TRANSITION ZONE WATER INVESTIGATION SUMMARY REPORT
EAST LANDFILL AREA OF CONCERN

Prepared for
Washington Department of Ecology
Lacey, Washington

On behalf of
Alcoa Inc.
Pittsburgh, Pennsylvania

Prepared by
Anchor QEA, LLC
Seattle, Washington

February 2010

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LIST OF ACRONYMS AND ABBREVIATIONS

µg	microgram
Alcoa	Alcoa Inc.
Anchor QEA	Anchor QEA, LLC
cm	centimeter
Ecology	Washington State Department of Ecology
FS	Feasibility Study
kg	kilogram
L	liter
RI	Remedial Investigation
Site	Former Alcoa Inc./Evergreen Aluminum, LLC site
TCE	trichloroethylene
TZW	transition zone water
UltraSeep	ultrasonic seepage meter

1 INTRODUCTION

The Former Alcoa Inc. (Alcoa)/Evergreen Aluminum, LLC site (Site) is located on NW Lower River Road on the northern shore of the Columbia River at River Mile 103.3 in Clark County. It is approximately 3 miles northwest of downtown Vancouver, Washington, and approximately 3 miles due west of Interstate 5. The operating facilities, which were demolished in 2008 and 2009, covered approximately 208 acres of industrial property. Remediation of the upland facility and adjacent Columbia River sediments was also completed in 2009 in accordance with Consent Decree No. 09-2-00247-2 between the Washington State Department of Ecology (Ecology) and Alcoa.

The Site is currently owned by the Port of Vancouver and is bound on the north by NW Lower River Road, on the east by the existing Port of Vancouver terminal, on the south by the Columbia River, and on the west by multiple industrial property owners. The current land uses in the general vicinity of the property are mixed use industrial and agricultural. The project location and surrounding area are shown in Figure 1. The East Landfill is located on the southeast corner of the property.

Waste hauling to the East Landfill began sometime after development of the Alcoa facility occurred in the 1940s. It is not known when trichloroethylene (TCE)-bearing materials were placed in the East Landfill; however, TCE was identified in groundwater in 1987. With Ecology oversight, Remedial Investigation (RI) activities were performed at the East Landfill between 1990 and 1997 and included groundwater, waste, and soil characterization. Per an Ecology Agreed Order, Alcoa constructed an engineered, low-permeability cap over the East Landfill to control the TCE source (i.e., the waste) and began quarterly groundwater monitoring in 2003. This quarterly monitoring includes sampling of one well cluster up-gradient of the landfill and two down-gradient well clusters that are installed in three geologic zones (referred to as Intermediate, Deep, and Aquifer). These results were summarized in *Remedial Investigation/Feasibility Study* (RI/FS) prepared Anchor Environmental, L.L.C. (Anchor), in 2008. The 2008 RI/FS also included fate and transport modeling of the groundwater to surface water pathway. The results indicated that natural attenuation was occurring prior to discharge into Columbia River and that no unacceptable risks to aquatic organisms in the adjacent riverbed were present.

To validate the RI modeling and verify that groundwater from the East Landfill was not affecting aquatic organisms in the adjacent riverbed and human health through exposure to surface water, Alcoa initiated a transition zone water (TZW) investigation in December 2008. TZW is defined as the sediment porewater just below the mudline that is influenced both by groundwater discharging from the uplands and by river water that infiltrates into the sediments. The primary goal of this investigation was to characterize sediment and porewater within the TZW. The field investigation was initiated in December 2008 and was completed in January 2009. This report summarizes the investigation approach, field methods used to characterize the hydrogeological conditions within the TWZ, and the results of the work.

The remainder of the report is organized into the following sections:

- Section 2 – TZW Investigation Approach provides information regarding the field investigation and sampling methods.
- Section 3 – Groundwater Flow System and the Transition Zone provides a summary of the conceptual site model for groundwater flow and the results of the hydrologic components of the investigation.
- Section 4 – TZW Characterization presents the analytical results for the various media associated with the transition zone.
- Section 5 – Summary provides a brief recap of the investigation.

2 TZW INVESTIGATION APPROACH

This section describes the methodology used to investigate TZW adjacent to the East Landfill. A general overview of the work is included as well as specific details for the various sampling methods.

2.1 Investigation Overview

The TZW investigation generally included the following activities:

- Installation of pressure transducers in the Columbia River at the on-site dock and in monitoring wells adjacent to the East Landfill (i.e., clusters MW-35, MW-94-1, and MW-94-2) to provide real-time river stage and groundwater hydrology data during the investigation
- Completion of a transect survey of TZW using the Trident probe to determine the location of groundwater discharge zones
- Collection of TZW samples using the Trident probe at a subset of the transect survey locations where the highest rates of discharge were observed to determine concentrations of TCE in the TZW
- Collection of surface water samples at the locations where Trident probe TZW samples were taken to determine concentrations of TCE in the surface water
- Installation of UltraSeep electronic seepage meters at three transect survey locations where the Trident probe survey indicated high discharge rates
- Installation of passive peeper samplers to collect TZW samples at the three transect locations where the highest rates of discharge were observed (co-located with the seepage meters and the Trident probe TZW samples)
- Collection of surface water samples during retrieval of passive peeper samplers to determine if TCE is present in the surface water
- Collection of sediment samples at the three transect locations where the highest rates of discharge were observed (co-located with the seepage meters, Trident probe TZW samples, and passive peeper TZW samples) to measure TCE concentrations within the surface sediments

2.2 Hydrology Monitoring

To document hydrologic conditions during the TZW investigation, real-time hydrology data were collected using pressure transducers installed in monitoring wells adjacent to the East Landfill and in the Columbia River. Data were used to evaluate hydraulic connectivity between the Intermediate, Deep, and Aquifer hydrogeological zones and the Columbia River. Specifically, each pressure transducer was installed using cables that extend from the surface to the instrument that is submerged in the well or river water. The cables allowed in situ calibration of depth-to-water measurements from the surface. Full-length cables also allow for venting to the atmosphere, eliminating the need for barometric data correction. The procedures used to install the transducers generally included the following tasks:

1. Each instrument was connected to a communication/vent cable of the appropriate length.
2. The instrument and cable were decontaminated before and after installation.
3. The instrument was calibrated to zero in ambient air conditions.
4. The instrument and cable were slowly fed down into the well to a depth that ensured submersion throughout the monitoring period.
5. The instrument cable was securely attached to the well casing.
6. The instrument and cable caused displacement of water in the well casing; therefore, the water level in the well was allowed to equilibrate for 30 to 60 minutes before depth-to-water reference measurements were collected.
7. Temperature and depth-to-water (pressure) measurements were collected every minute.

2.3 UltraSeep Survey and TZW Sampling

After installation of the pressure transducers, a transect survey using the Trident probe system was conducted to locate groundwater discharge zones adjacent to the East Landfill. The Trident probe is a combined conductivity sensor, porewater sampler, and temperature sensor probe that utilizes salinity, temperature, and chemical contrasts between groundwater and surface water to map areas of potential groundwater discharge. The Trident probe tip is pushed into the upper sediment in the river and simultaneous readings of porewater temperature and conductance are obtained. The probe can also be used to obtain porewater samples for chemical testing. The Trident probes are deployed from a boat using diver support. This system was developed by the U.S. Navy and Cornell University for investigation of seepage from contaminated terrestrial sites into estuaries (Chadwick and Hawkins 2008). Anchor QEA, LLC (Anchor QEA) successfully used this technology on other similar river projects.

On the first day of the investigation, the Trident probe was used for reconnaissance surveying of TZW and surface water temperature and conductance to identify potential groundwater discharge zones. Four survey transect lines were selected based on elevations that correlate with the hydrogeological zones with impacted groundwater. Transect A included eight locations near elevation 5 feet NGVD, Transect B included eight locations near elevation 0 feet NGVD, Transect C included six locations near elevation -15 feet NGVD, and Transect D included five locations near elevation -20 feet NGVD, for a total of 27 locations. The success of this reconnaissance method was based upon the contrast between the conductance and temperature of discharging groundwater from the TZW versus the conductance and temperature of reference (i.e., surface) water. For example, porewater in groundwater discharge zones that are impacted by the East Landfill should have higher conductance than river water.

On the second day, the Trident probe was used to obtain porewater samples for analytical testing from 12 locations that were evaluated on the first field day. Specific details for the survey and collection of TZW are described in *Coastal Contaminant Migration Monitoring: the Trident Probe and UltraSeep System, Hardware Description, Protocols, and Procedures* (SPAWAR 2003). In addition, surface water samples were collected at the time each Trident probe sample was collected. Surface water samples were collected using a Van Dorn-type sampling device as close as practicable to the mudline (approximately 6 inches above the mudline) to prevent to collection of sediment in the water sample.

At the completion of the Trident probe sampling, UltraSeep meters were installed and seepage data were collected at the two locations where the Trident probe survey indicated the highest potential for groundwater discharge and one with moderate potential. The UltraSeep meter is integrated ultrasonic seepage device that measures the continuous flow seepage rate. The meter provides a digital record of negative and positive seepage from the sediment/river interface presented in inches per day. For this investigation, the meters were deployed over a 48-hour period for seepage rates during both high and low river tide cycles to be measured.

At the end of the 48-hour UltraSeep deployment, small-volume passive peeper samplers were installed at locations adjacent to the seepage meters. Passive peeper samplers are porewater sampling devices that contain a reference fluid (de-oxygenated, deionized water) enclosed by a membrane that allows diffusion of volatile organic compounds (such as TCE). Once prepared, the entire peeper assembly was maintained in an anoxic (argon) atmosphere until immediately prior to deployment. The passive peepers were diver deployed into the upper 10 to 12 inches of sediment and allowed to come to equilibrium with sediment porewater over a 30-day period. At the end of the equilibration period, divers retrieved each of the peeper assembles. Porewater was extracted from the chambers using a syringe to transfer the water directly into the sample bottle.

River surface water samples were collected during high and low tide elevations on the day the peepers were retrieved. Sediment grab samples were also collected by divers at the passive peeper locations.

3 GROUNDWATER FLOW SYSTEM AND THE TRANSITION ZONE

This section describes the conceptual site model for groundwater flow in the vicinity of the East Landfill and the transition zone in the adjacent Columbia River. The hydrologic findings of the TZW investigation conducted in 2008 are also presented.

3.1 Groundwater Flow System

The 2008 RI/FS report provides a detailed description of the hydrogeology of the Site, including the East Landfill area. Four upland hydrogeological zones were identified for the Site, the Shallow, Intermediate, Deep, and Aquifer[1] hydrogeological zones.

The Shallow Zone consists primarily of fill and is the uppermost zone in the upland portion of the Site. The Shallow Zone is recharged primarily by infiltration of incident precipitation. The closed East Landfill waste material is within the Shallow Zone, as shown on the site model on Figure 2. The engineered cap placed over the East Landfill waste material prevents infiltration of incident precipitation into the waste. Groundwater levels in monitoring wells screened in the Shallow Zone fluctuate widely from the wet season to the dry season and several of the area Shallow Zone monitoring wells dry up during late summer and fall. The Shallow Zone is not hydraulically influenced by Columbia River fluctuations. Groundwater in the Shallow Zone migrates downward into the underlying Intermediate Zone.

The Intermediate, Deep, and Aquifer zones are alluvial sands, silts, and clays that were subdivided during the 2008 RI/FS based on their hydrogeologic properties. These zones are shown on the site model on Figure 2. All three zones are directly connected to the Columbia River. Upland monitoring wells screened in these three zones are present at locations MW-94-1 and MW-94-2. These two locations contain individual wells screened in each of the three zones between the East Landfill and the Columbia River shoreline. These two well clusters are the closest permanent groundwater monitoring stations to the Columbia River, and data are representative of groundwater quality adjacent to the East Landfill.

Groundwater in the Intermediate, Deep, and Aquifer zones is recharged primarily by lateral inflow from upland off-site recharge zones, to a lesser degree by downward infiltration of

[1] This unit was previously identified as the Troutdale Formation but has subsequently been redefined by the U.S. Geological Survey as the United States. The Troutdale Formation lies below the United States.

groundwater from shallower zones, and to a minor extent by Columbia River water during high river tides and seasonal flooding. All three zones discharge on a net daily basis directly to the river in the vicinity of the East Landfill. The water level hydrographs on Figures 3 and 4 show that the Intermediate and Deep zones are hydraulically connected to the river and that water level changes in the river have a nearly immediate affect on water levels in each zone. Groundwater levels in monitoring wells on the Site fluctuate continually in response to the diurnal river tides in the Columbia River. It is important to understand that the nearshore groundwater level changes are due to hydraulic pressure influences from river tidal fluctuations and that under ambient conditions net groundwater flow is from the uplands to the river. When the Alcoa facility was active, on-site industrial supply wells screened in the Aquifer Zone caused groundwater in all three zones to flow to those industrial supply wells and induced recharge from the river; however, those industrial wells are no longer active, so groundwater in the vicinity of the East Landfill flows under natural ambient conditions and discharges directly to the river. The 2008 RI/FS report also determined that the Clark County Public Utility wells located in the Aquifer Zone do not influence the direction of groundwater flow within that unit.

The subsurface profiles also show the River Alluvium that underlies the Columbia River riverbed. Groundwater discharges from the Intermediate, Deep, and Aquifer zones into the river through the River Alluvium, which contains the TZW. TZW is defined as the sediment porewater just below the mudline that is influenced both by groundwater discharging from the uplands and by river water that infiltrates into the sediments. River water infiltrates into the TZW under the hydraulic influences caused by river tidal fluctuations and by advection induced by river currents near the mudline. By definition, groundwater and surface water are intermixed in the TZW. The depth of mixing in the TZW is not constant and fluctuates depending upon many factors, including sediment permeability, river stage, and groundwater levels.

The 2008 RI/FS did not include an assessment of the TZW near the East Landfill; therefore, this assessment was conducted to determine if discharging groundwater results in unacceptable impacts to the aquatic receptors of the Columbia River. The findings of the TZW investigation are described in the following subsection.

3.2 TZW Investigation

The first step in the TZW investigation was to use Trident probe methods to sample TZW porewater at representative locations in the suspected discharge area, as shown on Figure 5. The Trident probe porewater samples were measured in real time in the field for conductivity and temperature. Based on the upland RI investigations, it was known that groundwater affected by the East Landfill has elevated conductivity compared to Columbia River water; therefore, TZW porewater samples with significantly higher conductance than river water should indicate potential groundwater discharge areas in the river that are affected by the landfill. Groundwater temperatures are fairly constant throughout the year, but river water temperatures vary widely depending upon the season, with the warmest river water temperatures in the summer and coldest in the winter. Since the TZW investigation was conducted in December 2008, the groundwater temperature as measured in upland monitoring wells was warmer than river water. Porewater temperatures measured by the Trident probes should indicate potential groundwater discharge zones. The Trident probe findings for TZW temperature and conductivity were used to identify TZW groundwater discharge zones that are influenced by the East Landfill. Figure 5 shows the temperature and conductance readings obtained at each of the Trident probe sample locations. Data show that many of the same Trident probe sample locations have both elevated temperatures and elevated conductance compared to river water, indicating zones of preferential TZW groundwater discharge (refer to Table 1).

The TZW discharge zones identified in the Trident reconnaissance survey were used to select a subset of locations to obtain TZW samples for laboratory chemistry testing from a second round of Trident sampling and from passive peepers. The findings of the TZW chemistry sampling are described in detail in Section 4.

UltraSeep meters were deployed at three of the identified TZW discharge locations, as shown on Figure 5. The seepage meters were deployed by divers and left in place for about 48 hours. The ultrasonic meters were installed at the sediment mudline and set to read the TZW discharge rate at 15-minute intervals for the 48-hour period. The discharge rate is measured in units of centimeters per day (cm/day).

The graphs on Figures 6, 7, and 8 show the discharge rates measured at each of the three UltraSeep meters. At each location, the seepage rates changed constantly as a function of groundwater elevation and river tide water level changes. The graphs on Figures 6, 7, and 8 also show the Columbia River water level changes due to the daily tidal fluctuations that are pushed up the Columbia River from the Pacific Ocean. The graphs show that there is an inverse correlation between the river water elevation and the TZW discharge rate at each location. The TZW seepage rate at the mudline is highest at approximately the same time as the low tide, and inversely the seepage rate is lowest at the time of high tide elevation. This occurrence is caused by the changing hydraulic head gradient between the upland groundwater elevation and the river elevation. The graphs also show that there is very little or no lag time between the river tidal fluctuations and the fluctuations in TZW seepage.

4 TZW CHARACTERIZATION

This section presents the analytical results for various media associated with the transition zone. Laboratory data reports and Level III validation reports are provided in Appendices A and B, respectively.

4.1 TZW Data

As previously discussed, TZW was collected using Trident probe extraction and small-volume passive peepers. Using these methods, data was collected at three intervals below the mudline: 0 to 5 inches, 5 to 10 inches, and at 14 inches. The uppermost interval (0 to 5 inches) is representative of the biologically active zone at the Site and where potential exposures to the benthic community would occur. Table 2 summarizes the field data collected during Trident probe extraction, while Table 3 summarizes the results for TCE and its various degradation products (i.e., chlorinated ethenes with reducing chlorine atoms). Figures 9, 10, and 11 include cross-sections that provide a graphic representation of the TZW and surface water in relation to the mudline.

4.2 Sediment Data

Sediment samples were collected at each of the passive peeper locations. A total of three samples were collected from the upper 4 to 6 inches of sediment. All samples contained non-detect concentrations of TCE as shown in Table 4.

4.3 Surface Water Data

Surface water samples were collected during two events. The first set of samples was collected during Trident probe extraction, regardless of tidal stage. The second set was collected during retrieval of the passive peepers at a high and low tide event. The results of the sampling are summarized in Table 5.

4.4 TZW Screening Values

Appendix C to this report summarized the various sources of available toxicity studies for TCE and vinyl chloride. Based on a review of the data and derivation methods, the use of the Michigan Final Tier II values is recommended. These values are 200 micrograms per liter (μg/L) and 930 μg/L for TCE and vinyl chloride, respectively. No TZW data within the biologically active zone (i.e., 0 to 5 inches below the mudline) and the next interval below exceed these recommended criteria for the protection of aquatic organisms for chronic exposures.

5 SUMMARY

To validate previous modeling efforts and to demonstrate that groundwater from the East Landfill was not affecting aquatic organisms in the adjacent riverbed and human health through exposure to surface water, Alcoa initiated a TZW investigation in December of 2008. The primary goal of the investigation was to characterize sediment and porewater within the zone where groundwater interacts with surface water. Zones of discharge were identified in a step-wise process. The first step included the use of a Trident probe to measure porewater temperature and conductance for comparison to local surface water values. Locations where the greatest differentials in temperature and conductance are observed are associated with the greatest potential discharge. For step two, three locations (two with high differentials and one with a moderate differential) were selected for deployment of the UltraSeep meter. Data was collected for a period of approximately 48 hours to measure the average net groundwater discharge rate over several tidal cycles. The preliminary results yielded an average net discharge rate of approximately 1 cm/day. The rates measured with the UltraSeep also correlate well with previously modeled discharge rates (Anchor 2008), which were based on the observed groundwater levels in the wells adjacent to the river collected during several monitoring events.

During the UltraSeep deployment, continuous water level measurements were also made in each of the East Landfill monitoring wells and in the Columbia River. The results of the investigation demonstrate that the groundwater levels for monitoring wells located in Intermediate and Deep hydrogeological zones between the East Landfill and the river are influenced by Columbia River tidal fluctuations. Review of precipitation data further indicate that groundwater elevations beneath the East Landfill are influenced primarily by Columbia River levels and not rainfall. Further review of historical information collected during quarterly monitoring events indicates that the net groundwater flow direction within the Intermediate and Deep hydrogeological zones is consistently towards the Columbia River, except during flood stage level events.

The final step in the TZW investigation included sampling of sediment porewater at various depths below the riverbed, river water as close to the riverbed as practicable, and sediment within the biologically active zone. Sediment concentrations were non-detect (less than 1.3 micrograms per kilogram [μg/kg] of TCE); surface water concentrations were non-detect (less than 0.1 µg/L of TCE). Small-volume passive peepers were installed at the three locations where UltraSeep tests were conducted (i.e., areas of moderate to high discharge). The passive peepers were deployed for an equilibration period of 30 days and upon retrieval TZW samples were extracted from chambers associated with the 0- to 5-inch and 5- to 10-inch intervals below the riverbed. Samples analyzed over both intervals were non-detect (less than 0.1 µg/L of TCE). All data collected within the transition zone were below recommended Tier II screening values for the protection of aquatic organisms.

6 REFERENCES

Anchor Environmental, L.L.C. (Anchor). 2008. Remedial Investigation/Feasibility Study. Alcoa/Evergreen Site. September 2008.

Chadwick, B. and A. Hawkins. 2008. Monitoring of Water and Contaminant Migration at the Groundwater-Surface Water Interface (ER200422): Final Report. SPAWAR Systems Center, San Diego. Technical Report 1967, 75 pp, January 2008.

PSpace and Naval Warfare Center, San Diego (SPAWAR). 2003. Technical Report #1902. Coastal Contaminant Migration Monitoring: the Trident Probe and UltraSeep System, Hardware Description, Protocols, and Procedures.

TABLES

Table 1
Trident Probe Sensor Log

Station ID	Long (deg. W)	Lat (deg. N)	Trident Probe Depth (in. bml)	Avg TZW Temperature (C)	Avg TZW Conductivity (µS/cm)	REF Location (in. aml)	Avg REF Temperature (C)	Avg REF Conductivity (µS/cm)	Δ Temp (C)	Δ Cond (µS/cm)	Bottom Type
AVTZ01	122.72685	45.64416	29	11.414	434	6	8.404	182	3.010	252	sandy mud
AVTZ02	122.72662	45.64415	29	10.615	345	6	8.394	186	2.221	160	sandy mud
AVTZ03	122.72648	45.64415	24	10.643	138	11	8.526	182	2.117	-44	sandy mud
AVTZ04	122.72627	45.64419	29	10.661	145	6	8.621	189	2.039	-44	sand over sandy mud
AVTZ05	122.72617	45.64415	29	11.846	159	6	8.648	207	3.198	-48	sand over muddy sand
AVTZ06	122.72593	45.64417	29	12.539	443	6	8.597	206	3.942	238	sand
AVTZ07	122.72575	45.64415	27	12.073	335	8	8.572	200	3.501	136	sand
AVTZ08	122.72560	45.64417	29	7.790	134	6	8.639	183	-0.849	-49	sand over sandy mud
AVTZ09	122.72683	45.64413	24	10.122	161	11	8.492	181	1.630	-20	sandy mud
AVTZ10	122.72663	45.64410	29	9.550	172	6	8.499	181	1.051	-9	sandy mud
AVTZ11	122.72648	45.64410	29	11.293	576	6	8.505	189	2.788	387	muddy sand
AVTZ12	122.72635	45.64409	29	11.466	638	6	8.528	210	2.938	428	muddy sand
AVTZ13	122.72618	45.64407	29	11.140	629	6	8.542	207	2.598	422	muddy sand
AVTZ14	122.72600	45.64407	29	11.575	1250	6	8.576	208	2.999	1042	muddy sand
AVTZ15	122.72580	45.64407	29	11.651	1031	6	8.555	198	3.096	833	sand
AVTZ16	122.72567	45.64403	29	11.632	808	6	8.604	202	3.028	606	sand over muddy sand
AVTZ17	122.72683	45.64405	29	11.169	745	6	8.485	182	2.684	563	muddy sand
AVTZ18	122.72668	45.64403	29	11.361	477	6	8.476	182	2.884	295	muddy sand
AVTZ19	122.72648	45.64402	29	10.883	590	6	8.506	189	2.377	401	muddy sand
AVTZ20	122.72637	45.64400	29	11.028	454	6	8.509	213	2.519	241	muddy sand
AVTZ21	122.72620	45.64397	29	10.364	410	6	8.537	205	1.827	205	sand
AVTZ22	122.72603	45.64395	29	11.067	946	6	8.550	201	2.517	745	muddy sand
AVTZ23	122.72592	45.64387	29	10.725	507	6	8.546	198	2.178	308	muddy sand
AVTZ24	122.72578	45.64377	29	10.748	408	6	8.558	197	2.190	211	gravelly sand over muddy sand
AVTZ25	122.72652	45.64392	29	11.108	423	6	8.513	215	2.594	208	muddy sand
AVTZ26	122.72635	45.64393	29	11.371	419	6	8.519	214	2.852	205	muddy sand
AVTZ27	122.72602	45.64387	29	11.280	928	6	8.549	199	2.731	729	muddy sand

Notes:
TZW = extracted using the Trident Probe
Reference (REF) = surface water
C = degrees Celsius
µS/cm = microsiemens per centimeter
Δ Temp = TZW minus REF (surface water) temperature
Δ Cond = TZW minus REF (surface water) conductivity

Table 2
Trident Probe TZW Extraction Sample Log

Station ID	Long (deg. W)	Lat (deg. N)	TZW Sample ID	Trident Probe Depth (in. bml)	TZW Temperature (C)	TZW Conductivity (µS/cm)	TZW Total Dissolved Solids (ppm)	TZW pH	TZW ORP (mV)	Surface Water Sample ID	Surface Water Sample Location (in. aml)	Bottom Type/Notes
AVTZ11	122.72645	45.64409	AVTZ11-TZ-121008	14	8.29	630.1	432.7	6.30	-51	AVTZ11-SW-121008	6	muddy sand
AVTZ12	122.72631	45.64410	AVTZ12-TZ-121008	14	9.85	704.6	483.7	6.55	47	AVTZ12-SW-121008	6	sandy mud
AVTZ13	122.72613	45.64409	AVTZ13-TZ-121008	14	9.41	308.1	205.7	6.71	94	AVTZ13-SW-121008	6	muddy sand
AVTZ14	122.72601	45.64405	AVTZ14-TZ-121008	14	9.46	1123	791.1	6.48	73	AVTZ14-SW-121008	6	muddy sand
AVTZ15	122.72580	45.64408	AVTZ15-TZ-121008	14	9.18	967.7	678.4	6.63	-24	AVTZ15-SW-121008	6	gravelly sand
AVTZ16	122.72569	45.64403	AVTZ16-TZ-121008	14	9.91	777.8	537.2	6.57	-94	AVTZ16-SW-121008	6	muddy sand
AVTZ16 DUP	122.72569	45.64403	-	14	10.1	800.1	553.5	6.66	-100	-	6	muddy sand
AVTZ17	122.72680	45.64399	AVTZ17-TZ-121008	14	8.21	520.7	357.6	6.33	-50	AVTZ17-SW-121008	6	muddy sand
AVTZ18	122.72668	45.64402	AVTZ18-TZ-121008	14	9.57	488.2	334.9	6.40	-31	AVTZ18-SW-121008	6	muddy sand
AVTZ22	122.72605	45.64396	AVTZ22-TZ-121008	14	9.69	1021	714.8	6.70	-113	AVTZ22-SW-121008	6	muddy sand
AVTZ27	122.72604	45.64387	AVTZ27-TZ-121008	14	10.1	850.9	590.8	6.75	-114	AVTZ27-SW-121008	6	muddy sand
AVTZ28	-	-	AVTZ28-TZ-121008	-	-	-	-	-	-	-	-	Trident Equip. Blank
AVTZ29	-	-	-	-	-	-	-	-	-	AVTZ29-SW-121008	-	Surface Water Equip. Blank
AVTZ30	-	-	-	-	-	-	-	-	-	AVTZ30-SW-121008	-	Equip Blank Source DI Water
AVTZ31	122.72669	45.64406	AVTZ31-TZ-121208	14	7.10	614.7	422.1	6.67	-94	-	-	muddy sand
AVTZ32	122.72629	45.64408	AVTZ32-TZ-121208	14	6.77	645.2	442.8	6.48	-62	-	-	muddy sand
AVTZ33	122.72575	45.64402	AVTZ33-TZ-121208	14	7.32	896.2	625.7	6.51	-104	-	-	muddy sand

Notes:
C = degrees Celsius
µS/cm = microsiemens per centimeter
ppm = parts per million
mV = millivolts

Table 3
TZW Analytical Results

Sample ID	Depth (cm BML)	Trichloroethene (TCE)	1,2-Dichloroethene, cis-	1,2-Dichloroethene, trans-	1,1-Dichloroethene	Vinyl chloride
AVTZ11-TZ-121008	14	0.1 U	**240**	**0.55**	**0.38**	**400**
AVTZ12-TZ-121008	14	**5.2**	**360**	**1.2**	**5.7**	**170**
AVTZ13-TZ-121008	14	**0.18**	**16**	**0.061 J**	**0.28**	**4.4**
AVTZ14-TZ-121008	14	**1.1**	**520**	**5.2**	**5.2**	**43**
AVTZ15-TZ-121008	14	**0.53**	**99**	**0.66**	**0.32**	**110**
AVTZ16-TZ-121008	14	**0.066 J**	**48**	**0.39**	**0.21**	**97**
AVTZ16-TZ-121008DUP	14	**0.089 J**	**38**	**0.29**	**0.24**	**99**
AVTZ17-TZ-121008	14	0.1 U	**32**	**0.04 J**	**0.06 J**	**330**
AVTZ18-TZ-121008	14	0.1 U	**470**	**0.51**	**2**	**150**
AVTZ22-TZ-121008	14	**0.046 J**	**2**	**0.025 J**	**0.054 J**	**1.2**
AVTZ27-TZ-121008	14	**0.038 J**	**2.6**	**0.033 J**	**0.048 J**	**1.5**
AVTZ28-TZ-121008	14	0.1 U	**10**	**0.14**	**0.028 J**	**10**
AVTZ31-PT-090112	0 to 5	0.1 U	**0.063 J**	0.1 U	0.1 U	**0.26**
AVTZ31-PB-090112	5 to 10	0.1 U	**1.2**	0.1 U	0.1 U	**12**
AVTZ31-TZ-121208	14	0.1 U	**0.11**	**0.021 J**	0.1 U	**0.29**
AVTZ32-PT-090112	0 to 5	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ32-PB-090112	5 to 10	0.1 U	**0.063 J**	0.1 U	0.1 U	0.02 U
AVTZ32-TZ-121208	14	0.1 U	**0.12**	0.1 U	0.1 U	**0.047**
AVTZ33-PT-090112	0 to 5	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ33-PB-090112	5 to 10	0.1 U	**0.021 J**	0.1 U	0.1 U	0.02 U
AVTZ33-TZ-121208	14	0.1 U	**0.17**	0.1 U	0.1 U	**3**

Notes:

All results are reported in µg/l unless otherwise noted.

Bold = Detected result

J = Estimated value

U = Compound analyzed, but not detected above detection limit

UJ = Compound analyzed, but not detected above estimated detection limit

TZ = Sample collected using trident sensor

PT or PB = Sample collected using passive peeper

DUP = field duplicate sample

cm BML = centimenters below mudline

Table 4
Sediment Analytical Results

Sample ID	Depth (cm BML)	Total solids	1,1-Dichloroethene	1,2-Dichloroethene, cis-	1,2-Dichloroethene, trans-	Trichloroethene (TCE)	Vinyl chloride
AVTZ31-SD-121108	0 - 15 cm	75%	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
AVTZ32-SD-121108	0 - 15 cm	77%	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
AVTZ33-SD-121108	0 - 15 cm	82%	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U

Notes:

U = Compound analyzed, but not detected above detection limit

UJ = Compound analyzed, but not detected above estimated detection limit

SD = sediment

cm BML = centimenters below mudline

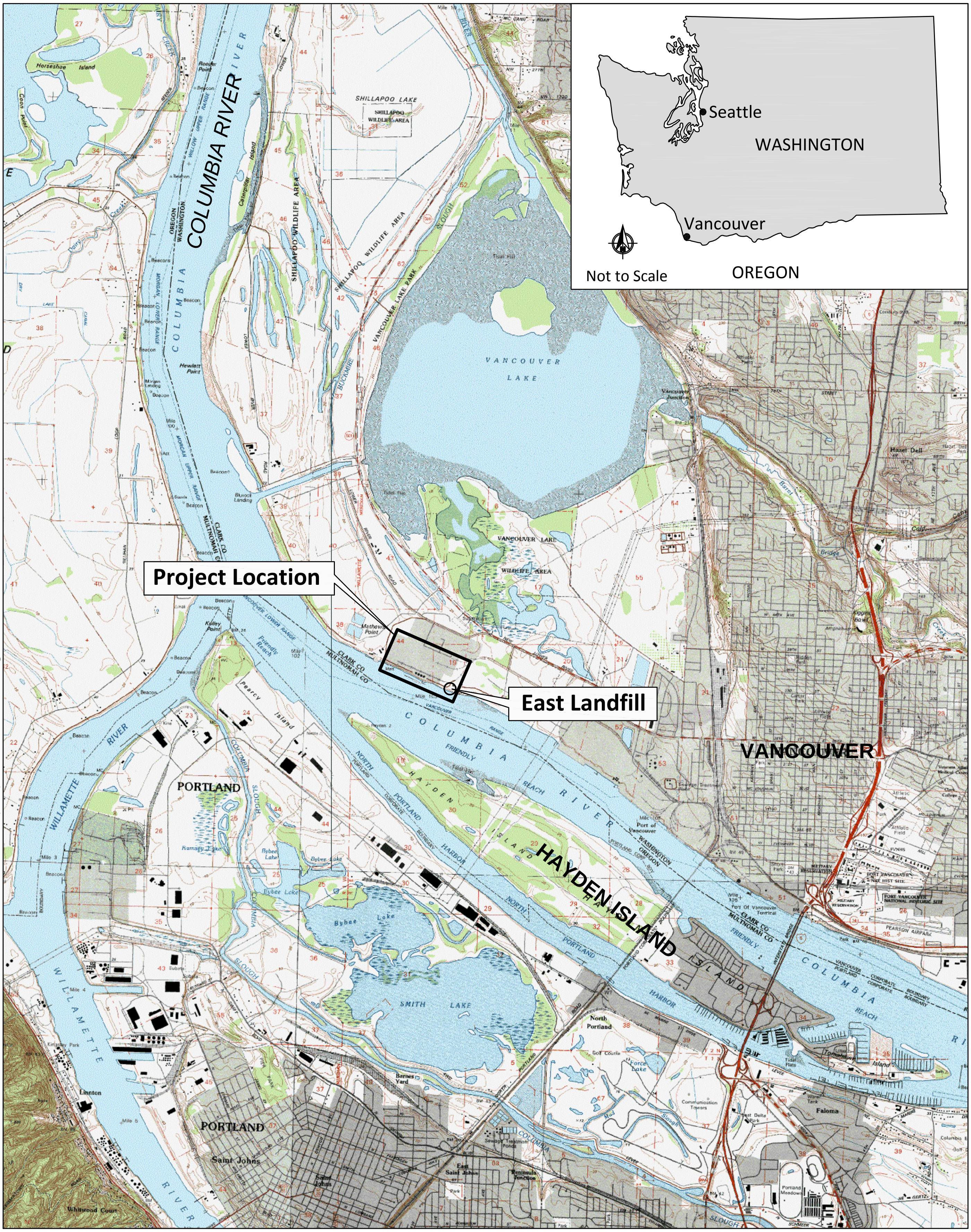
Table 5
Surface Water Analytical Results

Sample ID	Trichloroethene (TCE)	1,2-Dichloroethene, cis-	1,2-Dichloroethene, trans-	1,1-Dichloroethene	Vinyl chloride
AVTZ11-SW-121008	0.1 U	**0.02 J**	0.1 U	0.1 U	**0.021**
AVTZ12-SW-121008	0.1 U	**0.017 J**	0.1 U	0.1 U	0.02 U
AVTZ13-SW-121008	0.1 U	**0.014 J**	0.1 U	0.1 U	0.02 U
AVTZ14-SW-121008	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ15-SW-121008	0.1 U	**0.027 J**	0.1 U	0.1 U	0.02 U
AVTZ16-SW-121008	0.1 U	**0.027 J**	0.1 U	0.1 U	0.02 U
AVTZ16-SW-121008DUP	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ17-SW-121008	0.1 U	**0.029 J**	0.1 U	0.1 U	0.02 U
AVTZ18-SW-121008	0.1 U	**0.11**	0.1 U	0.1 U	**0.046**
AVTZ22-SW-121008	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ27-SW-121008	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ29-SW-121008	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ30-SW-121008	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ-31-SW-HT	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ-31-SW-LT	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ-32-SW-HT	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ-32-SW-HTDUP	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ-32-SW-LT	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ-33-SW-HT	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U
AVTZ-33-SW-LT	0.1 U	0.1 U	0.1 U	0.1 U	0.02 U

Notes:

All results are reported in µg/l unless otherwise noted.
All samples were collected approximately 6 inches above the mudline.
Bold = Detected result
J = Estimated value
U = Compound analyzed, but not detected above detection limit
UJ = Compound analyzed, but not detected above estimated detection limit
SW = Surface Water
DUP = field duplicate sample
HT = high tide
LT = low tide

FIGURES



Note: Base map prepared from Terrain Navigator Pro USGS 7.5 minute quadrangle maps of Linnton, Sauvie Island, and Vancouver, Washington, and Portland, Oregon.

0 1
Scale in Miles

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Figure 1
Vicinity Map
TZW Investigation Summary Report
Vancouver, Washington

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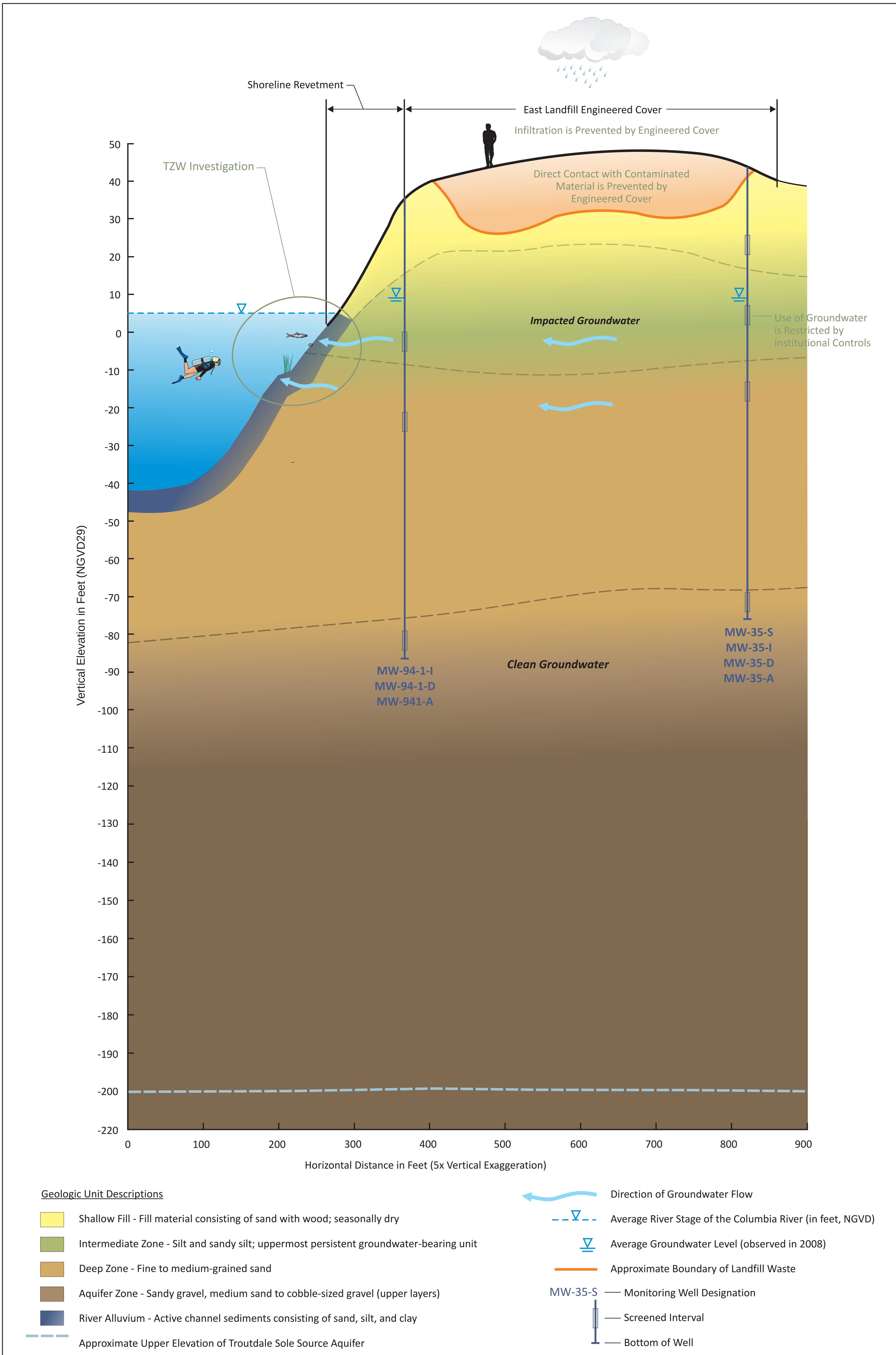

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Figure 2
East Landfill Site Model
TZW Investigation Summary Report
Vancouver, Washington

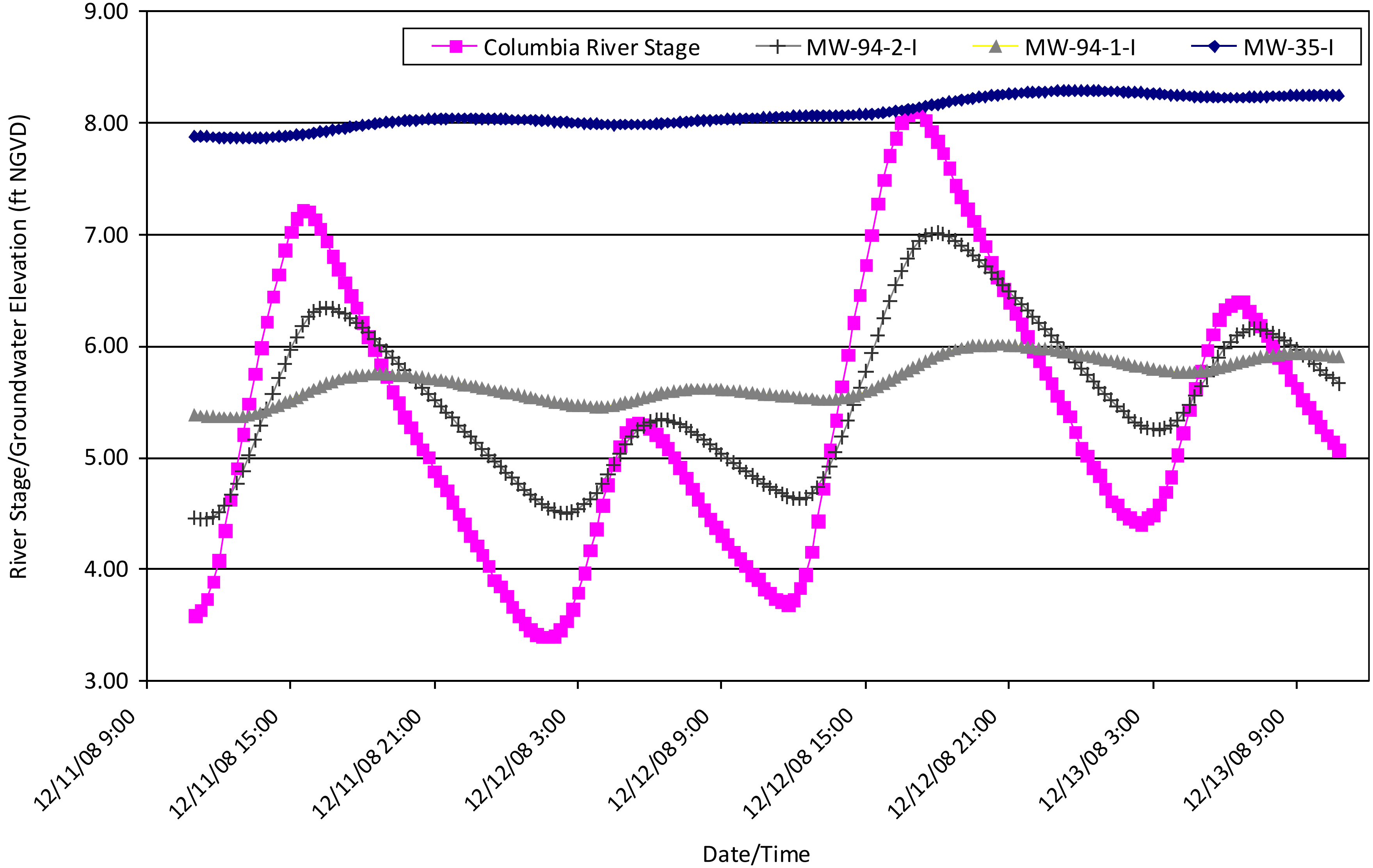

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Figure 3
Intermediate Zone Groundwater Elevations
TZW Investigation Summary Report
Vancouver, Washington

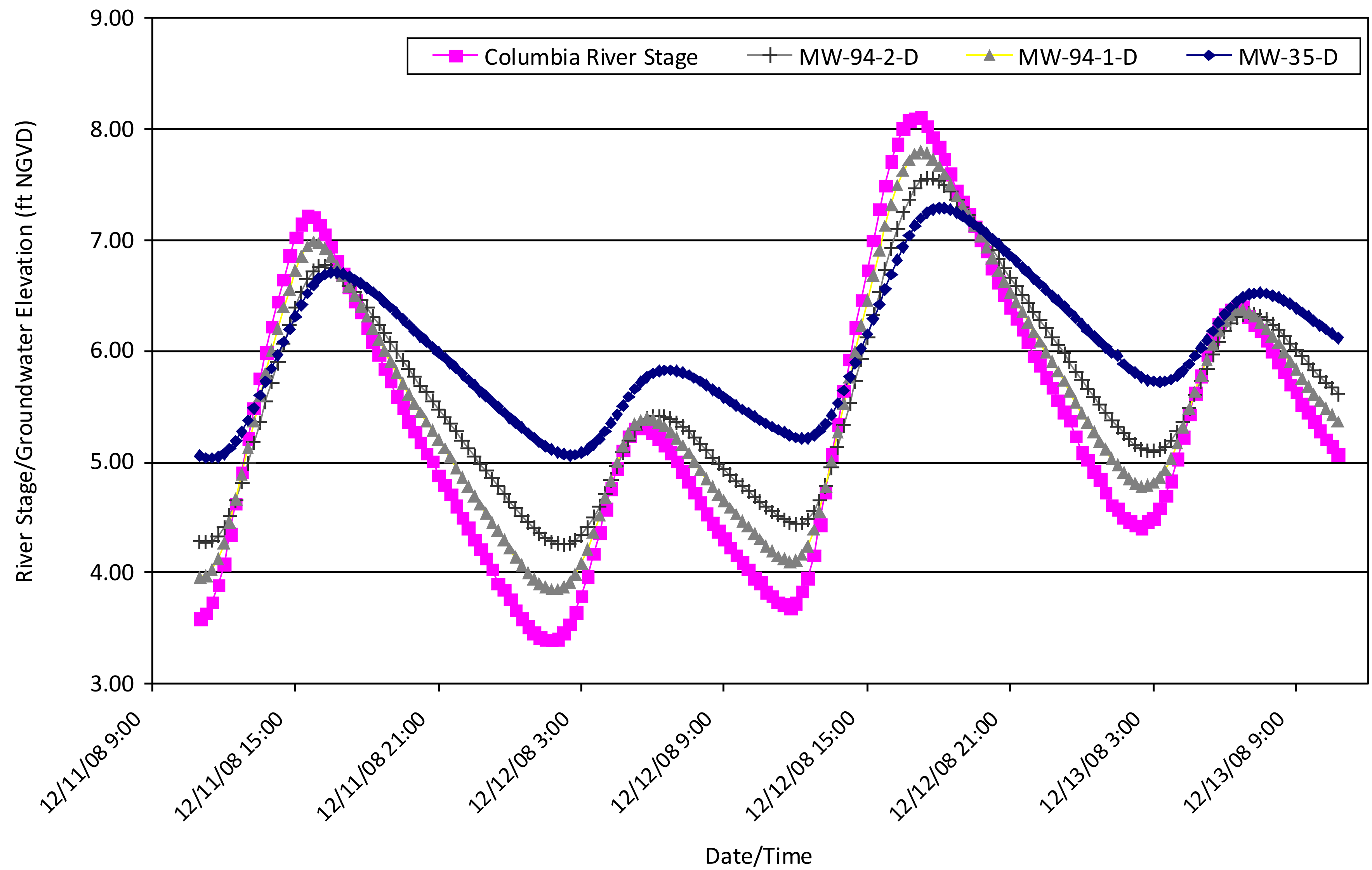

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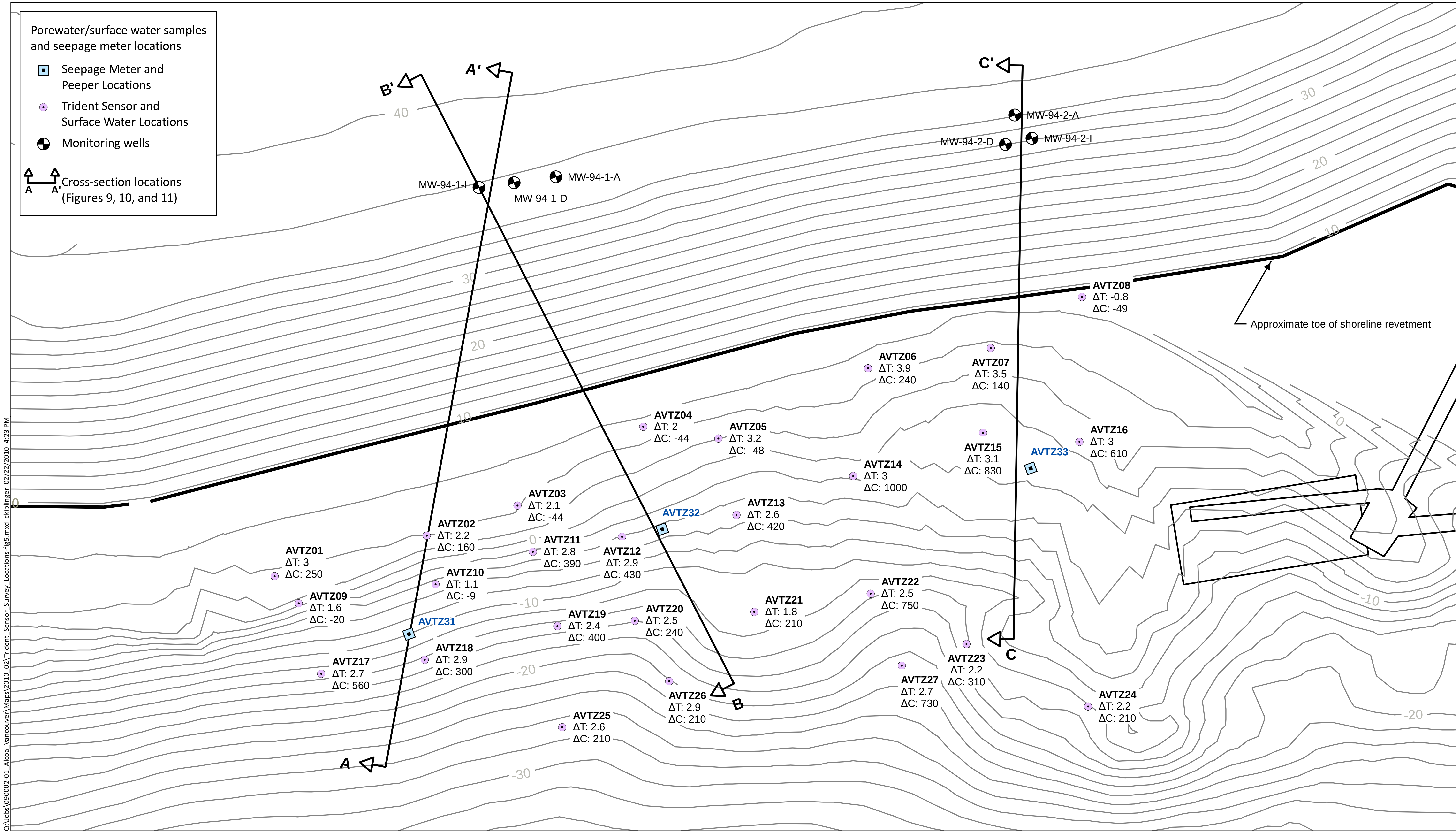
Figure 4
Deep Zone Groundwater Elevations
TZW Investigation Summary Report
Vancouver, Washington



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NOTE: Trident sensor, surface water, and sediment samples were also collected at peeper locations.

AVTZ01: Sample location ID
ΔT: Temperature differential measured in degrees Celsius (°C)
ΔC: Conductance differential measured in microsiemens per centimeter (µS/cm)

Topographic and bathymetric contours indicate elevations in NGVD29, US feet.

Feet
0 35 70

Figure 5
Sampling Locations
TZW Investigation Summary Report
Vancouver, Washington

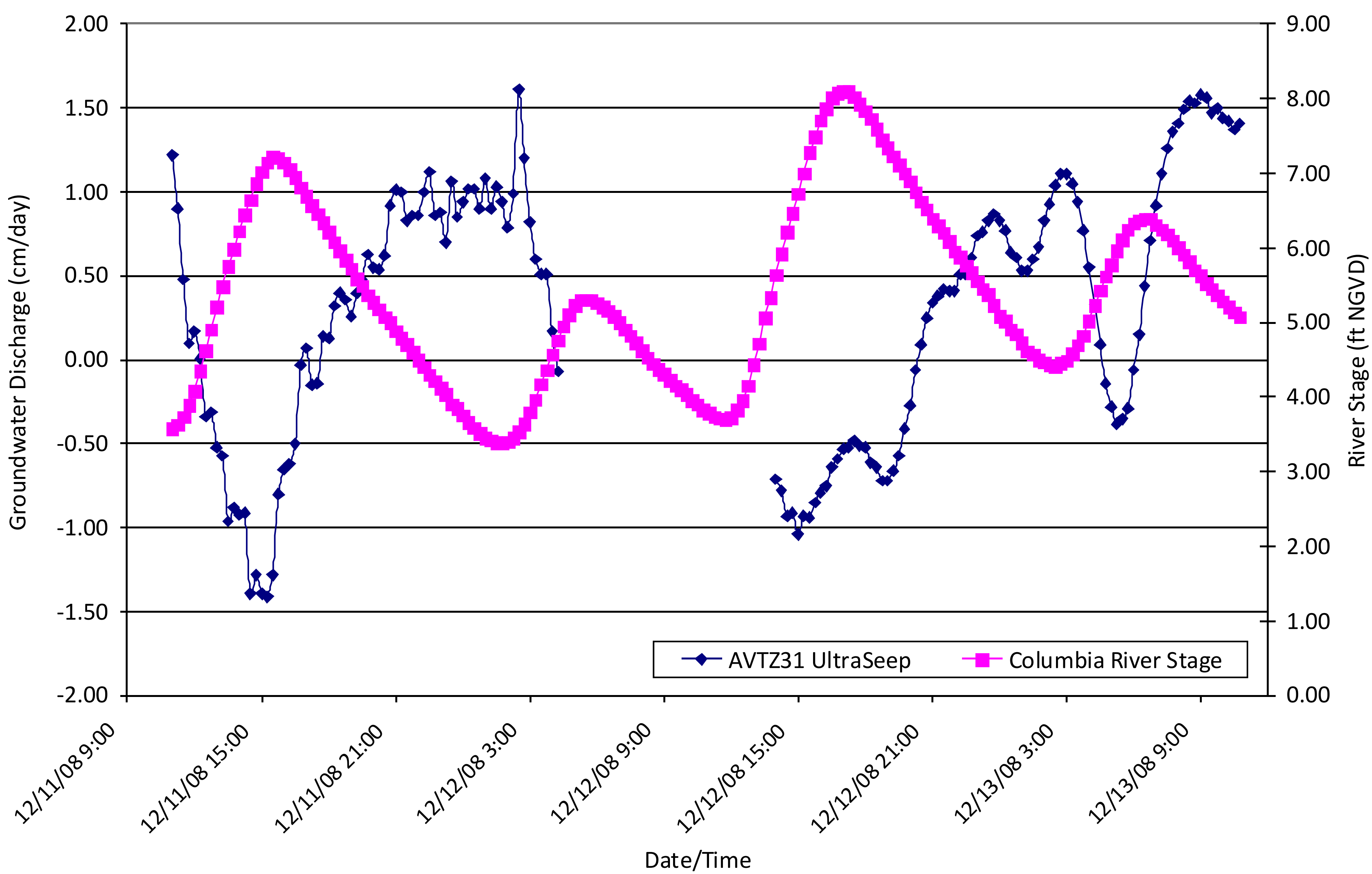

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Figure 6
Groundwater Discharge Rate at Location AVTZ31
TZW Investigation Summary Report
Vancouver, Washington

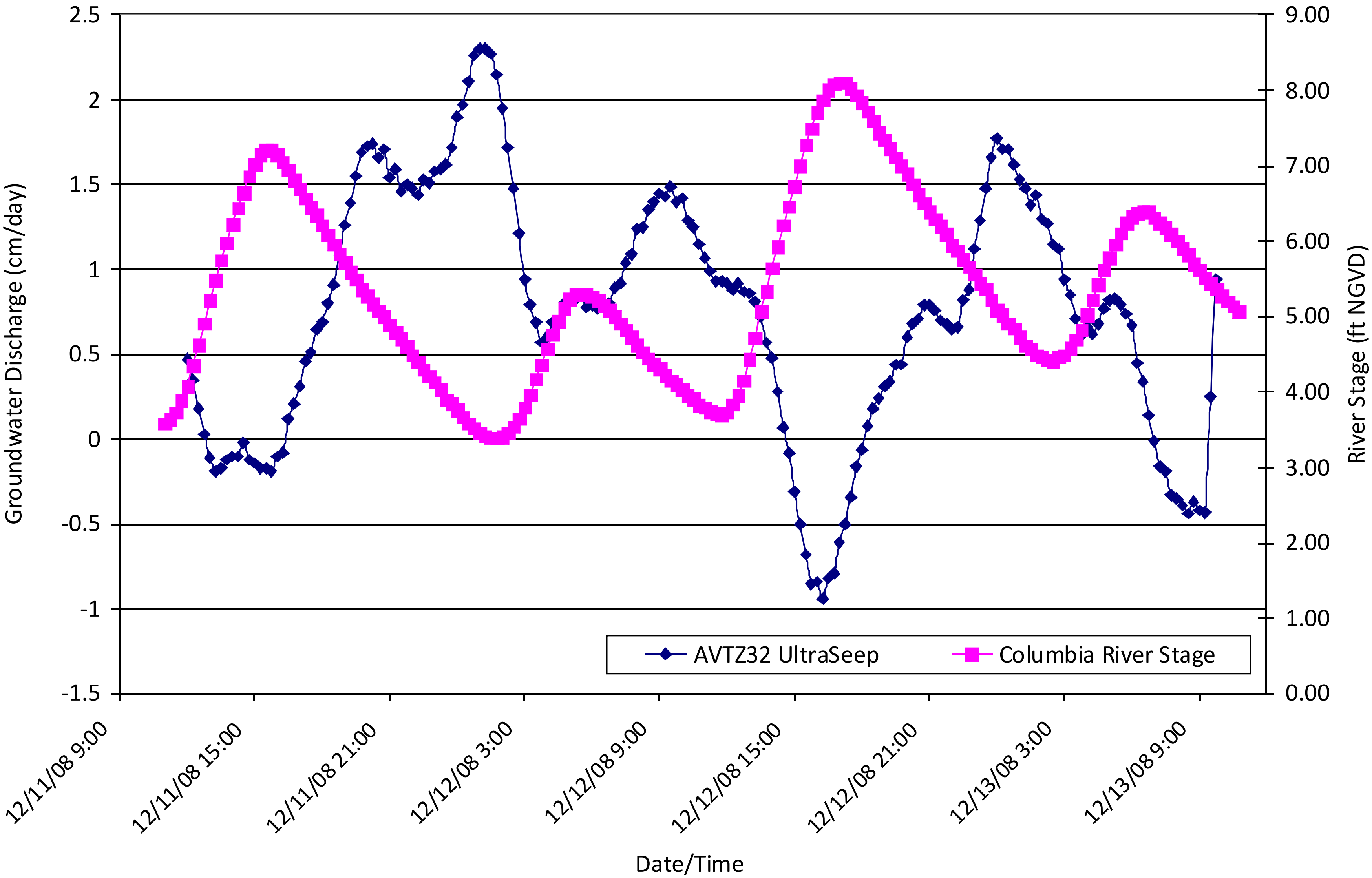

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Figure 7
Groundwater Discharge Rate at Location AVTZ32
TZW Investigation Summary Report
Vancouver, Washington

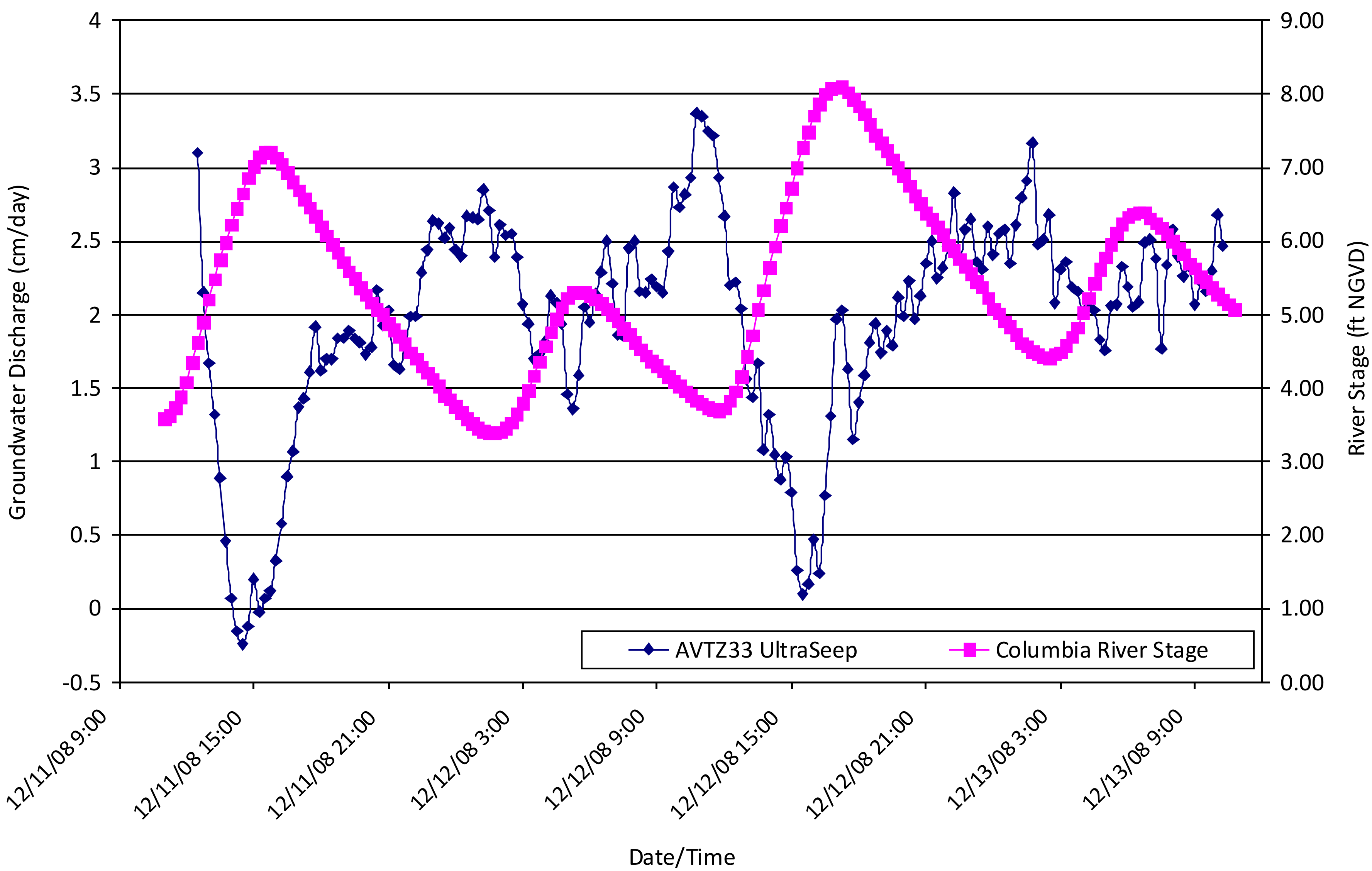

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Figure 8
Groundwater Discharge Rate at Location AVTZ33
TZW Investigation Summary Report
Vancouver, Washington

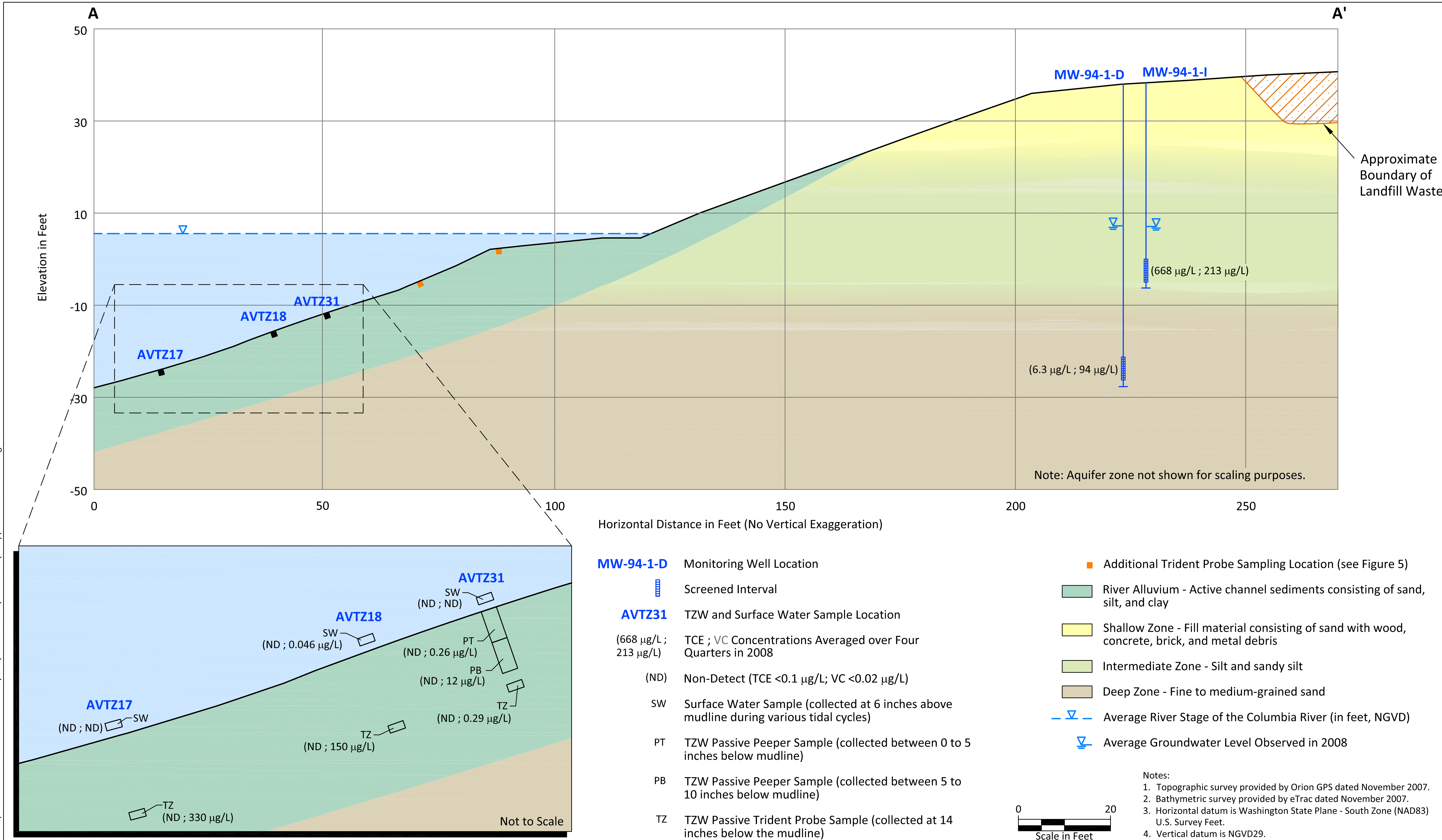

Figure 9
Cross-Section A-A' and TZW Results
TZW Investigation Summary Report
Vancouver, Washington

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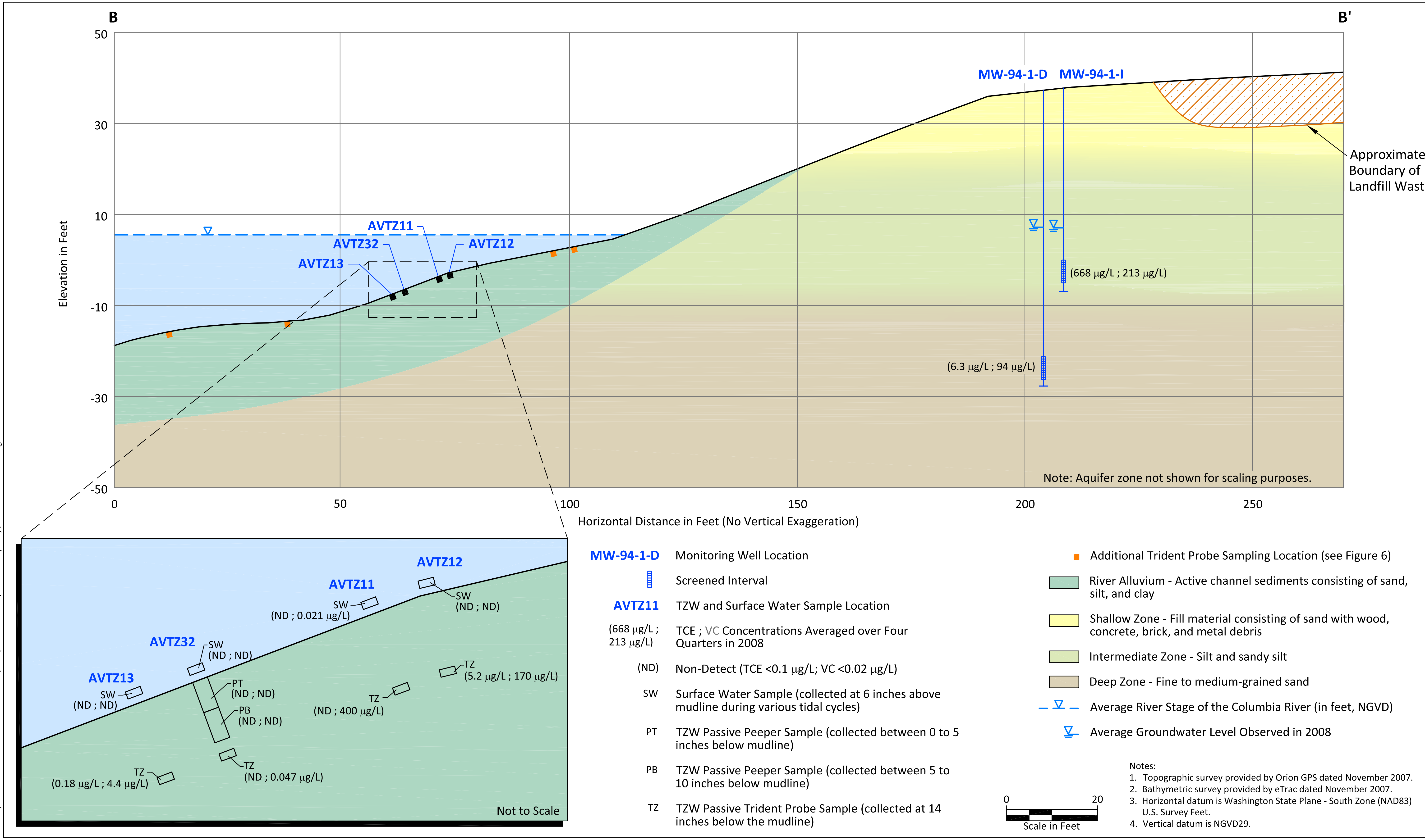

Feb 23, 2010 10:03am heriksen K:\Jobs\090002-Alcoa\090002-13 (DOE)\0900213-RP-003.dwg F10

Figure 10
Cross-Section B-B' and TZW Results
TZW Investigation Summary Report
Vancouver, Washington

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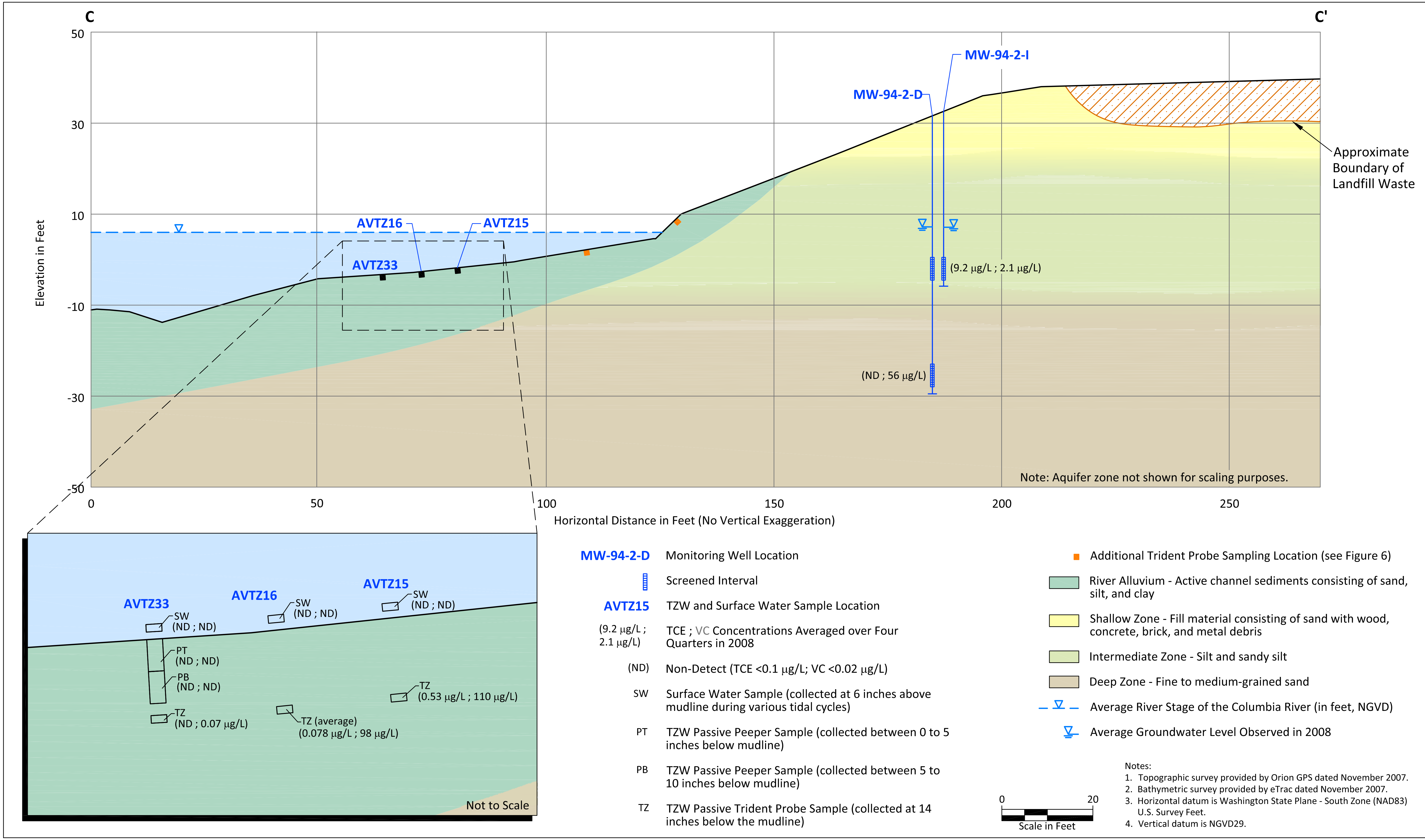

Figure 11
Cross-Section C-C' and TZW Results
TZW Investigation Summary Report
Vancouver, Washington

APPENDIX A
LABORATORY DATA REPORT

APPENDIX B
LEVEL III DATA VALIDATION REPORT

APPENDIX C
ECOLOGICAL SCREENING VALUES

Ecological Screening Levels (ESLs) for the protection of aquatic life in fresh water are recommended below for trichloroethylene (TCE) and vinyl chloride. Few studies with useable aquatic toxicity data for both compounds were identified and Tier I National Aquatic Life Criteria were not available. The fate and transport properties of these chemicals in surface water are a primary consideration in assessing the impact of these compounds on aquatic life as their concentrations in river and lake environments quickly decrease. The low risk potential of these chemicals to aquatic life is a reason that resources have not been put into testing these chemicals. Maintaining a consistent concentration of volatile organic compounds (VOCs) in toxicity test exposure solutions is challenging because of the vapor pressure of these compounds. For this reason, the Environmental Protection Agency (EPA; 2002; Stephen et al. 1985) and others (Suter and Tsao 1996) limited data used to calculate ESLs for VOCs to those generated by toxicity tests using flow-through exposures. In the EPA Ecotox database, there were only flow-through test records for fathead minnow (*Pimephales promelas*) and flagfish (*Jordanella floridae* available for TCE, and none for vinyl chloride.

An evaluation of TCE data was performed as part of the comprehensive Oak Ridge National Laboratory (ORNL) risk assessment work (Suter and Tsao 1996), and there were no new data were in the EPA Ecotox database to update this analysis. In addition to the above fish data, daphnia data from early EPA aquatic life criteria (EPA 1980) were also applied by Suter and Tsao (1996) to estimate a chronic value. Because of the limited data, Suter and Tsao provide a range of endpoints for TCE including (see Table 1):

- Highly conservative Tier II acute and chronic values, which are biased low for limited datasets,
- Chronic fish EC20 test- and population-based estimates, and
- Lower chronic values for fish and daphnia

Table 1
Summary of Available TCE and Vinyl Chloride Ecological Screening Levels for Aquatic Life in Freshwater

Chemical	ORNL Tier II Values		ORNL Alternative Chronic Values		ORNL Lowest Chronic Value for:		Michigan Final Value	
	Secondary Acute Value	Secondary Chronic Value	Lowest Test EC20 for Fish	Fish Population EC20 Estimate	Fish	Daphnids	Tier II Acute Value	Tier II Chronic Value
Trichloroethene	440	47	5,758	232	11,100	7,257	3,500	**200**
Vinyl Chloride	--	--	--	--	--	--	17,000	**930**

Notes:
All values are in μg/L unless otherwise noted.
Bold values are recommended for use as the site-specific ecological screening level for the protection of aquatic organisms.
Michigan water quality standards, Rule 57 water quality values, July 23, 2003 (Michigan DEQ 2010).

In addition to the values presented by Suter and Tsao, Michigan derived updated Tier II acute and chronic values for TCE and vinyl chloride, using the Great Lakes Initiative (GLI) Tier II Methods. While the EPA Ecotox database does not have suitable flow-through test data records for vinyl chloride, there are records for a static-replacement test with pike (*Esox lucius*) and a static test with mosquito (*Aedes aegypti*).

The Michigan Tier II values for TCE and vinyl chloride are based on the current application of the federal GLI methods for water quality criteria derivation and are relevant under the Model Toxics Control Act (MTCA; WAC 173-340-730). For TCE, this value can be compared to the ORNL alternative chronic values to illustrate the conservative nature of the derivation of this value (see Table 1). The ORNL fish 20% effects concentration (EC20) population estimate was based on a bluegill (*Lepomis*) recruitment model in a pond environment and represents a conservative exposure to fish. The daphnia lower chronic value was based on the conservative lower 95 percent prediction interval for an acute-to-chronic regression equation for nonmetallic compounds. Although lower than the Michigan Tier II value, the conservative ORNL Tier II values used a much higher safety factor (65) than is currently applied under the Michigan Tier II derivation (13). Overall, the Michigan Final Tier II TCE value of 200 μg/L and vinyl chloride value of 930 μg/L are conservative values, below which adverse effects to benthic invertebrate or fish communities in the Lower Columbia River are unlikely.

References

Environmental Protection Agency (EPA). 1980. Ambient water quality criteria for trichloroethylene. EPA 440/5-80-077.

EPA. 2002. Methodologies for Development of Aquatic Life Criteria and Values.

Michigan Department of Environmental Quality (Michigan DEQ). 2010. Rule 57 Water Quality values. Accessed at: http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-11383--,00.html.

Stephen et al. 1985. Guidelines for deriving numerical national water quality criteria for the protection of aquatic organisms and their uses. PB-85-227049

Suter, G.W. II, and C.L. Tsao. 1996. Toxicological Benchmarks for Screening of Potential Contaminants of Concern for Effects on Aquatic Biota on Oak Ridge Reservation: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 104pp. ES/ER/TM-96/R2.