3. Geologic and Hydrologic Setting

This section provides information on the geologic and hydrologic setting, and beneficial land and groundwater use within the study area.

3.1 Tectonic Setting

Oregon and Washington are located on the North American continent crustal plate. The continental plate boundary is convergent with the Juan de Fuca oceanic crustal plate and forms the Cascadia Subduction Zone. The oblique convergence of the North American Plate with the Juan de Fuca Plate has created northwest-trending fault zones and crustal blocks (Baldwin 1976). These structural features govern the geologic and hydrologic setting of the Portland Basin.

The Portland Basin, a north-west trending structural basin, encompasses approximately 1,310 square miles and is characterized by relatively low topographic relief with areas of buttes and valleys containing steep slopes (McFarland and Morgan 1996). The basin is bordered on the east by the foothills of the Cascade Mountains, on the west by the Tualatin Mountains, on the south by the Clackamas River, and on the north by the Lewis River.

3.2 Topography

The Columbia River dominates the topography of the study area. The project corridor lies within the Columbia River main valley, with the exception of a small area north of the SR 500 interchange that is located in the Burnt Bridge Creek watershed (Exhibit 1-1). Burnt Bridge Creek flows into Vancouver Lake before discharging to the Columbia River. Project area elevations vary from approximately 10 feet in the Columbia River floodplain to about 220 feet at the drainage divide between the Columbia River and Burnt Bridge Creek valleys.

3.3 Fluvial Setting

The Columbia River drains almost 220,000 square miles in seven states and Canada with land in forest, agricultural, residential, urban, and industrial uses. The Lower Columbia River, that section of the river most pertinent to the impact analysis, flows from Bonneville Dam at River Mile 146 to the mouth of the river, and drains an area of 18,000 square miles. Adjacent to the study area, Hayden Island divides the mainstem of the Columbia River, which flows to its north, from a side channel called the North Portland Harbor, which flows to its south. The I-5 highway crosses both channels near River Mile 106.5.

Exhibit 3-1 displays Columbia River bathometry within the study area. The figure indicates that depth of in-water sediments in the study area extends from the ordinary high water line [3] at 21.2 feet North American Vertical Datum 1988 (NAVD 88) to a depth of approximately -25 feet NAVD 88. Geotechnical borings and bathometric surveys completed within the footprint of the proposed crossing indicate that the depth to the bottom of unconsolidated sediments (alluvial and/or catastrophic flood deposits) in the study area ranges from -40 to -230 feet NAVD 88 (DEA 2006) (Shannon and Wilson 2008). Underlying these sediments is the top of the Troutdale Formation.

The top layer of river substrate is composed of loose to very dense alluvium (primarily sand and some fines), underlain by approximately 20 feet of dense gravel, underlain by the Troutdale Formation. Additional information regarding the characteristics of in-water sediment material in proximity to the study area is currently being compiled by the U.S. Army Corps of Engineers (USACE). This 2008 evaluation report should be open for public review sometime this summer (Siipola, April 4, 2009).

Burnt Bridge Creek defines the northern boundary of the study area. The creek originates in East Vancouver from field ditches that drain a large wetland area between NE 112th Avenue and NE 164th Avenue. The creek is approximately 12.9 miles in length and alternates between ditches and natural channels. Except for floodplains, parks, and wetlands, nearly the entire basin is urbanized. In the project area, the creek flows through a small canyon with a narrow floodplain. The creek passes under the existing highway in a culvert north of the project area.

3.4 Stormwater

3.4.1 Existing Stormwater Drainage System

The existing stormwater drainage systems in the study area are comprised of closed conveyance systems that discharge runoff to either the Columbia River or Burnt Bridge Creek Watersheds. These watersheds are highly urbanized within the study area. The existing drainage systems are described below based on their receiving waterbody.

Columbia River Watershed

The total drainage area included in the analyses of stormwater draining to the Columbia River Watershed is about 486 acres. Of this area, approximately 204 acres (or about 42 percent) is comprised of impervious surfaces that include highway, streets, parking lots and alleys. The area extends north from the Columbia River to just south of SR 500. The drainage area includes I-5, the western end of SR 14, and downtown Vancouver. With the exception of SR 14, runoff from this drainage area receives no water quality treatment prior to being released to the Columbia River. Runoff from the eastbound lanes of SR 14 (about 3 acres) sheds to the shoulder where it disperses and/or infiltrates to groundwater.

[3] The point on a stream bank to which the presence and action of surface water is so continuous as to leave a district marked by erosion; destruction or prevention of woody terrestrial vegetation; predominance of aquatic vegetation; or other easily recognized characteristics.

Runoff from Interstate Bridge drains directly from the bridge decks through scuppers to the Columbia River or ground below. North of the Columbia River, conveyance systems collect runoff from I-5, SR-14 and streets in downtown Vancouver. The runoff is discharged directly to the river via several outfalls located from about ½ mile east (upstream) of the existing bridges to about ½ mile west. Over 80 percent of the total drainage area is served by a single conveyance system that discharges to the Columbia via a 60-inch diameter outfall located immediately east of the Interstate Bridge. Runoff also discharges to the Columbia River via several outfalls located in the immediate vicinity of the existing I-5 bridges (see Exhibit 3-1) (Clark County 2005).

Burnt Bridge Creek Watershed

The total drainage area included in the analyses of stormwater draining to Burnt Bridge Creek is about 190 acres, of which approximately 86 acres (or about 45 percent) comprises highway, streets, parking lots and alleys. The area includes SR 500, the I-5/SR 500 interchange, I-5 north of the interchange, and adjacent neighborhoods. Runoff from approximately 66 acres of impervious surface is directed to an infiltration pond located immediately south of the I-5/Main Street interchange. Runoff from the remaining area flows to wet pond located east of the I-5/SR 500 interchange.

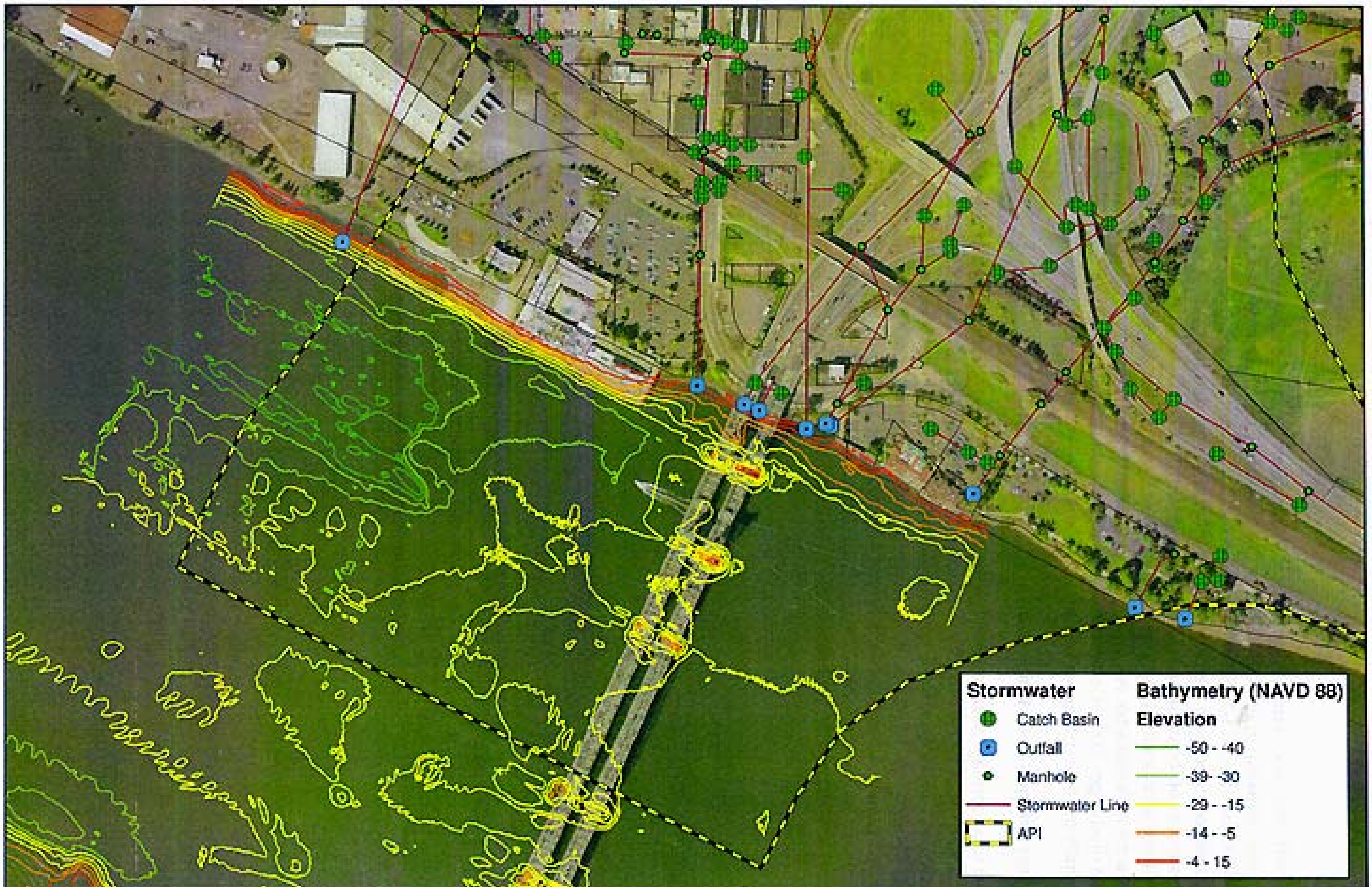

Exhibit 3-1: Columbia River Bathymetry Map
Troutdale SSA Evaluation

Columbia River CROSSING

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3.5 Geologic Units

Geologically recent deposits that fill in the Portland Basin consist of conglomerate, gravel, sand, silt, and some clay from volcanic, fluvial, and lacustrine material (Pratt et al. 2001). Late Pleistocene catastrophic flood deposits cover much of the surface within the study area. Deposits originating from an ancestral Columbia River underlie the catastrophic flood deposits. These sedimentary deposits overlie Miocene basalt flows of the Columbia River Basalt Group (Swanson et al. 1993). The Columbia River Basalt Group overlies lava flows and volcanic breccias of Oligocene age.

Geologic units within the study area are described below by increasing age. The spatial distribution of surficial geologic units is presented on Exhibit 3-2.

3.5.1 Artificial Fill (Qaf)

Artificial fill material was used to modify existing topographic relief and typically consists of sand, silt, and clay with some gravel and debris. Fill areas mapped with inferred contacts represent lakes and marshes that may have been drained rather than filled. Fill 5 to 15 feet thick is common in developed areas of the Willamette River and Columbia River floodplains (Madin, 1994). However, thickness and distribution are highly variable (Beeson et al. 1991).

3.5.2 Alluvium (Qal)

Alluvial deposits include material derived from present day streams and rivers, their floodplains, and abandoned channels. The alluvial deposits are typically Holocene to upper Pleistocene in age. Alluvial material consists of unconsolidated gravel, medium to fine sand, silt, and organic-rich clay. Cobble-sized material may be present within existing or abandoned stream channels. Thickness is typically less than 45 feet, but may be up to 150 feet thick locally. Alluvium is exposed at the surface from just south of the Columbia Slough in Oregon to approximately ¼ mile north of the Columbia River in Washington (Beeson et al. 1991; Phillips 1987).

3.5.3 Catastrophic Flood Deposits (Qff/Qfc)

The catastrophic flood deposits resulting from the Pleistocene-aged Missoula Floods are derived from the repeated failure of ice dams located on the Clark Fork River in northwestern Montana (Bretz and others 1956). Glacial Lake Missoula was created by ice dams from the advancing front of the Purcell Trench lobe of the Cordilleran ice sheet. The floods released approximately 500 cubic miles of water, flooding portions of eastern Washington, the Columbia Gorge, and the northern Willamette Valley (Bretz et al. 1956; Allen et al. 1986). The flooding occurred at least 40 times during the Pleistocene (16,000 to 12,000 years ago), depositing boulders, cobbles, gravel, sand, and silt (Waitt 1985). The flood waters would be impounded by valley constriction south of Kelso and backup to elevations as much as 350 feet mean sea level (msl). As flood water velocities were reduced, sediment loads were deposited in foreset bedded gravel and sand similar to delta deposition (Robinson, Noble and Carr 1980).

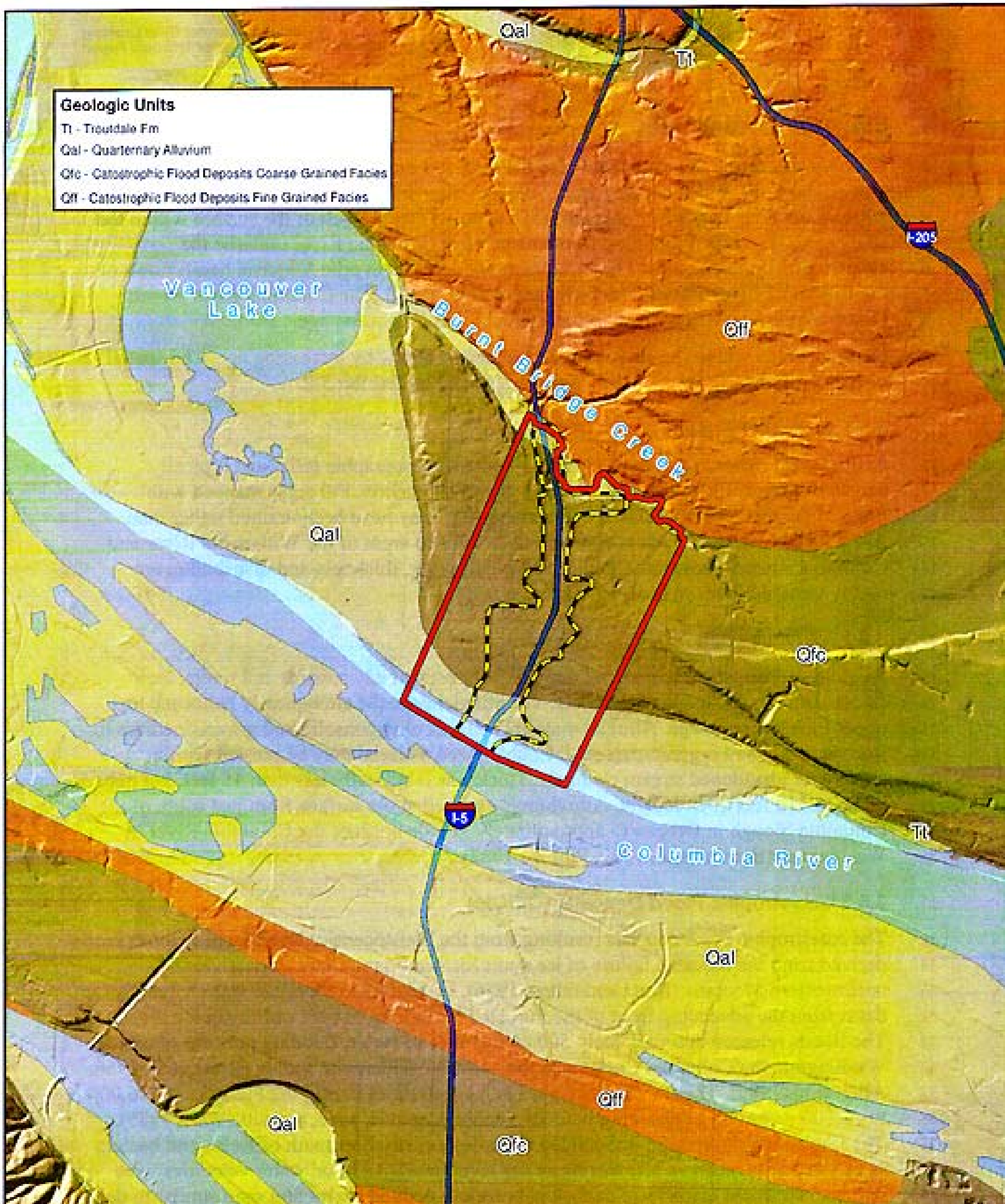


Exhibit 3-2: Geologic Units Location Map

Troutdale SSA Evaluation

Columbia River CROSSING

This deposit is subdivided into two facies by Madin (1994): a fine-grained facies (Qff) and coarse-grained facies (Qfc). Both are present locally. The finer sediments consist of primarily coarse sand to silt. The fine sand and silt is composed of quartz and feldspar with white mica. The coarser sand is composed primarily of basalt. The coarse-grained facies (Qfc) consists of pebble to boulder gravel with a coarse sand to silt matrix.

3.5.4 Troutdale Formation (Tt)

The Troutdale Formation (Miocene to Pliocene in age) underlies the catastrophic flood deposits and consists of coarse- to fine-grained fluvial sedimentary rock derived from the ancestral Columbia River. The unit is a friable to moderately strong conglomerate with minor sandstone, siltstone, and mudstone. Pebbles and cobbles are composed of Columbia River Basalt (described below), exotic volcanic, metamorphic, and plutonic rocks. The matrix and interbeds are composed of feldspathic, quartzo-micaceous, and volcanic lithic and vitric sediments. The formation exhibits cementation mantling on some of the grains (Beeson et al. 1991).

3.5.5 Sandy River Mudstone (Tsr)

The Sandy River Mudstone (Pliocene in age) underlies the Troutdale Formation and consists of fine-grained, predominantly fluvial and minor lacustrine sediments. The unit is a friable to moderately strong sandstone, siltstone, and claystone. The mudstone is composed of primarily quartz-feldspathic and white mica sediments (Beeson et al. 1991).

3.5.6 Miocene and Older Rocks

The Columbia River Basalt Group (CRBG) (late Miocene and early Pliocene in age) consists of numerous basaltic lava flows which cover approximately 63,000 square miles and extend to thicknesses greater than 6,000 feet. The CRBG is composed of dark gray to black, dense, crystalline basalt and minor interbedded pyroclastic material. Beneath the CRBG are upper Eocene to lower Miocene volcanic and marine sedimentary rocks. The volcanic rocks typically consist of altered basalt, basaltic andesite, and pyroclastic rocks. The marine sedimentary rocks typically consist of fossiliferous tuffaceous shale and sandstone with minor conglomerate lenses (Madin 1994).

3.6 Hydrogeologic Setting

As the geologic units described above were deposited in the deforming Portland Basin, hydrogeologic units were also formed. The physical nature and depositional environment of the geologic material will create units of material that possess dissimilar hydraulic properties. Groundwater moving through the material will travel at different rates depending on the physical properties of the hydrogeologic unit. The physical properties of units in the TSSA are further discussed below.

The 1993 United States Geologic Survey (USGS) (Swanson et al. 1993) report describes eight major hydrogeologic units in the Portland Basin (Exhibit 3-3). These units are, from youngest to oldest and increasing depth:

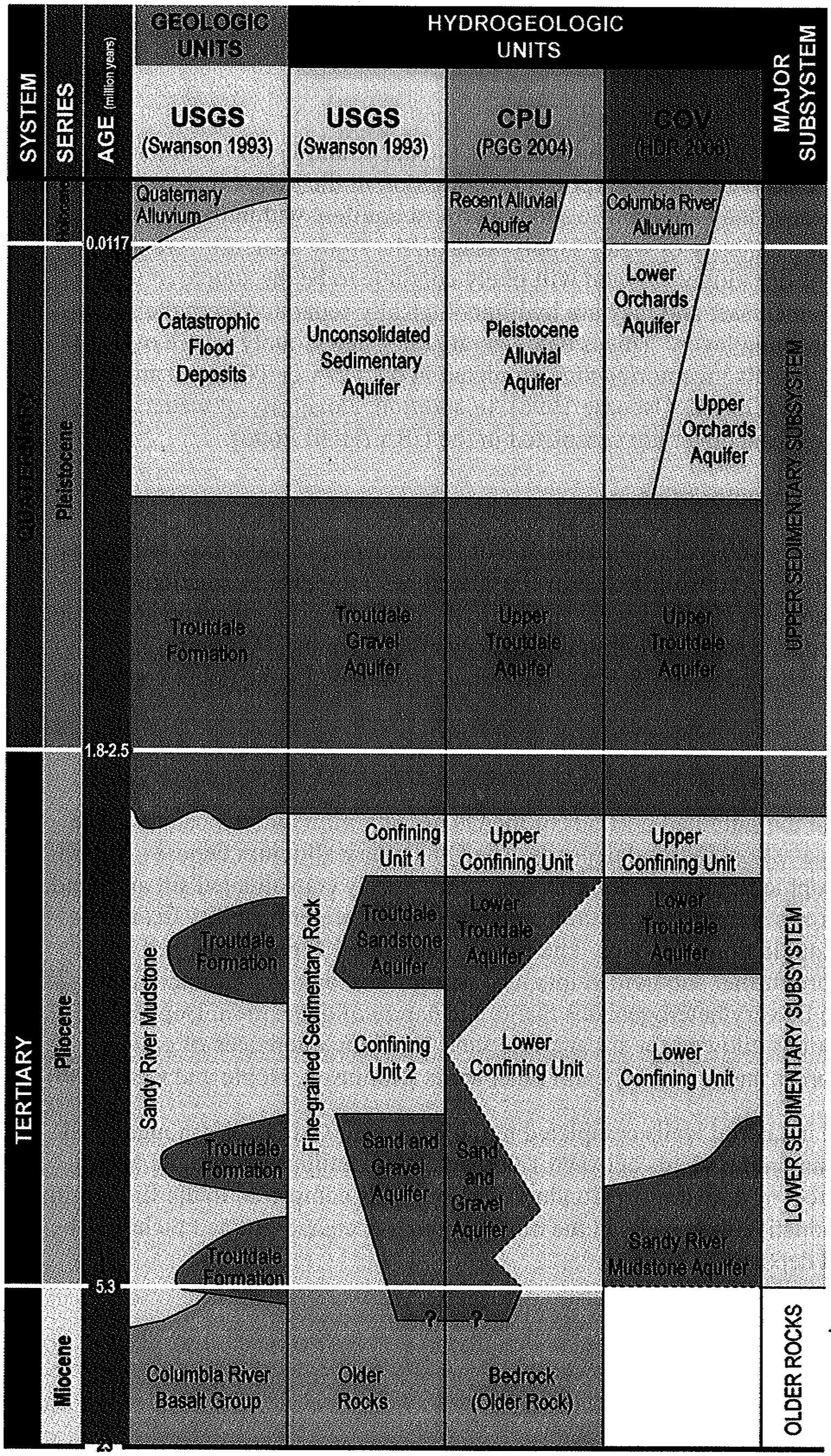
- Unconsolidated Sedimentary Aquifer (USA)
- Troutdale Gravel Aquifer (TGA)
- Confining Unit 1 (CU 1)
- Troutdale Sandstone Aquifer (TSA)
- Confining Unit 2 (CU 2)
- Sand and Gravel Aquifer (SGA)
- Older Rocks

The eighth unit is referred to as undifferentiated fine-grained sediments where the TSA and the SGA appear to have pinched out or there is insufficient information to characterize the aquifer units within the fine-grained Sandy River Mudstone. Where this occurs, CU 1 and CU 2 cannot be separated and have been mapped as undifferentiated fine-grained sediments. The older rocks, consisting of older volcanic and marine sedimentary rocks of generally low permeability, are present at depths estimated to range up to 1,600 feet in the central area of the basin. They are poor aquifers and too deep to be used as a primary source of water in the site region. Due to these conditions, no further discussion is presented regarding the older rock unit.

The Portland Basin aquifer system has also been grouped into three major subsystems:

- Upper sedimentary subsystem (USA and TGA)
- Lower sedimentary subsystem (CU 1, TSA, CU 2, and SGA)
- Older rocks

This grouping is based on regionally continuous contacts between units of different lithologic and hydrogeologic characteristics (Swanson et al. 1993). Exhibit 3-3 presents other nomenclatures used to describe the hydrogeologic units by Clark Public Utilities (CPU) and the City of Vancouver (COV). For the purpose of consistency with EPA's (2006) determination, terminology used by McFarland and Morgan (1996) which was derived from Swanson and others (1993) will be presented in this report.



Columbia River CROSSING

Exhibit 3-3
Geologic Units and Comparison of Hydrogeologic Unit Terminology
Troutdale SSA Evaluation

3.7 USA and TGA

The EPA (2006) defines the TSSA to include both the upper and lower sedimentary subsystems. For the purposes of this report, the discussion of the TSSA focuses on the USA and TGA because they are prolific and uppermost aquifers within the Portland Basin; they contain a majority of water supply wells in the study area; they are the primary aquifers for drinking water and will likely continue to be the source of water supply as demands increase; and they are hydrogeologically separated from the lower subsystem by a confining layer.[4] This is demonstrated in Clark County where over 90 percent of the 7,111 wells inventoried are completed in the USA or TGA and are less than 300 feet in depth (Gray & Osborne 1996). In addition, a majority of water supply wells for the City of Vancouver are completed in the USA (HDR 2006).

3.7.1 Hydrologic Characteristics

The upper sedimentary subsystem is composed of Pleistocene to Quaternary sediments and consolidated to semi-consolidated gravel of the upper Troutdale Formation. The Pleistocene to Quaternary deposits have similar hydrogeologic properties and are grouped as the USA. The upper Troutdale Formation deposits that form the TGA are hydrogeologically isolated from the lower Troutdale Formation by the upper confining unit (CU1).

USA

The USA occurs in the saturated portions of the Quaternary alluvium deposits and the Pleistocene-aged catastrophic flood deposits. The Quaternary alluvium deposits, which overlie the catastrophic flood deposits, consist of very poorly consolidated silt and sand. The alluvium deposits are partially saturated and have a lower permeability than the underlying catastrophic flood deposits. The catastrophic flood deposits mapped by Phillips (1987) were further subdivided into a course-grained and fine-grained facies. The flood deposits can be very heterogeneous due to the nature of deposition. Deposition under flood conditions allowed for silt and fine sand to fill the interstices of gravel deposits in some areas and remain open in other areas (Robinson, Noble and Carr 1980).

Public supply and industrial wells completed in the USA near Camas, Washougal, and Vancouver have maximum yields between 1,000 and 6,000 gallons per minute (gpm) with less than 10 feet of drawdown (Mundorff 1964). Wells completed in the fine-grained facies are less productive than wells in the more productive coarse-grained facies of the catastrophic flood deposits.

[4] This rationale was used to limit the study area to contain only the USA and TGA.

Mundorff (1964) estimated that the transmissivity portion of the USA ranged from 1.9 million to 3.5 million gallons per day per foot (gpd/ft).[5] The calculated transmissivities for City of Vancouver Water Stations WS-1, WS-3 and WS-4, all producing from the USA, were 2 million gpd/ft, 878,900 gpd/ft, and 586,000 gpd/ft, respectively (Robinson, Noble and Carr 1980).

Based on a review of transmissivities calculated for the City of Vancouver water stations and transmissivities estimated from reported pump test yields and drawdown (i.e., specific capacity), Swanson (1995) assigned a hydraulic conductivity of 1,000 feet/day to the USA in the Portland Basin. McFarland and Morgan (1996) estimated a median hydraulic conductivity for the USA of 200 feet/day, with a range of 0.03 to 70,000 feet/day.

The transition to the Pleistocene-aged Troutdale Formation is primarily based on a drop in permeability, followed by harder drilling conditions that were encountered and/or where cementation or a silty sandy matrix was encountered.

TGA

The TGA underlies the catastrophic flood deposits and alluvial deposits that make up the USA in the study area. The TGA is composed of partially cemented sandy conglomerate.

The elevation of the top of the Troutdale Formation varies noticeably due to an erosional period prior to the deposition of the catastrophic flood deposits and erosion that occurred during the flood events. It has been observed that where the upper Troutdale Formation has been severely weathered, a thick clayey soil may have developed in areas, thus creating a discontinuous confining unit between the two aquifers (Swanson et al. 1993, PGG 2002).

The permeability and the transmissivity of the TGA have been noted to be at least an order of magnitude lower than the USA (McFarland and Morgan 1996; PGG 2002). This difference in permeability and transmissivity is due to the presence of more fines in the Troutdale Formation, along with lithification and cementation, which ranges from consolidated to semi-consolidated. Although the TGA contains zones of significant cementation, it is sufficiently conductive to produce high yield wells. Wells completed in the TGA commonly yields up to 1,000 gpm (Swanson et al. 1993). The TGA has historically served as the most productive aquifer in the Salmon Creek basin.

Based on limited data, Robinson, Noble, and Ellis (1980) estimated that the transmissivity of the TGA ranges from about 5,000 to 20,000 gpd/ft in the South Clark County area. Mcfarland and Morgan (1996) estimated a median hydraulic conductivity of the TGA of about 7 feet/day.

Exhibit 3-4 shows cross-section orientation lines for selected wells near the study area. Hydrogeologic unit cross sections are presented in Exhibit 3-5 through Exhibit 3-7.

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[5] Transmissivity is the rate in which water travels through an aquifer of unit width under a unit hydraulic gradient. It is the function of the liquid, porous media and its thickness.

3.7.2 Groundwater Flow

Recharge and Discharge Areas

Recharge to the USA and TGA occurs from precipitation, and infiltration from rivers, streams, and stormwater. The principal recharge areas for groundwater in the USA and TGA are the upland areas of the western Cascade Mountains east of the study area (Exhibit 1-1). The combined average recharge rate is estimated to be about 22 inches/year (Snyder et al. 1994) for the Portland Basin. The highest rates (49 inches/year) occur in the Cascade Range, and the lowest rates (near zero inches/year) at the Columbia and Willamette Rivers. Seasonal fluctuations in groundwater elevations increase the aquifer saturated thickness during heavy spring and winter precipitation. As such, the depth to static water level is greater in the summer and fall months from low precipitation.

Groundwater within the USA and TGA likely discharges to the Columbia River, water supply wells, or infiltrates into the lower sedimentary subsystem. The portion of Clark County that drains directly to the Columbia River is known as the Columbia Slope watershed. This 25-square-mile watershed consists of a narrow band of hillsides between downtown Vancouver and Lacamas Creek. Its northern boundary generally follows Mill Plain Boulevard and hilltops in Camas, Washington. Except for some wetlands, parks, and steep hills, most of the area is urbanized.

Flow Direction and Gradient

Groundwater in the USA generally flows from recharge areas located northeast of the study area at elevations about 250 feet above mean sea level (msl) to the southwest (Exhibit 3-8).The movement of groundwater is controlled by topography, river levels, and supply well pumping. Within the study area, groundwater elevations are typically 50 feet msl just south of the Burnt Bridge Creek drainage and decrease to approximately 20 feet msl at the Columbia River.[6] Water level elevations sharply increase north of Burnt Bridge Creek drainage to approximately 150 feet msl. The large observed drop in groundwater levels south of Burnt Bridge Creek suggests that a low permeability conditions exists in the area of the creek. This lower permeability condition functions to reduce the volume of groundwater recharge to the area south of Burnt Bridge Creek. These physical attributes establish the northern boundary of the study area. Based on the hydraulically upgradient position, construction activities would not likely impact groundwater north of this boundary. Further details on groundwater levels within the study area are displayed on Exhibit 3-9. [7] The exhibit displays the estimated depth to groundwater below ground surface for May 1995 using 10-foot contour intervals.

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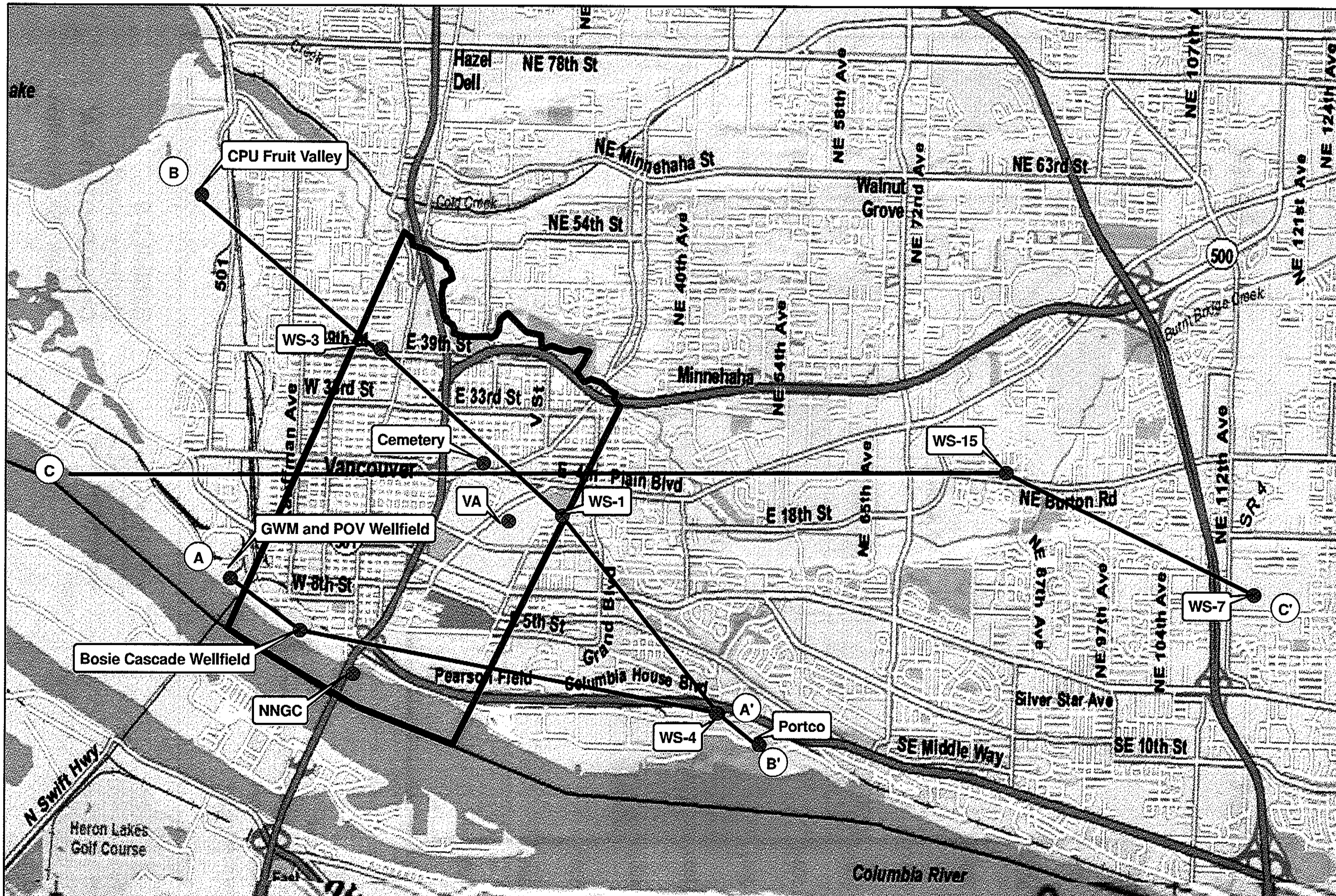
[6] Based on water levels collected during the spring of 1988 (McFarland and Morgan 1996).

[7] Clark County, GIS data layer, No. 1592



Study Area
Cross Section Lines
Well Locations

0 0.25 0.5
Miles

Exhibit 3-4: Cross Section Orientation Map
Troutdale SSA Evaluation

Columbia River CROSSING

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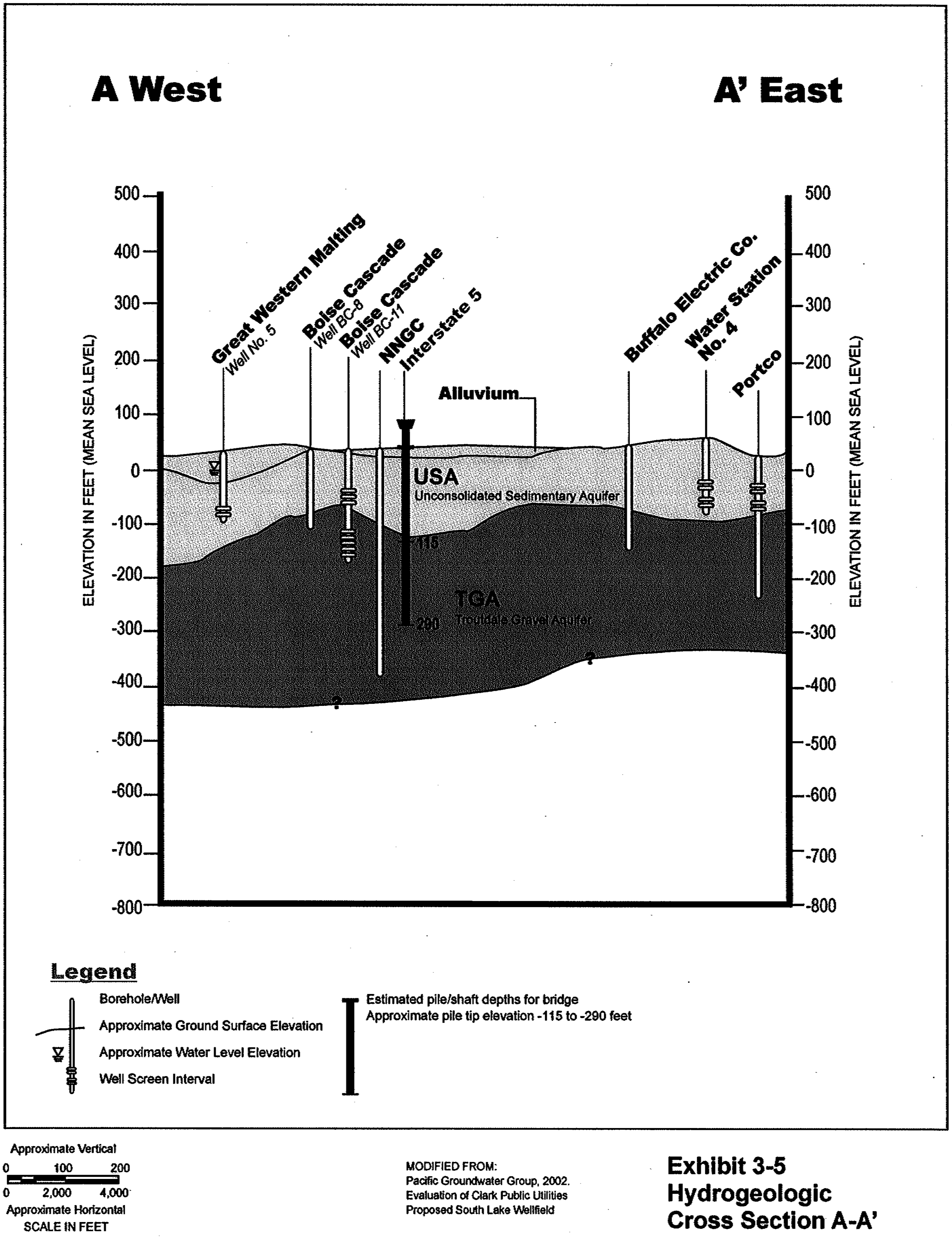
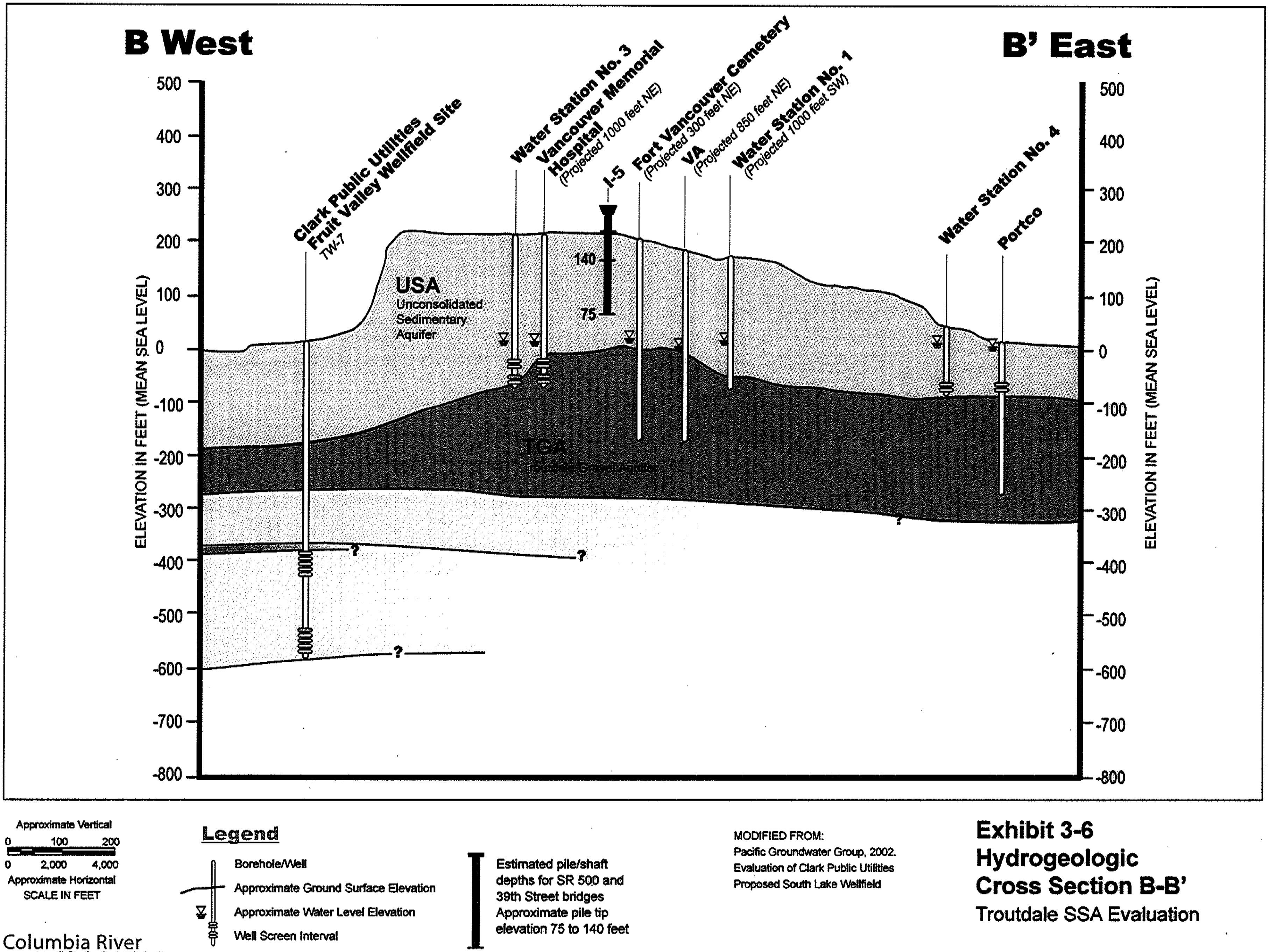


MODIFIED FROM:
Pacific Groundwater Group, 2002.
Evaluation of Clark Public Utilities
Proposed South Lake Wellfield

Exhibit 3-5
Hydrogeologic Cross Section A-A'
Troudale SSA Evaluation

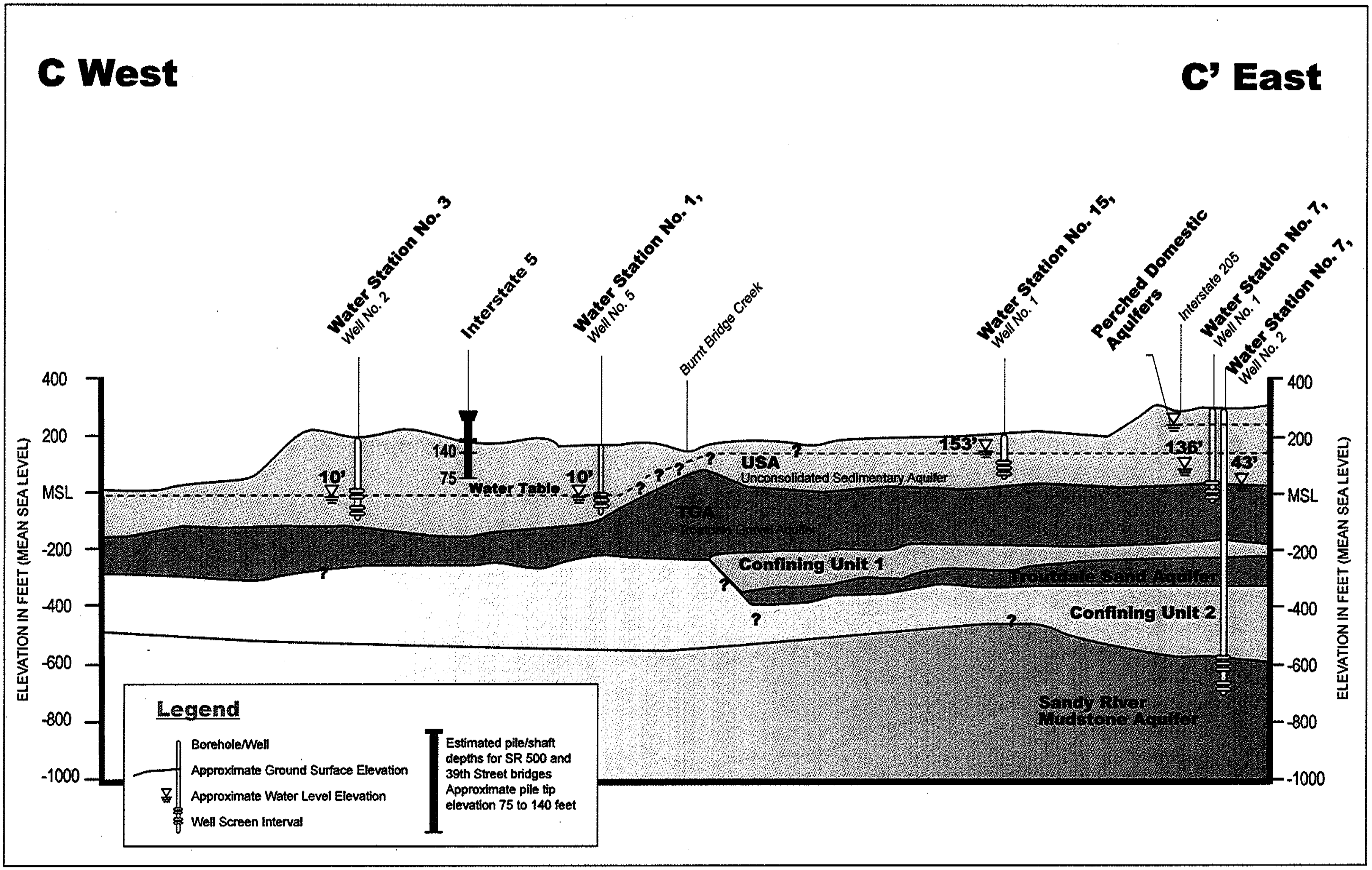
Columbia River CROSSING



MODIFIED FROM:
Pacific Groundwater Group, 2002.
Evaluation of Clark Public Utilities
Proposed South Lake Wellfield

Exhibit 3-6
Hydrogeologic Cross Section B-B'
Troutdale SSA Evaluation

Columbia River CROSSING



Parametrix

Approximate Vertical
0 200 400
0 2,000 4,000
Approximate Horizontal
SCALE IN FEET

Columbia River CROSSING

MODIFIED FROM:

Clark County Water Quality Division, 1994, Method to Evaluate Aquifer Vulnerability Through Conjunctive use of a Groundwater Flow Model and Geographic Information System.

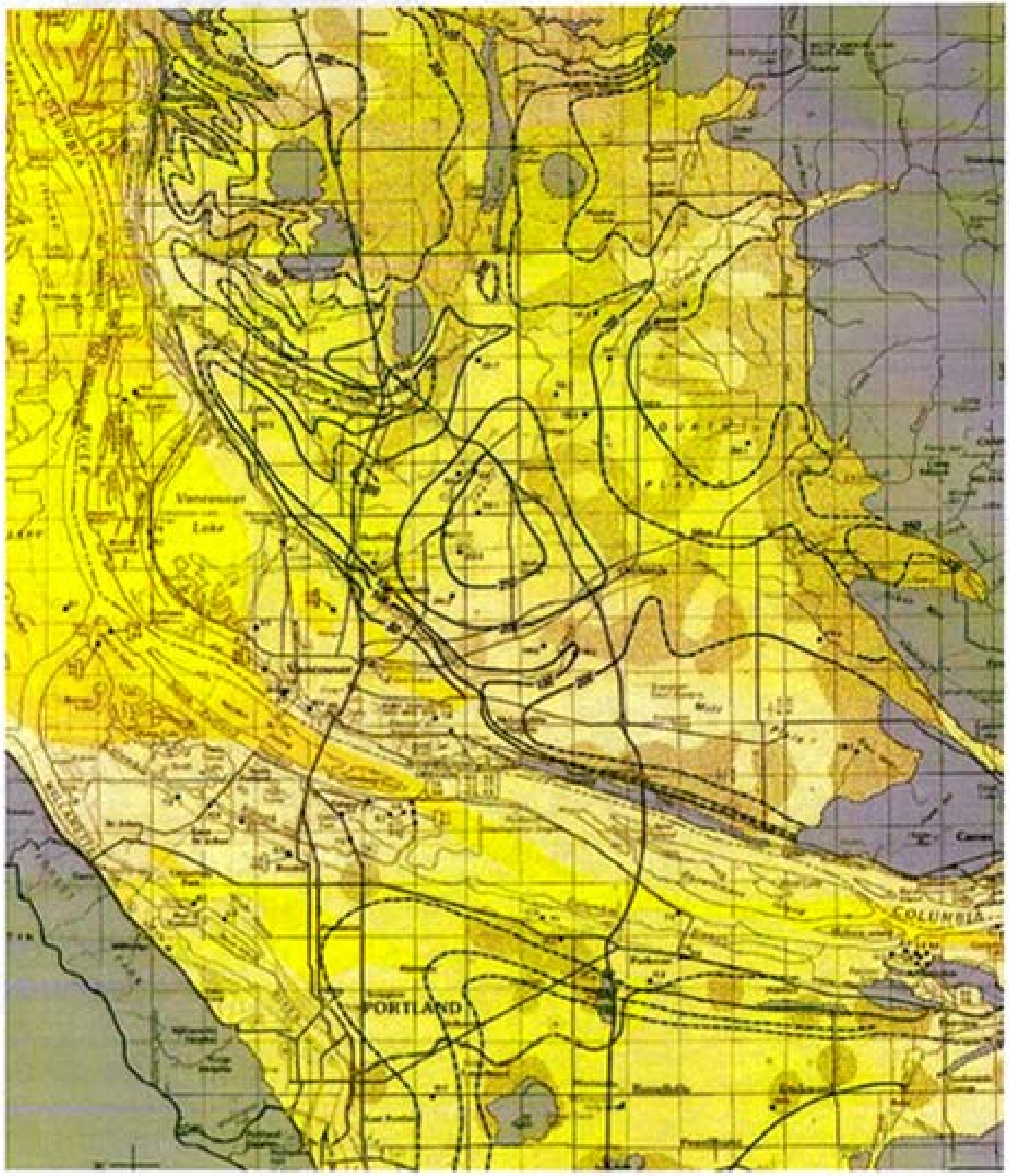
Robinson & Noble, Inc., 1992, Investigation of the Sandy River Mudstone Aquifer, City of Vancouver.

Robinson, Noble & Carr, Inc., 1980, City of Vancouver Groundwater Source and Use Study, Volume 1 Summary.

Gray & Osborne, Inc., 1996. Water System Comprehensive Plan, City of Vancouver, November 1996.

HDR Engineering, Inc. 2006 Water System Comprehensive Plan, Draft March 2006.

Exhibit 3-7
Hydrogeologic Cross Section C-C'
Troutdale SSA Evaluation



Legend

100 — GROUNDWATER LEVEL CONTOUR. Shows altitude, in feet, of groundwater level, Spring 1988, in the unconsolidated sedimentary aquifer. Dashed where approximate. Contour is variable. Datum is sea level.

FIELD LOCATED WELL. Completed in the USA. Number is altitude in feet above sea level.

N

0 5 miles

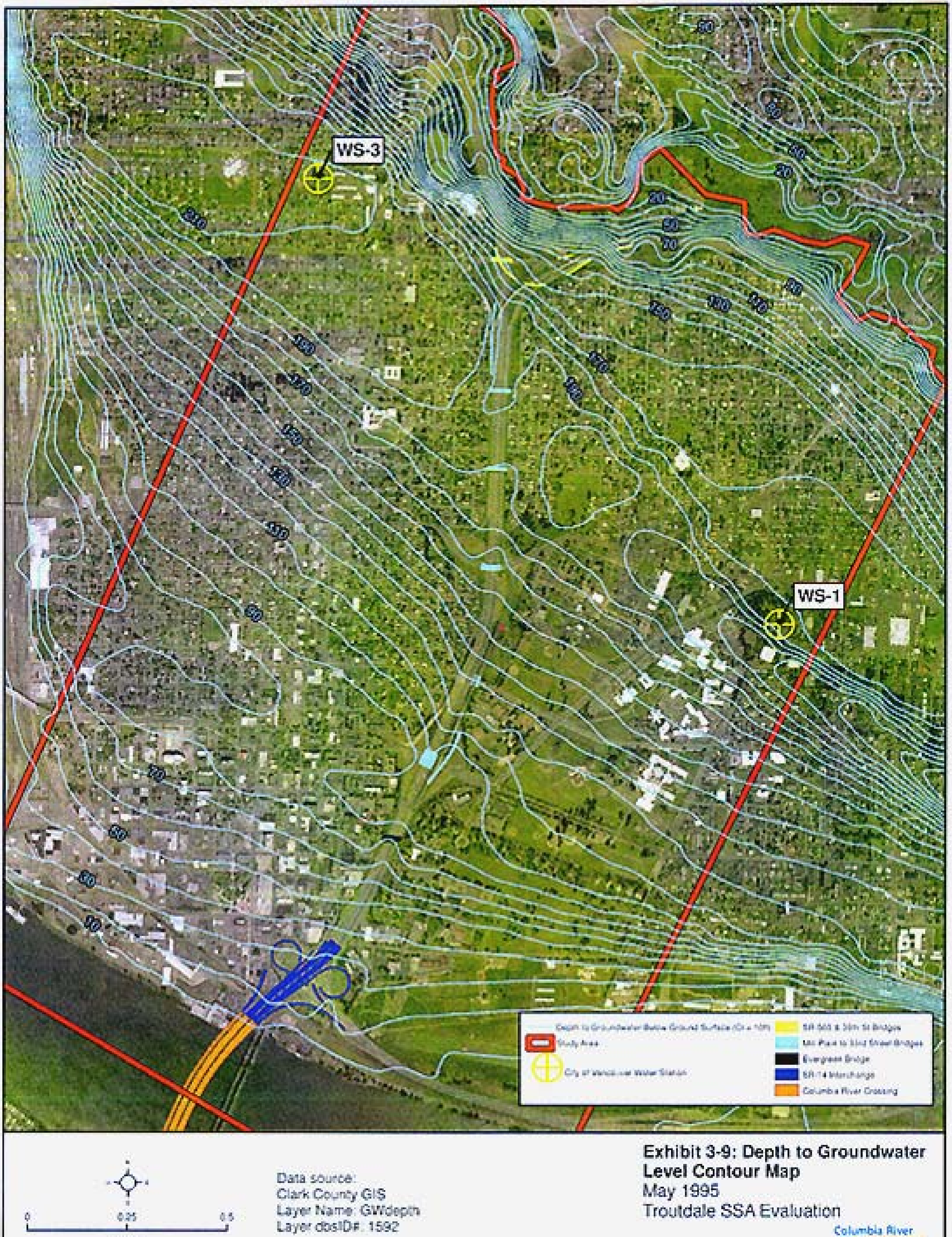
Approximate Scale

Columbia River CROSSING

Source:

McFarland, W.D. and Morgan, D.S. 1996
Description of Ground-Water Flow System in the Portland Basin, Oregon and Washington
U.S. Geological Survey Water Supply Paper 2470-A

Exhibit 3-8
Groundwater Level Contour Map
USA, Spring 1988
Troutdale SSA Evaluation



Data source:
Clark County GIS
Layer Name: GWdepth
Layer dbsID#: 1592

Exhibit 3-9: Depth to Groundwater Level Contour Map

May 1995

Troutdale SSA Evaluation

Columbia River CROSSING

Under natural conditions groundwater flow direction of the USA and TGA in the Vancouver area is to the south southwest. However, this flow condition does not consider influences from pumping on groundwater flow within the study area.

Influence from Pumping

Groundwater flow in Vancouver area is dominated by the operation of large production wells primarily at City of Vancouver Water Stations WS-1 and WS-3, the Port of Vancouver (POV) GPTI well, and Great Western Malting Company supply wells No. 4 and No. 5 (Exhibit 3-10).

Extraction rates for city water supply wells vary seasonally based on user demands. Water demands on the system are highest during the summer and lowest during winter months (HDR 2006). The average daily production in 2005 for WS-1 was 5.9 million gallons per day (mgd), and for WS-3 was 3.4 mgd (HDR 2006).

Great Western Malting, Inc. process water supply wells No. 4 and No. 5 influence groundwater flow in the western portion of downtown Vancouver. The wells are also being utilized by the Port of Vancouver to help contain and capture a chlorinated solvent plume stemming from the former Swan Manufacturing Company and Cadet Manufacturing sites. As such, Great Western Malting has been extracting water at a higher capacity than necessary for plant operations as requested by the Washington State Department of Ecology (Ecology) and the Port. Production wells—No. 4 and No. 5—pump at an average combined rate of 3,200 gpm (4.6 mgd). However, the production rates of these wells will be reduced to a total rate of approximately 900 gpm (1.3 mgd) when the Port implements its interim action (GPTIA). The GPTIA began operation in June 2009. The GPTIA well has been designed and constructed to produce an average of 3.6 mgd from the USA.

Design and placement of the GPTIA well is based on a groundwater flow model developed through a combined effort completed on behalf of the Port and Clark Public Utilities (CPU) (Parametrix, S.S. Papadopulos et al. 2008). The model was also developed to help evaluate the performance of the GPTIA well and evaluate the influence on groundwater flow from CPU's proposed south lake well field. The active area of the model is bounded by the Columbia River on its southern and western sides, and Burnt Bridge Creek to the north; it covers approximately 42 square miles including most of the Vancouver Lake Lowlands and portions of the City of Vancouver that lie west and south of Interstate 205.

Exhibit 3-10 displays model output for groundwater flow lines in the USA (Parametrix 2008). The figure indicates that a majority of the groundwater flow in the downtown Vancouver area is captured by WS-1, WS-3 and the GPTI well. Simulated groundwater flow lines have been used to help define the eastern and western boundaries of the study area (Section 1). Boundaries are necessary to place constraints on the active area in which the evaluation will be conducted. Specifically, the boundaries are drawn along internal flow lines that represent hydraulic capture of groundwater movement within the study area. Or stated another way, a particle of water within the study area will likely be retained within the study area and ultimately travel to a well head. Model simulations indicate that groundwater within the study area will be captured at a well head within a timeframe of 1 to 5 years (Mike Riley, S.S. Papadopulos, personal communication).

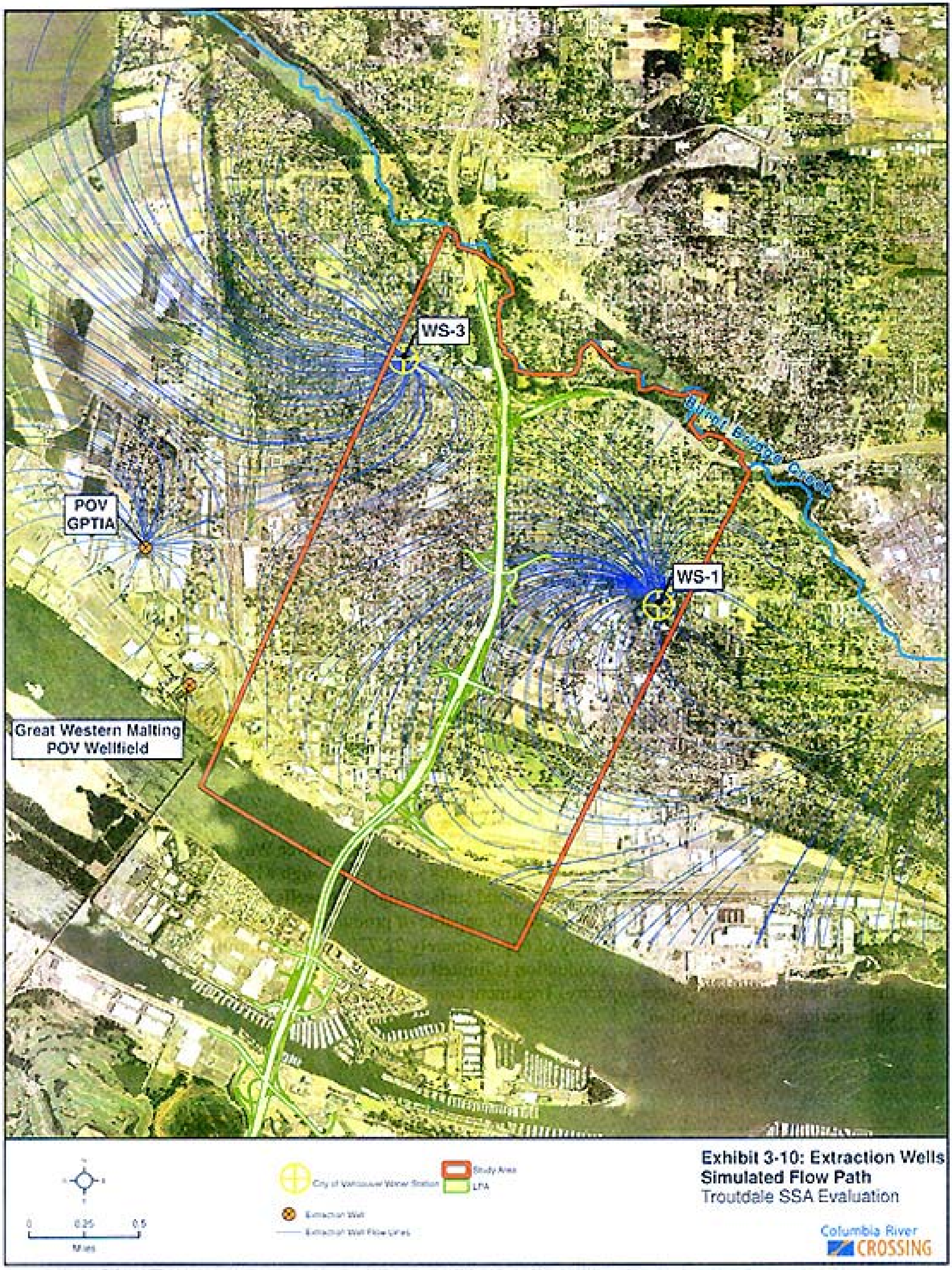


Exhibit 3-10: Extraction Wells Simulated Flow Path
Troutdale SSA Evaluation

Columbia River CROSSING

Tidal Influence

Water levels in the USA and TGA are influenced by changes in the Columbia River stage. The level of influence tends to be greatest near the river, and dissipates inland. In turn the river stage is influenced by tidal fluctuations and upstream dam releases (Parametrix, Papadopulos et al. 2008). The rapid response between changes in river stage and corresponding changes in groundwater levels indicates a high interconnectivity between the river, the USA, and the upper portion of the TGA. Groundwater table fluctuations due to river stage changes are less significant with increasing distance from the Columbia River.

3.7.3 Beneficial Groundwater Use

Groundwater within the TSSA has a variety of beneficial uses. These uses include drinking water for consumption, irrigation water for agriculture, and process and cooling water for industrial use. The TSSA is a suitable source for these beneficial uses due to its high water quality, accessibility, and overall capacity. Well head locations for approximately 36 wells[8] located within ½ mile of the LPA are displayed in Exhibit 3-11. Utilization of the TSSA in the study area includes industrial wells for heat exchange, irrigation wells, industrial-process water wells, and drinks water supply wells.

City of Vancouver Municipal Well Fields

The City of Vancouver (City) pumps an average of 26 mgd from the TSSA, with peak demands up to approximately 53 mgd in 2003 (HDR 2006). The City extracts groundwater from 16 water stations, each with several production wells. Based on the anticipated population growth for the City, demand on the water system is estimated to increase between 61 and 71 mgd by 2012, and between 74 and 90 mgd by 2026 (HDR 2006). These increases in demand will add additional stress to the aquifer. New well heads will likely be added to WS-1.

WS-1

Water Station 1 is located southeast of the intersection of Fort Vancouver Way and E. Fourth Plain and is composed of 12 wells (#1 through #5, and #7 through #13). The wells range in depth from 235 to 280 feet below ground surface (bgs). All wells at this water station extract water from the USA. Each well is capable of producing between 900 and 2,800 gpm, for a total pumping capacity of approximately 22,770 gpm (33.3 million gallons per day [mgd]). However, production is limited to approximately 27 mgd due to the wellhead treatment system capacity. Treatment consists of aeration/air stripping, chlorination, and fluoridation.

[8] These data were mapped by the USGS in the 1980s. These data have not been field checked. These points are out of date and incomplete but are the "best available" source of well information.

Exhibit 3-11: Groundwater Beneficial Use Locations
Troutdale SSA Evaluation

In 1989, the City and EPA began a sampling program to identify the source of PCE near WS-1. A soil-gas survey collected 19 soil-gas samples in the vicinity of WS-1. Five private wells were selected for the collection of groundwater samples within a 1-mile radius of WS-1. The source of PCE in groundwater was not determined. Although the source of PCE was not identified, EPA determined that the remedial action for the dissolved phase plume would be pump and treat. To remove PCE from the water supply, five air stripping towers were installed in 1993. In June 1994, EPA officially placed WS-1 on the NPL.

WS-3

Water Station 3 is located northwest of NW 42nd Street and NW Washington Street and is composed of three wells (#1 through #3). The wells range in depth from 259 to 275 feet bgs. All wells at this water station extract water from the USA. Each well has a pumping capacity of approximately 2,000 gpm, or a total pumping capacity of 5,800 gpm (8.9 mgd). This water station capacity is limited to 8.6 mgd due to water rights. All wells at this water station extract water from the USA. Water at the well head is treated by chlorination and fluoridation.

Boise Cascade

The Boise Cascade site contained several production wells for process water. According to the Ecology well logs for the site, the wells have been decommissioned in place by filling with cement grout.

Port of Vancouver

The Port of Vancouver has installed a large-diameter extraction well (GPTIA well) in the vicinity of the suspected source area of chlorinated solvent plume. The well is part of an interim remedial action effort to hydraulically contain source area contaminants. The GPTIA well has a pumping capacity of approximately 2,500 gpm. All water is treated using a combined carbon / aeration system prior to the water discharged to the Columbia River.

Great Western Malting

Great Western Malting (a.k.a. ConAgra Malt) currently operates two extraction wells, No. 4 and No. 5. Groundwater from the wells is treated using an air stripper tower. Treated water is used germination of malt and as process water for cooling. The wells are capable of producing 4,000 gpm, but are currently extracting water at a combined rate of 3,200 gpm.

3.7.4 Critical Aquifer Recharge Area Designation

The City of Vancouver relies entirely on the groundwater extracted from the TSSA for its drinking water supply. Prior to the EPA's designation of the Troutdale Aquifer System as an TSSA, the City of Vancouver recognized its dependence on the aquifer and the importance of protecting the resource. The City of Vancouver has designated the entire area within the city boundaries as a Critical Aquifer Recharge Area as specified the Water Resources Protection Ordinance VMC Title 14 Section 26, dated 2002. The ordinance requires minimum standards to protect critical aquifer, establishes compliance standards for business and industry to manage hazardous materials, and creates special protection areas around city well heads. Special protection areas are defined as areas that are 1,900 radial feet from any municipal water supply well. As such the city applies development restrictions to activities inside the special protection areas pursuant VM 14.26.135. These restrictions mainly address Class I and II Operations, septic systems, and infiltration systems.

3.7.5 Groundwater Quality

Contaminants from historic commercial and industrial activities within the City of Vancouver have resulted in diminishing groundwater quality. Exhibit 3-12 displays posted contaminant concentrations observed in the TSSA based on communications with Ecology site managers. The exhibit indicates that contaminants such as chlorinated ethenes, petroleum products, and metals are found in groundwater throughout the study area. [9]

As stipulated in the Safe Drinking Water Act (SDWA) and Washington Administrative Code (WAC) Chapter 290, suppliers of drinking water must monitor for and meet primary and secondary drinking water standards. From approximately January 1979 to October 2008, the City of Vancouver has sampled and analyzed groundwater from it WS for the following classes of compounds: inorganics, volatile organic compounds (VOCs), herbicides, pesticides, insecticides, radionuclides, fumigants, dioxins, and nitrate. Analytical results for WS-1 and WS-3 are tabulated at http://www4.doh.wa.gov/SentryInternet/SingleSystemViews/SamplesSingleSys.aspx

Review of water quality data by the Washington State Department of Health indicates that no analytes have been detected at or above their respective maximum contaminant limit (MCL) or secondary maximum contaminant limit (SMCL) in groundwater at WS-1, except for tetrachloroethene (PCE) at 9.2 micrograms per liter [µg/L] (MCL = 5 µg/L) in September 1999. However, no exceedance in drinking water standards has been documented in the last 5 years. The most recent available analytical results indicate that PCE and TCE were detected at 1.1 µg/L and 0.94 µg/L at WS-1 in April 2008.

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[9] No comprehensive study that describes the distribution of contaminants in groundwater for the Vancouver Area is available. Contaminant information was obtained from Ecology Site Managers to help graphically display generalized contaminant impacts.

ACRONYMS
PCE=Tetrachloroethene
TCE=Trichloroethene
DCE=Dichloroethene
CR(IV)=Chromium(IV)

UNITS
µg/L=Micrograms per liter

NOTES: Contaminant concentrations are based on communications with Ecology site managers, July 2009.
Noted constituent represents a site specific risk driver.

Exhibit 3-12: Summary of General Contaminant Concentrations in Groundwater
Troutdale SSA Evaluation

Columbia River CROSSING