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Pendleton Woolen Mill Land Application Site Ground Water Monitoring Evaluation

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Pendleton Woolen Mill Land Application Site Ground Water Monitoring Evaluation

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by
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Table of Contents

Page

Table of Contents (cont.)

Appendices

List of Tables

List of Figures

Abstract

Ground water and soils samples were collected at the Pendleton Woolen Mill land application site in Washougal, Washington in April and July 1995. A review was also conducted of existing data for biosolids, ground water, soils, and sediment from the adjacent Gibbons Creek remnant channel. The purposes of the study were to (1) evaluate the adequacy of a recently installed ground water monitoring network to detect contamination at the six-acre land application site in Washougal; (2) evaluate the potential for ground and surface water contamination due to the land application site operation; and (3) evaluate the effects of changing the crop from reed canary grass to hybrid poplar trees.

Two composite soil metals samples collected at the land application site as part of this study indicated that chromium and zinc concentrations far exceeded background concentrations. These results were also higher than previous results from the same area. Verification sampling is needed. If necessary, the site life estimate should be adjusted accordingly.

Because the monitoring wells are completed in the deeper, confined aquifer beneath the site, an unsaturated zone monitoring component is recommended to supplement the ground water monitoring network. This system would provide an early warning system and allow prompt adjustments to the land application operation before contamination reaches ground water.

An additional downgradient monitoring well is needed in the deeper aquifer to better define the ground water flow direction in the sand and gravel aquifer.

Biosolids exceeded the EPA (1993) municipal biosolids criterion for zinc on several occasions since 1994, including during this study. Because all samples that exceeded the criteria had been filtered, concentrations of total zinc, for which the criteria were designed, were probably even higher. These criteria are used for comparison only, because limits for industrial biosolids do not exist.

Reporting of biosolids loading to the site has not been required in the permit, nor has it been reported by the facility. This information, especially for zinc and other metals, is needed to update the site life estimate.

Further investigation of metals transport to Gibbons Creek remnant channel is needed to determine whether elevated metals concentrations in sediments are related to the land application operation, including transport from the silt zone, surface runoff, airdrift, or the slough draining East Pond.

Metals concentrations were below detection in samples from newly installed monitoring wells.

Conclusions

1) Evaluate the adequacy of the land application site monitoring network to detect subsurface contamination

The ground water monitoring wells are completed in the deeper, confined aquifer. Although the wells are located to determine the direction of flow in the deeper aquifer and the upgradient well is not affected by the facility, the network would not promptly detect contamination in the overlying silt water table aquifer.

There is currently no system to monitor the silt aquifer as required by the ground water quality standards. The monitoring network for the deeper aquifer cannot adequately describe ground water flow direction in the northern parts of the land application site due to the linear alignment of the downgradient wells.

Metals, the constituents of most concern for ground water protection at the site, are not currently required for analysis in ground water.

Monitoring data are reported and interpreted annually. However, data should be submitted quarterly as they are collected.

2) Evaluate the potential for ground and surface water, soils, and sediment contamination due to the land application site operation

Metals in soils

Chromium and zinc soil samples collected for this study at two sites far exceeded background concentrations for the site and for the county, despite use of a conservative analytical method. Chromium exceeded county background levels by 18 to 27 times; zinc by four times.

Chromium concentrations in samples from the current study were 20 to 30 times higher than soil samples collected in 1989. Zinc was four times higher in 1995 than in 1989.

If mobilized by surface runoff or saturated soil conditions, these metals could reach the Gibbons Creek remnant channel.

Biosolids concentrations and loading

Data from the facility's 1994 and 1995 Discharge Monitoring Reports and data from this study indicate that the EPA (1993) *pollutant concentration* criterion for zinc in municipal biosolids was exceeded several times during 1994 and 1995. However, these criteria are only used for comparison, because criteria do not exist for industrial biosolids.

Biosolids have not yet been tested for hazardous waste digestion as required under Chapter 173-303 WAC.

Ground water quality

Metals concentrations in all wells were below detection. However, detection limits were relatively high.

Gibbons Creek remnant channel

Sediment samples collected by others at two locations near the land application site in 1989 and 1995 exceeded Ontario's *lowest effect* threshold for chromium. One site exceeded the *severe effect* in 1989.

Zinc and copper have exceeded the *lowest effect* level at both sites. Copper approached the *severe effect* level at one site.

Gibbons Creek remnant channel is not hydraulically connected with the deeper aquifer. Therefore data from the monitoring wells are not indicative of potential surface water effects to the remnant channel.

The upper silt aquifer is hydraulically connected with the creek. The influence of seepage from the silt zone on the channel is probably not significant due to the low hydraulic conductivity, but should be investigated further.

If remnant Gibbons Creek is affected by Pendleton Woolen Mill, transport mechanisms other than ground water seepage may be more significant, such as overland transport from the land application site, air drift of biosolids, or discharge from a nearby swale that drains other parts of the facility.

3) Evaluate the effects of changing the crop from reed canary grass to poplar trees on biosolids treatment

A properly managed hybrid poplar stand would probably have many advantages over the current reed canary grass crop. Advantages of the poplars include increased wildlife habitat, cost effectiveness, and more efficient use of energy and biomass (Wilson, 1996).

Recommendations

The following activities are recommended:

Soil

Investigate soil chromium and zinc distributions by sampling at representative locations and depths within the land application area. Leaching tests for hexavalent chromium are recommended for at least two locations.

Metals data collected above should be used to adjust the site life calculations as necessary (EPA, 1993).

Determine if runoff and metals associated with runoff from the land application site are reaching the Gibbons Creek remnant channel under various seasonal and operational conditions. All runoff from the field should be collected and prevented from entering the creek.

Biosolids

Report the daily volume of biosolids applied to the land application site in monthly Discharge Monitoring Reports, as well as the surface area and location where biosolids were applied. This information is needed to track cumulative loading for comparison with EPA (1993) allowable limits.

In order to determine total loading of metals to the site, biosolid samples should not be filtered. Zinc data for unfiltered biosolids samples should be used in site life calculations.

Test biosolids for hazardous waste designation with guidance from Ecology's Southwest Regional Office.

Ground Water and Unsaturated Zone Monitoring

Add an unsaturated zone monitoring network to provide an early warning system as an alternative to installing a monitoring well network in the uppermost silt aquifer. (The unsaturated zone is the soil layer above the water table where the soil pores are partially filled with water and partially with air, as shown in Figure 1.) The network should include lysimeters in the land application area as well as a background site.

Metals should be sampled in both the ground water and unsaturated zone monitoring networks , i.e., chromium, copper, zinc, lead, and arsenic. A low level metals analysis method should be used. Hexavalent chromium should be sampled in the unsaturated zone for at least one year. Both monitoring networks should be sampled and results reported quarterly.

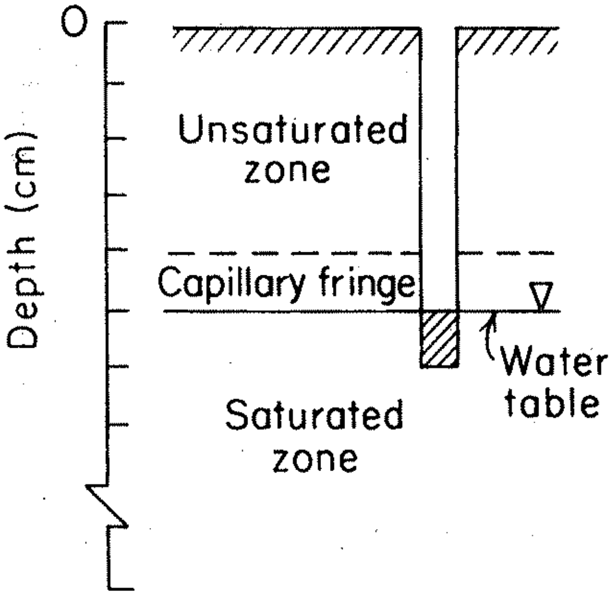

Figure 1. Sketch of the unsaturated zone relative to the saturated zone (from Freeze & Cherry, 1979)

Additional well(s) should be added to the water level monitoring network to provide more details about ground water flow between the upgradient and downgradient wells. An additional new ground water monitoring well is needed in the deeper aquifer near the northeast and northwest borders of the land application site to better determine the localized flow direction.

Gibbons Creek Remnant Channel

To determine if any change has occurred over time, sample the sediments in Gibbons Creek remnant channel near Site G-3 where chromium, zinc, and copper were highest in 1989.

Investigate the possibility of chromium, zinc, and copper from biosolids applied to the land application site reaching Gibbons Creek remnant channel under various seasonal conditions, i.e., surface runoff, discharge from the silt aquifer, or air drift. Also, investigate the influence of the slough draining the East Pond on the opposite side of the highway as a source of metals to the creek.

Reporting

Monitoring data should be reported to Ecology quarterly, including quality of ground water and soil pore water (unsaturated zone), biosolids quality, quantity of biosolids applied as well as the surface area and location to which they were applied, ground water elevations, and analysis of quality assurance and quality control data. Data should be submitted in hard copy as well as electronic format using a Microsoft-compatible data base or spreadsheet.

Annual reports like the one submitted by CH2M Hill (1995), interpreting the year's monitoring data, are also recommended. The following items should be included:

- water level contour maps for the sand and gravel aquifer
- comparison of metal concentrations in biosolids and loadings with EPA (1993) criteria for municipal biosolids, i.e., zinc
- comparison of background and affected unsaturated zone and ground water metal concentrations using methods acceptable to Ecology

Poplar Trees

A plan should be submitted to Ecology describing the proposed change in crop from reed canary grass to hybrid poplar trees. The plan should include metals loading rates, details of the irrigation system, operation, and maintenance. However, the issue of site life must be resolved before crop plans are completed.

Project Description

Background

The Pendleton Woolen Mill (PWM) is a wool processing plant located on the north side of the Columbia River at River Mile 123 southeast of the town of Washougal (Figure 2). Process wastewater is treated on site using an activated sludge process. The waste-activated sludge (biosolids) is land applied to a site adjacent to the treatment plant in accordance with Permit No. WA-000023-0 (Figure 3).

The six-acre land application site is south of Highway 14 and adjacent to the remnant Gibbons Creek channel. In 1992, Gibbons Creek was rerouted, leaving the 1-1/2- mile remnant channel parallel to the Columbia River (Figure 2). The channel receives ground and surface water from the area and flows into the Columbia River near the east side of the land application site. When the river level is high the channel water is pumped into the river.

Biosolids have been applied on the site since the mid-1970s. Improvements to the irrigation system implemented since 1992 include building a 100,000-gallon winter storage tank, decreasing the spacing between the fixed sprinkler heads, installing additional lateral lines, and replacing existing sprinkler heads with nozzles that improve application uniformity and lower the application rate.

Land use surrounding PWM is mostly industrial. Twenty-eight facilities in the Camas-Washougal Industrial Park discharge stormwater or other wastes into the remnant Gibbons Creek (Erickson and Tooley, 1996). Erickson and Tooley (1996) evaluated conditions in the creek and effects of multiple discharges on the creek. Contamination of water or sediment is a concern for wildlife using the Stiegerwald Lake National Wildlife Refuge, about 1-1/2 miles east of the land application site.

Introduction

This study was requested by Ecology's Southwest Regional Office to provide information to be used for updating the NPDES permit. The permit does not specify biosolids application limits or requirements for ground water monitoring, although it does require that biosolids samples be tested quarterly for metals and monthly for total solids. An additional requirement, which has been met, was to provide an updated solid waste control plan by August 1992. The plan addresses management of biosolids discharged to the land application site so that the facility will meet state surface and ground water quality standards. However, the permit did not require that the monitoring network be

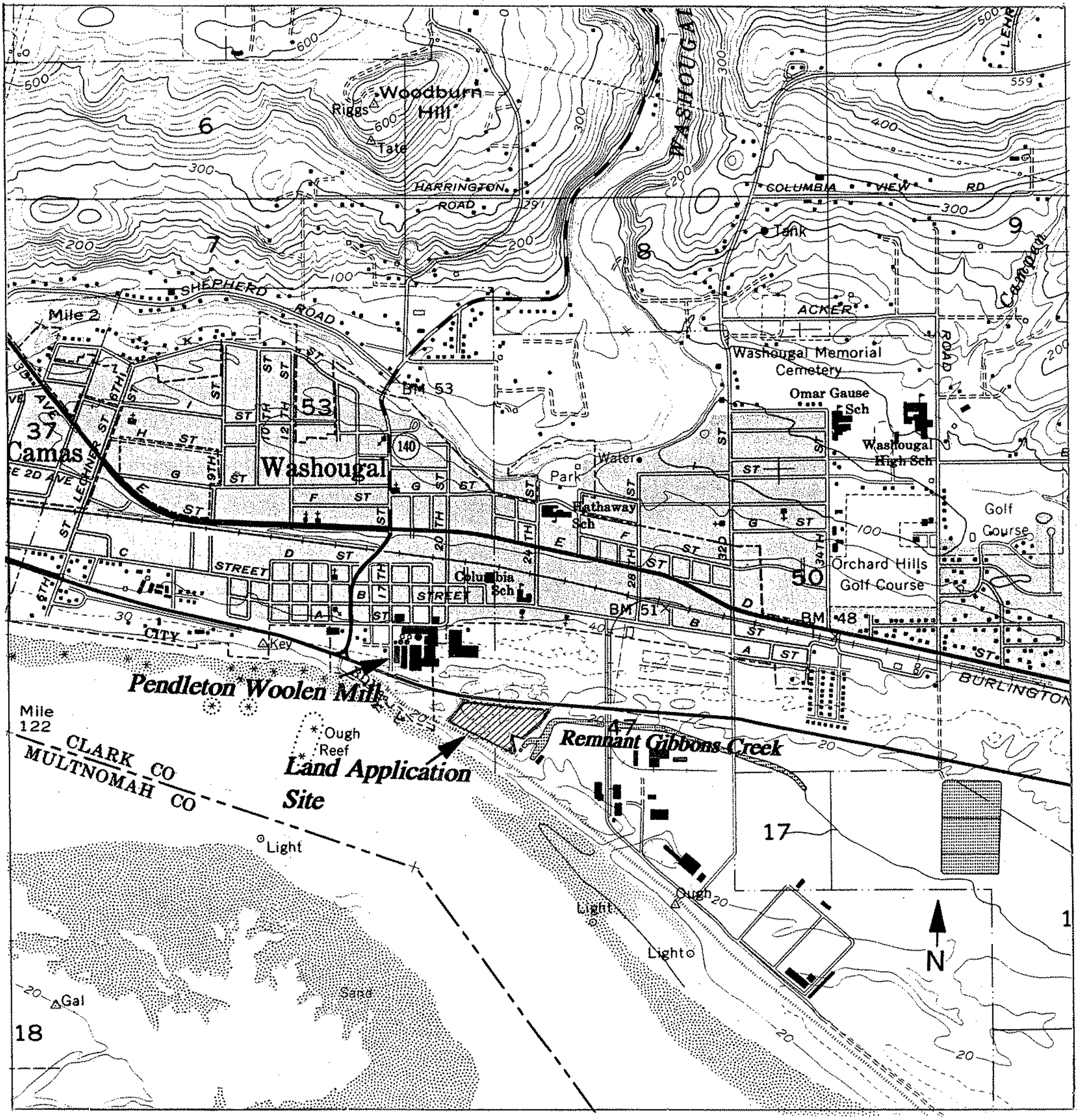

Figure 2. Map of Pendleton Woolen Mill facility, land application site, and vicinity.

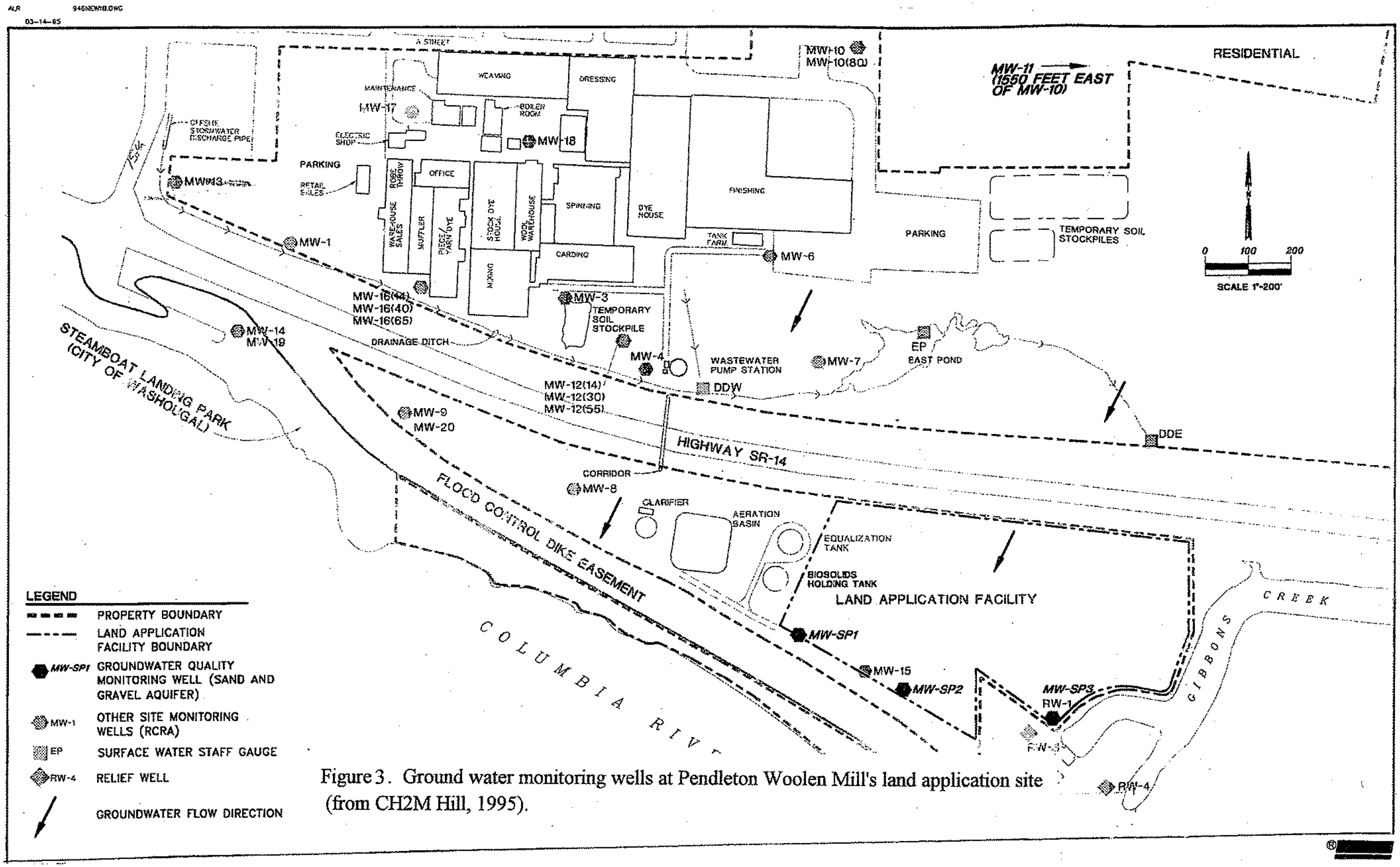

Figure 3. Ground water monitoring wells at Pendleton Woolen Mill's land application site (from CH2M Hill, 1995).

reviewed and approved before installation. The land application site ground water monitoring network was completed in 1993. An evaluation of the ground water monitoring network was needed to determine whether it is adequate to detect contamination.

In a recent study, water quality in remnant Gibbons Creek adjacent to the land application site did not meet its designated Class A water quality standards (Chapter 173-201A WAC) for several constituents, including pH, dissolved oxygen, and fecal coliform bacteria (Erickson and Tooley, 1996). It was not known what contribution, if any, the PWM land application site has to the creek.

PWM is considering changing the crop at the land application site from reed canary grass to densely spaced poplar trees. The potential effects of this change on the effectiveness of biosolids treatment had not been addressed.

Objectives

The objectives of the study were to:

- Evaluate the adequacy of the land application site monitoring network to detect subsurface contamination

- Evaluate the potential for ground and surface water, soils, and sediment contamination due to the land application operation

- Evaluate the effects of changing the crop from reed canary grass to poplar trees

Site Description

Soil

Soils beneath the land application site are mostly Sauvie silt loam overlying sand (SnA) (SCS, 1972). The west side of the site may also include some Sauvie silty clay loam (SpB). Both of these fine, silty soils have moderately high organic matter content and moderate to high cation exchange capacity (CH2M Hill, 1992a). Permeability of both soils is low (0.2-0.6 inch/hour). The mean available water capacity is high (10-12 inches of water in 60 inches of soil) (SCS, 1972).

Hydrogeology

Three hydrogeologic units have been identified beneath the land application site (CH2M Hill, 1992a and CH2M Hill, 1992b). These are:

Silt unit

The silt unit consists of silt and lesser amounts of silty sand and ranges in thickness from 15 to 25 feet based on soil borings in the land application area (CH2M Hill, 1992b and 1995). This layer has a low hydraulic conductivity (K), i.e., 10^{-4} to 10^{-5} cm/sec.

Based on relative travel times, the vertical component of flow to the underlying sand and gravel unit is the primary pathway of concern compared to horizontal off-site movement. However, the gradient near the adjacent Gibbons Creek remnant channel (Figure 2) is even or upward according to the drilling log for MW-SP3 (Appendix A) which may be important. Because of the low hydraulic conductivity of the silt zone, recharge to the underlying sand and gravel zone is probably low relative to throughflow (CH2M Hill, 1992b).

Fill material placed periodically over many years forms a thin layer over parts of the site, but could not be distinguished in soil borings from the land application site (CH2M Hill, 1992b).

Sand and gravel unit

The sand and gravel unit is the only aquifer monitored beneath the land application site. This unit consists of four distinctive layers with a total thickness of 60-80 feet (CH2M Hill, 1992a). The top layer is mostly gravel with varying percentages of silt, clay, and sand. The monitoring wells are completed in this zone. The K estimate is 1.4×10^{-2} to 6.2×10^{-2} cm/sec.

The next deeper layer is a sand and silty sand zone below which lies another gravel zone. The deepest layer in the unit is a poorly cemented sand. The K estimates for the three lower layers of the unit are 1.4×10^{-2} to 2.8×10^{-2} cm/sec (CH2M Hill, 1992b).

Drilling logs for the monitoring wells indicate that the sand and gravel unit is confined beneath the land application site by the overlying silt unit except near the Gibbons Creek remnant channel. The well log for MW-SP3 suggests that the gradient may be upward (Appendix A).

The sand and gravel unit is also hydraulically connected to the Columbia River (CH2M Hill, 1992a). The gradient is affected by the river stage.

Troutdale formation

The Troutdale formation underlies the sand and gravel unit (CH2M Hill, 1992a and 1992b). One on-site boring encountered the Troutdale formation at 92 feet below ground. The upper nine feet of the zone was medium-hard sandstone beneath which lay extremely hard-cemented conglomerate (CH2M Hill, 1992b).

The Troutdale formation is a regional aquifer with high-yielding areas. It supplies large amounts of water to the City of Washougal wells 3,500 feet northeast of the PWM facility (CH2M Hill, 1992b). However, significant water production was not observed in the deep boring described above (CH2M Hill, 1992b).

Land application operation

Biosolids are currently applied on the land application site from April through October. The site has been used for biosolids treatment since the mid-1970's. Until 1993, when a biosolids storage facility was constructed, application occurred year-round but at a lower rate during November and December (CH2M Hill, 1992a).

Methods

Sampling and analysis method used by Ecology are described below. Methods used by PWM for historical sampling as well as concurrent sampling in 1995 are also described.

Sampling Collection

Ecology collected ground water samples on April 17, and July 18, 1995 with PWM's consultant, CH2M Hill. Ecology and the consultant used CH2M Hill's equipment and sampling procedures described in Appendices B and C for ground water. They collected samples at the same time but for different lists of parameters.

Ecology ground water samples were analyzed for total dissolved solids, chloride, total and dissolved metals (cadmium, chromium, copper, nickel, lead, and zinc), ammonia-N, nitrate+nitrite-N, total Kjeldahl N (on April 17) and total persulfate N (on July 18); biosolids for percent solids and the same list of metals as for ground water.

CH2M Hill ground water samples were analyzed for pH, conductivity, nitrate, and total dissolved solids; biosolids for chromium, copper, magnesium, mercury, lead, and zinc.

Ecology and the consultant also collected samples from the four land application site monitoring wells: upgradient MW-11 and downgradient MW-SP1, -SP2, and -SP3. Well locations are shown in Figure 3.

Both the consultant and Ecology collected biosolids samples from the biosolids storage tank in April and from the discharge pipe to the field in July. The consultant filtered biosolids samples in the field. Samples that Ecology collected were not filtered in the field but were inadvertently filtered in the lab.

Ecology collected soil samples for metals analysis at two locations within the land application area on July 18, 1996 as described in Appendix B.

Sample Analysis

Analysis methods used for Ecology samples are listed in Appendix B; those for CH2M Hill are in Appendix C.

Both Ecology and PWM used EPA Method 6010 to analyze soil metal samples discussed in this report. However, Ecology's Manchester Laboratory used only peroxide in the digestion rather than peroxide and hydrochloric acid, as described in the method. This may have biased the Ecology samples toward lower results than if the normal digestion occurred.

Ecology's ground water and biosolids results may be even more conservative than those for soils, because an even less rigorous nitric acid digestion was used on these samples (EPA Method 200.7). The more rigorous digestion in Method 6010 is prescribed for biosolids analysis in EPA (1993).

Quality Assurance

A quality assurance review is presented in Appendix D. The data were judged to be acceptable for use in this report as qualified.

Results and Discussion

Results are organized to address the objectives listed in the Project Description above.

1) Evaluate the adequacy of the land application site monitoring network to detect contamination

The ground water monitoring network was evaluated in terms of well placement and well construction. The *Implementation Guidance for the Ground Water Quality Standards* (Kimsey, 1996) was used for reference. Aspects of well placement that are discussed below are: adequate definition of ground water flow direction in the target aquifer, whether the upgradient well is affected by the facility, location of downgradient wells for early detection of contamination, and the analytical parameters included. Well construction was evaluated using the Minimum Requirements for Construction and Maintenance of Wells, Chapter 173-160 WAC.

Determination of ground water flow direction

The monitoring well network design is based on the assumption that the sand and gravel aquifer underlying the silt layer is the only target aquifer. Although the sand and gravel aquifer may have more beneficial uses than the silt aquifer, including hydraulic connection with the Columbia River (CH2M Hill, 1992a), all aquifers are protected as potential drinking water sources (Kimsey, 1996). Beneficial use is not a criterion for monitoring or protection. In addition to the uppermost aquifer, any other potentially affected aquifers should be monitored (Kimsey, 1996).

The ground water monitoring network consists of four wells screened in the sand and gravel aquifer: one upgradient, MW-11; and three downgradient, MW-SP1, -SP2, and -SP3. All wells are constructed of two-inch diameter Schedule 40 PVC. The upgradient well was drilled in 1987, the downgradient wells in 1993.

Upgradient and downgradient wells appear to be in the same aquifer based on the types of materials described in the drilling logs. However, the upgradient well is not confined, while the downgradient wells are confined by the 20-to 25-foot thick silt layer. The upgradient well is about 2,000-2,500 feet northeast of the downgradient wells.

Water level data from two sampling dates, April 17 and July 18, 1995, shown in Table 1 indicate that flow near the downgradient wells is in a southeast direction.

Figure 4 shows the water level contours for April 1995. It is difficult to define flow direction beneath much of the field due to the linear alignment of the downgradient wells. An additional monitoring well is needed in the sand and gravel aquifer to allow flow characterization beneath the entire field.

Table 1. Ground water elevations in Pendleton Woolen Mill land application site monitoring wells in feet above sea level.

	MW-11	MW-SP1	MW-SP2	MW-SP3
Elevation of casing	47.41	25.93	25.65	20.80
Depth to water				
4/17/95	26.41	10.55	11.49	7.00
7/18/95	28.02	12.27	12.88	8.26
GW Elevations				
4/17/95	21.00	15.38	14.16	13.80
7/18/95	19.39	13.66	12.77	12.54

The general ground water flow direction for the site shown in Figure 3 is based on water level elevations in twelve monitoring wells used to evaluate clean-up of other parts of the PWM facility (CH2M Hill, 1992b).

Upgradient well unaffected

Water level information from both the land application site monitoring network (Figure 4) and the facility's cleanup network (Figure 3) indicate that MW-11 is upgradient of the land application site though fairly distant (CH2M Hill, 1992b).

Likelihood of downgradient wells detecting contamination

If contamination occurred, it could be observed in the upper aquifer long before reaching the deeper aquifer where the monitoring wells are located. The silt unit is apparently recharged from precipitation, spray irrigation, and nearby surface water bodies (CH2M Hill, 1992a). There are no monitoring wells in the uppermost silt layer, where the water level is eight to ten feet below ground.

A downward vertical gradient in the silt unit is apparent from the elevations of ground water shown in drilling logs for MW-SP1 and -SP2 and summarized

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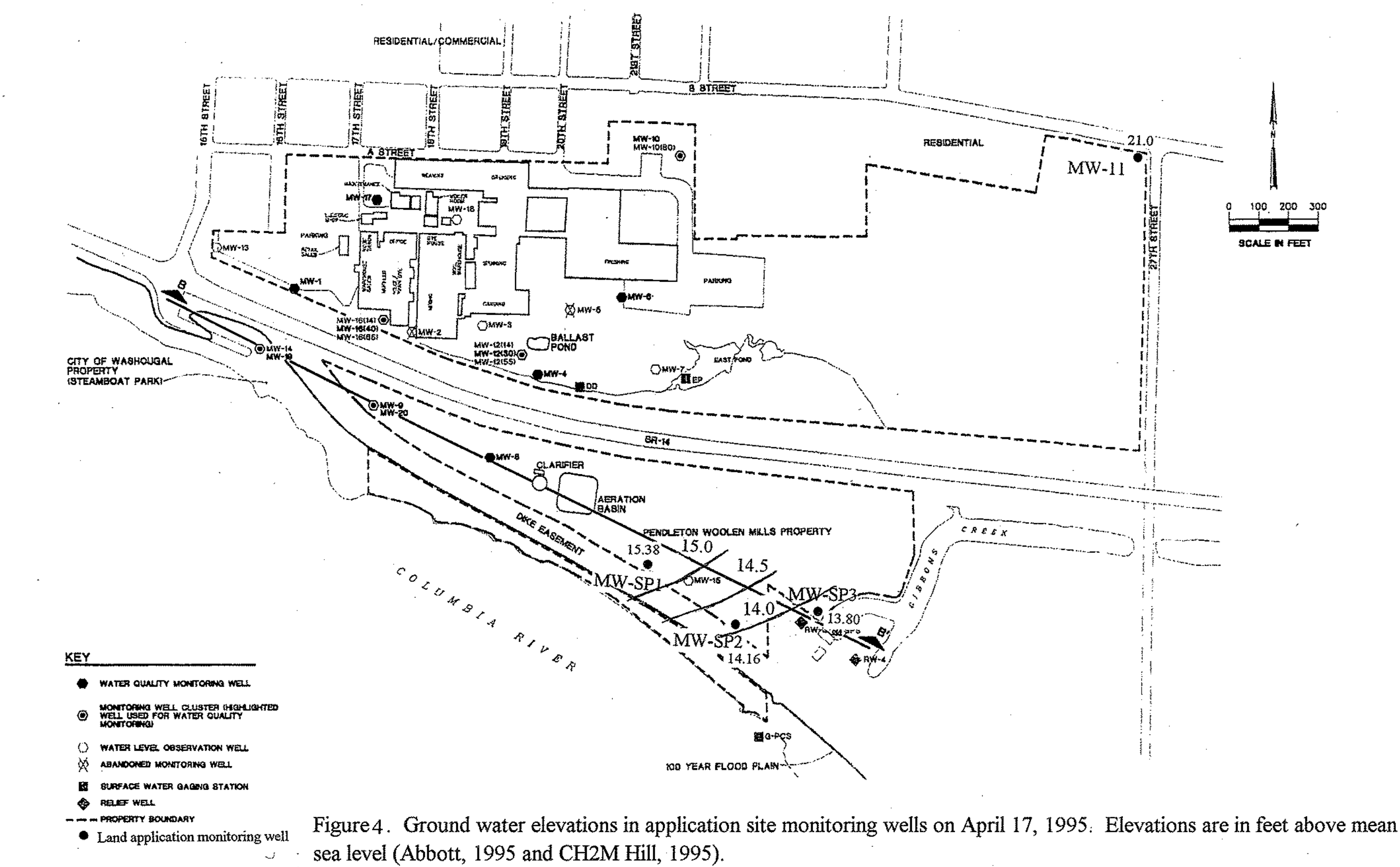

Figure 4. Ground water elevations in application site monitoring wells on April 17, 1995. Elevations are in feet above mean sea level (Abbott, 1995 and CH2M Hill, 1995).

in Table 2. At MW-SP3, however, the vertical gradient may be even or upward, indicating more horizontal movement toward Gibbons Creek remnant channel.

Table 2. Ground water elevations for the shallow silt aquifer and the deeper sand and gravel aquifer in application site monitoring wells. Elevations are based on drilling logs for the shallow aquifer and ground water elevation measurements for the deeper aquifer during drilling measured in feet above mean sea level (CH2M Hill, 1995).

Aquifer/ Monitoring Well	SP-1	SP-2	SP-3
Shallow	17.9	15.7	6-10
Deep	10.6	10.0	9.9

Only a small portion of the recharge to the sand and gravel unit comes from the silt unit (CH2M Hill, 1992a and 1992b). Therefore, if contaminants from the land application site were to reach the underlying sand and gravel unit, dilution by ground water from more distant upgradient sources would make detection difficult.

Monitoring wells screened in the upper silt aquifer would provide more prompt information on transport of metals to the uppermost aquifer. However, installing monitoring wells in fine-grained materials is difficult. Samples from wells completed in silt often contain large amounts of suspended material which tend to adsorb metals. Also, the wells usually have low yields making representative sampling difficult.

An alternative to monitoring the uppermost silt aquifer is to conduct unsaturated zone monitoring. Samples from an unsaturated zone monitoring system may be more useful than those from wells completed either in the top of the silt layer or in the deeper sand and gravel unit. In addition, unsaturated zone monitoring data would provide an early warning mechanism, allowing prompt adjustment of the land application operation, if needed, to prevent contamination of underlying ground water.

The guidance for the ground water quality standards states, "If ground water monitoring is not a viable option, then vadose zone monitoring may be used only if Ecology and the applicant agree that the results will be used to determine compliance" (Kimsey, 1996). Therefore, Ecology and PWM representatives would need to discuss this option.

Well construction

According to the drilling logs shown in Appendix A, the four ground water monitoring wells meet the requirements for resource protection wells stated in the construction standards, Chapter 173-160 WAC. The upgradient well, MW-11, was installed in September 1987, while the downgradient wells were installed in October 1993.

Parameters monitored

Dissolved zinc is the only metal currently analyzed in ground water by the facility. In addition to zinc, significant quantities of chromium, copper, and lead are found in the biosolids as discussed in the following subsection, *2) Evaluate the potential for soil, ground water, and surface water due to the land application operation.* Metals should be sampled at least quarterly in ground water monitoring wells.

2) Evaluate the potential for soil, ground water, and surface water contamination due to the land application operation

The potential for contamination of soil, ground water, and surface water due to the land application operation was evaluated in several ways. Metal concentrations in several affected or potentially affected media are discussed below, including:

- soil
- biosolids
- ground water
- sediment from Gibbons Creek remnant channel.

All samples collected by PWM were analyzed according to the method specified for the municipal biosolids criteria, Federal Register 40 CFR Part 503 (EPA, 1993). As explained in the Methods section, the digestion used in this method, SW-846 Method 3050, is somewhat more rigorous than that used for the Ecology ground water and biosolids samples, Method 200.7 (Ross, 1996).

PWM biosolids samples collected between April 1994 and October 1995 were filtered, a practice not specified in EPA (1993). It is not known if biosolids samples collected before April 1994 were filtered. Ecology biosolids samples were unintentionally filtered also.

Metals in soils

Metals data obtained in this study are presented below followed by a discussion of metals data collected at the site as part of the PWM remedial investigation and feasibility study (CH2M Hill, 1992b).

1995 Soil metals

Table 3 shows that soil chromium and zinc concentrations from Ecology's July 1995 samples far exceeded background concentrations for the site as well as background concentrations for Clark County (San Juan, 1994).

Table 3. Soil metals data for July 1995 compared to background levels for the site and for the county.

Metal	Background Concentrations (CH2M Hill, 1992b)	Background Concentrations for Clark County (San Juan, 1994)	7/18/95 SO-1 mg/kg dry wt		7/18/95 SO-2 mg/kg dry wt	
Cd	0.55	0.93	1.3	P	0.31	P
Cr	23	26.6	475		720	
Cu	21.8	34.4	170	N	46.3	J
Ni	17.1	21.0	15.5		13.6	
Pb	9.9	24.0	53.7		23.6	
Zn	89	95.5	407		422	

N: The spike sample recovery is not within control limits.
J: The analyte was positively identified. The numerical result is an estimate.
P: The analyte was detected above the instrument detection limit but below the minimum quantitation limit.
Bold: The concentration exceeded two times the San Juan (1994) 90th percentile concentration for Clark County.

The county background concentrations represent the 90th percentile of 81 samples collected at 4 to 24 inches depth at 21 locations in the county. The background metal concentrations at the site were similar to or lower than those for Clark County (CH2M Hill, 1992b).

The concentration of chromium was 475 to 720 mg/kg which is 18 to 27 times higher than the background concentration for Clark County of 34.4 mg/kg. Zinc concentrations, 407 to 422 mg/kg, were about four times higher than the county background.

Copper was five times the county background level in one 1995 sample, while the other sample was only slightly above background. One lead sample was two times the county background level, while the other was close to the background concentration.

Historical data for metals in soil

Table 4 summarizes the soil metal data for soils collected at the PWM land application site since 1989 near the two sites where samples were collected in July 1995. The sampling locations are shown in Figure 5, except 1994 for which sampling locations were not available.

Table 4. Summary of soil metals concentrations at the land application site (CH2M Hill, 1994 and 1992). See Figure 5 for station locations.

Station	Depth (feet)	Cadmium (mg/kg)		Chromium (mg/kg)	Copper (mg/kg)		Nickel (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Ecology 1995									
Ecology-1	0.2-0.6	1.3	P	475	170	N	15.5	53.7	407
Ecology-2	0.2-0.6	0.31	P	720	46.3	J	13.6	23.6	422
Pendleton 1994									
SOIL 1		1	U		40.4		16	42.1	237
SOIL 2		1	U		33.4		17	24.3	268
SOIL 3		1	U		32.5		19	33.9	175
Pendleton 1989									
11	0-0.5	1.9		24	42.7		20.5	51	247
	0.5-2.5	2.1		23	37		19.5	47.5	240
	2.5-4	2.2		22	31.2		18.4	44	233
	4-5	1.6		23	34		20	38	181
12	0-0.5	0.77		18.9	28.2		19.8	20.2	92.2
	0.5-2	0.77		18.9	28.2		19.8	20.2	92.2
	2-2.5	0.73		22.7	26.6		20.6	16.1	91.1
	2.5-3.5	0.69		26.5	25		21.4	12	89.9
	3.5-5	0.75		28	26		22	15	93
13	0-0.5	0.95		33	25.9		25.9	15	86
	0.5-1.5	0.90		29	24.8		24.8	11	78
	1.5-2.7	0.86		29	21.6		21.6	14	80
	2.7-3.5	0.82		23.5	22.8		22.8	12.5	70.5
	3.5-4.7	0.78		18	24		24	11	61
15	0-0.5	0.99		28	39.3		30.4	10	81

P: Analyte was above the detection limit but below the quantitation limit.
J: Analyte was positively identified. The numerical result is an estimate.
N: The spike sample recovery is not within control limits
U: Analyte was not detected at or above the reported result.

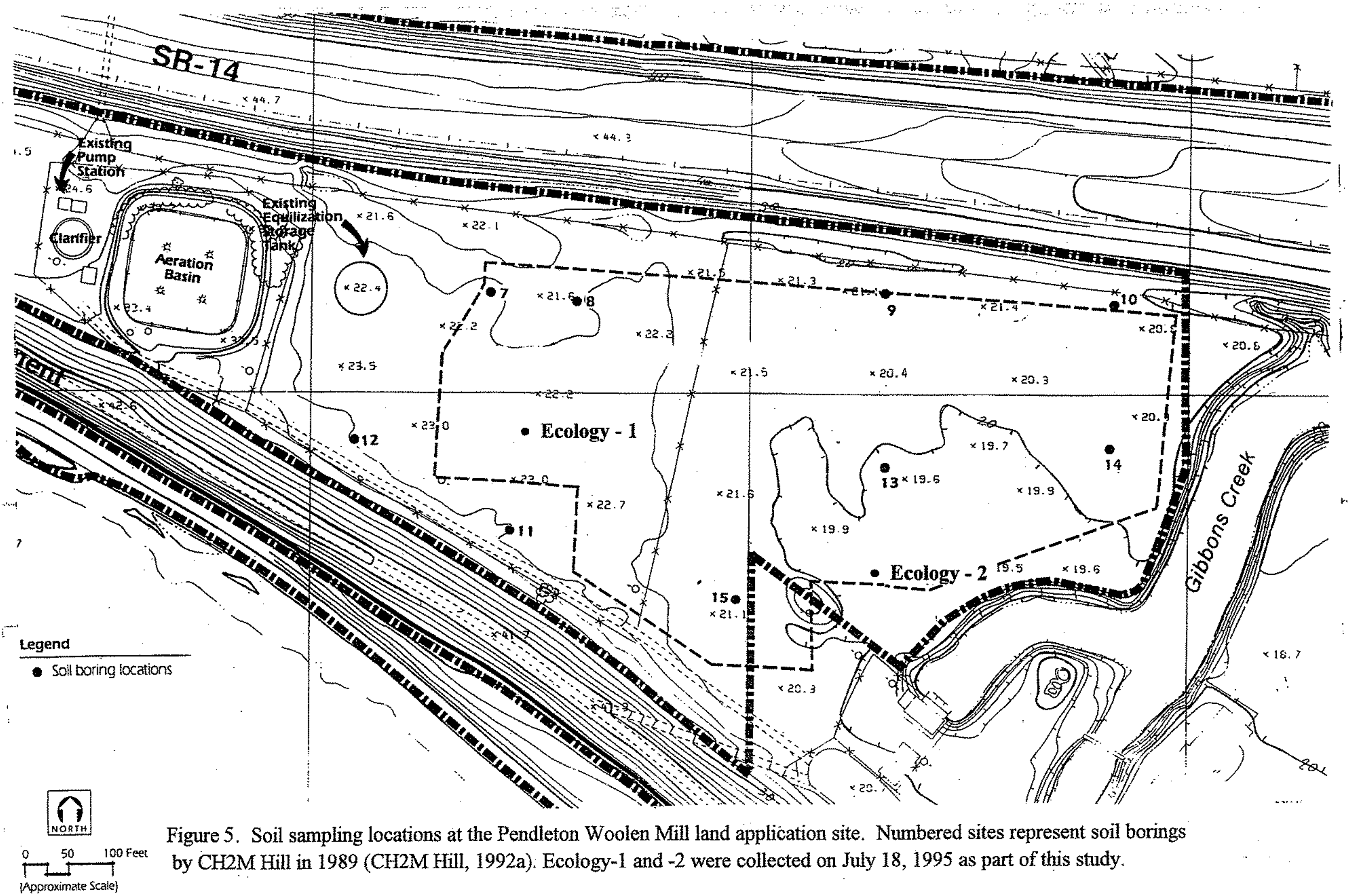

Figure 5. Soil sampling locations at the Pendleton Woolen Mill land application site. Numbered sites represent soil borings by CH2M Hill in 1989 (CH2M Hill, 1992a). Ecology-1 and -2 were collected on July 18, 1995 as part of this study.

Zinc concentrations were over four times higher in 1995 samples than those in three of four 1989 samples. Chromium concentrations in 1995 were 20 to 30 times higher than concentrations found at similar depths in 1989.

In 1989, zinc concentrations were twice as high at one site, Station 11, than at the other sites (181 to 247 mg/kg), but only half of the 1995 levels. Station 11 was considered an anomaly in 1994 and was not included in site life estimates for the land application site (CH2M Hill, 1992a). Zinc concentrations observed in 1994 by CH2M Hill (1995), 175 to 237 mg/kg, were similar to the concentrations considered anomalous at Station 11 in 1989.

Lead concentrations in the 1995 samples also correspond with the 1989 Station 11 concentrations which are somewhat higher than those at the other three 1989 stations. One 1995 copper sample corresponds to the 1989 concentration at Station 11, while the other is over four times higher.

Differences between historical metal concentrations in soil and those for 1995

Several factors may explain the higher concentrations of chromium, zinc, and possibly lead and copper in 1995 soil samples compared to earlier results. Sampling methods, spatial variability, or actual increases in soil metal concentrations may be responsible.

The 1995 soil samples were composite grab samples comprised of three subsamples. Each subsample was collected within a 20-foot radius at two to six inches depth with a stainless steel spoon. The 1989 PWM samples, in contrast, were taken from a stainless steel split spoon sampler as part of a soil boring (CH2M Hill, 1992b).

The two-inch diameter split spoon sample represents a smaller area of the field than the composite samples. The diameter of the split spoon is about 1-1/2 inch compared to the composite grab samples which represent three subsamples within a 20-foot radius, each of which were taken from an area eight to ten inches in radius. Patchiness and heterogeneity of soils and metals distribution should therefore have less effect on the composite samples than on those collected by split spoon sampler.

Metal samples collected in 1989 did not follow the typical pattern of higher concentrations near the surface and lower concentrations with depth. Additional soil sampling may help clarify these discrepancies.

If saturated soil conditions occur at the site due to high water table or heavy precipitation, metals could become mobilized. This study did not address possible mechanisms for surface runoff from the land application site, although this is a concern due to the site's proximity to Gibbons Creek remnant channel which discharges to the Columbia River.

Metals in biosolids compared with EPA (1993) criteria for municipal biosolids

Effects of biosolids were evaluated using two criteria from the Federal Register 40 CFR Part 503 (EPA, 1993):

a) concentration of metals in the biosolids (mg/kg)

b) cumulative pollutant loading rate (kg/hec)

These criteria are used only for reference, because they apply only to municipal biosolids. Concentrations of metals were converted from a liquid to a dry weight basis using the following formula:

mg/kg dry wt = (ug/L) / (% solids) / 10

a) Concentration of metals in biosolids

Zinc concentrations exceeded EPA (1993) *pollutant concentrations* five times in 1994 and 1995 as shown in Table 5, according to PWM's Discharge Monitoring Reports (DMRs). Because these samples were filtered, total metals applied were probably higher than those reported.

If municipal biosolids exceed *pollutant concentrations*, then loading rates to the site must be tracked to ensure that the health risk-based *cumulative loading rates* are not exceeded over the life of the site (EPA, 1993). The current permit does not require reporting of loading information which makes accurate cumulative loading tracking impossible.

Zinc concentrations in filtered metals samples collected by PWM at the same time as the Ecology samples and using the SW-846 method exceeded the *pollutant concentration* levels and were two times higher than the Ecology results (Table 6).

Although filtered biosolids samples collected by Ecology did not exceed the EPA (1993) *pollutant concentration*, the digestion method used, EPA 200.7, was not appropriate for comparison with the federal criteria. The *pollutant concentration* is based on the prediction that if one applied ten metric tons/hectare for 100 years, then health-based standards would not be exceeded.

Other metals were far below the EPA (1993) criteria, except chromium which has been removed from the regulation.

Table 5. Pendleton Woolen Mill biosolids metals concentrations for 1990-95 compared to EPA criteria for municipal biosolids. Results were calculated using PWM Discharge Monitoring Report data shown in Appendix E. Results from April 1994 through July 1995 represent filtered samples. It is not known if samples prior to April 1994 were filtered. Exceedences of EPA's (1993) "pollutant concentrations" for municipal biosolids are shown in bold.

Date	Units	Ceiling Concen-trations ^	Pollutant Concen-trations^	09/26/90	12/20/91	1/13/92	3/12/92	5/07/92	6/12/92	12/31/93	3/31/94	4/21/94	6/30/94	9/30/94	1/31/95	4/17/95	7/18/95
Total % Solids	%			0.7	0.27	0.25	0.25	0.20	0.26	0.28	0.31	0.3 *	0.42	0.42	0.28	0.25	0.37
Aluminum	mg/kg			896													
Arsenic	mg/kg	75	41	0.9													
Barium	mg/kg			56													
Cadmium	mg/kg	85	39	1.1								6.3 *					
Chromium	mg/kg			544		164	760	700	538	857	645		1,429	1,143	857	1,840	1,486
Copper	mg/kg	4,300	1,500	53	6.3	10		60	46	119	88	687 *	250	262	119	136	149
Iron	mg/kg			4,571													
Mercury	mg/kg	57	17	0.4		0.2				3.6	1.6			11.9	3.6		
Nickel	mg/kg	420	420	4.9								17.1 *					
Potassium	mg/kg			2914				8,500									
Sodium	mg/kg			20,571													
Lead	mg/kg	840	300			17	20			18	32	142 *	24	24	18		27
Zinc	mg/kg	7,500	2,800	1,017	922	1,460	1,760	2,000	1,538	2,286	2,161	**17,567** *	**4,762**	**3,571**	2,286	**3,880**	**2,973**

* No data for per cent solids were available on this date. The mean per cent solids value for 1991-1995 Pendleton Woolen Mill DMR data was used to convert ug/L to mg/kg.

^ EPA, 1993. Federal Register, Vol. 58, No. 32, Part 503, February 19, 1993.

Table 6. Biosolids metals results obtained by PWM and Ecology on April 17 and July 18,1995. The analytical method used by Ecology underestimated the concentrations compared to the SW-846 method used by Pendleton Woolen Mill. Metals concentrations (ug/L) used to calculate mass loadings (mg/kg) are shown in Appendix E. Exceedences of EPA's (1993) "pollutant concentrations" for municipal biosolids are shown in bold.

Date	Units	Ceiling Concen-trations *	Pollutant Concen-trations*	*Ecology* 04/17/95	*Ecology* 04/17/95	*PWM* 4/17/95	*Ecology* 07/18/95	*Ecology* 07/18/95	*PWM* 7/18/95
Total % Solids	%			1.4	1.3	0.25	0.44	0.49	0.37
Aluminum	mg/kg								
Arsenic	mg/kg	75	41						
Barium	mg/kg								
Cadmium	mg/kg	85	39						
Chromium	mg/kg			288	399	1,840	853	469	1,486
Copper	mg/kg	4,300	1,500	90	92	136	104	66	149
Iron	mg/kg								
Mercury	mg/kg	57	17						
Nickel	mg/kg	420	420						
Potassium	mg/kg								
Sodium	mg/kg								
Lead	mg/kg	840	300	9	10	16	10	7	27
Zinc	mg/kg	7,500	2,800	1,736	1,838	**3,880**	1,769	1,288	**2,973**

* EPA, 1993. Federal Register, Vol. 58, No. 32, Part 503, February 19, 1993.

b) Cumulative loading rates of metals

Table 7 shows the estimated annual loading of zinc to the land application site over the past four years compared to the *Cumulative Loading Rate* for municipal biosolids (EPA, 1993). These estimates may be low, because biosolids samples were filtered. On the other hand, water usage is probably less than the design flow used in calculations which would tend to overestimate loading. Loading estimates for other metals were farther below the criteria.

Table 7. Annual loading for zinc compared with the EPA (1993) *cumulative pollutant loading* limits for the life of the site. Annual loading is based on the mean annual biosolids metals concentrations and the facility's annual design flow of 1,620,000 gallons/year on six acres. The EPA criterion is in kg/hec; annual loadings are in kg/hec/year.

EPA Criterion	1992	1993	1994	PWM 1995	Ecology 1995
2,800	10	16	67	23	39

If the PWM site had not previously received metals and was just beginning operation, loading at the 1994-95 levels would provide between 42 and 120 years for land application of municipal biosolids. However, zinc already in the soil would have to be taken into account. Biosolids have been applied at the site for about 20 years. Loading estimates were not available for the years prior to 1992 (Underwood, 1995). Site life is discussed further under *Soil Analyses* above.

Hazardous waste designation

The state Dangerous Waste Regulation (Chapter 173-303 WAC) requires that facilities test all solid waste generated, including biosolids, to determine if they designate as hazardous waste. This has not been done at PWM but should be done as soon as possible (Michelina, 1996).

Metals and nitrogen in ground water 1995

Table 8 shows the 1995 Ecology results for metals and nitrogen results in the monitoring wells. Metal concentrations were below detection in all monitoring wells, although detection limits were high. Ammonia concentrations in downgradient MW-SP-1, 3.1 to 3.6 mg/L, were higher than those upgradient and in the other downgradient wells.

Nitrate concentrations in the upgradient well, MW-11, were higher than downgradient, i.e., 1.0 to 1.5 mg/L, compared to downgradient concentrations of 0.01 to 0.10 mg/L. Agricultural practices around the upgradient well are probably the source of elevated nitrate.

Table 8. Ground water monitoring results for samples collected by Ecology on April 17 and July 18, 1995. Only samples labeled "dissolved" were field-filtered. Other samples were not filtered.

Date	Site	pH	Conductivity (S.U.)	TDS (mg/L)	Chloride (mg/L)	Ammonia (mg/L)	NO3+NO2 (mg/L)	TKN* (mg/L)	Cd (ug/L)	Cr (ug/L)	Cu (ug/L)	Ni (ug/L)	Pb (ug/L)	Zn (ug/L)	Cr6+ (ug/L)
4/17/95	MW-11	6.0	69.2	61		0.010	1.10	2U	3 U	5 U	3 U	10 U	20 U	4 U	
4/17/95	MW-11 dissolved								3 U	5 U	3 U	10 U	20 U	4.3 P	
4/17/95	MW-SP1	6.7	622	403		3.12	0.015	4.1	3 U	5 U	3.1 P	10 U	20 U	4 U	
4/17/95	MW-SP1 dissolved								3 U	5 U	3 U	10 U	20 U	4 U	
4/17/95	MW-SP2	6.8	664	501		0.016	0.010	2U	3 U	5 U	3 U	10 U	20 U	4 U	
4/17/95	MW-SP2 dissolved								3 U	5 U	3 U	10 U	20 U	4 U	
								TPN*							
7/18/95	MW-11		84.0	71	2.45	0.010	1.52	1.55							2 U
7/18/95	MW-11 dissolved								3 U	5 U	3 U	10 U	20 U	4 U	
7/18/95	MW-SP1		649	360	2.18	3.58	0.011	3.90							2 U
7/18/95	MW-SP1 dissolved								3 U	5 U	3 U	10 U	20 U	4 U	
7/18/95	MW-SP2		663	411	2.53	0.021	0.010	0.103							2 U
7/18/95	MW-SP2 dissolved								3 U	5 U	3 U	10 U	20 U	4 U	
7/18/95	MW-SP3		187	135	1.65	0.192	0.105	0.363							2 U
7/18/95	MW-SP3 dissolved								3 U	5 U	3 U	10 U	20 U	4 U	

U: Analyte was not detected at or above the result.

* TKN: Total Kjeldahl Nitrogen; TPN: Total Persulfate Nitrogen

Gibbons Creek remnant channel

Elevated concentrations of chromium, zinc, and copper have previously been found in Gibbons Creek remnant channel sediments near the PWM facility (Erickson and Tooley 1996, and CH2M Hill 1992b). Table 9 shows the available sediment data for the remnant channel compared with the Province of Ontario's sediment protection guidelines (Persaud, et al., 1993). The Gibbons Creek sampling locations are shown in Figures 6 and 7.

The site with the highest metal concentrations, G-3, was only sampled once in 1989 (CH2M Hill, 1992b). The range in concentration of four chromium samples collected in a transect across the stream ranged from 68 to 161 mg/kg. Three out of the four samples exceeded the Ontario *severe effect* level of 100 mg/kg (Table 9).

Table 9. Sediment metals concentrations in mg/kg obtained in Gibbons Creek remnant channel in 1989 and 1995 near the PWM land application site. Stations RC-1 and G-4 are in approximately the same location, as shown in Figures 6 and 7. EPA SW-846 Method 3050 was used for digestion of all samples.

	Ontario sediment criteria (Persaud, et al, 1993)					
Metal	*Lowest Effect*	*Severe Effect*	**RC-1** 1995	**G-4** 1989	**G-3*** 1989	**RC-4**** 1995
Cr	26	110	65	63-87	68-161	18
Zn	120	820	138	148-169	208-270	77
Cu	16	110	47	43.7-56.3	57-100	20

* G-3 is about 300 feet downstream of RC-1 and G-4.

** RC-4 is the background site, 1.5 miles upstream.

A location about 100 feet downstream of G-3 was sampled in both 1989 and 1995 and provides a means of comparing concentrations over time. The site was called G-4 in 1989 and RC-1 in 1995. Chromium values were about half way between the *lowest* and *severe effect* levels on both dates. The background chromium concentration in 1995 (Site RC-4) was below the *lowest effect* level of 18 mg/kg.

Zinc concentrations in sediments were just above or one-quarter of the range between *lowest effect* and *severe effect*, as shown in Table 9. Similar to chromium concentrations, zinc was higher at G-3 than at G-4 in 1989 or RC-1 in 1995. The upstream zinc concentration was below the *lowest effect* level.

Copper concentrations approached the *severe effect* level of 110 mg/kg in 1989 at G-3 with a range across the creek from 57 to 110 mg/kg. Concentrations at G-4 or RC-1 were roughly half way between the *lowest effect*, 16 mg/kg, and *severe effect*. The background copper concentration, 20 mg/kg, was slightly above the *lowest effect* in 1995.

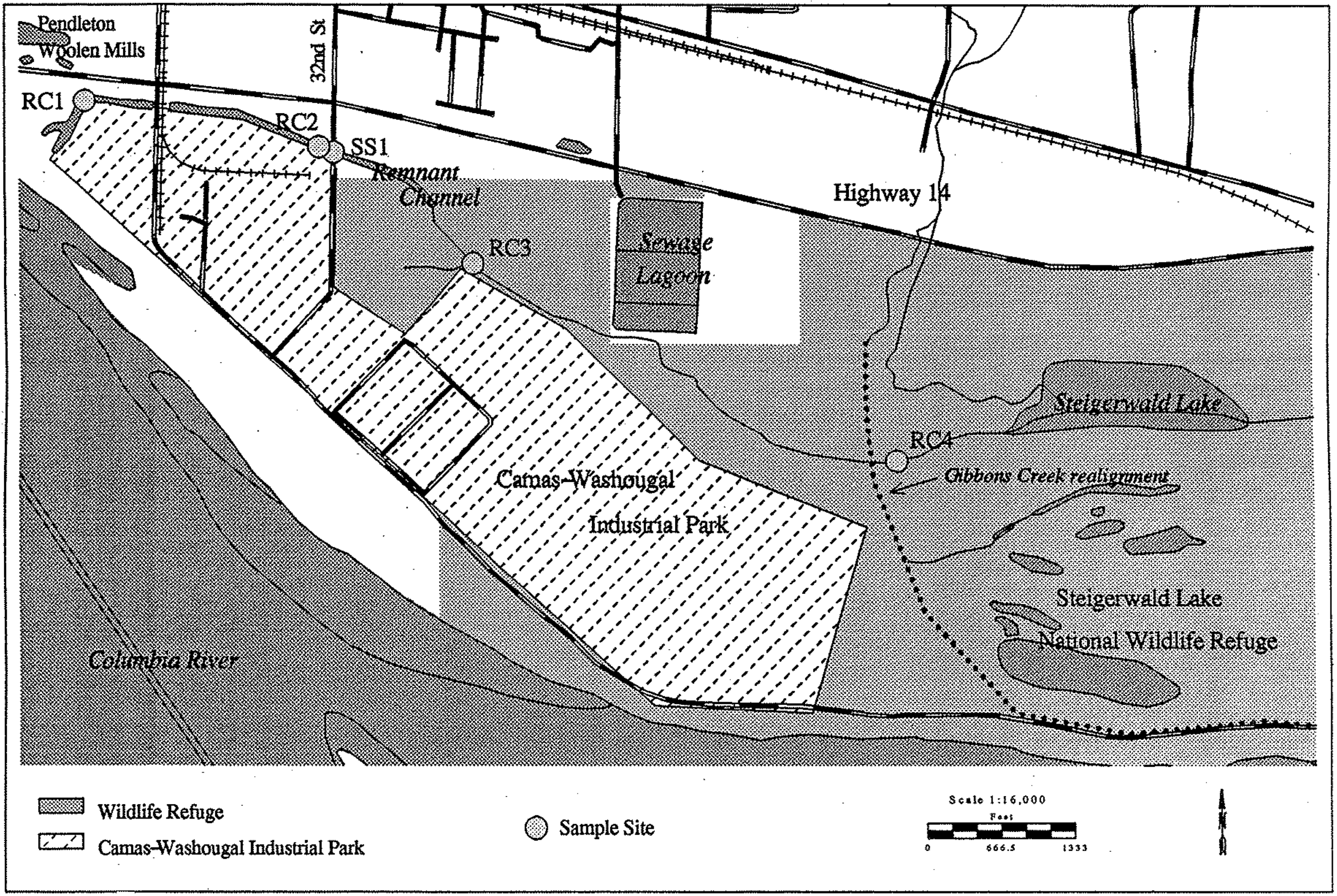

Figure 6. Locations where sediments were sampled in 1995 (Erickson and Tooley, 1996). Site RC-1 was actually near the middle of the fork in the channel, southwest of the marker shown.

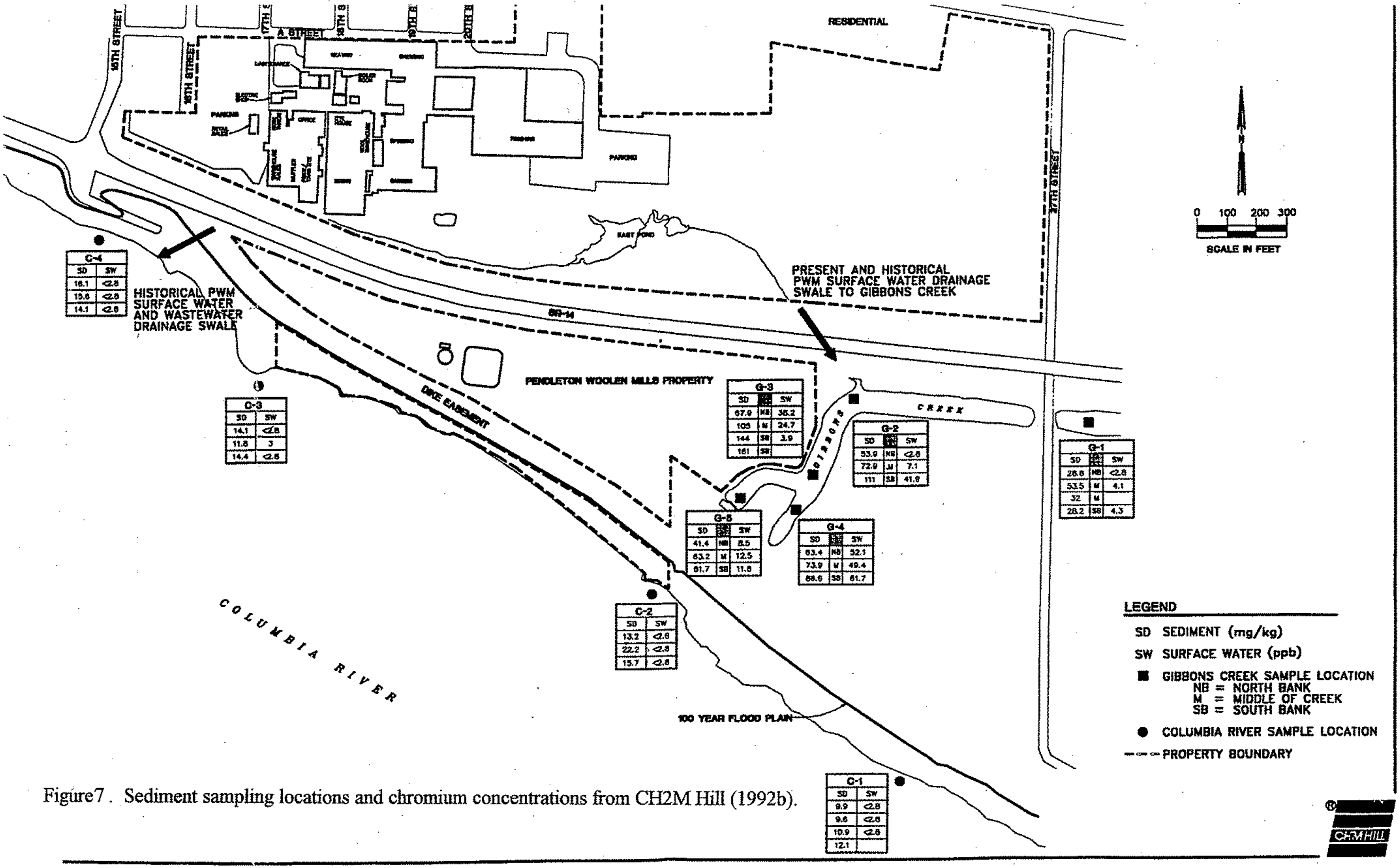

Figure7 . Sediment sampling locations and chromium concentrations from CH2M Hill (1992b).

3) Evaluate the effects on biosolids treatment of changing the land application site crop from reed canary grass to poplar trees

The effects of changing the land application site crop from reed canary grass to poplars depend on the way the new system is planted, operated, and maintained. A key factor for success is to ensure that loading to the field corresponds with the capacity of the trees and grass to take up the water applied.

If saturated conditions occur, then surface runoff is possible as well as anoxic soil conditions. Metals that are typically immobile when oxygenated may become dissolved and mobile in the soil under saturated conditions, regardless of the crop.
If additional soils data lead to a change in the site life estimate, the cost-effectiveness of changing the crop may also change.

The advantages of poplar trees over reed canary grass include:

- Poplar stands provide a relatively stable wildlife habitat with harvesting occurring every eight to twelve years. However, between harvesting and establishment of a new crop the wildlife habitat would not be available

- Poplar trees would be a more cost-effective crop than reed canary grass

- A poplar stand would be more aesthetically appealing than the current grass crop

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Appendices

Appendix A. Well logs for land application site monitoring wells (CH2M Hill, 1995).

CHM HILL

PROJECT NUMBER OPE26950.B0	WELL NUMBER MW-SP1	SHEET 1 OF 2

MONITORING WELL GEOLOGIC AND CONSTRUCTION LOG

PROJECT PWM Spray Irrigation Area LOCATION Washougal, WA

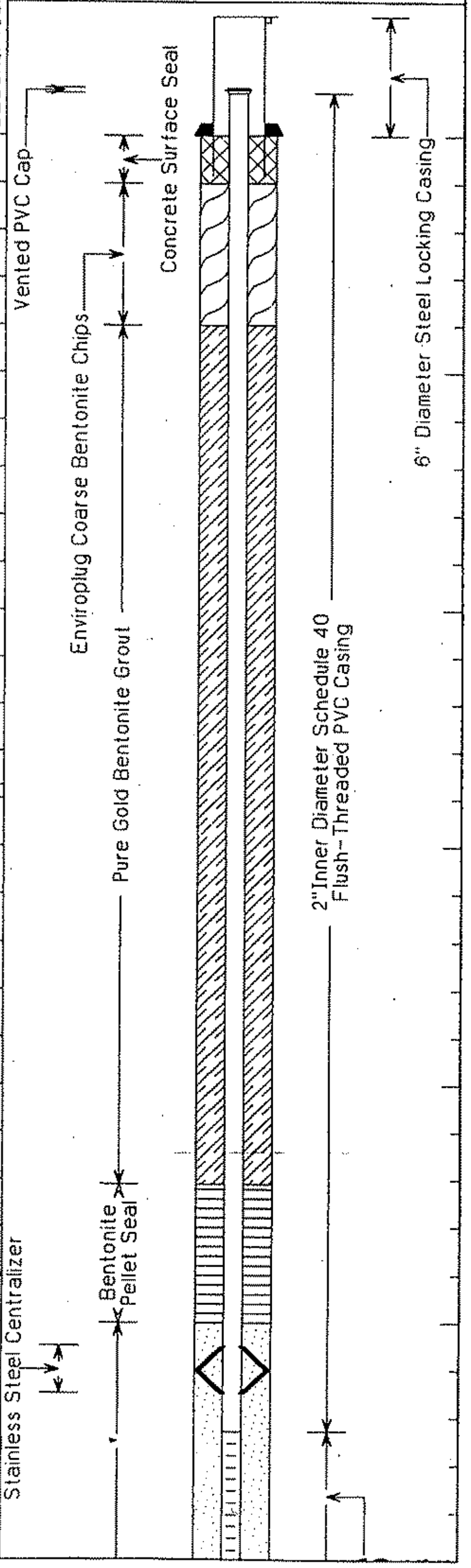
MEASURING POINT ELEV (NGVD) 25.93 (PVC) DRILLING CONTRACTOR R&R Drilling, Puyallup, WA

DRILLING METHOD AND EQUIPMENT 6" ID Air Rotary (ODEX); D&M Sampler (300 lb)

WATER LEVEL ELEV/DATE 10.56 (10/18/93) START 10/5/93 FINISH 10/5/93 LOGGER John Porcello

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	USCS DESCRIPTION
	INTERVAL	TYPE AND NUMBER	RECOVERY FEET	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	
					SILT, ML, medium brown. Geologic log maintained from drill cuttings and split-spoon samples. Start time 0835.	ML
					SILT W/CLAY, ML/CL, medium gray, moist at 4 feet.	ML/CL
5.0						
					Water in borehole at 8 feet.	
10.0						
15.0						
20.0						
					GRAVEL WITH SAND AND SILT, GP/GM, gray, wet. Subrounded, up to 3/4". Hard drilling at 23 feet.	GP/GM
25.0	25.0 26.5		0.7	15-40-50/2"	WELL-GRADED GRAVEL WITH SILT, GW/GM, gravel multi-colored, silt matrix mottled red, orange, yellow, brown. Wet. Gravel subangular to rounded, maximum size 3".	GW/GM

WELL COMPLETION DIAGRAM



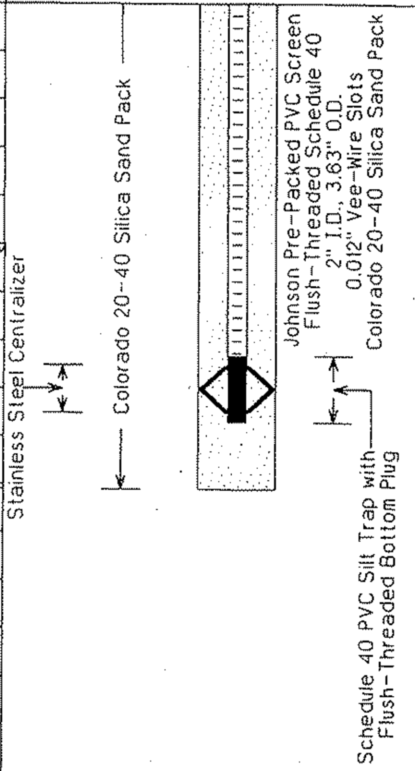
CH2M HILL

PROJECT NUMBER	WELL NUMBER
0PE26950.B0	MW-SP1 SHEET 2 OF 2

MONITORING WELL GEOLOGIC AND CONSTRUCTION LOG

PROJECT PWM Spray Irrigation Area LOCATION Washougal, WA
MEASURING POINT ELEV (NGVD) 25.93 (PVC) DRILLING CONTRACTOR R&R Drilling, Puyallup, WA
DRILLING METHOD AND EQUIPMENT 6" ID Air Rotary (ODEX); D&M Sampler (300 lb)
WATER LEVEL ELEV/DATE 10.56 (10/18/93) START 10/5/93 FINISH 10/5/93 LOGGER John Porcello

DEPTH BELOW SURFACE (FT)	SAMPLE: INTERVAL	SAMPLE: TYPE AND NUMBER	SAMPLE: RECOVERY FEET	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	USCS DESCRIPTION	WELL COMPLETION DIAGRAM
					Very hard drilling at 30 feet.		
					Grayish-green at 34 feet.		
35.0						GW/GM	
40.0					Time 1030: TOTAL DEPTH 40.1 FT BGS Note: No heaving sand encountered in this borehole.		
45.0							
50.0							
55.0							



CH2M HILL

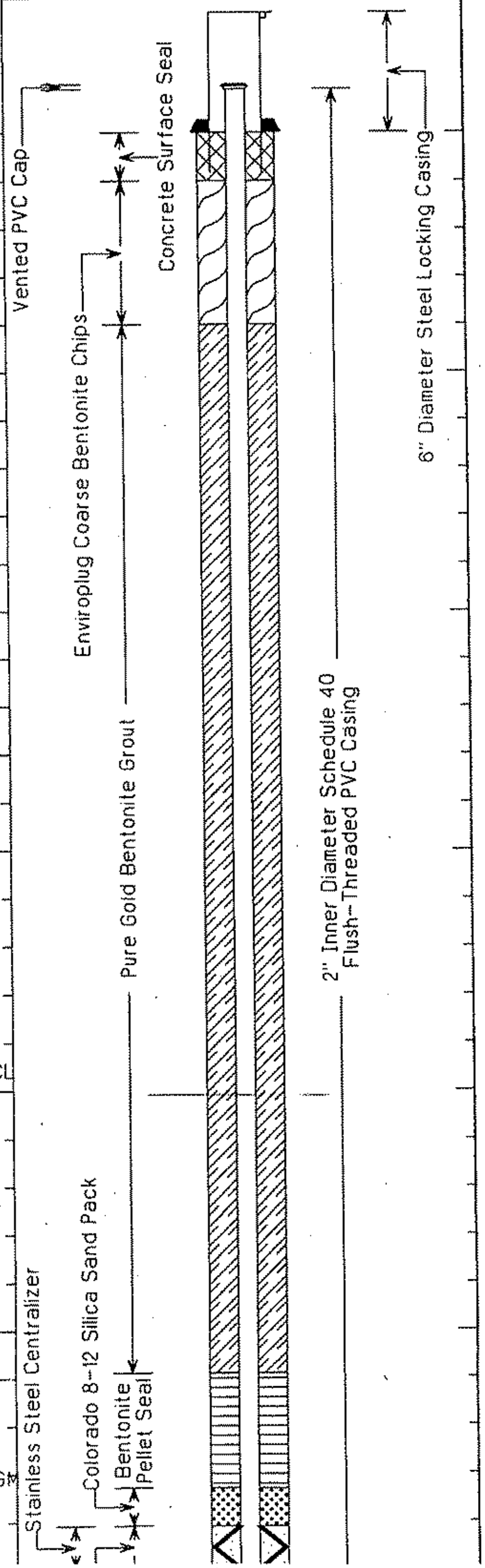
PROJECT NUMBER	WELL NUMBER
0PE26950.B0	MW-SP2 SHEET 1 OF 2

MONITORING WELL GEOLOGIC AND CONSTRUCTION LOG

PROJECT PWM Spray Irrigation Area LOCATION Washougal, WA
MEASURING POINT ELEV (NGVD) 25.65 (PVC) DRILLING CONTRACTOR R&R Drilling, Puyallup, WA
DRILLING METHOD AND EQUIPMENT 6" ID Air Rotary (ODEX); D&M Sampler (300 lb)
WATER LEVEL ELEV/DATE 9.98 (10/18/93) START 10/4/93 FINISH 10/4/93 LOGGER John Porcello

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE TYPE AND NUMBER	SAMPLE RECOVERY FEET	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	USCS DESCRIPTION
					SILT, ML, slightly moist to moist, medium brown. Geologic log maintained from drill cuttings and split-spoon samples. Start time 0800.	
5.0						
						ML
					Wet at 8 feet. Fewer cuttings, in clumps.	
10.0					Water in borehole at 10 feet.	
					SILT/CLAY, ML/CL at 13 feet. Medium gray, moist to wet.	
15.0						
					Add water to 18 feet to clean out hole.	
						ML/CL
20.0						
					SILT/CLAY WITH TRACE GRAVEL, ML/CL, at 23 feet, wet, medium gray. Slightly harder drilling at 23 feet.	
25.0					Poorly-graded.	
					GRAVEL WITH SAND AND SILT, GP/GM, at 26 feet. Greenish-gray, fine sand, wet.	
						GP/GM

WELL COMPLETION DIAGRAM



CH2M HILL

PROJECT NUMBER	WELL NUMBER
0PE26950.B0	MW-SP2

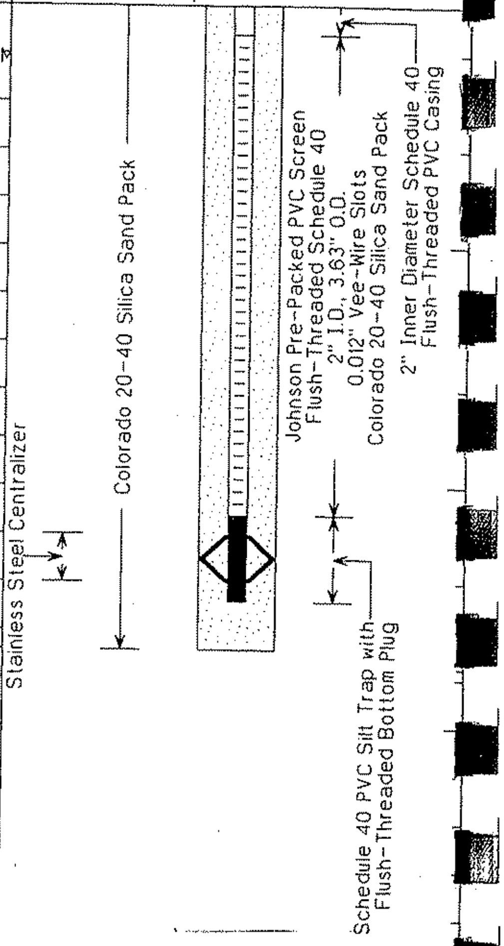
SHEET 2 OF 2

MONITORING WELL GEOLOGIC AND CONSTRUCTION LOG

PROJECT PWM Spray Irrigation Area LOCATION Washougal, WA
MEASURING POINT ELEV (NGVD) 25.65 (PVC) DRILLING CONTRACTOR R&R Drilling, Puyallup, WA
DRILLING METHOD AND EQUIPMENT 6" ID Air Rotary (ODEX); D&M Sampler (300 lb)
WATER LEVEL ELEV/DATE 9.98 (10/18/93) START 10/4/93 FINISH 10/4/93 LOGGER John Porcello

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE TYPE AND NUMBER	SAMPLE RECOVERY FEET	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	USCS DESCRIPTION
					Heaving sand at 30 feet.	GP/GM
					POORLY-GRADED SAND, SP, black and gray-green, wet, fine to medium grained. Faster drilling at 32 feet.	SP
35.0						
					POORLY-GRADED FINE SILTY SAND, SM at 39 feet, yellow-brown. Drilling a bit harder at 37 feet. No heave. Color change at 39 feet.	
40.0	40.0					SM
	41.5		1.4	31-51-50 (5")	POORLY-GRADED SAND, SP, brown and rust-colored, wet, sand fine-grained with occassional flakes of mica. SWL = 17 feet bgs; time 1005.	SP
					Time 1020: TOTAL DEPTH 43.4 FEET	
45.0						
50.0						
55.0						

WELL COMPLETION DIAGRAM



CH2M HILL

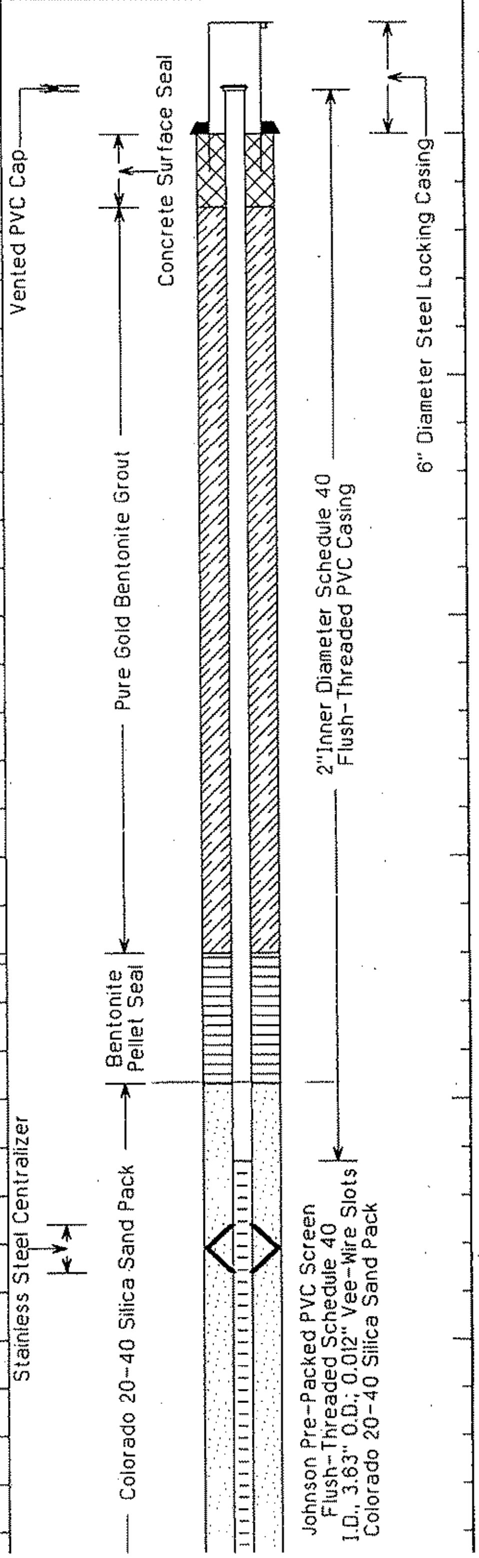
PROJECT NUMBER	WELL NUMBER
0PE26950.B0	MW-SP3 SHEET 1 OF 2

MONITORING WELL GEOLOGIC AND CONSTRUCTION LOG

PROJECT PWM Spray Irrigation Area LOCATION Washougal, WA
MEASURING POINT ELEV (NGVD) 20.80 (PVC) DRILLING CONTRACTOR R&R Drilling, Puyallup, WA
DRILLING METHOD AND EQUIPMENT 6" ID Air Rotary (ODEX); D&M Sampler (300 lb)
WATER LEVEL ELEV/DATE 9.88 (10/18/93) START 10/6/93 FINISH 10/6/93 LOGGER John Porcello

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	USCS DESCRIPTION
	INTERVAL	TYPE AND NUMBER	RECOVERY FEET	6" -6" -6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	
					SILT, ML, brown, slightly moist. Geologic log maintained from drill cuttings and split-spoon samples. Start time 0845.	
5.0						
						ML
10.0					Water appears in borehole during drilling from 10-15 feet.	
15.0					SILT/CLAY, ML/CL, medium gray, moist to wet.	
						ML/CL
					Hard drilling at 19 feet.	
20.0	20.0 21.5		0.8	30-23-43 (66)	WELL-GRADED GRAVEL WITH SAND, GW, medium gray, wet. Gravel subrounded to rounded with maximum size 2-1/2". Sand fine.	
						GW
25.0						
					SILTY SAND, SM, yellow-brown, wet, fine-grained.	SM

WELL COMPLETION DIAGRAM



CH2M HILL

PROJECT NUMBER	WELL NUMBER
OPE26950.B0	MW-SP3

SHEET 2 OF 2

MONITORING WELL GEOLOGIC AND CONSTRUCTION LOG

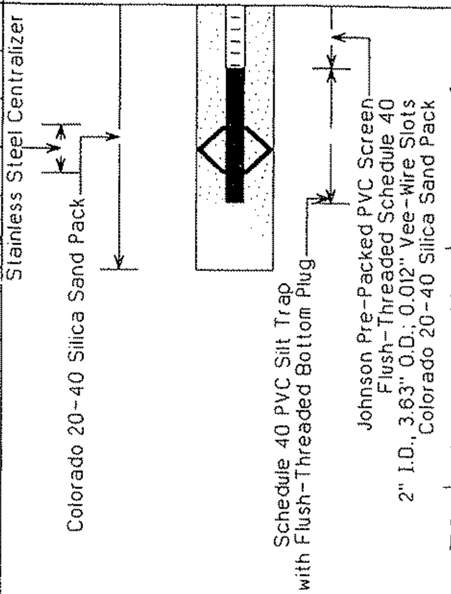
PROJECT PWM Spray Irrigation Area LOCATION Washougal, WA

MEASURING POINT ELEV (NGVD) 20.80 (PVC) DRILLING CONTRACTOR R&R Drilling, Puyallup, WA

DRILLING METHOD AND EQUIPMENT 6" ID Air Rotary (ODEX); D&M Sampler (300 lb)

WATER LEVEL ELEV/DATE 9.88 (10/18/93) START 10/6/93 FINISH 10/6/93 LOGGER John Porcello

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	USCS DESCRIPTION	WELL COMPLETION DIAGRAM
	INTERVAL	TYPE AND NUMBER	RECOVERY FEET	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY		
					POORLY-GRADED SAND, SP, medium gray, wet, fine-grained.	SM	
					SILTY SAND, SM, as at 27-31 feet.	SP	
35.0	34.0 35.5		1.5	64-50-50/5	Upper 0.5 feet: POORLY-GRADED SAND, SP, gray, wet, fine-grained with one 1/2" rounded gravel. Middle 0.5 feet: WELL-GRADED GRAVEL WITH SAND, GW, mottled gray and brown, maximum size 3". Lower 0.5 feet: SILTY SAND, SM, light brown, wet, sand fine to medium, occassional flakes of mica.	SP/GW	
					Time 0935: TOTAL DEPTH 35.5 FEET		
40.0							
45.0							
50.0							
55.0							



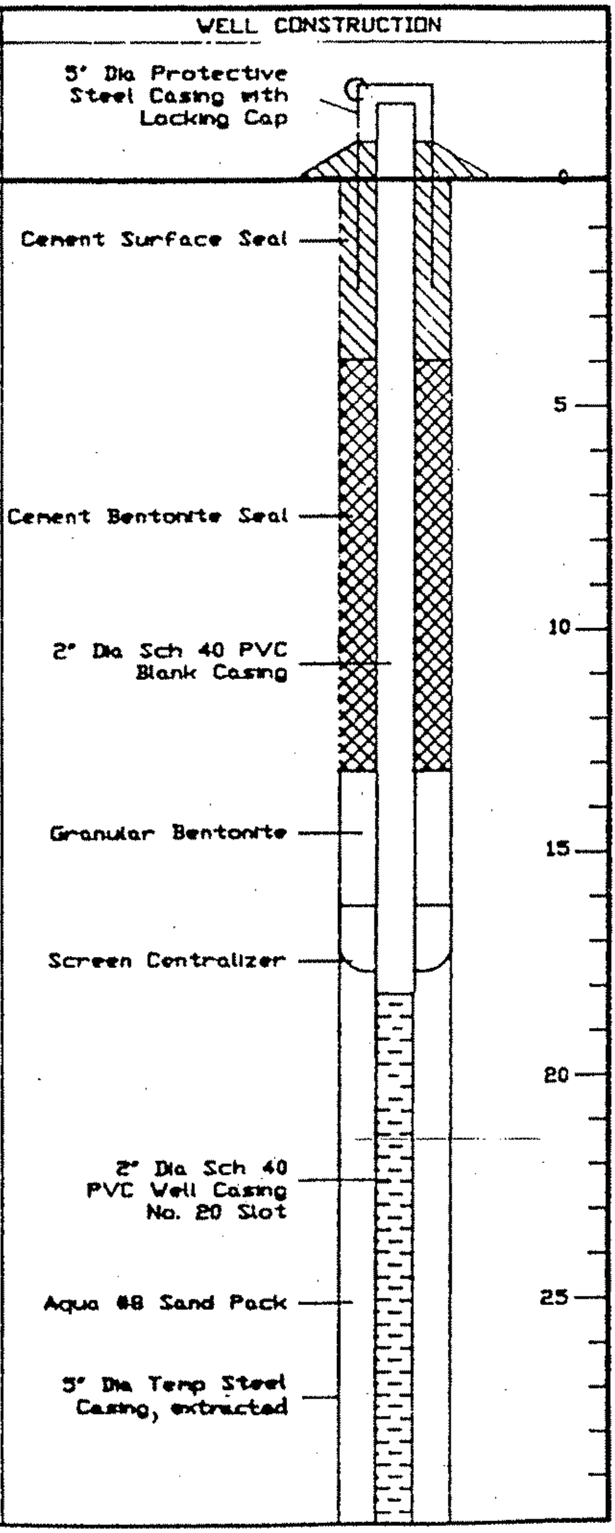
MONITORING WELL GEOLOGIC & CONSTRUCTION LOG

PROJECT NUMBER	WELL NUMBER	
P17721.G0	**MW-11**	SHEET 1 OF 2

PROJECT Pendleton Woolen Mills
LOCATION Washougal, Washington
ELEVATION, NGVD (Top of Well Casing) 47.41
SURFACE ELEVATION, NGVD 45.1
WATER LEVEL ELEVATION, NGVD 15.41 (9/11/87)
START DATE 09/03/87
DRILLING CONTRACTOR Kring Drilling
FINISH DATE 09/08/87
DRILLING METHOD 5" Dia Odex Air Rotary

DEPTH (Ft)	SAMPLE Recovery (%)	SAMPLE Blows	GEOLOGI LOG & USCS DESIGNATION	HYDROLOGIC UNIT
	0		No sample recovered	
5	0	36/6	SILT with GRAVEL (SM) Boulders ROCK	
10				
	33	50/6	GRAVELLY SAND, moist, well graded 1/4"-3" dia rounded-subrounded gravel, gray with visible oxidation, 25% well-graded sand and 10% moist, brown silt (GM) Boulders ROCK	
15				
20				
	58	16-25-16	SAND with GRAVEL, moist, gray, brown, well graded sand, 30% poorly graded 1/4"-3" dia subrounded gravel, visible oxidation, 10% fines (SM)	
25	0	50/6	Gravel cuttings.	
	33	50/6	GRAVEL, moist, gray, poorly graded, rounded and subrounded 1/4"-2" dia gravel, 20% well graded sand and 10% fines (GM)	

WELL CONSTRUCTION



CH2M HILL

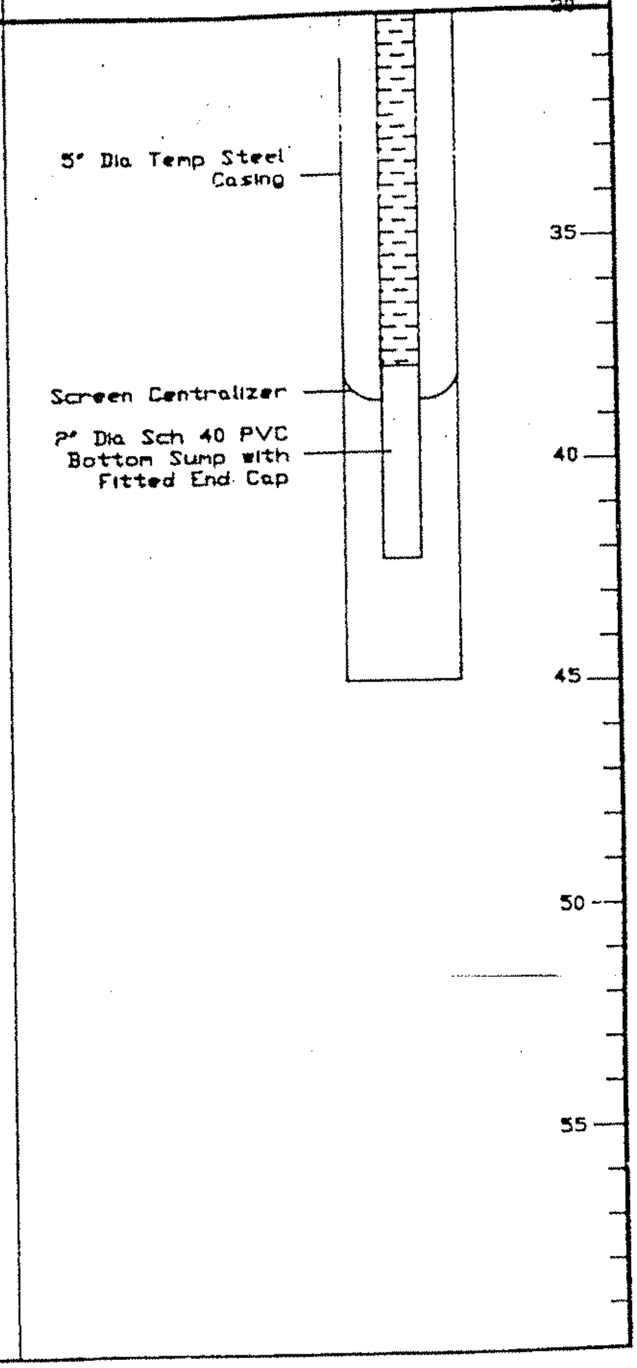
MONITORING WELL GEOLOGIC & CONSTRUCTION LOG

PROJECT NUMBER	WELL NUMBER	
P17721.G0	**MW-11**	SHEET 2 OF 2

PROJECT Pendleton Woolen Mills
LOCATION Vashougal, Washington
ELEVATION, NGVD (Top of Well Casing) 47.41
SURFACE ELEVATION, NGVD 45.1
WATER LEVEL ELEVATION, NGVD 15.41 (9/11/87)
START DATE 09/03/87
DRILLING CONTRACTOR Kring Drilling
FINISH DATE 09/08/87
DRILLING METHOD 5" Diameter Odex Air Rotary

DEPTH (Ft)	SAMPLE Recovery (%)	SAMPLE Blows	GEOLOGIC LOG & USCS DESIGNATION	HYDROLOGIC UNIT
	50	24-29-25	GRAVEL, wet, gray, gap graded 1/2" and 3" dia, subrounded, 30% well graded, grayish-brown sand and 10% fines (GM)	
	50	21-45-46	As above.	
35	58	25-36-34	GRAVELLY SAND, wet, gray & brown poorly graded 1/2"-2" dia subrounded gravel, 40% well graded sand, trace of fines (GM)	
	50	16-34-29	Decreasing sand.	
40	78	3-36-30	GRAVEL, wet, light brown to gray, poorly graded 1/4"-3" dia subrounded gravel, 10% well graded sand & 10% fines (GP-GM)	
	100	18-22-41	SAND, wet, yellowish-white, poorly graded medium sand (SP), 3" thickness silts-one lense at 43' light brown, dry, blocky, trace of of 2"-3" dia gravel.	
45				
50				
55				

WELL CONSTRUCTION



Appendix B. Sampling and analysis methods.

Sampling Procedures

Procedures for sampling ground water are described in the facility's "Sampling and Analysis Plan" (CH2M Hill, 1992a) exerpts of which are shown in Appendix C. Additional field procedures conducted during sampling in April and July 1995 for the Ecology samples are described below.

Ground water

Ground water samples were collected from the four land application site monitoring wells using CH2M Hill's low-flow submersible pump with dedicated tubing. A minimum of three bore volumes was removed prior to sampling. Specific conductance, pH, and temperature were also measured after each bore volume was removed. A sample was collected when the indicator parameters stabilized within 5-10% of the previous sample.

Metal samples, excluding hexavalent chromium, were filtered in the field using 0.45 um in-line filters. Unfiltered metals samples were also collected from the monitoring wells on April 17, 1995.

Biosolids

In April 1995, biosolids samples were collected from the biosolids storage tank after the tank was aerated for 20 to 30 minutes. The sample was collected from a pipe on the side of the tank about eight feet from the bottom and a minute or two after discharging. In July 1995 biosolids samples were collected from the pipe discharging to the field.

Although biosolids samples were intended to be analyzed unfiltered, samples were accidentally filtered in the laboratory.

Soil

Soil samples were collected at two locations in the land application site as shown in Figure 3. Each sample represented a composite of three samples collected within a 20- to 30-foot radius. Each subsample was collected by digging a 6- to 8-inch deep hole with a clean shovel . A stainless steel spoon pre-cleaned with nitric acid and rinsed with deionized water was then used to scrape the sides of the hole to obtain soil not exposed to the shovel. The sampling depth was two to six inches.

The subsamples were spooned into a pre-cleaned glass sampling jar and placed on ice until transported to the laboratory with the water samples.

Analytical Procedures

The parameters analyzed and procedures for analysis are shown in Table B.1.

Quality Control

Field

Field quality control procedures consisted of duplicate samples of ground water and biosolids to measure total sampling and analytical precision. In addition, standard methods for sample collection, preservation, storage, transport, and equipment calibration (pH) were used to minimize sampling bias (Cusimano, 1994).

Laboratory

Quality control procedures used in the laboratory for metals analysis include:

- Spike and duplicate spike samples,
- Check standard (1/group), and
- Calibration standard curve with correlation coefficient greater than 0.995.

Table B.1. Parameters, test methods, quantitation limits, and required precison and bias for the Pendleton Woolen Mill study.

Parameter	Test Method EPA(1)/Standard Methods(2)	Quantitation Limit	Matrix(3)	Required Precision (%)	Required Bias (%)
pH (Field)	Orion 250A	0.1 Std Unit	G, B	15	10
Specific Conductance (Lab)	/2510		G, B	15	10
Total Dissolved Solids	/2540	1 mg/L	G, B	15	10
Total Solids	/2540	1 mg/L	B	15	10
% Solids	/2540	1 mg/L	B	15	10
Ammonia-N	EPA 350.1/4500 NH3 D	0.01 mg/L	G, B	15	10
Nitrate+Nitrite-N	EPA 353.2/4500 NO3 F	0.01 mg/L	G, B	15	10
Chloride	EPA 330.0/4110B	0.1 mg/L	G, B	15	10
Metals (Cd, Cr, Cu, Ni, Zn)	ICAP 200.7	2-10 ug/L	G, S, B	15	10
Pb	ICAP 200.7	20 ug/L	G, S, B	15	10
Hexavalent Cr	218.5/3500-Cr D	5 ug/L	G, B(4)	15	10

(1) EPA, 1983. Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020. Revised March 1983.

(2) American Public Health Association, 1992. Methods for the Examination of Water and Wastewater, 18th Edition.

(3) Matrix Codes: G=Ground water, S=Soil, B=Biosolids

(4) This analysis is only available for liquid.

Appendix C. Sampling and Analysis Plan (CH2M Hill, 1992a).

Introduction

This sampling and analysis plan (SAP) presents the procedures to be followed for collecting water samples and measuring water levels that are part of the Pendleton Woolen Mills (PWM) groundwater monitoring program for the spray irrigation area. It also identifies laboratory analytical methods to be used on the samples and the quality assurance protocol.

Sampling Program

Samples will be collected from four PWM monitoring wells. Samples will be collected and analyzed quarterly, for one year, after which the frequency, monitoring locations, and analyses will be evaluated.

Sampling Procedures

Groundwater

Static Water Level Measurements

Water levels will be measured at the four sampled monitoring wells, at MW-15, a silt zone monitoring well located in the spray irrigation area, and at selected surface water locations. These water levels will form individual data sets that will be used to construct potentiometric maps of the site vicinity. The depth to water in each well will be measured with an electric water-level indicator (dedicated to PWM) from the top of the well casing at the surveyed measuring point to the nearest 1/100 foot. The water level indicator will be rinsed with distilled water before use in each well. If sampling does not occur on the same day as the sitewide water level measurement, the water level will be remeasured at the time of sampling. Water level measurements will be recorded in the logbook.

Because of the site's proximity to ditches, streams, and rivers that can vary in water surface elevation over a relatively short time, it is important that water level measurements at the site be taken over a short time period, preferably within a span of 3 hours or less. Surface water elevations may change substantially while measuring water levels at the site (during heavy rain, for example). Therefore, surface water levels will be measured at the beginning and again at the end of the measurement period. The additional data on surface water elevations may be helpful in explaining anomalous groundwater elevation data.

Well Purging

The goal of groundwater sampling is to collect samples that are representative of the groundwater in the water-bearing zone. Each well will be purged until the well is flushed of standing water and contains fresh water from the formation.

Before sampling, the volume of water in the well casing will be calculated and recorded in the field logbook. Wells will be purged of a minimum of three casing volumes before sampling. The casing volume will be calculated with the following equation:

$$\text{Casing volume} = H \times (TD_c - DTW_c)$$

where;

H = A constant that converts the length (in feet) of the standing water column in the well to the casing volume in gallons. For 2-inch wells H = 0.16, for 4-inch wells H = 0.65.

TD_c= The total depth of the well (in feet) measured from the top of the PVC casing (total well depth + stickup

DTW_c= The depth to water (in feet) measured from the top of the PVC casing.

DTW_c is measured during each sampling event. The total depth of each well should be measured at least annually to determine whether or not the well is filling with silt over time.

If the well yield is so low that purging three well volumes is impractical, the well will be purged as much as possible and a sample will be collected after the well has recovered sufficiently to fill the required sample containers (on the same day). All purge water will be placed in plastic trash cans, transported to the manhole in the vicinity of the Finishing Building, and then pumped into the pipeline that conveys wastewater to the PWM treatment plant. All wells will be purged using a dedicated stainless steel bailer or pump. Refer to the Hydrostar pump manual for operation instructions. A gasoline-powered compressor can be rented in Washougal.

Field Parameters and Instrument Calibration

During well purging and immediately before sample collection, field measurements of electrical conductivity (EC), pH, and temperature will be obtained. These measurements will be obtained at least three times during well purging and immediately before sample collection. Well purging will continue until pH, EC, and temperature have stabilized (±10 percent). Results will be documented in the field logbook.

The probes used to take these measurements will be rinsed with distilled water before each measurement. The pH and EC meters will be field-calibrated or checked according to the manufacturer's specification standards on a minimum daily basis. Temperature will be measured first so that a temperature adjustment, if necessary, can be applied to the measurement of the remaining parameters. Monitoring probes will not be placed in any sample container destined for laboratory analysis. Calibration procedures and meter descriptions will be recorded in the field logbook. The temperature of buffers and standards used to calibrate meters will be measured and recorded in the logbook.

Sample Collection and Preservation

Groundwater samples will be withdrawn from each well immediately after purging, except as previously described for low-yield wells. Samples will be collected with dedicated stainless steel bailers or pumps. The bailer will be suspended on monofilament line that is wound on a reel. The line will be discarded after use in each well.

Water will be transferred from the bailer directly into the container that has been specifically prepared for that constituent or set of constituents. For wells with dedicated pumps, a dedicated Teflon discharge hose will be used. Water will be poured slowly down the inside wall of the container to reduce aeration. When using the dedicated Hydrostar pump, both the up and down cycles will be slowed so that the sample discharge rate is approximately 100 milliliters (mL) per minute.

Groundwater samples collected for metals analysis using a bailer will be field-filtered through a Geo-Tech barrel filter with 0.45-micron filter membranes. Nitrogen gas will be used to apply positive pressure to the filtering device. Before filtering the sample, approximately 200 mL of sample will be passed through the filter and discarded as a means of flushing the filter membrane. A disposable in-line filter with a 0.45-micron pore size will be used for metals sampling with dedicated pumps.

Each sample container shipped from the laboratory will already contain the appropriate preservative. Appropriate sample containers and preservatives for each constituent or group of constituents are listed in Table 1. Sample containers will be supplied by the analytical laboratory. The laboratory will certify that the containers were prepared according to appropriate Environmental Protection Agency (EPA) protocol. All containers will be placed in iced coolers immediately after the samples have been collected. Sample containers and coolers should not be stored in an environment where high-concentration vapors are present (e.g., from gasoline or decontamination chemicals).

Surface Water

Water Level Measurement

Water levels will be measured monthly at three Port of Camas relief wells (adjacent to Gibbons Creek) and seven surface water measuring stations. The water level at each surface water measuring station, except for the Washougal River, will be measured using the established surface water staff gauges. The Washougal River elevation will be determined by measuring down to the water surface from an orange bolt on the center east edge of the 17th Street bridge. Depth to water will be measured with an electric water level indicator. The measurement will be recorded to the nearest 1/100 foot. If sampling does not occur on the same day as the sitewide water level measurement, the water level will be remeasured at the time of sampling. All water level measurements will be recorded in the field logbook.

Because of the site's proximity to ditches, streams, and rivers that can vary in water surface elevation over a relatively short time, all water level measurements at the site will be taken over a short time period (approximately 3 hours). Surface water elevations may change substantially while measuring water levels at the site (during heavy rain, for example). The additional data on surface water elevations may be helpful in explaining anomalous groundwater elevation data.

Sequence

Samples will be collected in order of potential increasing contamination; i.e., the upgradient background well will be sampled first, and the downgradient wells will be sampled last. The rationale is to reduce the potential for cross-contamination between wells.

Documentation

Field Logbook

The sample team will maintain a field logbook for all sampling information. The field logbook will be a bound notebook with numbered pages. All entries will be made in waterproof ink. At the start of each day, the names of sample team members, weather conditions, and reasons for sampling will be recorded. The team leader will keep the field logbook and sign the book at the end of each day's activities.

Data obtained on water samples will be entered into the logbook and may include the following items:

- The well number
- Well depth
- Static water level and measurement technique
- Water turbidity and color
- Water odor (if present)
- Well yield
- Sample identification number
- Well evacuation procedure and equipment
- Sample withdrawal procedure and equipment
- Date and time of collection

- Well sampling sequence
- Types of sampling containers and preservative(s) used
- Parameters requested for analysis
- Field measurement and calibration data
- Sample distribution and transporter
- Field observations on sampling event
- Decontamination procedures
- Name of collector

Documentation Correction Protocol

All original data recorded in the field logbook, sample identification tags, chain-of-custody records, and other forms are to be written with waterproof ink. If an error is made on a document, corrections may be made by crossing a single line through the error, initialing, and entering the correct information. The erroneous information must remain legible.

Labeling

An adhesive or wire-tie sample label will be affixed to each water sample container before sample collection. The information to be included on the sample labels includes:

- Sample number (including client identification)
- Container number
- Name of person collecting the sample
- Date and time of sample collection
- Type of preservative (if any)

Each sample container will be given a unique station number to avoid inadvertent data transfer. Each logbook will contain a specified station number, which will serve as the sample number.

All sample containers for a given station should have the same number. Be sure to enter the station number in the logbook.

Chain of Custody

A chain-of-custody (COC) record form will be used to track possession of a sample and to document analyses requested. Each time the sample containers change hands, both the sender and receiver will sign and date the chain-of-custody record form. When samples are shipped to the analytical laboratory, the top copy of the form will be enclosed in a plastic bag and placed inside the cooler. A second copy of the form is retained in the project files.

Laboratory Services Request

At the direction of the project manager, a Laboratory Services Request (LSR) form will accompany each shipment of samples to the laboratory. The LSR form will supplement the chain-of-custody form by providing additional instructions to the laboratory for requested analyses.

Field Data Transfer

After each water level measuring event and each sampling event is completed, the field documentation will be sent to the PWM project files in the Portland office. This documentation will include field logbooks, COC forms, LSR forms, and any notes or field observations that are pertinent to the project.

Packaging and Shipping

Sample bottles will be packed in iced coolers before shipment. Ice for keeping the samples cool will be placed in doubled 1-gallon Ziploc bags, and samples will be packed to avoid breakage during shipment. One copy of the chain-of-custody record form will be placed in a sealed plastic bag inside the cooler. The cooler lid will be sealed with fiber tape. At least two custody seals will be attached to the cooler so that the seals must be broken when the cooler is opened.

Samples will be shipped on a daily basis by commercial carrier to the CH2M HILL environmental laboratory in Redding, California. Samples must be received before the holding times specified in Table B-1 are exceeded.

Decontamination Procedures

Decontamination procedures are required to remove possible contaminants from nondedicated sampling equipment to prevent cross-contamination of samples. Nondedicated equipment, including valves, tubing, etc., will be disassembled and cleaned before field use and between each sample collection according to the following procedures:

1. Detergent solution wash
2. Tapwater rinse
3. HPLC water rinse
4. Air dry

Dedicated bailers should be rinsed with HPLC water before purging the well.

Disposable gloves are to be worn during all sampling activities. These gloves will be changed and discharged between wells. In addition, gloves will be kept scrupulously clean when handling bailers. If there is any doubt whether gloves are clean, the gloves will be discarded and replaced with new ones. All disposables should be bagged and placed in onsite refuse containers.

Analytical Procedures

The constituents to be analyzed, analytical methods, and the Target Quantitation Limits (TQL) are listed in Table C-2. The TQLs shown are those to be expected when no interfering components are present in the sample. It is anticipated that future sampling will focus on key contaminants and areas of concern; therefore, the number of wells sampled and the analyses could be fewer than presented in the SAP. If the scope of the sampling program changes in the future, an addendum to this SAP will be prepared.

Quality Assurance

These procedures are designed to ensure that (1) samples collected at the site under this program are consistent with project objectives, and (2) samples are identified, handled, and transported so that the data are representative of actual site conditions and information is not lost in sample transferral. The data collected will be used to monitor groundwater quality on an ongoing basis.

Sample Collection

Quality assurance objectives for sample collection will be accomplished by a combination of the following items.

- **Duplicate Samples.** Blind duplicate samples will be collected and analyzed for the same constituents as other samples. One sample will be submitted for duplicate analysis once for every two sampling events. The duplicate will be handled in a manner consistent with other samples. The duplicate will be labeled using a numbering system to keep its actual location unknown to the laboratory. The sampling time will be recorded on labels as 2400 hours (midnight) to prevent cross-checking on the basis of sample times. The actual well number and sampling times will be recorded in the field book.

- **Laboratory QA.** Analytical procedures will be evaluated by analyzing reagent or method blanks, matrix spikes, and checking standards once for every ten samples.

Because either dedicated sampling pumps or dedicated bailers will be installed in the monitoring wells, equipment blanks will not be collected. The dedicated equipment has been installed to eliminate the potential of introduced contamination or cross-contamination. Approval to not collect equipment blanks was granted by EPA on May 15, 1990.

Holding Times

Table C-1 summarizes the sample holding time limits. Samples must be shipped so that they are received by the laboratory before the holding time limit is exceeded.

Table C-1
Containers and Holding Times
Spray Irrigation Area Groundwater Monitoring

Constituent	Container	Preservation	Holding Time
pH	Plastic or Glass	None	Field Analysis
Temperature			
Electrical Conductivity			
Temperature			
Ferrous Iron		HCl	
Nitrate (N)	Plastic–500 ml	Cool, 4°C	48 hours
Nitrite (N)			
Total Kjeldahl Nitrogen	Plastic–250 ml	Cool, 4°C, H_2SO_4	28 days
Total Dissolved Solids	Plastic–250 ml	Cool, 4°C	7 days
Chloride			28 days
Total BOD_5	Plastic–1 liter	Cool, 4°C	48 hours
Zinc	Plastic–1 liter	Cool, 4°C, HNO_3 after field filtration with a 0.45µ filter	6 months

Note: Sample containers with the indicated preservative will be provided by the laboratory.

Table C-2
Summary of Quality Assurance Objectives for Groundwater Analysis
Pendleton Woolen Mill Spray Irrigation Area

Constituent	EPA Method[a]	Target Quantitation Limit (µg/L)
Nitrate (N)	300	7
Nitrite (N)	300	30
Total Kjeldahl Nitrogen	351.3	100
Total Dissolved Solids	160	3
Chloride	300	13
Total BOD_5	405.1	300
Zinc	7950	5
pH	Field	NA[c]
Electrical Conductivity	Field	NA[c]
Ferrous Iron[b]	Field	Qualitative

[a] EPA Method references are from U.S. Environmental Protection Agency. 1983. *Methods for Chemical Analysis of Water and Wastes*, except for EPA Method 7950 (for zinc), which is from U.S. Environmental Protection Agency. 1986. *Test Methods for Evaluating Solid Waste*. SW-846. Third edition.

[b] The method for ferrous iron is an adaptation of Ecology's Field Method for Detecting Ferrous Iron in Wetland Soils.

[c] NA = Not Appilcable.

Appendix D. Quality Assurance

All laboratory data were evaluated by the Manchester Laboratory staff for quality assurance. Written reviews of data were prepared for all results. Reviews for both sampling dates included holding times, instrument calibration, method blanks, matrix spikes, precision data, and laboratory control sample analyses. The data used in this report are considered acceptable for use as qualified. Details of interest are described below.

A small amount of copper was found in the laboratory soil blank. In addition, one of the soil spike recoveries for copper was high. Therefore copper results less than ten times the detection limit are qualified with a "J." Those above that are qualified with an "N."

There was a small amount of zinc in the soil blank as shown in Table D.1. However, it was small enough that the sample results did not require qualification.

Table D.1. Results of soil blank metals analyses for July 26, 1996.

Metal	Lab Soil Blank (mg/kg dry wt)
Cd	0.3 U
Cr	0.5 U
Cu	7.9 P
Ni	1 U
Pb	2 U
Zn	4.26

U: Analyte was not detected at or above the result.
P: Analyte was detected above the instrument detection limit but below the minimum quantitation limit.

The TKN result for the transport blank collected on April 17, 1995 was high, 2.7 mg/L. Only one sample, MW-SP-1, contained measurable TKN on that date and is qualified with a "J."

All other results of duplicates and spikes were within the 20% EPA Contract Laboratory Program (CLP) acceptance window. All analyses were performed within the EPA Contract Laboratory Program holding times.

Replicate samples of effluent were collected on both sampling dates. The results are shown in Table D.2.

Table D.2. Relative percent difference between replicate biosolids metals samples.

	4/17/95	7/18/95
Chromium	12	48
Copper	4.9	35
Lead	8.0	31
Zinc	1.7	21

The relative percent differences for all samples were less for the April 17, 1995 sample than those for July 18, 1995. This may be due to the different sampling locations on the two dates. In April, effluent was sampled from a valve in the storage tank after 25 to 30 minutes of mixing, because application to the field had not yet begun. In July, effluent was sampled from the discharge pipe to the application site. Apparently greater effluent heterogeneity occurs when effluent is applied directly than when it is stored and mixed over several months.

Appendix E. Pendleton Woolen Mill biosolids characteristics for 1990-95 from PWM Discharge Monitoring Reports. Data for April 1994 through July 1995 represent filtered samples. It is not known whether or not samples collected prior to April 1994 were filtered.

Date	Units	9/26/90	12/20/91	1/13/92	3/12/92	5/07/92	6/12/92	12/31/93	3/31/94	4/21/94	6/30/94	9/30/94	1/31/95	4/17/95	7/18/95
Total % Solids	%	0.7	0.27	0.25	0.25	0.20	0.26	0.28	0.31		0.42	0.42	0.28	0.25	0.37
pH	S.U.	6.92	6.9												
Aluminum	ug/L	6,270													
Arsenic	ug/L	6.3													
Barium	ug/L	393													
Cadmium	ug/L	8								19					
Chromium	ug/L	3,810		409	1,900	1,400	1,400	2,400	2,000		6,000	4,800	2,400	4,600	5,500
Copper	ug/L	374	17	24	<500	120	120	310	230	2,060	650	680	310	340	550
Iron	ug/L	32,000													
Mercury	ug/L	2.8		0.4	<10	ND	<2	10	5 U		ND	50	10		
Nickel	ug/L	34								120					
Potassium	ug/L	20,400				17,000									
Sodium	ug/L	144,000													
Lead	ug/L	0.25		42.3	50	ND	<100	50	100 U	425	100	100	50	40	100
Zinc	ug/L	7,120	2,490	3,650	4,400	4,000	4,000	6,400	6,700	52,700	20,000	15,000	6,400	9,700	11,000

ND: Not detected. No detection limit specified.

U: Analyte was not detected at or above the result.