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May 2, 2007

Mary Jane Nearman, EPA Project Manager
United States Environmental Protection Agency
1200 6th Avenue
Seattle, Washington 98101

Re: Review of Little Squalicum Park RI/FS – CERCLA Actionability Evaluation

Dear Ms. Nearman:

Please find attached three technical memoranda prepared by Ecology & Environment, Inc., (E & E) for the purpose of evaluating information provided in the *Draft Report Little Squalicum Park Remedial Investigation/Feasibility Study* (RI/FS) prepared by Integral Consulting Inc. (Integral) on October 27, 2006. As directed by the EPA, E & E reviewed the RI/FS report to evaluate whether newly obtained information regarding contaminants within Little Squalicum Park pose a threat to human health or ecological receptors, and whether action under the Comprehensive Environmental Response Compensation and Liability Act may be warranted.

Please contact me at (206) 624-9537 ext. 3603, or at mlongtine@ene.com if you have any questions regarding this deliverable.

Sincerely,
ECOLOGY AND ENVIRONMENT, INC.

Mark Longtine
E & E Project Manager

Cc: Don Heyer, CH2M HILL
Carl Mach, E & E
Stephanie Pingree, E & E

Attachments: Technical Memorandum – Conceptual Site Model
Technical Memorandum – Human Health Risk Evaluation
Technical Memorandum – Ecological Risk Actionability

Review of Little Squalicum Park RI/FS
Conceptual Site Model

Prepared by Ecology and Environment, Inc. for EPA Region 10

May 2, 2007

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TECHNICAL MEMORANDUM

To: Mary Jane Nearman, EPA Project Manager
From: Mark Longtine, Ecology and Environment, Inc.
Through: Don Heyer, CH2M HILL
Date: May 2, 2007
Re: Review of Little Squalicum Park RI/FS – Conceptual Site Model

For the United States Environmental Protection Agency (EPA) Region 10, Ecology & Environment, Inc., (E & E) performed a limited review of the *Draft Report Little Squalicum Park Remedial Investigation/Feasibility Study* (RI/FS) prepared by Integral Consulting Inc. (Integral) on October 27, 2006, for the purpose of evaluating the conceptual site model (CSM) as it pertains to the Oeser Company Site (Oeser). The scope and the results of the CSM review are briefly summarized below.

The 2006 Draft LSP RI/FS CSM discusses source characterization (Section 6.1), fate and transport of chemicals (Section 6.2), and potential receptors and exposure pathways (Section 6.3). Elements of the CSM as it pertains to potential receptors and exposure pathways were reviewed by E & E, as summarized in the accompanying technical memoranda addressing risk to human health and ecological receptors. The source characterization and fate and transport components of the LSP RI/FS CSM were reviewed for the purposes of evaluating whether Oeser could potentially be a source of the some of the contaminants of concern for human health and ecological receptors within the LSP. It should be noted that this review did not endeavor to determine specifically which contaminants observed in the various media within various locations of the LSP are attributable to Oeser, nor did the present review aim to determine whether the selected contaminants could be attributed to other potential sources.

Previous investigations, including the 2002 Oeser Company Site RI (E & E 2002), have documented that polycyclic aromatic hydrocarbon (PAH), pentachlorophenol (PCP), and dioxins/furans are contaminants commonly associated with wood treating operations and disposal practices such as those documented at Oeser. These contaminants have been detected in soil, sediment, surface water, and groundwater samples collected within the LSP, both during the Oeser RI (E & E 2002) and the LSP RI/FS (Integral 2006).

The 2006 LSP RI/FS concludes that a major source of these contaminants of concern within the LSP is stormwater and process wastewater discharged from the Oeser site, including historic discharges from the facility dating to the 1940s. This stormwater/wastewater has been discharged from the Oeser/Birchwood outfall into Little Squalicum Creek. The LSP RI/FS indicates that

subsequent migration of the contaminated stormwater/wastewater, including non-aqueous phase liquid (NAPL), has occurred via surface water and sediment transport within the Little Squalicum Creek, and infiltration into soils and sediments within both the current and historic channels of the creek. Groundwater contamination observed within the LSP is attributed to such infiltration of stormwater/wastewater and subsequent downgradient migration within the LSP.

Based on review of information presented in the 2006 LSP RI/FS report and previous investigations, E & E generally agrees that at least some of the PAH, PCP, and dioxin/furan contamination detected in soil, sediment, groundwater, and surface water within the LSP is likely attributable to Oeser. The LSP RI/FS report also notes the presence of other potential sources of contaminants found in the LSP, including other stormwater outfalls, historic operations at a former gravel pit, a historical landfill, and former railroad tracks.

References

Ecology and Environment, Inc., April 2002, *The Oeser Company Superfund Site Remedial Investigation Report*, Bellingham, Washington.

Integral Consulting, Inc., October 27, 2006, *Remedial Investigation/Feasibility Study, Little Squalicum Park, Bellingham, WA – Draft Report*.

Review of Little Squalicum Park RI/FS
Human Health Risk Evaluation

Prepared by Ecology and Environment, Inc. for EPA Region 10

May 2, 2007

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TECHNICAL MEMORANDUM

To: Mary Jane Nearman, EPA Project Manager
From: Stephanie Pingree, Ecology and Environment, Inc.
Through: Mark Longtine, Ecology and Environment, Inc. and Don Heyer, CH2M HILL
Date: May 2, 2007
Re: Review of Little Squalicum Park RI/FS – Human Health Risk Evaluation

For the United States Environmental Protection Agency (EPA) Region 10, Ecology & Environment, Inc. (E & E) has reviewed the *Draft Report Little Squalicum Park Remedial Investigation/Feasibility Study* (RI/FS) prepared by Integral Consulting Inc. (Integral) on October 27, 2006 to determine if the current site conditions pose a risk to current and future human receptors at the site. The methodology for review and results are presented in this technical memorandum. Specifically, this review focuses on Sections 6.3.1, 7.1, Appendix D, and Appendix F of the 2006 RI/FS. E & E focused its review on those areas within Little Squalicum Park (LSP) that could potentially be influenced by contamination for the Oeser Superfund Site. For this review, E & E evaluated the following issues:

- Conceptual Site Model;
- Screening for Compounds of Potential Concern;
- Exposure Assessment;
- Toxicity Assessment; and
- Risk Characterization.

E & E conducted a human health risk assessment (HHRA) at the Oeser Superfund Site, presented as Appendix M in the RI (E & E 2002). The 2002 E & E risk assessment included evaluation of a portion of the LSP that is the subject of the Integral 2006 LSP RI/FS. The conceptual site model and exposure parameters presented in the E & E Oeser HHRA for receptors at the Little Squalicum Creek were used in the current evaluation of the 2006 Integral LSP RI/FS data.

The geographic sub areas evaluated in the E & E Oeser HHRA within the Little Squalicum Creek area include the South Slope, Foot Path, and Soil Spoils Piles. The sub areas evaluated in the Integral LSP RI/FS that may potentially be impacted by the Oeser Superfund Site include the Upper Creek, Lower Creek, Beach, South Slope, General Site, and Historical Creek sub areas. This evaluation focused on these sub areas.

Conceptual Site Model

Figure 6-1 of the 2006 LSP RI/FS presents the human health conceptual site model (CSM). This CSM is similar to the CSM presented in the 2002 Oeser HHRA with respect to the receptors at Little Squalicum Park. Specifically, the following pathways were determined to be complete

pathways for recreational user/park visitor in both the Integral 2006 LSP CSM and the E & E 2002 Oeser CSM:

- Ingestion and dermal contact with surface soil;
- Inhalation of particulates from surface soil;
- Dermal contact with sediment; and
- Dermal contact with surface water.

Consistent with the E & E 2002 HHRA, these pathways were quantitatively evaluated in this review. In the E & E CSM, inhalation of volatiles from soil was also considered a complete pathway. The Integral 2006 CSM states that soil vapors were not considered a route of exposure because volatile organic compounds (VOCs) were rarely detected in soil. Two VOCs, 2-methylnaphthalene and naphthalene, were considered compounds of concern in subsurface soil in the Integral 2006 LSP RI. If these soils were brought to the surface exposure to vapors from the soil could be a complete pathway. Therefore, E & E included the inhalation of volatiles from soil as a complete pathway for quantitative assessment in this review.

In addition to the exposure pathways listed above, the Integral 2006 LSP CSM also considered the following pathways to be potentially complete:

- Ingestion of (surface) sediment; and
- Ingestion and dermal contact with subsurface soil.

These pathways were eliminated from quantitative evaluation in the E & E 2002 Oeser HHRA. It is not expected that ingestion of sediment by recreational users of the park would be a significant source of exposure. Therefore, this pathway was not quantitatively evaluated in this review. Direct contact (incidental ingestion and dermal contact) with subsurface soil is unlikely at the site unless excavation activities bring subsurface soil to the surface. It was conservatively assumed that contact with subsurface soil (to a maximum depth of 15 feet below ground surface), including ingestion, dermal contact, and inhalation of vapors and particulates, are potentially complete pathway for recreational users in the future. These pathways were added for quantitative evaluation in this review.

Exposure to groundwater (either through ingestion or dermal contact) was assumed to not be a compete pathway of exposure by both Integral (2006) and E & E (2002); therefore, this pathway was not evaluated in this review.

In addition to a recreational user/park visitor, Integral (2006) also identified complete pathways in the CSM for a park worker and a transient. For this evaluation, it is assumed that exposure to a recreational user would be greater than exposure to the other receptors; therefore, the recreational user was the only receptor quantitatively evaluated in this review. This is consistent with the approach taken in the E & E 2002 Oeser HHRA.

Screening for Compounds of Potential Concern

In the Integral 2006 LSP RI/FS, only a screening level evaluation was conducted for human receptors. As such, site concentrations were only compared to screening criteria to determine compounds of potential concern (COPCs). A complete risk assessment, including exposure assessment, toxicity assessment, and risk characterization, was not completed.

For the current review of Integral's selection of COPCs, E & E completed the following steps. The purpose of the review process is ensure that all COPCs are identified by Integral (2006) are carried through quantitative evaluation in this review:

1. E & E determined that the screening criteria used by Integral were at least as conservative as criteria accepted by EPA for soils, sediment, and surface water;
2. E & E compared maximum detected site concentrations to EPA Region 6 Human Health Medium-Specific Screening Levels (HHSLs); and
3. E & E determined if appropriate screening criteria for contaminants in plants and berries were used.

Currently, EPA Region 10's recommended screening process for determining COPCs is to compare site maximum detected concentrations in soils to the Region 6 HHSLs (EPA 2007). Because human exposure to sediments is similar to exposure to soil, maximum detected concentrations in sediments should also be compared to the soil HHSLs. In the Integral LSP RI/FS, Region 9 Preliminary Remediation Goals (PRGs) and Department of Ecology Model Toxics Control Act (MTCA) levels were used to determine COPCs in soil and sediment for human health evaluation.

To determine that the screening criteria used in the Integral 2006 LSP RI/FS were as least as stringent as the Region 6 HHSLs, E & E compared the screening criteria used by Integral to the EPA Region 6 HHSLs for residential soils for the compounds identified as COPCs in either Integral's 2006 LSP RI/FS or E & E's 2002 Oeser HHRA (see Table 1). The following exceptions are noted:

- Carcinogenic polycyclic aromatic hydrocarbons (cPAHs) and dioxins/furans were evaluated as groups of compounds in both the Integral 2006 LSP RI/FS and the 2002 E & E Oeser HHRA. Carcinogenic PAHs and dioxins/furans were identified as COPCs in all media and sub areas where data was available except for Beach sediments. Carcinogenic PAHs were added as a COPC in surface sediment for the Beach sub area for this review. Therefore, evaluation on an individual compound basis was not completed.
- Compounds identified as COPCs in the E & E 2002 Oeser HHRA or Integral 2006 LSP RI/FS that do not have available EPA screening or toxicity criteria were not quantitatively evaluated in this review. These compounds include 7-12-dimethylbenz(a)anthracene, 7H-dibenzo(e,g)carbazole, benzo(k)fluoranthene, dibenzo(a,h)pyrene, dibenzo(a,i)pyrene, dibenzo(a,l)pyrene, total extractable petroleum hydrocarbons, total volatile petroleum hydrocarbons, gasoline range hydrocarbons, diesel range hydrocarbons, motor oil, and total petroleum hydrocarbons.
- Inorganic compounds are not expected to be related to contamination from Oeser, and therefore were not evaluated.

For surface water, Integral (2006) compared maximum detected site concentrations to the National Ambient Water Quality Criteria (NAWQC) and the Washington State Department of Ecology MTCA Method B levels. These screening values are appropriate, and the COPCs identified by Integral (2006) were carried through as COPCs for quantitative evaluation in this review.

For all compounds except dioxins, the screening levels used in the Integral 2006 LSP RI/FS were more conservative than the Region 6 HHSLs. For dioxins, the Region 6 HHSL for residential

exposure is less than the value used in the 2006 LSP RI/FS; however, because dioxins were identified as a COPC in all media, this difference in the screening levels did not impact the final list of COPCs. In summary, all organic compounds identified as COPCs in subsurface soil, surface soil, surface sediment, and surface water in the 2006 Integral LSP RI/FS were initially identified as COPCs in this review. In addition, cPAH was added as a COPC in sediments in the Beach sub area.

To further refine the COPC list for the present evaluation, E & E identified the maximum concentration detected for each COPC by sub area and media. These values are show in Table 2. Table 2 also shows EPA Region 6 HHSLs and screening levels used in the 2006 Integral LSP RI/FS. Maximum concentrations above EPA Region 6 HHSLs (at a hazard quotient [HQ] of 1.0 and a cancer risk of 1×10^{-6}) were carried through this risk evaluation and quantitatively assessed in the risk characterization step. For surface soil, subsurface soil, and sediment, HHSLs for residential soils were used. Because exposure to surface water at this site is similar to (and less than) that for water from a drinking water source, HHSLs for tap water were used for surface water. To provide additional information regarding magnitude of exceedances of screening levels, maximum concentrations above a cancer risk of 10^{-4} (high end of the EPA cancer risk range) are bolded and shaded yellow in Table 2. Table 3 provides the final list of COPCs, the maximum site concentrations for all sub areas, and the locations of the maximum concentrations.

To determine if contaminants in berries should be carried through as COPCs for quantitative evaluation, concentrations of contaminants in berries were compared to a calculated screening level using site-specific ingestion rates. The screening levels used in the 2006 Integral LSP RI/FS (Table F-23) were, in general, an order of magnitude below the screening levels used in the 2002 E & E HHRA (Table AD-3). The difference in screening levels can largely be attributed to the difference in berry consumption rates. E & E (2002) used a berry consumption rate provided in EPA's Exposure Factors Handbook (1997a). No reference is provided for the berry consumption rate used by Integral (2006). Only four berry samples (washed and unwashed samples) exceeded the screening level for 2,3,7,8- tetrachlorodibenzo-p-dioxin (TCDD) toxic equivalency (TEQ) derived by E & E (2002). The screening level was consistent with a target cancer risk of 10^{-6}. No samples exceeded a screening level at a target cancer risk of 10^{-4}. Therefore, consumption of berries was not quantitatively evaluated in this memorandum.

Exposure Assessment

For this evaluation, in order to assess exposure to COPCs in soils, sediment, and surface water, E & E used the exposure parameters and intake equations presented in Tables 4.11 through 4.15 of the 2002 Oeser HHRA. The only exception was evaluation of dermal exposure to contaminants in surface water. For dermal exposure to surface water, E & E used the exposure parameters presented in Table 4.14 of the 2002 Oeser HHRA, but the intake equations provided in *Risk Assessment Guidelines for Superfund (RAGS), Part E* (EPA 2004) because the process for evaluating dermal exposure to contaminants in surface water has been updated since the 2002 HHRA was completed. To calculate the intake (or dermal absorbed dose) for dermal exposure to contaminants in surface water, it was assumed that the event frequency (number of times exposure occurred during a day) was one event per day and the event duration was one hour per event. This assumes a recreational visitor is in contact with surface water for one hour a day during each visit to the site. These values are conservative estimates based on best professional judgment of recreational exposure at the site, and consistent with other exposure parameters used in the 2002 Oeser HHRA.

Maximum detected site concentrations in each media were used as the exposure point concentration (EPC).

Toxicity Assessment

For the present review, E & E updated all toxicity criteria, cancer slope factors (SF) and non-cancer reference doses (RfDs), to ensure that the most recent values were used in this evaluation. Oral RfDs and SFs were used for both oral and dermal routes of exposure. Oral toxicity values were not adjusted for dermal exposure to the site COPCs, consistent with RAGS Part E (EPA 2004). All oral toxicity values were obtained from EPA's Integrated Risk Information System (IRIS), except for cPAHs and dioxins. An inhalation RfD from IRIS was available for naphthalene, only. Therefore, E & E obtained available inhalation toxicity criteria from other sources consistent with EPA's recommended hierarchy (2003). An inhalation SF was available for pentachlorophenol (SF = 0.018 $[mg/kg\text{-}d]^{-1}$) from the California EPA (2002). No other inhalation toxicity criteria were available.

The toxicity of cPAHs was assessed as a class of compounds. Various non-bioassay results have been used to determine relative potency factors (RPFs) for the constituent cPAHs. Therefore, the concentration of cPAHs was determined by multiplying the concentration of each individual cPAH constituent by its respective RPF and summing the results for all cPAHs. The SFs for benzo(a)pyrene were used to evaluate the toxicity of cPAHs. The oral SF is available from IRIS and the inhalation SF is available from the National Center of Environmental Assessment (EPA 2007). A value of one-half the detection limit was used as the concentration for each of the non-detected results. Integral (2006) used RPFs available from California Environmental Protection Agency (2005) in their calculation of cPAHs. Integral (2006) included seven of the 25 cPAHs RPFs in the calculation of total cPAHs. The other 18 cPAHs were thus not accounted for. In some instances, this resulted in a significantly lower cPAH concentration than obtained using all the cPAHs. EPA recommends using RPFs from the *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons* (EPA 1993). To conduct the exposure assessment and risk characterization for this review, E & E recalculated the cPAH concentrations using the EPA values. The cPAH concentration calculated by Integral (2006) and the value calculated by E & E using EPA RPFs are shown in Table 4 for the maximum detected concentration in each sub area.

Individual dioxins and furans are evaluated based on how their toxicity is related to the similar toxic effect of 2,3,7,8- tetrachlorodibenzo-p-dioxin. The relationship between the toxic effects is expressed in terms of a factor, known as the toxicity equivalency factor (TEF). A World Health Organization working group evaluated the TEF values based on existing literature. The WHO TEFs have been recently updated (Vanden Berg et al. 2005). The updated 2005 TEFs were used by Integral (2006) and E & E in this assessment. The assessment of human health risks resulting from exposure to dioxins relies not on individual data for the dioxins and furans, but rather on a value derived using compound-specific concentrations and TEFs. The result is a toxicity value expressed in terms of 2,3,7,8-TCDD TEQ. The TEQ is calculated by multiplying the measured concentration of each dioxin/furan by its assigned TEF and summing all the product values. A value of one-half the detection limit was used as the concentration for each of the non-detected results. The oral SF for 2,3,7,8-TCDD was used to assess the toxicity of the total TEQ. No oral SF is available from IRIS for 2,3,7,8-TCDD; therefore, a value from Health Effects Assessment Summary Tables (HEAST; EPA 1997b) was used in this assessment. This is consistent with the toxicity hierarchy approach specified by EPA (2003).

Risk Characterization

For the present evaluation, cancer risks and non-cancer hazard quotients (HQs) were calculated for recreational receptors potentially exposed to COPCs at the site using the exposure parameters, intake equations, and toxicity criteria described in the previous sections. Initially risks were

calculated based on the maximum detected site concentration. Because recreational receptors would most likely use the full site, the maximum concentration of all sub areas was used. The cancer risks and HQs for each exposure route and media are presented in Tables 5 through 12, and summarized in Table 13. In addition, to assist with the understanding of the contribution to risk by COPCs in each sub area, risks and HQs also were calculated based on the maximum detected site concentration in each sub area. The risks and HQs for the Upper Creek, Lower Creek, Beach, South Slope, General Site, and Historical Site sub areas are presented in Appendix A and summarized in Table 14.

The cancer risk for the site as a whole is 8×10^{-4}, above the EPA threshold of 10^{-4}. The cancer risks are strongly influenced by a surface water sample (collected at location SW-05) from the Upper Creek area, which had a TCDD TEQ cancer risk of 5.77×10^{-4} μg/L, and from cPAHs in a subsurface soil sample in the Upper Creek/Historical Creek sub area (collected at location SB-11). It should be noted that SB-11 was assigned to two sub areas – both Upper Creek and Historical Creek. Therefore, the risks of exposure to cPAHs from surface and subsurface soil for these sub areas are identical. Noncancer HQs for the site as a whole were below the EPA benchmark of 1.0.

To evaluate these risks further, the 95% upper confidence limit on the mean (UCL) was calculated for subsurface soil using EPA's ProUCL, Version 3.0 software. For subsurface soil, samples found at a depth up to 15 feet below ground surface were included in the 95% UCL calculation. This is the depth to which subsurface soil may be brought to the surface during excavation activities. Duplicate samples (i.e., samples included in both the Upper Creek and Historical Creek sub areas) were deleted to ensure they were not counted twice. The 95% UCL was calculated for the site as a whole based on the assumption that exposure to receptors would be distributed throughout the site. The resulting 95% UCL for cPAHs in subsurface soil for the site is 51.53 mg/kg; the maximum site concentration is 509.66 mg/kg. The resulting cancer risk for exposure to subsurface soil, using the 95% UCL as the EPC for cPAHs in subsurface soil is 1.3×10^{-5}, below the cancer risk threshold of 10^{-4}.

For surface water, 15 samples that were analyzed for dioxins/furans in the sub areas were included in this review. These samples were collected at seven discrete locations in the Upper Creek and Lower Creek sub areas. The maximum site concentration for TCDD TEQ (5.77×10^{-4} μg/L) was detected at location SW-05 during the November 1, 2005 sampling event. A subsequent sample collected at the same location on April 27, 2006 showed a concentration of TCDD TEQ of 1.86×10^{-5} μg/L, significantly lower than the concentration found in 2005. Although only a small body of data are available, the 95% UCL was calculated for the whole site to provide an estimate of average concentrations at the site. The resulting 95% UCL for surface water is 4.39×10^{-4} μg/L. The resulting cancer risk for exposure to surface water, using the 95% UCL as the EPC for TCDD TEQ in surface water is 5.1×10^{-4} (TCDD TEQ contribution is 4.2×10^{-4}), above the cancer risk threshold of 10^{-4}.

As mentioned previously, concentrations in surface water at individual sample locations have changed with time. Therefore, E & E also evaluated results for the most recent sampling event at each location. The maximum site concentration for pentachlorophenol, TCDD TEQ, and cPAHs during the most recent sampling event at each location was used to calculate cancer risks. The most recent maximum detected concentrations at each sampling location were 17 μg/L for pentachlorophenol at Upper Creek location 320 (1998), 8.86×10^{-5} μg/L for TCDD TEQ at Upper Creek location SW-04 (1999), and 0.388 μg/L for cPAHs at Upper Creek location OS03 (1996; calculated using EPA RPFs). The resulting cancer risk for exposure to surface water is 1.1×10^{-4}.

Although the maximum detected site concentrations were found in samples taken from 1996, 1998, and 1999 these represent the most recent information for that sampling location.

Groundwater Assessment

E & E compared the maximum detected groundwater concentration in each sub area to the federal maximum contaminant level (MCL). The results are presented in Table 15. Although groundwater is not considered a complete pathway, this comparison provides a reference for which to evaluate groundwater. Multiple metals, PAHs, pentachlorophenol, and TEQ exceed the MCL in one or more sub area. Exceedances of MCLs do not indicate potential risk at this site.

Evaluation of Analytical Results Database

During this review, E & E identified an error with the database provided in Appendix D of the Integral RI. Specifically, incorrect units were used when presenting cPAH data in the LSP Averaged Dataset table for some samples. E & E apprised Integral of the error and, subsequently, Integral provided E & E a revised database. Integral did not provide revised LSP RI/F report text, tables, or figures that were impacted by the database error. The review and risk calculations presented by E & E in this document are based on the revised database.

Summary and Conclusions

E & E evaluated the potential risk or hazard posed to recreational receptors exposed to contaminants in surface soil, subsurface soil, sediment, and surface water at the LSP. Using maximum detected site concentrations, the cancer risk for the site as a whole is 8×10^{-4}, above the EPA threshold of 10^{-4}. The cancer risks are strongly influenced by a single surface water sample (collected at location SW-05) from the Upper Creek area in 2005 and from cPAHs in a subsurface soil sample (collected at location SB-11) in the Upper Creek/Historical Creek sub area. Noncancer HQs were below the EPA benchmark of 1.0.

Further evaluation of site concentrations showed that the cancer risk for exposure to subsurface soil, using the 95% UCL as the EPC for cPAHs is 1×10^{-5}, below the cancer risk threshold of 10^{-4}.

Because contaminant concentrations in surface water at individual sample locations have changed with time, E & E also evaluated risk using the most recent sampling data at each location. The maximum site concentration during the most recent sampling event at each location was used to recalculate cancer risks. The resulting cancer risk for exposure to surface water is 1×10^{-4}. Therefore, potential risks to recreational receptors at LSP using maximum site concentrations for surface soil and sediment, 95% UCL for subsurface soil, and most recent maximum concentrations in surface water do not exceed the EPA cancer threshold of 10^{-4}.

References

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Review of Little Squalicum Park RI/FS
Human Health Risk Evaluation

TABLES

Table 1. Comparison of Screening Levels for Compounds of Potential Concern

				Screening Levels			
Media	**Compound**	**Units**	**C/NC**	**EPA R6 RBC - Residential**	**Integral**	**Integral Source**	**Most Conservative Screening Level**
Surface Soil	Carbazole	mg/kg	C	2.40E+01	3.00E-02	R9 PRG DAF1	R9 PRG DAF1
	2,4-Dinitrotoluene	mg/kg	NC	1.20E+02	4.00E-05	R9 PRG DAF1	R9 PRG DAF1
	2,6-Dinitrotoluene	mg/kg	NC	6.10E+01	3.00E-05	R9 PRG DAF1	R9 PRG DAF1
	Pentachlorophenol	mg/kg	C/NC	3.00E+00	1.00E-03	R9 PRG DAF1	R9 PRG DAF1
	2,4,6-Trichlorophenol	mg/kg	C	4.40E+01	8.00E-03	R9 PRG DAF1	R9 PRG DAF1
	Acenaphthene	mg/kg	NC	3.70E+03	2.90E+01	R9 PRG DAF1	R9 PRG DAF1
	Fluorene	mg/kg	NC	2.60E+03	2.80E+01	R9 PRG DAF1	R9 PRG DAF1
	2-methylnaphthalene	mg/kg	NC	1.20E+02	4.00E+00	R9 PRG DAF1	R9 PRG DAF1
	Naphthalene	mg/kg	NC	1.20E+02	4.00E+00	R9 PRG DAF1	R9 PRG DAF1
	cPAHs	mg/kg	C	6.20E-02	--		
	Dioxin TEQ	mg/kg	C	3.90E-06	6.67E-06	MTCA DC	R6 - Residential
Subsurface Soil	Carbazole	mg/kg	C	2.40E+01	3.00E-02	R9 PRG DAF1	R9 PRG DAF1
	2,4-Dinitrotoluene	mg/kg	NC	1.20E+02	4.00E-05	R9 PRG DAF1	R9 PRG DAF1
	Pentachlorophenol	mg/kg	C/NC	3.00E+00	1.00E-03	R9 PRG DAF1	R9 PRG DAF1
	2,4,6-Trichlorophenol	mg/kg	C	4.40E+01	8.00E-03	R9 PRG DAF1	R9 PRG DAF1
	Acenaphthene	mg/kg	NC	3.70E+03	2.90E+01	R9 PRG DAF1	R9 PRG DAF1
	Fluoranthene	mg/kg	NC	2.30E+03	2.10E+02	R9 PRG DAF1	R9 PRG DAF1
	Fluorene	mg/kg	NC	2.60E+03	2.80E+01	R9 PRG DAF1	R9 PRG DAF1
	2-methylnaphthalene	mg/kg	NC	1.20E+02	4.00E+00	R9 PRG DAF1	R9 PRG DAF1
	Naphthalene	mg/kg	NC	1.20E+02	4.00E+00	R9 PRG DAF1	R9 PRG DAF1
	Pyrene	mg/kg	NC	2.30E+03	2.10E+02	R9 PRG DAF1	R9 PRG DAF1
	cPAHs	mg/kg	C	6.20E-02	--		
	Dioxin TEQ	mg/kg	C	3.90E-06	6.67E-06	MTCA DC	R6 - Residential
Sediment	Carbazole	mg/kg	C	2.40E+01	3.00E-02	R9 PRG DAF1	R9 PRG DAF1
	n-Nitrosodiphenylamine	mg/kg	C/NC	9.90E+01	6.00E-02	R9 PRG DAF1	R9 PRG DAF1
	Pentachlorophenol	mg/kg	C/NC	3.00E+00	1.00E-03	R9 PRG DAF1	R9 PRG DAF1
	2,4,6-Trichlorophenol	mg/kg	C	4.40E+01	8.00E-03	R9 PRG DAF1	R9 PRG DAF1
	Acenaphthene	mg/kg	NC	3.70E+03	2.90E+01	R9 PRG DAF1	R9 PRG DAF1
	Fluoranthene	mg/kg	NC	2.30E+03	2.10E+02	R9 PRG DAF1	R9 PRG DAF1
	Fluorene	mg/kg	NC	2.60E+03	2.80E+01	R9 PRG DAF1	R9 PRG DAF1
	2-methylnaphthalene	mg/kg	NC	1.20E+02	4.00E+00	R9 PRG DAF1	R9 PRG DAF1
	Naphthalene	mg/kg	NC	1.20E+02	4.00E+00	R9 PRG DAF1	R9 PRG DAF1
	Pyrene	mg/kg	NC	2.30E+03	2.10E+02	R9 PRG DAF1	R9 PRG DAF1
	cPAHs	mg/kg	C	6.20E-02	--		
	Dioxin TEQ	mg/kg	C	3.90E-06	6.67E-06	MTCA DC	R6 - Residential
Surface Water	Pentachlorophenol	ug/L	C/NC	5.60E-01	2.70E-01	NAWQC	NAWQC
	cPAHs	ug/L	C	9.20E-03	3.80E-03	NAWQC	NAWQC
	Dioxin TEQ	ug/L	C	4.50E-07	8.64E-09	MTCA METHOD B	MTCA METHOD B

Key:
-- = Screening level not available
C = carcinogen
COPC = Compound of Potential Concern
cPAHs = carcinogenic polychlorinated aromatic hydrocarbons
mg/kg = milligrams per kilogram
MTCA DC = Model Toxics Control Act Direct Contact
NAWQC = National Ambient Water Quality Criteria
NC = noncarcinogen
R6 - Residential = EPA Region 6 Risk Based Concentration for Residential Soils
R9 PRG DAF1 = EPA Region 9 Preliminary Remediation Goal at a Dilution-Attenuation Factor of 1
TEQ = toxic equivalency to 2,3,7,8-TCDD
ug/L = microgram per liter

NOTES:
Screening level for benzo(a)pyrene used for cPAH.
Shaded text indicates Region 6 screening level more conservative than screening level used by Integral.

Table 2. Maximum Detected Concentration by Site Subarea

			Maximum Detected Concentration						Screening Levels			
Media	**Compound**	**Units**	**Upper Creek**	**Lower Creek**	**Beach**	**South Slope**	**General Site**	**Historical Creek**	**R6 - HHSL**	**C/NC**	**Integral**	**Integral Source**
Surface Soil	Carbazole	mg/kg	4.80E-01	4.46E-01			ND	8.40E-01	2.40E+01	C	3.00E-02	R9 PRG DAF1
	2,4-Dinitrotoluene	mg/kg				4.50E-02			1.20E+02	NC	4.00E-05	R9 PRG DAF1
	2,6-Dinitrotoluene	mg/kg				2.20E-02			6.10E+01	NC	3.00E-05	R9 PRG DAF1
	Pentachlorophenol	mg/kg	1.80E+00	**5.96E+00**			2.20E+00	**7.10E+00**	3.00E+00	C/NC	1.00E-03	R9 PRG DAF1
	2,4,6-Trichlorophenol	mg/kg	ND	3.20E-02			ND		4.40E+01	C	8.00E-03	R9 PRG DAF1
	Acenaphthene	mg/kg	7.20E+01						3.70E+03	NC	2.90E+01	R9 PRG DAF1
	Fluorene	mg/kg	5.70E+01						2.60E+03	NC	2.80E+01	R9 PRG DAF1
	2-methylnaphthalene	mg/kg	1.10E+01						1.20E+02	NC	4.00E+00	R9 PRG DAF1
	Naphthalene	mg/kg	5.50E+00						1.20E+02	NC	4.00E+00	R9 PRG DAF1
	cPAHs	mg/kg	**1.44E+02**	**3.71E+00**		**1.94E-01**	**3.41E+00**	**1.44E+02**	6.20E-02	C	--	
	TEQ	mg/kg	**1.37E-03**	**1.58E-03**		**7.81E-05**	**1.88E-03**	**1.33E-03**	3.90E-06	C	6.67E-06	MTCA DC
Subsurface Soil	Carbazole	mg/kg	9.30E-01					**3.30E+01**	2.40E+01	C	3.00E-02	R9 PRG DAF1
	2,4-Dinitrotoluene	mg/kg	ND					4.20E+00	1.20E+02	NC	4.00E-05	R9 PRG DAF1
	Pentachlorophenol	mg/kg	**6.40E+00**					**3.50E+00**	3.00E+00	C/NC	1.00E-03	R9 PRG DAF1
	2,4,6-Trichlorophenol	mg/kg	ND						4.40E+01	C	8.00E-03	R9 PRG DAF1
	Acenaphthene	mg/kg	1.60E+02					3.20E+02	3.70E+03	NC	2.90E+01	R9 PRG DAF1
	Fluoranthene	mg/kg						4.20E+02	2.30E+03	NC	2.10E+02	R9 PRG DAF1
	Fluorene	mg/kg	1.10E+02					2.40E+02	2.60E+03	NC	2.80E+01	R9 PRG DAF1
	2-methylnaphthalene	mg/kg	1.20E+02					**2.80E+02**	1.20E+02	NC	4.00E+00	R9 PRG DAF1
	Naphthalene	mg/kg	**1.60E+02**					**5.20E+02**	1.20E+02	NC	4.00E+00	R9 PRG DAF1
	Pyrene	mg/kg						3.00E+02	2.30E+03	NC	2.10E+02	R9 PRG DAF1
	cPAHs	mg/kg	**4.44E+02**					**4.44E+02**	6.20E-02	C	--	
	TEQ	mg/kg	**4.04E-04**					**3.59E-04**	3.90E-06	C	6.67E-06	MTCA DC
Sediment	Carbazole	mg/kg	2.84E+00	4.78E+00				2.60E-01	2.40E+01	C	3.00E-02	R9 PRG DAF1
	n-Nitrosodiphenylamine	mg/kg	1.95E-01	1.73E-01					9.90E+01	C/NC	6.00E-02	R9 PRG DAF1
	Pentachlorophenol	mg/kg	**4.27E+00**	**4.50E+00**	3.90E-02			**7.90E+00**	3.00E+00	C/NC	1.00E-03	R9 PRG DAF1
	2,4,6-Trichlorophenol	mg/kg	7.40E-01	ND	ND				4.40E+01	C	8.00E-03	R9 PRG DAF1
	Acenaphthene	mg/kg	1.30E+02						3.70E+03	NC	2.90E+01	R9 PRG DAF1
	Fluoranthene	mg/kg	3.40E+02						2.30E+03	NC	2.10E+02	R9 PRG DAF1
	Fluorene	mg/kg	1.00E+02						2.60E+03	NC	2.80E+01	R9 PRG DAF1
	2-methylnaphthalene	mg/kg	8.70E+00						1.20E+02	NC	4.00E+00	R9 PRG DAF1
	Naphthalene	mg/kg	4.30E+00						1.20E+02	NC	4.00E+00	R9 PRG DAF1
	Pyrene	mg/kg	2.20E+02						2.30E+03	NC	2.10E+02	R9 PRG DAF1
	cPAHs	mg/kg	**1.43E+01**	**2.89E+01**	**9.55E-02**			**7.94E+01**	6.20E-02	C	--	
	TEQ	mg/kg	**7.31E-04**	**5.93E-03**				**3.29E-03**	3.90E-06	C	6.67E-06	MTCA DC
Surface Water	Pentachlorophenol	ug/L	**1.40E+02**	**1.50E+01**					5.60E-01	C	2.70E-01	NAWQC
	cPAHs	ug/L	**3.56E-01**	**3.93E-02**	**2.30E-01**				9.20E-03	C	3.80E-03	NAWQC
	TEQ	ug/L	**5.77E-04**	**5.10E-05**					4.50E-07	C	8.64E-09	MTCA METHOD B

Key:
-- = Screening level not available
C = carcinogen
COPC = Compound of Potential Concern
cPAHs = carcinogenic polychlorinated aromatic hydrocarbons
HHSL = Human Health Medium-Specific Screening Level (EPA Region 6)
mg/kg = milligrams per kilogram
MTCA DC = Model Toxics Control Act Direct Contact
NAWQC = National Ambient Water Quality Criteria
NC = noncarcinogen
R9 PRG DAF1 = EPA Region 9 Preliminary Remediation Goal at a Diluation-Attenuation Factor of 1
TEQ = toxic equivalency to 2,3,7,8-TCDD
ug/L = microgram per liter

NOTES:
Bold and grey-shaded text indicates maximum concentration exceeded Region 6 HHSL for residential soils (soils and sediment) or tap water (surface water).
Bold and yellow shaded text indicates maximum concentration exceeded 100 times R6 - Residenital or Tap Water level for carcinogens (risk = 10^-4) or R6 screening level for noncarcinogens (HQ = 1).
Screening level for benzo(a)pyrene used for cPAH.

Table 3. Maximum Site Concentration					
Media	**COPC**	**Units**	**Maximum Concentration**	**Subarea**	**Location of Maximum**
Surface Soil	Pentachlorophenol	mg/kg	7.10E+00	Historical Creek	TP-16
	cPAHs	mg/kg	1.44E+02	Upper Creek/Historical Creek	SB-11
	TEQ	mg/kg	1.88E-03	General Site	SP-07
Subsurface Soil	Carbazole	mg/kg	3.30E+01	Historical Creek	TP-06 @ 1-2 ft bgs
	Pentachlorophenol	mg/kg	6.40E+00	Upper Creek	SB-09 @ 8-9 ft bgs
	2-methylnaphthalene	mg/kg	2.80E+02	Historical Creek	TP-06 @ 1-2ft bgs
	Naphthalene	mg/kg	5.20E+02	Historical Creek	TP-06 @ 1-2ft bgs
	cPAHs	mg/kg	4.44E+02	Upper Creek/Historical Creek	SB-11 @ 1-2 ft bgs
	TEQ	mg/kg	4.04E-04	Upper Creek	SB-11 @ 1-2 ft bgs
Sediment	Pentachlorophenol	mg/kg	7.90E+00	Historical Creek	SB-36
	cPAHs	mg/kg	7.94E+01	Historical Creek	SB-38
	TEQ	mg/kg	5.93E-03	Lower Creek	SB-02
Surface Water	Pentachlorophenol	ug/L	1.40E+02	Upper Creek	SW-05
	cPAHs	ug/L	3.56E-01	Upper Creek	SW-05
	TEQ	ug/L	5.77E-04	Upper Creek	SW-05
Key:					
ft bgs = feet below ground surface					
mg/kg = milligrams per kilogram					
ug/L = microgram per liter					

Table 4. Total Carcinogenic Polycyclic Aromatic Hydrocarbon Concentrations					
Media	**Subarea**	**Units**	**Max. Conc. - Integral (1)**	**Max. Conc. - E & E (2)**	**Location of Maximum**
Surface Soil	Upper Creek	mg/kg	1.44E+02	1.72E+02	SB-11
	Lower Creek	mg/kg	3.71E+00	3.83E+00	LSC-S1
	South Slope	mg/kg	1.94E-01	3.06E-01	RES-43
	General Site	mg/kg	3.41E+00	3.69E+00	SP07
	Historical Creek	mg/kg	1.44E+02	1.72E+02	SB-11
Subsurface Soil	Upper Creek	mg/kg	4.44E+02	5.10E+02	SB-11 @ 1-2 ft bgs
	Historical Creek	mg/kg	4.44E+02	5.10E+02	SB-11 @ 1-2 ft bgs
Sediment	Upper Creek	mg/kg	1.43E+01	1.50E+01	OS05
	Lower Creek	mg/kg	2.89E+01	2.87E+01	LSC-03
	Beach	mg/kg	9.55E-02	1.69E-01	OS01
	Historical Creek	mg/kg	7.94E+01	8.35E+01	SB-38
Surface Water	Upper Creek	ug/L	3.56E-01	3.93E-01	SW-05 (11/1/2005)
	Lower Creek	ug/L	3.93E-02	4.33E-02	SW-01 (7/26/1999)
	Beach	ug/L	2.30E-01	3.88E-01	OS01 (1/1/1996)
Key:					
ft bgs = feet below ground surface					
mg/kg = milligrams per kilogram					
ug/L = microgram per liter					
NOTES:					
1 - Total cPAHs calculated using relative potency factors from CalEPA 2005 for a subset of cPAHs.					
2 - Total cPAHc calcualted using relative potency factors from EPA 1993.					

Table 5
CALCULATION OF CANCER RISKS
RECRATIONAL USER - SURFACE SOIL
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Maximum of all locations
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	172.08	mg/kg	1.28E-06	mg/kg-day	7.30E+00	9.33E-06
Dermal	TCDD TEQ	0.00188	mg/kg	3.22E-12	mg/kg-day	1.50E+05	4.83E-07
Dermal	Pentachlorophenol	7.1	mg/kg	1.01E-07	mg/kg-day	1.20E-01	1.22E-08
Subtotal							9.82E-06
Ingestion	cPAHs	172.08	mg/kg	3.92E-06	mg/kg-day	7.30E+00	2.86E-05
Ingestion	TCDD TEQ	0.00188	mg/kg	4.29E-11	mg/kg-day	1.50E+05	6.43E-06
Ingestion	Pentachlorophenol	7.1	mg/kg	1.62E-07	mg/kg-day	1.20E-01	1.94E-08
Subtotal							3.51E-05
Inhalation	cPAHs	172.08	mg/kg	3.74E-10	mg/kg-day	3.10E+00	1.16E-09
Inhalation	Dioxin TEQ	0.00188	mg/kg	4.09E-15	mg/kg-day	1.50E+05	6.14E-10
Inhalation	Pentachlorophenol	7.1	mg/kg	1.54E-11	mg/kg-day	1.80E-02	2.78E-13
Subtotal							1.77E-09
Total							4.5E-05

Table 6
CALCULATION OF CANCER RISKS
RECRATIONAL USER - SUBSURFACE SOIL
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Maximum of all locations
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	509.66	mg/kg	3.78E-06	mg/kg-day	7.30E+00	2.76E-05
Dermal	TCDD TEQ	0.00040	mg/kg	6.92E-13	mg/kg-day	1.50E+05	1.04E-07
Dermal	Pentachlorophenol	6.4	mg/kg	9.14E-08	mg/kg-day	1.20E-01	1.10E-08
Dermal	Carbazole	33.0	mg/kg	1.88E-07	mg/kg-day	2.00E-02	3.77E-09
Subtotal							2.77E-05
Ingestion	cPAHs	509.66	mg/kg	1.16E-05	mg/kg-day	7.30E+00	8.48E-05
Ingestion	TCDD TEQ	0.00040	mg/kg	9.21E-12	mg/kg-day	1.50E+05	1.38E-06
Ingestion	Pentachlorophenol	6.4	mg/kg	1.46E-07	mg/kg-day	1.20E-01	1.75E-08
Ingestion	Carbazole	33.0	mg/kg	7.52E-07	mg/kg-day	2.00E-02	1.50E-08
Subtotal							8.62E-05
Inhalation	cPAHs	509.66	mg/kg	1.11E-09	mg/kg-day	3.10E+00	3.44E-09
Inhalation	Dioxin TEQ	0.00040	mg/kg	8.79E-16	mg/kg-day	1.50E+05	1.32E-10
Inhalation	Pentachlorophenol	6.4	mg/kg	1.39E-11	mg/kg-day	1.80E-02	2.51E-13
Inhalation	Carbazole	33.0	mg/kg	7.18E-11	mg/kg-day	--	--
Subtotal							3.57E-09
Total							1.1E-04

Table 7
CALCULATION OF CANCER RISKS
RECRATIONAL USER - SEDIMENT
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Maximum of all locations
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	83.48	mg/kg	5.95E-07	mg/kg-day	7.30E+00	4.34E-06
Dermal	TCDD TEQ	0.00593	mg/kg	9.75E-12	mg/kg-day	1.50E+05	1.46E-06
Dermal	Pentachlorophenol	7.9	mg/kg	1.08E-07	mg/kg-day	1.20E-01	1.30E-08
Subtotal							5.82E-06
Total							5.8E-06

Table 8
CALCULATION OF CANCER RISKS
RECRATIONAL USER - SURFACE WATER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Maximum of all locations
Receptor Population: Recreational User
Receptor Age: Adolescent

HIDE

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	c	DA_{event} (mg/cm^2 - event)	Slope Factor	RME Risk
Dermal	cPAHs	0.39	ug/L	2.74E-06	mg/kg-d	7.00E-01	2.69E+00	1.17E+01	1.00E+00	4.36E+00	1.25E-06	7.30E+00	2.00E-05
Dermal	TCDD TEQ	0.00058	ug/L	3.70E-09	mg/kg-d	8.10E-01	6.82E+00	3.01E+01	5.00E-01	5.65E+00	1.69E-09	1.50E+05	5.55E-04
Dermal	Pentachlorophenol	140.0	ug/L	5.43E-04	mg/kg-d	3.90E-01	3.33E+00	1.38E+01	9.00E-01	2.60E+00	2.48E-04	1.20E-01	6.52E-05
Subtotal													6.40E-04
Total													6.4E-04

Table 9
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER - SURFACE SOIL NON CANCER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Maximum of all locations
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	7.1	mg/kg	6.45E-07	mg/kg-day	3.00E-02	2.15E-05
Subtotal							2.15E-05
Ingestion	Pentachlorophenol	7.1	mg/kg	1.03E-06	mg/kg-day	3.00E-02	3.44E-05
Subtotal							3.44E-05
Inhalation	Pentachlorophenol	7.1	mg/kg	9.83E-11	mg/kg-day	--	--
Subtotal							0.00E+00
Total							5.6E-05

Table 10
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER - SUBSURFACE SOIL NON CANCER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Maximum of all locations
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	6.4	mg/kg	5.81E-07	mg/kg-day	3.00E-02	1.94E-05
Dermal	2-methylnaphthalene	280	mg/kg	1.32E-05	mg/kg-day	4.00E-03	3.31E-03
Dermal	Naphthalene	520	mg/kg	2.46E-05	mg/kg-day	2.00E-02	1.23E-03
Subtotal							4.55E-03
Ingestion	Pentachlorophenol	6.4	mg/kg	9.30E-07	mg/kg-day	3.00E-02	3.10E-05
Ingestion	2-methylnaphthalene	280	mg/kg	4.07E-05	mg/kg-day	4.00E-03	1.02E-02
Ingestion	Naphthalene	520	mg/kg	7.56E-05	mg/kg-day	2.00E-02	3.78E-03
Subtotal							1.40E-02
Inhalation	Pentachlorophenol	6.4	mg/kg	8.86E-11	mg/kg-day	--	--
Inhalation	2-methylnaphthalene	280	mg/kg	1.89E-04	mg/kg-day	--	--
Inhalation	Naphthalene	520	mg/kg	3.52E-04	mg/kg-day	8.60E-04	4.09E-01
Subtotal							4.09E-01
Total							4E-01

Table 11
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER - SEDIMENT NON CANCER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Maximum of all locations
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	7.9	mg/kg	6.89E-07	mg/kg-day	3.00E-02	2.30E-05
Subtotal							2.30E-05
Total							2.3E-05

Table 12
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER - SURFACE WATER NON CANCER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Maximum of all locations
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	B (unitless)	DA_{event} (mg/cm^2 - event)	Reference Dose	HQ
Dermal	Pentachlorophenol	140.0	ug/L	3.46E-03	mg/kg-d	3.90E-01	3.33E+00	1.38E+01	9.00E-01	2.50E+00	2.48E-04	3.00E-02	1.15E-01
Subtotal													1.15E-01
Total													1.2E-01

Table 13
SUMMARY OF RISKS AND HAZARD QUOTIENTS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Receptor Population: Recreational User
Receptor Age: Adolescent

Media	Cancer Risk	Hazard Quotient
Surface Soil	4.5E-05	5.6E-05
Subsurface Soil	1.1E-04	4.3E-01
Sediment	5.8E-06	2.3E-05
Surface Water	6.4E-04	1.2E-01
Total Risk/Hazard Index	8.0E-04	5.4E-01

Table 14
SUMMARY OF RISKS AND HAZARD QUOTIENTS
ALL SITES/RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Exposure Point: Maximum site/subarea concentration
Receptor Population: Recreational User
Receptor Age: Adolescent

LOCATION	ALL SITES		UPPER CREEK		LOWER CREEK		BEACH		SOUTH SLOPE		GENERAL SITE		HISTORICAL CREEK	
Media	Cancer Risk	Hazard Quotient	Cancer Risk	Hazard Quotient	Cancer Risk	Hazard Quotient	Cancer Risk	Hazard Quotient	Cancer Risk	Hazard Quotient	Cancer Risk	Hazard Quotient	Cancer Risk	Hazard Quotient
Surface Soil	4.5E-05	5.6E-05	4.3E-05	1.4E-05	6.7E-06	4.7E-05	--	--	3.5E-07	--	7.7E-06	1.7E-05	4.3E-05	5.6E-05
Subsurface Soil	**1.1E-04**	4.3E-01	**1.1E-04**	1.3E-01	--	--	--	--	--	--	--	--	**1.1E-04**	4.3E-01
Sediment	5.8E-06	2.3E-05	9.7E-07	1.2E-05	3.0E-06	1.3E-05	8.9E-09	1.1E-07	--	--	--	--	5.2E-06	2.3E-05
Surface Water	**6.4E-04**	1.2E-01	**6.4E-04**	1.2E-01	5.8E-05	1.2E-02	1.2E-05	--	--	--	--	--	--	--
Total Risk/Hazard Index	**8.0E-04**	5.4E-01	**8.0E-04**	2.5E-01	6.8E-05	1.2E-02	1.2E-05	1.1E-07	3.5E-07	0.0E+00	7.7E-06	1.7E-05	**1.6E-04**	4.3E-01

Bolded values indicate risk or hazard above a cancer risk of 10^-4 or a hazard above 1.0.

Table 15. Groundwater Maximum Concentrations				
Location	**COPC/IHS**	**Maximum Concentration**	**Units**	**MCL**
Upper Creek	Arsenic	25.9	ug/L	10
	Cadmium	1	ug/L	5
	Chromium	121	ug/L	100
	Lead	25	ug/L	15
	Manganese	420	ug/L	50 (1)
	Nickel	221	ug/L	NV
	Bis(2-ethylhexyl)phthalate	32	ug/L	NV
	Carbazole	43	ug/L	NV
	Pentachlorophenol	460	ug/L	1
	Fluoranthene	1400	ug/L	0.2 (2)
	Naphthalene	2800	ug/L	0.2 (2)
	Pyrene	1100	ug/L	0.2 (2)
	cPAHs	215.9	ug/L	0.2 (2)
	TEQ	1.85E-04	ug/L	3.00E-05
Lower Creek	Bis(2-ethylhexyl)phthalate	1.8	ug/L	NV
	cPAHs	0.72	ug/L	0.2 (2)
Historical Creek	Arsenic	3.4	ug/L	10
	Carbazole	43	ug/L	NV
	Pentachlorophenol	16	ug/L	1
	Naphthalene	2800	ug/L	0.2 (2)
	cPAHs	3.674	ug/L	0.2 (2)
	TEQ	8.91E-06	ug/L	3.00E-05
Key:				
cPAHs = carcinogenic polychlorinated aromatic hydrocarbons.				
MCL = Federal maximum contaminant level.				
NV = No value available.				
TEQ = toxic equivalency to 2,3,7,8-TCDD				
ug/L = microgram per liter.				
Notes:				
1 - Value is for a secondary standard. No MCL available.				
2 - The MCL for benzo(a)pyrene was used for all PAHs.				
Shaded text indicates maximum concentration exceeds the federal MCL.				

Review of Little Squalicum Park RI/FS
Human Health Risk Evaluation

APPENDIX

Table A-1-1
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Upper Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	172.08	mg/kg	1.28E-06	mg/kg-day	7.30E+00	9.33E-06
Dermal	TCDD TEQ	0.00137	mg/kg	2.35E-12	mg/kg-day	1.50E+05	3.52E-07
Dermal	Pentachlorophenol	1.8	mg/kg	2.57E-08	mg/kg-day	1.20E-01	3.08E-09
Subtotal							9.68E-06
Ingestion	cPAHs	172.08	mg/kg	3.92E-06	mg/kg-day	7.30E+00	2.86E-05
Ingestion	TCDD TEQ	0.00137	mg/kg	3.12E-11	mg/kg-day	1.50E+05	4.69E-06
Ingestion	Pentachlorophenol	1.8	mg/kg	4.10E-08	mg/kg-day	1.20E-01	4.92E-09
Subtotal							3.33E-05
Inhalation	cPAHs	172.08	mg/kg	3.74E-10	mg/kg-day	3.10E+00	1.16E-09
Inhalation	Dioxin TEQ	0.00137	mg/kg	2.98E-15	mg/kg-day	1.50E+05	4.47E-10
Inhalation	Pentachlorophenol	1.8	mg/kg	3.92E-12	mg/kg-day	1.80E-02	7.05E-14
Subtotal							1.61E-09
Total							4.3E-05

Table A-1-2
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Upper Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	509.7	mg/kg	3.78E-06	mg/kg-day	7.30E+00	2.76E-05
Dermal	Dioxin TEQ	0.0004	mg/kg	6.92E-13	mg/kg-day	1.50E+05	1.04E-07
Dermal	Pentachlorophenol	6.4	mg/kg	9.14E-08	mg/kg-day	1.20E-01	1.10E-08
Dermal	Carbazole	0.93	mg/kg	5.31E-09	mg/kg-day	2.00E-02	1.06E-10
Subtotal							2.77E-05
Ingestion	cPAHs	509.7	mg/kg	1.16E-05	mg/kg-day	7.30E+00	8.48E-05
Ingestion	Dioxin TEQ	0.0004	mg/kg	9.21E-12	mg/kg-day	1.50E+05	1.38E-06
Ingestion	Pentachlorophenol	6.4	mg/kg	1.46E-07	mg/kg-day	1.20E-01	1.75E-08
Ingestion	Carbazole	0.93	mg/kg	2.12E-08	mg/kg-day	2.00E-02	4.24E-10
Subtotal							8.62E-05
Inhalation	cPAHs	509.7	mg/kg	1.11E-09	mg/kg-day	3.10E+00	3.44E-09
Inhalation	Dioxin TEQ	0.0004	mg/kg	8.79E-16	mg/kg-day	1.50E+05	1.32E-10
Inhalation	Pentachlorophenol	6.4	mg/kg	1.39E-11	mg/kg-day	1.80E-02	2.51E-13
Inhalation	Carbazole	0.93	mg/kg	2.02E-12	mg/kg-day	--	--
Subtotal							3.57E-09
Total							1.1E-04

Table A-1-3
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Upper Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	15.0	mg/kg	1.07E-07	mg/kg-day	7.30E+00	7.81E-07
Dermal	Dioxin TEQ	0.00073	mg/kg	1.20E-12	mg/kg-day	1.50E+05	1.80E-07
Dermal	Pentachlorophenol	4.27	mg/kg	5.85E-08	mg/kg-day	1.20E-01	7.02E-09
Subtotal							9.68E-07
Total							9.7E-07

Table A-1-4
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Upper Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	B (unitless)	DA_{event} (mg/cm^2 - event)	Slope Factor	RME Risk
Dermal	cPAHs	0.39	ug/L	2.73E-06	mg/kg-d	7.00E-01	2.69E+00	1.17E+01	1.00E+00	4.30E+00	1.25E-06	7.30E+00	2.00E-05
Dermal	TCDD TEQ	0.00058	ug/L	3.70E-09	mg/kg-d	8.10E-01	6.82E+00	3.01E+01	5.00E-01	5.60E+00	1.69E-09	1.50E+05	5.55E-04
Dermal	Pentachlorophenol	140.0	ug/L	5.43E-04	mg/kg-d	3.90E-01	3.33E+00	1.38E+01	9.00E-01	2.50E+00	2.48E-04	1.20E-01	6.52E-05
Subtotal													6.40E-04
Total													6.4E-04

Table A-1-5
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Upper Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	1.8	mg/kg	1.64E-07	mg/kg-day	3.00E-02	5.45E-06
Subtotal							5.45E-06
Ingestion	Pentachlorophenol	1.8	mg/kg	2.62E-07	mg/kg-day	3.00E-02	8.72E-06
Subtotal							8.72E-06
Inhalation	Pentachlorophenol	1.8	mg/kg	2.49E-11	mg/kg-day	--	--
Subtotal							0.00E+00
Total							1.4E-05

Table A-1-6
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Upper Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	6.4	mg/kg	5.81E-07	mg/kg-day	3.00E-02	1.94E-05
Dermal	2-methylnaphthalene	120	mg/kg	5.67E-06	mg/kg-day	4.00E-03	1.42E-03
Dermal	Naphthalene	160	mg/kg	7.56E-06	mg/kg-day	2.00E-02	3.78E-04
Subtotal							1.81E-03
Ingestion	Pentachlorophenol	6.4	mg/kg	9.30E-07	mg/kg-day	3.00E-02	3.10E-05
Ingestion	2-methylnaphthalene	120	mg/kg	1.74E-05	mg/kg-day	4.00E-03	4.36E-03
Ingestion	Naphthalene	160	mg/kg	2.33E-05	mg/kg-day	2.00E-02	1.16E-03
Subtotal							5.56E-03
Inhalation	Pentachlorophenol	6.4	mg/kg	8.86E-11	mg/kg-day	--	--
Inhalation	2-methylnaphthalene	120	mg/kg	8.11E-05	mg/kg-day	--	--
Inhalation	Naphthalene	160	mg/kg	1.08E-04	mg/kg-day	8.60E-04	1.26E-01
Subtotal							1.26E-01
Total							1E-01

Table A-1-7
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Upper Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	4.3	mg/kg	3.72E-07	mg/kg-day	3.00E-02	1.24E-05
Subtotal							1.24E-05
Total							1.2E-05

Table A-1-8
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Upper Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	B (unitless)	DA_{event} (mg/cm^2 - event)	Reference Dose	HQ
Dermal	Pentachlorophenol	140.0	ug/L	3.46E-03	mg/kg-d	3.90E-01	3.33E+00	1.38E+01	9.00E-01	2.50E+00	2.48E-04	3.00E-02	1.15E-01
Subtotal													1.15E-01
Total													1.2E-01

Table A-1-9
SUMMARY OF RISKS AND HAZARD QUOTIENTS
UPPER CREEK, RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Receptor Population: Recreational User
Receptor Age: Adolescent

Media	Cancer Risk	Hazard Quotient
Surface Soil	4.3E-05	1.4E-05
Subsurface Soil	1.1E-04	1.3E-01
Sediment	9.7E-07	1.2E-05
Surface Water	6.4E-04	1.2E-01
Total Risk/Hazard Index	8.0E-04	2.5E-01

Table A-2-1
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Lower Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	3.83	mg/kg	2.84E-08	mg/kg-day	7.30E+00	2.08E-07
Dermal	Dioxin TEQ	0.00158	mg/kg	2.71E-12	mg/kg-day	1.50E+05	4.06E-07
Dermal	Pentachlorophenol	5.96	mg/kg	8.51E-08	mg/kg-day	1.20E-01	1.02E-08
Subtotal							6.24E-07
Ingestion	cPAHs	3.83	mg/kg	8.73E-08	mg/kg-day	7.30E+00	6.37E-07
Ingestion	Dioxin TEQ	0.00158	mg/kg	3.60E-11	mg/kg-day	1.50E+05	5.41E-06
Ingestion	Pentachlorophenol	5.96	mg/kg	1.36E-07	mg/kg-day	1.20E-01	1.63E-08
Subtotal							6.06E-06
Inhalation	cPAHs	3.83	mg/kg	8.33E-12	mg/kg-day	3.10E+00	2.58E-11
Inhalation	Dioxin TEQ	0.00158	mg/kg	3.44E-15	mg/kg-day	1.50E+05	5.16E-10
Inhalation	Pentachlorophenol	5.96	mg/kg	1.30E-11	mg/kg-day	1.80E-02	2.33E-13
Subtotal							5.42E-10
Total							6.7E-06

Table A-2-2
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Lower Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	--	mg/kg	--	mg/kg-day	7.30E+00	--
Dermal	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Dermal	Carbazole	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Ingestion	cPAHs	--	mg/kg	--	mg/kg-day	7.30E+00	--
Ingestion	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Ingestion	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Ingestion	Carbazole	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Inhalation	cPAHs	--	mg/kg	--	mg/kg-day	3.10E+00	--
Inhalation	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Inhalation	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.80E-02	--
Inhalation	Carbazole	--	mg/kg	--	mg/kg-day	--	--
Subtotal							0.00E+00
Total							0.0E+00

Table A-2-3
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Lower Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	28.7	mg/kg	2.04E-07	mg/kg-day	7.30E+00	1.49E-06
Dermal	Dioxin TEQ	0.00593	mg/kg	9.75E-12	mg/kg-day	1.50E+05	1.46E-06
Dermal	Pentachlorophenol	4.50	mg/kg	6.17E-08	mg/kg-day	1.20E-01	7.40E-09
Subtotal							2.96E-06
Total							3.0E-06

Table A-2-4
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Lower Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	B (unitless)	DA_{event} (mg/cm^2 - event)	Slope Factor	RME Risk
Dermal	cPAHs	0.04	ug/L	3.01E-07	mg/kg-d	7.00E-01	2.69E+00	1.17E+01	1.00E+00	4.30E+00	1.37E-07	7.30E+00	2.20E-06
Dermal	TCDD TEQ	0.00005	ug/L	3.27E-10	mg/kg-d	8.10E-01	6.82E+00	3.01E+01	5.00E-01	5.60E+00	1.49E-10	1.50E+05	4.90E-05
Dermal	Pentachlorophenol	15.0	ug/L	5.82E-05	mg/kg-d	3.90E-01	3.33E+00	1.38E+01	9.00E-01	2.50E+00	2.66E-05	1.20E-01	6.99E-06
Subtotal													5.82E-05
Total													5.8E-05

Table A-2-5
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Lower Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	6.0	mg/kg	5.42E-07	mg/kg-day	3.00E-02	1.81E-05
Subtotal							1.81E-05
Ingestion	Pentachlorophenol	6.0	mg/kg	8.66E-07	mg/kg-day	3.00E-02	2.89E-05
Subtotal							2.89E-05
Inhalation	Pentachlorophenol	6.0	mg/kg	8.31E-11	mg/kg-day	--	--
Subtotal							0.00E+00
Total							4.7E-05

Table A-2-6
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Upper Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Dermal	2-methylnaphthalene	--	mg/kg	--	mg/kg-day	4.00E-03	--
Dermal	Naphthalene	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Ingestion	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Ingestion	2-methylnaphthalene	--	mg/kg	--	mg/kg-day	4.00E-03	--
Ingestion	Naphthalene	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Inhalation	Pentachlorophenol	--	mg/kg	--	mg/kg-day	--	--
Inhalation	2-methylnaphthalene	--	mg/kg	--	mg/kg-day	--	--
Inhalation	Naphthalene	--	mg/kg	--	mg/kg-day	8.60E-04	--
Subtotal							0.00E+00
Total							0E+00

Table A-2-7
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Lower Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	4.5	mg/kg	3.93E-07	mg/kg-day	3.00E-02	1.31E-05
Subtotal							1.31E-05
Total							1.3E-05

Table A-2-8
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Lower Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	B (unitless)	DA_{event} (mg/cm^2 - event)	Reference Dose	HQ
Dermal	Pentachlorophenol	15.0	ug/L	3.71E-04	mg/kg-d	3.90E-01	3.33E+00	1.38E+01	9.00E-01	2.50E+00	2.66E-05	3.00E-02	1.24E-02
Subtotal													1.24E-02
Total													1.2E-02

Table A-2-9
SUMMARY OF RISKS AND HAZARD QUOTIENTS
LOWER CREEK, RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Receptor Population: Recreational User
Receptor Age: Adolescent

Media	Cancer Risk	Hazard Quotient
Surface Soil	6.7E-06	4.7E-05
Subsurface Soil	--	--
Sediment	3.0E-06	1.3E-05
Surface Water	5.8E-05	1.2E-02
Total Risk/Hazard Index	6.8E-05	1.2E-02

Table A-3-1
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Lower Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	--	mg/kg	--	mg/kg-day	7.30E+00	--
Dermal	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Subtotal							0.00E+00
Ingestion	cPAHs	--	mg/kg	--	mg/kg-day	7.30E+00	--
Ingestion	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Ingestion	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Subtotal							0.00E+00
Inhalation	cPAHs	--	mg/kg	--	mg/kg-day	3.10E+00	--
Inhalation	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Inhalation	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.80E-02	--
Subtotal							0.00E+00
Total							0.0E+00

Table A-3-2
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Beach
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	--	mg/kg	--	mg/kg-day	7.30E+00	--
Dermal	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Dermal	Carbazole	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Ingestion	cPAHs	--	mg/kg	--	mg/kg-day	7.30E+00	--
Ingestion	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Ingestion	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Ingestion	Carbazole	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Inhalation	cPAHs	--	mg/kg	--	mg/kg-day	3.10E+00	--
Inhalation	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Inhalation	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.80E-02	--
Inhalation	Carbazole	--	mg/kg	--	mg/kg-day	--	--
Subtotal							0.00E+00
Total							0.0E+00

Table A-3-3
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Beach
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	0.1692	mg/kg	1.21E-09	mg/kg-day	7.30E+00	8.80E-09
Dermal	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Dermal	Pentachlorophenol	0.04	mg/kg	5.35E-10	mg/kg-day	1.20E-01	6.41E-11
Subtotal							8.87E-09
Total							8.9E-09

Table A-3-4
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Beach
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	B (unitless)	DA_{event} (mg/cm^2 - event)	Slope Factor	RME Risk
Dermal	cPAHs	0.23	ug/L	1.60E-06	mg/kg-d	7.00E-01	2.69E+00	1.17E+01	1.00E+00	4.30E+00	7.30E-07	7.30E+00	1.17E-05
Subtotal													1.17E-05
Total													1.2E-05

Table A-3-5
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Beach
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Subtotal							0.00E+00
Ingestion	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Subtotal							0.00E+00
Inhalation	Pentachlorophenol	--	mg/kg	--	mg/kg-day	--	--
Subtotal							0.00E+00
Total							0.0E+00

Table A-3-6
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Beach
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Dermal	2-methylnaphthalene	--	mg/kg	--	mg/kg-day	4.00E-03	--
Dermal	Naphthalene	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Ingestion	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Ingestion	2-methylnaphthalene	--	mg/kg	--	mg/kg-day	4.00E-03	--
Ingestion	Naphthalene	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Inhalation	Pentachlorophenol	--	mg/kg	--	mg/kg-day	--	--
Inhalation	2-methylnaphthalene	--	mg/kg	--	mg/kg-day	--	--
Inhalation	Naphthalene	--	mg/kg	--	mg/kg-day	8.60E-04	--
Subtotal							0.00E+00
Total							0E+00

Table A-3-7
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Beach
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	0.039	mg/kg	3.40E-09	mg/kg-day	3.00E-02	1.13E-07
Subtotal							1.13E-07
Total							1.1E-07

Table A-3-8
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Beach
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	B (unitless)	DA_{event} (mg/cm^2 - event)	Reference Dose	HQ
Dermal	Pentachlorophenol	--	ug/L	--	mg/kg-d	3.90E-01	3.33E+00	1.38E+01	9.00E-01	2.50E+00	--	3.00E-02	--
Subtotal													0.00E+00
Total													0.0E+00

Table A-3-9
SUMMARY OF RISKS AND HAZARD QUOTIENTS
BEACH, RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Receptor Population: Recreational User
Receptor Age: Adolescent

Media	Cancer Risk	Hazard Quotient
Surface Soil	--	--
Subsurface Soil	--	--
Sediment	8.9E-09	1.1E-07
Surface Water	1.2E-05	--
Total Risk/Hazard Index	1.2E-05	1.1E-07

Table A-4-1
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: South Slope
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	0.31	mg/kg	2.28E-09	mg/kg-day	7.30E+00	1.66E-08
Dermal	Dioxin TEQ	0.00008	mg/kg	1.34E-13	mg/kg-day	1.50E+05	2.01E-08
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Subtotal							3.67E-08
Ingestion	cPAHs	0.31	mg/kg	6.99E-09	mg/kg-day	7.30E+00	5.10E-08
Ingestion	Dioxin TEQ	0.00008	mg/kg	1.78E-12	mg/kg-day	1.50E+05	2.67E-07
Ingestion	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Subtotal							3.18E-07
Inhalation	cPAHs	0.31	mg/kg	6.67E-13	mg/kg-day	3.10E+00	2.07E-12
Inhalation	Dioxin TEQ	0.00008	mg/kg	1.70E-16	mg/kg-day	1.50E+05	2.55E-11
Inhalation	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.80E-02	--
Subtotal							2.76E-11
Total							3.5E-07

Table A-4-2
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: South Slope
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	--	mg/kg	--	mg/kg-day	7.30E+00	--
Dermal	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Dermal	Carbazole	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Ingestion	cPAHs	--	mg/kg	--	mg/kg-day	7.30E+00	--
Ingestion	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Ingestion	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Ingestion	Carbazole	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Inhalation	cPAHs	--	mg/kg	--	mg/kg-day	3.10E+00	--
Inhalation	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Inhalation	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.80E-02	--
Inhalation	Carbazole	--	mg/kg	--	mg/kg-day	--	--
Subtotal							0.00E+00
Total							0.0E+00

Table A-4-3
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: South Slope
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	--	mg/kg	--	mg/kg-day	7.30E+00	--
Dermal	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Subtotal							0.00E+00
Total							0.0E+00

Table A-4-4
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: South Slope
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	B (unitless)	DA_{event} (mg/cm^2 - event)	Slope Factor	RME Risk
Dermal	cPAHs	--	ug/L	--	mg/kg-d	7.00E-01	2.69E+00	1.17E+01	1.00E+00	4.30E+00	--	7.30E+00	--
Dermal	TCDD TEQ	--	ug/L	--	mg/kg-d	8.10E-01	6.82E+00	3.01E+01	5.00E-01	5.60E+00	--	1.50E+05	--
Dermal	Pentachlorophenol	--	ug/L	--	mg/kg-d	3.90E-01	3.33E+00	1.38E+01	9.00E-01	2.50E+00	--	1.20E-01	--
Subtotal													0.00E+00
Total													0.0E+00

Table A-4-5
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: South Slope
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Subtotal							0.00E+00
Ingestion	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Subtotal							0.00E+00
Inhalation	Pentachlorophenol	7.1	mg/kg	9.83E-11	mg/kg-day	--	--
Subtotal							0.00E+00
Total							0.0E+00

Table A-4-6
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: South Slope
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Dermal	2-methylnaphthalene	--	mg/kg	--	mg/kg-day	4.00E-03	--
Dermal	Naphthalene	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Ingestion	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Ingestion	2-methylnaphthalene	--	mg/kg	--	mg/kg-day	4.00E-03	--
Ingestion	Naphthalene	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Inhalation	Pentachlorophenol	--	mg/kg	--	mg/kg-day	--	--
Inhalation	2-methylnaphthalene	--	mg/kg	--	mg/kg-day	--	--
Inhalation	Naphthalene	--	mg/kg	--	mg/kg-day	8.60E-04	--
Subtotal							0.00E+00
Total							0E+00

Table A-4-7
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: South Slope
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Subtotal							0.00E+00
Total							0.0E+00

Table A-4-8
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: South Slope
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	B (unitless)	DA_{event} (mg/cm^2 - event)	Reference Dose	HQ
Dermal	Pentachlorophenol	--	ug/L	--	mg/kg-d	3.90E-01	3.33E+00	1.38E+01	9.00E-01	2.50E+00	--	3.00E-02	--
Subtotal													0.00E+00
Total													0.0E+00

Table A-4-9
SUMMARY OF RISKS AND HAZARD QUOTIENTS
SOUTH SLOPE, RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Receptor Population: Recreational User
Receptor Age: Adolescent

Media	Cancer Risk	Hazard Quotient
Surface Soil	3.5E-07	--
Subsurface Soil	--	--
Sediment	--	--
Surface Water	--	--
Total Risk/Hazard Index	3.5E-07	0.0E+00

Table A-5-1
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: General Site
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	3.69	mg/kg	2.74E-08	mg/kg-day	7.30E+00	2.00E-07
Dermal	Dioxin TEQ	0.00188	mg/kg	3.22E-12	mg/kg-day	1.50E+05	4.83E-07
Dermal	Pentachlorophenol	2.2	mg/kg	3.14E-08	mg/kg-day	1.20E-01	3.77E-09
Subtotal							6.87E-07
Ingestion	cPAHs	3.69	mg/kg	8.42E-08	mg/kg-day	7.30E+00	6.15E-07
Ingestion	Dioxin TEQ	0.00188	mg/kg	4.29E-11	mg/kg-day	1.50E+05	6.43E-06
Ingestion	Pentachlorophenol	2.2	mg/kg	5.02E-08	mg/kg-day	1.20E-01	6.02E-09
Subtotal							7.05E-06
Inhalation	cPAHs	3.69	mg/kg	8.04E-12	mg/kg-day	3.10E+00	2.49E-11
Inhalation	Dioxin TEQ	0.00188	mg/kg	4.09E-15	mg/kg-day	1.50E+05	6.14E-10
Inhalation	Pentachlorophenol	2.2	mg/kg	4.79E-12	mg/kg-day	1.80E-02	8.62E-14
Subtotal							6.39E-10
Total							7.7E-06

Table A-5-2
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: General Site
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	--	mg/kg	--	mg/kg-day	7.30E+00	--
Dermal	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Dermal	Carbazole	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Ingestion	cPAHs	--	mg/kg	--	mg/kg-day	7.30E+00	--
Ingestion	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Ingestion	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Ingestion	Carbazole	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Inhalation	cPAHs	--	mg/kg	--	mg/kg-day	3.10E+00	--
Inhalation	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Inhalation	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.80E-02	--
Inhalation	Carbazole	--	mg/kg	--	mg/kg-day	--	--
Subtotal							0.00E+00
Total							0.0E+00

Table A-5-3
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: General Site
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	--	mg/kg	--	mg/kg-day	7.30E+00	--
Dermal	Dioxin TEQ	--	mg/kg	--	mg/kg-day	1.50E+05	--
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	1.20E-01	--
Subtotal							0.00E+00
Total							0.0E+00

Table A-5-4
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: General Site
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	B (unitless)	DA_{event} (mg/cm^2 - event)	Slope Factor	RME Risk
Dermal	cPAHs	--	ug/L	--	mg/kg-d	7.00E-01	2.69E+00	1.17E+01	1.00E+00	4.30E+00	--	7.30E+00	--
Dermal	TCDD TEQ	--	ug/L	--	mg/kg-d	8.10E-01	6.82E+00	3.01E+01	5.00E-01	5.60E+00	--	1.50E+05	--
Dermal	Pentachlorophenol	--	ug/L	--	mg/kg-d	3.90E-01	3.33E+00	1.38E+01	9.00E-01	2.50E+00	--	1.20E-01	--
Subtotal													0.00E+00
Total													0.0E+00

Table A-5-5
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: General Site
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	2.2	mg/kg	2.00E-07	mg/kg-day	3.00E-02	6.66E-06
Subtotal							6.66E-06
Ingestion	Pentachlorophenol	2.2	mg/kg	3.20E-07	mg/kg-day	3.00E-02	1.07E-05
Subtotal							1.07E-05
Inhalation	Pentachlorophenol	2.2	mg/kg	3.05E-11	mg/kg-day	--	--
Subtotal							0.00E+00
Total							1.7E-05

Table A-5-6
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: General Site
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Dermal	2-methylnaphthalene	--	mg/kg	--	mg/kg-day	4.00E-03	--
Dermal	Naphthalene	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Ingestion	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Ingestion	2-methylnaphthalene	--	mg/kg	--	mg/kg-day	4.00E-03	--
Ingestion	Naphthalene	--	mg/kg	--	mg/kg-day	2.00E-02	--
Subtotal							0.00E+00
Inhalation	Pentachlorophenol	--	mg/kg	--	mg/kg-day	--	--
Inhalation	2-methylnaphthalene	--	mg/kg	--	mg/kg-day	--	--
Inhalation	Naphthalene	--	mg/kg	--	mg/kg-day	8.60E-04	--
Subtotal							0.00E+00
Total							0E+00

Table A-5-7
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: General Site
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	--	mg/kg	--	mg/kg-day	3.00E-02	--
Subtotal							0.00E+00
Total							0.0E+00

Table A-5-8
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: General Site
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	B (unitless)	DA_{event} (mg/cm^2 - event)	Reference Dose	HQ
Dermal	Pentachlorophenol	--	ug/L	--	mg/kg-d	3.90E-01	3.33E+00	1.38E+01	9.00E-01	2.50E+00	--	3.00E-02	--
Subtotal													0.00E+00
Total													0.0E+00

Table A-5-9
SUMMARY OF RISKS AND HAZARD QUOTIENTS
GENERAL SITE, RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Receptor Population: Recreational User
Receptor Age: Adolescent

Media	Cancer Risk	Hazard Quotient
Surface Soil	7.7E-06	1.7E-05
Subsurface Soil	--	--
Sediment	--	--
Surface Water	--	--
Total Risk/Hazard Index	7.7E-06	1.7E-05

Table A-6-1
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Historical Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	172	mg/kg	1.28E-06	mg/kg-day	7.30E+00	9.33E-06
Dermal	Dioxin TEQ	0.00133	mg/kg	2.28E-12	mg/kg-day	1.50E+05	3.42E-07
Dermal	Pentachlorophenol	7.1	mg/kg	1.01E-07	mg/kg-day	1.20E-01	1.22E-08
Subtotal							9.68E-06
Ingestion	cPAHs	172	mg/kg	3.92E-06	mg/kg-day	7.30E+00	2.86E-05
Ingestion	Dioxin TEQ	0.00133	mg/kg	3.03E-11	mg/kg-day	1.50E+05	4.55E-06
Ingestion	Pentachlorophenol	7.1	mg/kg	1.62E-07	mg/kg-day	1.20E-01	1.94E-08
Subtotal							3.32E-05
Inhalation	cPAHs	172	mg/kg	3.74E-10	mg/kg-day	3.10E+00	1.16E-09
Inhalation	Dioxin TEQ	0.00133	mg/kg	2.89E-15	mg/kg-day	1.50E+05	4.34E-10
Inhalation	Pentachlorophenol	7.1	mg/kg	1.54E-11	mg/kg-day	1.80E-02	2.78E-13
Subtotal							1.59E-09
Total							4.3E-05

Table A-6-2
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Historical Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	509.7	mg/kg	3.78E-06	mg/kg-day	7.30E+00	2.76E-05
Dermal	Dioxin TEQ	0.0004	mg/kg	6.15E-13	mg/kg-day	1.50E+05	9.23E-08
Dermal	Pentachlorophenol	3.5	mg/kg	5.00E-08	mg/kg-day	1.20E-01	6.00E-09
Dermal	Carbazole	33.0	mg/kg	1.88E-07	mg/kg-day	2.00E-02	3.77E-09
Subtotal							2.77E-05
Ingestion	cPAHs	509.7	mg/kg	1.16E-05	mg/kg-day	7.30E+00	8.48E-05
Ingestion	Dioxin TEQ	0.0004	mg/kg	9.21E-12	mg/kg-day	1.50E+05	1.38E-06
Ingestion	Pentachlorophenol	3.5	mg/kg	7.98E-08	mg/kg-day	1.20E-01	9.58E-09
Ingestion	Carbazole	33.0	mg/kg	7.52E-07	mg/kg-day	2.00E-02	1.50E-08
Subtotal							8.62E-05
Inhalation	cPAHs	509.7	mg/kg	1.11E-09	mg/kg-day	3.10E+00	3.44E-09
Inhalation	Dioxin TEQ	0.0004	mg/kg	8.79E-16	mg/kg-day	1.50E+05	1.32E-10
Inhalation	Pentachlorophenol	3.5	mg/kg	7.61E-12	mg/kg-day	1.80E-02	1.37E-13
Inhalation	Carbazole	33.0	mg/kg	7.18E-11	mg/kg-day	--	--
Subtotal							3.57E-09
Total							1.1E-04

Table A-6-3
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Historical Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Slope Factor	RM Risk
Dermal	cPAHs	83.48	mg/kg	5.95E-07	mg/kg-day	7.30E+00	4.34E-06
Dermal	Dioxin TEQ	0.00329	mg/kg	5.41E-12	mg/kg-day	1.50E+05	8.12E-07
Dermal	Pentachlorophenol	7.90	mg/kg	1.08E-07	mg/kg-day	1.20E-01	1.30E-08
Subtotal							5.17E-06
Total							5.2E-06

Table A-6-4
CALCULATION OF CANCER RISKS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Historical Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	B (unitless)	DA_{event} (mg/cm^2 - event)	Slope Factor	RME Risk
Dermal	cPAHs	--	ug/L	--	mg/kg-d	7.00E-01	2.69E+00	1.17E+01	1.00E+00	4.30E+00	--	7.30E+00	--
Dermal	TCDD TEQ	--	ug/L	--	mg/kg-d	8.10E-01	6.82E+00	3.01E+01	5.00E-01	5.60E+00	--	1.50E+05	--
Dermal	Pentachlorophenol	--	ug/L	--	mg/kg-d	3.90E-01	3.33E+00	1.38E+01	9.00E-01	2.50E+00	--	1.20E-01	--
Subtotal													0.00E+00
Total													0.0E+00

Table A-6-5
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Historical Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	7.1	mg/kg	6.45E-07	mg/kg-day	3.00E-02	2.15E-05
Subtotal							2.15E-05
Ingestion	Pentachlorophenol	7.1	mg/kg	1.03E-06	mg/kg-day	3.00E-02	3.44E-05
Subtotal							3.44E-05
Inhalation	Pentachlorophenol	7.1	mg/kg	9.83E-11	mg/kg-day	--	--
Subtotal							0.00E+00
Total							5.6E-05

Table A-6-6
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Subsurface Soil
Exposure Medium: Subsurface Soil
Exposure Point: Historical Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	3.5	mg/kg	3.18E-07	mg/kg-day	3.00E-02	1.06E-05
Dermal	2-methylnaphthalene	280	mg/kg	1.32E-05	mg/kg-day	4.00E-03	3.31E-03
Dermal	Naphthalene	520	mg/kg	2.46E-05	mg/kg-day	2.00E-02	1.23E-03
Subtotal							4.55E-03
Ingestion	Pentachlorophenol	3.5	mg/kg	5.09E-07	mg/kg-day	3.00E-02	1.70E-05
Ingestion	2-methylnaphthalene	280	mg/kg	4.07E-05	mg/kg-day	4.00E-03	1.02E-02
Ingestion	Naphthalene	520	mg/kg	7.56E-05	mg/kg-day	2.00E-02	3.78E-03
Subtotal							1.40E-02
Inhalation	Pentachlorophenol	3.5	mg/kg	4.85E-11	mg/kg-day	--	--
Inhalation	2-methylnaphthalene	280	mg/kg	1.89E-04	mg/kg-day	--	--
Inhalation	Naphthalene	520	mg/kg	3.52E-04	mg/kg-day	8.60E-04	4.09E-01
Subtotal							4.09E-01
Total							4E-01

Table A-6-7
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment
Exposure Point: Historical Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Reference Dose	HQ
Dermal	Pentachlorophenol	7.9	mg/kg	6.89E-07	mg/kg-day	3.00E-02	2.30E-05
Subtotal							2.30E-05
Total							2.3E-05

Table A-6-8
CALCULATION OF NON-CANCER HAZARDS
RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water
Exposure Point: Historical Creek
Receptor Population: Recreational User
Receptor Age: Adolescent

Exposure Route	Chemical of Potential Concern	Max Value	Units	RME Intake	Units	Kp (cm/hr)	τ_{event} (hr)	t* (hr)	FA (unitless)	B (unitless)	DA_{event} (mg/cm^2 - event)	Reference Dose	HQ
Dermal	Pentachlorophenol	--	ug/L	--	mg/kg-d	3.90E-01	3.33E+00	1.38E+01	9.00E-01	2.50E+00	--	3.00E-02	--
Subtotal													0.00E+00
Total													0.0E+00

Table A-6-9
SUMMARY OF RISKS AND HAZARD QUOTIENTS
HISTORICAL CREEK, RECRATIONAL USER
Oeser Company
Bellingham, Washington

Scenario Timeframe: Current/Future
Receptor Population: Recreational User
Receptor Age: Adolescent

Media	Cancer Risk	Hazard Quotient
Surface Soil	4.3E-05	5.6E-05
Subsurface Soil	1.1E-04	4.3E-01
Sediment	5.2E-06	2.3E-05
Surface Water	--	--
Total Risk/Hazard Index	1.6E-04	4.3E-01

Ecological Risk Actionability Technical Memorandum
Oeser Company Superfund Site

Prepared by Ecology and Environment, Inc. for EPA Region 10

May 2, 2007

ecology and environment, inc.
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To:	Mary Jane Nearman, EPA Project Manager
From:	Carl Mach, Ecology and Environment, Inc.
Through:	Mark Longtine, Ecology and Environment, Inc. and Don Heyer, CH2M HILL
Date:	May 2, 2007
Re:	Review of Little Squalicum Park RI/FS – Ecological Risk Evaluation

1. Introduction

This technical memorandum evaluates potential ecological risks in Little Squalicum Park (LSP) using data assembled by Integral Consulting, Inc. (Integral) for the *Little Squalicum Park Remedial Investigation/Feasibility Study Draft Report* (RI/FS, Integral 2006). The LSP RI/FS database includes data for a wide range of chemicals in water, sediment, and soil collected by Integral in 2005 and 2006, by E & E for the Oeser Company RI (E & E 2002), by the Washington Department of Ecology (Ecology) during their 2003 investigation of Little Squalicum Creek (Ecology 2004), and during several previous investigations, as discussed in the draft LSP RI/FS (Integral 2006). For the LSP area, the 2006 LSP RI/FS database is more extensive than the database that was available to E & E for the Oeser Company Site RI and associated ecological risk assessment (ERA, E & E 2002). This memorandum makes use of this larger database to determine if contamination found in LSP can be considered actionable under CERCLA. For this analysis, E & E focused on the chemicals known to be associated with the Oeser Company Site (Oeser) — pentachlorophenol (PCP), polycyclic aromatic hydrocarbons (PAHs), and dioxins/furans. As was done in the 2002 Oeser ERA, PAHs were evaluated collectively as total PAHs and dioxins/furans were evaluated collectively as the 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD) toxic equivalent (TEQ) concentration.

The remainder of this memorandum is organized as follows:

- Section 2 presents a reassessment of ecological risks to terrestrial ecological receptors, including plants, soil invertebrates, and wildlife;
- Section 3 presents a reassessment of ecological risks to aquatic biota in Little Squalicum Creek; and
- Section 4 provides a summary of the reassessment, presents conclusions regarding actionability under CERCLA, describes the need for additional investigation at the site, and provides a brief evaluation of remediation and risk reduction.

2. Terrestrial Ecological Receptors

Soil contamination at the site has the potential to adversely affect three assessment endpoints: (1) plants, (2) soil invertebrates, and (3) wildlife. Potential risks to these assessment endpoints were reassessed using surface and subsurface soil samples (up to 6 feet below ground surface [bgs]) from the 2006 LSP RI/FS database. Samples up to 6 feet bgs were used because plants, soil invertebrates, and/or burrowing mammals may be reasonably expected to contact soil contamination down to this depth. The reassessment used the same screening benchmarks, exposure parameters, and calculation methods as the original Oeser ERA (E & E 2002) so the original and updated results would be comparable.

2.1 Plants and Soil Fauna

Potential risks to plants and soil fauna were evaluated by comparing concentrations of PCP, total PAHs, and dioxins/furans in soil to benchmarks for the protection of plants and soil fauna. No benchmarks were exceeded in samples collected on the south slope (see Table 1).

In the Little Squalicum Creek (LSC) ravine, the PCP phytotoxicity benchmark was exceeded at three locations and the PCP earthworm benchmark was exceeded at one location (see Table 1). The exceedances occurred in soil samples collected from the historic and lower creek areas (see Table 2). In general, the magnitude of the exceedances was not great (see Table 2).

For total PAHs, the benchmarks for phytotoxicity and earthworms were exceeded at ten and nine locations, respectively, in the LSC ravine (see Table 1). Nearly all of the exceedances occurred in the historic and upper creek areas (see Table 3). In eight samples, the benchmarks were exceeded by a factor of ten or more (see Table 3).

2.2 Wildlife

In the 2002 Oeser ERA, two wildlife receptors with a high potential for exposure to soil contamination, the American robin (*Turdus migratorius*) and masked shrew (*Sorex cinereus*), were evaluated. The exposure point concentrations, exposure estimates, and hazard quotients for these two receptors were recalculated using the 2006 LSP RI/FS database. Tables 2 through 5 list the soil samples and concentration data that were used. Table 6 compares the original and updated exposure point concentrations, exposure estimates, and hazard quotients. The results are discussed below by chemical group.

2.2.1 Pentachlorophenol

For PCP, the results of the wildlife assessment for the 2002 Oeser ERA change little when the 2006 LSP RI/FS database is used in the analysis. There is an 80% increase in the exposure point concentrations for surface soil and prey (i.e., earthworms) and a

similar increase in the exposure estimates and hazard quotients for the shrew (see Table 6). However, as in the 2002 Oeser ERA, the lowest observed adverse effects level (LOAEL)-based hazard quotient for the shrew is much less than 1, suggesting that risks to insectivorous mammals from PCP in soil are negligible. Risks to other groups of mammals from PCP are also likely to be negligible given that their exposure to PCP through the food chain would be lower than for the shrew. No avian toxicity reference value for PCP is available; hence, risks cannot be calculated for the robin (see Table 6).

2.2.2 Total PAHs

For total PAHs, the exposure estimates and hazard quotients for the robin and shrew are greater for the 2006 LSP RI data than the 2002 Oeser ERA data by a factor of five. For the robin, this increase has little effect on the conclusions of the assessment because the LOAEL-based hazard quotient is still less than 1.0 (see Table 6). However, for the shrew, the LOAEL-based hazard quotient increases from 3.4 to 15.8 using the 2006 LSP RI/FS data (see Table 6). This result suggests that insectivorous mammals in the ravine may be affected by PAH contamination in soil.

It should be noted that the LOAEL-based hazard quotient for the shrew for total PAHs also was greater than 1 in the 2002 Oeser ERA (see Table 6). In the conclusions of the 2002 Oeser ERA, it was argued that although the critical value of 1 was exceeded for the shrew, an adverse impact to the local shrew population was unlikely for several reasons: (1) only one hotspot of soil contamination was identified in 1999; (2) the total PAH concentration in earthworms, the assumed prey of the shrew, was conservatively modeled, not measured; and (3) besides earthworms, shrews consume other foods (e.g., grasshoppers and other insects) that are less likely to accumulate PAHs from soil. This argument is no longer supportable given that a more extensive area of PAH contamination in soil has been identified in the historic and upper creek areas and the LOAEL-based hazard quotient for the shrew is 15.8 for total PAHs.

2.2.3 Dioxins/furans

For dioxins/furans, the exposure estimates and hazard quotients for the robin and shrew increase by a factor of two using the 2006 LSP RI/FS data. For the robin, this increase results in a LOAEL-based hazard quotient of 1 (see Table 6), suggesting that a threshold for adverse effects has been reached. For the shrew, the LOAEL-based hazard quotient increases to 14.4 (see Table 6). This result suggests that insectivorous mammals in the ravine may be affected by dioxin/furan contamination in soil.

As noted above for total PAHs, the LOAEL-based hazard quotient for the shrew for dioxins/furans also exceeded 1 in the 2002 Oeser ERA. However, for the same reasons given above for total PAHs, a population level risk from dioxins/furans was considered unlikely. This position is no longer supportable given that additional contamination hotspots have been identified and the LOAEL-based hazard quotient is 14.4 for dioxins/furans.

3. Aquatic Biota in Little Squalicum Creek

Both Ecology and Integral have investigated Little Squalicum Creek since the 2002 Oeser RI was completed. Ecology (2004) presents results from a sediment investigation conducted in September 2003. Integral (2005) provides results for surface water samples collected in November 2005. Both studies found greater levels of contamination than were found in 1999 for the 2002 Oeser RI.

3.1 Surface Water

For the 2002 Oeser RI, surface water was collected from six locations in the creek, a seep, and a tapped spring. Each station was sampled in July and December 1999. In July 1999, no chemicals in surface water exceeded water quality criteria or benchmarks. In December 1999, the PCP concentration in a single sample marginally exceeded the PCP chronic water quality criterion. Overall, the 1999 data suggested that levels of site-related chemicals in surface water did not pose a threat to aquatic life in the creek; therefore, no remedial action was deemed necessary at that time.

In November 2005, Integral collected surface water from two creek locations. The PCP concentration in both samples (13 and 15 µg/L) exceeded the acute national ambient water quality criterion (NAWQC) for PCP (2.5 µg/L at pH 5.74). PAHs were not detected in the samples and dioxins/furans were not analyzed. Integral also sampled storm-sewer flows in November 2005. A sample collected at the Oeser/Birchwood outfall contained 140 µg/L PCP. This concentration greatly exceeds the acute water quality criterion for PCP. No PCP was detected in a sample of Birchwood neighborhood stormwater collected upstream from the Oeser Company property. These data suggest that PCP is being released to the creek from the Oeser Company property and resulting in concentrations in creek surface water that may be toxic to aquatic life.

3.2 Sediment

For sediment, a weight-of-evidence approach typically is used to determine if an ecological risk is present that may require sediment remediation. The approach begins by comparing sediment chemical concentrations with benchmarks and, if benchmarks are exceeded, continues with sediment bioassays and/or field surveys of the benthic community. Sediment bioassays and benthic surveys provide a site-specific measure of toxicity (or the lack thereof) and thus carry more weight than benchmark comparisons when making decisions about the need for sediment remediation. Hence, this section focuses on the available sediment bioassay data for the creek.

The most current bioassay data that can be used to evaluate ecological impacts from sediment contamination in the Little Squalicum Creek are from Ecology (2004). In September 2003, Ecology conducted toxicity tests with sediment from five creek locations. Three tests (10-day amphipod, 20-day midge, and Microtox) were conducted with sediment from each location. At two of their sampling locations (LCS02 and LSC03, located midway between the Marine Drive Bridge and Bellingham Bay) midge

and/or amphipod survival was depressed by 25% or more compared with laboratory controls. Lesser effects were observed at other locations.

In 1999 for the Oeser Company Site RI, no adverse effects on survival or growth were observed in a 10-day amphipod test conducted with sediment from ten locations in the creek. The difference between the 1999 and 2003 results is most likely due to greater levels of sediment contamination in 2003 compared with 1999. For example, at one location, Ecology found 430 mg/kg total PAHs in sediment, a concentration 50 times greater than anything encountered in 1999. In addition, naphthalene levels in sediment throughout the creek in 2003 were much greater than in 1999. Because naphthalene is the least persistent PAH, the 2003 data suggest that there are ongoing sources of naphthalene and other PAHs to the creek. Because the creek is used as an extension of the storm sewer system, it seems likely that new contamination from various potential sources, including Oeser (see Section 3.1), may enter the creek from time to time.

4. Summary and Conclusions

Using the LSP RI/FS database, risks to terrestrial and aquatic ecological receptors in LSP were reassessed. Key results are described below.

- **Plants and Soil Invertebrates --** Risks to plants and soil invertebrates are primarily driven by total PAHs in soil in the historic and upper creek areas. Total PAH levels in soil exceed the screening benchmarks for plants and soil invertebrates by an order-of-magnitude or more at locations TP-6, TP-16, TP-17, SB-11, SB-12, and SP02.

- **Wildlife --** Insectivorous mammals (e.g., shrew) using the LSC ravine may be impacted by total PAHs in soil in the historic and upper creek areas and by dioxins/furans in soil in the historic, upper, and lower creek areas; the LOAEL-based hazard quotients for the masked shrew were 15.8 for total PAHs and 14.4 for dioxins/furans. The original Oeser Site ERA concluded that a population-level risk to insectivorous mammals from chemicals in soil was unlikely for various reasons. This conclusion appears unsupportable now that additional contamination hotspots have been identified and the LOAEL-based hazard quotients for the shrew exceed 14 for both total PAHs and dioxins/furans. Lastly, dioxin/furans in soil in the LCS ravine appear to be at a threshold for adverse effects to insectivorous songbirds such as the American Robin; the LOAEL-based hazard quotient for this receptor was found to be 1 for dioxins/furans in this reevaluation.

- **Aquatic Life in Little Squalicum Creek --** The original Oeser Site ERA concluded that contaminant levels in water and sediment in 1999 did not pose a serious threat to aquatic biota in the creek. More recent data from Ecology (2004) and Integral (2005) suggest otherwise. Ecology (2004) observed significant benthic toxicity at several creek sampling locations where sediment PAH levels were high. Integral (2005) presented data suggesting that PCP was

being released to the creek from the Oeser Company Site and resulting in PCP concentrations in creek water that exceed the NAWQC for PCP. In general, it appears that conditions in LSC have worsened since the creek was sampled in 1999 for the Oeser Company Site RI.

Are Ecological Risks in Little Squalicum Park Actionable Under CERCLA?

- **South Slope Soil –** No ecological risks are posed by levels of Oeser-related chemicals in soils on the south slope. Hence, no action is needed in this area.

- **Soil in the Little Squalicum Creek Ravine –** Remediation appears warranted to address soil contamination in the historic and upper creek areas. Surface and subsurface soils in these areas are highly contaminated with PAHs. The contamination is great enough to pose risks to plants, soil invertebrates, and insectivorous mammals. In addition, dioxin/furan levels in surface and subsurface soils in the historic, upper, and lower creek areas are great enough to pose risks to insectivorous mammals, and should be considered for remedial action.

- **Sediment in Little Squalicum Creek --** In E & E's experience, the benthic toxicity documented in some areas of the creek in 2003 by Ecology (2004) could be considered actionable under CERCLA. At other Superfund sites, sediment remediation is being undertaken to protect benthic life. For example, at the Onondaga Lake Superfund Site in Syracuse, New York, sediment-bioassay data were used to develop site-specific sediment benchmarks that subsequently were used to delineate areas of the lake bottom in need of dredging and/or capping (EPA 2005).

- **Surface Water in Little Squalicum Creek –** Surface water data collected in 2005 by Integral suggest that PCP is being released to the creek from Oeser's activities and resulting in concentrations in creek water in excess of NAWQC. Typically, exceedances of NAWQC create a regulatory imperative for action under CERCLA because they are applicable or relevant and appropriate requirements (ARARs).

Is Additional Ecological Risk Assessment Work Warranted?

- **Little Squalicum Creek --** Additional sampling of creek sediment and/or surface water for analysis of chemical parameters and/or toxicity is not recommended. The data collected by Ecology in 2003 illustrate that levels of contamination in LSC can increase to a point that results in mortality of aquatic life, and that chemicals used by the Oeser Company are present.

- **Little Squalicum Creek Ravine –** No additional work is recommended to further evaluate soils contamination in the LSC ravine. E & E's conclusion that actionable levels of soil contamination are present is based on risks to three assessment endpoints—plants, soil invertebrates, and insectivorous wildlife. For

these three assessment endpoints, risk thresholds for total PAHs have been exceeded by a factor of ten or more. Although additional evaluation may provide a more accurate estimate of risk, it seems unlikely that the overall conclusion of this reassessment would be altered by additional data.

Remediation and Risk Reduction

Figures 1 and 2 identify sample locations that drive ecological risks for total PAHs and dioxins/furans, respectively, at the site. The sample locations shown on Figures 1 and 2 correspond with the shaded concentrations presented in Tables 3 and 4, respectively. A similar figure for PCP was not generated because ecological risks from PCP are minimal compared with total PAHs and dioxins/furans.

Figure 1 identifies 10 locations where total PAH levels in soil between 0 and 6 ft bgs are elevated above risk-based benchmarks for plants (20 mg/kg) and/or soil fauna (30 mg/kg). These ten locations also contribute most to wildlife risk from total PAHs. Remediation of soil at the locations and depths shown on Figure 1 would eliminate risks to plants and soil fauna and reduce wildlife risk to an acceptable level (i.e., the LOAEL-based HQ for the shrew would be reduced from 15.8 to 0.24) from total PAHs. Remediation of sediment at locations LSC02 and LSC03 in the LSC channel would address the locations where Ecology (2004) found that survival of benthic invertebrates was reduced by 25% or more compared with controls; Ecology (2004) considers this level of mortality to be a "cleanup screening level" exceedance. Based on data presented in Ecology (2004), PAHs appeared to be the causative agent of toxicity at locations LSC02 and LSC03.

Figure 2 identifies 12 locations where dioxins/furans in soil between 0 and 6 ft bgs contribute significantly to risk to mammalian wildlife, the group most sensitive to dioxins/furans. Remediation of soil at the locations and depths shown on Figure 2 would reduce the risk to mammalian wildlife to an acceptable level (i.e., the LOAEL-based HQ for the shrew would be reduced from 14.4 to 1).

5.0 References

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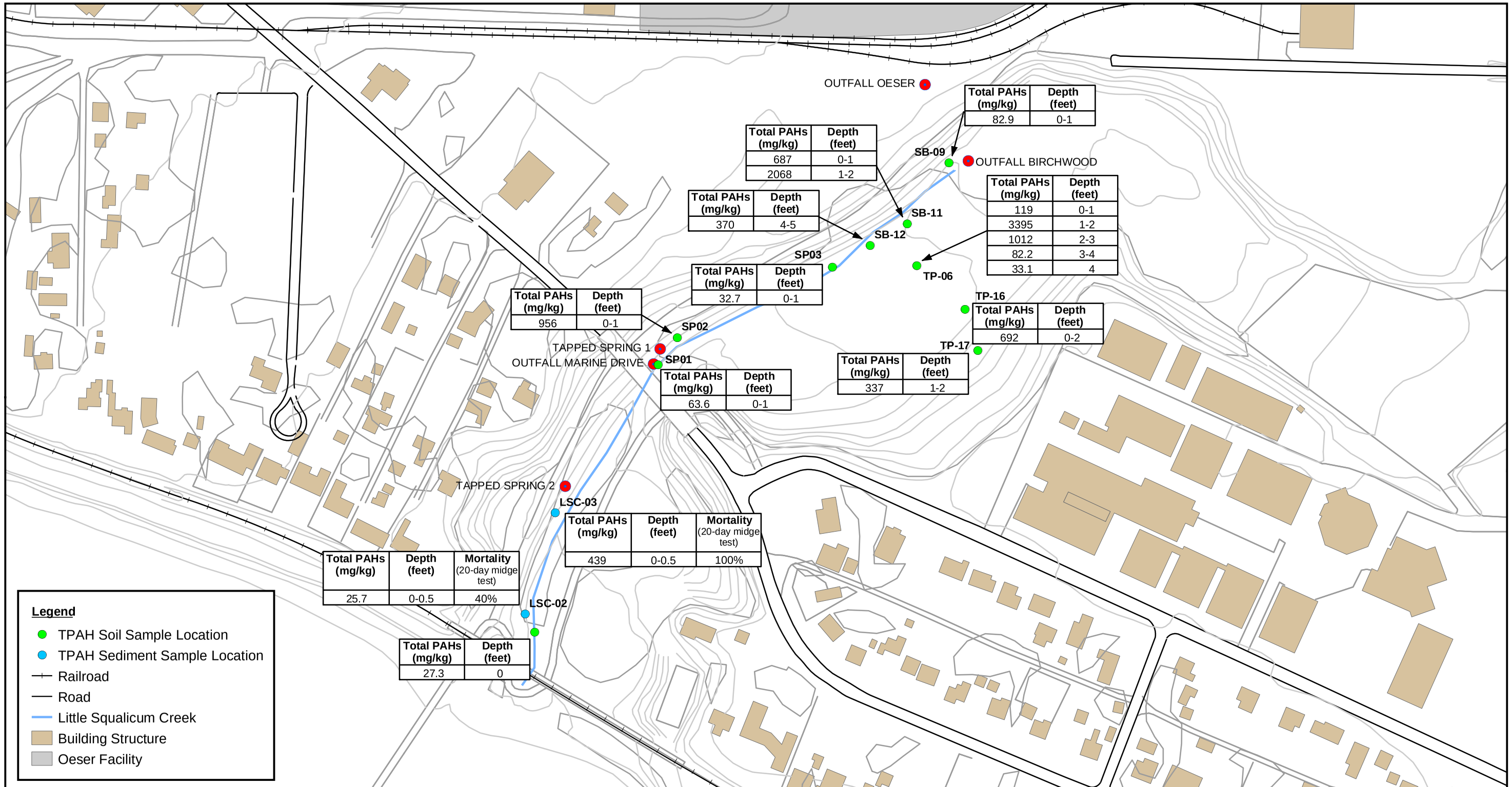
Ecological Risk Actionability Technical Memorandum
Oeser Company Superfund Site

Prepared by Ecology and Environment, Inc. for EPA Region 10

May 2, 2007

FIGURES



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Seattle, Washington

Figure 1

Soil and Sediment Sample Locations Driving Ecological Risks for Total PAHs
Ecological Risk Technical Memorandum, May 2007

Little Squalicum Park, Bellingham, Washington

Key:
LSP = Little Squalicum Park
PAHs = Polycyclic Aromatic Hydrocarbons
RI/FS = Remedial Investigation / Feasibility Study

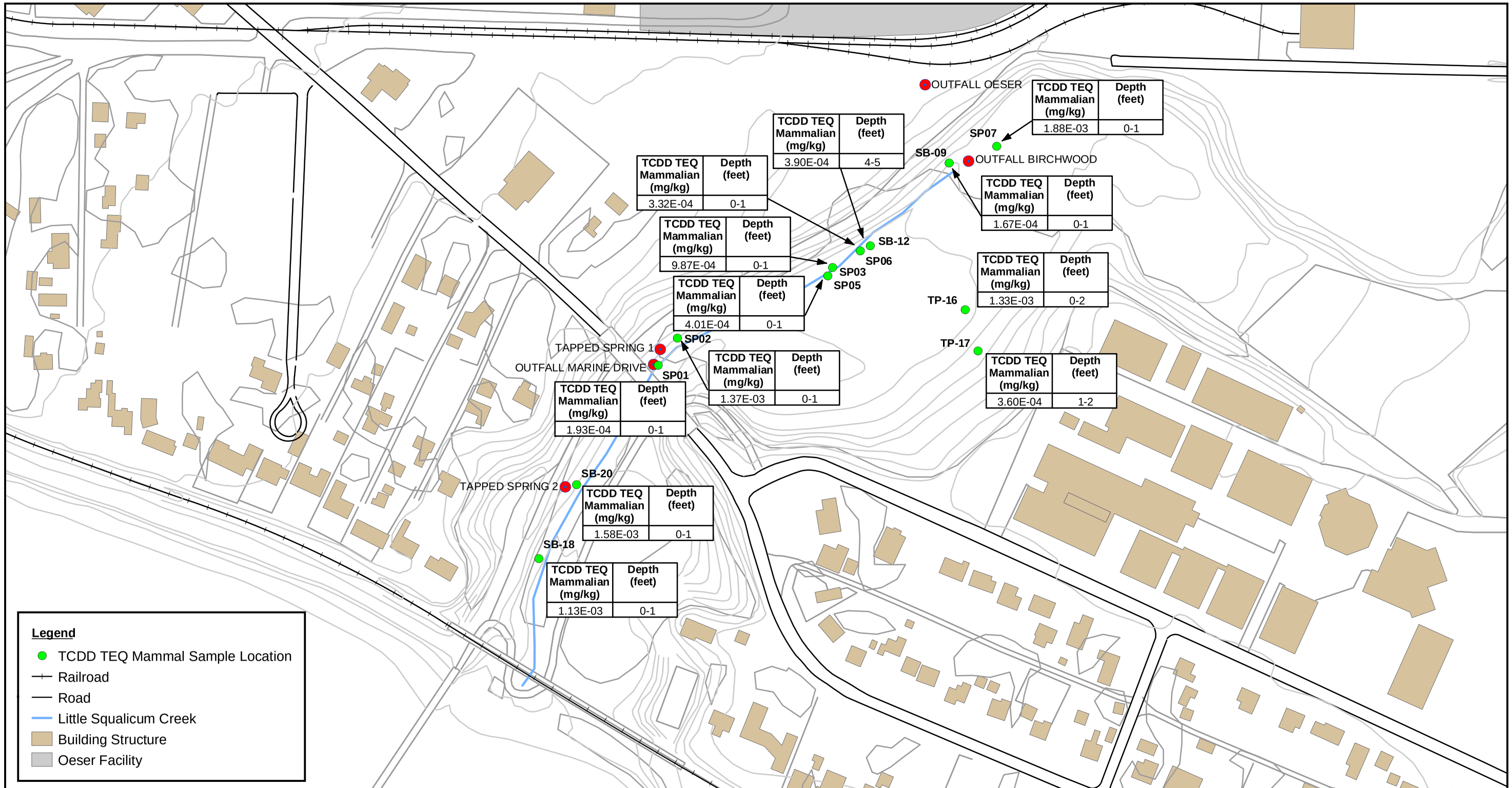
Note: Samples shown exceed plant benchmark (20 mg/kg) and/or earthworm benchmark (30 mg/kg) and drive risks for masked shrew.

Map Source Information:
Integral LSP RI/FS Database

Date:
5/1/2007

GIS Analyst:
avh

Project ID:
001900.CH18.DE.01



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Seattle, Washington

Figure 2

Soil Sample Locations Driving Ecological Risks for Dioxins/Furans
Ecological Risk Technical Memorandum, May 2007

Little Squalicum Park, Bellingham, Washington

Key:
LSP = Little Squalicum Park
RI/FS = Remedial Investigation / Feasibility Study
TCDD = 2,3,7,8 tetrachorodibenzo-p-dioxin
TEQ = toxic equivalent

Note: Samples shown drive risks for masked shrew.
No samples exceed earthworm benchmark (0.5 mg/kg).

Map Source Information:
Integral LSP RI/FS Database

Date:
5/1/2007

GIS Analyst:
avh

Project ID:
001900.CH18.DE.01

Ecological Risk Actionability Technical Memorandum
Oeser Company Superfund Site

Prepared by Ecology and Environment, Inc. for EPA Region 10

May 2, 2007

TABLES

Table 1
Summary of Comparisons of Little Squalicum Park Soils Data[1] with Phytotoxicity and Soil-Fauna Screening Benchmarks
Oeser Company Site Ecological Risk Assessment

Chemical	Phytotoxicity Benchmark (mg/kg)[2]	Earthworm Benchmark (mg/kg)[3]	Soil Microbe Benchmark (mg/kg)[3]	Summary of Comparisons for South Slope	Summary of Comparisons for Little Squalicum Creek Ravine
PCP	3	6	400	No benchmark exceeded.	Phytotoxicity benchmark exceeded at three locations in the historic and lower creek areas (see Table 2 for locations and concentrations). Earthworm benchmark exceeded at one location in the historic creek area (see Table 2). Soil microbe benchmarks not exceeded.
Total PAHs	20	30	-	No benchmark exceeded.	Phytotoxicity and earthworm benchmarks exceeded at 10 and nine locations, respectively, in the historic, upper, and lower creek areas (see Table 3 for locations and concentrations).
TCDD TEQ	-	0.5	-	Benchmark not exceeded.	Benchmark not exceeded.

Key:
- (dash) = not available
bgs = below ground surface
PAHs = polycyclic aromatic hydrocarbons
PCP = pentachlorophenol
TCDD TEQ = 2,3,7,8-tetrachlorodibenzo-p-dioxin toxic equivalent concentration.

Notes:
1. Based on surface and subsurface (up to 6 feet bgs) soil samples from the Little Squalicum Park RI/FS database. See Tables 2 to 5 for data used.
2. Efroymson et al. (1997b). Phytotoxicity benchmark listed for total PAHs is for acenaphthalene, the only PAH for which a benchmark is available in Efroymson et al. (1997b).
3. Efroymon et al. (1997a) for PCP and total PAHs. USEPA (1999) for TCDD TEQ. Earthworm benchmark listed for total PAHs is for fluorene, the only PAH for which a benchmark is available in Efroymson et al. (1997a).

Table 2. PCP Analytical Data for Surface and Subsurface (up to 6 feet bgs) Soil Samples from Little Squalicum Park.

Site Area	Location	Sample ID	Sample Date	Upper Depth	Lower Depth	Depth Unit	Analyte	ERA Value (mg/kg)	Database Value (mg/kg)	Qualifier
Upper creek	TT01-BW	99070649	08/05/99	2.5	2.5		PCP	0.0048	0.0095	U
Upper creek	TT01-SW	99070648	08/05/99	4.0	4.0		PCP	0.005	0.01	U
South Slope	B-BB5	99070593	08/06/99	4.0	6.0	ft	PCP	0.0055	0.011	U
South Slope	B-BB5	99070536	08/03/99	0.0	0.17	ft	PCP	0.0055	0.011	U
Upper creek	MWLSC04	99070538	08/02/99	4.0	6.0		PCP	0.0055	0.011	UJ
Upper creek	SP04	99070653	08/06/99	0.0	0.0		PCP	0.0055	0.011	U
Upper creek	MWLSC03	99070513	08/05/99	0.0	0.5		PCP	0.0056	0.0056	J
South Slope	B-BB3	99070535	08/03/99	0.0	0.17	ft	PCP	0.006	0.012	U
South Slope	B-BB3	99070596	08/06/99	2.0	4.0	ft	PCP	0.0065	0.013	U
South Slope	B-AA4	99070533	08/03/99	0.0	0.17	ft	PCP	0.0085	0.0085	J
South Slope	B-AA6	99070534	08/03/99	0.0	0.17	ft	PCP	0.011	0.011	J
South Slope	B-AA2	99070532	08/03/99	0.0	0.17	ft	PCP	0.015	0.015	J
Upper creek	MWLSC02	99070512	08/05/99	0.0	0.17	ft	PCP	0.015	0.015	
Historical creek	TP-06	LSP0047	11/08/05	3.0	4.0	ft	PCP	0.0225	0.045	UJ
Historical creek	TP-06	LSP0048	11/08/05	4.0	4.0	ft	PCP	0.023	0.046	UJ
Landfill	TP-23	LSP0110	01/31/06	3.5	4.0	ft	PCP	0.023	0.046	UJ
Upper creek	SB-14	LSP0220	02/08/06	5.0	6.0	ft	PCP	0.0235	0.047	UJ
Upper creek	MWLSC01	99070511	08/05/99	0.0	0.17	ft	PCP	0.026	0.026	
Upper creek	SB-14	LSP0219	02/08/06	4.0	5.0	ft	PCP	0.05	0.1	UJ
Historical creek	TP-21	LSP0102	11/17/05	0.0	2.0	ft	PCP	0.07	0.14	UJ
Upper creek	SP02	99070651	08/06/99	0.0	0.0		PCP	0.075	0.15	UJ
Historical creek	TP-06	LSP0046	11/08/05	2.0	3.0	ft	PCP	0.18	0.18	J
Upper creek	SB-11	LSP0274	02/11/06	0.0	1.0	ft	PCP	0.24	0.24	J
South Slope	RES-43	99224021	05/25/99	0.0	0.17	ft	PCP	0.3305	0.661	U
General Site	RES-49	99224035	05/26/99	0.0	0.17	ft	PCP	0.339	0.678	U
Landfill	TP-23	LSP0108	01/31/06	0.0	2.0	ft	PCP	0.35	0.35	J
General Site	RES-47A	99224036	05/26/99	0.0	0.17	ft	PCP	0.3565	0.713	U
Upper creek	SB-09	LSP0213	02/08/06	0.0	1.0	ft	PCP	0.375	0.375	
Upper creek	SB-29	LSP0464	04/06/06	5.0	5.5	ft	PCP	0.38	0.38	
General Site	RES-48	99224034	05/26/99	0.0	0.17	ft	PCP	0.3905	0.781	U
Lower creek	SB-20	LSP0271	02/10/06	0.0	1.0	ft	PCP	0.4	0.4	
Upper creek	MWLSC04	99070514	08/05/99	0.0	0.5		PCP	0.41	0.41	
Lower creek	SB-18	LSP0250	02/10/06	0.0	1.0	ft	PCP	0.41	0.41	J
South Slope	RES-46	99224022	05/25/99	0.0	0.17	ft	PCP	0.4765	0.953	U
Upper creek	SB-11	LSP0275	02/11/06	1.0	2.0	ft	PCP	0.5	1	UJ
Historical creek	TP-17	LSP0090	11/16/05	1.0	2.0	ft	PCP	0.54	0.54	J
Upper creek	LSC-S2	03394048	09/25/03	0.0	0.0		PCP	0.673	0.673	J
Upper creek	SP01	99070650	08/06/99	0.0	0.0		PCP	1.1	1.1	
Historical creek	TP-06	LSP0044	11/08/05	0.0	1.0	ft	PCP	1.1	1.1	J
Upper creek	SB-12	LSP0201	02/07/06	4.0	5.0	ft	PCP	1.2	1.2	
Upper creek	SP05	99070654	08/06/99	0.0	0.0		PCP	1.2	1.2	
Upper creek	SP06	99070655	08/06/99	0.0	0.0		PCP	1.4	1.4	J
Upper creek	SP03	99070652	08/06/99	0.0	0.0		PCP	1.8	1.8	
General Site	SP07	99070656	08/06/99	0.0	0.0		PCP	2.2	2.2	J
Historical creek	TP-06	LSP0045	11/08/05	1.0	2.0	ft	PCP	3.5	3.5	
Lower creek	LSC-S1	03394047	09/25/03	0.0	0.0		PCP	5.96	5.96	J
Historical creek	TP-16	LSP0088	11/16/05	0.0	2.0	ft	PCP	7.1	7.1	
							Mean ->	0.71		
							Min ->	0.005		
							Max ->	7.10		
							Count ->	47		

Source: Integral project database for draft Little Squalicum Park RI/FS.

Key:

bgs = below ground surface

PCP = pentachlorophenol

shading = concentration exceeds phytotoxicity benchmark (3 mg/kg) and/or earthworm benchmark (6 mg/kg).

Table 3. Total PAH Analytical Data for Surface and Subsurface (up to 6 feet bgs) Soil Samples from Little Squalicum Park.

Site Area	Location	Sample ID	Sample Date	Upper Depth	Lower Depth	Depth Units	Analyte	Value (mg/kg)	Qualifier
Upper creek	TT01-BW	99070649	08/05/99	2.5	2.5		TPAHs (ND = 1/2 DL)	0.019	U
Upper creek	MWLSC04	99070538	08/02/99	4	6		TPAHs (ND = 1/2 DL)	0.021	U
South Slope	B-BB5	99070593	08/06/99	4	6.00	ft	TPAHs (ND = 1/2 DL)	0.022	U
Upper creek	SP04	99070653	08/06/99	0	0		TPAHs (ND = 1/2 DL)	0.022	UJ
South Slope	B-BB3	99070596	08/06/99	2	4.00	ft	TPAHs (ND = 1/2 DL)	0.025	U
South Slope	B-AA6	99070534	08/03/99	0	0.17	ft	TPAHs (ND = 1/2 DL)	0.056	J
South Slope	B-BB5	99070536	08/03/99	0	0.17	ft	TPAHs (ND = 1/2 DL)	0.059	
Upper creek	MWLSC03	99070513	08/05/99	0	0.5		TPAHs (ND = 1/2 DL)	0.082	J
South Slope	B-AA4	99070533	08/03/99	0	0.17	ft	TPAHs (ND = 1/2 DL)	0.084	J
South Slope	B-BB3	99070535	08/03/99	0	0.17	ft	TPAHs (ND = 1/2 DL)	0.089	
South Slope	B-AA2	99070532	08/03/99	0	0.17	ft	TPAHs (ND = 1/2 DL)	0.112	J
Upper creek	TT01-SW	99070648	08/05/99	4	4		TPAHs (ND = 1/2 DL)	0.151	J
General Site	RES-48	99224034	05/26/99	0	0.17	ft	TPAHs (ND = 1/2 DL)	0.312	U
Landfill	TP-23	LSP0110	01/31/06	3.5	4	ft	TPAHs (ND = 1/2 DL)	0.366	J
Upper creek	MWLSC02	99070512	08/05/99	0	0.17	ft	TPAHs (ND = 1/2 DL)	0.437	J
Upper creek	SB-14	LSP0219	02/08/06	4	5	ft	TPAHs (ND = 1/2 DL)	0.770	J
Landfill	TP-23	LSP0108	01/31/06	0	2	ft	TPAHs (ND = 1/2 DL)	0.983	J
Upper creek	MWLSC04	99070514	08/05/99	0	0.5		TPAHs (ND = 1/2 DL)	1.145	J
Upper creek	MWLSC01	99070511	08/05/99	0	0.17	ft	TPAHs (ND = 1/2 DL)	1.183	J
General Site	RES-49	99224035	05/26/99	0	0.17	ft	TPAHs (ND = 1/2 DL)	1.570	J
South Slope	RES-43	99224021	05/25/99	0	0.17	ft	TPAHs (ND = 1/2 DL)	1.638	J
General Site	RES-47A	99224036	05/26/99	0	0.17	ft	TPAHs (ND = 1/2 DL)	1.716	J
South Slope	RES-46	99224022	05/25/99	0	0.17	ft	TPAHs (ND = 1/2 DL)	1.877	J
Upper creek	SB-14	LSP0220	02/08/06	5	6	ft	TPAHs (ND = 1/2 DL)	3.835	
Lower creek	SB-18	LSP0250	02/10/06	0	1	ft	TPAHs (ND = 1/2 DL)	4.498	J
Lower creek	SB-20	LSP0271	02/10/06	0	1	ft	TPAHs (ND = 1/2 DL)	6.660	J
Upper creek	SP06	99070655	08/06/99	0	0		TPAHs (ND = 1/2 DL)	8.017	J
Upper creek	SP05	99070654	08/06/99	0	0		TPAHs (ND = 1/2 DL)	8.585	J
Upper creek	LSC-S2	03394048	09/25/03	0	0		TPAHs (ND = 1/2 DL)	10.80	J
Upper creek	SB-29	LSP0464	04/06/06	5	5.5	ft	TPAHs (ND = 1/2 DL)	12.72	J
Historical creek	TP-21	LSP0102	11/17/05	0	2	ft	TPAHs (ND = 1/2 DL)	18.78	
General Site	SP07	99070656	08/06/99	0	0		TPAHs (ND = 1/2 DL)	18.97	J
Lower creek	LSC-S1	03394047	09/25/03	0	0		TPAHs (ND = 1/2 DL)	27.25	J
Upper creek	SP03	99070652	08/06/99	0	0		TPAHs (ND = 1/2 DL)	32.70	J
Historical creek	TP-06	LSP0048	11/08/05	4	4	ft	TPAHs (ND = 1/2 DL)	33.07	J
Upper creek	SP01	99070650	08/06/99	0	0		TPAHs (ND = 1/2 DL)	63.60	J
Historical creek	TP-06	LSP0047	11/08/05	3	4	ft	TPAHs (ND = 1/2 DL)	82.18	J
Upper creek	SB-09	LSP0213	02/08/06	0	1	ft	TPAHs (ND = 1/2 DL)	82.86	J
Historical creek	TP-06	LSP0044	11/08/05	0	1	ft	TPAHs (ND = 1/2 DL)	119.0	J
Historical creek	TP-17	LSP0090	11/16/05	1	2	ft	TPAHs (ND = 1/2 DL)	337.0	
Upper creek	SB-12	LSP0201	02/07/06	4	5	ft	TPAHs (ND = 1/2 DL)	370.3	
Upper creek	SB-11	LSP0274	02/11/06	0	1	ft	TPAHs (ND = 1/2 DL)	687.0	J
Historical creek	TP-16	LSP0088	11/16/05	0	2	ft	TPAHs (ND = 1/2 DL)	692.3	J
Upper creek	SP02	99070651	08/06/99	0	0		TPAHs (ND = 1/2 DL)	956.4	J
Historical creek	TP-06	LSP0046	11/08/05	2	3	ft	TPAHs (ND = 1/2 DL)	1012.2	
Upper creek	SB-11	LSP0275	02/11/06	1	2	ft	TPAHs (ND = 1/2 DL)	2067.6	J
Historical creek	TP-06	LSP0045	11/08/05	1	2	ft	TPAHs (ND = 1/2 DL)	3394.7	
							Mean ->	214.1	
							Min ->	0.019	
							Max ->	3394.7	
							Count ->	47	

Source: Integral project database for draft Little Squalicum Park RI/FS.

Key:

bgs = below ground surface

PAHs = polycyclic aromatic hydrocarbons

shading = concentration exceeds phytotoxicity benchmark (20 mg/kg) and/or earthworm benchmark (30 mg/kg).

Table 4. Mammalian 2,3,7,8 TCDD Toxic Equivalent (TEQ) Concentrations in Surface and Subsurface (up to 6 feet bgs) Soil from LSP.

Site_Area	Location	Sample ID	Sampling Date	Upper Depth	Lower Depth	Depth Unit	Analyte Group	Mammalian TEQ Value (mg/kg)	Qualifier
Upper creek	TT01-BW	99070649	08/05/99	2.5	2.5		Dioxins_Furans	8.499E-07	
Upper creek	SP04	99070653	08/06/99	0	0		Dioxins_Furans	1.486E-06	
General Site	RES-47A	99224036	05/26/99	0	0.16667	ft	Dioxins_Furans	2.551E-06	
South Slope	B-BB5	99070536	08/03/99	0	0.16667	ft	Dioxins_Furans	4.695E-06	
South Slope	RES-46	99224022	05/25/99	0	0.16667	ft	Dioxins_Furans	5.130E-06	J
General Site	RES-49	99224035	05/26/99	0	0.16667	ft	Dioxins_Furans	5.802E-06	
General Site	RES-48	99224034	05/26/99	0	0.16667	ft	Dioxins_Furans	6.596E-06	
South Slope	B-BB3	99070535	08/03/99	0	0.16667	ft	Dioxins_Furans	6.862E-06	
South Slope	B-AA4	99070533	08/03/99	0	0.16667	ft	Dioxins_Furans	7.246E-06	
South Slope	B-AA6	99070534	08/03/99	0	0.16667	ft	Dioxins_Furans	9.441E-06	
South Slope	B-AA2	99070532	08/03/99	0	0.16667	ft	Dioxins_Furans	1.076E-05	
Upper creek	MWLSC03	99070513	08/05/99	0	0.5		Dioxins_Furans	1.400E-05	
South Slope	B-BB5	99070593	08/06/99	4	6	ft	Dioxins_Furans	1.450E-05	U
Upper creek	MWLSC02	99070512	08/05/99	0	0.16667	ft	Dioxins_Furans	2.356E-05	
Upper creek	MWLSC01	99070511	08/05/99	0	0.16667	ft	Dioxins_Furans	2.944E-05	
South Slope	RES-43	99224021	05/25/99	0	0.16667	ft	Dioxins_Furans	7.814E-05	
Upper creek	MWLSC04	99070514	08/05/99	0	0.5		Dioxins_Furans	1.271E-04	
Upper creek	SB-09	LSP0213	02/08/06	0	1	ft	Dioxins_Furans	1.677E-04	J
Upper creek	SP01	99070650	08/06/99	0	0		Dioxins_Furans	1.927E-04	
Upper creek	SP06	99070655	08/06/99	0	0		Dioxins_Furans	3.320E-04	J
Historical creek	TP-17	LSP0090	11/16/05	1	2	ft	Dioxins_Furans	3.589E-04	J
Upper creek	SB-12	LSP0201	02/07/06	4	5	ft	Dioxins_Furans	3.897E-04	J
Upper creek	SP05	99070654	08/06/99	0	0		Dioxins_Furans	4.012E-04	
Upper creek	SP03	99070652	08/06/99	0	0		Dioxins_Furans	9.867E-04	
Lower creek	SB-18	LSP0250	02/10/06	0	1	ft	Dioxins_Furans	1.133E-03	J
Historical creek	TP-16	LSP0088	11/16/05	0	2	ft	Dioxins_Furans	1.333E-03	J
Upper creek	SP02	99070651	08/06/99	0	0		Dioxins_Furans	1.372E-03	
Lower creek	SB-20	LSP0271	02/10/06	0	1	ft	Dioxins_Furans	1.581E-03	J
General Site	SP07	99070656	08/06/99	0	0		Dioxins_Furans	1.877E-03	
							Mean -->	3.61E-04	
							Min -->	8.49876E-07	
							Max -->	1.88E-03	
							Count -->	29	

Source: Integral database for draft Little Squalicum Park RI/FS.

Key:

LSP = Little Squalicum Park
Shading = contributes significantly to mammlian wildlife risk
TEQ = 2,3,7,8 TCDD toxic equivalent
TCDD = tetrachlorodibenzo-p-dioxin

Table 5. Avian 2,3,7,8 TCDD Toxic Equivalent (TEQ) Concentrations in Surface and Subsurface (up to 6 feet bgs) Soil from LSP.

Site_Area	Location	Sample ID	Sampling Date	Upper Depth	Lower Depth	Depth Unit	Analyte Group	Avain TEQ Value (mg/kg)	Qualifier
Upper creek	TT01-BW	99070649	08/05/99	2.5	2.5		Dioxins_Furans	1.077E-06	
Upper creek	SP04	99070653	08/06/99	0	0		Dioxins_Furans	1.105E-06	
South Slope	RES-46	99224022	05/25/99	0	0.16667	ft	Dioxins_Furans	2.679E-06	J
South Slope	B-BB3	99070535	08/03/99	0	0.16667	ft	Dioxins_Furans	3.907E-06	
General Site	RES-47A	99224036	05/26/99	0	0.16667	ft	Dioxins_Furans	4.322E-06	
South Slope	B-BB5	99070536	08/03/99	0	0.16667	ft	Dioxins_Furans	4.880E-06	
South Slope	B-AA2	99070532	08/03/99	0	0.16667	ft	Dioxins_Furans	4.882E-06	
South Slope	B-AA4	99070533	08/03/99	0	0.16667	ft	Dioxins_Furans	5.888E-06	
South Slope	B-AA6	99070534	08/03/99	0	0.16667	ft	Dioxins_Furans	6.692E-06	
General Site	RES-49	99224035	05/26/99	0	0.16667	ft	Dioxins_Furans	8.324E-06	
General Site	RES-48	99224034	05/26/99	0	0.16667	ft	Dioxins_Furans	1.025E-05	
Upper creek	MWLSC03	99070513	08/05/99	0	0.5		Dioxins_Furans	1.126E-05	
South Slope	B-BB5	99070593	08/06/99	4	6	ft	Dioxins_Furans	1.450E-05	U
Upper creek	MWLSC02	99070512	08/05/99	0	0.16667	ft	Dioxins_Furans	1.599E-05	
Upper creek	MWLSC01	99070511	08/05/99	0	0.16667	ft	Dioxins_Furans	1.990E-05	
Upper creek	SP01	99070650	08/06/99	0	0		Dioxins_Furans	4.525E-05	
Upper creek	MWLSC04	99070514	08/05/99	0	0.5		Dioxins_Furans	5.662E-05	
Upper creek	SB-09	LSP0213	02/08/06	0	1	ft	Dioxins_Furans	6.048E-05	J
South Slope	RES-43	99224021	05/25/99	0	0.16667	ft	Dioxins_Furans	6.522E-05	
Upper creek	SB-12	LSP0201	02/07/06	4	5	ft	Dioxins_Furans	1.237E-04	J
Historical creek	TP-17	LSP0090	11/16/05	1	2	ft	Dioxins_Furans	1.420E-04	J
Upper creek	SP06	99070655	08/06/99	0	0		Dioxins_Furans	1.485E-04	J
Upper creek	SP05	99070654	08/06/99	0	0		Dioxins_Furans	1.892E-04	
Upper creek	SP03	99070652	08/06/99	0	0		Dioxins_Furans	3.069E-04	
Historical creek	TP-16	LSP0088	11/16/05	0	2	ft	Dioxins_Furans	3.898E-04	J
Upper creek	SP02	99070651	08/06/99	0	0		Dioxins_Furans	5.012E-04	
Lower creek	SB-18	LSP0250	02/10/06	0	1	ft	Dioxins_Furans	5.444E-04	J
General Site	SP07	99070656	08/06/99	0	0		Dioxins_Furans	7.745E-04	
Lower creek	SB-20	LSP0271	02/10/06	0	1	ft	Dioxins_Furans	8.058E-04	J
							Mean -->	1.47E-04	
							Min -->	1.07654E-06	
							Max -->	8.06E-04	
							Count -->	29	

Source: Integral database for draft Little Squalicum Park RI/FS.

Key:

LSP = Little Squalicum Park
TEQ = 2,3,7,8 TCDD toxic equivalent
TCDD = tetrachlorodibenzo-p-dioxin

Table 6
Comparison of Original and Updated Exposure Point Concentrations, Exposure Estimates, and Hazard Quotients for the American Robin and Masked Shrew
Oeser Company Site Ecological Risk Assessment

Parameter	Units	American Robin		Masked Shrew	
		Original[1]	Updated[2]	Original[1]	Updated[2]
Pentachlorophenol					
Soil EPC	mg/kg	0.392	0.71	0.392	0.71
Soil-to-worm BAF	unitless	0.98	0.98	0.98	0.98
Earthworm EPC	mg/kg	0.384	0.70	0.384	0.70
EE-diet	mg/kg-day	0.348	0.634	0.410	0.747
EE-soil	mg/kg-day	0.036	0.067	0.054	0.099
EE-total	mg/kg-day	0.384	0.701	0.463	0.846
LOAEL	mg/kg-day	na	na	3.86	3.86
HQ-LOAEL	unitless	na	na	0.12	0.22
Total PAHs					
Soil EPC	mg/kg	46.08	214.1	46.08	214.1
Soil-to-worm BAF	unitless	0.98	0.98	0.98	0.98
Earthworm EPC	mg/kg	45.16	209.8	45.16	209.8
EE-diet	mg/kg-day	40.91	190.1	48.17	223.8
EE-soil	mg/kg-day	4.27	20.2	6.32	30.0
EE-total	mg/kg-day	45.18	210.3	54.49	253.8
LOAEL	mg/kg-day	400	400	16.1	16.1
HQ-LOAEL	unitless	0.11	0.53	**3.4**	**15.8**
Dioxins/Furans					
Soil EPC	ng/kg	65.53	147	145.5	361
Soil-to-worm BAF	unitless	0.98	0.98	0.98	0.98
Earthworm EPC	ng/kg	64.23	144.1	142.6	354
EE-diet	ng/kg-day	58.2	127.8	152.1	377.4
EE-soil	ng/kg-day	6.07	13.9	19.96	50.5
EE-total	ng/kg-day	64.3	141.7	172.1	427.9
LOAEL	ng/kg-day	140	140	29.7	29.7
HQ-LOAEL	unitless	0.46	**1.0**	**5.8**	**14.4**

Key:
BAF = Bioaccumulation Factor
EPC = Exposure point concentration
EE-soil = Estimated exposure from incidental soil ingestion
EE-diet = Estimated exposure from diet (100% earthworms assumed)
EE-total = Estimated total exposure (EE-diet + EE-soil)
HQ-LOAEL = Hazard quotient based on LOAEL

LOAEL = Lowest observed adverse effect level
PAHs = Polycyclic aromatic hydrocarbons
Shading = HQ exceeds 1.0

Footnotes:

1. From the ecological risk assessment (Appendix N) for the Oeser Company Site Remedial Investigation (dated April 2002). In the original assessment, 24 surface soil samples from the Little Squalicum Creek ravine and south slope were used to assess risks to terrestrial wildlife.

2. Based on surface and subsurface (up to 6 feet below ground surface) soil samples from the Little Squalicum Park RI/FS database assembled by Integral Consulting, Inc. See Tables 2 through 5 for data used.