Investigation of Discharges from Water Treatment Plant Filter Backwash

By

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For the

Water Quality Program

Washington State Department of Ecology
Olympia, Washington

February 2024, Publication 24-10-010

Publication Information

This document is available on the Department of Ecology's website at:
https://apps.ecology.wa.gov/publications/SummaryPages/2410010.html

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Department of Ecology's Regional Offices

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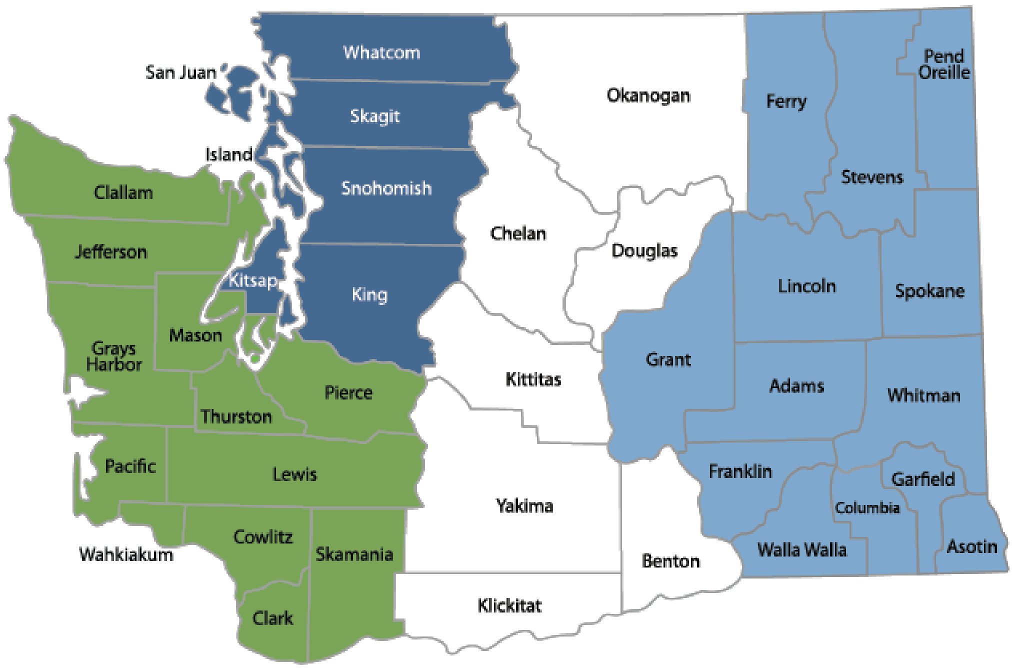

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Eastern Region 509-329-3400

Region	Counties served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	PO Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	PO BOX 330316 Shoreline, WA 98133-9716	206-594-0000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 W Alder St Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 N Monroe Spokane, WA 99205	509-329-3400
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Shoreline, WA

August 2020 | Publication 20-10-037

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Acknowledgements

The author of this report thanks the following people for volunteering to allow sampling of their treatment system to support this study: their contribution to this study:

- Bill Boxx of Boxx Berry Farms in Ferndale, Washington.
- John Calhoon of Woodinville, Washington.
- Del Nestegard of the City of Everett water treatment plant in Monroe, Washington.
- Malcom Bishop, Public Works Director of the City of Coupeville, Washington.
- Andy Campbell, System Operator of the Harbor Hills Water System; the Mutiny View Manor
- Community Club water system; and the Ridgeview Estates water system, all on Whidbey Island, Washington.
- Jan Martin, Commissioner, and Bill Bradkin of the Ledgewood Beach Water District near Coupeville, Washington.
- Omero Vargas, System Operator of the Lost Lake water system on Camano Island, Washington.
- Mike Nettles, Water System Commissioner with the Mariners Cove Beach Club water system near Oak Harbor, Washington.
- Richard Bradley, President of the Mission Ranch Estates water system near Bellingham, Washington.
- Corey Thompson of the Mountain Road Estates water system near Bellingham, Washington.
- Towns of Outlook and Naches, Washington.
- Doug Dolstad of the Westside Water System on Vashon Island, Washington.

The author of this report thanks the following people for their contributions to this study:

- Nancy Darling of the Washington Department of Health, Office of Drinking Water.

Washington State Department of Ecology staff:

- Rod Thompson, for starting this study by obtaining funding, contracting for work and oversight of field collection, and analytical data upload to EIMS.
- Barb Carey, Lyn Doremus, Melissa Gildersleeve, James Maroncelli, Laurie Morgan, Don Nichols, Mary Shaleen-Hansen, John Stormon, and Diana Washington, for their careful review and comments on the draft report.
- Jerry Shervey, for his exceptional supervisory skills displayed over the course of this project.

Abstract

Water treatment units can range from those installed at individual residences up to multi-million dollar facilities that treat the water supply for an entire city. One thing that water treatment plants (WTPs) have in common is the need to clean out the waste materials collected by the treatment system filters. The clean-out method most often used is called “backwashing.” In this process, clean water is run backwards through the treatment filter to flush the accumulated material out of the filter. This backwash water and the accumulated material are then discharged as a waste stream.

The purpose of this project is to assess a selection of water treatment types that dispose of their treated filter backwash water onto the ground. This project entailed collection and analyses of samples of treated backwash water and soils from 16 different water systems around the state.

Ecology expected that the concentrations of contaminants originally in raw source waters would be:

- Greater in the filter backwash water than in the source water.
- Greater in the disposal site (DS) soil than in the background (BK) soil.

The data did show that detected concentrations of arsenic, iron, manganese, chloride, and nitrate-nitrogen in the filter backwash water is greater than in the source water and in some instances concentrations exceeded groundwater quality criteria.

Since the characteristics of soil vary considerably at differing locations some form of normalization of the analyzed parameters is needed. The first step is to determine whether the BK soils are representative of the DS soils. The cation exchange capacity (CEC) is used for this comparison.

Once it was determined that the BK and DS soils are comparable, the reported concentrations of the other constituents are normalized to the CEC of that sample. Comparison of the ratio of the CEC-normalized concentrations between the BK and DS samples for each parameter is done next. If the ratio of the CEC-normalized concentration for the DS sample is dissimilar (less than 0.5 or greater than 2.0) from the CEC-normalized concentration for the BK sample, the soil in the DS may have been impacted by the disposal of backwash water.

The data did suggest that wastewater discharges from WTPs generally tend to increase the CEC-normalized specific conductance and concentrations of arsenic, chloride, and the hydroxyl ion (pH) in disposal site soils. However, for uncertain reasons, normalized contaminant concentrations in disposal site soils were relatively less than those in background soils at the two of the WTPs. Therefore, given the absence of significant concordance between wastewater concentrations and normalized disposal site impacts for any of the pollutants, no broad associations can be drawn.

Introduction

Background

Water treatment units can range from those installed at individual residences, through small businesses, up to multi-million dollar facilities that treat the water supply for an entire city.

Regardless of size, one thing that these water treatment plants (WTPs) have in common is the need to periodically clean out the waste materials collected by the treatment system.

The clean-out method most often used is “backwashing.” In this process, clean water is run backwards through the treatment filter to flush the accumulated material out of the filter media. This backwash water and the accumulated material are then discharged as a waste stream. The Washington State Department of Ecology (Ecology) has several wastewater discharge general permits that identify numeric limits for the harmful components of various wastewaters (including backwash fluids) that may be discharged to waters of the State. While discharges to surface waters are covered under the WTP general permit, Ecology has not yet conducted a substantive evaluation of the risk to groundwater when this waste stream is discharged to the ground surface and allowed to infiltrate.

Purpose

The limited data available on the chemistry of treated filter backwash illustrates the concentrations of some constituents that treatment plants remove from the raw source water and suggests that these concentrated constituents could pose a substantial threat to groundwater quality. Although the soil column acts as a filter and binds many of these constituents, over a period of time the capacity of the soil to bind these contaminants may decrease.

The purpose of this project is to assess a selection of WTPs that dispose of their treated filter backwash wastewater by infiltration into the ground. This project entailed collection and analyses of samples of treated backwash wastewater and soils for: (1) The level of contaminants in the filter backwash, and (2) Whether those contaminants were present at concentrations greater than background in the soils where the discharges occurred. The results of this study may support future updates of the wastewater discharge general permit that covers water treatment facilities.

Objectives

As with any project, a firm set of objectives must be established before setting off to collect data. Without a clear understanding of what the critical questions are, the collection of any data is unguided. This study is designed to address two issues:

- What is the potential that discharges of treated filter backwash wastewater to the ground may adversely impact groundwater quality?

- What critical characteristics or other screening factors can Ecology use to identify those water treatment methods that might present the greatest threats to groundwater quality via discharges of treated filter backwash wastewater to the ground?

Methods

Selection of WTP Systems

Ecology obtained from the Washington State Department of Health (DOH) its list of the Group A and Group B water systems in the State. Ecology then attempted to contact 147 of those systems to learn about the operational characteristics of their systems and to gauge their interest in participating in this project. Ecology asked the representative(s) of each system the following nine preliminary questions concerning their system.

1. What type of filtering method (or system) do you use?
   (e.g., reverse osmosis (RO), ion exchange (IX), or else please describe)
2. Do you backflush the filtering system?
3. If answer to Question 2 is "Yes":
   Where do you discharge the filtered backwash wastewater?
   (e.g., sanitary sewer, lined or unlined lagoon or pond, bioswale, grass-lined ditch, septic system, storm drain, or other land application area)
4. What are the target contaminants being removed from the source water?
   (e.g., arsenic, iron, manganese, or chloride)
5. How many homes are connected to the water system?
6. What is the average backwash discharge rate or volume?
   (e.g., gallons per day per month for volume; gallons per minute for rate)
7. How long has the water system been in operation?
8. Would the operator be willing to allow Ecology to sample their system?
9. What is the location and address of the water system?

Ecology then selected a group of 16 WTPs for participation in this study, based on their responses to these questions. The identities of the water treatment systems and their responses to the preliminary questions are provided in Appendix A.

Field and Laboratory Work

The project team conducted the following tasks to accomplish the stated purpose and objectives.

<u>Task 1:</u> Prepared a quality assurance project plan (QAPP) for this project.

> The QAPP set out the appropriate level of data quality required to ensure that data collected for this project were sufficient to address the stated purpose and objectives. The QAPP identified the measures of quality for sampling and analyzing soil and water, as described in Tasks 2 and 3, below. Copies of the QAPP are available from Ecology (*Quality Assurance Project Plan for Multi-County Water Treatment Facility Soil and*

Process Water Collection and Testing, Golder Associates, Inc., Redmond, December 30, 2008).

Task 2: Collected one sample of treated backwash effluent from each identified WTP.

Also analyzed the effluent on site for the parameters pH, specific conductance, temperature, and dissolved oxygen.

Task 3: Collected soil samples from two locations at each WTP: A background area (BK); and the disposal site (DS) onto which the facility had discharged its filter backwash. Where an infiltration pond was the route of discharge, the DS sampling location was within the wetted perimeter and as near as possible to the bottom of the pond.

Soil samples were collected to represent a vertical profile of the subsurface by targeting the following depths below the ground surface: 0 to 1 foot (top); 2 to 3 feet (middle); and 4 to 5 feet (bottom). Ecology employed a hand auger or equivalent device to collect the soil samples, and did not composite them. If sampler refusal occurred before reaching the final target depth, sampling ended at the depth of refusal.

Task 4: Submitted all collected backwash effluent and soil samples for chemical analyses to two Ecology-approved and accredited laboratories in November and December, 2008. TestAmerica of Seattle analyzed all of the soil samples and the effluent samples from 15 of the WTPs. Cascade Analytical, Inc. of Wenatchee analyzed the remaining effluent sample from the Outlook WTP.

Wastewater samples were analyzed for total arsenic, total barium, total iron, total manganese, total sodium, chloride, fluoride, nitrate-nitrogen, specific conductance, pH, and temperature. Soil samples were analyzed for cation exchange capacity, total arsenic, total barium, total iron, total manganese, total sodium, chloride, fluoride, nitrate, and specific conductance and pH of a soil-water paste.

Task 5: Evaluated the data (described below), and prepared this report of the project results.

Data Evaluation

Ecology reviewed and summarized the results of the chemical analyses of the backwash effluent to help develop an understanding of several potential pollutants expected in the various wastewaters. Summarization entailed determining the mean, standard deviation, and median of the results for each parameter except pH. For the purpose of obtaining these statistics, “less than” values were replaced with one-half the numeric reporting limit.

Review of the results of the chemical analyses of the soil samples was more involved. Since the characteristics of soil vary considerably at differing locations, the first step was to assess for each WTP whether the background area soils (BK soils) were representative of the disposal site soils (DS soils) prior to any impacts from the ongoing wastewater disposal activities. Given the limited amount of data available about the soils from the WTPs, Ecology used the cation exchange capacity (CEC) to compare the soils. For each depth range (top, middle, and bottom), if the ratio of the DS CEC to the BK CEC was similar (greater than 0.5 and less than 2.0) for a given pair of samples, Ecology concluded that their soil types were similar and they could be used in the subsequent evaluation. For soil sample pairs where the CEC ratio was outside this range, Ecology could not conclude that the BK soil was comparable with the DS soil, and therefore excluded those sample pairs from further evaluation.

Since the concentrations of the analyzed parameters commonly vary considerably even within soil types, Ecology first normalized the reported concentrations of the potential pollutants (except pH) within each sample to the CEC of that sample. In cases where a result was non-detect ("less than"), Ecology substituted one-half the numerical reporting limit into this calculation. In cases where a result was "greater than," Ecology substituted the cited value into this calculation. Ecology then determined whether disposal of backflush wastewater had possibly impacted the disposal sites by comparing the ratio of the CEC-normalized concentrations between the BK and DS samples. For each parameter except pH, if the ratio of the CEC-normalized concentration for the DS sample was dissimilar (less than 0.5 or greater than 2.0) from the CEC-normalized concentration for the BK sample, Ecology concluded that the soil in the DS may have been impacted by the disposal of backflush wastewater. For pH, Ecology concluded dissimilarity between the BK and DS soils if their difference exceeded 1.00 pH standard unit (S.U.).

Results

Preliminary Survey

Of the 147 water treatment systems initially contacted, Ecology identified 35 for further consideration based on their responses. Of those, 4 declined to participate further, 8 did not provide responses complete enough for further consideration, and 23 agreed to participate in the study. Of those 23, Ecology selected 16 for sampling and designated 7 of them as reserve. The 16 WTPs finally selected for sampling represented three different size ranges: Large (more than 100 connections), Medium (15 to 100 connections), and Small (1 to 14 connections). Fourteen of the WTPs were located in western Washington, and two were located in eastern Washington. Table 1 identifies the 16 WTPs that participated in this study.

Filter Backwash

The results from the analyses of the filter backwash effluent samples are summarized in Table 2. Through either sampling or laboratory error, the results for the total metals (arsenic, barium, iron, manganese, and sodium) in the effluent from the Everett Water Filtration plant were lost. Also, the reporting limit for arsenic cited by the two analytical laboratories differed substantially. While Cascade Analytical employed a reporting limit of 6.9 µg/L or less, TestAmerica provided a reporting limit of 60 µg/L.

The concentrations of each pollutant in the filter backwash wastewaters varied widely. The generally large differences between each median and mean and the large standard deviations were consistent with a large variability. Of the 16 water treatment systems, the discharges from the Bayview Beach, Mutiny View Manor Community Club, and Outlook WTPs yielded the smallest pH value: 7.7 S.U. The discharge from the Westside Water System WTP yielded the greatest arsenic and pH values: 190 µg/L and 8.44 S.U., respectively. The discharge from the

Boxx Berry Farm WTP showed the greatest nitrate-nitrogen concentration: 11 mg/L. The discharge from the Lost Lake WTP contained the greatest barium and iron concentrations: 460 and 75,000 µg/L, respectively. The discharge from the Ledgewood Beach Water District yielded the greatest manganese concentration: 12,000 µg/L. The discharge from the Mission Ranch Estates WTP showed the greatest sodium, chloride, and specific conductance values: 850 mg/L for both sodium and chloride, and 980 µmhos/cm for specific conductance. The discharge from the Mountain Road Estates WTP contained the greatest fluoride concentration: 540 µg/L.

Several of the reported concentrations of arsenic, iron, manganese, chloride, and nitrate-nitrogen detected in backwash wastewater exceeded groundwater quality criteria. The applicable criteria are also identified in Table 2.

Disposal Area Soils

The results from the analyses of the soil samples are summarized in Tables 3 (page 16) through 13 (page 26). Each table addresses one of the 11 analytes. The table below summarizes the number of soil samples collected and analyzed (of the possible maximum of 96).

Table A. Soil samples collected

Targeted Depth	Total Number of Soil Samples Background	Total Number of Soil Samples Disposal Site	
Top	16	16	
Middle	12	14	
Bottom	8	10	
Totals	36	40	Total = 76

Assessment of the comparability of the soil samples (BK versus DS) is illustrated in Table 3. The right three columns in Table 3 display whether the soil types of each pair of samples were similar based on the cation exchange capacity (CEC) of each sample. Ecology assumed that the soil types were similar if the CECs of the pair members were within a factor of 2 of each other, i.e., if the "first ratio" was between 0.5 and 2.0, exclusively. The green shading in Table 3 indicates pairs with similar soil types. No shading indicates either dissimilar pairs or those pairs lacking one or more CEC result. Ecology excluded the pink-shaded soil pairs from further evaluation. Four of the WTPs had no comparable soil pairs; four of the WTPs had only one comparable soil pair; five of the WTPs had two comparable soil pairs; and three WTPs had three comparable soil pairs. The table below summarizes the number of similar soil pairs.

Table B. Soil pairs

Actual Depth	Total Number of Similar Soil Pairs
Top	10
Middle	8
Bottom	5
Total	23

The yellow shading in Tables 4 through 13 identifies those soil pairs (BK and DS) that are not be comparable because they may represent different soil types as indicated by differing cation exchange capacities. The entries in the last three columns of those tables represent comparisons between the concentrations, normalized to the CECs, of BK soils versus DS soils. Ecology assumed that a factor of at least 2 between the normalized BK-DS pairs (i.e., if the “second ratios” were less than 0.5 or greater than 2.0) indicated an impact from wastewater disposal. Green shading identifies those pairs with substantial differences that may be due to disposal of backflush wastewater.

Although the arsenic results for five soil sample pairs from four different WTPs indicated substantial impacts from wastewater disposal, all of those pairs showed **greater** normalized arsenic concentrations in DS soils than in BK soils.

Although the barium results from four soil sample pairs from four different WTPs indicated substantial impacts from wastewater disposal, only one of those impacts was an **increase** in the normalized barium concentration in DS soil. The three other apparent effects were substantial **decreases** of the normalized barium concentrations in DS soils compared with BK soils.

The iron results from three soil sample pairs from three different WTPs indicated substantial differences in the normalized iron concentrations between the BK and DS soils. Two of the pairs showed a **decrease** in the DS soils, and one of the pairs showed an **increase**.

The manganese results from five soil sample pairs from five different WTPs indicated substantial impacts from wastewater disposal. However, three of those impacts showed an **increase** of the normalized manganese concentrations in the DS soils, and two showed a **decrease**.

Although the sodium results from six soil sample pairs from four different WTPs indicated substantial impacts from wastewater disposal, only two of those impacts were **increases** in the normalized sodium concentrations in DS soils. The four other apparent effects were substantial **decreases** of the normalized sodium concentrations in DS soils compared with BK soils.

The chloride results from nine soil sample pairs from five different WTPs indicated substantial impacts from wastewater disposal. Six of those impacts showed an **increase** of the normalized chloride concentrations in the DS soils, and three showed **decreases** compared with BK soils.

The fluoride results from nine soil sample pairs from seven different WTPs indicated substantial impacts from wastewater disposal. Six of those impacts showed an **increase** of the normalized fluoride concentrations in the DS soils, and three showed **decreases** compared with BK soils.

Although the nitrate results from nine soil sample pairs from seven different WTPs indicated substantial impacts from wastewater disposal, only three of those impacts were **increases** in the normalized nitrate concentration in DS soil. The six other apparent effects were substantial **decreases** of the normalized nitrate concentrations in DS soils compared with BK soils.

The specific conductance results from 14 soil sample pairs from eight different WTPs indicated substantial impacts from wastewater disposal. Nine of those impacts showed an **increase** of the normalized specific conductance values in the DS soils, and five showed **decreases**.

Although the pH results from seven soil sample pairs from seven different WTPs indicated substantial impacts from wastewater disposal, six of those impacts were **increases** in the pH of

DS soils. The one other apparent effect was a substantial **decrease** in the pH of the DS soil compared with the BK soil.

Table 14 illustrates the apparent effects of the wastewater discharge on the DS soils. The "**+**" symbols indicate a higher constituent concentration (or a higher pH) in the DS area, while the "**–**" symbols indicate a lower constituent concentration (or a lower pH) in the DS area than in the BK area. The parameters that yielded the most consistently greater normalized **increases** in DS soils compared with BK soils were arsenic, chloride, specific conductance, and pH. The five WTPs that showed the most consistently greater normalized **increases** in DS soils compared with BK soils were Boxx Berry Farm, Coupeville, Ledgewood Beach Water District, Mutiny View Manor Community Club, and Ridgeview Estates. The two WTPs that showed the most consistently greater normalized **decreases** in DS soils compared with BK soils were Mountain Road Estates and Outlook.

Ecology assessed the data to determine whether the apparent impacts from wastewater disposal would show a pattern in correspondence with the depth of the soil samples. Table 15 displays the ratios of CEC-normalized results for the four WTPs that showed substantial differences between the DS and BK soils at multiple depths. The Boxx Berry Farm showed **greater** normalized values for chloride and specific conductance in DS soils than in BK soils. The Mutiny View Manor Community Club showed **greater** normalized values for fluoride and specific conductance in DS soils than in BK soils. The Westside Water System showed **greater** normalized concentrations for arsenic in DS soils than in BK soils. Outlook showed **smaller** normalized values for sodium, chloride, fluoride, nitrate, and specific conductance in DS soils than in BK soils. The substantial differences between DS soils and BK soils **did not** display a consistent pattern with depth.

Finally, Ecology searched for a correlation between the concentrations of pollutants in the WTP backwash effluent and the contaminant concentrations normalized to CEC for the substantially impacted DS soils. Table 16 shows that none of the parameters displayed potentially significant correspondence when evaluated with Kendall's coefficient of concordance either for individual BK-DS soil pairs or for WTP-specific results averaged across the available sampling depths. Thus, the data collected from this investigation **do not** support the conclusion that greater pollutant concentrations in the wastewater lead to greater contamination of the DS soils.

Conclusions

1. Based on the relative contaminant concentrations found in the filter backwash wastewater and soil samples among the 16 WTPs, the treatment processes used by the 16 WTPs generally appeared to address the most significant water quality issues in the source water as reported by the water systems. This indirect evidence suggested that:
    - The ion exchange system at the Boxx Berry Farm appeared to remove nitrate from the source water, and transfer it to the wastewater and then to the soil column.
    - The reverse osmosis process at the Mission Ranch Estates discharged a considerable amount of chloride and fluoride to the soil column.

- The ozonation and oxidation systems at Ridgeview Estates and the Westside Water System appeared to remove arsenic, iron, and manganese from the source water, and transferred those contaminants to the wastewater and then to the soil column.
- The two activated carbon and six other oxidation systems (employing ozone or ferric chloride) yielded mixed results based on the limited data.
- Insufficient wastewater and soil data were available to characterize the functioning of the other four WTPs.

2. Prior to this project, Ecology expected that the concentrations of contaminants originally in raw source waters would be:
   - Greater in the filter backwash wastewater than in the source water.
   - Greater in the DS soil than in the BK soil after normalization to the CEC.

   The data did suggest that wastewater discharges from WTPs generally tend to increase the CEC-normalized specific conductance and concentrations of arsenic, chloride, and the hydroxyl ion (pH) in disposal site soils. In particular, the WTPs at Boxx Berry Farm, Coupeville, Ledgewood Beach Water District, Mutiny View Manor Community Club, and Ridgeview Estates showed **increased** normalized contaminant concentrations in disposal site soils. However, for uncertain reasons, normalized contaminant concentrations in disposal site soils were relatively **less** than those in background soils at the Mountain Road Estates and Outlook WTPs. Therefore, given the absence of significant concordance between wastewater concentrations and normalized disposal site impacts for any of the pollutants, no broad associations can be drawn.

3. Although some of the detected concentrations of arsenic, iron, manganese, chloride, and nitrate-nitrogen in the filter backwash wastewater exceeded groundwater quality criteria, the resultant impact of discharging this wastewater to ground is still unknown, but in some cases may adversely affect groundwater quality.

Recommendation

Since discharge to ground of WTP filter backwash wastewater may adversely affect groundwater quality, Ecology should assess the level of that risk. This assessment may be accomplished by collecting and analyzing multiple samples of backwash wastewater and groundwater from beneath the disposal sites and background areas of a sufficient number of WTPs to represent each of the major treatment processes (e.g., ozonation, oxidation by other chemicals, adsorption to activated carbon, ion exchange, and reverse osmosis). Piezometers may be required to confirm the direction of groundwater flow.

Tables

Table 1. Water Treatment Plants Who Participated in This Study

Connections	Treatment Type	Study Location Name	Contact Name - Title	Address	County
NR [a]	NR	Bayview Beach	Andy Campbell Operator, Whidbey Water System	Intersection of Useless Bay Ave and SR 525, Freeland	Island
4	Ion Exchange	Boxx Berry Farm	Bill Boxx Owner	6211 Northwest Drive, Ferndale	Whatcom
4	AdEdge Adsorption	Bummer #2	John Calhoon	24130 NE Woodinville-Duvall Road, Woodinville	King
1,000+	Pressure Sand Filtration	Coupeville	Malcolm Bishop Public Works Director	434 W Wanamaker Road, Coupeville	Island
NR	Anthracite Coal Filter	Everett Water Filtration	Del Nestegard	6133 Lake Chaplin Road, Monroe	Snohomish
400	NR	Harbor Hills Water System	Andy Campbell Operator, Whidbey Water System	1207 Antelope Drive, Freeland	Island
134	Ozonation & Aeration	Ledgewood Beach Water District	Ms. Jan Martin(or Bill Bradkin) Commissioner, Whidbey Water System	1904 Pinecrest, Coupeville	Island
385	Ozonation	Lost Lake	Omero Vargas System Operator	1478 Lake Drive, Camano Island	Island
158	Green Sand Filter	Mariners Cove Beach Club	Mike Nettles Commissioner, Whidbey Water System	2170 Poinell Road, Oak Harbor	Island
5	Reverse Osmosis	Mission Ranch Estates	Richard Bradley President	4960 Mission Road, Bellingham	Whatcom
4	Anthracite Coal Filter	Mountain Road Estates	Laurie and Corey Thompson	1840 Squalicum Mountain Road, Bellingham	Whatcom
73	Green Sand Filter	Mutiny View Manor Community Club	Andy Campbell Operator, Whidbey Water System	Intersection of Manor Way and Mountain View Lane, Freeland	Island
NR	NR	Naches Water treatment		Yakima	Yakima
NR	NR	Outlook		Outlook	Yakima
32	Green Sand Filter	Ridgeview Estates	Andy Campbell Operator, Whidbey Water System	2370 Goss Ridge Road, Freeland	Island
225	BERM, Oxidation & Filtration	Westside Water System	Doug Dolstad or Scott Derky	Vashon	King
a	NR = Not Reported. The number of connections and/or treatment type are either not reported or unknown.				

Table 2. Results from Analyses of Filter Backwash Wastewater

Study Location Name	Total Arsenic (□g/L)	Total Barium (□g/L)	Total Iron (□g/L)	Total Manganese (□g/L)	Total Sodium (mg/L)	Chloride (mg/L)	Fluoride (□g/L)	Nitrate-N (mg/L)	Specific Conductance (□mhos/cm)	pH (S.U.)	Temperature (oC)
Bayview Beach	140 [a]	280	28,000	5,700	16	18	79	0.51	347	7.7	10.4
Boxx Berry Farm	<60	37	<200	<20	220	29	<60	11	236	7.75	11.9
Bummer #2	<60	<10	<200	<20	36	12	<60	<0.04	143	8.34	9.3
Coupeville	<60	52	210	170	31	45	110	1.9	146	8.04	8.3
Everett Water Filtration	<60	10	770	230	3.2	2.1	73	0.077	43	8.19	9.6
Harbor Hills Water System	<60	37	18,000	630	11	9.3	72	0.05	212	7.72	9.3
Ledgewood Beach Water District	150	370	19,000	12,000	28	44	130	<0.04	139	8.39	10.4
Lost Lake	<60	460	75,000	660	20	22	120	0.29	186	7.83	9.6
Mariners Cove Beach Club	<60	72	2,400	260	16	20	110	0.19	123	8.42	9.2
Mission Ranch Estates	<60	210	300	44	850	850	300	<0.04	980	8.35	11.4
Mountain Road Estates	<60	37	<200	<20	77	15	540	<0.04	268	8.21	10.7
Mutiny View Manor Community Club	<60	31	530	2,000	13	15	96	2.2	306	7.7	9.7
Naches Water treatment	<60	<10	<200	42	5.2	5.0	220	<0.04	79	8.18	7.5
Outlook	6.9	37	640	150	24	14	300	0.05	558	7.7	15.8
Ridgeview Estates	<60	54	330	540	17	18	140	<0.04	275	8.06	8.9
Westside Water System	190	140	17,000	380	30	3.3	120	<0.04	161	8.44	9.7
Median =	30	45	585	245	22	17	115	0	199	8.12	9.7
Mean =	53	115	10,161	1,427	87	70	154	1	263	8.06	10.1
Standard Deviation =	54	141	19,559	3,155	210	208	131	3	227	0.29	1.9
Groundwater Quality Criterion =	0.05 [b]	1,000 [c]	300 [d]	50 [d]	---	250 [d]	4,000 [c]	10 [c]	---	6.5 - 8.5 [d]	---

µg/L = Micrograms per liter.
mg/L = Milligrams per liter.
S.U. = Standard units.
µmhos/cm = Micromhos per centimeter.
ºC = Degrees Celsius.
na = Not analyzed.

Note: Calculations for the median, mean, and standard deviation employed one-half the reporting limit for "less than" results.
a Bold Text indicates a value above the groundwater quality standard.
b Washington State groundwater quality criterion for carcinogens (Table 1, WAC 173-200-040).
c Washington State primary groundwater quality criterion (Table 1, WAC 173-200-040).
d Washington State secondary groundwater quality criterion (Table 1, WAC 173-200-040).

Table 3. Cation Exchange Capacity Results from Analyses of Soils

Study Location Name	Parameter	Background Area (CEC$_{BK}$)			Disposal Area (CEC$_{DS}$)			CEC$_{DS}$/CEC$_{BK}$ Ratio (First Ratio)		
		Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Bayview Beach	Cation Exchange Capacity (meq/100 gm)	12	na	na	0.9	0.86	1.9	0.08		
	Sample Depth (inches)	0 - 10	na	na	0 - 10	24 - 32	48 - 56	0 - 10		
Boxx Berry Farm	Cation Exchange Capacity (meq/100 gm)	89	75	69	110	78	61	**1.24**	**1.04**	**0.88**
	Sample Depth (inches)	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60
Bummer #2	Cation Exchange Capacity (meq/100 gm)	140	na	na	94	na	na	**0.67**		
	Sample Depth (inches)	0 - 8	na	na	0 - 8	na	na	0 - 8		
Coupeville	Cation Exchange Capacity (meq/100 gm)	24	8.1	5.6	13	8.8	38	**0.54**	**1.09**	6.79
	Sample Depth (inches)	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53
Everett Water Filtration	Cation Exchange Capacity (meq/100 gm)	110	110	130	750	110	na	6.82	**1.00**	
	Sample Depth (inches)	3 - 12	24 - 32	48 - 60	0 - 12	22 - 28	na	3 - 12	24 - 32	
Harbor Hills Water System	Cation Exchange Capacity (meq/100 gm)	10	6.9	na	8.5	na	na	**0.85**		
	Sample Depth (inches)	0 - 8	24 - 30	na	0 - 12	na	na	0 - 8		
Ledgewood Beach Water District	Cation Exchange Capacity (meq/100 gm)	15	57	7.1	8.1	6.3	5.2	**0.54**	0.11	**0.73**
	Sample Depth (inches)	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 8	24 – 32	48 - 51
Lost Lake	Cation Exchange Capacity (meq/100 gm)	23	na	na	56	10	na	2.43		
	Sample Depth (inches)	0 - 10	na	na	0 - 12	24 - 35	na	0 - 10		
Mariners Cove Beach Club	Cation Exchange Capacity (meq/100 gm)	28	na	na	8.9	5.3	na	0.32		
	Sample Depth (inches)	0 - 8	na	na	0 - 8	24 - 30	na	0 - 8		
Mission Ranch Estates	Cation Exchange Capacity (meq/100 gm)	110	42	57	140	120	58	**1.27**	2.86	**1.02**
	Sample Depth (inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 – 52
Mountain Road Estates	Cation Exchange Capacity (meq/100 gm)	120	99	na	120	110	93	**1.00**	**1.11**	
	Sample Depth (inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	48 - 51	0 - 12	24 – 30	
Mutiny View Manor Community Club	Cation Exchange Capacity (meq/100 gm)	4.4	3.0	3.2	5.0	4.1	5.9	**1.14**	**1.37**	**1.84**
	Sample Depth (inches)	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 – 30	48 - 55
Naches Water Treatment	Cation Exchange Capacity (meq/100 gm)	120	110	na	580	4.32	na	4.83	0.04	
	Sample Depth (inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	na	0 - 12	24 - 30	
Outlook	Cation Exchange Capacity (meq/100 gm)	120	150	140	110	130	140	**0.92**	**0.87**	**1.00**
	Sample Depth (inches)	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53
Ridgeview Estates	Cation Exchange Capacity (meq/100 gm)	22	9.9	na	5.8	5.6	5.2	0.26	**0.57**	
	Sample Depth (inches)	0 - 8	24 - 33	na	0 - 8	24 - 32	48 - 53	0 - 8	24 - 33	
Westside Water System	Cation Exchange Capacity (meq/100 gm)	120	140	78	170	88	na	**1.42**	**0.63**	
	Sample Depth (inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	na	0 - 12	24 - 36	

na = Chemical analysis was not conducted. These cells are empty in Tables 4 through 14.

Blank cells indicate that no calculation was performed because at least one location lacked a chemical analysis.

nc = Soil in the disposal site is not similar to soil in the background area, based on cation exchange capacity. (First Ratio $\leq$ 0.5 ; or First Ratio $\geq$ 2.0)

Soil in the disposal site is similar to soil in the background area, based on cation exchange capacity. (0.5 < First Ratio < 2.0)

Table 4. Total Arsenic Results from Analyses of Soils

Study Location Name	Parameter	Background Area (BK)			Disposal Site (DS)			Normalized to CEC: As/CEC BK Ratio			Normalized to CEC: As/CEC DS Ratio			(As/CEC DS) / (As/CEC BK) Ratio (Second Ratio)		
		Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Bayview Beach	Total Arsenic (mg/Kg)	4.8	na	na	11	<2.8	2.8	nc			nc			nc		
	Sample Depth (inches)	0 - 10	na	na	0 - 10	24 - 32	48 - 56	0 - 10			0 - 10	24 - 32	48 - 56	0 - 10		
Boxx Berry Farm	Total Arsenic (mg/Kg)	6.1	5.8	6.0	6.8	21	5.7	0.07	0.08	0.09	0.06	0.27	0.09	0.90	**3.5**	1.1
	Sample Depth (inches)	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60
Bummer #2	Total Arsenic (mg/Kg)	12	na	na	6.1	na	na	0.09			0.06			0.76		
	Sample Depth (inches)	0 - 8	na	na	0 - 8	na	na	0 - 8			0 - 8			0 - 8		
Coupeville	Total Arsenic (mg/Kg)	2.9	<2.6	<2.2	3.1	2.2	5.4	0.12	<0.32	nc	0.24	0.25	nc	2.0	>0.78	nc
	Sample Depth (inches)	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53
Everett Water Filtration	Total Arsenic (mg/Kg)	9.3	8.1	6.8	69	5.9	na	nc	0.07		nc	0.09		nc	1.2	
	Sample Depth (inches)	3 - 12	24 - 32	48 - 60	0 - 12	22 - 28	na	3 - 12	24 - 32	48 - 60	0 - 12	22 - 28		3 - 12	24 - 32	
Harbor Hills Water System	Total Arsenic (mg/Kg)	<3.2	<2.4	na	<3.8	na	na	<0.32			<0.45			>1.41		
	Sample Depth (inches)	0 - 8	24 - 30	na	0 - 12	na	na	0 - 8	24 - 30		0 - 12			0 - 8		
Ledgewood Beach Water District	Total Arsenic (mg/Kg)	3.6	<6.6	<2.6	4.5	<2.5	<2.8	0.24	nc	<0.37	0.56	nc	<0.54	**2.3**	nc	>1.46
	Sample Depth (inches)	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 10	24 – 32	48 - 51	0 - 8	24 –33	48 - 51	0 - 8	24 – 32	48 - 51
Lost Lake	Total Arsenic (mg/Kg)	6.8	na	na	12	<3.0	na	nc			nc			nc		
	Sample Depth (inches)	0 - 10	na	na	0 - 12	24 - 35	na	0 - 10			0 - 12	24 - 35		0 - 10		
Mariners Cove Beach Club	Total Arsenic (mg/Kg)	5.0	na	na	15	3.4	na	nc			nc			nc		
	Sample Depth (inches)	0 - 8	na	na	0 - 8	24 - 30	na	0 - 8			0 - 8	24 - 30		0 - 8		
Mission Ranch Estates	Total Arsenic (mg/Kg)	4.8	5.0	8.3	4.8	4.7	7.1	0.04	nc	0.15	0.03	nc	0.12	0.79	nc	0.84
	Sample Depth (inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 53
Mountain Road Estates	Total Arsenic (mg/Kg)	9.2	8.5	na	8.4	9.0	21	0.08	0.09		0.07	0.08		0.91	0.95	
	Sample Depth (inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	48 - 51	0 - 12	24 - 30		0 - 12	24 - 36	48 - 51	0 - 12	24 - 30	
Mutiny View Manor Community Club	Total Arsenic (mg/Kg)	<2.8	<2.9	<3.3	<2.4	<3.1	3.1	<0.64	<0.97	<1.0	<0.48	<0.76	0.53	>0.75	>0.78	>0.51
	Sample Depth (inches)	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 32	48 - 56
Naches Water treatment	Total Arsenic (mg/Kg)	3.4	3.4	na	<11	12	na	nc	nc		nc	nc		nc	nc	
	Sample Depth (inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	na	0 - 12	24 - 30		0 - 12	24 - 36		0 - 12	24 - 30	
Outlook	Total Arsenic (mg/Kg)	9.7	9.5	11	6.9	7.7	8.0	0.08	0.06	0.08	0.06	0.06	0.06	0.78	0.94	0.73
	Sample Depth (inches)	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 – 53
Ridgeview Estates	Total Arsenic (mg/Kg)	6.9	3.1	na	7.6	4.5	2.7	nc	0.31		nc	0.80		nc	**2.6**	
	Sample Depth (inches)	0 - 8	24 - 33	na	0 - 8	24 - 32	48 - 53	0 - 8	24 - 33		0 - 8	24 - 32	48 - 53	0 - 8	24 - 32	
Westside Water System	Total Arsenic (mg/Kg)	4.0	7.6	<3.6	36	11	na	0.03	0.05	nc	0.21	0.13		**6.4**	**2.3**	
	Sample Depth (inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	na	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36		0 - 12	24 - 36	

na = Chemical analysis was not conducted.

Blank cells indicate that no calculation was performed because at least one location lacked a chemical analysis.

nc = Soil in the disposal site is not similar to soil in the background area, based on cation exchange capacity (CEC), and no calculation was performed. See Data Evaluation section for details.

The concentration of total arsenic in the disposal site differed from that in the background area, normalized to CEC. (Second Ratio < 0.50 ; or Second Ratio > 2.0)

Table 5. Total Barium Results from Analyses of Soils

Study Location Name	Parameter		Background Area (BK)			Disposal Site (DS)			Normalized to CEC: Ba/CEC BK Ratio			Normalized to CEC: Ba/CEC DS Ratio			(Ba/CEC DS) / (Ba/CEC BK) Ratio (Second Ratio)		
			Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Bayview Beach	Total Barium	(mg/Kg)	120	na	na	71	42	39	nc			nc			nc		
	Sample Depth	(inches)	0 - 10	na	na	0 - 10	24 - 32	48 - 56	0 - 10			0 - 10	24 - 32	48 - 56	0 - 10		
Boxx Berry Farm	Total Barium	(mg/Kg)	97	130	90	95	61	72	1.09	1.73	1.30	0.86	0.78	1.18	0.79	**0.45**	0.90
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60
Bummer #2	Total Barium	(mg/Kg)	91	na	na	72	na	na	0.65			0.77			1.2		
	Sample Depth	(inches)	0 - 8	na	na	0 - 8	na	na	0 - 8			0 - 8			0 - 8		
Coupeville	Total Barium	(mg/Kg)	120	43	35	78	38	95	5.00	5.31	nc	6.00	4.32		1.2	0.81	nc
	Sample Depth	(inches)	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53
Everett Water Filtration	Total Barium	(mg/Kg)	98	100	78	61	35	57	nc	0.91		nc	0.05		nc	**0.05**	
	Sample Depth	(inches)	3 - 12	24 - 32	48 - 60	0 - 6	0 - 12	22 - 28	3 - 12	24 - 32	48 - 60	0 - 12	22 - 28		3 - 12	24 - 32	48 - 60
Harbor Hills Water System	Total Barium	(mg/Kg)	49	57	na	61	na	na	4.90			7.18			1.5		
	Sample Depth	(inches)	0 - 8	24 - 30	na	0 - 12	na	na	0 - 8	24 - 30		0 - 12			0 - 8	24 - 30	
Ledgewood Beach Water District	Total Barium	(mg/Kg)	53	110	38	110	65	50	3.53	nc	5.35	13.6	nc	9.62	**3.8**	nc	1.8
	Sample Depth	(inches)	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 10	24 - 32	48 - 51	0 - 8	24 - 32	48 - 51	0 - 8	24 - 32	48 - 51
Lost Lake	Total Barium	(mg/Kg)	61	na	na	110	52	na	nc			nc			nc		
	Sample Depth	(inches)	0 - 10	na	na	0 - 12	24 - 35	na	0 - 10			0 - 12	24 - 35		0 - 10		
Mariners Cove Beach Club	Total Barium	(mg/Kg)	88	na	na	91	46	na	nc			nc			nc		
	Sample Depth	(inches)	0 - 8	na	na	0 - 8	24 - 30	na	0 - 8			0 - 8	24 - 30		0 - 8		
Mission Ranch Estates	Total Barium	(mg/Kg)	150	98	120	120	84	86	1.36	nc	2.11	0.86	nc	1.48	0.63	nc	0.70
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 – 52
Mountain Road Estates	Total Barium	(mg/Kg)	250	190	na	340	97	120	2.08	1.92		2.83	0.88		1.4	**0.46**	
	Sample Depth	(inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	48 - 51	0 - 12	24 - 30		0 - 12	24 - 30	48 - 51	0 - 12	24 - 30	
Mutiny View Manor Community Club	Total Barium	(mg/Kg)	71	46	34	45	41	49	16.1	15.3	10.6	9.00	10.0	8.31	0.56	0.65	0.78
	Sample Depth	(inches)	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 32	48 - 56	0 - 12	24 - 32	48 - 56	0 - 10	24 - 32	48 - 56
Naches Water treatment	Total Barium	(mg/Kg)	57	58	na	42	31	na	nc	nc		nc	nc		nc	nc	
	Sample Depth	(inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	na	0 - 12	24 - 30		0 - 12	24 - 30		0 - 12	24 - 30	
Outlook	Total Barium	(mg/Kg)	130	150	140	130	110	120	1.08	1.00	1.00	1.18	0.85	0.86	1.1	0.85	0.86
	Sample Depth	(inches)	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53
Ridgeview Estates	Total Barium	(mg/Kg)	94	80	na	81	65	57	nc	8.08		nc	11.6		nc	1.4	
	Sample Depth	(inches)	0 - 8	24 - 33	na	0 - 8	24 - 32	48 - 53	0 - 8	24 - 33		0 - 8	24 - 32	48 - 53	0 - 8	24 - 32	
Westside Water System	Total Barium	(mg/Kg)	47	55	55	94	55	na	0.39	0.39	nc	0.55	0.63		1.4	1.6	
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	na	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36		0 - 12	24 - 36	48 - 53

na = Chemical analysis was not conducted.

Blank cells indicate that no calculation was performed because at least one location lacked a chemical analysis.

nc = Soil in the disposal site is not similar to soil in the background area, based on cation exchange capacity (CEC), and no calculation was performed. See Data Evaluation section for details.

The concentration of total arsenic in the disposal site differed from that in the background area, normalized to CEC. (Second Ratio < 0.50 ; or Second Ratio > 2.0)

Table 6. Total Iron Results from Analyses of Soils

Study Location Name	Parameter		Background Area (BK)			Disposal Site (DS)			Normalized to CEC: Fe/CEC BK Ratio			Normalized to CEC: Fe/CEC DS Ratio			(Fe/CEC DS) / (Fe/CEC BK) Ratio (Second Ratio)		
			Top	**Middle**	**Bottom**	**Top**	**Middle**	**Bottom**	**Top**	**Middle**	**Bottom**	**Top**	**Middle**	**Bottom**	**Top**	**Middle**	**Bottom**
Bayview Beach	Total Iron	(mg/Kg)	12,000	na	na	15,000	13,000	14,000	nc			nc			nc		
	Sample Depth	(inches)	0 - 10	na	na	0 - 10	24 - 32	48 - 56	0 - 10			0 - 10	24 - 32	48 - 56	0 - 10		
Boxx Berry Farm	Total Iron	(mg/Kg)	24,000	26,000	26,000	23,000	37,000	27,000	270	347	377	209	474	443	0.78	1.4	1.2
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60
Bummer #2	Total Iron	(mg/Kg)	19,000	na	na	24,000	na	na	136			255			1.9		
	Sample Depth	(inches)	0 - 8	na	na	0 - 8	na	na	0 - 8			0 - 8			0 - 8		
Coupeville	Total Iron	(mg/Kg)	17,000	16,000	16,000	14,000	15,000	36,000	708	1,980	nc	1,080	1,700	nc	1.5	0.86	nc
	Sample Depth	(inches)	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53
Everett Water Filtration	Total Iron	(mg/Kg)	32,000	39,000	34,000	9,400	21,000	24,000	nc	355		nc	28		nc	**0.08**	
	Sample Depth	(inches)	3 - 12	24 - 32	48 - 60	0 - 6	0 - 12	22 - 28	3 - 12	24 - 32	48 - 60	0 - 12	22 - 28		3 - 12	24 - 32	
Harbor Hills Water System	Total Iron	(mg/Kg)	14,000	14,000	na	9,700	na	na	1,400			1,140			0.81		
	Sample Depth	(inches)	0 - 8	24 - 30	na	0 - 12	na	na	0 - 8	24 - 30		0 - 12			0 - 8	24 - 30	
Ledgewood Beach Water District	Total Iron	(mg/Kg)	19,000	15,000	16,000	18,000	16,000	15,000	1,270	nc	2,250	2,220	nc	2,880	1.7	nc	1.3
	Sample Depth	(inches)	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 8	24 - 32	48 - 51
Lost Lake	Total Iron	(mg/Kg)	16,000	na	na	19,000	16,000	na	nc			nc			nc		
	Sample Depth	(inches)	0 - 10	na	na	0 - 12	24 - 35	na	0 - 10			0 - 12	24 - 35		0 - 10		
Mariners Cove Beach Club	Total Iron	(mg/Kg)	23,000	na	na	25,000	19,000	na	nc			nc			nc		
	Sample Depth	(inches)	0 - 8	na	na	0 - 8	24 - 30	na	0 - 8			0 - 8	24 - 30		0 - 8		
Mission Ranch Estates	Total Iron	(mg/Kg)	29,000	29,000	37,000	25,000	28,000	33,000	264	nc	649	179	nc	569	0.68	nc	0.88
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 – 52
Mountain Road Estates	Total Iron	(mg/Kg)	29,000	27,000	na	30,000	24,000	26,000	242	273		250	218		1.0	0.80	
	Sample Depth	(inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	48 - 51	0 - 12	24 - 30		0 - 12	24 - 36	48 - 51	0 - 12	24 - 30	
Mutiny View Manor Community Club	Total Iron	(mg/Kg)	13,000	14,000	15,000	13,000	14,000	17,000	2,960	4,670	4,690	2,600	3,420	2,880	0.88	0.73	0.61
	Sample Depth	(inches)	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 32	48 - 56
Naches Water treatment	Total Iron	(mg/Kg)	22,000	26,000	na	11,000	8,600	na	nc	nc		nc	nc		nc	nc	
	Sample Depth	(inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	na	0 - 12	24 - 30		0 - 12	24 - 36		0 - 12	24 - 30	
Outlook	Total Iron	(mg/Kg)	29,000	30,000	29,000	12,000	30,000	31,000	242	200	207	109	231	221	**0.45**	1.2	1.1
	Sample Depth	(inches)	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 – 53
Ridgeview Estates	Total Iron	(mg/Kg)	13,000	15,000	na	17,000	18,000	15,000	nc	1,520		nc	3,210		nc	**2.1**	
	Sample Depth	(inches)	0 - 8	24 - 33	na	0 - 8	24 - 32	48 - 53	0 - 8	24 - 33		0 - 8	24 - 32	48 - 53	0 - 8	24 - 32	
Westside Water System	Total Iron	(mg/Kg)	12,000	14,000	12,000	17,000	15,000	na	100	100	nc	100	170		1.0	1.7	
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	na	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36		0 - 12	24 - 36	48 - 53

na = Chemical analysis was not conducted.

Blank cells indicate that no calculation was performed because at least one location lacked a chemical analysis.

nc = Soil in the disposal site is not similar to soil in the background area, based on cation exchange capacity (CEC), and no calculation was performed. See Data Evaluation section for details.

The concentration of total arsenic in the disposal site differed from that in the background area, normalized to CEC. (Second Ratio < 0.50 ; or Second Ratio > 2.0)

Table 7. Total Manganese Results from Analyses of Soils

Study Location Name	Parameter	Background Area (BK)			Disposal Site (DS)			Normalized to CEC: Mn/CEC BK Ratio			Normalized to CEC: Mn/CEC DS Ratio			(Mn/CEC DS) / (Mn/CEC BK) Ratio (Second Ratio)		
		Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Bayview Beach	Total Manganese (mg/Kg)	700	na	na	3,100	270	400	nc			nc			nc		
	Sample Depth (inches)	0 - 10	na	na	0 - 10	24 - 32	48 - 56	0 - 10			0 - 10			0 - 10		
Boxx Berry Farm	Total Manganese (mg/Kg)	350	300	340	350	470	660	3.93	4.00	4.93	3.18	6.03	10.82	0.81	1.5	**2.2**
	Sample Depth (inches)	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60
Bummer #2	Total Manganese (mg/Kg)	570	na	na	320	na	na	4.07			3.40			0.84		
	Sample Depth (inches)	0 - 8	na	na	0 - 8	na	na	0 - 8			0 - 8			0 - 8		
Coupeville	Total Manganese (mg/Kg)	710	260	220	780	250	530	29.6	32.1	nc	60.0	28.4		2.0	0.89	nc
	Sample Depth (inches)	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53
Everett Water Filtration	Total Manganese (mg/Kg)	430	440	380	150	490	420	nc	4.00		nc	0.65		nc	**0.16**	
	Sample Depth (inches)	3 - 12	24 - 32	48 - 60	0 - 6	0 - 12	22 - 28	3 - 12	24 - 32	48 - 60	0 - 12	22 - 28		3 - 12	24 - 32	
Harbor Hills Water System	Total Manganese (mg/Kg)	180	210	na	120	na	na	18.0			14.1			0.78		
	Sample Depth (inches)	0 - 8	24 - 30	na	0 - 12	na	na	0 - 8	24 - 30		0 - 12			0 - 8	24 - 30	
Ledgewood Beach Water District	Total Manganese (mg/Kg)	340	610	220	470	250	220	22.7	nc	31.0	58.0	nc	42.3	**2.6**	nc	1.4
	Sample Depth (inches)	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 8	24 - 32	48 - 51
Lost Lake	Total Manganese (mg/Kg)	200	na	na	380	210	na	nc			nc			nc		
	Sample Depth (inches)	0 - 10	na	na	0 - 12	24 - 35	na	0 - 10			0 - 10	24 - 35		0 - 10		
Mariners Cove Beach Club	Total Manganese (mg/Kg)	310	na	na	750	370	na	nc			nc			nc		
	Sample Depth (inches)	0 - 8	na	na	0 - 8	24 - 30	na	0 - 8			0 - 8	24 - 30		0 - 8		
Mission Ranch Estates	Total Manganese (mg/Kg)	490	370	630	420	460	410	4.45	nc	11.1	3.00		7.07	0.67	nc	0.64
	Sample Depth (inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 52
Mountain Road Estates	Total Manganese (mg/Kg)	1,200	560	na	1,100	400	1,300	10.0	5.66		9.17	3.64		0.92	0.64	
	Sample Depth (inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	48 - 51	0 - 12	24 - 30		0 - 12	24 - 36	48 - 51	0 - 12	24 - 30	
Mutiny View Manor Community Club	Total Manganese (mg/Kg)	240	200	190	240	200	230	54.5	66.7	59.4	48.0	48.8	39.0	0.88	0.73	0.66
	Sample Depth (inches)	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 30	48 - 55
Naches Water treatment	Total Manganese (mg/Kg)	350	320	na	250	130	na	nc	nc					nc	nc	
	Sample Depth (inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	na	0 - 12	24 - 30		0 - 12	24 - 36		0 - 12	24 - 30	
Outlook	Total Manganese (mg/Kg)	450	520	450	180	490	440	3.75	3.47	3.21	1.64	3.77	3.14	**0.44**	1.1	0.98
	Sample Depth (inches)	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53
Ridgeview Estates	Total Manganese (mg/Kg)	500	190	na	2,800	280	340	nc	19.2			50.0		nc	**2.6**	
	Sample Depth (inches)	0 - 8	24 - 33	na	0 - 8	24 - 32	48 - 53	0 - 8	24 - 33		0 - 8	24 - 32	48 - 53	0 - 8	24 - 32	
Westside Water System	Total Manganese (mg/Kg)	150	190	150	310	210	na	1.25	1.36	nc	1.82	2.39		1.5	1.8	
	Sample Depth (inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	na	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36		0 - 12	24 - 36	48 - 53

na = Chemical analysis was not conducted.

Blank cells indicate that no calculation was performed because at least one location lacked a chemical analysis.

nc = Soil in the disposal site is not similar to soil in the background area, based on cation exchange capacity (CEC), and no calculation was performed. See Data Evaluation section for details.

The concentration of total arsenic in the disposal site differed from that in the background area, normalized to CEC. (Second Ratio < 0.50 ; or Second Ratio > 2.0)

Table 8. Total Sodium Results from Analyses of Soils

Study Location Name	Parameter	Background Area (BK)			Disposal Site (DS)			Normalized to CEC: Sodium/CEC BK Ratio			Normalized to CEC: Sodium/CEC DS Ratio			(Na/CEC DS) / (Na/CEC BK) Ratio (Second Ratio)		
		Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Bayview Beach	Total Sodium (mg/Kg)	160	na	na	150	180	180	nc			nc			nc		
	Sample Depth (inches)	0 - 10	na	na	0 - 10	24 - 32	48 - 56	0 - 10			0 - 10	24 - 32	48 - 56	0 - 10		
Boxx Berry Farm	Total Sodium (mg/Kg)	<120	<110	<110	140	<110	<110	<1.35	<1.47	<1.59	1.27	<1.41	<1.80	>0.94	>0.96	>1.13
	Sample Depth (inches)	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60
Bummer #2	Total Sodium (mg/Kg)	150	na	na	230	na	na	1.07			2.45			**2.3**		
	Sample Depth (inches)	0 - 8	na	na	0 - 8	na	na	0 - 8			0 - 8			0 - 8		
Coupeville	Total Sodium (mg/Kg)	130	100	120	150	140	350	5.42	12.3	nc	11.5	15.9	nc	**2.1**	1.3	nc
	Sample Depth (inches)	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53
Everett Water Filtration	Total Sodium (mg/Kg)	<120	<120	<110	<310	<750	260	nc	<1.09		nc	<1.00		nc	>0.92	
	Sample Depth (inches)	3 - 12	24 - 32	48 - 60	0 - 6	0 - 12	22 - 28	3 - 12	24 - 32	48 - 60	0 - 12	22 - 28		3 - 12	24 - 32	
Harbor Hills Water System	Total Sodium (mg/Kg)	260	210	na	140	na	na	26.0			16.5			0.63		
	Sample Depth (inches)	0 - 8	24 - 30	na	0 - 12	na	na	0 - 8	24 - 30		0 - 12			0 - 8	24 - 30	
Ledgewood Beach Water District	Total Sodium (mg/Kg)	210	<220	120	130	130	110	14.0	nc	16.9	16.0	nc	21.15	1.1	nc	1.3
	Sample Depth (inches)	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 8	24 - 32	48 - 51
Lost Lake	Total Sodium (mg/Kg)	140	na	na	160	160	na	nc			nc			nc		
	Sample Depth (inches)	0 - 10	na	na	0 - 12	24 - 35	na	0 - 10			0 - 12			0 - 10		
Mariners Cove Beach Club	Total Sodium (mg/Kg)	300	na	na	230	150	na	nc			nc			nc		
	Sample Depth (inches)	0 - 8	na	na	0 - 8	24 - 30	na	0 - 8			0 - 8	24 - 30		0 - 8		
Mission Ranch Estates	Total Sodium (mg/Kg)	<130	<120	140	<130	<130	<120	<1.18	nc	2.46	<0.93	nc	<2.07	>0.79	nc	<0.84
	Sample Depth (inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 52
Mountain Road Estates	Total Sodium (mg/Kg)	600	<130	na	<130	<110	<110	5.00	<1.31		<1.08	<1.00		**<0.22**	>0.76	
	Sample Depth (inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	48 - 51	0 - 12	24 - 30		0 - 12	24 - 36	48 - 51	0 - 12	24 - 30	
Mutiny View Manor Community Club	Total Sodium (mg/Kg)	160	210	230	180	240	230	36.4	70.0	71.9	36.0	58.5	39.0	0.99	0.84	0.54
	Sample Depth (inches)	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 30	48 - 55
Naches Water treatment	Total Sodium (mg/Kg)	190	180	na	<380	<270	na	nc	nc		nc	nc		nc	nc	
	Sample Depth (inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	na	0 - 12	24 - 30		0 - 12	24 - 36		0 - 12	24 - 30	
Outlook	Total Sodium (mg/Kg)	2,600	570	1,000	<110	<110	190	21.67	3.80	7.14	<1.00	<0.85	1.36	**<0.05**	**<0.22**	**0.19**
	Sample Depth (inches)	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53
Ridgeview Estates	Total Sodium (mg/Kg)	150	150	na	260	170	310	nc	15.2		nc	30.4		nc	2.0	
	Sample Depth (inches)	0 - 8	24 - 33	na	0 - 8	24 - 32	48 - 53	0 - 8	24 - 33		0 - 8	24 - 32	48 - 53	0 - 8	24 - 32	
Westside Water System	Total Sodium (mg/Kg)	<110	<120	<120	170	130	na	<0.92	<0.86	nc	1.00	1.48		>1.1	>1.7	
	Sample Depth (inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	na	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36		0 - 12	24 - 36	48 - 53

na = Chemical analysis was not conducted.

Blank cells indicate that no calculation was performed because at least one location lacked a chemical analysis.

nc = Soil in the disposal site is not similar to soil in the background area, based on cation exchange capacity (CEC), and no calculation was performed. See Data Evaluation section for details.

The concentration of total arsenic in the disposal site differed from that in the background area, normalized to CEC. (Second Ratio < 0.50 ; or Second Ratio > 2.0)

Table 9. Chloride Results from Analyses of Soils

Study Location Name	Parameter		Background Area (BK)			Disposal Site (DS)			Normalized to CEC: Chloride/CEC BK Ratio			Normalized to CEC: Chloride/CEC DS Ratio			(Cl/CEC DS) / (Cl/CEC BK) Ratio (Second Ratio)		
			Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Bayview Beach	Chloride	(mg/Kg)	6.3	na	na	<3.5	<3.5	<3.5	nc			nc			nc		
	Sample Depth	(inches)	0 - 10	na	na	0 - 10	24 - 32	48 - 56	0 - 10			0 - 10	24 - 32	48 - 56	0 - 10		
Boxx Berry Farm	Chloride	(mg/Kg)	<4.0	<3.8	<3.7	120	13	7.9	<0.045	<0.051	<0.054	1.1	0.17	0.13	**>24**	**>3.3**	**>2.4**
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60
Bummer #2	Chloride	(mg/Kg)	<4.2	na	na	<3.7	na	na	<0.030			<0.039			>1.3		
	Sample Depth	(inches)	0 - 8	na	na	0 - 8	na	na	0 - 8			0 - 8			0 - 8		
Coupeville	Chloride	(mg/Kg)	7.5	<3.5	<3.4	8.5	4.7	7.5	0.31	<0.43	nc	0.65	0.53	nc	**2.1**	>1.2	nc
	Sample Depth	(inches)	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53
Everett Water Filtration	Chloride	(mg/Kg)	<4.0	<4.1	<3.6	44	<26	<3.6	nc	<0.037		nc	<0.035		nc	>0.95	
	Sample Depth	(inches)	3 - 12	24 - 32	48 - 60	0 - 6	0 - 12	22 - 28	3 - 12	24 - 32	48 - 60	0 - 12	22 - 28		3 - 12	24 - 32	
Harbor Hills Water System	Chloride	(mg/Kg)	<4.0	<3.6	na	6.9	na	na	<0.40			0.81			**>2.0**		
	Sample Depth	(inches)	0 - 8	24 - 30	na	0 - 12	na	na	0 - 8	24 - 30		0 - 12			0 - 8	24 - 30	
Ledgewood Beach Water District	Chloride	(mg/Kg)	4.4	11	<3.6	3.9	<3.3	<3.4	0.29	nc	<0.51	0.48	nc	<0.65	1.6	nc	>1.28
	Sample Depth	(inches)	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 10	24 - 32	48 - 51
Lost Lake	Chloride	(mg/Kg)	5.5	na	na	8.7	<3.9	na	nc			nc			nc		
	Sample Depth	(inches)	0 - 10	na	na	0 - 12	24 - 35	na	0 - 10			0 - 12	24 - 35		0 - 10		
Mariners Cove Beach Club	Chloride	(mg/Kg)	12	na	na	17	6.0	na	nc			nc			nc		
	Sample Depth	(inches)	0 - 8	na	na	0 - 8	24 - 30	na	0 - 8			0 - 8	24 - 30		0 - 8		
Mission Ranch Estates	Chloride	(mg/Kg)	<4.1	<3.9	<4.0	<4.3	<4.1	4.8	<0.037	nc	<0.070	<0.031	nc	0.083	>0.84	nc	**>2.1**
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 52
Mountain Road Estates	Chloride	(mg/Kg)	<4.6	<4.0	na	<4.3	<3.9	<3.6	<0.038	<0.040		<0.036	<0.035		>0.95	>0.88	
	Sample Depth	(inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	48 - 51	0 - 12	24 - 30		0 - 12	24 - 36	48 - 51	0 - 12	24 - 30	
Mutiny View Manor Community Club	Chloride	(mg/Kg)	<3.6	<3.6	<3.5	<3.7	<3.8	<4.0	<0.82	<1.2	<1.1	<0.74	<0.93	<0.68	>0.90	>0.78	>0.62
	Sample Depth	(inches)	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 30	48 - 55
Naches Water treatment	Chloride	(mg/Kg)	<3.3	<3.3	na	58.0	25.0	na	nc	nc		nc	nc		nc	nc	
	Sample Depth	(inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	na	0 - 12	24 - 30		0 - 12	24 - 36		0 - 12	24 - 30	
Outlook	Chloride	(mg/Kg)	340	31.0	110	<3.5	9.4	<4.0	2.8	0.21	0.79	<0.032	0.072	<0.029	**<0.011**	**0.35**	**<0.037**
	Sample Depth	(inches)	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53
Ridgeview Estates	Chloride	(mg/Kg)	<5.1	5.5	na	<4.5	<3.8	<4.0	nc	0.56		nc	<0.68		nc	<1.2	
	Sample Depth	(inches)	0 - 8	24 - 33	na	0 - 8	24 - 32	48 - 53	0 - 8	24 - 33		0 - 8	24 - 32	48 - 53	0 - 8	24 - 32	
Westside Water System	Chloride	(mg/Kg)	<3.8	<4.0	<3.9	<5.0	<4.2	na	<0.032	<0.029		<0.029	<0.048		>0.91	>1.66	
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	na	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36		0 - 12	24 - 36	48 - 53

na = Chemical analysis was not conducted.

Blank cells indicate that no calculation was performed because at least one location lacked a chemical analysis.

nc = Soil in the disposal site is not similar to soil in the background area, based on cation exchange capacity (CEC), and no calculation was performed. See Data Evaluation section for details.

The concentration of total arsenic in the disposal site differed from that in the background area, normalized to CEC. (Second Ratio < 0.50 ; or Second Ratio > 2.0)

Table 10. Fluoride Results from Analyses of Soils

Study Location Name	Parameter		Background Area (BK)			Disposal Site (DS)			Normalized to CEC: Fluoride/CEC BK Ratio			Normalized to CEC: Fluoride/CEC DS Ratio			(F/CEC DS) / (F/CEC BK) Ratio (Second Ratio)		
			Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Bayview Beach	Fluoride	(mg/Kg)	<0.71	na	na	0.78	<0.63	<0.63	nc						nc		
	Sample Depth	(inches)	0 - 10	na	na	0 - 10	24 - 32	48 - 56	0 - 10			0 - 10	24 - 32	48 - 56	0 - 10		
Boxx Berry Farm	Fluoride	(mg/Kg)	2.0	1.2	0.99	1.3	<0.69	<0.64	0.022	0.016	0.014	0.012	<0.009	<0.010	0.53	<0.56	<0.71
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60
Bummer #2	Fluoride	(mg/Kg)	<0.76	na	na	<0.67	na	na	<0.005			<0.007			>1.40		
	Sample Depth	(inches)	0 - 8	na	na	0 - 8	na	na	0 - 8			0 - 8			0 - 8		
Coupeville	Fluoride	(mg/Kg)	<0.71	<0.64	<0.63	1.6	0.86	2.1	<0.030	<0.079	nc	0.12	0.10	nc	**>4.0**	>1.3	nc
	Sample Depth	(inches)	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53
Everett Water Filtration	Fluoride	(mg/Kg)	<0.73	<0.75	<0.65	<4.8	<1.8	<0.66	nc	<0.007		nc	<0.002		nc	>0.29	
	Sample Depth	(inches)	3 - 12	24 - 32	48 - 60	0 - 6	0 - 12	22 - 28	3 - 12	24 - 32	48 - 60	0 - 12	22 - 28		3 - 12	24 - 32	
Harbor Hills Water System	Fluoride	(mg/Kg)	0.81	1.20	na	<0.81	na	na	0.081			<0.10			<1.2		
	Sample Depth	(inches)	0 - 8	24 - 30	na	0 - 12	na	na	0 - 8	24 - 30		0 - 8			0 - 8	24 - 30	
Ledgewood Beach Water District	Fluoride	(mg/Kg)	0.86	<1.5	2.0	1.5	1.5	1.4	0.057	nc	0.28	0.19	nc	0.27	**3.2**	nc	0.96
	Sample Depth	(inches)	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 8	24 - 32	48 - 51
Lost Lake	Fluoride	(mg/Kg)	1.1	na	na	1.0	<0.71	na	nc			nc			nc		
	Sample Depth	(inches)	0 - 10	na	na	0 - 12	24 - 35	na	0 - 10			0 - 12	24 - 35		0 - 10		
Mariners Cove Beach Club	Fluoride	(mg/Kg)	<0.77	na	na	<0.72	<0.70	na	nc			nc			nc		
	Sample Depth	(inches)	0 - 8	na	na	0 - 8	24 - 30	na	0 - 8			0 - 8	24 - 30		0 - 8		
Mission Ranch Estates	Fluoride	(mg/Kg)	<0.74	<0.71	1.1	<0.78	<0.75	1.1	<0.007	nc	0.019	<0.006	nc	0.019	>0.86	nc	0.98
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 52
Mountain Road Estates	Fluoride	(mg/Kg)	5.6	<0.73	na	<0.78	<0.71	<0.65	0.047	<0.007		<0.007	<0.006		**<0.15**	>0.86	
	Sample Depth	(inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	48 - 51	0 - 12	24 - 30		0 - 12	24 - 36	48 - 51	0 - 12	24 - 30	
Mutiny View Manor Community Club	Fluoride	(mg/Kg)	<0.65	<0.65	<0.64	0.76	0.73	1.0	<0.15	<0.022	<0.020	0.15	0.18	0.17	>1.0	**>8.2**	**>8.5**
	Sample Depth	(inches)	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 30	48 - 55
Naches Water treatment	Fluoride	(mg/Kg)	<0.61	<0.59	na	3.7	<1.6	na	nc	nc		nc	nc		nc	nc	
	Sample Depth	(inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	na	0 - 12	24 - 30		0 - 12	24 - 36		0 - 12	24 - 30	
Outlook	Fluoride	(mg/Kg)	<0.64	8.0	5.3	<0.63	<0.68	<0.72	<0.005	0.053	0.038	<0.006	<0.005	<0.005	>1.20	**<0.094**	**<0.13**
	Sample Depth	(inches)	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53
Ridgeview Estates	Fluoride	(mg/Kg)	<0.93	<0.81	na	1.7	1.4	0.92	nc	<0.082		nc	0.25		nc	**>3.0**	
	Sample Depth	(inches)	0 - 8	24 - 33	na	0 - 8	24 - 32	48 - 53	0 - 8	24 - 33		0 - 8	24 - 32	48 - 53	0 - 8	24 - 32	
Westside Water System	Fluoride	(mg/Kg)	<0.70	<0.73	<0.71	2.8	<0.76	na	<0.006	<0.005	nc	0.016	<0.009		**>2.7**	>1.80	
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	na	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36		0 - 12	24 - 36	48 - 53

na = Chemical analysis was not conducted.

Blank cells indicate that no calculation was performed because at least one location lacked a chemical analysis.

nc = Soil in the disposal site is not similar to soil in the background area, based on cation exchange capacity (CEC), and no calculation was performed. See Data Evaluation section for details.

The concentration of total arsenic in the disposal site differed from that in the background area, normalized to CEC. (Second Ratio < 0.50 ; or Second Ratio > 2.0)

Table 11. Nitrate Results from Analyses of Soils

Study Location Name	Parameter		Background Area (BK)			Disposal Site (DS)			Normalized to CEC: Nitrate/CEC BK Ratio			Normalized to CEC: Nitrate/CEC DS Ratio			(NO_3/CEC DS) / (NO_3/CEC BK) Ratio (Second Ratio)		
			Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Bayview Beach	Nitrate	(mg/Kg)	<0.50	na	na	0.57	<0.44	<0.44	nc			nc					
	Sample Depth	(inches)	0 - 10	na	na	0 - 10	24 - 32	48 - 56	0 - 10			0 - 10	24 - 32	48 - 56	0 - 10		
Boxx Berry Farm	Nitrate	(mg/Kg)	2.0	<0.48	<0.47	3.8	0.72	1.8	0.022	<0.006	<0.007	0.035	0.009	0.030	1.5	>1.5	**>4.3**
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60
Bummer #2	Nitrate	(mg/Kg)	<0.53	na	na	<0.47	na	na	<0.004			<0.005			>1.25		
	Sample Depth	(inches)	0 - 8	na	na	0 - 8	na	na	0 - 8			0 - 8			0 - 8		
Coupeville	Nitrate	(mg/Kg)	<0.50	<0.45	<0.44	0.65	<0.46	0.64	<0.021	<0.056	nc	0.050	<0.052	nc	**>2.4**	>0.93	
	Sample Depth	(inches)	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53
Everett Water Filtration	Nitrate	(mg/Kg)	4.5	<0.53	<0.45	<1.3	14	<0.46	nc	<0.005		nc	0.019			**>3.8**	
	Sample Depth	(inches)	3 - 12	24 - 32	48 - 60	0 - 6	0 - 12	22 - 28	3 - 12	24 - 32	48 - 60	0 - 12	22 - 28		3 - 12	24 - 32	
Harbor Hills Water System	Nitrate	(mg/Kg)	<0.51	<0.46	na	<0.56	na	na	<0.051			<0.066			>1.29		
	Sample Depth	(inches)	0 - 8	24 - 30	na	0 - 12	na	na	0 - 8	24 - 30		0 - 12			0 - 8	24 - 30	
Ledgewood Beach Water District	Nitrate	(mg/Kg)	<0.48	<1.0	<0.45	<0.45	<0.42	<0.43	<0.003	nc	<0.063	<0.056	nc	<0.083	**>18.67**		>1.32
	Sample Depth	(inches)	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 8	24 - 32	48 - 51
Lost Lake	Nitrate	(mg/Kg)	<0.52	na	na	<0.62	<0.50	na	nc			nc					
	Sample Depth	(inches)	0 - 10	na	na	0 - 12	24 - 35	na	0 - 10			0 - 12	24 - 35		0 - 10		
Mariners Cove Beach Club	Nitrate	(mg/Kg)	<0.54	na	na	<0.50	<0.49	na	nc			nc					
	Sample Depth	(inches)	0 - 8	na	na	0 - 8	24 - 30	na	0 - 8			0 - 8	24 - 30		0 - 8		
Mission Ranch Estates	Nitrate	(mg/Kg)	<0.52	<0.50	<0.51	<0.55	<0.53	<0.50	<0.005	nc	<0.009	<0.004	nc	<0.009	>0.80		>1.00
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 53
Mountain Road Estates	Nitrate	(mg/Kg)	5.6	<0.51	na	<0.55	<0.49	<0.46	0.047	<0.005		<0.005	<0.004		**<0.11**	>0.80	
	Sample Depth	(inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	48 - 51	0 - 12	24 - 30		0 - 12	24 - 36	48 - 51	0 - 12	24 - 30	
Mutiny View Manor Community Club	Nitrate	(mg/Kg)	<0.46	<0.45	<0.45	<0.47	<0.49	<0.51	<0.10	<0.15	<0.14	<0.094	<0.12	<0.086	>0.94	>0.80	>0.61
	Sample Depth	(inches)	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 32	48 - 56
Naches Water treatment	Nitrate	(mg/Kg)	<0.43	<0.41	na	<1.5	<1.1	na	nc	nc		nc	nc				
	Sample Depth	(inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	na	0 - 12	24 - 30		0 - 12	24 - 36		0 - 12	24 - 30	
Outlook	Nitrate	(mg/Kg)	86	12	52	<0.44	<0.48	<0.50	0.72	0.080	0.371	<0.004	<0.004	<0.004	**<0.006**	**<0.050**	**<0.011**
	Sample Depth	(inches)	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53
Ridgeview Estates	Nitrate	(mg/Kg)	<0.65	2.80	na	<0.58	<0.48	<0.50	nc	0.283		nc	<0.086			**<0.30**	
	Sample Depth	(inches)	0 - 8	24 - 33	na	0 - 8	24 - 32	48 - 53	0 - 8	24 - 33		0 - 8	24 - 32	48 - 53	0 - 8	24 - 33	
Westside Water System	Nitrate	(mg/Kg)	1.0	2.5	0.58	1.5	0.72	na	0.008	0.018	nc	0.009	0.008		1.06	**0.46**	
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	na	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36		0 - 12	24 - 36	48 - 53

na = Chemical analysis was not conducted.

Blank cells indicate that no calculation was performed because at least one location lacked a chemical analysis.

nc = Soil in the disposal site is not similar to soil in the background area, based on cation exchange capacity (CEC), and no calculation was performed. See Data Evaluation section for details.

The concentration of total arsenic in the disposal site differed from that in the background area, normalized to CEC. (Second Ratio < 0.50 ; or Second Ratio > 2.0)

Table 12. Specific Conductance Results from Analyses of Soils

Study Location Name	Parameter		Background Area (BK)			Disposal Site (DS)			Normalized to CEC						(SpCon/CEC DS) / (SpCon/CEC BK) Ratio (Second Ratio)		
									SpecCond/CEC BK Ratio			SpecCond/CEC DS Ratio					
			Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Bayview Beach	Specific Conductance	(µmhos/cm.)	41	na	na	97	28	29	nc			nc			nc		
	Sample Depth	(inches)	0 - 10	na	na	0 - 10	24 - 32	48 - 56	0 - 10			0 - 10	24 - 32	48 - 50	0 - 10		
Boxx Berry Farm	Specific Conductance	(µmhos/cm.)	52	32	26	330	110	76	0.58	0.43	0.38	3.0	1.4	1.2	**5.1**	**3.3**	**3.3**
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60
Bummer #2	Specific Conductance	(µmhos/cm.)	12	na	na	27	na	na	0.086			0.29			**3.4**		
	Sample Depth	(inches)	0 - 8	na	na	0 - 8	na	na	0 - 8			0 - 8			0 - 8		
Coupeville	Specific Conductance	(µmhos/cm.)	82	31	28	73	44	110	3.4	3.8	nc	5.6	5.0	nc	1.6	1.3	nc
	Sample Depth	(inches)	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53
Everett Water Filtration	Specific Conductance	(µmhos/cm.)	64	8.6	7.5	42	29	21	nc	0.078		nc	0.039		nc	**0.49**	
	Sample Depth	(inches)	3 - 12	24 - 32	48 - 60	0 - 6	0 - 12	22 - 28	3 - 12	24 - 32	48 - 60	0 - 12	22 - 28		3 - 12	24 - 32	
Harbor Hills Water System	Specific Conductance	(µmhos/cm.)	27	19	na	43	na	na	2.7			5.1			1.9		
	Sample Depth	(inches)	0 - 8	24 - 30	na	0 - 12	na	na	0 - 8	24 - 30		0 - 12			0 - 8	24 - 30	
Ledgewood Beach Water District	Specific Conductance	(µmhos/cm.)	44	59	29	73	33	32	2.9	nc	4.1	9.0	nc	6.2	**3.1**	nc	1.5
	Sample Depth	(inches)	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 8	24 - 32	48 - 51
Lost Lake	Specific Conductance	(µmhos/cm.)	82	na	na	73	56	na	nc			nc			nc		
	Sample Depth	(inches)	0 - 10	na	na	0 - 12	24 - 35	na	0 - 10			0 - 12	24 - 35		0 - 10		
Mariners Cove Beach Club	Specific Conductance	(µmhos/cm.)	150	na	na	190	150	na	nc			nc			nc		
	Sample Depth	(inches)	0 - 8	na	na	0 - 8	24 - 30	na	0 - 8			0 - 8	24 - 30		0 - 8		
Mission Ranch Estates	Specific Conductance	(µmhos/cm.)	13	10	19	23	24	31	0.12	nc	0.33	0.16	nc	0.53	1.4	nc	1.6
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	48 - 52
Mountain Road Estates	Specific Conductance	(µmhos/cm.)	110	20	na	27	39	31	0.92	0.20		0.23	0.35		**0.25**	1.8	
	Sample Depth	(inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	48 - 51	0 - 12	24 - 30		0 - 12	24 - 36	48 - 51	0 - 12	24 - 30	
Mutiny View Manor Community Club	Specific Conductance	(µmhos/cm.)	14	8.9	8.1	42	27	56	3.2	3.0	2.5	8.4	6.6	9.5	**2.6**	**2.2**	**3.7**
	Sample Depth	(inches)	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 32	48 - 55
Naches Water treatment	Specific Conductance	(µmhos/cm.)	44	20	na	12	69	na	nc	nc		nc	nc		nc	nc	
	Sample Depth	(inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	na	0 - 12	24 - 30		0 - 12	24 - 36		0 - 12	24 - 30	
Outlook	Specific Conductance	(µmhos/cm.)	8,000	1,100	2,600	120	350	180	67	7.3	19	1.1	2.7	1.3	**0.016**	**0.37**	**0.069**
	Sample Depth	(inches)	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	46 - 53
Ridgeview Estates	Specific Conductance	(µmhos/cm.)	120	52	na	110	63	54	nc	5.3		nc	11		nc	**2.1**	
	Sample Depth	(inches)	0 - 8	24 - 33	na	0 - 8	24 - 32	48 - 53	0 - 8	24 - 33		0 - 8	24 - 32	48 - 53	0 - 8	24 - 32	
Westside Water System	Specific Conductance	(µmhos/cm.)	19	33	34	41	39	na	0.16	0.24		0.24	0.44		1.5	1.9	
	Sample Depth	(inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	na	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36		0 - 12	24 - 36	48 - 53

na = Chemical analysis was not conducted.

Blank cells indicate that no calculation was performed because at least one location lacked a chemical analysis.

nc = Soil in the disposal site is not similar to soil in the background area, based on cation exchange capacity (CEC), and no calculation was performed. See Data Evaluation section for details.

The concentration of total arsenic in the disposal site differed from that in the background area, normalized to CEC. (Second Ratio < 0.50 ; or Second Ratio > 2.0)

Table 13. pH Results from Analyses of Soils

Study Location Name	Parameter	Background Area			Disposal Site			Difference in pH Values		
		Top	Middle	Bottom	Top	Middle	Bottom	Top	Middle	Bottom
Bayview Beach	pH (S.U.)	5.50	na	na	7.30	7.46	7.43	1.80		
	Sample Depth (inches)	0 - 10	na	na	0 - 10	24 - 32	48 - 56	0 - 10		
Boxx Berry Farm	pH (S.U.)	6.56	6.15	6.30	6.20	5.64	5.81	-0.36	-0.51	-0.49
	Sample Depth (inches)	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60	0 - 12	24 - 36	48 - 60
Bummer #2	pH (S.U.)	5.95	na	na	7.33	na	na	**1.38**		
	Sample Depth (inches)	0 - 8	na	na	0 - 8	na	na	0 - 8		
Coupeville	pH (S.U.)	6.29	6.47	6.76	7.20	7.61	7.58	0.91	**1.14**	0.82
	Sample Depth (inches)	0 - 12	24 - 30	48 - 53	0 - 12	24 - 32	48 - 54	0 - 12	24 - 30	48 - 53
Everett Water Filtration	pH (S.U.)	4.56	5.23	5.56	5.83	5.83	6.17	1.27	0.60	0.61
	Sample Depth (inches)	3 - 12	24 - 32	48 - 60	0 - 6	0 - 12	22 - 28	0 - 6	0 - 12	24 - 32
Harbor Hills Water System	pH (S.U.)	5.65	6.34	na	5.39	na	na	-0.26		
	Sample Depth (inches)	0 - 8	24 - 30	na	0 - 12	na	na	0 - 8		
Ledgewood Beach Water District	pH (S.U.)	6.58	6.01	7.00	7.66	7.27	7.33	**1.08**	1.26	0.33
	Sample Depth (inches)	0 - 10	24 - 32	48 - 51	0 - 8	24 - 33	48 - 51	0 - 8	24 - 32	48 - 51
Lost Lake	pH (S.U.)	6.98	na	na	6.49	7.08	na	-0.49		
	Sample Depth (inches)	0 - 10	na	na	0 - 12	24 - 35	na	0 - 10		
Mariners Cove Beach Club	pH (S.U.)	6.99	na	na	6.93	6.91	na	-0.06		
	Sample Depth (inches)	0 - 8	na	na	0 - 8	24 - 30	na	0 - 8		
Mission Ranch Estates	pH (S.U.)	6.09	6.51	7.15	6.31	6.47	6.77	0.22	-0.04	-0.38
	Sample Depth (inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	46 - 52	0 - 12	24 - 36	46 - 52
Mountain Road Estates	pH (S.U.)	7.20	5.97	na	5.91	6.03	6.40	**-1.29**	0.06	
	Sample Depth (inches)	0 - 12	24 - 30	na	0 - 12	24 - 36	48 - 51	0 - 12	24 - 30	
Mutiny View Manor Community Club	pH (S.U.)	5.80	6.45	7.04	7.52	7.28	7.08	**1.72**	0.83	0.04
	Sample Depth (inches)	0 - 10	24 - 32	48 - 56	0 - 12	24 - 30	48 - 55	0 - 10	24 - 30	48 - 55
Naches Water treatment	pH (S.U.)	7.28	7.39	na	6.77	6.59	na	-0.51	-0.80	
	Sample Depth (inches)	0 - 12	24 - 31	na	0 - 12	24 - 36	na	0 - 12	24 - 31	
Outlook	pH (S.U.)	8.89	8.95	8.53	8.84	8.08	8.94	-0.05	-0.87	0.41
	Sample Depth (inches)	0 - 8	24 - 31	46 - 53	0 - 12	24 - 36	48 - 54	0 - 8	24 - 31	48 - 53
Ridgeview Estates	pH (S.U.)	4.09	4.13	na	6.95	7.16	7.02	2.86	**3.03**	
	Sample Depth (inches)	0 - 8	24 - 33	na	0 - 8	24 - 32	48 - 53	0 - 8	24 - 32	
Westside Water System	pH (S.U.)	5.42	5.50	5.84	6.63	6.43	na	**1.21**	0.93	
	Sample Depth (inches)	0 - 12	24 - 36	48 - 53	0 - 12	24 - 36	na	0 - 12	24 - 36	

na = Chemical analysis was not conducted.

The pH of the soil in the disposal site was more than 1.0 S.U. greater than the pH of the soil in the background area.

The pH of the soil in the background area was more than 1.0 S.U. greater than the pH of the soil in the disposal site.

Soil in the disposal site is not similar to soil in the background area, based on cation exchange capacity (CEC), calculation was performed, but may not be valid.
See Data Evaluation section for details.

Blank cells indicate that no calculation was performed because at least one location lacked a chemical analysis.

Red Text values in the Difference columns indicates the background area has a higher pH than the disposal site.

Note: The relative values of pH differences are not directly comparable. For example, the difference between pH values of 5.00 and 6.00 is not the same as the difference between pH values of 7.00 and 8.00.

Table 14. Differences between Normalized Contaminant Concentrations in Background Area versus Disposal Site Soils

Study Location Name	Total Arsenic	Total Barium	Total Iron	Total Manganese	Total Sodium	Chloride	Fluoride	Nitrate	Specific Conductance	pH	Totals
Bayview Beach											
Boxx Berry Farm	**+**	**–**		**+**		**+ + +**		**+**	**+ + +**		**9 +, 1 –**
Bummer #2					**+**				**+**	**+**	**3 +**
Coupeville					**+**	**+**	**+**	**+**		**+**	**5 +**
Everett Water Filtration		**–**	**–**	**–**				**+**	**–**		**1 +, 4 –**
Harbor Hills Water System						**+**					**1 +**
Ledgewood Beach Water District	**+**	**+**		**+**			**+**		**+**	**+**	**6 +**
Lost Lake											
Mariners Cove Beach Club											
Mission Ranch Estates						**+**					**1 +**
Mountain Road Estates		**–**			**–**		**–**	**–**	**–**	**–**	**6 –**
Mutiny View Manor Community Club							**+ +**		**+ + +**	**+**	**6 +**
Naches Water Treatment											
Outlook			**–**	**–**	**– – –**	**– – –**	**– –**	**– – –**	**– – –**		**16 –**
Ridgeview Estates	**+**		**+**	**+**			**+**	**–**	**+**	**+**	**6 +, 1 –**
Westside Water System	**+ +**						**+**	**–**		**+**	**4 +, 1 –**
Totals =	**5 +**	**1 +, 3 –**	**1 +, 2 –**	**3 +, 2 –**	**2 +, 4 –**	**6 +, 3 –**	**6 +, 3 –**	**3 +, 6 –**	**9 +, 5 –**	**6 +, 1 –**	

An impact was apparent of the backwash wastewater on the disposal site soil for either the indicated WTP or parameter (sometimes both).

Differences are shown for only those comparisons where the ratio between disposal site and background were less than 0.5 or greater than 2.0.

+ = Average normalized result in the disposal site was greater than that in the background area.

– = Average normalized result in the disposal site was less than that in the background area.

Table 15. Differences among Normalized Contaminant Concentration Ratios in Impacted Disposal Site Soils by Depth

Study Location Name	Depth	(Result/CEC DS) / (Result/CEC BK) Ratio					
		Total Arsenic (mg/kg)	**Total Sodium (mg/kg)**	**Chloride (mg/kg)**	**Fluoride (mg/kg)**	**Nitrate (mg/kg)**	**Specific Conductance (µmhos/cm of extract)**
Boxx Berry Farm	Top	--	--	>24	--	--	5.1
	Middle	--	--	>3.3	--	--	3.3
	Bottom	--	--	>2.4	--	--	3.3
Mutiny View Manor Community Club	Top	--	--	--	na	--	2.6
	Middle	--	--	--	>8.2	--	2.2
	Bottom	--	--	--	>8.5	--	3.7
Outlook	Top	--	<0.05	<0.011	na	<0.006	0.016
	Middle	--	<0.22	0.35	<0.094	<0.050	0.37
	Bottom	--	0.19	<0.037	<0.13	<0.011	0.069
Westside Water System	Top	6.4	--	--	--	--	--
	Middle	2.3	--	--	--	--	--
	Bottom	na	--	--	--	--	--

Values are those "Second Ratios" from Tables 4 through 12, where disposal site soils may have been affected at multiple depths by wastewater discharges. Comparable data existed for only these six parameters and four study locations.

Top = Soil samples from 0 to 8, 0 to 10, or 0 to12 inches depth.

Middle = Soil samples from 24 to 30, 24 to 31, 24 to 32, or 24 to 36 inches depth.

Bottom = Soil samples from 46 to 53, 48 to 53, 48 to 54, 48 to 55, 48 to 56, or 48 to 60 inches depth.

na = Either the disposal site soil was not similar to the background area soil (based on the cation exchange capacities), or an insufficient difference existed between the normalized concentrations from the background area versus the disposal site.

Table 16. Correspondence between Filter Backwash Wastewater

Parameter	Depth-Specific Comparisons (use each soil sample)		WTP-Specific Comparisons (average all available depths)	
	Number of Data Pairs	Significant Association? (α = 0.05)	Number of Data Pairs	Significant Association? (α = 0.05)
Total Arsenic	18	No	10	No
Total Barium	22	No	11	No
Total Iron	22	No	11	No
Total Manganese	22	No	11	No
Total Sodium	18	No	11	No
Chloride	12	No	7	No
Fluoride	17	No	10	No
Nitrate	12	No	7	No
Specific Conductance	23	No	12	No
pH	23	No	12	No

Comparisons between the available Second Ratios of the soil data, normalized to cation exchange capacity, versus the corresponding available backwash wastewater concentrations.

Second Ratios or pH differences are provided in Tables 3 through 13.

Associations were assessed with Kendall's coefficient of concordance.

Appendix A.
Results from Preliminary Survey

Sampled Facilities

System Name	Contact Person	Survey Question 1 Treatment System	Survey Question 2 Backflush?	Survey Question 3 Discharge to?	Survey Question 4 Source Issues	Survey Question 5 Connections	Survey Question 6 Discharge Rate	Survey Question 7 Start Year	Survey Question 8 Access?	Survey Question 9 Address	Comments
Bayview Beach	Andy Campbell	Unknown							Yes	Intersection of Useless Bay Ave and SR 525 Freeland	
Boxx Berry Farm	Bill Boxx	Ion Exchange		Initially: French drain (gravel-filled trench) Currently: Grassy surface (lawn).	NO_3	4		~ 2008	Yes	6211 NW Road Ferndale	Recommended by John Thielemann, Whatcom County DOH.
Bummer #2	John Calhoon	AdEdge Adsorption	Yes	Grassed ground surface near well house	As	4	Once / 20 days	June 2007	Yes	24130 NE Woodinville-Duvall Road Woodinville	Consists of a sand "reactor" (filter) where arsenic reacts with ferric chloride, HCl, and chlorine.
Coupeville (Fort Casey Well field)	Malcom Bishop	Pressure Sand Filtration	Yes	Small pond with overflow to a grass swale	As, Fe, Mn, Cl	1,000+	220K gal/month Cycles every 20 hours	1999	Yes	434 W Wanamaker Road Coupeville	Step 1: Chlorination; Step 2: Aeration; Step 3: "BERM" process (positive Fe and Mn ions attach to negative particles in filter). One 63-inch ozone contact tank and two 63-inch ozone filters (200 gpm). Recommended by Erika Peterson, Island County DOH.
Everett Water Filtration	Del Nestegard	Anthracite Coal Filter	Yes	Five acres with a lagoon	Cl, F		4 to 5 cycles / day 170K to 200K gal / cycle	1983 to 1984	Yes	6133 Lake Chaplain Road Monroe	Polymer coagulates and settles solids in lagoon. Reprocess liquid through plant. Bag and dispose of solids off site.
Harbor Hills Water System	Andy Campbell	Unknown				400				1207 Antelope Drive, Freeland	
Ledgewood Beach Water District	Ms. Jan Martin Bill Bradkin	Ozonation & Aeration	Yes	Ditch	Fe, Mn	134	1,900 gal / discharge	2000	Yes	1904 Pincrest Coupeville	Aeration followed by 36-inch ozone contact tanks and two 36-inch ozone filters (67 gpm). Recommended by George Bratton.
Lost Lake	Omero Vargas	Ozonation	Yes	Unlined pond overflows to a catch basin and then to a county ditch	Fe, Mn	385		1999	Yes	1478 Lake Drive Camano Island	Two 48-inch ozone contact tanks and four 48-inch ozone filters (240 gpm). Recommended by George Bratton.
Mariners Cove Beach Club	Mike Nettles	Green Sand Filtration	Yes	Grass-lined county ditch	Fe, Mn	158	1,800 gal / 3 times per week	1966 with 1999 upgrade	Yes	2170 Polnell Road Oak Harbor	One 30-inch ozone contact tank and three 30-inch ozone filters (69 gpm). Double septic system to settle solids.
Mission Ranch Estates	Richard Bradley	Reverse Osmosis	Yes	Grassed ground area (lawn)	Cl, F	5		~ 2008	Yes	4960 Mission Road Bellingham	⅔ of backwash water is flushed; and ⅓ is sent back through process. Recommended by John Thielemann, Whatcom County DOH.
Mountain Road Estates	Laurie Thompson Corey Thompson	Anthracite Coal Filter			As, Odor, Taste	4		~ 2005	Yes	1840 Squalicum Mountain Road Bellingham	Activated carbon filtration. Recommended by John Thielemann, Whatcom County DOH.
Mutiny View Manor Community Club	Andy Campbell	Green Sand Filtration			Fe, Mn	73		1995	Yes	Intersection of Manor Way and Mountain View Lane, Freeland	One 36-inch ozone contact tank and two 36-inch ozone filters (67 gpm). Recommended by George Bratton.
Naches Water treatment		Unknown								Yakima County	
Outlook		Unknown								Outlook	
Ridgeview Estates	Andy Campbell	Green Sand Filtration	Yes		Fe, Mn	32		2003	Yes	2370 Goss Ridge Road, Freeland	Aeration followed by one 24-inch ozone contact tank and two 24-inch ozone filters (30 gpm). Recommended by George Bratton.

System Name	Contact Person	Survey Question 1 Treatment System	Survey Question 2 Backflush?	Survey Question 3 Discharge to?	Survey Question 4 Source Issues	Survey Question 5 Connections	Survey Question 6 Discharge Rate	Survey Question 7 Start Year	Survey Question 8 Access?	Survey Question 9 Address	Comments
Westside Water System	Doug Dolstad Scott Derky	BERM, Oxidation, & Filtration	Yes	Unlined earthen ditch	As	225	600 gal backwash / 40K gal product		Yes	Colvos Passage Vashon Island	Seasonal during the summer

Facilities Reserved for Possible Future Assessment

System Name	Contact Person	Survey Question 1 Treatment System	Survey Question 2 Backflush?	Survey Question 3 Discharge to?	Survey Question 4 Source Issues	Survey Question 5 Connections	Survey Question 6 Discharge Rate	Survey Question 7 Start Year	Survey Question 8 Access?	Survey Question 9 Address	Comments
Dugualla Community	Steven Spring		Yes	Unlined pond	Fe, Mn	204		~ 2008	Yes	Emory Trail and Birch Oak Harbor	Recommended by Erika Peterson, Island County DOH.
Isle Aire Beach Association	Art Hole			Ground or a french drain	As	64		~ 2009		Lummi Island	
Lake Terrell - Mobile Ranch	Joe Freeman			Ground near pump house	As	18		~ 2009		Lake Terrell	
Mabana Shores	Bruce Miller	Pressure Sand Filtration	Yes		Fe, Mn	42		2001	Yes		Aeration followed by one 24-inch ozone contact tank and two 24-inch ozone filters (30 gpm). Recommended by George Bratton.
Marine View Estates	John Kelly				As	12				Lummi Island	Empty Cell
Mount Vernon Water Plant	George Atkinson Jamie LeBlanc	Multi-Media Filter	Yes	One of three lagoons	Turbidity		60K to 80K gal / 30 to 72 hours Rinse 2 filters / day	1992	Yes	14489 Riverbend Road Mount Vernon	Six filters with coal, sand, and garnet sand. Remove settled solids by scraping down to clean sand (3,600 cu yd in 2009).
Saratoga Shores	Bruce Miller	Pressure Sand Filtration	Yes		Fe, Mn	39		February 1999	Yes		Aeration followed by one 24-inch ozone contact tank, two 24-inch ozone filters (30 gpm), and a finish pass through a pressurized sand filter. Recommended by George Bratton.

Facilities Who Declined to Participate

System Name	Contact Person	Survey Question 1 Treatment System	Survey Question 2 Backflush?	Survey Question 3 Discharge to?	Survey Question 4 Source Issues	Survey Question 5 Connections	Survey Question 6 Discharge Rate	Survey Question 7 Start Year	Survey Question 8 Access?	Survey Question 9 Address	Comments
Brutus	Carl Garrison Jerry Canaday	Iron Chloride & Filtration			As, Fe, Mn	30		October 2009	No	Camano Island	Ferric chloride to remove arsenic. Recommended by Erika Peterson, Island County DOH.
Camano City Community Club	Bob Hubert	Not installed yet		Backwash pond	As, Fe, Mn, Hardness	158			No	Camano Island	Recommended by Erika Peterson, Island County DOH
Fall City Water District, Rutherford	Terri Divers	ATEC Media Filter	Yes	Infiltration to ground	As, Mn	21		November 1993	No	33015 SE 43rd Street Fall City	Newer system online for ~1 year
Maberry Packing, Inc.	Maureen Maberry	Reverse Osmosis (Ion Exchange)	Yes		NO_3				No	Whatcom County	

Facilities Who Provided Too-Limited Responses

System Name	Contact Person	Survey Question 1 Treatment System	Survey Question 2 Backflush?	Survey Question 3 Discharge to?	Survey Question 4 Source Issues	Survey Question 5 Connections	Survey Question 6 Discharge Rate	Survey Question 7 Start Year	Survey Question 8 Access?	Survey Question 9 Address	Comments
DMS Water Association	Cary Clemenson	Reverse Osmosis			As and others						Recommended by John Thielemann, Whatcom County DOH
Harris Custer Estates					Cu, Pb, Mn, SO_4					Oak Harbor	
Lemieux	William Byrd				Cl					King County	Recommended by Bill Lasby, South King County Health District
Miller Water System	Thomas Miller				As, SO_2	4					Recommended by John Thielemann, Whatcom County DOH
Reidt, Charles	Wes Wood				Cl					King County	Recommended by Bill Lasby, South King County Health District
Relwof Water System	John Fowler	Chlorine & Iron Chloride			As					King County	Recommended by Bill Lasby, South King County Health District
Seawest	Clive Defty					28					Recommended by Erika Peterson, Island County DOH
Useless Bay Shores					Fe, Mn	26				Camano Island	Recommended by Erika Peterson, Island County DOH

Facilities Not Selected for This Study

System Name	Contact Person	Survey Question 1 Treatment System	Survey Question 2 Backflush?	Survey Question 3 Discharge to?	Survey Question 4 Source Issues	Survey Question 5 Connections	Survey Question 6 Discharge Rate	Survey Question 7 Start Year	Survey Question 8 Access?	Survey Question 9 Address	Comments
123rd Avenue Water System	Arthur Stutsman				Fe, Mn	4				Lake Stevens	Chlorination and filtration.
Alpine West Water	Thomas & Lisa Stimach				Mn					King County	Recommended by Bill Lasby, South King County Health District
Autumn Lane Mobile Home Park	Douglas Wright					14				Whatcom County	Recommended by John Thielemann, Whatcom County DOH
Backwater Co-op	Pete & Lynne Holderbein				As					King County	Recommended by Bill Lasby, South King County Health District
Beau Lodge Water System	Mary Elmore	Aeration / Filtration			Fe, Mn					Skagit County	Recommended by Nancy Feagin, Skagit County DOH.
Berg, Herb	Eric Fosnes	Filtration			Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Bill Wright Water System	Kenneth McCoy	Ozonation			Fe, Mn	3				Snohomish County	
Blanchard Edison Water System	Dave Lohman	Aeration / Filtration			Fe, Mn					Skagit County	Recommended by Nancy Feagin, Skagit County DOH.
Blomgren Water	Robert Blomgren				Fe					King County	Recommended by Bill Lasby, South King County Health District
Bremerton Ski Cruisers	Brad Ulrich	UV Light & Cartridge Filter								King County	Recommended by Bill Lasby, South King County Health District
Brown, Don	Donald Brown				Fe					King County	Recommended by Bill Lasby, South King County Health District

System Name	Contact Person	Survey Question 1 Treatment System	Survey Question 2 Backflush?	Survey Question 3 Discharge to?	Survey Question 4 Source Issues	Survey Question 5 Connections	Survey Question 6 Discharge Rate	Survey Question 7 Start Year	Survey Question 8 Access?	Survey Question 9 Address	Comments
Burnett Landing III	Joe Mills	Oxidation / Filtration								Pierce County	Recommended by Todd Krause, NW Water Systems.
Bush Point	Carl Garrison				As, Fe, Mn					South Whidbey Island	Ferric chloride to remove arsenic.
Canyon Creek Tracts Water System	Patrick Belt				Fe, Mn	8				Marysville	
Carlin, H.	James Volkman				Mn					King County	Recommended by Bill Lasby, South King County Health District
Cedar Rapids Grocery	George McCall				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Cherry Valley Water Association	Frank Winfield				Specific Conductivity					King County	Recommended by Bill Lasby, South King County Health District
Chuckanut Manor Restaurant	Pat Woolcock	Ion Exchange			Fe, Mn					Skagit County	Recommended by Nancy Feagin, Skagit County DOH.
Country Manor	Fred Woolley				Mn					King County	Recommended by Bill Lasby, South King County Health District
Country Meadows Water Association	Richard Emery				Fe, Mn	2				Arlington	
Cruisin NW Ltd	Scott Donaldson				Mn					King County	Recommended by Bill Lasby, South King County Health District
Davis/Watt	Jim & Kelly Watt				Na					King County	Recommended by Bill Lasby, South King County Health District
Decorah	Doug Hoffman				Fe					King County	Recommended by Bill Lasby, South King County Health District
Desalvo	Nate Brown				Fe					King County	Recommended by Bill Lasby, South King County Health District
Dick #1	Jodi Spitalli				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Dora Wyakes Water Association	John Shields				Fe, Mn	9				Marysville	aka: Algo Water System
Drllevich #2	Ken Carlton	Water Softener & Brine Tank								King County	Recommended by Bill Lasby, South King County Health District
East Lake Alice	Bud Cooper				Mn					King County	Recommended by Bill Lasby, South King County Health District
Eckhardt	Steve Jacobson				Mn					King County	Recommended by Bill Lasby, South King County Health District
Elzea Water System	Bob Elzea				Fe, Mn	5				Snohomish County	
Enterprise Estates Water Association	Wayne Braun									Whatcom County	Recommended by John Thielemann, Whatcom County DOH
Everett / Culliton	Richard Everett				Fe					King County	Recommended by Bill Lasby, South King County Health District
Everett Ski Club, Inc	Thomas Eckstrom	UV Light & Cartridge Filter								King County	Recommended by Bill Lasby, South King County Health District

System Name	Contact Person	Survey Question 1 Treatment System	Survey Question 2 Backflush?	Survey Question 3 Discharge to?	Survey Question 4 Source Issues	Survey Question 5 Connections	Survey Question 6 Discharge Rate	Survey Question 7 Start Year	Survey Question 8 Access?	Survey Question 9 Address	Comments
Febus	Wayne & Lorrie Febus									King County	Recommended by Bill Lasby, South King County Health District
Ferndale Mobile Village	Jim Elliott									Whatcom County	Recommended by John Thielemann, Whatcom County DOH
Ferndale	Richard Blair			Drying beds						Whatcom County	Recommended by John Thielemann, Whatcom County DOH
Fletcher	Jeff & Denise Emtman									King County	Artesian system. Recommended by Bill Lasby, South King County Health District
Freshwater	Don Hein	Ion Exchange								Kitsap County	Recommended by Todd Krause, NW Water Systems.
Gooch-Rakwanna	Larry Rowland				Mn					King County	Recommended by Bill Lasby, South King County Health District
Grandridge	John Ravagni				Mn					King County	Recommended by Bill Lasby, South King County Health District
Hammersley	Kim Delaney	Ion Exchange								Mason County	Recommended by Todd Krause, NW Water Systems.
Hansens Landing	Kulpreet Rana	Cation / Anion Exchange								Kitsap County	Recommended by Todd Krause, NW Water Systems.
Harder	Dave Harder				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Harmony	Larry King				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Havekost	M. K. Havekost				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
HBR Water System	Mark & Debra Nelson				Fe, Mn	6				Monroe	
Hemmi Road Water Association	John Harding									Whatcom County	Recommended by John Thielemann, Whatcom County DOH
High Valley Well	John House				Fe					King County	Recommended by Bill Lasby, South King County Health District
Hiland, A.	Don Early				Mn					King County	Frequent bacteria contamination. Recommended by Bill Lasby, South King County Health District
Hinton Estates #4 Water System	Lorraince Hinton				Fe, Mn	2				Lynnwood	
Hinton Estates #6 Water System	Lorraince Hinton				Fe, Mn	3				Lynnwood	
Hollenbeck, C.	Charles Hollenbeck				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Holm	Eric Holm	Oxidation / Filtration								Kitsap County	Recommended by Todd Krause, NW Water Systems.
Holm 2	Eric Holm	Oxidation / Filtration								Kitsap County	Recommended by Todd Krause, NW Water Systems.
Holmes, E. W.	Bill Rumburg									King County	Shallow spring. Recommended by Bill Lasby, South King County Health District

System Name	Contact Person	Survey Question 1 Treatment System	Survey Question 2 Backflush?	Survey Question 3 Discharge to?	Survey Question 4 Source Issues	Survey Question 5 Connections	Survey Question 6 Discharge Rate	Survey Question 7 Start Year	Survey Question 8 Access?	Survey Question 9 Address	Comments
Kismet	Mike Brewer				Fe, Mn, Salinity					Pierce County	Recommended by Todd Krause, NW Water Systems.
Kitsap PUD	Virpi Salo-Zieman										
Kramer, Griswold, et. al.	Peter Zenack				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Lake Meridian Estates Water System	Mary Gere	AdEdge Adsorption	Yes	Storm drain						Lake Meridian	
Lindberg, P.	Paul Lindberg				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Long House Water Association	Frank Brese				Mn					King County	Recommended by Bill Lasby, South King County Health District
LWWSD - Agate Heights	James Neher									Whatcom County	Recommended by John Thielemann, Whatcom County DOH
Lynch Road View Tracts	Rodney Richards	Ion Exchange								Kitsap County	Recommended by Todd Krause, NW Water Systems.
Mantheys Country Mobile Park	John Kuntz									Whatcom County	Recommended by John Thielemann, Whatcom County DOH
Maple Hill Water System	Carl Garrison	Anion Exchange	Yes	Drain field or ditch	NO_3					Oak Harbor	Uses ~3,500 lbs of salt / year.
Mason Farm	Roger Brown	Chlorinator, Unidose								King County	Recommended by Bill Lasby, South King County Health District
Maxwell, D.	Jerry Casper				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Meadowlake Water Treatment	Jim Repp									Pierce County	Recommended by Todd Krause, NW Water Systems.
Midnight	Larry & Jennifer Clay				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Moore-Peterson Water System	Craig Schuck				Fe, Mn	8				Bothell	
Mountain View Water Association	Ken Robinson				Fe, Mn	5				Arlington	
Mountaineers, Stevens Lodge	Scott Eby	UV Light & Cartridge Filter								King County	Recommended by Bill Lasby, South King County Health District
Mutiny Sands Club	Andy Campbell	Green Sand Filtration				65		1997		Freeland	One 36-inch ozone contact tank and two 36-inch ozone filters (67 gpm). Recommended by George Bratton.
North Perry	Virpi Salo-Zieman										
Norvold Arden Anderson	Paul Swartz				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Peace Arch Factory Outlet	Kevin Burke				NO_3					Whatcom County	Recommended by John Thielemann, Whatcom County DOH
Penguin Ski Club	Bruce Byers	UV Light & Cartridge Filter								King County	Recommended by Bill Lasby, South King County Health District
Perrow Community	Greg Pickles				Mn					King County	Recommended by Bill Lasby, South King County Health District
Peter Johnson Community System	Sandra Hansen				Mn					King County	Recommended by Bill Lasby, South King County Health District

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Pole Road Water Association	Dave Olson									Whatcom County	Recommended by John Thielemann, Whatcom County DOH
Potlach	Greg Peterka	Reverse Osmosis								Guemes Island	Recommended by Nancy Feagin, Skagit County DOH.
Raven's Reach	Kelly Winn	Oxidation / Filtration								Kitsap County	Recommended by Todd Krause, NW Water Systems.
Redwood	Shelly Riley				Turbidity					Washington Water Services King County	Recommended by Bill Lasby, South King County Health District
Reedal, S.	Linda Reedal	Chlorination								King County	Recommended by Bill Lasby, South King County Health District
Ridgeview	Leonard Law				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Rocky Ridge	Adele Strom	Multi-Layer Filter			Turbidity					King County	Recommended by Bill Lasby, South King County Health District
Sedgewick HOA	Debbie Abbott	Ion Exchange								Kitsap County	Recommended by Todd Krause, NW Water Systems.
Sepanen	Loren Knudsen				Mn					King County	Recommended by Bill Lasby, South King County Health District
Short Plat 139-79 Water System	Dan Mattson				Fe	3				Arlington	
SI Shadow System	Larry & Jennifer Clay				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Skagit PUD - Alger	Greg Peterka				Fe, Mn					Skagit County	Recommended by Nancy Feagin, Skagit County DOH.
Skagit PUD - Cedar Grove	Greg Peterka				Fe, Mn					Skagit County	Recommended by Nancy Feagin, Skagit County DOH.
Skagit PUD - Rockport	Greg Peterka				Fe, Mn					Skagit County	Recommended by Nancy Feagin, Skagit County DOH.
Sky Valley Church of the Nazarene	James Cornell				Fe, Mn	2				Startup	Softener for iron and manganese.
South Bainbridge Water Systems	Virpi Salo-Zieman										
Spiketon Springs	Karen George	Oxidation / Filtration								Pierce County	Recommended by Todd Krause, NW Water Systems.
Stabbert-Gunn	Reba Brennan				Fe, Mn					King County	Recommended by Bill Lasby, South King County Health District
Sunrise Hills Community	Andy Campbell		Yes	Ground surface	Fe, Mn	70		2006	No	Oak Harbor	One 36-inch ozone contact tank and two 36-inch ozone filters (67 gpm). Recommended by George Bratton.
Tiger Vista	John Cool				Mn					King County	Recommended by Bill Lasby, South King County Health District
Tokul Creek Hatchery	Debi Saudiez				Mn					King County	Recommended by Bill Lasby, South King County Health District
Uplands II	Steven Herman				Mn					King County	Recommended by Bill Lasby, South King County Health District

System Name	Contact Person	Survey Question 1 Treatment System	Survey Question 2 Backflush?	Survey Question 3 Discharge to?	Survey Question 4 Source Issues	Survey Question 5 Connections	Survey Question 6 Discharge Rate	Survey Question 7 Start Year	Survey Question 8 Access?	Survey Question 9 Address	Comments
Van Oeveren	Barbara van Oeveren				Mn					King County	Recommended by Bill Lasby
Van Zandt Community Hall	Amy Margolis				Fe, Mn	1				Whatcom County	Recommended by John Thielemann, Whatcom County DOH
Vitamin R	Mark Lingen				Fe					King County	Recommended by Bill Lasby, South King County Health District
Walter Water System	Robert Raduziner				Fe, Mn	3				Granite Falls	
Washington Water Service Company	Virpi Salo-Zieman										
Webster Community	Larry Kadeg				Fe					King County	Recommended by Bill Lasby, South King County Health District
West Sound Utility	Virpi Salo-Zieman										
Wingsness Acres	Terry Crow				Fe					King County	Recommended by Bill Lasby, South King County Health District
Wingsness Acres Water	Terry Crow				Mn					King County	Recommended by Bill Lasby, South King County Health District
Young's: Larson Road Water System	Andy Campbell		No	No discharge	As						Backwash is reused.
	Tom Jensen	Anthracite / Sand Filter	Yes	Leaky lined pond ~ 800 sq feet by 2 feet deep		27	300 gal / 2 to 3 days	1998		Auburn	Seasonal impact on backwash volume. Backwash runs brown for first 30 seconds, then clears up.

Question 1: What type of filtering method (or system) do you use? (e.g., reverse osmosis (RO), ion exchange (IX), or else please describe)

Question 2: Do you back flush the filtered water?

Question 3: If answer to Question 2 is "Yes": Where do you discharge the filtered backwash wastewater? (e.g., sanitary sewer, lined or unlined lagoon or pond, bioswale, grass-lined ditch, septic system, storm drain, or other land application area?

Question 4: What are the target contaminants being removed from the source water? (e.g., arsenic, iron, manganese, or chloride)

Question 5: How many homes are connected to the water system?

Question 6: What is the average backwash discharge rate or volume? (e.g., gallons per day per month for volume; gallons per minute for rate)

Question 7: How long has the water system been in operation?

Question 8: Would the operator be willing to allow Ecology to sample their system?

Question 9: What is the location and address of the water system?

Appendix B. Units of Measure, and Definitions Report Template

Acronyms & Abbreviations

As	Arsenic
Ba	Barium
BK	Background area
CEC	Cation exchange capacity
Cl	Chloride
DOH	Washington State Department of Health
DS	Disposal site
Ecology	Washington State Department of Ecology
F	Fluoride
Fe	Iron
HCl	Hydrochloric acid
IX	Ion exchange
Mn	Manganese
Na	Sodium
na	Not analyzed
nc	Not calculated
NO_3	Nitrate
NO_3-N	Nitrate nitrogen
QAPP	Quality assurance project plan
RO	Reverse osmosis
SO_2	Sulfite
SO_4	Sulfate
UV	Ultraviolet
WAC	Washington Administrative Code
WTP	Water treatment plant

Units of Measure

°C	Degrees Celsius
cu yd	Cubic yards
Gm	Gram
gpm	Gallons per minute
meq	Milliequivalents
mg	Milligram
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
µg/L	Micrograms per liter
S.U.	Standard units
µmhos/cm	Micromhos per centimeter

Definitions

Activity: A discernible set of related actions or processes conducted within a facility, operation, or site. Examples include, but are not limited to, construction; manufacturing; production or use of raw materials, products, or wastes; transportation; and cleanup or treatment of machinery, structures, land, or water. See Action, Facility, Operation, Treatment, and Waste.

Background: The biological, chemical, physical, and radiological condition that exists in the absence of any human influences.

Beneficial use: Use of waters of the State of Washington, which includes, but is not limited to, domestic consumption, stock watering, industrial, commercial, agricultural, irrigation, mining, fish and wildlife maintenance and enhancement, recreation, generation of electric power, and preservation of environmental and aesthetic values, and all other uses compatible with the enjoyment of waters of the State. See Waters of the State.

Carcinogen: Any substance or agent that produces or tends to produce cancer in humans. The term carcinogen applies to substances on the U.S. Environmental Protection Agency lists of A (known human) and B (probable human) carcinogens, and any substance which causes a significant increased incidence of benign or malignant tumors in a single, well conducted animal bioassay, consistent with the weight of evidence approach specified in the U.S. Environmental Protection Agency Guidelines for Carcinogenic Risk Assessment.

Clean Water Act: The primary Federal law in the United States governing water pollution, with the objective to restore and maintain the chemical, physical, and biological integrity of the nation's waters by preventing point and nonpoint pollution sources, providing assistance to publicly owned treatment works for the improvement of wastewater treatment, and maintaining the integrity of wetlands. (Public Law 92-500, as amended by Public Laws 95-217, 95-576, 96-483, 97-117, and 100-4; USC 1251, et seq.)

Composite sample: An homogenous mixture of material that reasonably characterizes the nature or quality of a monitored discharge or environmental medium that varies over time or space. Creation of the sample from a temporally varying source (e.g., a wastewater stream) may involve continuous sampling or collection of discrete samples and their combination on a "time-composited" or "flow-proportional" basis. A time-composited sample consists of identical volumes of wastewater collected from constant time intervals. A flow-proportional sample may consist of a combination of either variable sample volumes collected over constant time intervals or constant sample volumes collected over variable sampling intervals, proportional to the stream flow. Samples must be collected and stored in accordance with the procedures prescribed in Standard Methods for the Examination of Water and Wastewater. See Discharge and Discrete sample.

Contaminant: Any biological, chemical, physical, or radiological substance that does not occur naturally in a given environmental medium or that occurs at concentrations greater than those in the natural or background conditions. See Background and Natural condition.

Control:

1. To direct, oversee, supervise, manage, perform, or give instruction about any decision, action, or operation of the specific facility, operation, site, waste stream, or other object "under control."
2. To eliminate some individuals of a species from a geographical feature or other defined area.

See Action, Facility, and Operation.

Criteria: The numeric values and the narrative standards that represent contaminant concentrations which are not to be exceeded in the receiving environmental media (surface water, ground water, sediment) to protect beneficial uses. See Beneficial use, Contaminant, Groundwater, Sediment, and Surface water.

Discharge (the noun form is the same as Effluent):

1. To release or add material to waters of the State.
2. The material discharged, including surface runoff that has been collected or channeled by man.

See Runoff and Waters of the State.

Discharge to groundwater: To release water into an unlined impoundment or onto the surface of the ground that allows the discharged water to percolate, or potentially percolate, to ground water. Discharge to ground water, discharge to land, and discharge to ground all have the same meaning. See Discharge and Groundwater.

Discharger: An owner or operator of any activity, facility, or operation subject to regulation under Chapter 90.48 RCW or the Federal Clean Water Act. See Activity, Clean Water Act, Facility, and Operation.

Discrete sample (same as Grab sample): An individual sample collected on a one-time basis from a continuous or intermittent stream without consideration of flow or time.

Disturbed area: Any area where activity has physically disrupted, compacted, moved, or otherwise altered the characteristics of soil, bedrock, vegetation, or existing topography, including activity in preparation for surface mining, the construction of structures, or mobilization of processing equipment. See Activity.

Effluent (same as the noun form of Discharge): Material (usually an aqueous liquid) added or released to waters of the State of Washington, including surface runoff that has been collected or channeled by man. See Runoff and Waters of the State.

Entity: Any person or organization, including, but not limited to: cities, counties, municipalities, Indian tribes, public utility districts, public health districts, port authorities, mosquito control districts, special purpose districts, irrigation districts, state and local agencies, companies, firms, corporations, partnerships, associations, consortia, joint ventures, estates, industries, commercial pesticide applicators, licensed pesticide applicators, and any other commercial, private, public, governmental, or non-governmental organizations, or their legal representatives, agents, or assignees.

Erosion: The detachment and movement of soil or rock fragments and the wearing away of the land surface by precipitation, running water, ice, wind, or other geological agents, including processes such as gravitational creep.

Facility: The physical premises within a site (including the land, water, structures, and appurtenances) where an activity or operation occurs. See Activity, Operation, and Site.

General permit: A single permit that covers multiple characteristically similar dischargers of a point source category within a designated geographical area, in lieu of many individual permits that are issued separately to each discharger. See Discharger, Individual permit, Permit, and Point source.

Grab sample (same as Discrete sample): An individual sample collected on a one-time basis from a continuous or intermittent stream without consideration of flow or time.

Groundwater: The water located in a saturated zone or stratum beneath the surface of the land or below a surface water body. Groundwater is a water of the State of Washington and includes interflow, which is a type of perched water, and water in all other saturated soil pore spaces and rock interstices, whether perched, seasonal, or artificial. Although underground water within the vadose zone (unsaturated zone) also is a type of groundwater, the Washington State ground-water quality standards do not specifically protect soil pore water or soil moisture located in the vadose zone. See Interflow, Saturated zone, Surface water, Vadose zone, Water quality standard, and Waters of the State.

Group A water system: Public supplier of water that regularly serves 15 or more service connections or 25 or more people per day for 60 or more days per year.

Group B water system: Public supplier of water that serves fewer than 15 service connections and less than 25 people per day or that serves 25 or more people per day during fewer than 60 days per year.

Individual permit: A permit that covers only a single point source discharger. See Discharger, Permit, and Point source.

Interflow: Water derived directly from rainfall or snowmelt that percolates into the shallow soil, travels laterally through the soil near the land surface, and subsequently either seeps back onto the land surface where it mixes with runoff, or discharges to a surface water body. See Discharge, Runoff, and Surface water.

Method detection limit (MDL): The minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero, and is determined from analysis of a sample in a given matrix containing the analyte. The MDL (often incorrectly identified as simply the "detection limit") is the smallest measured amount or concentration of analyte in a sample that gives rise to a Type I error tolerance of alpha under the null hypothesis that the true amount or concentration of analyte in the sample is equal to that of a blank. (The alternative hypothesis is that the true amount or concentration of analyte is greater than that of a blank.)

Natural condition: The environmental condition that existed before the introduction of any human-caused pollution or other disturbance. For estimating natural conditions in the headwaters of a disturbed watershed, a potentially useful reference condition may be the less disturbed condition of a neighboring or similar watershed. See Disturbed area and Pollution.

Operation: The organized activities that take place within a facility or site. See Activity, Facility, and Site.

Parameter: A biological, chemical, physical, or radiological property.

Permit: An authorization, license, or equivalent control document issued by a formally constituted legal body, such as the Washington State Department of Ecology, to a facility, activity, or entity to treat, store, dispose, or discharge materials or wastes, specifying the waste treatment and control requirements and waste discharge conditions. Unless the context requires differently, "permit" refers to individual and general permits authorized under the National Pollutant Discharge Elimination System program. See Activity, Control, Discharge, Entity, Facility, General permit, Individual permit, Treatment, and Waste.

pH: A measure of the acidity or alkalinity of water. A pH of 7.0 is defined as neutral. Large variations above or below 7.0 are harmful to most aquatic life. Mathematically, pH is the negative logarithm of the activity of the hydronium ion (often expressed as the negative logarithm of the molar concentration of the hydrogen ion). Since the pH scale is logarithmic, a water sample with a pH of 8.0 is ten times more basic than one with a pH of 7.0.

Point source: Any discernible, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters of the State of Washington, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, vessel, or other floating craft. Point sources do not include certain agricultural stormwater discharges and return flows from irrigated agriculture. See 40 CFR 122.3 for specific exclusions.

Pollutant (in water): Any discharged substance or pathogenic organism that would: (1) Alter the biological, chemical, physical, radiological, or thermal properties of any water of the State of Washington, (2) Would be likely to create a nuisance or render such water harmful, detrimental, or injurious (a) to the public health, safety, or welfare, (b) to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (c) to any animal or plant life, either terrestrial or aquatic, either directly from the environment or indirectly by ingestion through the food chain.

Pollutants may include, but are not limited to, the following: solid waste, incinerator residue, garbage, sewage, sewage sludge, filter backwash, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, dredged spoil, rock, sand, cellar dirt, and other industrial, municipal, and agricultural wastes.

Pollutant does not mean: (1) Sewage from marine vessels or a discharge incidental to the normal operation of a vessel of the Armed Forces, within the meaning of Section 312 of the Clean Water Act (CWA); (2) Dredged or fill material discharged in accordance with a permit issued under Section 404 of the CWA; or (3) Water, gas, or other material which is injected into a well to facilitate production of oil or gas, or water derived in association with oil or gas production and disposed of in a well, if the well is used either to facilitate production or for disposal is approved by authority of the Washington State Department of Ecology (Ecology), and if Ecology determines that such injection or disposal will not result in the degradation of ground- or surface water resources. See Beneficial use, Clean Water Act, Discharge, Permit, Solid waste, and Waters of the State.

Pollution (in water): The man-made or man-induced contamination or other alteration of the biological, chemical, physical, or radiological properties of any water of the State of Washington, including change in temperature, taste, odor, color, or turbidity of the water; or such discharge of any solid, liquid, gaseous, or other substance into any water of the State that will, or is likely to, create a nuisance or render such water harmful, detrimental, or injurious to: (1) The public health, safety, or welfare; (2) Domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses; or (3) Any animal or plant life, either terrestrial or aquatic, either directly from the environment or indirectly by ingestion through the food chain. See Beneficial use, Discharge, and Waters of the State.

Quality assurance project plan (QAPP): A document that describes the objectives of an environmental study and the procedures to be followed to achieve those objectives.

Reporting limit (RL): The minimum concentration at which detection of an analyte is reported, usually chosen by the laboratory and usually greater than the method detection limit. See Method detection limit.

Representative (sample): A sample that yields data that accurately characterizes the nature of a discharge or other sampled matrix for the parameters of concern. A representative sample should account for the factors that contribute to the variability of the parameters, such as the quantity of the discharge, the date and time of the sampling event, and whether the particular sampling location or associated physical events may affect the material sampled. Combining grab samples collected from multiple outfalls from a designated area of the facility during a certain time range to create a flow-weighted composite sample may be required to obtain a representative sample.

A random sample may not be a representative sample. Representative sampling schemes should vary based on the population distribution and variability. For a relatively constant discharge, a grab sample is representative. For a discharge that varies greatly over time or space, a grab sample would likely not be representative.

See Composite sample, Discharge, Facility, and Grab sample.

Runoff: Water derived directly from rainfall or snowmelt that travels across the land surface and discharges: (1) To water bodies either directly or through a constructed collection and conveyance system, or (2) To the subsurface through a constructed collection and conveyance system. See Discharge.

Saturated zone: The zone below the water table in which all soil and rock interstices are filled with water. See Water table.

Sediment: The fragmented material that originates from the weathering and erosion of rocks, unconsolidated deposits, organic material, or unpaved yards; and is suspended in, transported by, or deposited by water. See Erosion.

Site: A specific area of land or water subject to regulation under the Clean Water Act or the Washington Water Pollution Control Act: (1) Where any facility, operation, or activity is or was physically located or conducted, including any adjacent land or buffer areas used in connection with such facility, operation, or activity; or (2) Which receives or received any effluent discharged from any facility, operation, or activity. See Activity, Clean Water Act, Discharge, Effluent, Facility, and Operation.

Solid waste: Any discarded, abandoned, unwanted, or unrecovered material, except the following: (1) Discharges into the ground or groundwater of return flow, unaltered except for temperature, from a groundwater heat pump used for space heating or cooling, provided that such discharges do not have significant potential, either individually or collectively, to affect groundwater quality or uses; (2) Discharges of stormwater that is not contaminated or potentially contaminated by industrial or commercial sources; (3) Domestic sewage and any mixture of domestic sewage and other wastes that passes through a sewer system to a publicly-owned treatment works for treatment; (4) Industrial wastewater discharges that are point source discharges subject to regulation under Section 402 of the Clean Water Act, as amended; and (5) Irrigation return flows. Additional details are provided in 40 CFR 261.2 and 261.4. See Clean Water Act, Discharge, Groundwater, Point source, and Water quality.

Specific Conductance: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

State: The State of Washington.

Surface water: Lakes, rivers, ponds, streams, inland waters, wetlands, marine waters, estuaries, and all other fresh or brackish waters and water courses, plus drainages to those water bodies. Surface waters do not include hatchery ponds, raceways, pollution abatement ponds, and wetlands constructed solely for wastewater treatment. See Treatment.

Treat:

1. To intentionally apply a pesticide or other chemical to the water, vegetation, or soil to control or kill a target organism or species; to remove or inactivate bioavailable phosphorus; or to regulate some other ecosystem process.
2. To remove a pollutant from wastewater or stormwater, or to perform some other manipulation of wastewater or stormwater, to reduce or control the adverse effects of a pollutant therein.

See Control and Pollutant.

Treatment:

1. The intentional application of a pesticide or other chemical to the water, vegetation, or soil to control or eradicate a target organism or species; to remove or inactivate bioavailable phosphorus; or to regulate some other ecosystem process.
2. The removal of a pollutant from wastewater or stormwater, or some other manipulation of wastewater or stormwater, to reduce or control the adverse effects of a pollutant therein.

See Control and Pollutant.

Vadose zone: The zone extending from the surface of the ground down to the top of the water table. See Water table.

Waste: Any discarded, abandoned, unwanted, or unrecovered material, except the following are not waste materials for the purposes of this permit: (1) Discharges into the ground or ground water of return flow, unaltered except for temperature, from a groundwater heat pump used for space heating or cooling, provided that such discharges do not have significant potential, either individually or collectively, to affect groundwater quality or uses; and (2) Discharges of stormwater that is not contaminated or potentially contaminated by industrial or commercial sources. See Discharge, Groundwater, Permit, and Water quality.

Water quality (WQ): The biological, chemical, physical, and radiological characteristics of water, usually with respect to its suitability for a particular purpose.

Water quality standard (WQS): Numerical or narrative criterion meant to protect the beneficial uses of the waters of the State of Washington. WQSs may be found in 40 CFR 131; and Chapters 173-200, 173-201A, and 173-204 of the Washington Administrative Code. See Beneficial use and Waters of the State.

Water table: The groundwater surface where the water pressure head is equal to the atmospheric pressure. The water table may be conveniently visualized as the “surface” of the subsurface materials that are saturated with groundwater in a given vicinity. However, saturated conditions may extend above the water table as surface tension holds water in some pores below atmospheric pressure. See Groundwater.

Waters of the State: All waters within the geographic boundaries of the State of Washington defined as “waters of the United States” in 40 CFR 122.2, and all waters defined as “waters of the state” in RCW 90.48.020. These waters of the state include lakes, rivers, ponds, streams, inland waters, wetlands, marine waters, estuaries, underground waters, and all other fresh or brackish waters and water courses within the jurisdiction of the State of Washington, plus drainages to those surface waters. See Groundwater and Surface water.