater.

“Dissolved arsenic is likely influenced by site geochemistry in areas where carbon sources from TPH or the presence of residual organics in the former Septic Drainage Field contribute reducing conditions.”

This statement has been repeatedly stated throughout the report without sufficient supporting evidence collected from monitoring wells. The evidence, at most, is anecdotal. Appendix B-2 presents some geochemical parameters of the RGS samples from the septic field. I note that the only soil samples collected in the Septic Field area were limited to the vadose zone while saturated zone soil samples were not collected. Collect more geochemical groundwater data from monitoring wells and provide other soil data to support this conclusion. For instance, collect soil samples in the septic field to analyze for soil f_{oc} .

I note that a limited number of groundwater samples were collected from the septic field to evaluate for DRO and ORO. The impetus for evaluating the septic field was the presence of two waste oil lines from the engine house that drained either to the septic field or to the sewer outfall at pump house #1. See Appendix A of the draft RI report, diagram labeled as Station Layout, dated December 1959. Samples collected at B-18-26 and B-18-28 show detections of DRO and ORO. The combined TPH results at both locations exceeded MTCA Method A groundwater CULs. B-18-30 had detection of DRO at 427 ug/L, which is near the compliance limit of 500 ug/L. The groundwater analyses were performed without SGC and perhaps using that method may reduce the concentrations to compliance. To petition for using SGC, collect pairs with and without SGC from a monitoring well for comparison of groundwater analytical results. In any event, the installation of monitoring wells at the septic field near these locations is warranted to demonstrate compliance with MTCA Method A groundwater CULs.

Groundwater analysis was also not performed to screen for and evaluate total arsenic in the RGW samples from the septic field. Monitoring wells installed to assess petroleum hydrocarbons for compliance will also be used to evaluate total arsenic and perform further evaluation of its presence at concentrations above Method A groundwater CULs. The results elsewhere on the site shows there is not much difference between the dissolved arsenic and the total arsenic concentrations throughout the site. However, in some instances, the dissolved arsenic concentration is greater than the total arsenic. The level of data at this point is inconclusive.

Comment 41. Section 2.3.3.3.6, Monitoring Well Results Summary: According to Figure 8, boring locations, WMD-1 and WMW-1, are situated approximately 100 feet apart, contrary to what is stated in this section. Is WMW-1 a typographic error that should have read WMW-11?

Comment 42. Section 2.3.3.3.7, Natural Attenuation Parameters Evaluation: Provide other lines of evidence besides the collection of geochemical parameters for evaluation of natural attenuation. These lines of evidence should be consistent with the Ecology document, *Guidance on Remediation of Petroleum-Contaminated Ground Water by Natural Attenuation* (ECY Publ. No. 05-09-091).

The text states: “*Due to the disturbance of the soil and groundwater...DO concentrations...may not be the best representation of geochemistry at these locations.*”

Provide a table that shows all of the geochemical parameters collected and incorporate details for a more complete initial evaluation of these parameters. This information together with additional analysis and interpretation should form part of the FS.

In a natural attenuation scenario, we have to make a distinction between the diesel and the heavy oil since the diesel more likely to undergo natural attenuation. This situation may require more narrowly screened wells for compliance purposes so that the effects of flow averaging do not mask natural attenuation.

Comment 43. Section 2.3.3.4, LNAPL Testing Results: The LDRM manual states that the LNAPL samples for assessing physical properties should be collected separately from the samples collected for LNAPL mobility analysis. However, a question is whether, due to the mixed nature of the submerged NAPL, the in-well LNAPL mass is representative of the in-situ submerged NAPL. Should we see a difference also if there is time for the volatiles to escape from a sample if the temperature is not sufficiently cool?

In addition, as explained in Volume 2, User and Parameter Selection Guide, scale issues may exist if hydrogeologic parameters are based solely on the lab testing of small volume core samples.

As such, the measured multiphase parameters are best viewed as a reasonable starting point that may require adjustment to more closely resemble field conditions. As such, comparison should be made between the field-derived values for transmissivity versus the calculated values for transmissivity.

Comment 44. Section 2.3.3.4.1, Terminology: NAPL mobility is a function of various factors including substrate matrix properties, e.g., grain size and permeability, and product characteristics, e.g., composition and weathering. For this reason, residual saturation is best represented as a range rather than a single value. Under MTCA, Ecology does not specifically distinguish NAPL categories as defined by ITRC as being relevant for meeting compliance given that NAPL source mass can lead to cross contamination of other media, which is prohibited under the regulation.

I also note that the NAPL footprint is a rather simple projection of the lateral extent of contamination. A better depiction of the NAPL takes into account the lateral and vertical shape of the NAPL bodies and their distribution with regard to flux and storage zones.

Comment 45. Section 2.3.3.4.2, Fluid Physical Properties: The text states: *“While the LNAPL density is less than water, the majority of the LNAPL beneath the site is submerged below the water table because of its high viscosity at site temperatures and the rapid change in groundwater levels due to the increase in surface water elevation of the Columbia River....”*.

I hypothesize that the reason we don't see more LNAPL in monitoring wells is that the outer edges of the heavy oil mixture bodies are weathered. It is when you penetrate through the weathered surface and into the interior of the NAPL mass that you likely see separation of the majority of the LNAPL from the submerged NAPL body. However, there may be an expression at the water table of a diesel or diesel-like submerged NAPL that is exclusive of the submerged NAPL that consists of a blended heavy oil mixture.

Comment 46. Section 2.3.3.4.3, Soil Core and LNAPL Mobility Analyses: The text states: *“Grain size analysis classified the OHM-1 soil core as gravel with silt and sand.”*

What was the orientation of the subsamples obtained from the core samples? Were the circular sections cut so that their diameters were perpendicular to the long axis of the core or was the section cut so that its diameter was parallel to the long axis? The orientation is important since typically horizontal hydraulic conductivity (K_H) is greater than vertical hydraulic conductivity (K_V) due to the presence of sedimentary features such as bedding. Also, was the centrifugal force applied parallel to the original core length or perpendicular to that length? If perpendicular, then the NAPL mobility test is conducted parallel to bedding, thus measures “horizontal” mobility. State the cut orientation of the subsamples.

“Though visible LNAPL was observed in the soil boring for OHM-4 (Appendix B), the LNAPL mobility soil core testing results for OHM-4 as ‘immobile’ have been confirmed by absence of measurable apparent LNAPL thicknesses in the well since its installation in December 2016.”

The boring log for OHM-4 shows signs of NAPL at two depth intervals, one from approximately 11 feet (where sheen is present and the PID reading increases coincident with the water table) to about 13 feet (smear zone) and another in the saturated zone from 23 feet down to the bedrock contact at 25.4 feet bgs. However, the well is only screened from 20.4 to 25.4 feet bgs. This well should have been screened from about 10.4 feet to 25.4 feet bgs to capture NAPL since there appears to be two potentially mobile NAPL units or intervals. It is likely that the water table NAPL consists of a composition that more readily yields in-well NAPL thickness. The LIF log EO-W25 shows the thicknesses of two NAPL masses in profile, one that spans the smear zone at the water table and the other in the saturated zone approximately ten feet below the water table. This LIF profile is the closest one to OHM-4. What is shown in that profile is a line of evidence that may support what I state regarding the length of the screened interval as a contributing factor for in-well NAPL thickness.

“The inferred lateral extents of submerged oil and/or diesel impacts on Figure 19 (and Figures 9 to 14) is based on interpretation of LIF, soil borings, and LNAPL monitoring results and LNAPL mobility evaluation.”

The lateral extents shown in Figures 9 through 14 and Figure 19 are idealized estimates. The extent of the LNAPL that has fluid properties similar to diesel may be more dynamic with changing conditions such as fluctuations in groundwater elevation.

“The inferred LNAPL extent in the vicinity of LIF location EO-W25 has been reduced to the edge of well OHM-4 based on lack of LNAPL accumulating in the well and the LNAPL mobility testing results.”

See my discussion above regarding the screened interval for OHM-4. Also, even if the lack of LNAPL accumulating in the well is not an artifact of the specifics of well construction, the absence is not an indicator of dissolution of residual NAPL, which may still reside in the formation potentially as source mass for aqueous phase concentrations. The in-well LNAPL thickness only refers to the mobile portion of the NAPL proximate to the formation intersected by the screen and includes sorbed phase, residual phase, and separate phase NAPL.

NAPL dissolution is directly related to the mass transfer coefficient and the concentration gradient. The NAPL mass inferred to exist as shown in the LIF log is submerged in the saturated zone; it is not subject to the effects of natural source zone depletion (NSZD).

“These wells have not yet reached equilibrium, likely due to the high viscosity of the LNAPL, as the apparent LNAPL thicknesses continue to increase in the monitoring wells.”

Clarify what you mean by equilibrium. For instance, are you referring to the NAPL body with respect to the release(s), to the hydrologic conditions, and/or to the installation of a monitoring well through the NAPL body? This statement is misworded since wells do not reach equilibrium rather it refers to the formation NAPL following well installation. Equilibrium should refer to the formation fluids in contact with the screened interval of the wells.

Comment 47. Section 2.3.3.4.4, Light Non-Aqueous Phase Liquid Data Analysis and

Discussion: The text states: *“The model assumes homogeneity of the soil, vertical equilibrium of the LNAPL/groundwater system, a constant groundwater volume, and unconfined groundwater conditions.”*

What is the basis for holding the assumption that equilibrium conditions of the LNAPL/groundwater system dominate despite short-term changes in groundwater level and the variation in vertical gradient? Also, what is the magnitude of the effect of a vertical hydraulic gradient on the results?

The model assumes homogeneity of the soil. Does this assumption only apply to the parts of the aquifer where the mobile NAPL units exist? Does this assumption apply to the entire aquifer? If the latter, then observe the bimodal grain size distribution revealed by the grain size analysis for the OHM-1 core log including what is shown in the core photograph. This condition would potentially be a violation of the assumption of homogeneity.

The text states: *“Because of the extent of submerged LNAPL at the site, the API distribution and recovery model may underestimate the total LNAPL volume; however, the model is still appropriate for calculating the LNAPL transmissivity and LNAPL discharge rate.”*

Changes in wettability will have impact on the pressure-saturation relationship. These changes may be driven by the present of surfactants, organic acids, and bases. In situations, where the NAPL acts as a wetting fluid, LDRM will not successfully model NAPL recoverability. Is this situation likely given the petroleum hydrocarbon mixtures and biogeochemical conditions?

The text states: *“Because of the extent of submerged LNAPL at the site, the API distribution and recovery model may underestimate the total LNAPL volume, however, the model is still appropriate for calculating the LNAPL transmissivity and LNAPL discharge rate.”*

What alternate method of estimating LNAPL volume have you performed or can be performed to account for the majority of the NAPL mass?

According to Hawthorne (ANSR Vol 5, Issue 3, The Mobile NAPL Interval, Part 1: Unconfined LNAPL): “*Understanding the location and extent of mobile LNAPL is a critical element of the conceptual site model (CSM). Failure to understand the correct MNI will introduce error of unknown magnitude into numerical effects to analyze and predict the distribution, mass, mobility, and recoverability of the LNAPL.*”

Accordingly, page 38 of the LDRM manual states that the horizontal volume flux for the LNAPL layer may be calculated by integrating the LNAPL specific discharge over the mobile thickness of the layer. Did you identify and assess the mobile NAPL intervals throughout the vertical thickness of the stratigraphic sequence? Does the derivation of input for the LDRM require that the screened interval to straddle primarily the mobile NAPL interval?

Per Volume 2 of API Publication 4760 (LNAPL LDRM), it is suggested to compare the model results with field data to evaluate the assumptions on which the model is based. Include the comparison of values obtained from the baildown tests performed to determine field transmissivity to the calculated results from LDRM.

Since you received contradictory results for NAPL mobility based on the centrifuge method and the water drive, did you calculate the potential NAPL mass flux (dM_n/dt) and the pore velocity of NAPL (v_n) using field and laboratory data? The relevant equations are $dM_n/dt = Q_n \rho_n = K_n i_n A \rho_n$, and $v_n = K_n i_n / (nS)$, where K_n = NAPL hydraulic conductivity, i_n = net gradient in the field (hydraulic gradient and “gradient due to gravity”), A = the area of potential NAPL flow perpendicular to flow direction [L^2], ρ_n = NAPL density, n = porosity, and S = NAPL saturation..

Comment 48. Same section, Fluid Input Parameters: Table F1 is referred to repeatedly in this section. I did not see a Table F1 in Appendix F.

According to the chains-of-custody, fluid properties were determined using the in-well LNAPL samples while matrix properties such as porosity and other NAPL properties such as PFS were determined using the core samples. Might this approach lead to discrepancies caused by collecting NAPL samples that may be dissimilar since the core samples represent in situ conditions whereas the in-well NAPL represents the fraction that separated from the submerged NAPL? This represents a potential problem with the collection of samples at this site.

Comment 49. Same section, Light Non-Aqueous Phase Liquid Recovery Model

Recoverability: The estimated transmissivity applies to the LNAPL that was sourced from the submerged NAPL. Compare the transmissivity values estimated using LDRM to the transmissivity values obtained through field methods such as baildown testing. How do the results between the modeled and the field measured values compare?

You state in the text: *“Because of the extent of submerged LNAPL at the site, the API distribution and recovery model may underestimate the total LNAPL volume; however, the model is still appropriate for calculating the LNAPL transmissivity and LNAPL discharge rate.”*

What do you base your claim regarding use of LDRM as being appropriate for calculating the LNAPL transmissivity and LNAPL discharge rate given that more than one composition of NAPL exists? Also, discuss the uncertainties in the data output yielded by LDRM.

The text states: *“These transmissivity values are all much less than the ITRC threshold for practicable NAPL recoverability of 0.8 ft²/d.”*

This statement applies to the field conditions of a fluid to be recovered strictly by hydraulic recovery. NAPL transmissivity (T_{NAPL}) is a function of the NAPL hydraulic conductivity multiplied by the thickness of the mobile NAPL unit or interval. NAPL hydraulic conductivity (K_{NAPL}) can be enhanced by altering the viscosity or other properties of the fluid since K_{NAPL} is a function of the fluid properties and the matrix properties. In addition, as shown in Table 23, Summary of LNAPL Physical Properties, the dynamic viscosity varies by temperature and raising the temperature by 60 degrees F, decreases the viscosity by an order of magnitude and nearly by two orders of magnitude.

Hydraulic recovery only deals with physical recovery of separate phase product and thus does not address other steps to enhance NAPL dissolution into its aqueous phase which is more readily degraded.

The text states: *“Given the low estimated transmissivity and discharge rate, a long timeframe of 1,000 years was evaluated to demonstrate the minimal recovery that would be achieved through these technologies.”*

This statement refers to hydraulic recovery only, without taking into account additional steps to change the NAPL properties to increase recovery or to enhance NAPL dissolution. The Feasibility Study should include enough different remedial alternatives and components rather than be limited simply to relatively passive remedies such as bioventing and NSZD.

Comment 50. Section 2.3.3.5, Oil Sheen/Oil Droplets: The text states: *“These results indicate the oil sheen and oil droplets are comprised of petroleum hydrocarbons; however, their source is unknown.”*

Have the chromatograms been compared? The chromatograms are shown following Appendix E. The relative heights of the Unresolved Complex Mixture (UCM) hump can be compared to evaluate whether the product resembles a fresh diesel product or a weathered diesel product. A weathered diesel product will have a more pronounced UCM hump than what the fresh diesel chromatogram will show.

Consequently, fresh diesel sources may be discounted. In addition, if sufficient volume is obtained, forensics analysis may possibly be performed based on presence of recalcitrant biomarkers.

Comment 51. Section 2.4, RI Summary: Refer to Comment #11. Further evaluation of arsenic is required through the installation of monitoring wells to collect representative groundwater samples. Also, the statement concerning absence of ORO and DRO in the nearshore area is premature.

Regarding the groundwater flow conditions, the wording, “*back-and-forth surging*” implies a more vigorous dynamic system in terms of groundwater velocity and distance of travel than is warranted. Essentially, the dip of the slope of the hydraulic gradient is observed to alternate in direction yet the magnitude of that dip is often very slight. The reference to surging should be removed.

Figure 31a and 31b: These diagrams appear to show that certain wells are focal points depending on whether there is a losing stream condition or a gaining stream condition and that the patterns may be related to the vertical hydraulic gradient. On average, is the hydraulic gradient flatter during the losing stream condition versus the gaining stream condition?

The laboratory testing results are only one set of data regarding point values of residual saturation within the profile and is specific to the in-situ product mixture type of the submerged NAPL. Care must be taken to distinguish the applicability of the results to the different product mixture types:

- Known diesel LNAPL at the groundwater table near the diesel distribution line and pumphouse.
- Diesel-like LNAPL yielded from the heavy oil mixture of the submerged NAPL penetrated into the less weathered mass of the NAPL body
 - The presence of gasoline in the mixture suggests that the Bunker C was either “cut” with lighter petroleum hydrocarbons to produce a modified mixture, or alternatively
 - The presence of gasoline suggests its use as a solvent and application of that property during activities such as repair and maintenance.
- In-situ NAPL of the heavy oil mixture submerged NAPL

In addition to the caveats expressed above, the laboratory results should be compared to empirical data gained by running tests to derive the NAPL transmissivity. However, this type of testing is more applicable to the lighter-end petroleum hydrocarbons since its use is to evaluate the hydraulic recovery of the petroleum hydrocarbon as it applies in the field without any enhancements that may alter the properties of the petroleum mass.

Add a discussion of sheen monitoring and chemical analyses of sheen samples in comparison to analyses performed on upland samples. Discuss the comparison of the chromatograms and, if available, include analysis of biomarkers.

Comment 52. Section 3, Conceptual Site Model: The text states: *“The purpose of the RI was to investigate the nature and extent of compounds in soil and groundwater at the site and evaluate related fate and transport mechanisms.”*

Change the wording: *“...nature and extent of compounds in soil and groundwater at the site...”* to *“...nature and extent of potential contaminants of concern in soil and groundwater to define the site based on identified contaminants of concern...”*.

Discuss reasonable maximum exposure scenarios for actual and potential receptors including humans and ecological organisms to allow selection cleanup levels in support of a feasibility study.

Comment 53. Section 3.1.1, Petroleum Hydrocarbons: The text states: *“Limited documentation is available about historical releases of petroleum hydrocarbon products...”* and *“...when and where release(s) occurred or quantities potentially released...”*.

This is true; however, we can look at contaminant distribution spatially in association to proximity of various portions of the fuel distribution system, other storage tanks, and various process areas. We can couple that information with chemical data to make further inferences regarding the transport and fate of the released contaminants. As said earlier, the presence of gasoline in the heavy oil mixture suggests that lighter petroleum hydrocarbons were added to the heavy oil mixture sometime in the release process stream. This altered composition may have aided vertical transport by changes in the physical properties of the mixture.

The distillation step of the petroleum refining process for crude oil should have separated the lighter petroleum hydrocarbons fractions to leave the residual oil that form Bunker C. Consequently, the presence of the light distillate, gasoline, implies later addition to the mass, either pre-use or post-use as a fuel.

The text states: *“...site-related constituents and LNAPL have been identified in a layer of fill contained within the river sediment...”*.

This statement is not the final word on the contamination in the sediments since further work remains to be done.

Comment 54. Section 3.1.2, Arsenic: Have you performed a geochemical analysis to augment your interpretation regarding naturally occurring background?

Even given this presumed situation, detrimental effects resulting from the degradation of petroleum mass that liberates arsenic from a pre-existing parent material at levels above naturally occurring background is a condition that must be addressed for possible mitigation. A situation may exist where the groundwater concentrations of arsenic within the groundwater-surface water interface exceed the surface water standards per the designated uses of this portion of the Columbia River.

The suggestion that the septic field yields geochemical conditions conducive to dissolution of soil arsenic into groundwater has not been supported with sufficient evidence, e.g., through additional collection of soil samples to determine the soil organic carbon fraction (f_{oc}). What other lines of evidence are available to bolster your expanded claim based primarily on the spatial distribution of dissolved arsenic? The level of analysis for supporting your hypothesis seems rather selective rather than comprehensive in coverage.

Comment 55. Section 3.2, Fate and Transport: The text states: “...*residual petroleum hydrocarbons in shallow and subsurface soil are a potential secondary source in groundwater.*”

This wording should be changed to “*residual petroleum hydrocarbon NAPL in shallow and subsurface soil are a potential continuing source for aqueous-phase concentrations in groundwater.*” The NAPL source zone represents a primary source rather than a secondary source.

The text states: “*Consequently, potentially complete exposure routes for both human and ecological receptors exist for site soil and groundwater, and surface water adjacent to the site...*”.

State that the exposure routes are still being evaluated with regard to sediments and surface water.

The text states: “...*the Columbia River is a losing stream approximately 80 percent (10 months) of the year.*”

The gaining stream condition coincides with seasonal fluctuation in precipitation and/or snowmelt runoff. As such, the length of that condition may vary between comparative years depending on those factors as well as the lake storage requirements along the length of the river system.

The text states: “*Concentrations of arsenic in soil above MTCA Method A CULs have not been reported...*” and “...*arsenic concentrations...in groundwater...in areas where petroleum hydrocarbons and/or residual organics...create reducing groundwater conditions, resulting in transformation of naturally occurring arsenic in soil to dissolved phase*”.

I note that Table 1A indicates that TCLP was performed on soil samples for select metals including arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. The soil borings locations were WSB-04-30, WSB-04-31 and WSB-04-33. These samples were collected near the engine house in close proximity to the dissolved-phase petroleum hydrocarbon plume. However, only barium, lead and chromium were evaluated with TCLP. Arsenic was not evaluated as appears to be stated in Table 1A. Also, note that Table 4 of the 2004 Site Assessment report shows that TCLP was only performed on those samples that showed lower concentrations of these metals as opposed to those samples that exhibited higher concentrations of metals. This procedure calls into question the completeness of the TCLP evaluation.

Specifically, note that the TCLP procedure was not performed for arsenic although the levels of the soil arsenic were found to potentially exceed the maximum concentration of contaminants for the toxicity characteristic. See the Dangerous Waste Regulations, WAC 173-3-3-090(8)(c). State these three observations in the report.

In addition, I note that barium, lead and chromium were shown to be present at their highest concentrations in areas where Bunker C and/or diesel were released yet these locations with the highest metals concentrations were not assessed by TCLP procedure (Table 4, Site Assessment Report, 2004).

Arsenic is a metalloid that exhibits amphoteric behavior in that it can act as a base or as an acid. Therefore, arsenic is most stable under conditions in the middle of the pH scale especially if sulfur is present. Solubility and mobility increases at either of the pH scale above or below pH 7 under low ORP conditions. Geochemical parameters collected in 2004 show that groundwater pH ranged from 6.8 to 7.7 which is near the middle of the pH range.

Also, low redox potential (Eh) will dissolve iron hydroxides leading to liberation of arsenic. However, the Eh values for those samples ranged from 117 to 330 millivolts. Thus, these measurements of redox potential are problematic. (See SRNL-STI-2011-00459, *The Scenarios Approach to Attenuation-Based Remedies for Inorganic and Radionuclide Contaminants*).

In the septic field area, ORP was negative and the pH varied from 7.42 to 8.45. The geochemical parameters collected in this area also included dissolved oxygen but did not include analyses for Fe (II), sulfate, and methane for evaluation in conjunction with the dissolved oxygen measurements.

The text states: “*This assessment is also supported by the high viscosity of the LNAPL...*”.

With regard to NAPL mobility, does the assessment consider whether the LNAPL body has reached equilibrium in that despite its high viscosity the body may still yield very slow movement so that a stable NAPL body condition may take decades to reach?

Correct the reference to Figure 48. This should be Figure 47, Conceptual Site Model.

Comment 56. Section 3.3, Potential Exposure Pathways and Receptors: The text states: “...shallow site groundwater is also an incomplete exposure pathway...”.

Delete this wording. Communication of groundwater between the shallow saturated depth and the deeper saturated depth is possible through the preferential flow pathways potentially provided by the former water supply wells. The express intention of MCTA is to preserve and/or to restore the potability of groundwater regardless of whether it is a current source of drinking water or not.

Add discussion of terrestrial ecological receptors as well as aquatic receptors.

Comment 57. Section 3.3.1, Groundwater Use and Potability: This section does not mention the presence of three former water supply wells within the site boundary. The screened intervals of these wells extend down into the potable drinking water zones of the basalt aquifer. These former water supply wells exist as preferential flow pathways or conduits for aqueous phase contamination to travel vertically and laterally in bedrock fracture zones and/or permeable sedimentary interbeds depending on the pumping rate of current water wells and the nature of the contamination. State this information in the report.

The text states: “*The non-potable nature of the shallow groundwater beneath the site...*”.

Remove this wording. Ecology considers the shallow freshwater to be potable even if it is not a current source of drinking water. Our groundwater cleanup levels are based on protection of the highest beneficial use, i.e., a drinking water standard unless you can demonstrate a precluding factor that would lead to a designation of non-potability

Comment 58. Same section: The text states: “*Future potential exposures are anticipated to continue to be managed via railroad safety programs and other land use controls.*”

This statement refers more specifically to potential worker exposure and is a foregone conclusion that is premature at this point in the process. Replace this wording by stating that potential exposures will be addressed under the MTCA process after establishment of the cleanup standards and of the reasonable maximum exposure scenarios.

Comment 59. Section 3.3.2, Human Receptors: Describe what other human exposure pathways may occur in the river based on designated beneficial uses of the river. These human uses, including those protected by treaty, and potential exposures should be discussed in the same detail as upland exposure pathways since cleanup standards for groundwater, surface water, and sediments cannot be established until a complete reasonable maximum exposure scenario under MTCA is identified.

Comment 60. Section 3.3.3., Ecology Receptors: Potential impacts to aquatic receptors from contaminated surface water and sediments have yet to be assessed. Add bullets that refer to (1) exposure of aquatic organisms to sheen and surface water contaminants (2) exposure of aquatic organisms to contaminants in sediments. Identify potentially exposed ecological organisms that are associated with the site and the adjacent inundated lands and river.

Comment 61. Section 4, Conclusions and Recommendations: The text states: *“Based on the data and information collected...characterization of the nature and extent of constituents...of the site is complete.”*

Additional offshore characterization may require supplemental uplands investigation depending on the findings. As such, that statement is premature.

Comment 62. Section 4.1, Conclusions: These conclusions are subject to change based on Ecology’s comments on this draft document.

In the third main bullet, the text states: *“Evaluation of the gradients show the Columbia River is a losing stream for the majority of the year, with river water infiltrating beneath the site during these periods.”*

Does the latter part of this statement refer to a predominantly upwards vertical gradient? If so, is this generalization consistent with the data shown in Table 15 as well as in Figure 31?

In the fourth main bullet, state that the groundwater is potable unless demonstrated to be non-potable under MTCA and that contaminated groundwater will be restored to the drinking water standard by meeting the MTCA Method A groundwater cleanup levels.

In the sixth bullet point, postpone stating a conclusion with regard to the sheen until after the inundated lands and offshore investigation is complete.

Add a bullet point that the presence of PCBs in sediments has not been fully investigated and information obtained from the conclusion of the sediment investigation may require additional uplands work.

Comment 63. Section 4.2, Recommendations: Remove any statement regarding sufficiency of the investigation. Ecology disagrees since the sediments investigation has to conclude to determine if the uplands investigation is sufficient.

Remove the prescriptive portions of this section since it is unnecessary given that MTCA outlines the process to follow. What constitutes your recommendations should properly be addressed in the body of the Feasibility Study and/or the Draft Cleanup Action Plan.

Comment 64. Section 4.2.4, Inundated Lands Investigation: Integrate the findings of the Inundated Lands Investigation into the uplands RI once that investigation is complete. Final cleanup standards and remedies for the uplands cannot be selected until the offshore area is fully investigated and the sources and pathways to surface water and sediments are identified.

Comment 65. Table 23: Note that borings, OHM-1 and TG-D4, are located near each other. Yet, the viscosity of the fluid NAPL samples collected varied considerably. What accounts for the significant difference in fluid properties?

Comment 66. Figures 2 and 3: Add the appropriate identification numbers of the former water supply wells to the figures.

Figure 3 only: Note the location of former water supply well #2 in relation to a linear feature visible in Figure 1-2 of the Inundated Lands report. The trace of that feature, oriented roughly north south, near what is identified as a former well manhole in that figure appears to coincide with a feature described in a SPS correspondence dated January 16, 1926 as a bedrock fault (file name: 1926-1-16 ltr re Well 2 alternatives+Well 1 probs.pdf). Several lineaments, including faults, are visible in the general vicinity of Celilo Falls in aerial photographs, LiDAR images, and in the bathymetric images. Entry of petroleum hydrocarbon NAPL into rock fractures in the saturated zone is a function, not solely of viscosity, but of various factors such that the combination of factors leads to the exceedance of the pore entry pressure of the fracture. One determinant of NAPL pressure head is the height of the NAPL mass. Even with high viscosity, given sufficient pressure head and time NAPL may enter rock fractures and well screen slots.

Comment 67. Figure 21: In the legend, please describe what the blue dashed line represents. Also, note the elongated aqueous phase plume at the engine house and the lateral extension of the dissolved phase plume east from the main NAPL source zone to the shoreline reaching to the well pair, WMW-20/RMD-6. This lateral extension contradicts the expected aqueous phase contamination based on the hydraulic gradient and the flow direction of the Columbia River. In both cases, the elongation is perpendicular to the presumed groundwater flow direction. This suggests a contaminant distribution based on depositional patterns and permeability as the dominant control. Alternatively, are these distribution patterns an artifact of the limited points of observation?

Comment 68. Figure 27, Hydrogeologic Cross Section Transect H to H' (West): The cross section in Figure 22 shows that TG-CR-03 has inferred residual NAPL resident in the smear zone. However, Figure 27 does not show the presence of inferred residual NAPL in the smear zone for TG-CR-03. Please revise Figure 27 to depict the NAPL at CR-03. Also, CR-2 in this figure should show inferred residual TPH.

Comment 69. Figure 46, Conceptual Site Model (CSM) Plan View Map: Clarify that the yellow area refers to separate-phase product. Show the NAPL-impacted areas in the offshore area. Also, add the locations of all of the outfalls from the facility.