DEPARTMENT OF ECOLOGY
State of Washington

Occidental Chemical Corporation Feasibility Study Report, Agreed Order, and Related Documents

Responsiveness Summary

Ecology's response to stakeholder and public comments

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Hazardous Waste and Toxics Reduction Program

Washington State Department of Ecology

Olympia, Washington

Table of Contents

Executive summary

This Responsiveness Summary contains Ecology's responses to public comments about the draft Feasibility Study Report, draft Agreed Order (AO), and related technical documents for the Occidental Chemical Inc. (Occidental) cleanup site in Tacoma, Washington. The public comment period was held from January 27, 2017 to June 26, 2017.

Ecology thoroughly considered comments made by the public and stakeholders. Ecology reviewed the public-noticed documents in consideration of comments and concerns, and made appropriate changes. Additional evaluations were documented in technical memos that are attached to this document and are now part of the administrative record.

Ecology's decision is to approve the documents provided with the public notice, with revisions, as final for the administrative record. You will find the complete list of documents, including this Responsiveness Summary, on Ecology's Occidental Chemical Corp. website.[1]

In addition, Ecology and Occidental agreed to non-substantive changes to the draft AO that was included in the documents posted for public review. The changes updated the scope of work to reflect the current project status and to incorporate approved work plans as attachments.

This Responsiveness Summary document addresses each of the topic areas from the comments received. A list of commenters and an index of relevant responses is provided as an attachment. The following is a list of the topic areas:

- Human health concerns
- Ecological risk, protection and restoration
- The extent of the current and future contaminant plume
- Natural disasters and climate change
- Cleanup to the maximum extent practicable
- Paying for cleanup
- Cleanup technologies and options
- Addressing pH contamination
- Protecting workers and the environment during cleanup actions
- Impacts to and from neighboring projects
- Long-term monitoring and the cleanup process
- Public meeting and hearing practices

[1] https://fortress.wa.gov/ecy/gsp/Sitepage.aspx?csid=4326

Introduction

Ecology and the United States Environmental Protection Agency (EPA) continue to work with Occidental Chemical Corporation (Occidental) on an on-going basis to address environmental issues at the Occidental Site associated with former industrial operations located in Tacoma, Washington. Much of this work was performed under an Administrative Order on Consent (AOC) with EPA, Ecology, and Occidental. The AOC was amended in 2002 to recognize Ecology's oversight role under Washington State's cleanup law, the Model Toxics Control Act, Chapter 70.105D RCW (MTCA).[2] Ecology will be the sole oversight agency for the uplands cleanup, and plans to withdraw as a party to the AOC once the Agreed Order (AO) is signed.

As part of the cleanup process for historical contamination, Occidental produced a Remedial Investigation Report and Conceptual Site Model that Ecology made available for public comment and subsequently approved in 2016. The next phase of the project was compiled in a Feasibility Study (FS) and made available for public review in the first half of 2017. Ecology has now approved the FS, as amended, after receiving public comment.

The FS presents the evaluation of remedial alternatives to address the impacts from historical contamination from industrial operations found in groundwater, soil, and soil vapor. The various alternatives were developed by Occidental with the approval of Ecology. The list of feasible technologies developed in the FS have the potential to be effective given the nature and extent of the contamination in this technically challenging environment.

Also presented for public review was a draft AO between Ecology and Occidental. The AO requires Occidental to continue with the remedial action by working with Ecology to prepare a draft Cleanup Action Plan and to put in place a schedule for the next steps in preparing for cleanup. The AO was developed under Ecology's Corrective Action Program under the MTCA regulations. This new agreement between Ecology and Occidental lays out the schedule for a proposed cleanup action plan and implementation of baseline monitoring of the impacts of contamination. The AO was revised to make non-substantive changes after public review, to reflect the current status of the scope of work and include additional work plans that were originally anticipated to be follow-on documents but were instead finalized as exhibits to the AO.

EPA will continue to oversee impacts to sediments in the Hylebos Waterway and Commencement Bay from Occidental under existing administrative orders and as part of the Commencement Bay Nearshore-Tideflats (CB/NT) Superfund Records of Decision. Concerns

[2]www.ecology.wa.gov/MTCA

expressed in public comments that focused on the status of the CB/NT were referred by Ecology to Kristine Koch, EPA's Remedial Project Manager at EPA Region 10.

Background

The site is located on the eastern-most peninsula of Commencement Bay bounded on one side by the Hylebos Waterway and on the other side by the Blair Waterway. This area was created by dredging operations conducted over decades. Once dredging was complete, toward the end of the 1920's, industrial activities began in the area. These activities included chemical manufacturing and waste management from shipbuilding and military operations to support the war efforts for WWI and WWII. Occidental's predecessor company began operations in 1929, and the site was continuously used for industrial operations until 2005 when aboveground facilities were demolished. Operations primarily involved the production of chlorine and caustic soda, but during various timeframes involved the production of a number of other chemicals, including trichloroethene (TCE) and tetrachloroethene (PCE). Contamination from these operations was found in soil and groundwater at and near the property.

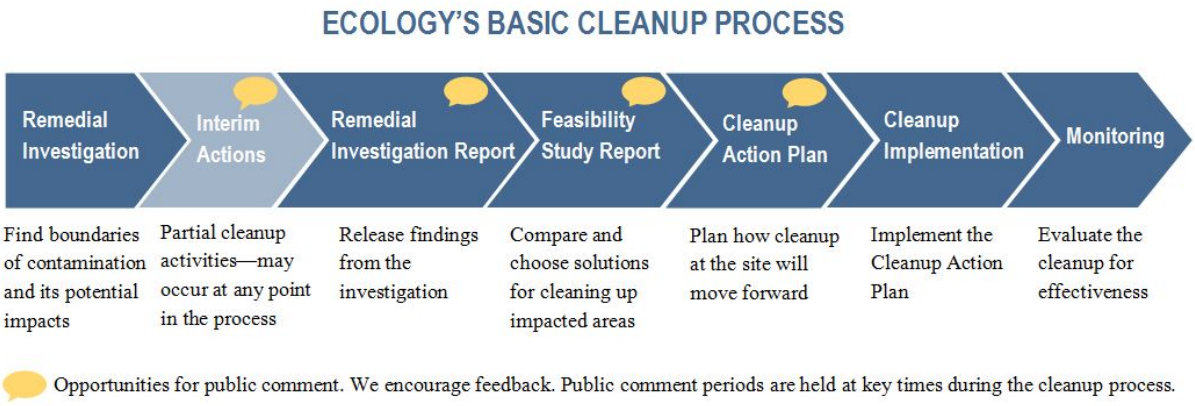
Ecology and EPA have been jointly overseeing the remedial activities under an AOC, with Occidental. The agencies have also been using federal and state laws to regulate the management and cleanup of hazardous wastes. Along with federal and state cleanup laws, the Resource Conservation and Recovery Act (RCRA) ensures safe management and disposal of hazardous waste generated nationwide. It also established a program to handle wastes safely from the moment they are generated to their final disposal, known as "cradle to grave." Owners and operators of waste treatment, storage, and/or disposal (TSD) facilities, such as Occidental, are required to submit a permit application covering all aspects of design, operation, maintenance, and closure of the facility. RCRA requires owners and operators of these facilities to clean up contamination resulting from *past* and *present* practices. This includes practices of previous owners. Washington has been delegated authority to regulate hazardous and dangerous wastes under both state law and RCRA. Cleanup of RCRA regulated facilities in Washington can be done under a Corrective Action Order, with review by EPA. These cleanup activities, known as corrective actions, are usually done after a facility closes with a closure permit. Ecology's preferred cleanup remedy will satisfy both state and federal law.

On November 16, 1988 Ecology and EPA jointly issued a permit for Occidental to store dangerous and hazardous waste at their facility. The permit stipulated how wastes stored at the facility were to be managed. When production ceased in 2002, the permit was re-issued to refer to a cleanup process in an amended AOC signed by EPA, Ecology, and Occidental. Occidental no longer stores dangerous wastes at the site and its permit does not allow the company to operate as a waste management facility at this location.

The cleanup process

The cleanup process has many phases. The first is to identify the nature and extent of contamination in a Remedial Investigation Report (RI). The RI, conditionally approved after a 2015-2016 public comment period, provides important information about how Occidental investigated contamination at the site in both soil and groundwater. It describes both historical sources of contamination and estimated amounts of released chemicals. The report also describes on-going sources of releases from the site. Maps in the report show the extent of a large groundwater plume that migrated, over decades, beyond the property boundary.

Following Ecology's conditional approval of the RI report, Occidental was required to study alternatives for how to address on-going sources of contamination and past releases of contamination. To evaluate options, Occidental was required to develop a Feasibility Study report (FS). The next phase of the cleanup will be the completion of a draft cleanup action plan.



Site contamination

The Occidental cleanup site is one of many along the Hylebos Waterway and within the CB/NT Superfund Site. There are hazardous substances in the groundwater, soil, and sediment throughout the Site. Contamination is from historical operations and waste disposal practices. Occidental and past owners and operators of the facility contributed to the contamination.

The primary contaminants from this site include:

- Chlorinated volatile organic compounds (CVOCs)
- Sodium hydroxide
- Salt (sodium chloride)
- Metals
- By-products of chlorinated solvent production
- Poly-chlorinated Biphenyls (PCB)

- Dioxins/furans

Soil contamination

CVOCs, hexachlorobenzene (HCB), PCBs, and metals are present in Site soil. CVOC and HCB impacts are found on Site and beneath the Hylebos Waterway. There are PCBs and metals impacts primarily along the embankment (bank of the Hylebos).

Groundwater contamination

Groundwater is contaminated with CVOCs, dense non-aqueous phase liquid (DNAPL) consisting of concentrated PCE and TCE, and elevated pH. The CVOC plume extends to the north from below the Site to the northern end of the peninsula and under Commencement Bay, and to the east below the Hylebos Waterway. The plume gets deeper as it extends away from the Site. The depth of the CVOC plume extends to 160 ft. below sea level.

The pH plume is mostly below the Site, but does extend to the north under the peninsula and to the west under the Hylebos Waterway. The depth of the pH plume extends to 100 ft. below sea level. Other contaminants including hexechlorobenzen (HCB), PCBs, and metals were found in groundwater, but in limited to small areas.

Proximity of the facility to the Hylebos Waterway poses unique challenges for measuring the contamination. Several studies were conducted over the years to attempt to understand the hydrogeology. Efforts over the past two years have focused on filling data gaps and supplementing data.

Documents for review during this public comment period

Draft Feasibility Study

The draft Feasibility Study (FS) develops remedial action goals, identifies remedies for contamination, and evaluates cost estimates for cleanup alternatives. All of the proposed alternatives will include institutional controls, groundwater use restrictions, and groundwater and soil vapor monitoring. An overview of the three cleanup alternative categories described in the FS report is provided below. All of these technologies require combining in various combinations in order to meet performance requirements as well as regulatory requirements.

Containment alternatives

- An asphalt cover over the Site
- A sheet pile vertical barrier wall adjacent to the Hylebos Waterway

- Variable amounts of groundwater extraction and treatment

Volatile organic compounds mass removal or reduction alternatives

- Extracting and treating groundwater
- Excavating shallow contaminated soils
- Treating soil contamination using heat
- Extracting soil vapor
- Treating groundwater using a chemical oxidant
- Treating groundwater using bioremediation

pH reduction/enhanced containment

The pH reduction/enhanced containment alternatives are designed to address high pH in groundwater and soil. These alternatives include in-situ treatment or containment of soil and groundwater. These alternatives would need to be combined with containment alternatives.

Additional documents

In addition to the draft FS report, we had other supporting documents available for review. Key documents on the list of materials provided for public review (posted on Ecology's Occidental Chemical Corp. website)[3] include the following:

Vapor intrusion memo and reports

Vapor intrusion occurs when gases from chemicals in the soil and groundwater enter buildings. Vapor intrusion can cause potentially unhealthy levels of hazardous substances in indoor air. Ecology reviewed Occidental's site vapor intrusion study and found significant vapor footprints below the former Occidental plant production area. There is also a significant vapor footprint from the solvent production settling ponds. Occidental's study and Ecology's memo about the study were available for public review and comment.

Sediment and porewater sampling results

In the summer of 2016, Occidental sampled sediment and porewater – the water in the small spaces between soil particles. The sampling was completed to collect data for the Occidental Site and to satisfy requirements of the Operations, Maintenance, and Monitoring Plan (OMPP) for the CB/NT Superfund site. Samples were taken in the Hylebos Waterway and Commencement Bay to see if any contamination from the groundwater plume was entering the water. The results show that there is one small area where contamination may enter the

[3] https://fortress.wa.gov/ecy/gsp/Sitepage.aspx?csid=4326

Hylebos, near the shore of the Occidental property. The proposed sheet pile wall will contain this area.

Reports on pH treatment

Examination of Silica Precipitation Gelation and Hydraulic Fouling at the OCC Site (Korshin and Benjamin January 23, 20.

Administrative decision documents

Also included for review were two documents with separate requirements for public notice and comment, the draft Agreed Order and the Dangerous Waste Corrective Action Permit. These documents often receive public review separately. Ecology determined that it would be appropriate to include them with the FS public review.

Draft Agreed Order

The AO is a legal document that requires Occidental to:

- Perform pumping tests to assist in evaluating the reliability and performance of hydraulic containment systems.
- Implement an approved monitoring program in advance of the remedy selection.
- Submit a draft Cleanup Action Plan.

Corrective Action Permit

This permit is an administrative document that incorporates the agreed order by reference. The permit provides a regulatory path for the EPA to step in and enforce the requirements of Ecology's AO if necessary. This type of permit is specific to current or former facilities that treated, disposed of, or stored dangerous waste under RCRA.

Public outreach and involvement

Informing the public about the comment period

Ecology followed its public participation plan[4] for this site, ensuring the public and stakeholders were informed about the public comment period for the draft FS, draft AO, and other supporting documents. Ecology extended the original 60-day public comment period twice in response to requests for extensions. The public was able to review the draft documents and provide comments for 120 days from January 29 to June 26, 2017. Ecology posted a public

[4] https://fortress.wa.gov/ecy/publications/SummaryPages/1504028

notice on Ecology's Occidental Chemical Corp. website,[5] public involvement calendar,[6] and Site Register.[7] Initial public notice was sent to 2,725 interested parties and 222 email addresses. Ecology published display ads in the Tacoma News Tribune on January 29, 2017 and in the Tacoma Weekly on January 27, February 10, and 24 and March 10, 2017.

In February, Ecology issued a press release and posted information on Twitter and Facebook in both English and Spanish. On March 1, 2017, Ecology sent a reminder postcard to the updated mailing list of 2,500 interested parties. This was an updated list based on public feedback, mainly duplicates needing to be deleted. In March, the public comment period was extended based on feedback from the public and the Puyallup Tribe of Indians. On March 7, 2017, Ecology sent an email to the 222 email addresses regarding the new due date for comments.

Public meetings

On March 8, 2017, Ecology hosted an open house and public hearing about this site at the Center at Norpoint in Tacoma. Handouts, display boards, and staff provided more information about the draft documents. Ecology staff gave a brief presentation followed by a question and answer session. Ecology collected public comments formally during the public hearing.

In addition to the public open house and hearing, Ecology presented to and met with several interested parties including:

- The Puyallup Tribal Council
- Puyallup Tribe's environmental staff
- City of Tacoma environmental staff
- Tacoma-Pierce County Health Department
- Citizens for a Healthy Bay
- Tacoma City Council Planning Commission
- Puyallup River Watershed Council
- Commencement Bay Natural Resource Trustees
- Port of Tacoma

These meetings allowed Ecology to engage with others about the complex process and shared goals when cleaning up properties burdened with historical contamination. Ecology appreciates the thoughtful contributions of the individuals and organizations who commented.

[5] https://fortress.wa.gov/ecy/gsp/Sitepage.aspx?csid=4326
[6] www.ecology.wa.gov/Events/Search/Listing
[7] www.ecology.wa.gov/contamination-cleanup/site-register

Reponses to comments

Ecology accepted comments from January 27, 2017 through June 26, 2017. It received 155 comments through email, letter, and oral testimony. This Responsiveness Summary consolidates comments that either ask the same question or express similar concerns. Ecology has carefully considered each public comment and responded to the comments consolidated according to major themes. Ecology's decision moving forward is to conditionally approve the FS with a number of edits and changes. Some of these edits shown in redline/strikeout format were already embedded in the documents when posted. The final FS with edits will be posted on our website at the same time this Responsiveness Summary is published.

Many comments are related not only to the Occidental Site, but also to the Commencement Bay/Nearshore Tideflats (CB/NT) Superfund site. The Occidental Site is one site of seven Operable Units (a Superfund-only term) that make up the CB/NT Superfund site. The CB/NT encompasses all of the waterways of Commencement Bay, the upland areas of the Bay, and the Asarco Smelter site. Where comments stray from the Occidental Site and address concerns about the CB/NT Ecology attempted to clarify the separation of the two projects. The responses provide general information when comments about the CB/NT overlap concerns about the impacts of the Occidental Site to Commencement Bay.

At the end of this document, you'll find a reference table showing who commented, who they represent, and the topic of their comments. Ecology sought to provide a complete and comprehensive response to each concern. Responses based on each major theme follow.

Human health concerns

Human health impacts continue to be a concern. The concerns people had were:

- Consuming fish and shellfish from the Hylebos and Commencement Bay
- Environmental justice concerns – that the contamination may disproportionately affect low-income people, immigrants, and people of color
- Potential contamination of drinking water
- Risks to people living nearby
- Risks to workers at nearby businesses
- Risks to workers during cleanup

Ecology heard these concerns during the RI public comment period and took steps to do an independent evaluation of human health risks. Our consultant, Ridolfi Environmental, looked at the current available data to assess the risk from potential exposure to humans from contamination. Their assessment was included in the RI Responsiveness Summary. Because human health risks continue to be a concern for members of the public and stakeholders,

Ecology has again attached the assessment in the appendices section of this document. Ecology also required Occidental to conduct a sediment and porewater study to see if any contamination from the groundwater plume was entering the water.

Ecology also revisited our evaluation of the vapor intrusion risk and potential for exposure above an acceptable human health standard. Ecology will be discussing an appropriate protective cleanup standard with Occidental as deliberate over the remedy selection.

The state's cleanup law, MTCA, requires cleanup actions to be evaluated and compared to each other for protectiveness, permanence, cost, effectiveness, management of short-term risk, implementability, and consideration of public concerns. MTCA requires that cleanup actions must protect human health and the environment by achieving cleanup levels within a reasonable restoration timeframe.

The following sections respond to specific health concerns.

Consuming fish and shellfish from Hylebos and Commencement Bay

Ecology heard from the public, during this comment period and the draft RI public comment period, that there are people who consume fish and shellfish (fishers) from the Hylebos waterway and Inner Commencement Bay. Occidental acknowledged the potential risk to fishers in its conceptual site model adopted into the RI Report.

Ecology continues to be concerned that people are consuming fish and shellfish from the Hylebos Waterway and Inner Commencement Bay. We reached out to Washington Department of Health (DOH), Tacoma-Pierce County Health Department, and Washington Department of Fish and Wildlife to learn more about fish and shellfish consumption in this area. DOH is the state agency tasked to monitor, establish, and update shellfish and fish consumption advisories, when necessary. Ecology recommends that all impacted parties heed consumption advisories. For more information about Puget Sound fish consumption, visit Washington Department of Health's Fish website[8] or read their *Puget Sound Fish Consumption Advice* newsletter.[9]

The Department of Health has determined that the following advisories are necessary for this area:

- Do not eat crab, shellfish, and bottom fish from Commencement Bay Waterways including the Hylebos Waterway.
- Limit flatfish to two servings per month for Inner Commencement Bay.

[8] www.doh.wa.gov/fish
[9] www.doh.wa.gov/Portals/1/Documents/Pubs/334-098.pdf

- Limit flatfish to one serving per week for Outer Commencement Bay (boundary between Boathouse Marina and Brown's Point).

PCBs and mercury are found in fish and shellfish tissue near the Occidental Site. These chemicals stay in animal tissues for a long time and build up in concentration as they move up the food chain. Volatile organic chemicals (VOCs) and semi-volatile organic chemicals (SVOCs) from solvents are the primary contaminants of concern from the Occidental Site and are not prompting the consumption advisories.

The Sediment and Porewater Study, also out for review during this comment period, was a response to continued concerns that contamination was in the shallow sediments where fish and shellfish live in the Hylebos Waterway and Commencement Bay. The data indicate that the Site is not currently a source of contaminants for the upper layers of the sediment (where biological activity occurs) and does not impact surface water of the Hylebos. However, the results showed there is still a small shallow groundwater source of contamination entering the Hylebos Waterway in or near the shoreline of the Occidental Site. Ecology plans to address this source when choosing the final remedy.

Environmental justice concerns

Commenters expressed concern about the disproportionate impact of contamination on low-income people, immigrants, and people of color. The Occidental Site is one of many sources of contamination in the Tacoma Tideflats. There are many cleanup sites and operating industrial facilities that contribute to the overall pollutant loading in the waterway and Commencement Bay. The presence of industries in the area is a legacy of history integral to pre- and post-WWI and WWII activities. The consequences of these activities include residual contamination the community continues to grapple with today.

Ecology's goals in cleanup and environmental restoration work include pollution prevention, promoting healthy communities, and protecting natural resources. We strive to ensure communities affected by cleanup sites are informed and engaged in our decision making process. This includes ADA accommodations, translated documents and interpretation services when appropriate, and multiple opportunities for engagement. We are continuing to broaden our outreach to communities that are disproportionately affected by contamination.

Impacts to tribal treaty rights

The Puyallup Tribe of Indians has treaty-reserved rights for taking fish and shellfish "at all usual and accustomed grounds and stations," including Commencement Bay and its surrounding watersheds. Ecology is committed to working with the Tribe on a government-to-government basis to protect treaty-reserved rights and resources. A goal of the cleanup at the Occidental

Site is to ensure that releases of contaminants from the Site do not preclude the safe use and consumption of aquatic resources.

Nearby wells

There were comments about the impacts of contamination on nearby drinking water wells and homes. Ecology heard similar concerns during the public comment period for the draft RI. Ecology has repeatedly looked into the potential for nearby wells to be impacted. Based on Ecology's Washington State Well Report database,[10] there are only remedial and industrial wells near the site contamination, and no drinking water wells. These wells are either used to pump out water to be used in industrial settings or to pump out contaminated groundwater to be treated. The groundwater related to this site has been deemed non-potable and unfit for human consumption.

The municipal water source is not impacted by this Site or by contamination within Commencement Bay in general. You can learn more about Tacoma's drinking water source at Tacoma Public Utilities Water Source website.[11] If you have a drinking water well we encourage you to visit Tacoma-Pierce County Health Department's Individual Wells website.[12]

Nearby homes

There were concerns about how the contamination may impact nearby homes. Ecology has researched the area to learn more about where people may live near the groundwater plume. The nearest homes are approximately 1-mile east on the bluff, across the Hylebos from the site, ¾ miles across the Hylebos to the northeast, and approximately 3-miles to the south. Ecology did not find any homes near the plume. The contamination is located in an area zoned for heavy industry and commercial purposes.

Nearby businesses

The Occidental Site is bounded on one side by the Hylebos Waterway, and on the opposite side by Alexander Avenue, referred to as "plant east" and "plant west", respectively. The north and south property boundaries on each side are currently shared with properties owned by the Port of Tacoma (Port).

The property to the south is currently leased to Puget Sound Energy by the Port. Relatively low levels of groundwater contamination from Occidental are found to have moved beyond the south property boundary. The embankment along the Hylebos Waterway also contains soils and other contaminated materials that were historically placed in fill. The embankment extends on to the Port's property along the shoreline. The contamination from Occidental extending

[10] https://fortress.wa.gov/ecy/waterresources/map/WCLSWebMap/default.aspx
[11] https://www.mytpu.org/tacomawater/water-source/
[12] https://www.tpchd.org/healthy-homes/drinking-water/individual-wells

beyond the south property boundary are part of the Occidental Site contamination and will be addressed by the Cleanup Action Plan (CAP).

The north property is occupied by a number of lease tenants in buildings that were built prior to purchase by the Port. Contamination beyond the north boundary from the Occidental Site extends to within the Port's property in the form of groundwater and soil vapor. Soil vapor is when residual hazardous chemicals in soil are released to air. Vapor can move through soils and intrude into buildings through unsealed foundations, cracks, or intentionally constructed vents.

Occidental conducted four rounds of air and vapor sampling activities from June-July 2013, March 2014, and May-June 2015 to assess air and vapor concentrations associated with nine buildings at and near the Occidental Site.

Based on the data, Occidental (GHD, 2016) concluded that two of the nine buildings, Building 595 (Trident Seafoods Warehouse) and the Occidental office, may be potentially impacted by vapor phase migration. Occidental proposed continued monitoring for Building 595 and limited mitigation (opening doors and windows) for the Occidental office as interim measures.

Ecology conducted a detailed review of these vapor intrusion studies. Ecology's findings are in part consistent with Occidental. However, it is also Ecology's opinion that the residual chlorinated solvent mass associated with the former production settling ponds poses a vapor intrusion risk and is a complete exposure pathway. Ecology's technical work on this issue resulted in a determination that Building 595 and the Occidental office building are at a continued risk of vapor intrusion. Ecology recommended more actions to reduce risk from vapor intrusion than that proposed by Occidental, and continues to push for more mitigation of buildings as well as on-going monitoring.

Occidental's investigations and reports were shared with the Port's environmental staff. Ecology discussed the vapor intrusion concerns on several occasions with Port representatives. More work is needed to make sure the Port and tenants are aware of the possible on-going impacts of vapor intrusion to buildings within the vapor footprint coming from Occidental's historical contamination. Ecology will be asking both Occidental and the Port to come up with a vapor intrusion plan that prevents short-term exposures of workers to TCE from vapor intrusion. Further work on pinpointing sources may be needed, and source control or removal measures will be addressed in the CAP.

Ecological risk, protection, and restoration

Several commenters expressed concerns about the potential effects of the Site on marine life in the surrounding waterways. Ecology shares these concerns. We also recognize that the health of the Bay is a bigger issue than one cleanup site. With the conditional approval of the FS,

Ecology is addressing the impacts of contamination with alternatives that contain or mitigate those impacts from the Occidental Site.

As the lead agency for the cleanup of the Bay, including the sediment, EPA will make its cleanup decisions based on area-wide surface water and sediment contamination. The bay-wide contamination will be addressed through ongoing efforts that are part of the CB/NT Superfund site. Ecology will continue to be involved in that effort.

Under federal cleanup law, EPA has investigated the CB/NT Superfund site for over 30 years. The investigations led to cleanups being conducted throughout Commencement Bay under a Record of Decision (ROD) with EPA. Many of the actions required under the ROD have been completed, and EPA continues to conduct 5-year reviews to monitor progress. The latest five-year review was completed in 2014.

Sediments in the Hylebos Waterway were remediated under two EPA actions, one for the Head of the Hylebos Waterway, and another for the Mouth of the Hylebos waterway. EPA will continue to monitor those sediments as part of the Operation and Maintenance Monitoring Plan for the site. In addition, EPA continues to evaluate the entire Commencement Bay as part of the required Five Year Review Process. The next review is scheduled for 2020. As part of this review, EPA has informed Ecology that it intends to conduct a fish study to determine the health of the fish in the Bay. Ecology will continue to engage with EPA regarding policy issues around the ecological health of Commencement Bay. You can learn more about EPA's role by visiting EPA's Commencement Bay/NearshoreTideflats website.[13]

Ecology continues work with EPA to monitor the sediments, surface water, and porewater that may be impacted by the Occidental Site.

Ecological impacts and requirements for cleanup at the Occidental site

Impacts to ecological resources in the Hylebos Waterway and Commencement Bay may potentially occur through exposure to contaminants in surface water, sediment, sediment porewater, or through the food chain. The primary pathway of Occidental Site contaminants to surface water and sediment is through groundwater entering surface water.

MTCA requires Ecology to establish cleanup levels that protect human health and the environment. In the draft CAP, Ecology is required to set cleanup levels that are based on surface water and sediment standards. These standards are protective of ecological resources and any potential human contact.

[13] https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=1000981

The contaminants most frequently found in groundwater at the Occidental Site, including volatile and semi-volatile organic chemicals, do not have state or federal water quality criteria or standards based on the protection of aquatic life. Although the cleanup levels will not be based on the protection of aquatic life, Ecology conducted a review of available scientific literature and determined that the human health criteria are also protective of aquatic organisms. Therefore, Ecology plans to set cleanup levels based on water quality standards for the protection of human health.

Concerns about current and future contaminant plume extent

Some comments expressed concern that the nature and extent of the contaminant plume has not been adequately characterized, as required by MTCA. Commenters also expressed concerned that there has not been data collected beneath Commencement Bay and that there are data gaps about how, or if, the plume will move in the future.

Ecology recognizes these concerns. There are uncertainties about how far the plume has moved beneath Commencement Bay to date but Ecology is confident that these uncertainties will not prevent the development, evaluation, and selection of cleanup alternatives. The physical and chemical processes that control how the plume moves beneath Commencement Bay are well known, as summarized in the attached memo, Addendum A, *Plume Movement beneath Commencement Bay (Joel Massmann)*. Recognizing and understanding these processes allows Ecology to adequately evaluate the cleanup alternatives included in the Feasibility Study in tandem with the information that we currently have.

In response to the concerns of stakeholders, Ecology staff recently completed an independent review and analysis of the groundwater and soil data using different tools. The contaminant plumes from this new evaluation are similar to the plumes shown in the Report and the draft FS. This additional evaluation supports the understanding of the plume based on the current model.

The contaminant plumes at the site were identified and described by Occidental after collecting and analyzing groundwater, soil, and sediment samples over 37 years, between 1979 and 2016. The plumes are shown in Figures 2.14 through 2.17 in the FS. The contaminants have moved in a pattern that is consistent with data that describe groundwater flow and Site geology. The movement is also consistent with predictions made with the computer model that simulates groundwater flow at the Site.

The contaminant plume moves northerly through the deep sediments and potentially underneath Commencement Bay. The plume in this area is over 100 feet below ground surface. Ecology has not verified that the plume enters the Bay with actual sampling data, but according

to models, if it does move into the Bay, it is likely to surface offshore and in very deep water. Ecology will consider obtaining additional data about the front edge of the plume as the parties move forward with groundwater monitoring plans and while evaluating the success of remedy implementation. With the approval of the FS our focus will first turn to selecting a remedy that contains, monitors, and removes contamination.

Impacts of natural disasters and climate change

Many people shared their concerns about how natural disasters may affect the contamination remaining underground or on an engineered remedy built at this Site. Some stakeholders also pointed out that climate change could pose potential problems for the Site in the long term. For a number of years, Ecology has been focusing on learning more about how these potential threats impact cleanup.

Ecology researched the potential natural disasters that may occur specific to this Site. The result of this research is a detailed memo attached to this Responsiveness Summary as Addendum C, *Summary of Potential Effects of Geologic Disasters on the Occidental Site Cleanup Project* (Seamus M^{c}Laughlin).

Like much of Washington, the Tacoma area is at risk of major geologic events like earthquakes, landslides, tsunamis, and lahar flows. These types of events have the potential to impede cleanup progress, but it is likely only earthquakes and landslides that would disturb the soil and groundwater contamination enough to cause significant movement of contamination.

Coastal Washington is not only vulnerable to chronic hazards such as erosion and flooding but is also subject to potential catastrophic hazards such as a Cascadia Subduction Zone earthquake and tsunami in which both will occur in tandem. To be effective, preparing for these disasters requires a full range of efforts and a comprehensive strategy. The Tacoma and Seattle fault zones are the two features most capable of producing earthquakes that could significantly affect the Tacoma area. Both fault zones produced approximately magnitude 7 earthquakes 1,000 – 1,100 years ago, and similar earthquakes are almost certain to occur in the future. A repeat of similar magnitude earthquakes today would cause significant shaking, liquefaction, landslides, and tsunamis that could inundate parts or all of the Site.

The main concern with worst-case scenario tsunami flooding is that it could significantly impact cleanup operations by damaging facilities such as the groundwater treatment plant and by depositing large volumes of sediment.

Subsurface movements that may occur with an earthquake at the Occidental Site have much greater potential to disturb and mobilize contaminants than tsunami flooding. Both landslides and earthquakes are capable of generating substantial subsurface movements. However, due

to the uncertainty about earthquakes in this region, it is difficult to predict how seismic activity will affect the Occidental Site.

Landslides are also capable of generating subsurface movements. To affect Occidental contaminants, landslide events would need to occur on or very close to the Site. Fortunately, onsite landslide risk is very low due to the location and position of the peninsula. Any landslides generated from slope failures on the east side of the Hylebos will likely be too far away to cause significant damage.

MTCA requires the permanence of cleanup options be considered when selecting a preferred alternative - this includes how a cleanup option would withstand natural disasters. During the design phase, where Ecology works with Occidental to design what the different parts of the cleanup will look like, Ecology will require consideration of potential natural disasters and their impacts. Occidental is also required to do emergency and pollution prevention planning as part of its National Pollutant Discharge Elimination System (NPDES) permit.

In addition to learning more about the geological risk for this site, Ecology also looked into broader emergency planning efforts in the Tacoma Tideflats area. For more information on these efforts, please visit the Pierce County's Emergency Management's website[14] and the City of Tacoma's Emergency Management website.[15] You can also learn more about how Ecology works with state and federal partners to coordinate program improvements and leverage resources to better support community needs on our Shoreline and Coastal Management Program's earthquake and tsunami webpage.[16]

The effects of climate change, notably sea level rise, on the Site were also a concern for many people. Ecology has recently developed guidance that outlines the climate change adaptation strategies to increase the resilience of remedies and sites statewide. For more information on developing cleanup remedies that are more resilient to the effects of climate change, please see Ecology's *Adaptation Strategies for Resilient Cleanup Remedies* publication.[17]

Clean up the Occidental site to the maximum extent practicable

The public's concerns about human and ecological health, the future of the contaminant plume, and concerns about natural disasters were often connected to comments that Ecology must ensure the site is cleaned up to the maximum extent practicable. Ecology heard concerns from the public and stakeholders about some of the alternatives in the FS that leave contamination

[14] www.co.pierce.wa.us/104/Emergency-Management
[15] www.cityoftacoma.org/government/emergency_management
[16] https://ecology.wa.gov/Water-Shorelines/Shoreline-coastal-management/Hazards/Earthquakes-tsunamis
[17] https://fortress.wa.gov/ecy/publications/SummaryPages/1709052.html

in the soil and groundwater. Worries about risks, as well as about making sure responsible parties take care of their contamination physically and financially, were clearly expressed by the public.

Because Ecology is delegated authority under federal law for many of the sites that have or had RCRA permits to treat, store, and dispose of hazardous waste, Ecology must obtain concurrence from EPA Region 10 on the cleanup actions at the Site. Through a review process, EPA provides a critical eye on Ecology's proposed decisions including remedy selection. The preferred remedy, as selected by Ecology, must be agreed to by EPA. EPA will also continue to review progress at this site into the future.

Within the framework of this federal delegation, Ecology provides formal oversight of the remedial action at the Site to ensure that the cleanup meets the requirements of MTCA. MTCA was established as a citizen initiative with cleanup standards to protect human health and the environment. It is Ecology's duty to make sure cleanup standards are achieved and to ensure that the initiative's goals are adhered to. MTCA sets out these goals, but it also provides for flexibility to allow cleanups to be addressed on a site-specific basis.

Ecology presented the evidence and information about the type and location of contamination at the site when we published Occidental's RI in October 2015. In response to comments regarding that document, Ecology explained how difficult it would be to find solutions for the type of chemicals, site conditions, and for the quantity released over such a long period of time. Much of the contamination was released in the environment decades before MTCA and many other environmental laws were enacted.

Ecology did make a commitment to the public and to stakeholders at that time to look for all of the options that use permanent solutions to the maximum extent practicable, given these challenges. When Ecology and Occidental sat down to discuss the types of alternatives that were feasible, the resulting list was the basis for the FS. Ecology's team specified many of the technologies that were compiled into the alternatives presented in the report and to the public. The FS is a complete description of all of the alternatives Ecology requested and, using best professional judgment, determined to be technically feasible.

The majority of the comments received asked Ecology to ensure the Site will be cleaned up to the "maximum extent practicable." This is one of the criteria that Ecology must use when evaluating the alternatives and selecting the cleanup. Many people commented that Occidental's preferred alternative did not meet this criteria. Importantly, MTCA mandates that Ecology choose the remedy to be implemented, regardless of the preferred alternatives proposed by a PLP, and that the selected alternative be either permanent or remediate to the maximum extent practicable.

What does maximum extent practicable mean? MTCA defines practicable as:

> …capable of being designed, constructed and implemented in a reliable and effective manner including consideration of cost. (WAC 173-340-200, Definitions)

MTCA also states that

> …the comparison of benefits and costs may be quantitative, but will often be qualitative and require the use of best professional judgment. In particular, the Department has discretion to favor or disfavor qualitative benefits and use that information in selecting a cleanup action. Where two or more alternatives are equal in benefits, the department shall select the less costly alternative. (WAC 172-240-360(3)(e)(ii)(C) [Emphasis added]

To contribute to a complete evaluation of benefit and cost, MTCA requires a disproportionate cost analysis (DCA) to compare alternatives. At this Site, it was challenging to compare head-to-head because the alternatives are not equal in benefit. Each of the alternatives add to a basic containment remedy Ecology has established as an essential component to the final remedy, regardless of the alternative. Therefore, the alternatives' benefits and costs increase as additional treatment or removal is added. This makes it necessary to evaluate benefits for each alternative separately. Consequently, the remedy selection will require best professional judgment, in addition to considering costs.

Prior to the public comment period, Ecology realized the DCA provided by Occidental needed to be independently verified. Ecology shared with the public that more work was needed, and committed to presenting a revised independent analysis to the public at a later date. Currently, the Ecology team is comparing alternatives based on benefit, as well as verifying cost estimates provided by Occidental. This analysis will be provided in the draft CAP and will be part of the future public comment period. Therefore, Ecology will choose an alternative based on this independent analysis and will not rely solely on Occidental's findings.

Ecology has also added an additional Remedial Action Objective (RAO) for mass removal in response to public concerns. This objective was not clearly stated in the draft FS, although the objective was clearly incorporated into a number of the alternatives presented by Occidental. Thus, the following Remedial Action Objective will be considered:

"Remove as much of the contaminant mass from groundwater and soil using permanent solutions to the maximum extent practicable using acceptable engineering means."

We define "acceptable engineering means" as proven environmental cleanup measures with proven outcomes that have been used in the past to accomplish cleanup goals. It is not

Ecology's expectation, at this time, that experimental or unproven technologies will be used to remove mass.

This additional RAO responds to the public's concern that Ecology choose the best remedy consistent with MTCA's requirements for cleanup actions. Ecology will select a remedy that complies with the following MTCA objectives:

- Protect human health and the environment
- Comply with cleanup standards
- Comply with applicable state and federal laws
- Provide for compliance monitoring
- Use permanent solutions to the maximum extent practicable
- Provide for a reasonable restoration time frame
- Consider public concerns

The public comments called for the removal of as much of the contaminant mass as possible, using means more aggressive than long-term containment and pumping and treating groundwater. Ecology is committed to using permanent solutions to the maximum extent practicable and will carefully consider the best options for removing mass when selecting the final remedy for the Site.

Make sure Occidental pays for cleanup

Many people are concerned that Occidental may not pay for cleanup in the future if the company goes out of business or goes bankrupt. Some people were also concerned that Ecology's work to oversee cleanup costs taxpayer money.

Occidental paid for all costs of the cleanup including paying both Ecology's and EPA's staffing costs for this project under a legal agreement, called an agreed order, since 1997. The costs of Ecology staff and contractors working on the Occidental cleanup have been paid under a cost recovery agreement since 2005. Previous work to address contamination at the Occidental Site have all been funded by the company. For future cleanup activities, Ecology will require financial assurance from Occidental to cover the construction and long-term maintenance costs.

What is financial assurance?

The goal of financial assurance is to protect taxpayers and ensure that Ecology can continue the cleanup of a site. Financial assurance is a way to insulate the state from having to pay for cleanup at sites where there are potentially liable parties (PLP) required to fund the cleanup. Depending on which laws are applicable to the cleanup, financial assurance is a requirement for many cleanups. Here, because the Site is subject to regulations under both RCRA and MTCA,

Occidental must provide financial assurance to both complete the cleanup, and to fund any long-term operations for monitoring and/or institutional controls, even if the company is sold, leaves the state, or goes out of business. Financial assurance can be provided to Ecology in many ways, including a corporate guarantee, a letter of credit, a surety bond, or a trust. The financial assurance rules are also designed to protect taxpayers in case a PLP goes bankrupt.

How much financial assurance does Occidental need?

Financial assurance amounts are specific to each facility based on the cleanup at that site. The PLP of the facility must prepare a cost estimate that details everything they will be required to do and how much each item costs. Ecology reviews and approves these estimates. The Occidental cost estimates vary based on the different cleanup alternatives. Ecology will decide on a remedy in the next phase, the draft CAP. Occidental will be required to have financial assurance for the remedy we select as well as for the costs of operations and maintenance of the remedy long term. Regardless of the type or amount of financial assurance secured, Ecology has the ability to require a different type of financial assurance if there are concerns about the financial stability of the company.

What about future costs and inflation?

Facilities must update their cost estimates each year. They can either do a brand-new cost estimate, or they can simply increase last year's amount for inflation. Almost all companies increase for inflation.

During construction, the Occidental Site cost estimate may go down each year by subtracting costs for the work that was finished. The cost estimate for all work still left will be increased for inflation. After construction is finished, the cost estimate will be determined by taking the annual maintenance costs from the previous year, multiplying by inflation, and then multiplying by 30 to get the minimum amount for 30 years' of coverage.

In summary, Occidental will have a number of regulatory requirements to make sure that a remedy can continue to be financially supported and maintained over the long term.

Specific cleanup technologies and options

Some people asked questions and made suggestions about specific cleanup technologies that may be used at the Occidental Site. These included comments about the proposed sheet pile wall, horizontal drilling, chemicals to treat contaminated soils, and monitored natural attenuation. These comments are addressed below. However, in most cases, the comments about cleanup technologies focused on specific elements that will be more fully considered during the design phase for the cleanup action and included in the draft Cleanup Action Plan that will be made available for public comment prior to being finalized.

Sheet pile wall

People shared concerns that the sheet-pile wall may be too shallow. The purpose of the sheet-pile wall is to stop the flow of contamination from seeps and shallow groundwater into the Hylebos Waterway. The proposed wall's depth is about 75-feet below ground surface. This will put the bottom of the wall below the Hylebos Waterway. While some people expressed concerns that the wall is not deep enough, Ecology agrees with Occidental that a deeper wall would have a negative impact on groundwater pumping remedies. The goal for the proposed hydraulic containment and pumping system is to bring contamination beneath the Hylebos Water back to the property boundaries. A deeper wall would decrease the effectiveness of this system by preventing contamination deep in the groundwater from being drawn back to the property.

Some people were concerned that the high pH in groundwater will ruin the wall over time. Steel sheet-pile walls can be designed to withstand corrosive conditions over long periods of time. They can be made with different materials or fill material can be placed around the wall to neutralize corrosive elements before reaching the wall. If a sheet pile wall is selected as part of the final remedy, preventing corrosion will be part of the design considerations. In addition, Occidental would be responsible for repair and replacement of a sheet pile wall in the future as part of any agreement with Ecology.

Horizontal or directional drilling

A comment suggested that Ecology should consider directional drilling to treat contamination beneath the Hylebos Waterway. Ecology will evaluate specific drilling techniques as part of the design phase for the pump-and-treat system and will select drilling methods and technologies to meet those performance standards as part of remedy design. After a containment system has been installed, its performance will be monitored. If the system doesn't meet the performance standards and the remedial action goals, then changes will be made to the system. Those changes could include directional drilling.

Chemical oxidants

Some alternatives in the Draft FS include treating contamination in the ground using chemicals called oxidants. Oxidants are added to contaminated soil and groundwater and cause a chemical reaction that destroys contaminants and produces harmless byproducts. There are several oxidants that could be used for treating contamination, including sodium persulfate and potassium permanganate. People commented on which chemicals might be best. If these alternatives are selected as part of the final remedy in the draft Cleanup Action Plan, the specific chemical or chemicals that will be used will be determined in the design phase.

Monitored natural attenuation

Monitored natural attenuation (MNA) is a remedy that uses natural biological and chemical processes to break down chemicals into non-toxic chemicals that do not pose a risk to human health and the environment. The Draft FS does not include MNA as a specific alternative because it does not meet minimum requirements for a cleanup action at the Occidental Site. This does not preclude using MNA in the future if it makes sense. People commented that MNA should be considered as a component of the selected remedy. The potential effects of natural attenuation on the selected remedy will be considered as part of the Draft Cleanup Action Plan.

Addressing pH contamination

Commenters and stakeholders were concerned about high pH in the soil and groundwater. They were concerned about how this high pH could affect the environment and thought that the rocks under the ground were being dissolved into a sludge they referred to as "jelly." This is not an accurate description of what is going on in the subsurface at the Occidental Site.

The high pH conditions in the subsurface do not pose a risk to people, the environment, or to the stability of the ground. The primary concern about the high pH is that it presents technical problems for physically pumping groundwater in areas that contain the solvent contamination we want removed or contained.

High pH chemicals, from leaks during operation at the Site, created conditions in the subsurface that mobilized small particles of silica and other minerals within the soil, like salt dissolved in water. Under normal conditions, silica and these minerals would be stable and stay where they were originally deposited. However, once mobilized, the silica and minerals are heavier (more dense) than water or solvent and move downward through the aquifer, slowly, over time. This dense plume displaced water and solvent or dragged contamination along as it moved through the pores of the aquifer.

Extracting groundwater is one of the technologies that has potential to contain and remove contamination – all of the alternatives under consideration employ this technology. When groundwater is pumped in the high pH areas, the silica and other minerals mixed with water can solidify and plug extraction wells. As such, pumping and treating groundwater from areas with highest pH at the Occidental Site, generally above 11 pH, is not feasible using normally accepted engineering practices.

People also said that research needs to be done to see if it is possible to treat the high-pH areas and urged Ecology to keep looking. During this project, Ecology and EPA requested research from both Occidental and the University of Washington.

Occidental and their contractors completed laboratory and field studies approved by Ecology and EPA to provide data and information to evaluate the feasibility of treating high pH areas

and pumping in high pH areas. Occidental's studies are described in four primary reports published between 2004 and 2013. These are listed in Addendum B, *Overview of Results from the UW Research Related to pH Transport and Treatment (Joel Massmann)*. Occidental's reports were reviewed by an independent expert reviewer. The recommendations from the independent reviewer were then used to make plans for additional pH studies conducted by the University of Washington (UW). For more information, read the UW's *Examination of Silica Precipitation, Gelation and Hydraulic Fouling in Occidental Chemical Corporation Soils* (PDF).[18] Two primary reports describing the UW work were published in 2015 and 2017, as listed in Addendum B.

The technologies that are currently available to allow pumping in high-pH, high-silica areas are limited. While the UW work suggested that plugging could be avoided when pumping in areas with pH in the range of 10 to 11, plugging is much more likely if pumping occurs in areas with pH above 11. However, even if they cannot pump from the high-pH areas, Occidental will be responsible for containing the contaminant plumes and meeting the remedial action goals through other measures.

The field and laboratory studies provide information and data that allow us to evaluate a range of treatment and containment alternatives for the pH plume on the Occidental site. These alternatives include in-situ treatment through soil mixing or through injection of acid. The studies also considered aboveground treatment of high-pH water and the effects of pH on aquifer properties and extraction well plugging. Both the UW research and the Occidental studies showed similar results. Results from the UW research are summarized in Addendum B.

The studies done by Occidental showed that the high-pH soils can be treated in the ground by injecting acids such as iron sulfate. Multiple applications would likely be needed. The acids could also be mixed into the soil using soil augers instead of being injected. The studies also looked at treating high-pH water that is pumped out of the ground. The results from these studies showed that diluting the water at the Site with clean water from another source before treating it helped to reduce the likelihood of silica gels that could plug up the treatment system.

The available information and data from these studies are sufficient to evaluate available alternatives for treating or containing the high-pH plume and for pumping groundwater in high-pH areas. Technologies to treat the pH in the ground or to prevent high-pH groundwater from moving are currently available and could be implemented at the Site. Those are included in alternatives described in the draft FS.

Ecology also recognizes that technologies and practices may be developed in the future that would allow pumping in higher pH areas. As required by MTCA for cleanup sites with

[18] https://fortress.wa.gov/ecy/gsp/DocViewer.ashx?did=61633

institutional controls and consistent with an adaptive management approach, Ecology must conduct periodic reviews at a minimum every five years post-cleanup.

The UW investigation, as well as the Occidental studies, have provided a significant amount of information about the pH plume. Ecology will be considering what to do with the pH plume as part of the remedy decision for the site. There is no evidence that the high pH plume presents a risk to aquatic life or human health. Shallow discharges of the high-pH plume into the Hylebos Waterway will be prevented in the future with the sheet pile wall, a component of all the alternatives.

Protection of workers and the environment during cleanup activities

Many people commented that they want Ecology to ensure that cleanup workers and the environment are protected during the construction of the cleanup action. When it's time to clean up this site and put in place a remedy, Occidental will develop a health and safety plan. Ecology will review and comment on the plan before work can begin. The safety and health plan must be consistent with the Occupational Safety and Health Act of 1970 and Washington Industrial Safety and Health Act. All governmental agencies and private employers are directly responsible for the safety and health of their own employees and compliance with those requirements. These requirements are subject to enforcement by the designated federal and state agencies.

Occidental will be required to meet any applicable air quality and water quality standards to prevent any impacts to the environment during the cleanup. All applicable relevant and required laws will be considered as part of the CAP. Additionally, any proposed cleanup work being done under government oversight is evaluated using the State Environmental Protection Act (SEPA) to determine if there are any adverse impacts to the environment that require mitigation or further study. The SEPA determination and any associated work plans will be publicly available on our website and be made available for public comment.

Concerns about impacts from neighboring projects

People were concerned that construction of the proposed Puget Sound Energy (PSE) Liquefied Natural Gas (LNG) project on the neighboring property to the south of the Occidental site would interfere with cleanup activities. The design for the Occidental remediation, and any work done on the southern property will have to ensure that the sites do not negatively impact each other.

During the public meeting, we displayed a map that depicted the footprint of the LNG construction in relation to the groundwater plume from Occidental, as well as the soil contamination from an old petroleum tank farm (see map next page).

The petroleum tank farm area is referred to as the Alexander Avenue Petroleum Tank Facilities site and is a separate cleanup action from the Occidental Site. It is located between Occidental and the LNG plant construction area. The Alexander Tank Facilities site is partially on a large parcel of property leased by the Port of Tacoma to Puget Sound Energy for the LNG facility. The LNG facility construction itself is not on the same area where the tank plume is located. Ecology's site manager for the Alexander Avenue Petroleum Tank Facilities site has coordinated activities to make sure the cleanup site remains unaffected by the construction. Figure 1 below shows the Site's VOC groundwater plume, the Alexander Tank farm petroleum plume, the property boundary for the proposed LNG project, and the footprint of the proposed LNG plant. Neither the VOC nor the petroleum plume is under the plant footprint.

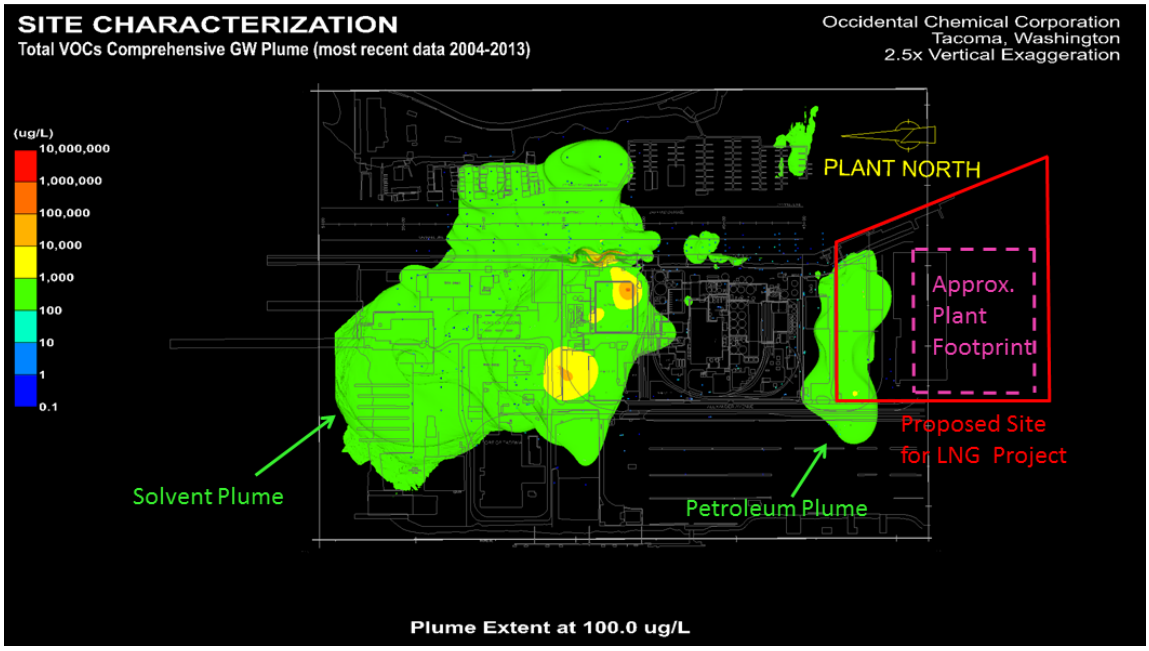


Figure 1. Total VOC groundwater plume and proposed LNG project.

Concerns about our public meeting and hearing

Many people found the information at our meeting helpful, but others had concerns about the outreach efforts and the format of the public hearing. Ecology have outlined the major themes and responses below.

There were some concerns about us not recording the Q&A session. Recording a public meeting is not required by MTCA or RCRA. Based on legal considerations and logistical challenges, it is standard Ecology practice to not record question and answer sessions during our public meetings. Ecology also wanted people to feel free to ask questions about this complex Site without going on the formal record. Many people come to an open house and public hearing to learn more about the Site, not necessarily to submit their comments. Ecology received thoughtful questions and the staff provided the best possible answers at the time. Ecology

wanted to provide as much information as time allowed before the formal testimony portion of the public hearing.

Some people were concerned that the display items only showed Occidental's preferred alternative. In the draft FS, responsible parties are allowed to submit a preferred alternative. The cleanup options are complicated and Ecology could have done a better job at explaining the different alternatives to cleanup. People also stated that Ecology should have had different groupings of alternatives in the displays. In the future, Ecology will strive to improve the displayed materials when presenting to the public.

Lastly, there were concerns that the public hearing was not amplified with a microphone. Ecology knows that this was disappointing to some because they could not hear what others were saying before they provided their testimony. The purpose of a public hearing is to add comments to the official record. Every comment was recorded and transcribed. You can find all of the comments, including those during the public hearing on Ecology's Occidental Chemical Corp. website.[19] Ecology plans to use a microphone for the next public hearing.

Cleanup process next steps

The FS is an important part of our state's cleanup process. The draft FS outlined practicable cleanup options for this Site. The next step is for Ecology to decide on proposed remedy in the draft Cleanup Action Plan (CAP).

The draft CAP will:

- Describe the Site.
- Summarize current site conditions.
- Summarize the cleanup action alternatives considered in the remedy selection process.
- Describe the selected cleanup action for the Site and the rational for selecting this alternative.
- Identify site-specific cleanup levels and points of compliance for each hazardous substance and medium of concern for the proposed cleanup action.
- Identify applicable state and federal laws for the proposed cleanup action.
- Identify residual contamination remaining on the site after cleanup and restrictions on future uses and activities at the site to ensure continued protection of human health and the environment.
- Discusses compliance monitoring requirements
- Presents the schedule for implementing the CAP.

[19] https://fortress.wa.gov/ecy/gsp/Sitepage.aspx?csid=4326

Long-term monitoring is an essential part of MTCA and RCRA. Regular monitoring reports will be available online. In addition to monitoring reports, Ecology will conduct periodic reviews at a minimum every five years. These periodic reviews will be available for public review and comment when they are available.

Ecology is deciding on a remedy that meets MTCA requirements. Our proposed draft remedy will be outlined in the draft cleanup action plan, the next phase of the project.

Stay informed

Ecology will continue to keep the public informed during major decision points and times of investigative or interim work. You can sign up for our email list or join our mailing list to receive public notices. Ecology sends out updates as they are available to the Site's email list and updates the website regularly. The website includes all of the reports and other documents in the electronic documents database for Occidental.[20] Finally, Ecology will hold public meetings and offer presentations to interested groups during formal public comment periods. To learn more about the public outreach process, check out the public participation plan on our website. If you have suggestions on how Ecology can better communicate and engage with the public, e-mail Bridgette Valdez-Kogle at bridgette.valdez-kogle@ecy.wa.gov or call her at 360-407-7616.

[20] https://fortress.wa.gov/ecy/gsp/CleanupSiteDocuments.aspx?csid=4326

Comments reference table

Commenter	Representing	Topic
Albert Wheeler	Self	• Clean up site to maximum extent practicable.
Alison Hale	Self	• Impacts to tribe. • Proposed LNG Plant. • Clean up site to maximum extent practicable.
Andrea Urban and Ivan Ramirez	Self	• Proposed LNG Plant. • Clean up site to maximum extent practicable.
Andrew Berger	Self	• Proposed LNG Plant. • Clean up site to maximum extent practicable. • Natural disasters. • Nature and extent of contamination.
Ann Locsin	Self	• Clean up site to maximum extent practicable.
April Davis	Self	• Clean up site to maximum extent practicable.
Barbara Menne	Self	• Clean up site to maximum extent practicable. • Natural disasters. • Ensure Occidental pays for cleanup.
Barret Carpenter	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Becca Fairchild	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Bob Fredrickson	Self	• Clean up site to maximum extent practicable.
Bob Snider	Self	• Nature and extent of contamination. • Specific cleanup technologies and options.
Carol Hubbird	Self	• Clean up site to maximum extent practicable.
Carol Strobel Colleran	Self	• Clean up site to maximum extent practicable. • Natural disasters.
Carrie Parks	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Cecelia Callison	Self	• Clean up site to maximum extent practicable.

Commenter	Representing	Topic
Gil Chapa	Challenge Masters, Inc.	• Clean up site to maximum extent practicable.
Char Naylor	Puyallup Tribe of Indians	• Human health risk and health concerns.
Charlotte and Harry McDonald	Self	• Other
Chris Wooten	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Public outreach efforts and access to data.
Melissa Malott and Karen Gogins	Citizens for a Healthy Bay	• Clean up site to maximum extent practicable. • Impacts to tribe. • Ensure Occidental pays for cleanup. • Nature and extent of contamination. • Natural disasters. • Human health risks and health concerns. • Ecological risk, restoration, and protection. • Future community development. • Long-term monitoring. • Public outreach efforts and access to data. • Specific cleanup technologies and options.
Mayor Marilyn Strickland	City of Tacoma	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Nature and extent of contamination. • Human health risks and health concerns. • Long-term monitoring. • Public outreach efforts and access to data. • Specific cleanup technologies and options. • Next steps and the cleanup process.
Councilmember Ryan Mello	City of Tacoma Council	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Natural disasters. • Ecological risk, restoration, and protection. • Long-term monitoring. • Public outreach efforts and access to data. • Specific cleanup technologies and options.

Commenter	Representing	Topic
Michael P. Slevin III, P.E.	City of Tacoma Environmental Services Department	• Clean up site to maximum extent practicable. • Nature and extent of contamination. • Human health risks and health concerns. • Ecological risk, restoration, and protection. • Next steps and the cleanup process. • Future community development.
Claudia Reidener	Self	• Clean up site to maximum extent practicable. • Impacts to the tribe. • Ensure Occidental pays for cleanup. • Nature and extent of contamination. • Proposed LNG plant. • Human health risks and health concerns. • Ecological risk, restoration, and protection.
Angela Wehnert	Crescent Moon Gifts	• Clean up site to maximum extent practicable. • Nature and extent of contamination.
Dan Rosner	Self	• Clean up site to maximum extent practicable.
Dana Deckard	Self	• Clean up site to maximum extent practicable.
Darlin' Boudreau	Self	• Clean up site to maximum extent practicable.
Dean Burke	South Sound Sports Commission	• Clean up site to maximum extent practicable.
Debbie Hill	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Proposed LNG plant. • Natural disasters.
Debby Herbert	Self	• Clean up site to maximum extent practicable. • Human health risks and health concerns.
Lis Smith	DeWind One-Pass Trenching	• Specific cleanup technologies and options.
Diane Shaughnessy	Self	• Clean up site to maximum extent practicable. • Natural disasters. • Ecological risk, restoration, and protection.
Diane Tilstra	Self	• Clean up site to maximum extent practicable.

Commenter	Representing	Topic
Donna Slayback	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Natural disasters. • Ecological risk, restoration, and protection.
Drew Amdahl	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Proposed LNG plant. • Nature and extent of contamination.
Elisabeth Benard	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Eric Olsen	Self	• Clean up site to maximum extent practicable.
Norman Gollub	Foss Waterway Development Authority	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Ecological risk, restoration, and protection. • Long-term monitoring. • Specific cleanup technologies and options.
Heidi Hutchison	Self	• Clean up site to maximum extent practicable.
Jacquelin Wayland	Self	• Ecological risk, restoration, and protection. • Human health risks and health concerns.
James Clark	Self	• Clean up site to maximum extent practicable. • Proposed LNG plant.
Janna Stewart	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Human health risks and health concerns. • Ecological risk, restoration, and protection. • Public outreach efforts and access to data.
Jennifer Severns	Self	• Clean up site to maximum extent practicable.
Jennifer Trahan	Veterans of Tacoma	• Clean up site to maximum extent practicable.
Joe Tieger	Self	• Ensure Occidental pays for cleanup. • Public outreach efforts and access to data. • Specific cleanup technologies and options.

Commenter	Representing	Topic
Jori Adkins	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Specific cleanup technologies and options.
Judi Hook	Self	• Clean up site to maximum extent practicable.
Judy Ferguson	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Human health risks and health concerns. • Public outreach efforts and access to data. • Proposed LNG plant.
Julie Christoph	Self	• Clean up site to maximum extent practicable. • Proposed LNG plant.
Justin Haight	Self	• Clean up site to maximum extent practicable.
Justin Lytle	Self	• Ecological risk, restoration, and protection. • Ensure Occidental pays for cleanup. • Human health risks and health concerns. • Long-term monitoring. • Natural disasters. • Nature and extent of contamination. • Specific cleanup technologies and options.
Kami Huynh	Self	• Clean up site to maximum extent practicable.
Karelina Resnick	Self	• Clean up site to maximum extent practicable.
Karen Ramage	Self	• Clean up site to maximum extent practicable. • Long-term monitoring. • Next steps and the cleanup process. • Public outreach efforts and access to data.
Kathleen Hall	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Kiri Kreamer	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Ecological risk, restoration, and protection.
Kristina Loper	Self	• Clean up site to maximum extent practicable. • Impacts to tribe. • Proposed LNG plant.

Commenter	Representing	Topic
Laure Nichols	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Leah Brady	Self	• Clean up site to maximum extent practicable.
Lena Gibson	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Linda Cohan	Self	• Clean up site to maximum extent practicable. • Natural disasters.
Linda Fortune	Self	• Clean up site to maximum extent practicable.
Lisa Eyre	Self	• Clean up site to maximum extent practicable.
Loan Vo	Self	• Clean up site to maximum extent practicable.
Lorna Zurkowski-Fuller	Self	• Clean up site to maximum extent practicable. • Nature and extent of contamination. • Long-term monitoring. • Specific cleanup technologies and options.
Lucas Drawdy	Self	• Clean up site to maximum extent practicable.
Lynnette Shureb	Self	• Clean up site to maximum extent practicable.
Malakay Betor	Self	• Human health risks and health concerns.
Margarita Andreeva	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Mark Brady	Self	• Clean up site to maximum extent practicable.
Marty Webb	Self	• Clean up site to maximum extent practicable.
Mary Coleman	Self	• Clean up site to maximum extent practicable.
Maude Laslie	Self	• Clean up site to maximum extent practicable.
Maureen Howard	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Meng Li Che	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Merri Sanders	Self	• Clean up site to maximum extent practicable.

Commenter	Representing	Topic
Mike Huseby	Self	• Clean up site to maximum extent practicable. • Proposed LNG plant. • Natural disasters.
Mike Webb	Self	• Clean up site to maximum extent practicable. • Nature and extent of contamination. • Human health risks and health concerns. • Specific cleanup technologies and options.
Missy Zenczak	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Nancy Reining	Self	• Clean up site to maximum extent practicable.
Nancy Shafer	Self	• Clean up site to maximum extent practicable.
Dr. Todd Hay	NOAA Northwest Fisheries Science Center	• Nature and extent of contamination.
Noah Davis	IN PACTA Lawyers PLLC	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Human health risks and health concerns. • Proposed LNG plant. • Specific cleanup technologies and options.
Norma Ramirez	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Ozgu okgoz	Self	• Clean up site to maximum extent practicable. • Nature and extent of contamination. • Human health risks and health concerns. • Long-term monitoring. • Public outreach efforts and access to data.
Pamela Transue	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Patricia Tyvand	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Patti Gora-McRavin	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Human health risks and health concerns. • Ecological risk, restoration, and protection. • Natural disasters.

Commenter	Representing	Topic
Paul Sonnenfeld	Self	• Ensure Occidental pays for cleanup. • Specific cleanup technologies and options.
Peter McLean	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Pheobe Toland	Self	• Clean up site to maximum extent practicable.
Phil Brooke	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Public outreach efforts and access to data.
Robert Healy	Port of Tacoma	• Human health risks and health concerns. • Long-term monitoring. • Specific cleanup technologies and options.
Kurt Fremont	Puyallup River Watershed Council	• Long-term monitoring. • Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Ecological risk, restoration, and protection.
Ricardo Noguera	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Rick Fuller	Self	• Nature and extent of contamination.
Rick Semple	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Riley Haizlip	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Robert Bearden	Self	• Clean up site to maximum extent practicable.
Robert Chesney	Self	• Public outreach efforts and access to data.
Robin Yeager	Self	Other
Roxanne Murray	Self	• Clean up site to maximum extent practicable. • Proposed LNG plant.

Commenter	Representing	Topic
Russ Ladley	Puyallup Tribe of Indians	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Nature and extent of contamination. • Human health risks and health concerns. • Ecological risk, restoration, and protection. • Future community development. • Long-term monitoring. • Impacts to tribe. • Specific cleanup technologies and options. • Proposed LNG plant. • Next steps and the cleanup process. • Unclassified
Sarah Morken	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Brad D. Harp, L.Hg. Water Resources Program Manager	Environmental Health Division, Tacoma-Pierce County Health Department	• Nature and extent of contamination. • Human health risks and health concerns. • Long-term monitoring. • Specific cleanup technologies and options.
Sheri Tonn	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Nature and extent of contamination. • Natural disasters. • Specific cleanup technologies and options. • Natural disasters. • Next steps and the cleanup process.
Shirley Low	Citizens for a Healthy Bay	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Human health risks and health concerns. • Ecological risk, restoration, and protection. • Specific cleanup technologies and options. • Natural disasters.
Dorothy Walker	Sierra Club Tatoosh Group of Pierce County	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Nature and extent of contamination. • Natural disasters. • Proposed LNG plant.

Commenter	Representing	Topic
Sierra Diamond	Self	• Clean up site to maximum extent practicable. • Long-term monitoring.
Skyler McVaugh	Self	• Clean up site to maximum extent practicable.
Venus Dergan	South Tacoma Neighborhood Council	• Clean up site to maximum extent practicable.
Stena Troyer	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Steven Dunkelberger	Tacoma Weekly	• Next steps and the cleanup process.
Steven Storms	Self	• Clean up site to maximum extent practicable. • Nature and extent of contamination. • Ecological risk, restoration, and protection. • Proposed LNG plant.
Mike Webb	Surfrider Foundation	• Clean up site to maximum extent practicable. • Human health risks and health concerns. • Specific cleanup technologies and options.
Suzanna Stoike	Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup.
Scott Knox	Tacoma Waterfront Association	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Nature and extent of contamination. • Natural disasters. • Long-term monitoring. • Specific cleanup technologies and options.
Sharon Bell	Tacoma-Pierce County Health Department	• Clean up site to maximum extent practicable. • Nature and extent of contamination. • Human health risks and health concerns. • Long-term monitoring. • Specific cleanup technologies and options.

Commenter	Representing	Topic
Bruce Hoeft	Tahoma Audubon	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Long-term monitoring. • Specific cleanup technologies and options. • Future community development. • Natural disasters. • Public outreach efforts and access to data.
Tim Valdez	Self	• Clean up site to maximum extent practicable.
Todd Hay	Self	Other
Todd Silver	Self	• Clean up site to maximum extent practicable.
Toni Webb	Self	• Clean up site to maximum extent practicable.
Trischa Lohr Barlet	Self	• Clean up site to maximum extent practicable.
Trisha VanderGiessen	Self	• Clean up site to maximum extent practicable. • Public outreach efforts and access to data. • Proposed LNG plant.
Virginia Myers	Self	• Clean up site to maximum extent practicable. • Proposed LNG plant. • Natural disasters.
Mindy Roberts	Washington Environmental Council Self	• Clean up site to maximum extent practicable. • Ensure Occidental pays for cleanup. • Nature and extent of contamination. • Impacts to tribe. • Human health risks and health concerns. • Specific cleanup technologies and options. • Proposed LNG plant. • Future community development. • Next steps and cleanup process.
William Kupinse	Self	• Clean up site to maximum extent practicable.
William Towey	Self	• Clean up site to maximum extent practicable.

Appendix A: Plume movement beneath Commencement Bay (Joel Massmann)

People are concerned that we have not collected data beneath Commencement Bay and that we don't know what the plume will do in the future. This addendum describes what we know about how the plumes will move near Commencement Bay. The description is based on well-known and accepted processes that occur in these types of sites and situations.

The locations and distributions of the contaminant plumes under current conditions are illustrated in Figures 2.14 through 2.17 in the Draft Feasibility Study. These are also shown in Figures 5.5 through 5.8 and 5.10 through 5.12 in the Final Conceptual Site Model Report (CRA, April 2014).[21] Figures showing the plumes and various depths are also shown in the Site Characterization Report (CRA, August 2015).[22] Chapter 5 in the Conceptual Model Report (CSM) discusses contaminant fate and transport. Future migration of the ADP plume is described in Section 5.2, pages 25 and 26. Migration of the chlorinated volatile organic compounds (CVOC) plume is discussed in Section 5.4 of the CSM.

There are three primary groundwater plumes on the Occidental site: the anthropogenic density plume (abbreviated as ADP), the pH plume, and the plume of chlorinated volatile organic compounds (abbreviated as the CVOC plume). The ADP is the plume that resulted from spills and discharges of caustic materials and brine. The density of this plume is greater than the density of sea water. The CVOC plume is the plume that resulted from spills and discharges of solvents that were manufactured on the site. The pH plume is the plume with high pH that resulted from spills and discharges of caustic materials. The discussions that follow focus on the ADP and the CVOC plume. Processes affecting future transport of the pH plumes will be similar to the CVOC plume.

ADP plume

Figure 1 below provides simplified drawings of the current and expected future distribution of the ADP plume. The focus of these drawings is the potential for transport to Commencement Bay. Figure 1a shows expected conditions before any contamination had happened. Important features of the geology include deltaic deposits and underlying glacial and mudflow deposits.[23] The deltaic deposits are relatively permeable while the glacial and mudflow deposits are

[21] CRA, 2014a. Final Conceptual Site Model Report, Groundwater and Sediment Remediation, Occidental Chemical Corporation, Tacoma, Washington, April.

[22] The ADP is shown in Figures 3.62 through 3.66, the CVOC plume is shown in Figures 4.5 through 4.10, and the pH plume is shown in Figures 4.13 through 4.18.

[23] The glacial deposits depicted in Figures 1 and 2 may be covered with mudflow deposits. The important characteristic of these deposits, whether they are glacial or mudflow, is that they are less permeable than the deltaic deposits and they restrict downward movement of contamination.

generally much less permeable. Groundwater in the deltaic deposits include freshwater beneath the peninsula and a saltwater wedge beneath Commencement Bay. Most groundwater flow to Commencement Bay occurs along the relatively shallow zones near the shoreline. Because freshwater has lower density than saltwater, the freshwater does not penetrate into the saltwater wedge. The saltwater wedge is nearly static with very little flow.

Current conditions for the ADP are shown in Figure 1b. The ADP has moved downward through the deltaic deposits to the glacial and mudflow layer and has then migrated to the north toward Commencement Bay. Because the density of the ADP is higher than the density of saltwater, the leading edge of the plume has penetrated into the saltwater wedge.

Anticipated future conditions for the ADP are illustrated in Figure 1c. The ADP will eventually migrate into the saltwater wedge and will likely become immobilized before reaching Commencement Bay. Over a very long period of time (likely hundreds to thousands of years), the ADP plume will eventually dissipate by slowly diffusing into the saltwater wedge. The pH will likely be neutralized before discharging to Commencement Bay because of the long time involved.

VOC Plume

Figure 2 provides simplified drawings of the current and expected future distribution of the CVOC plume. Current conditions for the CVOC plume are shown in Figure 2a. The plume consists of two primary components: one component is dissolved in fresh groundwater and the second component is comingled with the ADP plume. Figure 2b shows the CVOC plume under future conditions if no hydraulic containment or hydraulic mass removal actions are implemented. The CVOC in fresh groundwater will migrate with the groundwater and will likely degrade prior to discharge into Commencement Bay along the relatively shallow zones near the shoreline. The CVOC in the ADP plume will penetrate into the saltwater wedge and will likely stop moving before it reaches Commencement Bay. Over a very long period of time (likely hundreds to thousands of years), this part of the CVOOC plume will eventually dissipate by slowly diffusing into the saltwater wedge. Because of the very long time periods required for to this will occur, it is expected that the CVOC will be transformed or degraded prior to reaching the bay.

Figure 2 depicts the CVOC plume under future conditions after the hydraulic containment and hydraulic mass removal system has been installed. Groundwater levels will be lowered in the vicinity of the containment system and the direction of groundwater flow along the saltwater wedge will be reversed. The hydraulic containment and hydraulic mass removal system will likely change the configuration of the saltwater wedge to some degree, but it is not expected to capture CVOC that has penetrated into the wedge via the ADP.

Sediment samples were collected in 2016 in shallow parts of Commencement Bay. These are described in 2016 Anchor QEA report referenced in the Draft Feasibility Study.[24] The samples did not detect contamination at any of the five locations in Commencement Bay. Plans are underway to collect more groundwater data below Commencement Bay in the near future as part of a baseline monitoring plan.

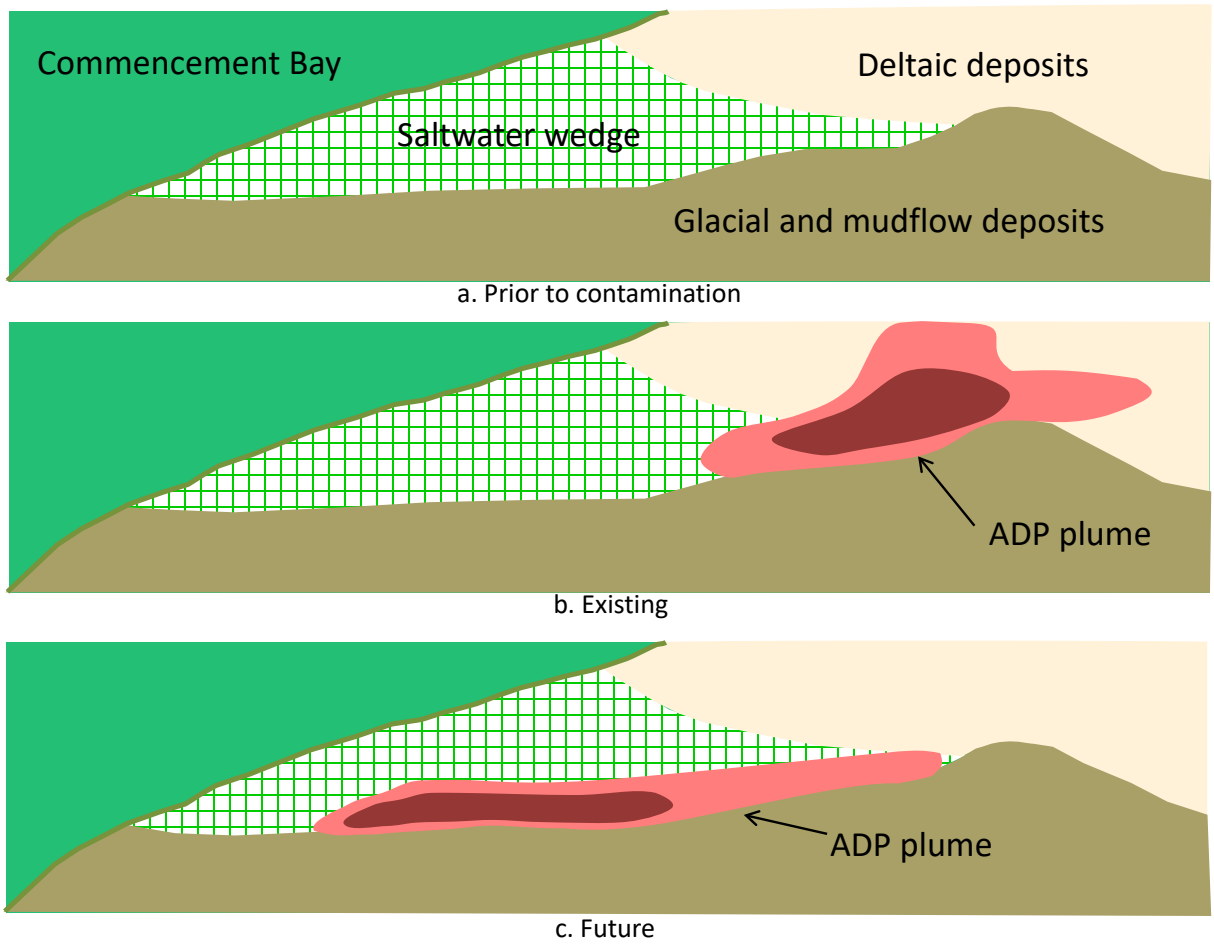


Figure 1. Simplified illustrations of the current and expected future distribution of the ADP.

[24] Anchor QEA, 2016. Data Summary Report, Occidental Chemical Corporation, Tacoma Groundwater Site, November.

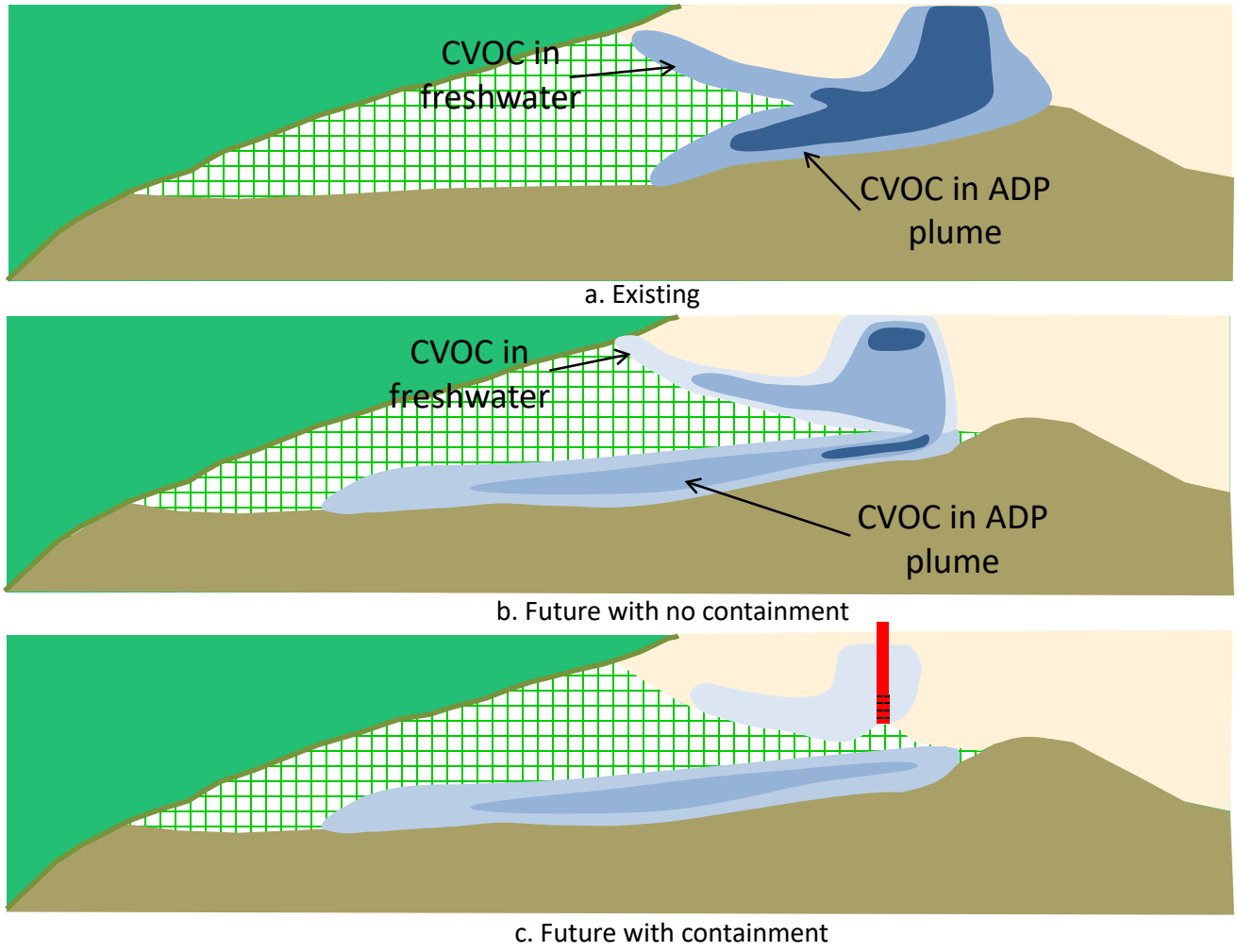


Figure 2. Simplified illustrations of the current and expected future distribution of the CVOC plume

Appendix B: Overview of results from the UW research related to pH transport and treatment (Joel Massmann)

Extensive laboratory and field studies have been completed to provide data to evaluate the feasibility of pH treatment and containment alternatives. These studies were completed by Occidental's consultant CRA (GHD) and by the University of Washington. The studies completed by CRA are described in four primary reports published between 2004 and 2013, as listed below.

- CRA, 2004. Draft Rapid pH Assessment Report (Revised July 1, 2004), July.
- CRA, 2004. Laboratory Treatability Study for pH Source Control (Revised August 9, 2004), August.
- CRA, 2011. Draft pH Pilot Study Report, January.
- CRA, 2013. Soil Flushing Treatability Study, ref. No 7843 Memo 14.

The CRA reports were reviewed by an independent expert reviewer hired through the Department of Ecology in 2013. The recommendations from the independent reviewer were incorporated into a work plan for additional pH studies conducted by the University of Washington. Two primary reports describing the University of Washington work were published in 2015 and 2017, as listed below.

Korshin, G., M. Benjamin, and Y. Gao, 2015. Effects of pH and Redox Potentials on the Partition Coefficients Characterizing Heavy Metal Release from Oxy Site Soils, prepared by the University of Washington for Glenn Springs Holding Inc., May 3, 2015.

Korshin, G., and M. Benjamin, 2017. Examination of Silica Precipitation, Gelation and Hydraulic Fouling in Occidental Chemical Corporation (OCC) Soils, prepared by the University of Washington for Glenn Springs Holding Inc., January 23, 2017.

The findings of the UW research were generally consistent with findings from the CRA studies. The UW study, however, considered additional topics and issues. This addendum provides an overview of some of the results from the UW research in question-and-answer form.

Will the high-pH source areas continue to generate high-pH groundwater?

Yes. As clean groundwater flows through high pH soils, the soils will continue to generate high pH water for a very long time.

Will the groundwater from the high-pH source area continue to dissolve silica from the aquifer?

No. Laboratory experiments done on aquifer samples from the site showed that additional silica

will not likely be dissolved from high-pH groundwater. The silica that is currently dissolved in the groundwater was the result of discharges of very caustic materials. Groundwater, even with very high pH values, is not sufficiently caustic to dissolve the aquifer materials.

Is the pH plume expected to move?

Yes. The UW experiments showed that as the high pH groundwater moves through previously affected soils, the pH does not change significantly. As high pH groundwater moves through soils not previously affected by the pH plume, some pH change does occur at the front end of the plume. All in all, the pH plume is expected to migrate, stabilize, and be neutralized before discharging to Commencement Bay due to the long times involved.

Do we know how much acid would be needed to neutralize the high-pH areas?

Yes. Experiments were done to determine the amount of acid needed to neutralize the high-pH areas. These experiments show that the amount of acid needed for a particular location can be estimated by measuring the groundwater pH.

Can gels be purposely formed to create flow barriers within the aquifer?

Yes, with caveats. Experiments have shown that this is theoretically possible. However, there are practical difficulties. The flow barriers are created through acid injection. The acid causes the pH to drop which in turn causes gels to plug the soil pores. However, large amounts of acid would be required and it is difficult to get the acid spread uniformly to all areas. There are also questions about the long-term stability of the gels that result from acid injection.

Can wells be designed and operated in ways to reduce the likelihood of plugging?

Yes. Experiments showed that plugging was more likely to occur if the groundwater velocity was high (above about 50 to 100 feet per day). Pumping wells at lower rates and using wells with larger diameters are expected to reduce the likelihood of plugging.

Where are wells expected to be most susceptible to plugging?

The areas that are most susceptible to plugging are those areas with higher levels of aluminum, areas with lower levels of dissolved organic carbon, and areas where the silica plume is drawn into previously un-impacted soils.

Will there likely be warnings that a well is becoming plugged?

Yes, there will likely be warnings. The laboratory experiments using columns of soil showed that fouling occurs over a period of time. The onset of plugging can likely be identified by measuring water pressures and flow rates in the well and by measuring silica concentrations in groundwater from the well.

If wells get plugged, can they be rehabilitated?

Yes, with caveats. If the aquifer in the vicinity of the well does not become completely plugged, then it is likely that the wells can be rehabilitated by using solutions of acid. However, if the aquifer becomes too plugged, then it becomes difficult to get the acid to the plugged areas. These locations would likely need to be abandoned or replaced.

Are there are commercially available products that prevent silica dissolution?

Yes, there are such products. However, the UW research showed that these products will not likely be effective in reducing the likelihood of silica gel formation in the high-pH, high-silica groundwater pumped from the OCC site.

Does diluting the high-pH, high-silica water with potable water reduce the likelihood of gels being formed?

Yes, with some caveats. Gels are formed when the pH of water with high silica concentrations is reduced below a pH of about 11. If the concentration of silica is reduced sufficiently through dilution before the pH is dropped, then gels will be less likely. However, at some locations on the Occidental site, the groundwater is super-saturated with silica and the concentrations are so high that dilution with potable water will not likely be effective.

Can the silica be removed from groundwater after it is pumped out of the ground?

Yes. The UW experiments showed that nearly all of the dissolved silica can be removed from the groundwater by adjusting the pH to an appropriate level (e.g., <10.5) and by adding salts of calcium or magnesium.

What do we know about the solids that result from removing the silica?

We know that the solids can be dried using press-filters and mild heating (about 30 degrees C or 90 degrees F) and we know that large volumes may be produced. For example, about five tons per day would result from pumping 25 gallons per minute in areas with silica concentrations of about 35 grams per liter.

Appendix C: Summary of potential effects of geologic disasters on the Occidental site cleanup project (Seamus McLaughlin)

The purpose of this memorandum is to address concerns about geologic disaster events that could affect cleanup of the Occidental Site, in Tacoma, Washington if they come to pass. Like much of Washington, the Tacoma area is at risk of being impacted by several major geologic disasters: earthquakes, landslides, and lahar flows. This memorandum summarizes how these events could affect the Occidental Site. All these disaster events have the potential to impede cleanup progress, but only earthquake and landslide events likely have the capacity to disturb contaminated zones and cause significant mobilization of Site contaminants.

Earthquake and Landslide Hazards

Washington State contains several fault zones capable of producing large earthquakes, such as a Cascadia Subduction Zone earthquake. To be effective, preparing for these disasters requires a full range of efforts and a comprehensive strategy. The Tacoma and Seattle fault zones (Figure 1) are the two features most capable of producing earthquakes that could significantly affect the Port of Tacoma area. Both fault zones produced approximately magnitude 7 earthquakes 1,000 – 1,100 years ago, and similar earthquakes are almost certain to occur in the future (Gomberg et al., 2010). A repeat of similar magnitude earthquakes today, would cause significant shaking, liquefaction, landsliding, and tsunamis (Gomberg et al., 2010).

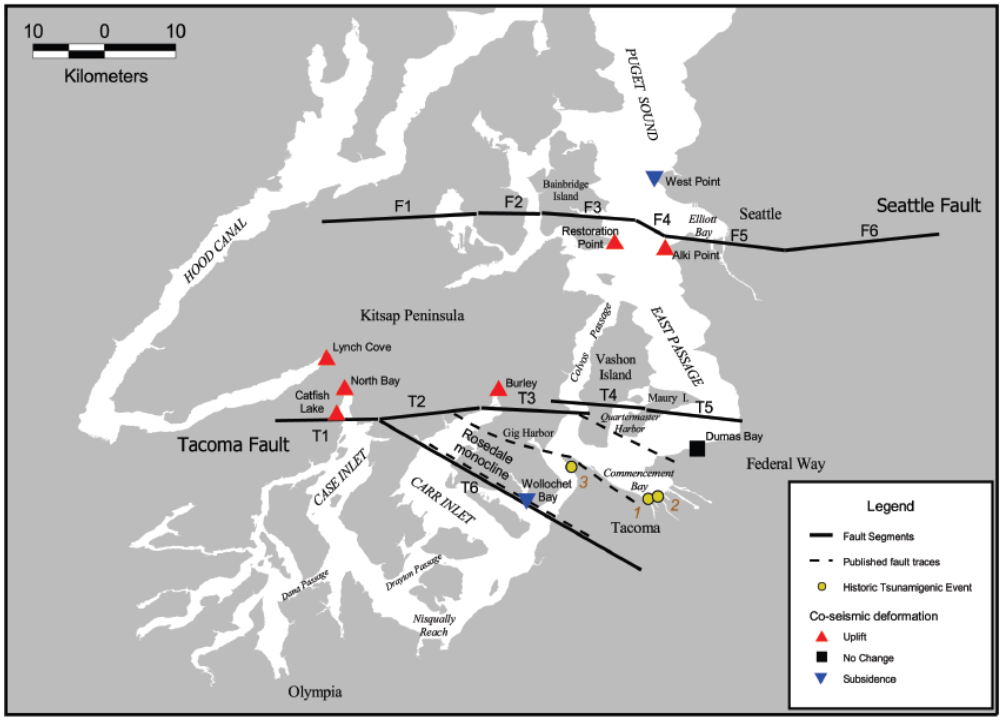


Figure 2: Puget Sound map displaying Seattle and Tacoma fault segments, published fault traces, coseismic deformation, and known historic tsunami events (Walsh et al., 2009).

Results from numerical modelling (Figure 2) show that a worst case scenario earthquake (magnitude 7.3) on the Seattle fault would generate inundation depths of more than 2 meters in much of the Puyallup Delta, possibly inundating areas along the Hylebos waterway by more than 5 meters (WA DNR 2009). Results show that flooding from a worst case scenario earthquake (magnitude 7.3) on the Tacoma Fault Zone would be less significant (Appendix A), but areas along the Hylebos waterway could still be inundated by more than 4 meters (Walsh et al., 2009).

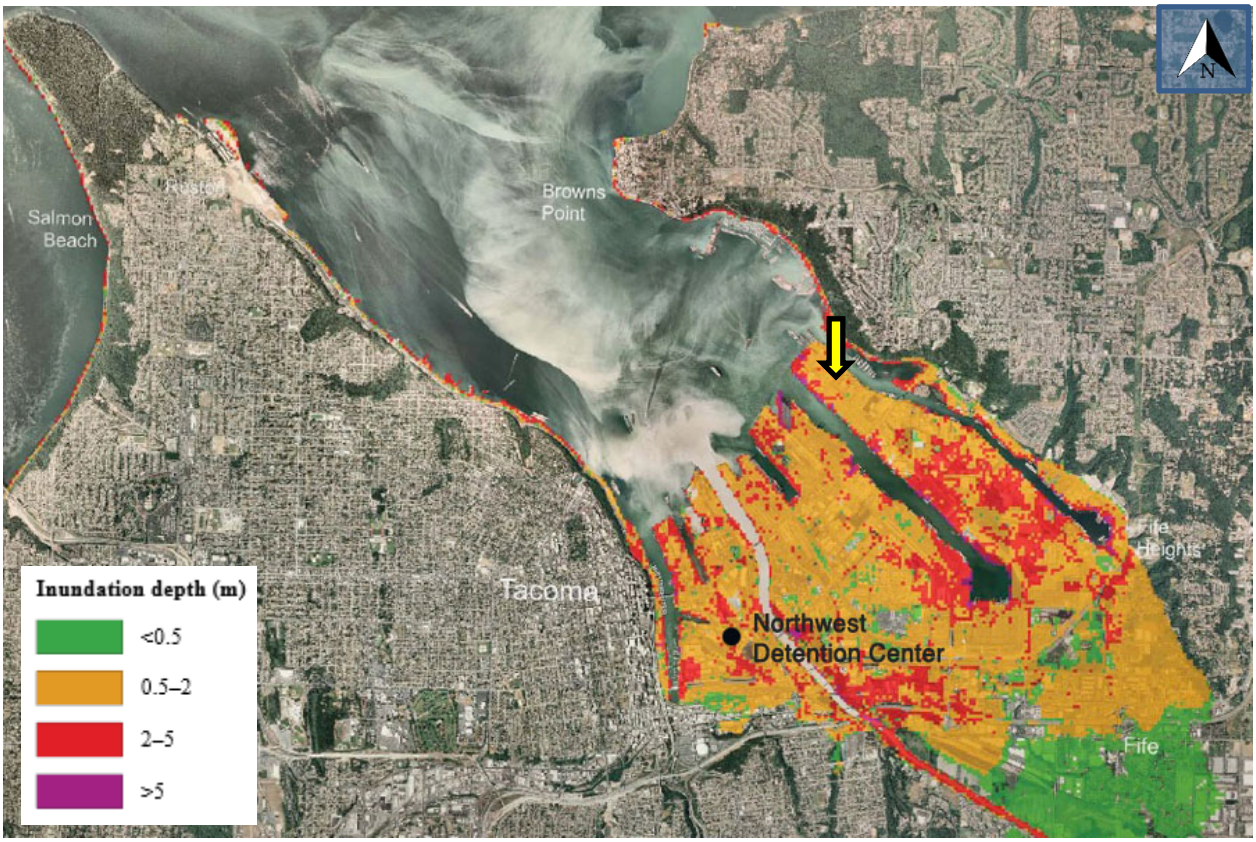


Figure 3: Modeled inundation from a tsunami induced by a magnitude 7.3 Seattle Fault earthquake (Walsh et al., 2009). A yellow arrow indicates the location of the Occidental Site. 1:36,000 map scale.

If tsunami flooding occurs at the Occidental Site, it is unlikely to mobilize many contaminants. Hazardous wastes are no longer stored on the Site, and the only operational structures consist of the groundwater treatment and containment facility, and associated office space (GHD, 2017). Approximately 89 percent of the total chlorinated volatile organic compounds (TCVOC) mass, is located at least 33 feet below the ground surface (GHD, 2017). It is expected that flooding from a tsunami would not mobilize these contaminants, or even those located only a few feet below the surface. The main concern with worst-case scenario tsunami flooding is that it could significantly impact cleanup operations by damaging facilities and/or depositing large volumes of sediment on site.

Subsurface movements at the Occidental Site have much greater potential to disturb and mobilize contaminants than tsunami flooding. Both landsliding and seismic shaking are capable of generating substantial subsurface movements; however, due to the uncertainty about earthquakes in this region, it is difficult to predict how seismic activity will affect the Occidental Site specifically. Certain earthquake scenarios may induce severe seismic shaking in the area, while others may not result in any perceptible ground movements at the Site.

Landslides are also capable of generating subsurface movements, but to physically disturb Occidental contaminants, landslide events would need to occur on or very close to the Site. Not many landslide hazards exist on the Site peninsula, because very few slopes have gradients greater than or equal to forty percent, a main indicator of landslide hazards in Washington State (City of Tacoma, 2008). Numerous slopes on the eastern side of the Hylebos waterway do have this qualification, and pose increased risks for landslide events (City of Tacoma, 2008). However, a landslide initiated on the east side of the waterway would likely be too far away to impact Site contaminants. It could still damage cleanup-related structures, such as monitoring wells, if any are located within its path.

Mt. Rainier Lahars

A study completed by Hoblitt and others (1998), indicates that the only immediate volcanic risks posed to the Tacoma area are from Mt. Rainier lahars. Lahars, also called volcanic mudflows, are mixtures of water and debris that flow downhill, often traveling tens of miles and exceeding speeds of thirty miles per hour. Mt. Rainier lahars typically form when slope failures on Mt. Rainier generate a rapidly moving landslide, called a debris avalanche. Debris avalanches turn into lahars when they obtain enough water. This can happen when a debris avalanche enters a waterway, or simply from the melting of ice and snow mixed in with the debris, which has often been the circumstance with Mt. Rainier (Hoblitt et al., 1998).

Only two lahar cases are capable of reaching the Occidental Site. These are Case II and Case M lahars (Hoblitt, et al., 1998). The average time interval between Case II lahars from Mount Rainier is near the lower end of the 100 to 500-year range, making them analogous to the so-called "100-year flood" (Hoblitt, et al., 1998). Case M lahars are those similar in magnitude to the Osceola Mudflow, the largest lahar to occur at Mount Rainier in the past 10,000 years, and occur much less frequently than Case II lahars (Hoblitt, et al., 1998). Due to the distance of the Occidental Site from Mt. Rainier, it is likely that any lahars reaching the Site will not have the capacity to significantly disturb contaminants beneath the ground surface. Similar to tsunamis, the greatest risk of lahars is their potential to damage facilities and deposit significant volumes of sediment on site.

Emergency Response

The Washington State, Pierce County, and City of Tacoma Emergency Management Divisions are aware of geologic disaster events that have potential to impact their respective jurisdictions. Pierce County is currently in the process of developing a three-county coordination plan in preparation for a Mt. Rainier eruption and/or lahar event. No emergency management plans specifically address disaster-related releases of waste at the Occidental Site, but plans do exist at the state, county, and city levels for responding to hazardous material releases in general. The purpose of these plans are to coordinate responses from multiple levels of government that will minimize the effects of hazardous material releases on people and the environment.

The WA State Department of Ecology is aware of impacts geologic disasters may have on the Occidental Site, and will take this knowledge into consideration during the design process for Site cleanup. It is understood that large releases of hazardous wastes into Commencement Bay and adjacent waterways, would contaminate not only the areas of release but also, the coastline of Pierce and neighboring counties, due to tides within Puget Sound (Pierce County Department of Emergency Management, 2015). Depending on quantities and characteristics of the chemicals released, this could pose a threat to citizen's health for weeks or even longer (Pierce County Department of Emergency Management, 2015). Ecology will recommend that Occidental has an emergency plan in place, to address any impacts to the Site in the event of a geologic disaster.

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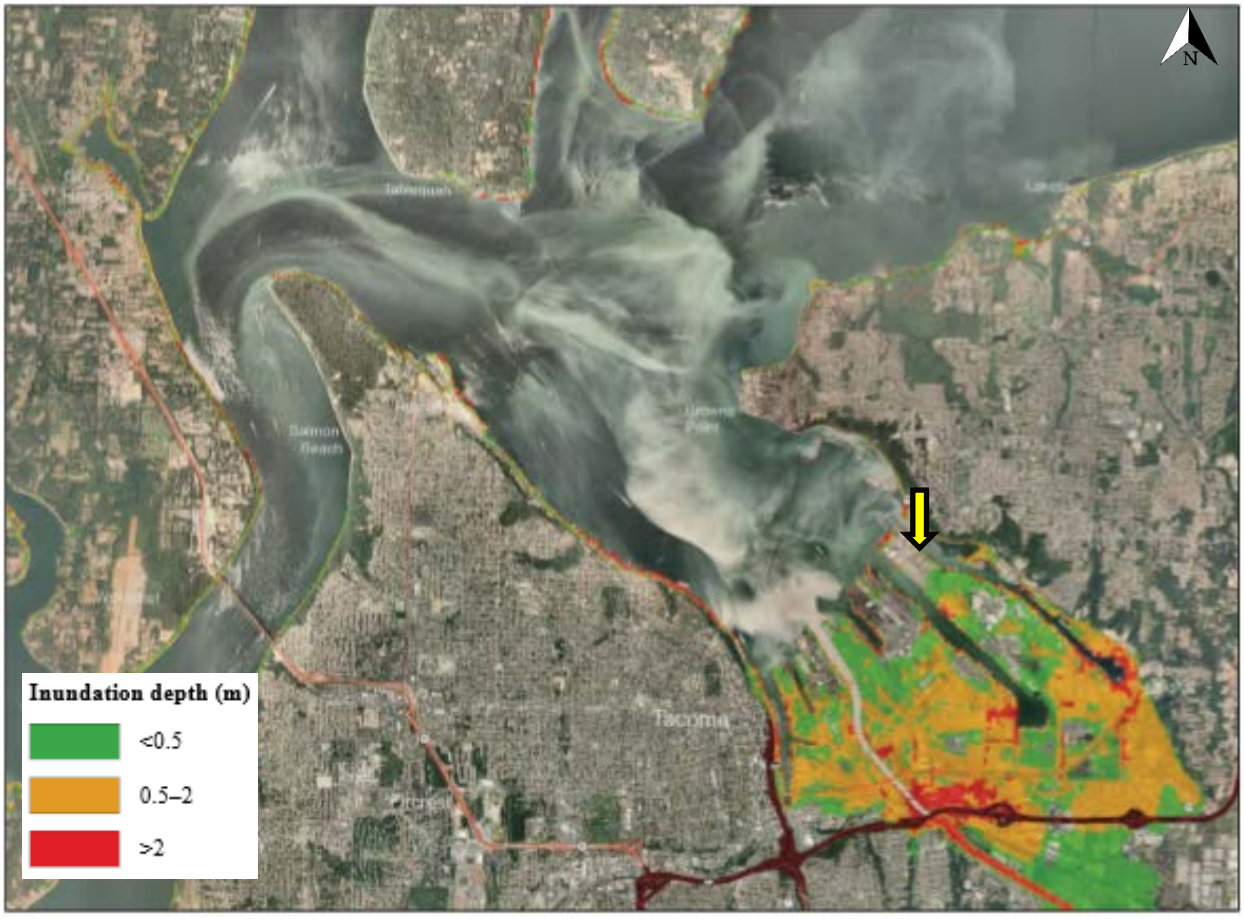

Figure 4: Modeled inundation from a tsunami induced by a magnitude 7.3 Tacoma Fault earthquake (Walsh et al., 2009). A yellow arrow indicates the approximate location of the Occidental Site. 1:62,500 map scale.

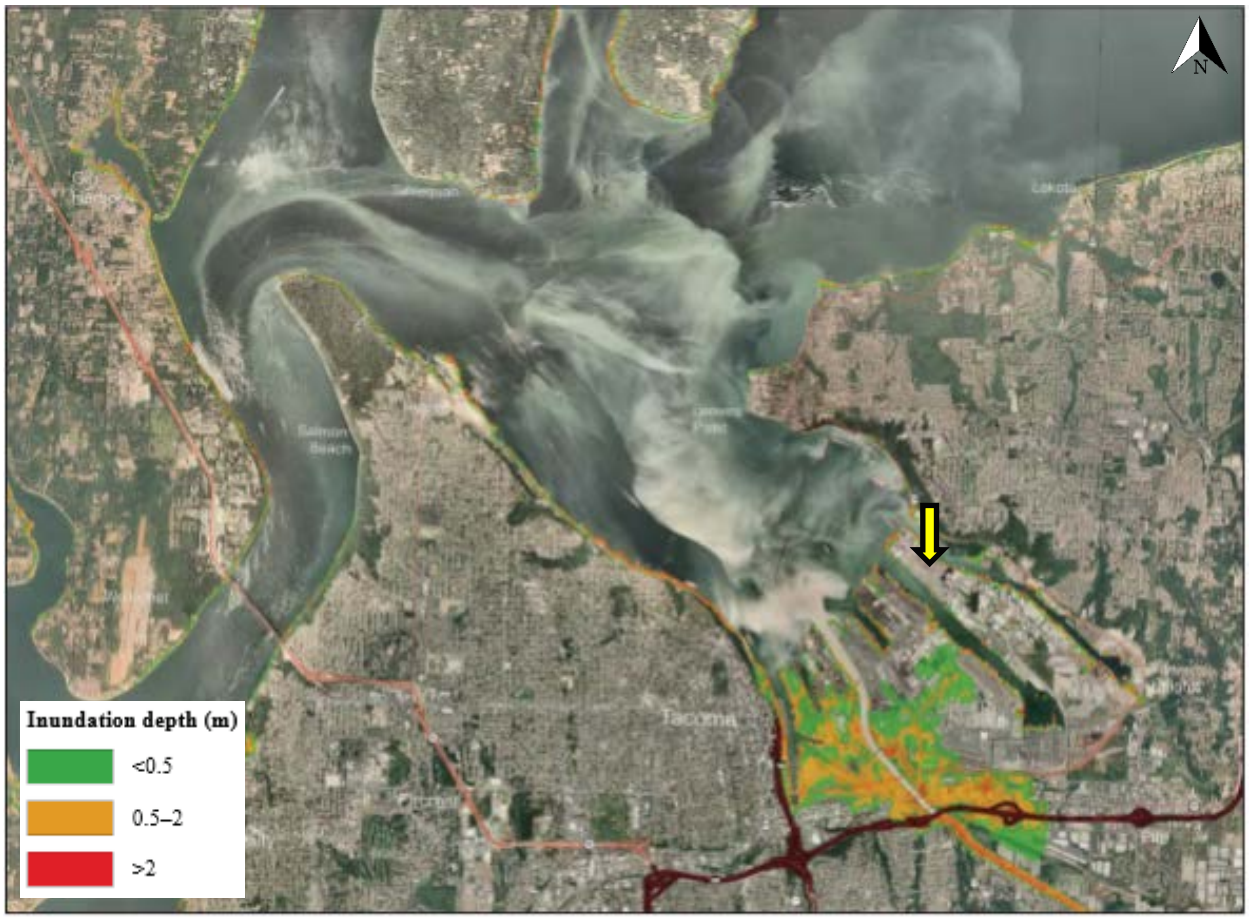

Figure 5: Modeled inundation from a tsunami induced by a magnitude 7.3 Tacoma-Rosedale Fault earthquake (Walsh et al., 2009). A yellow arrow indicates the approximate location of the Occidental Site. 1:62,500 map scale.

Appendix D: Review and Evaluation of Risk Assessment Documents for the Occidental Chemical Corporation Corrective Action Site (Ridolfi Environmental)

RIDOLFI Environmental

M E M O R A N D U M

DATE: October 30, 2015

TO: Kerry Graber, Washington Department of Ecology
Hazardous Waste and Toxics Reduction Program

FROM: Bill Beckley, Sherrie Duncan, and Bob Dexter – RIDOLFI Inc.

SUBJECT: **Review and Evaluation of Risk Assessment Documents for the Occidental Chemical Corporation Corrective Action Site**

1.0 Purpose and Scope of Review

The objective of this technical memorandum is to present a summary and evaluation of specific documents related to human health and ecological risk posed by the Occidental Chemical Corporation (OCC) Corrective Action site. To support the Department of Ecology (Ecology) Hazardous Waste and Toxics Reduction Program in overseeing ongoing investigation and remediation efforts at the Occidental Site, the Ridolfi project team reviewed risk assessments performed by the Environmental Protection Agency (EPA) for the Commencement Bay Nearshore Tideflats (CB/NT) Superfund Site, and a Streamlined Risk Assessment and Exposure Pathway Assessment Report prepared by OCC. This memorandum provides Ridolfi's professional opinions regarding the evaluation of risk that has been completed by OCC so far, and makes recommendations for further study and assessment.

2.0 Background Review

2.1 EPA Risk Assessment Summary

The primary background documents reviewed relative to previous risk assessment work performed by EPA for the Hylebos problem area included: *Commencement Bay Nearshore/Tideflats Record of Decision* (September 1989); *Explanation of Significant Difference for the Record of Decision: Commencement Bay, Near Shore/Tide Flats, Operable Unit 01 - Sediments and Operable Unit 05 - Source* (July 28, 1997); and *Third Five-Year Review Report for Commencement Bay Nearshore/Tideflats Superfund Site Tacoma, Washington* (December 23,

2009). A brief description and evaluation of the relevant portions of these documents is provided in the following sections.

2.1.1 Commencement Bay Nearshore/Tideflats Record of Decision (1989)

Human health and environmental risk assessments were conducted as part of the Remedial Investigation (RI) for the CB/NT Superfund site. The risk assessments were based on exposure of marine biota to contaminated sediment and exposure of humans to contaminated seafood. Health risks were estimated for consumers of CB/NT fish and shellfish for both carcinogens and non-carcinogens.

Sediment Quality Objectives (SQOs) for all "problem chemicals" were set based on an evaluation of the ecological and human health risks posed by those chemicals. The SQO for polychlorinated biphenyls (PCBs) was based on the human health risk assessment. The SQOs for all other chemicals were based on the ecological risk assessment, as it was determined that the ecologically-based cleanup levels were also protective of human health.

2.1.1.1 Human Health Risk Assessment

For the human health risk assessment, the average concentration of each chemical in English sole from the study area was used to calculate exposure, based on two seafood consumption rates (1 pound/day and 1 pound/month) and a 70-year exposure duration. Based on these exposure assumptions, six chemicals were predicted to result in a cancer risk greater than 10^{-6} at the maximum fish consumption rate of 1 pound/day (453 grams/day). Those chemicals included PCBs, arsenic, hexachlorobenzene, hexachlorobutadiene, bis(2-ethylhexyl)phthalate, and tetrachloroethene. Only PCBs and arsenic had predicted risk levels greater than 1×10^{-4} (although hexachlorobenzene risks were predicted to be *equal to* 1×10^{-4}). At a fish consumption rate of 1 pound/month (12.3 grams/day), only PCBs and arsenic would exceed the 10^{-6} risk level. A lifetime excess cancer risk of 2×10^{-4}, or 2 in 10,000, was estimated for a person eating one pound of Commencement Bay fish per month.

Arsenic was not subjected to further evaluation relative to human health because of its lower cancer risk level (compared to PCBs) and because arsenic concentrations in CB/NT fish were similar to concentrations in fish from the reference area.

For non-carcinogens, three metals (antimony, lead, and mercury) were present in fish muscle tissue in concentrations that would exceed the Acceptable Daily Intake (ADI) values at the consumption rate of 1 pound/day. However, the ADI values would also be exceeded for fish

from Carr Inlet (a reference area) at the 1 pound/day consumption rate. Limiting consumption of fish to 0.5 pounds/day would result in exposure below the ADI values for all three metals.

Bioaccumulation data indicated that sediment contamination by metals in Commencement Bay was not resulting in significantly increased tissue levels for metals. Therefore, risks of non-carcinogens in fish tissue were not evaluated further in estimating sediment cleanup levels. Additionally, based on the information available on the toxicity of PCBs at that time, it was concluded that the potential for non-cancer impacts was not of concern.

The baseline risk assessment concluded that the most significant human health risks were associated with elevated concentrations of PCBs in the tissues of resident seafood, and the SQO for total PCBs was set at 150 micrograms per kilogram (µg/kg).

2.1.1.2 Ecological Risk Assessment

The chemical SQOs for protection of aquatic life were set using the Apparent Effects Threshold (AET) method. The AET method does not address bioaccumulation, and thus may underestimate risks to organisms who eat invertebrates or fish contaminated with bioaccumulative compounds like PCBs. It was determined that the SQO for PCBs should be set based on the risks to human health from eating PCB-contaminated seafood, because a lower PCB cleanup level was necessary to protect human health.

The ecological risk assessment identified adverse biological effects, primarily toxic effects to the benthic infaunal community.

2.1.1.3 Discussion/Evaluation

The risk assessments performed in support of the Remedial Investigation/Feasibility Study (RI/FS) and Record of Decision (ROD) for the CB/NT site were conducted prior to the promulgation of State cleanup standards (either under the Model Toxics Control Act [MTCA] or the Sediment Management Standards [SMS]), and were generally similar to other Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) risk assessments of that era. However, the assessments would not necessarily be consistent with regulations and guidance that were promulgated, revised, or finalized shortly after the ROD was signed. The "acceptable range of risk" used to develop cleanup standards (10^{-7} to 10^{-4}) is less protective than the risk range that would be allowable under the MTCA regulations. The MTCA regulations [Washington Administrative Code (WAC 173-340)] require that cleanup levels do not

result in cancer risks exceeding 1 x 10^{-6} for individual carcinogens and 1 x 10^{-5} for multiple carcinogens, and that effects from non-carcinogens do not exceed a hazard quotient (HQ) of 1.

Additionally, Risk Assessment Guidance for Superfund (RAGS), finalized shortly after the ROD, recommends the use of an upper confidence limit on the mean concentration for characterizing exposures, rather than a simple arithmetic mean, which is the value that was used in the human health risk assessment to represent contaminant concentrations in English sole tissue. The ROD acknowledges that "for English sole, there was considerable variability in PCB concentrations among the waterways and within the waterways." Maximum PCB concentrations in English sole from the Hylebos Waterway were six times higher than the average concentration used for the risk assessment. Use of an upper confidence limit on the mean would have likely resulted in higher risk estimates and may have resulted in a greater number of chemicals exceeding risk thresholds.

Finally, while the ROD acknowledged that the AET method may underestimate risks to higher trophic level species from bioaccumulative compounds, it is not clear that SQOs for other bioaccumulative compounds, including hexachlorobenzene, were set at levels protective of higher trophic level species (PCBs and hexachlorobenzene were selected as chemical indicators at the mouth of Hylebos waterway).

2.1.2 Explanation of Significant Difference for the Record of Decision (1997)

In 1997, EPA published an Explanation of Significant Difference (ESD) for the 1989 ROD. The purpose of the ESD was to modify the cleanup level for remediation of marine sediments contaminated with PCBs at the CB/NT Superfund site.

2.1.2.1 Human Health Assessment

EPA updated the human health risk evaluation as a basis to evaluate the risks associated with a variety of potential PCB cleanup levels. Although EPA's risk assessment methodology had not been modified substantially since the original risk assessment was performed in 1988, some of the exposure and toxicity assumptions had been changed based on new information and new Superfund guidance.

Because the Puyallup Tribe of Indians has treaty rights to fish in Commencement Bay, "high-end Tribal fishing" was used as the reasonable maximum exposure scenario for EPA's decision-making purposes. An average and high-end recreational fishing scenario and an average Tribal fishing scenario were also calculated for purposes of comparison. Fish consumption rates for the

recreational fishing scenario were the same as those used in the 1989 ROD. Because no studies had documented Tribal fish consumption rates in Commencement Bay, rates were estimated from recently completed surveys (1996) of fish consumption by members of two other Puget Sound tribes, the Tulalip Tribes and the Squaxin Island Tribe.

The high-end Tribal scenario was intended to represent risks to "a tribal fisherperson who consumes a relatively large amount (upper 90th percentile) of fish compared to other tribal members."

The estimated post-cleanup cancer risks at a PCB SQO of 300 µg/kg were determined to be within EPA's acceptable risk range of 10^{-4} to 10^{-6}. Cleanup to a PCB sediment remedial action level (SRAL) of 450 µg/kg was determined to result in interim risks that were also within EPA's acceptable risk range. Although the estimated risk was 1.4×10^{-4} for the CB/NT Site and 1.6×10^{-4} for the Hylebos Waterway, EPA indicated that its policy states that the upper boundary of the risk range is "not a discrete line at 1×10^{-4}". Cleanups to levels "slightly greater than" 1×10^{-4} may be considered acceptable if justified based on site-specific conditions. EPA assumed that people were more likely to fish in more than one location in Commencement Bay than in Hylebos Waterway alone, so the CB/NT Site-wide risk estimate was determined to be the best estimate of risks to area fisherpersons.

The National Oil and Hazardous Substances Contingency Plan (NCP) does not set a numeric target range for non-cancer risks, but states that acceptable exposure levels shall represent "concentrations to which the human population, including sensitive subgroups, may be exposed without adverse effect during a lifetime or part of a lifetime, incorporating an adequate margin of safety." Cleanup to 300 µg/kg PCBs was determined to result in a CB/NT Site-wide Hazard Quotient (HQ) of 7. EPA reasoned that "the HQ of 7 is not appreciably different than the HQ of 6 estimated for cleanup to 150 µg/kg PCBs under the 1989 ROD."

2.1.2.2 Discussion/Evaluation

During pre-design sampling, new data were collected from the Hylebos Waterway that indicated approximately twice the amount of sediment originally estimated in the ROD would require cleanup, and that cleanup costs would also be about twice the estimate in the ROD. This appears to be a primary driver for increasing the PCB SQO. However, in 1996 the cancer slope factor for PCBs was decreased from 7. 7 to 2.0 milligrams/kilograms-day^{-1}, and the risk evaluation updated for the ESD includes the new cancer slope factor, as well as a new exposure duration, and a new range of fish consumption rates.

Although not prominently explained in the text of the ESD, the tribal "high-end" and average consumption rates (listed as 123 grams/day and 41.7 grams/day, respectively) were modified to reflect that only a portion of that rate (69 percent) would be associated with the site, effectively making the rates 85 grams/day and 29 grams/day. Further, rather than assuming a 70-year (lifetime) exposure duration, as was assumed in the ROD, the ESD assumes a shorter, 30-year exposure duration. Consumption rates of 85 grams/day and 29 grams/day over a 30-year exposure duration are equivalent to 36 grams/day and 12.4 grams/day over a 70-year exposure duration. While intended to represent Tribal fisher exposure scenarios, these rates may underestimate a Tribal exposure scenario.

Since the ESD only updated the human health risk assessment for PCBs, it did not account for risks from other carcinogens that may result from leaving higher levels of contamination in place. The allowable risk range cited by EPA (10^{-4} to 10^{-6}) is intended to address *cumulative site risk* from multiple carcinogens.

In addition to these updates, the ESD also acknowledges that "[s]ince publication of the ROD, the State of Washington has promulgated Sediment Management Standards (SMS), which require that contaminant levels in sediments within the State be protective of human health and aquatic life." There is not a further acknowledgement that the cleanup standards in the MTCA regulations, including maximum allowable risk levels, had also been revised and updated since publication of the ROD.

In a letter of qualified concurrence with the ESD, the Department of Ecology states that "[a]s the proposal currently stands, the termination of cleanup after dredging to 450 parts per billion (ppb) will not achieve a level of protection for humans or wildlife that will meet Ecology's requirements. Ecology's goals for acceptable human health risk for carcinogens are 1×10^{-6} to 1×10^{-5} and for noncarcinogens, hazard indices for human or ecological health are not to exceed a value of one." Since the requirements of MTCA are considered applicable requirements for CERCLA cleanup actions, the proposed changes in the ESD do not appear to comply with Applicable or Relevant and Appropriate Requirements (ARARs) that existed in 1997, which is one of the "threshold criteria" for CERCLA cleanups.

Despite the fact that the proposed change would not meet Ecology's requirements, Ecology did concur with the proposed increase in the PCB SQO, noting that the agency would "endorse the implementation of a 10 year natural recovery period as an element of the cleanup to achieve further reduction of PCBs." Ecology's concurrence was subject to the following conditions:

- Active Remediation to 450 ppb PCBs throughout Commencement Bay
- Recovery within ten (10) years to a maximum level of 300 ppb
- Monitoring to confirm recovery will be achieved
- Additional remedial action triggered if recovery will not meet cleanup levels
- Cleanup action to commence no later than year 2001

The Puyallup Tribe of Indians did not concur with the selected PCB cleanup level.

2.1.3 Third Five-Year Review Report (2009)

The purpose of a Five-Year Review (FYR) is to determine whether the remedy at a site is protective of human health and the environment.

2.1.3.1 Human Health Risk Assessment

Since the 1989 ROD, new information had become available on Tribal seafood consumption rates and exposure durations for Tribal populations. In the Third FYR EPA considered this new information for the Sediments Operable Unit (OU).

In August 2007, EPA Region 10 issued a "*Framework for Selecting and Using Tribal Fish and Shellfish Consumption Rates for Risk-Based Decision Making at CERCLA and RCRA Cleanup Sites in Puget Sound and the Strait of Georgia*". The Framework was designed to assist EPA Region 10 with managing hazardous waste cleanup sites with Tribal seafood consumption exposures and concerns.

In areas of the Sediments OU where PCBs remain in sediments (including the Hylebos Waterway), PCBs are a human health contaminant of concern. Therefore, for its Third FYR, EPA identified the consumption rates and exposure duration in the Framework (97.6 grams/day over 70 years) as new information that could impact the estimated risk associated with residual PCBs that could call into question the long-term protectiveness of the remedy.

The "high end" Tribal fishing scenario used in the 1997 ESD, which modified the PCB goals for the CB/NT Sediments OU, used a rate of 123 grams/day over 30 years and estimated the post-cleanup residual excess cancer risk associated with that level at 1.2×10^{-4}. In the ESD, EPA stated that "The analysis focused on cancer risks as the most conservative estimate of risks to human health. The risk assessment estimated cancer risks only, because a PCB cleanup level based on cancer risks was shown to be protective of non-cancer risks as well." EPA indicated in the FYR that the Agency was "still evaluating whether the revised exposure assumptions could make a significant difference to non-cancer risk. "

Application of the Framework exposure assumptions discussed above resulted in a revised post-cleanup estimated residual excess individual lifetime cancer risk of 2.2×10^{-4}.

Based on this evaluation, EPA did not believe that this difference was significant enough to call into question the protectiveness of the remedy nor to require any additional action at this time. EPA believed that the PCB SQO (300 µg/kg) remained protective.

The Third FYR notes that since the ROD, the Dredged Material Management Program (DMMP) had listed both Chlordane and dioxins/furans as bioaccumulative chemicals in the Hylebos Waterway. Neither chemical was evaluated for human health risks in the RI/FS.

2.1.3.2 Discussion/Evaluation

Since there was no indication in the Third FYR that additional fish tissue sampling had been conducted, it is assumed that the updated risk assessment was based on the same tissue concentrations as the previous risk assessments.

It appears that the revised risk estimate (2.2×10^{-4}) was calculated by simply determining the difference between the previous exposure assumptions (123 grams/day over 30 years) and the revised Framework assumptions (97.6 grams/day over 70 years). A consumption rate of 123 grams/day over 30 years is equivalent to an exposure of 52.7 grams/day over 70 years. The relationship between these two rates (97.6 and 52.7 grams/day) is identical to the relationship between the calculated risk levels (1.2×10^{-4} and 2.2×10^{-4}).

However, as noted previously, the 1997 ESD used a modified Tribal consumption rate based on the assumption that only 69 percent of the consumption was attributable to the Site, so the effective rate, over a 70-year exposure, would be 36.3 grams/day (52.7 x 69 percent). Based on the actual difference in exposure assumptions, the revised post-cleanup risk level would be 3.2×10^{-4}, and as noted previously, this is only for a single carcinogen, and does not account for cumulative risk. It is not clear whether this difference is "significant enough to call into question the protectiveness of the remedy." The potential risks from other carcinogens were not evaluated based on the revised exposure assumptions.

Based on updated exposure assumptions regarding fish consumption, and the level of protection required by State regulations, it is possible that other contaminants, that may not be co-located with higher concentrations of PCBs, may still be present at unacceptably high

concentrations. As noted in the Third FYR, certain bioaccumulative chemicals, including dioxins, were not evaluated for human health risks in the RI/FS, and may be present at levels that present unacceptable risks to human health.

2.1.4 Other Relevant Background

In addition to the documents discussed in the preceding sections, other relevant background documents were reviewed and are briefly summarized below.

Explanation of Significant Difference for the Record of Decision (2000)
EPA published another ESD for the CB/NT Site in 2000. Among other changes, this ESD required the inclusion of the Endangered Species Act (ESA) as an ARAR for remedial actions conducted under the ROD.

Measurement of VOCs in Finfish and Shellfish Harvested from Commencement Bay, Washington (2009)
EPA worked with Ecology to measure volatile chemicals in resident fish and shellfish to assist in evaluating human health exposures related to the Occidental site. The Washington Department of Fish and Wildlife provided EPA with 23 specimens of resident finfish and crab harvested from "an area affected by releases of chlorinated VOCs from Occidental."

VOCs analyzed for the Occidental site were perchloroethylene (PCE), trichloroethylene (TCE), vinyl chloride, and hexachlorobutadiene. At least one VOC was detected in all samples. Vinyl chloride was not detected in any samples, but EPA noted that it "probably was not present as a contaminant in the immediate area where the tissue samples were obtained". The highest VOC concentrations were detected in crab hepatopancreas samples, the highest being 79.8 µg/kg PCE. PCE, TCE, and hexachlorobutadiene were detected in 90 percent, 83 percent, and 40 percent of all samples, respectively.

EPA indicated that the study, while limited, "demonstrates that the common assumption that VOCs will not be present in fish or shellfish tissue where VOCs have been released to surface waters is not necessarily true." Further, EPA noted that because anadromous species, particularly salmon, were not included in this study, this remains a data gap.

2.1.4.1 Discussion

The majority of risk assessment work related to the Occidental Site has been conducted as part of the larger CB/NT Site, and has focused primarily on PCBs in sediment. While the human health risk assessment done in support of the 1989 ROD ultimately focused on health risks from PCBs, it did identify PCE as one of three carcinogens present in fish tissue above background concentrations (in addition to PCBs and BEHP). At a fish consumption rate of one pound/day, the cancer risk from PCE was estimated to be 1×10^{-5}. EPA noted that "as the predicted risk values for tetrachloroethene and BEHP are so much lower than those for PCBs, they would not significantly add to the CB/NT Site risk due to PCBs", and no additional risk evaluation of PCE or other VOCs was conducted.

The primary VOCs present at the Occidental Site (PCE, TCE, and vinyl chloride) have a low tendency to bioaccumulate in the food chain, but can bioconcentrate in fish and shellfish tissue by exposure through the water column. VOCs have been measured in shallow groundwater potentially discharging to the Hylebos Waterway at concentrations several orders of magnitude higher than applicable water quality criteria for the protection of human health based on the consumption of fish and shellfish. They have also been detected in fish and shellfish tissue in the "area affected by releases of chlorinated VOCs from Occidental." While the most common route of exposure to VOCs is inhalation, ingestion of VOCs in contaminated foods may lead to both cancer and non-cancer health effects.

Based on a number of factors, including current MTCA and SMS requirements, known concentrations of VOCs in shallow groundwater, and the limited number and age of tissue samples, additional fish and shellfish tissue sampling would support a more robust evaluation of potential human health exposures.

3.0 Summary of Review Comments

Based on a review of both the *Streamlined Risk Assessment* (April 2011) and Appendix V (Exposure Pathway Assessment Report) of the *Draft Site Characterization Report Groundwater and Sediment Remediation* (August 2014), we recognized that the documents are sufficiently similar that we have focused our comments on the more recent Exposure Pathway Assessment Report. The Exposure Pathway Assessment Report includes a Site Characterization, which provides a discussion of the Conceptual Site Model (CSM); a Human Health Exposure Pathway Assessment (HHEPA); and an Ecological Health Exposure Pathway Assessment (EHEPA). General

comments regarding the Exposure Pathway Assessment Report are provided in the following section, followed by specific comments in the next section.

3.1 General Comments

1. The Exposure Pathway Assessment Report does not provide adequate characterization of natural resources, including habitats and species and their life histories, present at the Site and in the surrounding area. The Exposure Pathway Assessment Report also does not adequately describe the human activities that occur in the area. This incomplete information results in major gaps in the risk assessments and the CSMs, which in turn results in an inadequate selection and assessment of exposure pathways, receptors, and endpoints.

2. Because contamination remains in the sediments and embankment area of Hylebos Waterway, including contamination resulting from bioaccumulative chemicals, and has or will potentially reach Commencement Bay, the assessment should be revised to adequately evaluate the potential risks to human health and the environment.

3. While the Site and the surrounding areas are not pristine, they are certainly not devoid of life. Commencement Bay and the Hylebos Waterway provide important rearing, foraging, migratory, and adult habitat for numerous aquatic and terrestrial species. These estuarine waters are an important transitional area for juvenile salmonid species, bottom fish, forage fish, crab, bivalves and many other resident marine species. All of these species are found in these waters during every month of the year. The riparian buffers, salt marshes, and mudflats in the area provide important habitats for these aquatic species including plants, birds, and mammals. Commencement Bay and the Hylebos Waterway also provide recreational access and opportunities to the communities residing in and outside of the area.

4. The 2000 ESD added the ESA as an ARAR to the CB/NT ROD, which includes the Hylebos Waterway and Commencement Bay. The Hylebos Waterway and Commencement Bay provide habitat for federally-listed species, and critical habitat for several of these species has been designated in both waterbodies. Additionally, the area is home to several non-listed species, including forage fish, flatfish, crab, bivalves, and other inshore resident marine fish and benthic species which provide important prey resources to the federally listed fish, bird, and mammal species. Federally listed species for the area include Chinook salmon, steelhead trout, bull trout, three rockfish species, two whale species (including Southern resident killer whale), marbled murrelet, and streaked horned lark.

Several other bird and mammal species including but not limited to purple martin, great blue heron, kingfisher, osprey, bald eagle, peregrine falcon, raccoon, river otter, seal, and sea lion are also found in the area.

5. The Exposure Pathway Assessment Report does not provide adequate information regarding the existing and proposed mitigation and habitat restoration that has, is, and will continue to occur in the Hylebos Waterway in the vicinity of the Site and in Commencement Bay. Aside from the habitat restoration related to the Commencement Bay Natural Resource Damage Assessment settlement and mitigation related to Port of Tacoma development, millions of dollars have been and continue to be spent on salmon recovery efforts in the Puyallup River Watershed, which includes habitat restoration in the nearshore areas of Commencement Bay and its tributaries. As shown in Figure 3-1 of the Fourth FYR for CB/NT, several of the mitigation and restoration sites are in Commencement Bay and the Hylebos Waterway in the vicinity of the Site. These areas are backed by undeveloped wooded bluffs and green belts that provide terrestrial habitat for several bird species. These sites provide terrestrial, riparian, and aquatic habitat to the species discussed above, several of which have been observed in the Hylebos Waterway, and at the habitat restoration and mitigation areas and wooded bluffs and green belts across from the Site.

6. The Exposure Pathway Assessment Report does not provide adequate information about the human uses of Commencement Bay and the Hylebos Waterway. Human uses in the area include recreational and tribal fishing, crabbing, marina use, boating, sailing, diving, kayaking, paddle boarding, beach play, and bird and wildlife viewing. Commencement Bay supports both hatchery and listed- and non-listed salmon species including Chinook, coho, chum, and pink salmon for which run sizes have increased in recent years. These salmon species support a robust recreational fishery and provide food and sustenance to sport and tribal fishers in the area. The area is also within a tribal Usual and Accustomed fishing area.

7. The Exposure Pathway Assessment Report does not consider that it is unknown what development and future use will occur on the Puyallup Tribe's properties across the Hylebos Waterway from the Site. It should be assumed that humans will continue to access the beaches and riparian areas along the Hylebos Waterway.

8. As stated in the Exposure Pathway Assessment Report, the area is in an active shipping and industrial area. Because of this, more information should be provided regarding the potential for contaminated sediments below the biologically active zone [BAZ (0 to10

centimeters)] to be brought to the surface as a result of dredging activities and scouring related to shipping.

9. In addition to providing more robust information on ESA-listed species, designated critical habitats and human uses, the Exposure Pathway Assessment Report should include additional descriptive information for the area and reference the following:
    - Washington State designated uses and criteria for the Hylebos Waterway and Commencement Bay (WAC-173-201A-210; WAC-173-201A-612), which among other parameters includes criteria for pH and temperature.
    - Washington Department of Fish and Wildlife Priority Habitats and Species.
    - Mitigation and restoration sites in the Hylebos Waterway and Commencement Bay.

10. The guidance listed for performing the Exposure Pathway Assessment should also include the revised SMS, and the guidance for implementing the SMS included in the Sediment Cleanup User's Manual II (SCUM II).

    Because the revised SMS are an ARAR for the Site, the Exposure Pathway Assessment Report should be updated to include the current marine sediment chemical criteria to ensure that risks to human health and the environment are adequately assessed at the Site.

    The Exposure Pathway Assessment Report should be revised to include the appropriate methods and procedures from the SCUM II for assessing risks to human health and the environment, which are presented in Chapters 8 and 9 and Appendices E and K of the Manual. It should also be noted that the Manual suggests reviewing the Lower Duwamish Waterway and Portland Harbor risk assessments for additional guidance. The Lower Duwamish Waterway CSMs are included as examples in the SCUM II manual.

11. Per the SMS, sediment cleanup objectives and cleanup screening levels for contaminants based on protection of human health "shall be calculated using reasonable maximum exposure scenarios that reflect the highest exposure that is reasonably expected to occur under current and potential future site use conditions" (WAC 173-204-561). The default reasonable maximum exposure scenario "shall be tribal consumption of fish and shellfish." The sediment exposure pathway description should be updated to include this exposure scenario.

    Additionally, the SCUM II notes that "exposure scenarios for human health typically assume activities such as beach play and clam digging that may involve exposure to

sediment at least as deep as targeted shellfish species are found. Depending on the activities, depth of exposure may exceed the BAZ." Since site-related contaminants are known to exist at elevated levels in embankment and intertidal sediments, these activities should be considered as part of a recreational user exposure scenario, and the HHEPA should be modified to include this scenario.

12. Chapter 9 of the SCUM II provides detailed guidance on approaches for addressing risk-based sediment concentrations for bioaccumulative chemicals, and should be followed. This chapter notes that the preferred approach for setting cleanup standards where only sediment data are available (and not both sediment and tissue data) is to base cleanup levels on background concentrations or Practical Quantitation Limits (PQLs), whichever is higher. It further notes that this approach is appropriate "for sites where it is expected that risk-based sediment concentrations would be below background, which is the case for most bioaccumulative carcinogenic chemicals (e.g., dioxin/furan congeners, PCB congeners, and cPAHs)." Bioaccumulative contaminants are known to be present at elevated concentrations in the embankment, intertidal, and subtidal sediments, including PCBs, DDT, dioxins/furans, hexachlorobenzene, and hexachlorobutadiene.

13. The SMS also require that sediment cleanups are protective of "higher trophic level species", and that sediment cleanup objectives and cleanup screening levels based on protection of higher trophic level species shall be established at concentrations that have no adverse effects. The Exposure Pathway Assessment Report should consider "the potential for the contaminant to bioaccumulate or biomagnify through the food chain. According to the SMS, a contaminant will be presumed to have this potential if any of the following conditions are met:
    - The contaminant is listed as a persistent, bioaccumulative, or toxic (PBT) contaminant on the department's PBT list in WAC 173-333-310; or
    - The log of the contaminant's octonal-water partitioning coefficient is greater than 3.5 (log Kow > 3.5).

    Note that Site-related contaminants of concern (COCs) including PCBs, DDT, dioxins/furans, hexachlorobenzene, and hexachlorobutadiene are listed on the PBT list. In general, the high fish/shellfish consumption rates and the exposure factors for individual humans based on the tribal fisher scenario will also be protective of most of the higher trophic level species at the population level.

14. Because groundwater at the Site has been determined to be non-potable, and because contaminated groundwater discharges to surface water, groundwater cleanup levels are based on the protection of surface water. While this requirement is noted in the

Exposure Pathway Assessment Report, recently updated national water quality criteria have not been included. MTCA requires that surface water cleanup levels be at least as stringent as "water quality criteria based on the protection of aquatic organisms (acute and chronic criteria) and human health published under Section 304 of the Clean Water Act." The Section 304 human health criteria for a number of site-related contaminants have been updated, and the report should be updated to reflect this. Note that the criteria for most Site-related contaminants have become more stringent than those listed in the Exposure Pathway Assessment Report.

Additionally, the potential for Washington State water quality criteria to be updated prior to the final Cleanup Action Plan should be evaluated. On September 14, 2015, EPA published draft revised federal water quality criteria applicable to Washington in the Federal Register.

Because surface waters at the site are marine waters, and not suitable for drinking water, the applicable human health water criteria are those based on the consumption of organisms only.

15. Certain site-related chemicals, including PCE, TCE, and vinyl chloride, do not have applicable numeric water quality criteria for the protection of aquatic life. The EHEPA proposes addressing ecological effects from these chemicals in porewater through a narcosis-based screening approach. To address the potential site-specific toxicity of these chemicals, both individually and cumulatively, and to address other factors potentially affecting toxicity (e.g. elevated pH or temperature), toxicity testing of sediment porewater should be considered.

16. For various media, including soil, groundwater, and sediment, the Exposure Pathway Assessment Report should include a discussion of the likely point of compliance based on MTCA requirements. This will be important when considering and evaluating remedies in the FS.

    Soil Point of Compliance

    - For soil cleanup levels based on the protection of ground water, the point of compliance shall be established in the soils throughout the Site.
    - For soil cleanup levels based on protection from vapors, the point of compliance shall be established in the soils throughout the Site from the ground surface to the uppermost ground water saturated zone (e.g., from the ground surface to the uppermost water table).
    - For soil cleanup levels based on human exposure via direct contact or other exposure pathways where contact with the soil is required to complete the

pathway, the point of compliance shall be established in the soils throughout the Site from the ground surface to fifteen (15) feet below the ground surface. This represents a reasonable estimate of the depth of soil that could be excavated and distributed at the soil surface as a result of Site development activities.

The Exposure Pathway Assessment Report discusses only the upper 10 feet of soil, and it is not clear how deeper soils will be assessed. Table 3.10 indicates that the depth to groundwater at the Site is 12 feet below ground surface (bgs).

MTCA recognizes the remedies that rely on containment may not meet cleanup levels at these points of compliance. If the selected remedy involves containment of hazardous substances and the cleanup levels will not be met at the standard points of compliance, the cleanup must meet all the requirements included at WAC 173-340-740(6)(f).

Groundwater Point of Compliance

The Exposure Pathway Assessment Report, while not specifically discussing a groundwater point of compliance, leads the reader to understand that compliance with groundwater cleanup levels based on the protection of surface water will be determined based on porewater concentrations. The standard point of compliance for groundwater is "throughout the site from the uppermost level of the saturated zone extending vertically to the lowest most depth which could potentially be affected by the site." Under specific conditions, Ecology can allow an off-property conditional point of compliance in surface water "as close as technically possible to the point or points where ground water flows into the surface water" (WAC 173-340-720(8)(d)). However, there are several conditions that must be met before Ecology can allow such a point of compliance, including the following:

- It has been demonstrated that the contaminated groundwater is entering the surface water and will continue to enter the surface water even after implementation of the selected cleanup action;
- It has been demonstrated that it is not practicable to meet the cleanup level at a point within the groundwater before entering the surface water, within a reasonable restoration time frame;
- Use of a mixing zone under WAC 173-201A-100 to demonstrate compliance with surface water cleanup levels shall not be allowed;

- Groundwater discharges shall be provided with all known available and reasonable methods of treatment before being released into surface waters;
- Groundwater discharges shall not result in violations of sediment quality values published in chapter 173-204 WAC;
- Groundwater and surface water monitoring shall be conducted to assess the long-term performance of the selected cleanup action including potential bioaccumulation problems resulting from surface water concentrations below method detection limits; and
- Before approving the conditional point of compliance, a notice of the proposal shall be mailed to the natural resource trustees, the Washington state department of natural resources, and the United States Army Corps of Engineers. The notice shall be in addition to any notice provided under WAC 173-340-600 and invite comments on the proposal.

Sediment Point of Compliance

The point of compliance for sediments "shall be established at a location that is protective of both aquatic life and human health." To protect aquatic life, the point of compliance shall be established within the BAZ (the upper 10 cm). However, in cases where humans could be exposed to deeper sediments, the point of compliance may be established at a different location that is also protective of human health. In areas including the embankment and intertidal areas of the Site, which includes intertidal areas on the east side of the Hylebos Waterway, the potential for recreational users or fishers to be exposed to deeper sediments should be considered.

3.2 Specific Comments

Section 2.2.1, 2.2.3 and Figures 2.1 and 2.3: The Exposure Pathway Assessment Report does not seem to include Commencement Bay in the CSM and does not evaluate risks to human health and the environment of Commencement Bay. It should be revised to do so. The SCUM II manual should be referenced for guidance on how to develop an adequate CSM.

Section 2.2.2, 2.2.3, and Figures 2.2 and 2.3: The human health CSM should be revised to include direct contact to sediments for recreational users, recreational fishers, and tribal fishers. The SCUM II manual should be referenced for guidance on how to develop an adequate CSM.

Section 2.2.2, 2.2.3, and Figures 2.2 and 2.3: As required by the SMS (WAC-173-204-564), the Exposure Pathway Assessment Report needs to consider risks to higher trophic levels including birds, fish, and mammals. The assessment should evaluate higher trophic level species that currently utilize, may potentially inhabit, or have historically inhabited the Site. Higher trophic level species should be included in the CSM and evaluated in the risk assessments. Species to consider for inclusion include the following:

- Insectivorous birds
- Crab, flatfish, sculpin
- Great blue heron, belted kingfisher, hooded merganser, bald eagle, osprey
- River otter, harbor seal

Additional information can be found in Chapters 3, 4, 9, and in Appendices E and K of the SCUM II manual. The Lower Duwamish Waterway CSM and risk assessments should also be referred to for more guidance.

Section 2.2.2: The evaluation of terrestrial ecological risks should follow the procedures outlined in MTCA for the Terrestrial Ecological Evaluation (WAC 173-340-7490 through 7492), including completion of Table 749-1.

Section 2.2.2: The ecological risks are only considered for the limited areas of identified groundwater discharge and adjacent nearshore sediments. It would be useful to include a figure to identify the specific areas of the Site the authors are addressing.

Section 2.2.2: The Exposure Pathway Assessment Report should consider whether deeper soils and sediments (greater-than3 feet) may be exposed with future development, particularly since the Port of Tacoma is projected to receive larger, deeper draft ships in coming years.

Section 3.2.2: While this section acknowledges that site-related COCs may migrate through "leaching or partitioning from one medium to another", this route is not discussed in Section 3.2.2.2 (Fate and Transport in Receiving Media). The potential for soil contamination to migrate from soil to groundwater should be thoroughly evaluated.

Section 3.2.2.2: Where hazardous substances are released to the surface water as a result of groundwater flows, no mixing zone shall be allowed to demonstrate compliance with surface water cleanup levels. The recreational user surface water exposure pathway should be maintained.

Section 3.2.2.4: Human exposure to contaminants in sediment through consumption of biota should be evaluated.

Section 3.2.3: The recreational user exposure scenario, including potential exposure to sediment, should be maintained in the evaluation.

Section 3.3: This list should include the SMS, SCUM II manual, National Toxics Rule, and the most up-to-date Clean Water Act Section 304(a) water quality criteria.

Section 3.3.4: In addition to sediment ingestion and dermal contact, the sediment to biota to human consumer should be evaluated. Per the SMS, the default human health exposure scenario for sediment is tribal consumption of fish and shellfish. This scenario should be included. (While the fish consumption pathway is included in the Fisher exposure scenario, it is only considered with respect to the surface water to biota pathway, and does not consider bioaccumulation from the sediment or food chain pathways.)

Section 3.3.5: MTCA cleanup levels for surface water include "Water quality criteria based on the protection of aquatic organisms (acute and chronic criteria) and human health criteria published under Section 304 of the Clean Water Act." The national 304 water quality criteria for human health have recently been updated, and should be included as ARARs for surface water and groundwater discharging to surface water.

Section 4.2.2: The phrase "at least temporarily" should be removed. There is no reason to believe that federally listed salmonids will not continue to use the Hylebos Waterway, and given the focus for salmon recovery in the watershed their numbers are expected to increase.

Section 4.2.2: Columbia River coho salmon should be removed, and the ESA-listed species and designated critical habitat for Commencement Bay and the Hylebos Waterway should be added.

Section 4.2.6: The discussion of assessment endpoints should be refined. "Productivity" is a complex concept that is difficult to assess. It would be better to consider using the more typical metrics of survival, growth, and reproduction. In addition, the report should clearly identify the specific measurement endpoints, according to the guidance that will be used to evaluate whether the assessment endpoints are protected.

Section 4.2.6: As noted above, the report improperly limits the species to be addressed in the assessment. In addition, the benthos are stated to include "benthic" fish, although it is not clear what species or feeding guild the authors are referring to. Exposure to contaminated sediments is an important exposure route that should be identified, rather than simply assuming that exposure through shallow contaminated groundwater discharge is the most important.

Section 4.2.6: PCBs and DDT may have greater groundwater transport in association with higher concentrations of volatile organic compounds (VOCs), and this potential for greater transport should be considered. The risks posed by "moderate" concentrations and "very limited areas" should be evaluated quantitatively, and not simply discounted. At the screening level, there should be no assumptions used to *a priori* limited exposure areas. It is also not clear whether the whole of the non-dredged area was considered as previously stated in the earlier sections of the Exposure Pathway Assessment Report.

Section 4.2.6: Direct toxicity to benthos (which would apply only to benthic infauna) has little to do with the protection of the food web via bioaccumulation. In fact, the more healthy the benthos, the greater the transfer from sediments to higher organisms may be. Toxicity data for aquatic species are limited, and the "true" exposure conditions are poorly estimated with available data. There is a difference between identifying the "conservative" (i.e., reasonable worst-case) situation and deciding whether that situation warrants corrective action. As the text notes early on, the screening risk assessment is intended to identify those worst-case scenarios.

Section 4.3, Table 4.1 and 4.2: The Exposure Pathway Assessment Report uses several Site SQOs as ecotoxicity screening values (ESVs) to calculate screening quotients (SQs). These SQOs are cleanup levels, and they are not risk based. The Report should be revised to include the applicable water quality criteria and SMS marine sediment chemical criteria for ESVs to more adequately assess potential risks to human health and the environment related to the Site.

Additionally, it is unclear how the estimated exposure concentrations (EEC) were calculated for each constituent. The report should clarify what was used to develop each EEC (i.e. maximum, 95 percent upper confidence level, and mean concentration).

The report makes judgements on level of risk related to the SQs. For a screening level risk assessment all SQs greater than 1 should be further evaluated.

Section 4.3.1.1: The Washington State aquatic life criteria for PCBs and DDTs should be used, as they are legally applicable requirements. There are both avian and mammal species to be protected. At the screening stage, "home range" considerations should not be included.

Section 4.3.1.1: The Exposure Pathway Assessment Report states that new information was used to revise the Site's previous clean up goals for VOCs, but does not apply the same reasoning to the criteria for other substances.

Section 4.3.1.1: The list of "qualifiers" on this page are uncertainties, and should be moved to a separate discrete section. In addition, the items listed include unsupported assumptions, and unnecessary qualifiers on the meaning of SQs greater than one.

Section 4.3.1.2: As noted in the text, the 300 µg/kg cleanup goal for PCBs is not protective of natural resources. A much lower concentration is appropriate. At the Portland Harbor site, for comparison, the accepted lowest preliminary remedial goal (PRG) for PCBs in sediments is 36 µg/kg for the protection of predators of the benthos, and the cleanup objective for PCBs is even lower for the Lower Duwamish Waterway site where it is 2 µg/kg, based on a "natural background" concentration.

Section 4.3.2.5: High concentrations of VOCs can have a solvent effect on PCBs and DDTs in groundwater, potentially increasing their mobility. The post-construction monitoring at Area 5106 found concentrations of VOCs that could indicate free product. The distribution of the PCBs and DDTs should be carefully compared to the locations of the discharge of contaminated groundwater to determine if evidence exists for enhanced transport.

Section 4.4: The Exposure Pathway Assessment Report summary section continues to use professional judgment to dismiss risks to natural resources from all exposures. This section is based on faulty evaluations in the previous sections.

4.0 Summary and Recommendations

Based on our review of the Draft Exposure Pathway Assessment Report, a summary of significant issues and recommendations follows.

1. The characterization of ecological and human use is inadequate.

The Exposure Pathway Assessment Report does not provide adequate characterization of natural resources, including habitats and species and their life histories that are present at the site and in the surrounding area.

Commencement Bay and the Hylebos Waterway provide important rearing, foraging, migratory, and adult habitat for numerous aquatic and terrestrial species. These estuarine waters at and in the vicinity of the Site are an important transitional area for juvenile salmonid species, bottom fish, forage fish, crab, bivalves and many other resident marine species. All of these species are found in these waters during every month of the year. The riparian buffers, salt marshes, and mudflats in the area provide important habitats for these aquatic species including plants, birds, and mammals. Commencement Bay supports both hatchery and listed- and non-listed salmon species including Chinook, coho, chum and pink salmon for which have run sizes have increased in recent years.

The Exposure Pathway Assessment Report does not provide adequate information regarding the human uses of Commencement Bay and the Hylebos Waterway in the vicinity of the Site. Human uses in the area include recreational and tribal fishing, crabbing, marina use, boating, sailing, diving, kayaking, paddle boarding, beach play, and bird and wildlife viewing. Anadromous and resident fish species support a robust recreational fishery and provide food and sustenance to sport and tribal fishers in the area. The area is within a tribal Usual and Accustomed fishing area.

This incomplete information results in major gaps in the exposure pathway assessments and their associated CSMs which leads to inadequate selection and assessment of exposure pathways, receptors, and endpoints.

Recommendation: The Exposure Pathway Assessment Report should be revised to fully characterize ecological and human uses, including potential futures uses of the Site and surrounding area, and the CSMs should be revised to more fully address all potentially complete

exposure pathways. Further evaluation of current and potential future human uses and associated exposure pathways should be considered.

2. References to and use of applicable regulations and guidance are incomplete.

The Exposure Pathway Assessment Report omits reference to and inclusion of a variety of applicable regulations and relevant guidance documents that affect Site cleanup requirements, including most notably the Washington Sediment Management Standards (SMS) and supporting guidance included in the Sediment Cleanup Users Manual II (SCUM II). Requirements related to the protection of human health and higher trophic level species are not addressed in both the development of CSMs and the evaluation of exposures. Federal regulations and guidance not referenced include the recently revised Clean Water Act Section 304 water quality criteria and the federal Endangered Species Act.

Recommendation: The Exposure Pathway Assessment Report should be revised to include all relevant regulations and guidance. Most significantly, the Exposure Pathway Assessment Report should ensure that the exposure assessment fully complies with SMS requirements and is consistent with the guidance provided in the SCUM II manual. Further, all screening levels should be reviewed and updated as appropriate, including updating the Clean Water Act Section 304 human health water quality criteria.

3. The discussions of human health and ecological exposure pathways are incomplete.

For both the reasons discussed above, the Exposure Pathway Assessment Report provides an incomplete discussion and evaluation of human health and ecological exposure pathways. The incomplete evaluation of sediment and food-chain exposures to fishers and to higher trophic level species is a significant gap in the exposure assessment. The SMS requires that sediment cleanup objectives for the protection of human health are based on tribal consumption of fish and shellfish, unless that scenario is not appropriate.

Recommendation: Since tribal fish and shellfish consumption is a recognized use and treaty-reserved right, the exposure pathway assessment for the fisher scenario should be revised to include consumption of biota impacted by contaminated sediments. The recreational user exposure scenario should also be revised and fully evaluated and should include exposures to contaminated sediments through ingestion and dermal contact, exposure to shallow groundwater discharging to surface water through ingestion and dermal contact, and ingestion of contaminated biota. Ecological exposures should consider exposure to bioaccumulative

chemicals of higher trophic level species, as required by the SMS. Finally, the evaluation of terrestrial ecological exposure should be consistent with the terrestrial ecological evaluation requirements of MTCA.

4. The discussion of points of compliance is inadequate.

The Exposure Pathway Assessment Report does not include a discussion of the relevant points of compliance for the media evaluated. An understanding of the standard and conditional points of compliance for soil, groundwater, and sediment are critical for understanding what data and exposure pathways need to be considered. This is also a critical element in evaluating the protectiveness of remedies that will be evaluated in the feasibility study.

Recommendation: For each of the media and exposure pathways evaluated, a relevant discussion of the regulatory points of compliance should be included to assist in determining the adequacy of both the existing data and the appropriate exposure pathways.

5. The discussion of total site risk is incomplete.

The human health risk assessment procedures included in MTCA state that "[a]t sites where the same individuals or groups of individuals are or could be consistently exposed through more than one pathway, the reasonable maximum exposure shall represent the total exposure through all of those pathways" (WAC 173-340-708). The Exposure Pathway Assessment Report does not include a discussion of the potential or likelihood of exposures to the same individuals through multiple exposure pathways.

Recommendation: In addition to ensuring that all potentially complete human health exposure pathways are adequately evaluated, the Report should include a discussion of the potential and probability of individuals being exposed through multiple pathways (e.g. as both a site worker and a fisher), and the combined risk of multiple exposures. Cleanup levels based on one pathway of exposure must be adjusted downward to take into account exposures from more than one exposure pathway if the total risk exceeds the maximum allowable cancer risk or poses a non-cancer health hazard. This may be particularly important to consider since different regulatory authorities (Ecology and EPA) are addressing different exposure areas within the same site.

5.0 References

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