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The Holocene Sedimentary Framework of the Lower Columbia River Gorge

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An abstract and thesis of Edward Breed Gates for the Masters of Science degree in Geology were presented April 8, 1994 and accepted by the thesis committee and the department.

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ABSTRACT

An abstract of the thesis of Edward Breed Gates for the Masters of Science in Geology presented April 8, 1994.

Title: The Holocene Sedimentary Framework of the lower Columbia River Basin.

The Columbia River is the largest fluvially dominated estuary in the Pacific Northwest, yet the Holocene transgressive fill of this system has not previously been studied. Nearly 1500 industry borehole and water well records in the lower Columbia River basin (LCRB) were analyzed. These records document the sedimentary infilling of the lower 120 miles of the drowned river valley that occurred during the Holocene marine transgression (10-0 ka). Of particular importance is a key stratigraphic marker horizon of volcanic tephra that has been identified throughout the LCRB. INAA was used to determine the geochemical composition of the target tephra layer. The tephra geochemistry was then compared to geochemical data from potential Cascade source volcanos to determine whether the tephra layers are geochemically related, and the possible age and source of the tephra. The geochemical comparisons indicate that the suspect tephra horizon was

derived from the climax eruption of Mount Mazama approximately 6845 years ago.

Cross-sections have been constructed that record the lateral and longitudinal depositional development of the river basin. Sediment grain size distribution data have also been compiled and shows that grain size distribution does not change with respect to subsurface elevation within the LCRB. The results indicate that the LCRB has been dominated by fine sand deposition throughout the Holocene period, and silt and clay sized fractions were bypassed through the system to be deposited offshore.

A total volume of 74.6 km^3 of sediment has accumulated in the basin since the time of the catastrophic floods 12,700 years ago. Sediment volume analysis was used to predict past fluvial sediment supply rates and sediment retention. The volume of sediment deposition from early to late Holocene time has decreased by a factor of 2.4.

Sedimentation rates in the basin are estimated from a basin isopach of the Holocene fill and from an extrapolated sediment sea-level curve. Basin sedimentation rates ranged from 12.6 mm/yr^{-1} for the early Holocene to 2.5 mm/yr^{-1} for the late Holocene period. This factor of 5 decrease in the sedimentation rate also indicates that the Columbia River bypassed much of its fine grained fraction through to the marine environment during the mid-late Holocene.

THE HOLOCENE SEDIMENTARY FRAMEWORK OF THE LOWER COLUMBIA RIVER BASIN

by

EDWARD BREED GATES

A thesis submitted in partial fulfillment of the
requirements for the degree of

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This thesis is dedicated to Ken Robbins. The idea of studying the Holocene deposits of the lower Columbia River basin was made possible because Ken had carefully maintained records for about 145 occurrences of tephra in the Portland, Oregon and Longview, Washington areas of the LCRB. Ken's detailed data of the Mazama ash layer were kindly donated for the purpose of continuing his research of the LCRB Holocene deposits. I express my utmost gratitude to Ken Robbins for his generous and insightful contributions.

I also greatly appreciate the contributions of industry borehole logs, water well logs, and supplemental information from the following organizations: Dames and Moore inc., Portland, Oregon, Fujitani and Hilts, inc., Portland, Oregon, L.R. Squires inc., Lake Oswego, Oregon, Oregon Department of Transportation Region I and II offices, Department of Oregon Geology and Mineral Industries, Northwest Oil and Gas Report, U.S. Geological Survey Water Resources, Oregon Division, Washington Department of Transportation Region IV office, U.S. Army Corps of Engineers, Portland Division, and the Washington Department of Ecology.

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INTRODUCTION

Holocene transgressive sedimentary sequences along uplifted coastlines, such as the Cascadia margin, are generally poorly preserved due to the active tectonic development of the coastline. Yet, locally drowned river valleys that cut below the level of the coastal plain can preserve these transgressive sedimentary sequences. In the Pacific northwest the Lower Columbia River valley sediments record the local onset of marine transgression and the stratigraphic development of this basin during this transition.

The Columbia River is the largest fluvial system in the Pacific Northwest. While surface sediment deposition and distribution in historic times (1800 to the present) has been studied extensively (Sherwood and others, 1990; Sherwood and Creager, 1990), the subsurface (Holocene) depositional history of the basin has not had any comprehensive analysis. At present, data for the Holocene fill exist in the form of geotechnical borehole data from both public and private industry records, but they have never been compiled into a single report. The late Quaternary incised valley of the Columbia River provides a narrow but very long basin for the infilling Holocene sediments. These Holocene sediments directly address questions about: A) the effects of historic

damming of the upper river and its tributaries on sediment supply to the coastal beaches, i.e. is the basin a sink or source of littoral sediments (Phipps, 1992); B) the geometry and lithologic characteristics of the basin ground water aquifer (Frank, 1970; U.S.G.S., 1988), and C) geotechnical properties of the sedimentary fill for foundation and liquefaction susceptibility studies (Obermeier, in prep.).

Recently, several tephra occurrences have been identified within the Holocene fill of the lower Columbia River basin. Ken Robbins, (Portland, Oregon) has noted the occurrence of a deep tephra horizon, generally 45-70 feet below mean sea level (msl) from drill cores taken in the Portland and Longview, Washington areas of the Lower Columbia River basin. Thirty tephra samples were previously prepared and analyzed for source analysis by various investigators.

Pumice and ash that have erupted from vents in the Cascade Range have been widely used as chronostratigraphic horizon markers in the Pacific Northwest (Sarna-Wojcicki and others, 1991; Mullineux and Wilcox, 1980). Tephrastratigraphy and tephrachronology constitute a valuable correlation tool when used in combination, because the age of a well-dated tephra layer at an individual site can be extended to any other site where the same layer occurs. Once positive identification of the age and source for a particular tephra layer has been determined it then becomes a time horizon for correlation of other stratigraphic intervals over broad areas.

Several methods have been employed to distinguish pyroclastic deposits from different eruptive sources. These include the use of refractive index of glass, bulk composition of both glass and mineral separates, and instrumental neutron activation analysis (INAA) of major and trace elements. Application of INAA allows for rapid characterization of ash by analysis of both rare earth and transition element concentrations. Several investigators (Randal, Goles, and Kittleman, 1971; Dudas, Harward, and Schmitt, 1973) have applied INAA for identification of volcanic ash deposits in the Pacific Northwest.

The objectives of this study are to compile available preexisting borehole data on the thickness and composition of Holocene fill in the LCRB into a single comprehensive report. The report contains: (1) A database for boreholes penetrating the LCRB sedimentary alluvial fill; (2) cross-sections showing the lateral distribution of both the Mazama ash layer and the late Quaternary sedimentary fill at selected localities; (3) isopach maps for the Holocene/late Pleistocene sedimentary fill; (4) documentation and detailed descriptions of the ash bed occurrences, including geochemical data, and the Holocene sedimentary deposits; (5) volumetric analysis of the late Quaternary sedimentary deposits, including calculations for prehistoric sediment deposition rates; and (6) predicted sediment age-level curve for the LCRB with estimates for the rates of sediment accumulation.

The results of this study include an improved understanding of the Holocene sedimentary dynamics of the lower Columbia and lower Willamette River basins. The results allow us to construct the first detailed record of the stratigraphic development of the LCRB sediments.

BACKGROUND AND PREVIOUS WORK

THE COLUMBIA RIVER

The Columbia River drainage basin covers an area of 660,480 km^2 west of the North American continental divide. The eastern drainage basin extends from the Rocky Mountains of Southern British Columbia and the Northern United States to its southern margin along the northern divide of the Basin and Range province of Utah and Nevada and the high lava plateau of Oregon (Figure 1). The Cascade Range divides the drainage basin into eastern and coastal sub-basins with different climatic, hydrologic, and geologic characteristics (Simenstad and others, 1990). The western drainage basin includes the Cascade volcanic arc and forarc Willamette-Puget lowland of Oregon and Washington.

The Columbia River has the third largest flow of all the rivers in the United States. The modern mean annual riverflow is about 6,800 m^3s^{-1}. The modern value shows a slight drop since 1878 (Simenstad and others, 1990) when riverflow measurements were initiated. Flow regulation from irrigation removal and engineered channel modifications have contributed to the decreased flow rate. Subsequent construction of hydroelectric dams has greatly depressed extreme flow (flood) rates (Sherwood and others, 1990). The Vanport flood of 1948 exceeded 28,600 m^3s^{-1} at The Dalles. The floods of 1972 and

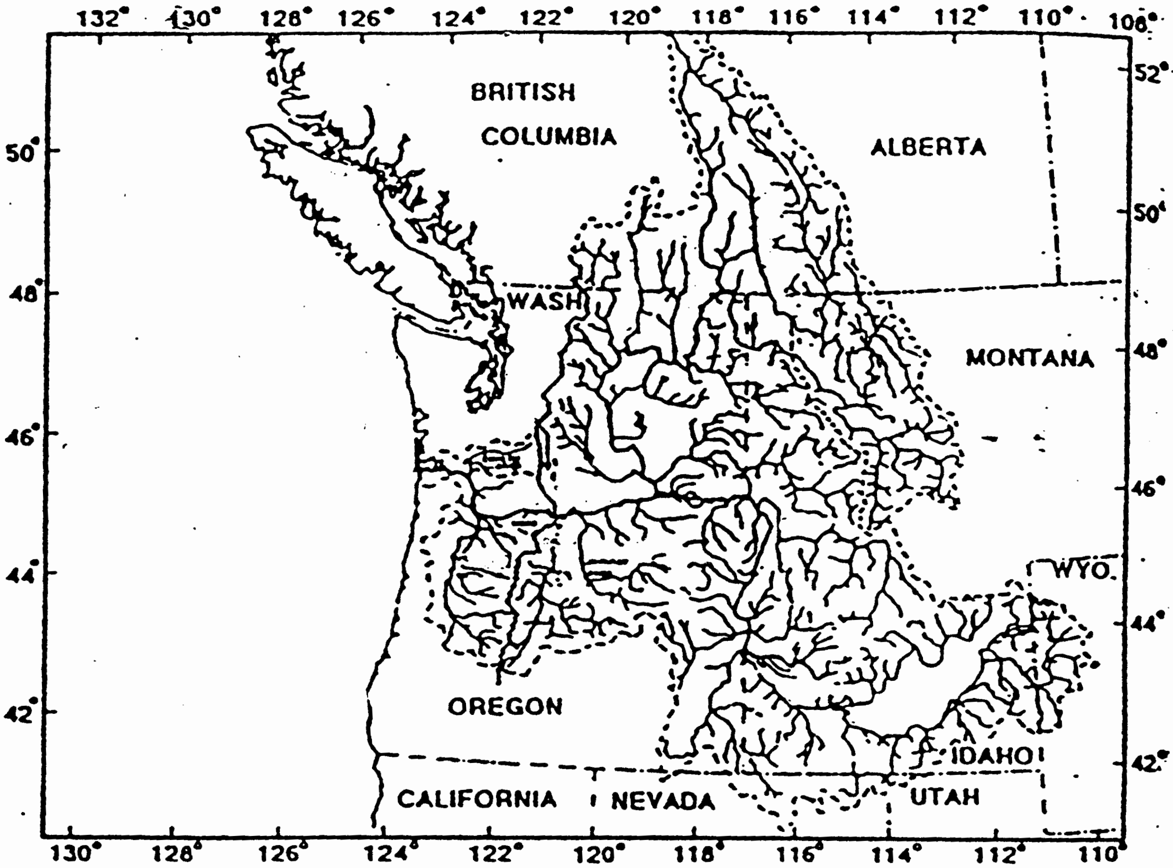

Figure 1. Map of the lower Columbia River drainage basin (Simenstad et al., 1990).

1974 flowed at less then 17,600 m^3s^{-1} at The Dalles. The flow rate for these two floods were reduced by 12,318 m^3s^{-1} and 11,864 m^3s^{-1} respectively. Had there not been flow regulation, these two floods would have been as large as the Vanport flood event (Sherwood and others, 1990).

HOLOCENE TEPHRAS

The following information summarizes the eruptive history for active volcanic vents capable of producing large volumes of tephra in the Columbia River drainage basin area during Holocene time.

Table I (Sarna-Wojcicki and others, 1983) lists the age, ash layer designation, volcanic source area, and area of distribution, for Holocene ash layers of moderate to large volume in the western United States. For the volcanic source areas listed, four of the source vents appear capable of producing large volumes of tephra in the Columbia River drainage basin. The four vents are Glacier Peak, Mount Mazama (Crater Lake), Newberry volcano, and Mount St. Helens. Figure 2 (Sarna-Wojcicki and others, 1983) shows the extent of areal distribution for the tephra units from source vents listed in Table I. Due to the limited extent of tephra distribution for the Newberry volcano, it is not likely that this vent is a possible source for the extensive tephra deposits in the lower Willamette and lower Columbia Rivers. Therefore, the remaining three vents (Glacier Peak, Mount Mazama, and Mount St. Helens)

TABLE I

VOLCANIC ASH LAYERS OF MODERATE TO LARGE VOLUME ERUPTED DURING LATEST PLEISTOCENE AND HOLOCENE TIME

AGE	ASH LAYER SET	VOLCANIC SOURCE AREA
1980 (datum)	D	Mt St Helens, Wa.
-180 (AD 1800)	T	Mt St Helens, Wa.
-500 (AD 1500)	We, Wn	Mt St Helens, Wa.
-1150 - 1350	-	Newberry Volcano, Or.
2580 - 2930 ±250	P	Mt St Helens, Wa.
3350 - 3510 ±240	Ye,Yn	Mt St Helens, Wa.
6700 - 7000	O (Mazama)	Crater Lake, Or.
8300 ±300 - 11,700 ±400	J	Mt St Helens, Wa.
11,200 - 11,300 ±230	B	Glacier Peak, Wa.
≥ 12,000 (?)	M	Glacier Peak, Wa.
12,750 ±350	G	Glacier Peak, Wa.
≥ 11,900 < 13,130 ±350	So,Sg	Mt St Helens, Wa.

Data from Sarna-Wojcicki and others, 1983.

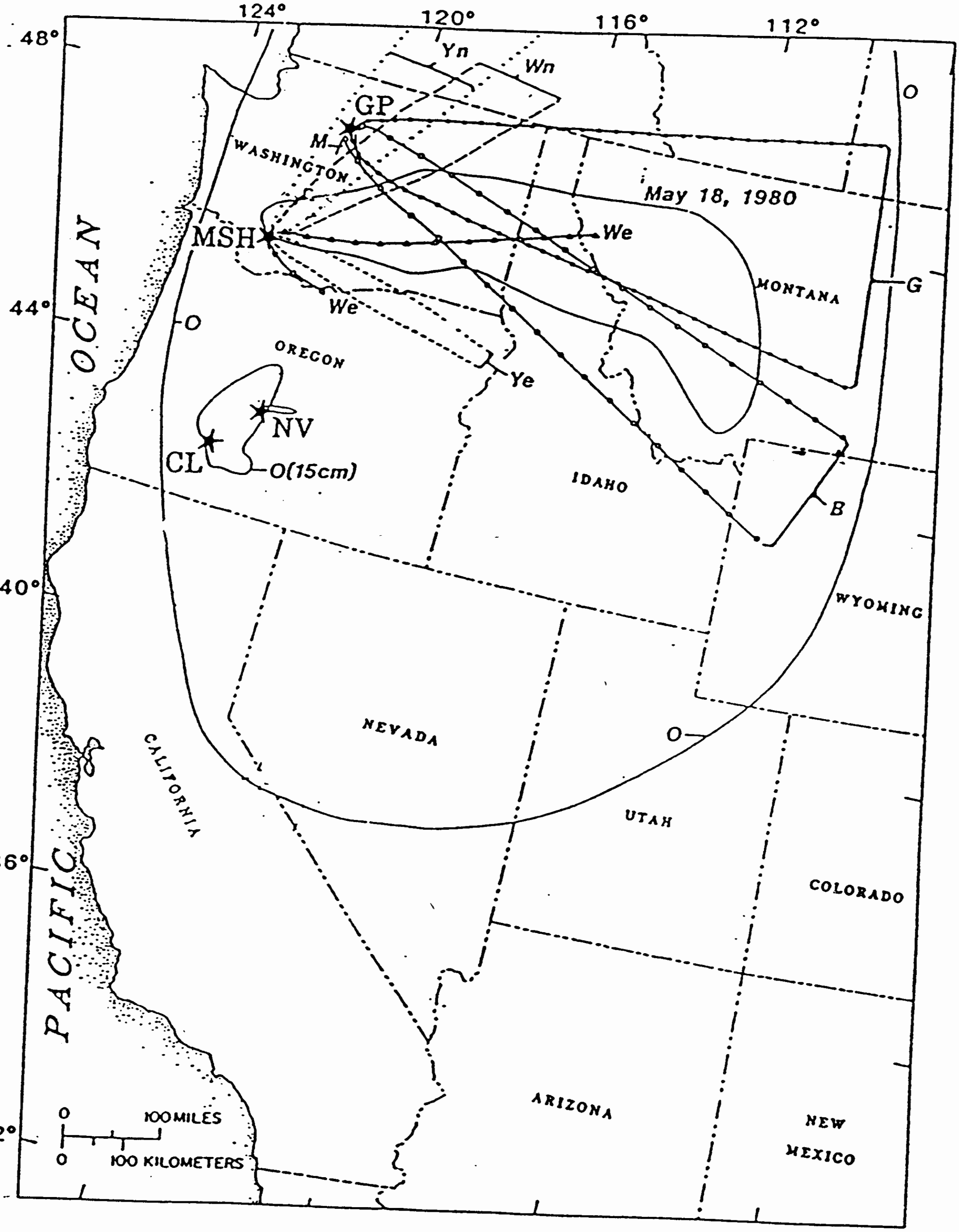

Figure 2. Areal distribution of latest Quaternary tephra units. Distributions shown for tephra units are probably minimal. Distribution shown for Mazama ash (layer O) is a composite of several lobes (Sarna-wojcicki et al.; in Wright, 1983).

are potential sources for the suspect ash layer, because of their widespread distribution and/or frequency of explosive activity.

Mount St. Helens has erupted nine major widespread tephra sets prior to 1980 (Crandell and Mullineaux, 1973, 1978; Mullineaux and others, 1975, 1978). Six of these sets were erupted within the last 12,500 years. From oldest to youngest they are sets; S, J, Y, P, W, and T (Table I).

Glacier Peak volcano in northern Washington was active during a relatively short interval, from about 12,750 to 11,250 yr bp (Fryxell, 1965; Mehringer and others, 1977; Porter, 1978). Three layers (G, M, and B) were spread over large areas east and south of the volcano (Porter, 1978).

The most widespread Holocene tephra layer in the United States is that of Mount Mazama. The tephra was erupted from a composite stratovolcano (named Mount Mazama by Williams, 1942) that stood at the present site of Crater Lake, Oregon.

The Mazama ash [(layer O), Table I, Figure 3; Williams, 1942; Powers and Wilcox, 1964; Randle, Goles, and Kittleman, 1971; Bacon, 1981)] actually consists of several tephra layers presumably erupted within a relatively short period of time. Williams (1942) and Mehringer and others (1977) estimated the period to be short as three years, while Bacon (1983) suggests as long as 100 to 200 years for the sequence of eruptions. The minimum area covered by the Mazama ash (Figure 3) is nearly 1.7 million km^2 (Mullineaux, 1975;). Bacon, (1988) reported an

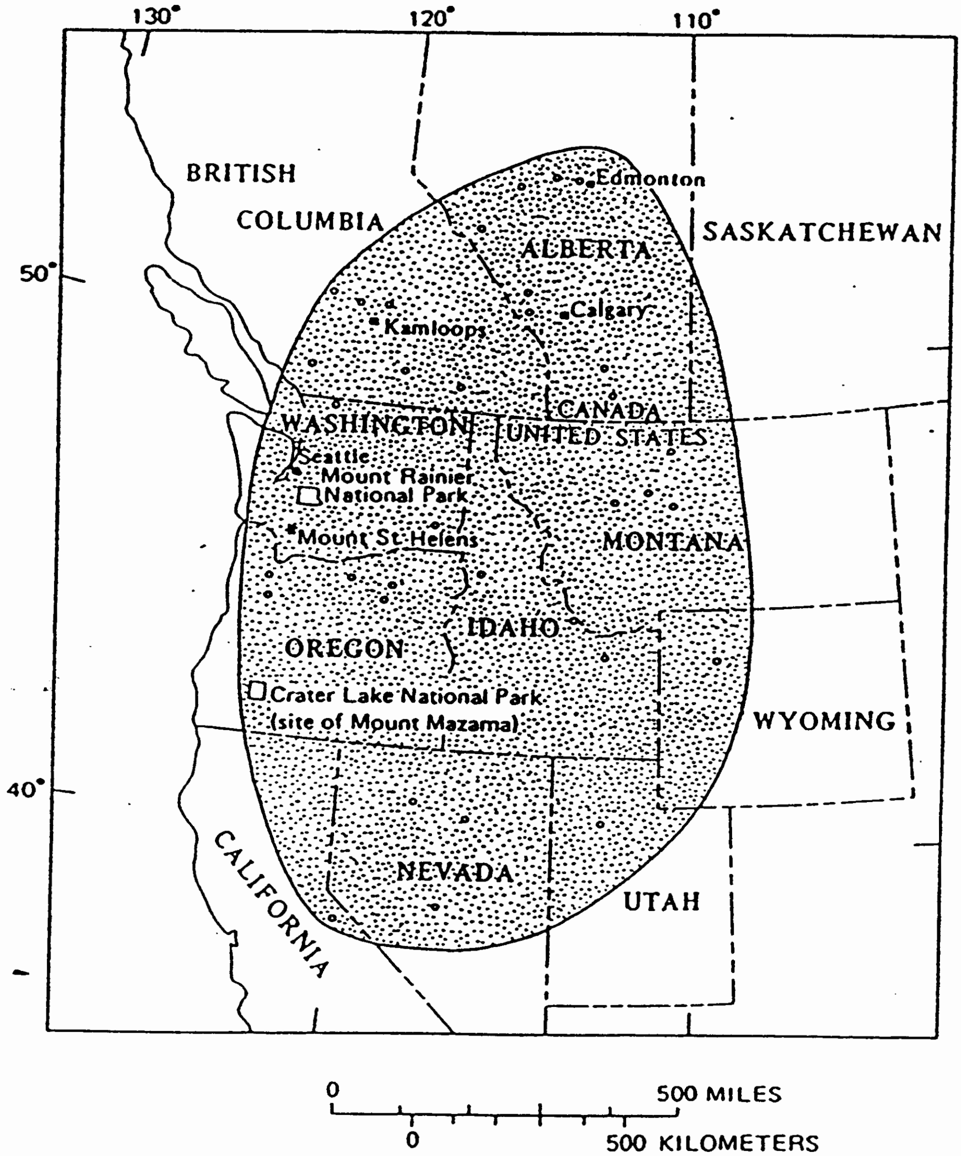

Figure 3. Minimum extent of Mazama ash (patterned) in the western United States and Canada. Circles mark sites where ash layer has been identified (Mullineaux, 1974; in Wright; 1983).

age of 6,845 ± 50 yr bp from a weighted mean age of four analyses of charcoal from within or beneath ash flow and air fall deposits from the climactic eruption. Numerous investigators have reported ages ranging from 6600 to 7015 years bp for the Mazama tephra deposits.

SEDIMENTARY GEOLOGY OF THE LOWER COLUMBIA RIVER

The Columbia River drains geologically varied terrains which include igneous, sedimentary, and metamorphic rocks and extensive alluvial and eolian surficial deposits. The highest sediment yield is from the eolian Palouse soils of the Palouse and Walla Walla River basins (Whetten, Kelly, and Hanson, 1969). Compared to other major rivers, the Columbia transports relatively little sediment (Sherwood and Creager, 1990). Estimates of the total suspended load for the river vary from 7 to 30 X 10^6 metric tons (mt)y^{-1} (Van Winkle, 1941 a,b; Judson and Ritter, 1964; Haushild et al., 1966; Jay and Good, 1978).

Simenstad and others (1990) reported that the river supplies about 9.7 million metric tons of sediment per year to the estuary, in the form of fine sand and coarse silt carried in suspension (Table II). Eight to 10 percent of the river sediment is very fine sand to medium sand, which is transported as bedload (Simenstad and others, 1990).

Calculations for present conditions by Sherwood, Jay, Harvey, Hamilton, and Simenstad (1990) indicate that the average sediment discharge under modern conditions is about

TABLE II

HINDCAST SEDIMENT DISCHARGE RATES AT VANCOUVER, WASHINGTON, BY HISTORIC PERIOD

Period	Sand (>0.062mm)		Silt & Clay (<0.062mm)		Total	
	10^6 metric tons y^{-1}	$10^6 m^3 y^{-1}$	10^6 metric tons y^{-1}	$10^6 m^3 y^{-1}$	10^6 metric tons y^{-1}	$10^6 m^3 y^{-1}$
1868-1934	7.4	(7.0)	7.5	(7.1)	14.9	(14.0)
1935-1957	4.8	(4.5)	5.7	(5.5)	10.4	(10.0)
1958-1981	2.5	(2.5)	5.1	(4.8)	7.6	(7.2)
Entire Period	5.9	(5.5)	6.7	(6.3)	12.5	(11.8)

Volume estimates assume uniform density of 2,650 kg m^{-3} and 40% porosity.
Data from Sherwood and others, 1990.

7.6 X 10^6 mt y^{-1}, lower than historic values of 10-15 X 10^6 mt y^{-1} prior to dam construction (Table III).

Haushild and others (1966) indicate that the sand fraction in transport at Vancouver, Washington, at river flows corresponding to the mean annual riverflow is 10-15% of the total sediment load. However, because most sediment transport occurs at higher river flows, the effective transport of sand is higher than implied by the 10-15% of total under mean flow conditions (Sherwood and Creager, 1990). U.S. Geological Survey (U.S.G.S.) calculations provided by Hubbel (in Sherwood and Creager, 1990) suggest that, on average, about 45% of the total sediment load is sand sized material (Sherwood and others, 1990). As noted above much of the finer sand travels in suspension during periods of high river flow.

Whetten (1966) performed extensive analysis of the sediment from the Columbia River. His findings indicate that sediments trapped behind upriver reservoirs reflect the plutonic, igneous,and metamorphic source rocks of the upper Columbia River basin and the eolian deposits found in the Palouse region of eastern Washington and the lower Snake River basin. The petrology of the modern lower Columbia River sands is predominantly volcanic rock fragments (basalt to dacite) and plagioclase feldspar (Sherwood and others, 1984) supplied in large part from the volcanic arc. Metamorphic and plutonic rock fragments are also common. Minor components of quartz, potassium feldspar, and micas reflect the plutonic and

TABLE III

SEDIMENT DISCHARGE ESTIMATES FROM THE COLUMBIA RIVER

Estimate 10^6 metric tons y^{-1}	Water Year	Reference
6.7,13.7*	1910,1911-1912	Van Winkle, 1914a,b
10.1*[a]	1950-1952	Judson and Ritter, 1964
7.7*[b]	1969	USGS, unpublished data[f]
11.2[c]	1964-1970	USGS, unpublished data[f]
12.4[d]	1964-1970	Sherwood et al., 1990
12.5[e]	1878-1981	Sherwood et al., 1990

[a] Snake and Columbia Rivers at Pasco, based on 2 years of incomplete data.
[b] Based on measurements at Beaver Army Terminal/Port Westward (RM-53).
[c] Includes estimate of "unmeasured" suspended load and bedload, omits contribution of Willamette, Lewis, Cowlitz, and other tributaries below Vancouver Wa.
[d] Same as (c), corrected for Willamette River contribution using average total load of 1.2 million tons y^{-1} (based on USGS, unpublished data, WY 1963-1964).
[e] Based on hindcast 1878-1981.
[f] D. Hubbel, (Personal Communication, in Sherwood and others, 1990).
* Suspended load only.

Data from Sherwood and others, 1990.

metamorphic source terrains to the east (Sheidegger and others, 1971). The dominant minerals in upper river sediments are quartz and feldspars. The dominant heavy mineral there is hornblende. The sediments in the lower reaches of the Columbia River reflect the contribution of andesitic volcanic materials from the tributaries draining the slopes of the Cascades. Downriver, the sediments contain increasing amounts of plagioclase feldspar and volcanic rock fragments and decreasing percentages of quartz and potassium feldspar. Pyroxenes become the dominant heavy minerals in the lower Columbia reaches (Whetten, Kelly, and Hanson, 1969). It is not known whether the relative contributions of the two different sources, i.e. the distal metamorphic belt or the proximal volcanic arc, changed in the LCRB during Holocene time.

Sherwood and Creager (1990) cite previous works by others (U.S. Army Corps of Engineers, 1933, 1960; Lockett and Kidby, 1961; Jay, 1984; Jay and Smith, 1990) that shows evidence that some of the sediments in the estuary may have been recently transported into the estuary from the adjacent nearshore and shelf regions. Studies of currents in the estuary have documented episodic landward flow predominance in the deeper portions of the entrance channels. Various physical and numeric models indicate net landward bottom flow and sediment transport through the entrance under low and moderate riverflow conditions (O'Brien, 1952, 1971; Herrmann, 1968; Hamilton, 1983, 1984, 1990; McAnally, Brogdon, and Stewart,

1983). These interpretations imply that the Columbia River may be a sink rather then a source of littoral sands in recent times.

The most comprehensive investigation of modern sedimentation in the lower Columbia River has been performed by Sherwood and Creager (1990) under the Columbia River Data Development Program (CREDDP). A brief summary of their results is as follows (Sherwood and Creager,1990):

1. "The energy levels available for transporting sediment in the Columbia River Estuary are high relative to many of the estuaries of the world. These high energies are produced by large tidal range, large riverflow, and strong ocean wave activity near the mouth. The various circulations produced by the interactions of these three energy inputs together with the esturine density circulation frequently results in currents that are more than sufficient to move most of the sediment sizes (fine sand, silt and clay) found in the estuary".

2. "The ultimate source of the sediment for the estuary is the Columbia River which contributes a somewhat restricted range of sizes generally finer than 1.00 phi (0.5mm). Local tributary and marine (littoral) sources contribute only minor amounts of sediment to the estuary. Evidence suggests that some marine sediments consisting of older or relatively recent Columbia River sediment and minor amounts of sediment from

headland erosion along the Oregon coast are being transported into the estuary" (Sherwood and Creager, 1990).

3. "The patterns of sediment distribution within the estuary are complex and reflect the variety of processes acting over various time scales. Most of the estuary reflects an even more restricted range of sediment size than is supplied by the river (Figure 4). The mean size of the estuary sediment is 2.50 phi (0.117mm) or fine sand. Sediment of this size is highly mobile" in strong currents, found in the primary channels of the estuary.

4. "Fine sediment that is normally transported in suspension comprises only a small percentage of the sediment deposited in the estuary. Fine grained sediments (silt and clay) are found in the peripheral bays, swamps, marshes, and minor, inactive channels, especially Cathlamet, Baker, and Youngs Bays. Ephemeral deposits of fine sediment also occur in the channels of the central estuary".

5. "Inspection of the distribution of rip-up clasts, fine sediment deposition, and the excursion of the turbidity maximum suggests that suspended sediments concentrated in the turbidity maximum may be mixed into upper layers of the water column and advected either out of the estuary or into peripheral bays. In the latter instance, currents would be insufficient to resuspend the sediment if it settles to the bottom. Deposition of fine sediments in the main channels occurs intermittently beneath the turbidity maximum, but does

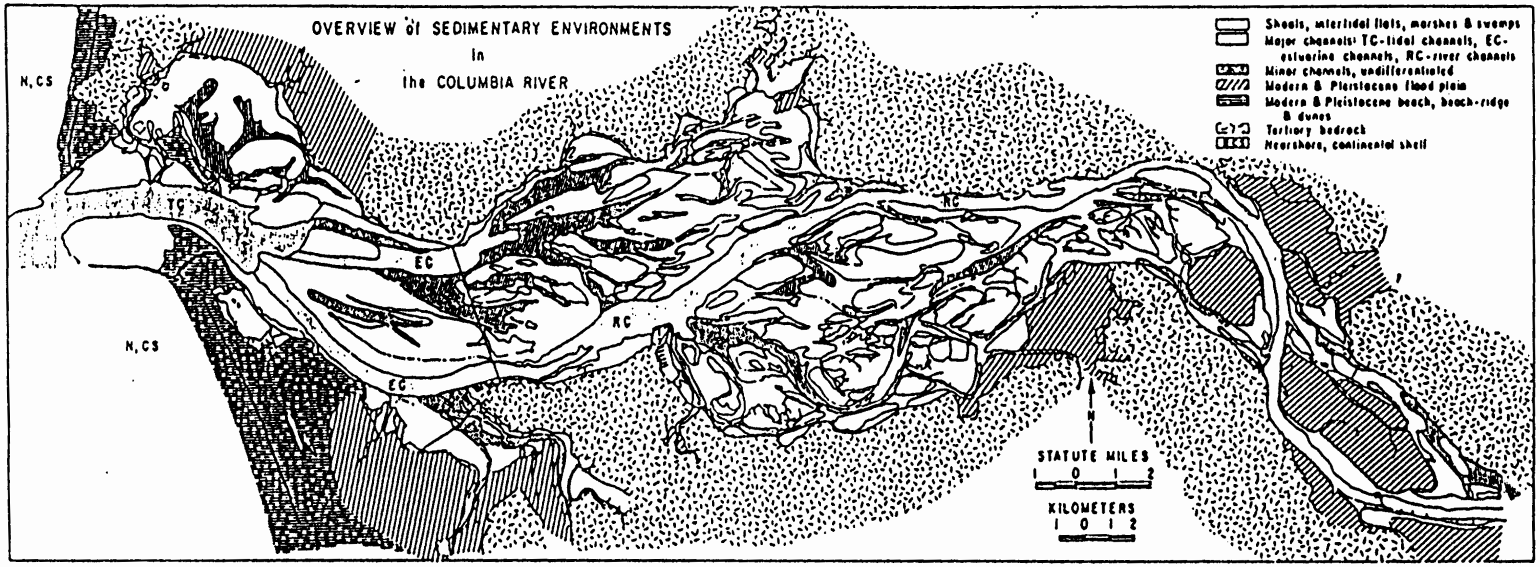

Figure 4. Sedimentary environments of the Columbia River estuary (Sherwood and Creager, 1990).

not result in a long-term accumulation of fine material in the estuary, due to subsequent scouring by strong currents".

STRUCTURAL DEVELOPMENT OF THE STUDY REGION

The Pacific Coast of the northwestern United States is located on an active continental margin. The study region lies at the margin between the North American continental plate and the subducting Juan de Fuca oceanic plate (Figure 5). The results of this collision have been active tectonic and volcanic activity in the Pacific Northwest region for at least the last 55 million years (Lowry and Baldwin, 1952). The regional tectonic characteristics exert both direct and indirect effects on the physical processes within the lower Columbia River basin, and controls the overall sedimentary framework on a geological time scale.

The present location of the lower Columbia River is largely the result of late Paleogene-early Neogene tectonics in what is now northwest Oregon and southwest Washington. Approximately 25° of clockwise rotation (post Oligocene) occurred in the northern Oregon Coast Range, possibly in small blocks, as a result of collision with the North American plate (Simpson and Cox, 1977; Magill and Cox, 1981; Wells, 1988). Much of the rotational E-W shearing took place in the vicinity of the present lower Columbia River, roughly paralleling the pre-Neogene structure. Coastal compression in the Northwest during the last 5 million years has resulted in structural

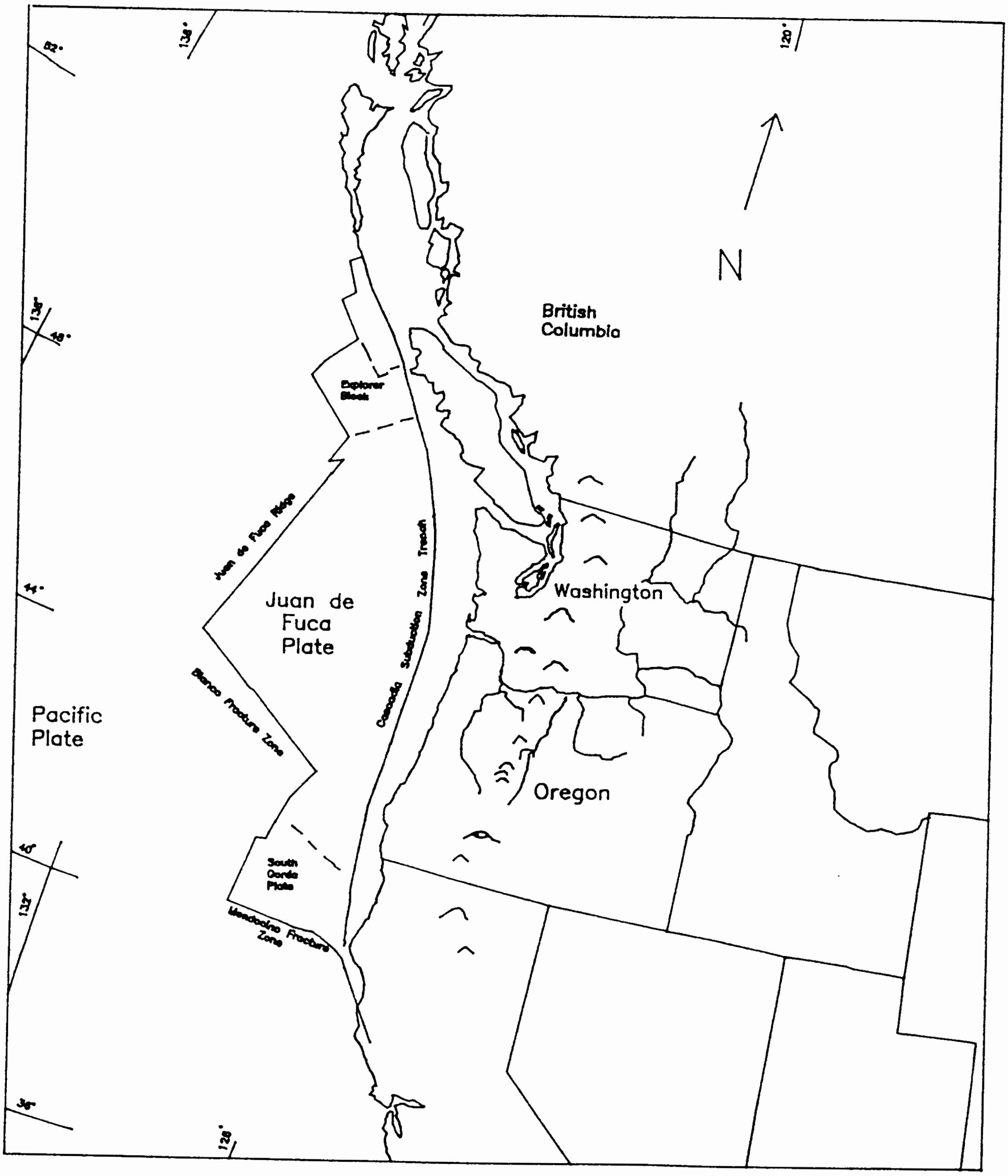

Figure 5. Tectonic setting of the Oregon and Washington Coast showing the Cascadia Subduction Zone trench, the Juan de Fuca Plate, and smaller plate segments at each end. The Cascade volcanic arc parallels the trench about 250–300 km inland.

deformation (folds) and extensive faulting of the bedrock geology. The resulting dextral wrench fault zone has produced two sets of fault trends. Most of the lower Columbia River and its major tributaries are controlled by these major faults. Generally, the northwest trending faults strike N36W and the conjugate (antithetic Reidel Shears) northeast faults occur at nearly 90° offset to the northwest faults (Beeson and others, 1991; Yelin and Patton, 1991). During the period of rotation, ongoing subduction and island arc volcanism continued to shape the continental margin in the vicinity of the Lower Columbia River. The Cascade volcanic arc trends parallel to the Cascadia subduction zone. The arc occurs about 250 to 300 km inland from the trench axis.

BEDROCK STRATIGRAPHIC DEVELOPMENT

Bedrock formations in the LCRB consist of deep to shallow water and subaerial sedimentary rocks intercalated with flood basalt and volcanic rock sequences going back 50-60 million years before present. The Cascade Range volcanos began developing approximately 35 ma, and have been a major source terrain for sands transported through the lower Columbia River.

The bedrock stratigraphy directly under the Columbia River entrance area has not been reported. By projection of bedrock units mapped in the Astoria 15′ Quadrangle by Schlicker and others (1972), it appears that the study area is

underlain by an undifferentiated sequence of sedimentary rocks of Oligocene to middle Miocene age. These beds are estimated to be approximately 5000 feet thick and consist of thin bedded to massive tuffaceous siltstone and claystone with lesser amounts of sandstone and shale locally. Tertiary basalts also may occur at depth (Neim and Neim, 1985).

Several wells have been drilled in the Clatsop Plains area south of the south jetty within a few miles of the study area (Frank, 1970). Near the surface, these wells encountered a variety of unconsolidated dune, beach, and shallow marine sands interbedded with alluvium, all of probable late Pleistocene to Holocene age. These young unconsolidated deposits extend to depths between 250 and 300 feet below sea level and rest unconformably on a semi consolidated sandy unit that extends to depths of approximately 400 feet below sea level. This second unit was tentatively identified as the Astoria Formation by Frank (1970), but subsequently called upper Miocene sandstone by Schlicker and others (1972). This unit is typically a buff-colored, medium to coarse grained, semi consolidated sandstone of marine origin. The upper part of the Oligocene-Miocene beds are reported to include the Astoria Formation (Frank, 1970).

Late Pleistocene deposits that are common in smaller esturine river valleys in the Pacific Northwest, such as the Coquille Formation (Snavely, 1948; Baldwin, 1981), are not

well preserved subaerialy in the lower reaches of the Columbia River estuary.

By early Miocene the present Coast Range location was uplifted, restricting marine sedimentation to isolated embayments (Niem and others, 1987). In early Pliocene time, the uplift yielded a complete transition to terrestrial deposition in the lower Columbia region. Repeated filling/downcutting of the ancestral Columbia River flood basalts (Beeson and Moran, 1979) demonstrates the maintenance of the antecedent river valley through mid-Miocene time. From the mid-Miocene to Pliocene, fluvial sediments (Sandy River Mudstone and lower Troutdale Formation) were deposited by the Columbia River in the transtensional Portland basin (Trimble, 1963; Beeson and others, 1985; Swanson, 1986) and possibly further downriver. The Sandy River mudstone and Troutdale Formations represent a large thickness of lacustrine and fluvial sediments derived from east of the study area. Differential uplift of the Coast Range after 2 ma, terminated Troutdale deposition (Tolan and Beeson, 1984) and has continued to the present.

The most recent stratigraphic information for bedrock lithologies of the Columbia River basin in the vicinity of the Coast Range is derived from the Champlin well (Appendix B, Map ID# 1292), located just south of Clatskanie Oregon, on the flood plain of the Columbia river at about river mile 50. From the surface the well penetrated 300 feet (91 meters) of

unconsolidated Holocene sands and silts, followed by 315 feet (96 meters) of coarse grained sediments interpreted by the author to be equivalent to the Bretz flood deposits and the underlying Quaternary Troutdale and Sandy River Mudstone Formations. At 615 feet below mean sea level (msl) the upper contact with underlying Gobel (?) volcanics was encountered. Below the Gobel basalts Tertiary sedimentary rocks were reported below depths of -1100 feet subsurface, along with interbedded volcanic strata. Volcanic material is the dominant lithology to the end of the drill hole at -5700 msl elevation.

In the upper portions of the study area near Portland Oregon, the oldest rocks exposed in the Columbia River basin are the Skamania Volcanics. These rocks display limited exposure at Ione Reef and along the south shore of Lady Island near Camas Washington. The Columbia River Basalt Group (CRBG) overlie the Skamania Volcanics and are exposed in numerous small bedrock knobs and along the steep valley walls throughout the study area. The Miocene CRBG flows were erupted from 17 to 6 ma from fissures in northeast Oregon, eastern Washington, and western Idaho (Beeson and others, 1989). The basalts flowed west through the ancestral Columbia River valley filling topographic lows such as the transtensional Portland basin. The Columbia River basalts have recorded nearly continuous tectonic activity through the Tertiary (Beeson and others, 1989). The basalt flows crop out primarily at the margins of the Portland basin. Overlying the CRBG is a

thick section, up to 1,200 feet (366 meters), of Pliocene to Pleistocene fluvial sediments. The Sandy River Mudstone is the lower member of this section. It is composed of mudstone, claystone, siltstone, and very fine sands. The Sandy River Mudstone has been interpreted by Trimble (1963) to represent lacustrine or overbank deposits. Above the Sandy River Mudstone is the Troutdale Formation. The Troutdale Formation consists of two distinct members (Tolan and Beeson, 1984). The lower member consists of pebble and cobble conglomerates of predominantly Columbia River Basalt along with clasts of quartzite and micaceous sandstones interpreted to be derived from the ancestral Columbia River and is confined to an area near the present Columbia River channel (Tolan and Beeson, 1984). The upper member is composed of locally derived pebble and cobble vitric sandstones with basalt conglomerate interbeds (Tolan and Beeson, 1984). Interbedded with the Troutdale Formation are the Boring lavas. These Pliocene to Pleistocene lavas are high alumina basalt that originated from 90 vents throughout the Portland and Vancouver area (Allen, 1975).

During latest Pleistocene time catastrophic flood debris was deposited in the Portland basin (Bretz, 1928, Bretz, 1969). The floods were the result of glacial melt water outbursts from glacial Lake Missoula in western Montana (Waitt, 1985). Waitt (1985) determined that a minimum of 40, and most likely greater than 60, flood events inundated the

Columbia River Valley. These successive flood events probably resulted in extensive scouring of the Columbia River valley. Both coarse and fine grained sediments were deposited upon much of the backflooded Portland basin and Willamette valley floors. The narrows at Kalama, Washington restricted the outflow from the Portland basin, but downstream of Kalama the floods diminished, possibly decreasing to 0 m elevation (relative to modern sea level) at Astoria (Allen, 1986). Allen (1986) indicated that the over-steepened northeast face of Nicolai Mountain, east of Clatskanie Oregon, represents the furthest downriver geomorphic expression from the Bretz floods. The actual depths of the flood-scoured, pre-Holocene contact between Kalama and Astoria are unknown, but they are unlikely to be deeper then the minimum sea level of -390 ft (-120 m) below modern sea level, that prevailed during the end of the last glacial stage (Bloom, 1983). Waitt (1985) estimated that the age of the last catastrophic flood event occurred about 12,700 years ago. This date is based on the 11,250 ± 250 years Glacier Peak ash layer G which overlies deposits of one huge flood but not those of the smaller, late stage floods that followed deglaciation of the Columbia River valley. The nature of the sediments back filling the presumed flood scour basins in the pre-Holocene Columbia River channel have not previously been documented.

SEA LEVEL CHANGES

Along most of the worlds coastlines sea level has been rising throughout the Holocene. The geologic community defines the beginning of the Holocene period at 10,000 years bp From a glacially lower level of about 120 ± 60 meters below present sea level (Bloom, 1983), the sea surface rapidly rose in reciprocal proportion to the volume of the shrinking late Wisconsin glacial ice sheets and mountain glaciers. By 10,000 years bp, the area of former ice cover was reduced to about 50% of its maximum extent during the late Wisconsin glaciation (Bloom, 1983). The Holocene has been a period characterized by global marine transgression, although the rates and amounts have varied from place to place. Geological evidence suggests that global sea level rose at a relatively rapid rate of at least 10 mmy^{-1}, and subsequently slowed to the present rate of 1-2 mm y^{-1} about 5,000 years ago (Bloom, 1983).

Along the Pacific Coast one of the well studied estuaries is San Francisco Bay, California. Its entrance near the Golden Gate is 60 to 70 m below present sea level and was probably entered by the sea about 11,000 to 10,000 years ago (Atwater and others, 1977). By 8000 years bp, most of the present Bay area was flooded. Prior to 8,000 years bp, the submergence rate was about 2 cm per year (Figure 6). Since 6000 years bp, the rate has been only one tenth as fast, about 1 to 2 mm per year (Atwater and others, 1977).

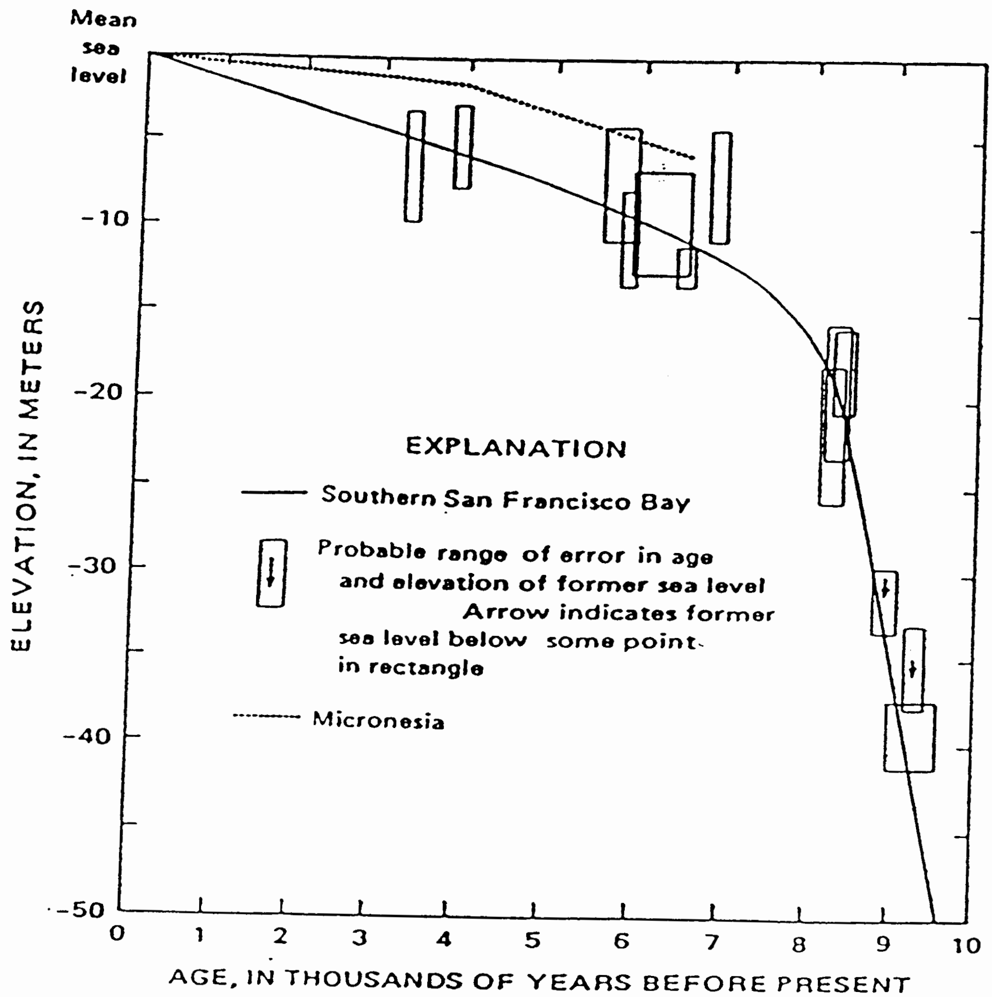

Figure 6. Holocene sea-level history for southern San Francisco Bay (Atwater et al., 1977).

Glenn (1978) reports radiocarbon dates in a core from Tillamook Bay that suggest similar rates for coastal Oregon (Figure 7). Studies at Alsea Bay, Oregon (Peterson and others, 1984), and at Grays Harbor, Washington (Peterson and Phipps, 1992) showed that sediment infilling rates in the active margin estuaries decreased substantially following the declining rate of eustatic sea level rise in mid Holocene time. Figure 8 (Peterson and Phipps, 1992) shows a sediment level curve for Grays Harbor that clearly displays the rapid sedimentation rate (1.2 cm/yr) that corresponds to the early Holocene rapid sea level rise followed by a sharp decrease in the sedimentation rate (0.5 cm/yr), particularly after 5.5 ka, which is in accord with the declining rate of sea level rise.

Rankin (1983) considered sea level fluctuations as controlling factors in the beach ridge and dune development in the Clatsop Plains region immediately south of the mouth of the Columbia River. His analysis was based on radiocarbon dating of developed peat layers within the Clatsop Plains dune complex. Figure 9 is a sea level plot of radio-carbon dates compared to sea level curves from various sources. Rankin (Figure 9) reported that sea level fluctuations consisted of a sharp rise until 2300 years bp followed by a gradual fall until 1400 years bp and then reversed to show a gradual rise to the present. However, local tectonics are now thought to dominate the short period sea level fluctuations (350-500 years) along the Pacific northwest coast. This coastline is

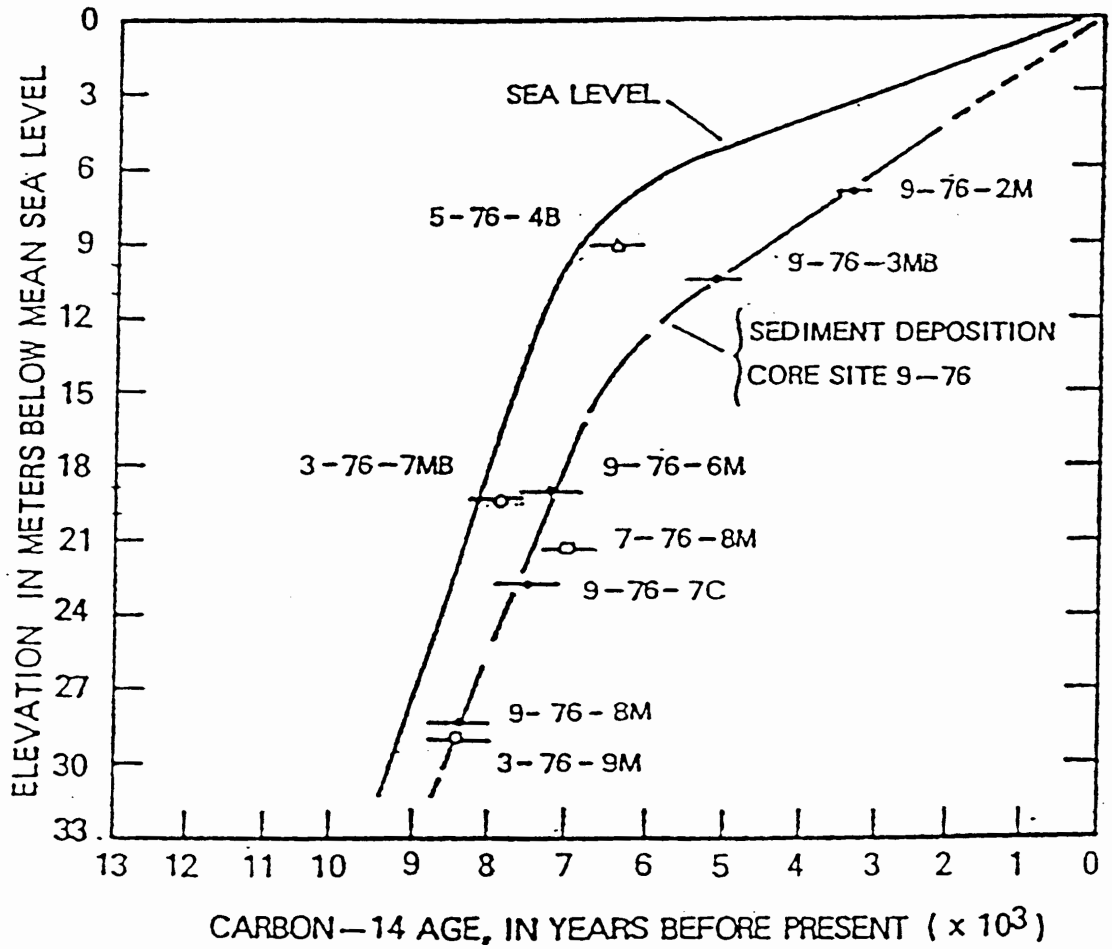

Figure 7. Generalized curve of world-wide sea-level rise (Kraft, 1971) and curve of sediment deposition from Tillamook Bay, Oregon (Glenn, 1978).

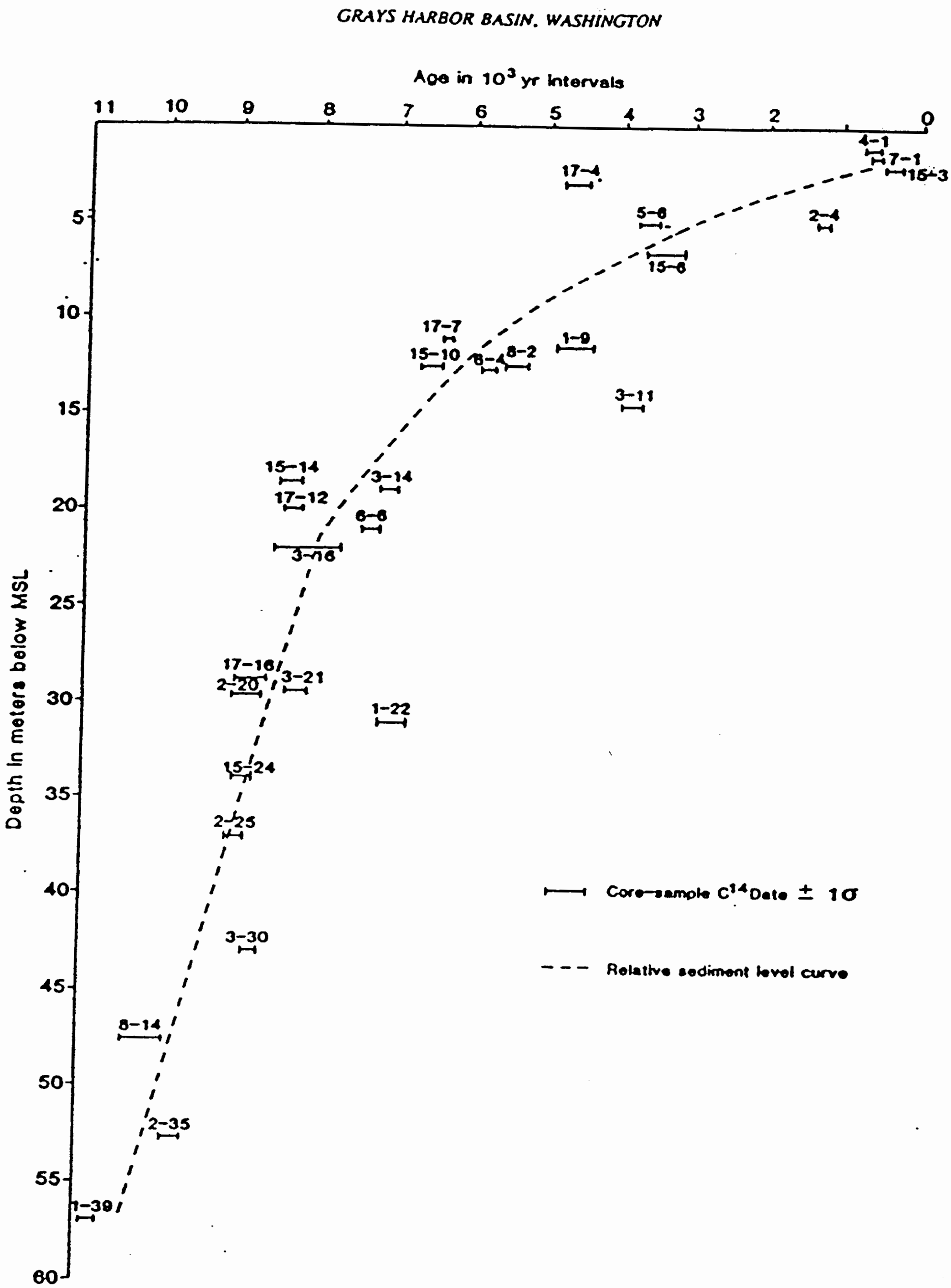

Figure 8. Sediment level curve for Grays Harbor Washington (Peterson and Phipps, 1992). Note the abrupt decrease in sediment accumulation about 7,000 years ago.

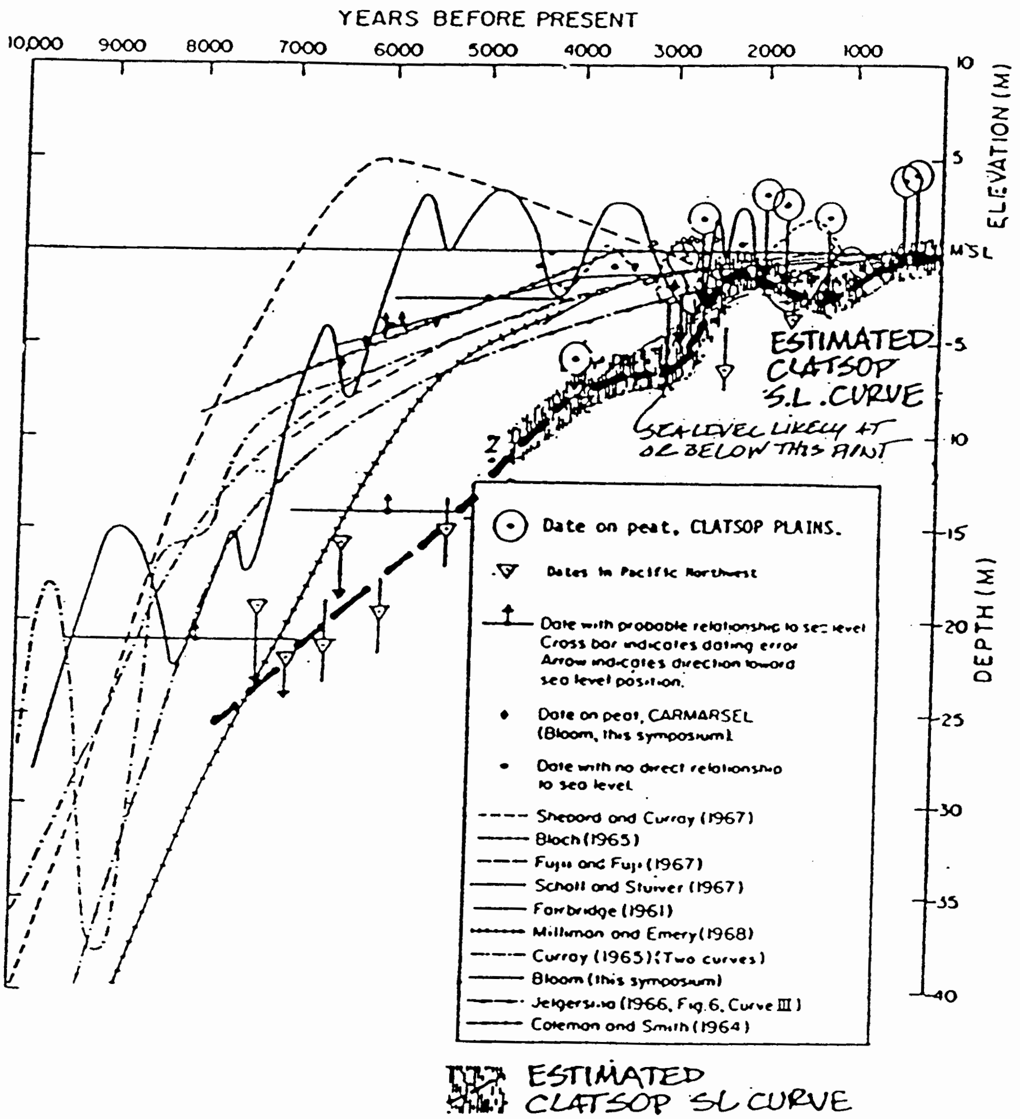

Figure 9. Sea level plot of carbon dates from the Clatsop plains (Rankin, 1983) compared to sea level curves from various sources, (modified from Curry, Shepard, and Veech, 1970 and Bloom, 1977).

known to have experienced megathrust earthquakes (Darienzo and Peterson, 1990).

Since 1940 the average sea level around the United States has been rising at a rate of about 1.5mm y^{-1} (Hicks, 1978). However, sea level has not continued to rise along the Oregon and Washington coast adjacent to the Columbia River estuary in historic times. Modern tectonic uplift of coastal Oregon and Washington is producing in a lowering of relative sea level (Hicks, 1972). Geodetic levelling from 1904 to 1974 (Ando and Balazas,1979) and tide gauge data from 1946 to 1974 (Hicks, 1972, 1978; Chelton and Davis, 1982) both suggest that sea level in Astoria has been falling since the turn of the century. The estimated rates of sea level fall ranges between 0.01 and 0.11cm y^{-1} depending on method and period considered; the higher and probably more reliable estimate (0.11cm y^{-1}) is that of Chelton and Davis (1982). The mechanisms for this tectonic uplift are the result of interseismic strain accumulation associated with interplate coupling between the Juan de Fuca Plate and the North American Plate in the Cascadia subduction zone (Darienzo and Peterson, 1990; Atwater and others, 1987). The last dislocation of the central Cascadia margin occurred about 300 years ago and resulted in 1-2 meters of subsidence at the mouth of the Columbia River (C.D. Peterson, personal communication, 1993).

A study of beach sediments along the southern Washington coast by Ballard (1964) indicates that the net longshore drift

of sands on the inner shelf between the Columbia River and Grays Harbor is to the north. The broad fan shaped pattern of bottom contours north and west of the outer end of the north jetty called Peacock Spit is undoubtedly formed from sediments that have been carried northward, possibly from dredge spoils deposited offshore of the Columbia River entrance.

STUDY AREA

The study area (Figure 10) includes the lower Willamette River basin (Portland area to the mouth) and lower Columbia River basin (LCRB) (Troutdale, Oregon to Cape Disappointment, Washington). The area is defined as the tidally influenced regions of the lower Columbia River and Willamette basins that had the Mazama ash bed deposited in the Holocene sedimentary alluvium, including the adjacent floodplain. The eastern boundary is at the mouth of the Sandy River near river mile 120. The southern boundary is about 200 meters upriver from the Fremont Bridge crossing of the Willamette River in Portland. The western boundary is defined by a vertical plane extending across the mouth of the river from Cape Disappointment, Washington to the northwestern extent of the uplifted marine terrace deposits near Warrenton Oregon. Figure 10 shows the locations mentioned in text.

Depth profiles extend down to at least the elevations of the Mazama ash horizon (generally -70 to -45 feet, or -21 to -14 meters msl), and are extended to the pre-Holocene contact in the areas where this data is available.

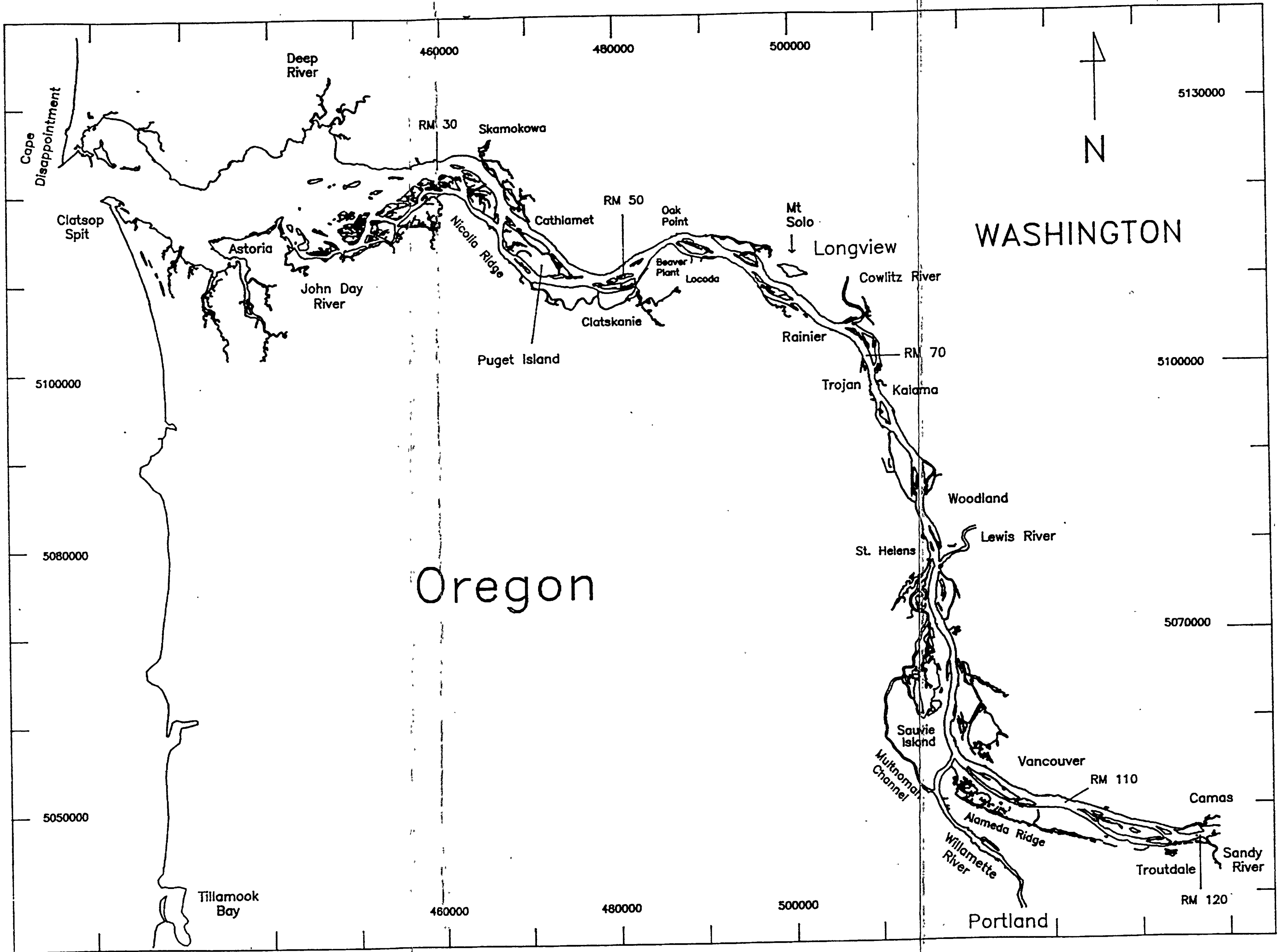

Figure 10. Locations mentioned in text. RM = River Mile, coordinates are in UTM, zone 10. Study area extends from Cape Disappointment to the Sandy River.

METHODS OF INVESTIGATION

This investigation includes a compilation of existing borehole records and reported occurrences of a key tephra layer bed in the Holocene fill of the lower Columbia River. Analysis of facies types and their stratigraphic distributions are derived from drill core logs within the lower Columbia River flood plain and its adjacent tributaries. The dating and stratigraphic correlation of the key ash beds in the Holocene fill are established by tephra chronologic methods (discussed below). These marker beds are used in conjunction with extrapolated sea level curves to predict a sediment depth-age curve for the lower Columbia River sedimentary fill.

TEPHRA CORE DATA IN THE COLUMBIA RIVER VALLEY FILL

Core data for many of the Mazama ash occurrences were derived from Ken Robbins, a retired engineer for Dames and Moore Inc., of Portland, Oregon. Ken noted from borehole logs 73 occurrences of the target ash bed in the Portland area and 72 occurrences in the Longview, Washington area. I have noted an additional 50+ occurrences of this ash horizon mostly from areas outside of the Portland and Longview regions, with most of these occurring in the lower estuary region.

TEPHRA SOURCE ANALYSIS

For this study nine samples of tephra were collected from five different drill core borings in the lower estuary. Three of the borings are from the Oregon Department of Transportation (ODOT) John Day River Bridge project near Astoria, Oregon. Another boring is located approximately 0.5 km east of the John Day River Bridge project in the flood plain of the John Day River. The fifth drill core is from a proposed bridge site on Holbrook Slough in Warrenton Oregon. Appendix A contains the geochemical data used in this study.

Detrital material and organics were removed from each sample (except sample NG-9), and the sample was subjected to the following laboratory procedures: 1) all visible grains larger then fine sand size were removed using stainless steel tweezers; 2) the samples were ground to a powder using a washed porcelain mortar and pestle; 3) samples were transferred to 200ml glass beakers and deionized water was added and mixed to produce a slurry; 4) the slurry was transferred to porcelain petri dishes and dried overnight in a lab oven; 5) the dried samples were then prepared with H_2O_2 to remove the organic material and placed in a vent hood overnight; 6) samples were then placed on a hot plate for 30 minutes to drive off vapors; 7) after heating the samples were again mixed with deionized water to aid in the transfer to plastic centrifuge containers; 8) the samples were then centrifuged to further separate out any detrital material that

remained; 9) after centrifuging the samples were redried overnight and ground to a powder the following morning with a porcelain mortar and pestle.

An approximate one gram split from each sample was placed into clean 2/5 dram polyvials and weighed to 0.0001 gram with a Mettler H10T balance. To reduce the effects of varying geometries with respect to the gamma ray detector, each sample was filled to approximately an equal volume. The polyvials were then heat sealed and placed in 2 dram polyvials for irradiation.

The samples were exposed to a flux of 2.0 X 10^{12} neutrons cm^{-2} sec^{-1} at 250 KW for one hour. Gamma ray spectra were obtained using a high purity Germanium coaxial photon detection system. Initially, 4-5 days (1000 sec live time), and again 12-16 days (3000 sec live time) after irradiation. Elemental concentration peaks and percent errors were obtained with the use of the EG&G ORTEC 92x Spectrum Master program package. The standard U.S.G.S. rocks BCR-1, JB-2, JR-1, and Mag-1 were analyzed simultaneously with samples to provide a check on the accuracy of the method. Two recounts were also performed to check the precision of the instrumental method.

Analysis for the geochemical data sets was performed by constructing two dimensional plots (Appendix A, graphs A-1 through A-16) of various elements in an attempt to establish groupings and/or linear trends between the different sets, as

well as comparison with the other reported tephra compositions.

COMPILATION OF BOREHOLE LOGS

The most extensive subsurface data base in the LCRB is that of industry boreholes drilled and logged for foundation testing. The borehole records include locations at all of the major bridges, port facilities, and industrial centers. Many of the borehole logs record lithologies from depths of at least 30 meters below msl. Water well logs are also available for much of the river basin in areas not adequately explored by the industry borehole logs. Wherever possible the foundation test bore hole logs were used rather then existing water well logs to characterize the Holocene fill in areas adequately represented by industry drillhole records. This preference of using the industry drillhole records is because these logs generally have more detailed and reliable lithologic descriptions and the locations are more accurate.

The methods of analysis for the industrial drill core logs are as follows: initially over 1000 drill core and 200 water well logs were obtained from the following sources; Oregon Department of Transportation (ODOT) region I and region II geology offices; Washington Department of Transportation (WASHDOT) region IV geology office; U.S. Geological Survey Water Resources Department, Oregon Division; Washington Department of Ecology; Northwest Oil and Gas Report; Fujitani

and Hilts Inc., Portland office; U.S. Army Corps of Engineers, Portland division; L.R. Squires Inc., Lake Oswego, Oregon; and Dames and Moore Inc. of Portland, Oregon. The drill core logs were then compiled by the author who analyzed the logs and compared the location, elevation, lithology of the sediments, stratigraphic sequences, and nature of the lithologic contacts. These sedimentary characteristics were then incorporated into data base files for the purpose of evaluating the Holocene sedimentary stratigraphy.

Data for the last 163 borehole records (MAP ID# 1324 through MAP ID# 1487, Appendix B) were compiled by Ian Maden (1990), who generously contributed this information on the behalf of the Oregon Department of Geology and Mineral Industries (DOGAMI).

Appendix B is a table of numeric information compiled from both industrial borehole and water well records. The table is designed to convey both geographical position (in UTM coordinates) and geologic information (depth to Holocene contact). A complete explanation of the data base appears in Appendix B. A brief sample appears in Table IV. The existing data distribution did not permit a regularly spaced network of sample sites or include a statistically valid grid for comparisons of sediment distribution. However, the distribution of 1487 core logs distributed throughout the

TABLE IV

APPENDIX B EXAMPLE TABLE

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min Max
Weyerhauser	1	500775	5108222	-16	6.5	-22.5	-22	-6.7	1	Rock	6	1.8	0	
Longview	2	500801	5108183	-18	38	-56			0		38	0.3	0	
Mt Coffin	3	500828	5108152	-20.5	35.5	-56			0		35.5	2.3	1	
Site	4	500868	5108110	-12.5	16.5	-29	-28	-8.5	1	Rock	15.5	4.7	0	
	5	500789	5108201	-19	34	-53	-52	-15.8	1	Rock	33	10.1	0	
	6	500838	5108218	20	36.5	-16.5	-16	-4.9	1	Rock	36	11.0	0	

Location: General description of the borehole location.
Map ID#: Point Number that represents the unique designation for each borehole log.
UTM EAST: Universal Transverse Mercator grid position in zone 10. All values are in meters.
UTM NORTH: Universal Transverse Mercator grid position north of the equator. All values are in meters.
Surface Elev Ft: Surface Elevation in feet from sea level (USC&GS datum) indicated on the borehole records.
Hole Depth Ft: Hole depth in feet.
Hole Base Ft: Hole Base Elevation in Feet; Base elevation in feet of the borehole.
QalBasel ContactFt: Qal Base Elevation in Feet; Elevation of the basal contact between the overlying unconsolidated Quaternary Alluvium (Qal) and the underlying Formation.
QalBasal ContactM: Qal Base Elevation in meters; Same as above column only in meters.
Basal Lithol: Basal Lithology; Lithology of the underlying strata below the unconsolidated alluvium.
Isopach Feet: Isopach in feet; Thickness of Qal and Qff in feet.
Isopach Meters: Isopach in meters; Thickness of Qal and Qff in meters.
Ash Code: Binary code used to indicate the presence of the Mazama Ash occurrence. 1 = yes; 0 = no.
SPT MinMax: Standard Penetration test values. Reported as minimum and maximum values for the unconsolidated alluvial fill.

study area, is sufficient to qualitatively analyze trends of sediment distribution, such as general grain size partitioning within the valley fill.

The two dimensional cross sections of the river valley fill were constructed by using a computer graphing program (Golden Software Grapher). The linear distributions of the bore hole sites, surface elevations, and underlying lithologic contact elevations were plotted. Then the graphs were imported into a computer drafting program (Autocad) for lithologic pattern designation and final preparation of the cross sections.

A Geographic Information System (PC Arc Info) was used to construct plan view maps of the entire study area. The maps for the lower Willamette and lower Columbia River regions were created by digitizing the 32 U.S.G.S. 7.5 minute topographic sheets that cover the Columbia and lower Willamette River floodplains. The margins of the Columbia and Willamette river floodplains served as the boundary for the 0 isopach contour line. In the areas upriver from Longview, Washington the USGS 7.5 minute topographic 40' contour line was delineated as the edge of the floodplain. This elevation also closely corresponds to areas mapped as "Qal" by previous investigators. In only one case was an area above the 40 foot contour line included within the floodplain boundary. This occurrence is on Sauvie Island and is discussed later in the text. The 40 foot contour line was used because it represents

a consistent reference line that appeared on all of the U.S.G.S. topographic maps. The maximum elevation of floods in historic time recorded by the U.S. Army Corps of Engineers reached elevations of only 32.8 feet (1948) and slightly greater during the 1894 flood event in the Portland basin. Below Longview in the estuary region and adjacent tributaries the floodplain margin was digitized along the 25′ supplemental contour line. The 0 isopach surface is defined as the upper surface of the modern flood plain. This floodplain surface elevation decreases in the downstream direction and also from the margins of the floodplain towards the modern river position. Note, that while the isopach surface undulates with floodplain topography, it represents a consistent time line. Therefore, the isopach lines do not necessarily represent equal elevation surfaces, but do represent equal sediment depth surfaces.

The isopach maps for the sedimentary fill volume of the LCRB were also constructed using the GIS system. Initially the post catastrophic flood sediment thicknesses in meters (column 13 of Appendix B) were plotted on base maps for the entire study area. Then contour lines were drawn by hand at 10 meter intervals. Finally the contour lines were digitized into a separate coverage using the GIS system.

The volume of fill calculations were derived by partitioning the LCRB into 12 depth intervals (0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100, 100-

110, and 110-120 meters) from the isopach map. The volume of each depth interval was calculated by taking the product of area (in M^2) for each polygon and the average thickness for the respective isopach interval. Note, even though there is no 120 meter isopach contour, the depth calculation used a 115 m value as the average amount of fill for the 110-120 m polygon. Finally, all of the polygon areas for the isopach intervals were summed to reach the final value for each depth interval.

ANALYSIS OF BOREHOLE DATA USED FOR THE CROSS-SECTIONS

Analysis of the industrial bore hole logs used in the cross-sections was performed by partitioning the Holocene sediments into general groupings based on the most abundant grain size fractions distributed within the sedimentary horizons as indicated by the core logs. All sediments that were delineated as silt, clay, or mud, on the logs are termed silt and clay on the cross-sections. The sand size fractions were partitioned into fine, medium, and coarse sands when adequate detail was given on the core log. But, for many of the water wells and some of the industry holes the logs did not partition the sand sized sediments into fine, medium, and coarse fractions and therefore the description of sand is used for all three fractions. Mixtures of sand and silt are also included and termed sandy silt, silty sand, stratified sand and silt, etc., depending on the lithological description in

the corresponding drillhole log. The term gravel is used for all sediments in the gravel size range.

The depth of the Holocene contact with the underlying sedimentary strata was delineated from borehole logs as the boundary horizon in which the drillhole penetrated sediments described as cobbles, boulders, or dense gravel. This partition is based on the assumption that the last of the catastrophic Pleistocene floods were of very high energy. The floods were apparently capable of transporting much larger grain size sediments then is observed in the modern river environment, particularly as the head of tide has since progressed up the valley with the ensuing marine transgression. However, it is possible that some of these coarse grained sediments could have been transported and deposited by the river system since the Missoula floods. Conversely, some of the deep sands found in the drillholes that are designated as part of the Holocene fluvial system could represent lag deposits (especially in the Portland basin area) left by the winnowing flood events.

In short, the basal contact elevations of the Holocene fill are taken here to be at major lithologic transitions between the overlying unconsolidated sand and/or silts, and the underlying unconsolidated coarse grained gravel or cobble fill, or consolidated units such as cemented sedimentary units (Troutdale and Astoria Formations) or bedrock units (Boring

Basalts, Columbia River Basalt Group, Gobel volcanics, and the Skamania volcanics).

ANALYSIS OF THE SEDIMENT PARTITION DATA

Borehole records 1 through 1324 (Appendix B) contain some form of lithologic description based on grain size for the late Quaternary alluvial sediments deposited in the LCRB. The borehole records collected from engineering firms, Oregon Department of Transportation (ODOT), WASHDOT, etc., all used grain size analysis to delineate the respective lithologic characteristics. The grain size partitioning increments are based on the Unified Soil Classification (USC) system. The USC system defines the grain size boundary between sand and silt at 0.074 mm. The water well lithologies did not use the USC system for lithologic distribution. These lithologies were recorded by the driller, who is generally experienced at giving rough estimates of sediment lithology based on observed grain size.

Appendix D displays the sediment grainsize partition data used for lithologic partitioning. The lithologies were partitioned into four primary categories discussed below. The 54 borehole records used in Appendix D were chosen primarily on their total depth. I generally chose the borehole records that reached the lowest hole base elevation to ensure that the lowest elevation horizons would be represented. To ensure a wide spread distribution, boreholes from throughout the basin

were selected even if they did not penetrate to lower elevations then other boreholes. I preferred to use boreholes from engineering projects as opposed to water wells drillers logs because the engineered holes involved laboratory testing and better quality lithologic descriptions. But, water well logs were used in areas where the engineered holes were not available, or where the water wells penetrated to lower elevations and therefore were used to add additional control for greater subsurface depths.

The four lithologic designations were delineated as sand, silty sand, sandy silt, and silt. These four lithologic components were used because nearly all of the borehole records described the sediments using these lithologic terms, and rarely were coarser and finer grained sediments encountered according to the core logs. When grain sizes larger than sand were encountered, such as gravel, sandy gravel, sand and gravel, and gravelly sand, they were included with the sand designation for the grain size partitioning data. As mentioned earlier, often the Holocene contact with the underlying catastrophic flood deposits was delineated at the boundary between medium and very coarse sediments. The coarse grain sizes classified here refer to those sediments which had substantial amounts of finer unconsolidated sediments below and were not designated as pre-Holocene deposits. Similarly, when grain sizes smaller than silt, such as clay, mud, peat, clayey silt, and silty clay, were

encountered they were included with the silt grain size category for the sediment partitioning designations. The silty sand designation includes lithologies described as silty sand, sandy loam, and, sand and gravel and silt. The sandy silt designation includes lithologies that implied a greater component of silt than sand, such as sandy silt, silt loam, and, sand and silt and clay (or mud). Occasionally, when the lithologic description used sand and silt, or loam, as the lithologic description, these intervals were split in half with 50% of the respective interval assigned to the sand category and the other 50% assigned to the silt category.

The isopach depth listed in Appendix D for the borehole records occasionally deviates from the isopach depth listed in Appendix B. This occurs because the isopach used in Appendix B occasionally includes material (such as dredge spoils) used for fill. For the isopach used in Appendix D, any fill material indicated on the borehole record was subtracted out because I wanted to account for only grain size distribution that occurred from natural depositional processes.

Appendix D represents a table of numerical values derived from the borehole logs. This table was constructed for the purpose of displaying the measured values for sand, silty sand, sandy silt, and silt, and the subsequent percentages of each grain size lithology for each of the borehole record. Three types of total values are listed. The first value labeled "borehole percent" is the average percentage for each

grain size lithology for all of the boreholes. This value gives equal representation to each borehole regardless of its penetrated depth. The second total value listed labeled "isopach percent" is the average percentage for each lithology based on total penetrated depth for the boreholes. This value gives a proportionately greater influence to those boreholes that penetrated deeper into the basin fill, because the total sum of a particular grainsize amount was divided by the sum of the total penetrated isopach depth. Therefore each foot of penetrated depth carries equal value, (i.e. a 300 foot penetration hole carries 3 times as much value as a 100 foot penetrated depth hole. This value was used as the lithologic percentage of "total infilled sediment" in the LCRB stated later in the thesis. Below each of the elevation interval columns is the total percentage of grain size distribution for each of the elevation intervals. The subsurface elevation intervals are listed in feet (rounded to the nearest 0.5 feet) but correspond to 10 meter intervals (i.e. the 0 to 33 foot subsurface elevation interval approximately equals the 0 to 10 meter interval). The values were used for comparison of grain size distribution with subsurface elevation.

The Map ID# numbers in column 1 correspond to the Map ID# of Appendix B. Generally, the borehole records are arranged in order of their upstream progression.

RESULTS

THE MAZAMA ASH LAYER

A distinctive layer of volcanic ash has been encountered in numerous (197) (Appendix C) deep test borings in the flood plains of the Willamette River from Swan Island to the mouth, and the Columbia River from Troutdale to Warrenton. Since 1959, when the layer was first recognized and sampled in borings from the Rivergate area of North Portland, mapping of its occurrence has been maintained primarily by Ken Robbins. Microscopic analysis showed the ash is mainly glass shards with indices of refraction in the range of Mazama ash. Additional efforts for identification were undertaken in 1975 when samples were submitted to Dr. Beeson (Portland State University) for trace element studies and to Dr. Kittleman (University of Oregon) for mineralogical analysis. The trace element studies clearly showed the ash to be Mazama; however, the mineralogical studies could identify only those samples that were already known to be Mazama (i.e. samples of untransported ash).

The ash layer is waterlain and is a good marker for the flood plain elevation in the Portland area at the time of the Mazama eruption. A complete database for the Mazama ash layer occurrences appears in Appendix C. The general basinwide range

is from -41 to -92 feet msl. The average elevation of the base of the ash layer for the Portland basin occurrences (includes sites down river to Trojan) is -56.8 feet (-17.3 meters) msl. The average elevation in the Longview basin (includes sites down river to the Beaver Army terminal near Locoda Oregon) is -62.9 feet (-19.2 meters). For the sites down river from Skamokowa, Washington, the average elevation is -59.3 feet (-18.1 meters). No occurrences were recorded between Skamokowa, Washington and the Beaver Army terminal area. The layer thickness is quite variable from thin layers less then 1/2 inch to a maximum of 35.5 feet (Map ID# 940, in the main Willamette River channel near Linnton, Oregon). The average thickness is about 3.4 feet (1.0 meters). For the isopach calculations, layers designated as TL (thin layer) or NG (not given) were assigned an isopach of 0.1 feet. Also, layers that were assigned a less than (<) value assumed the maximum thickness indicated.

The May 18, 1980 eruption of Mount St. Helens provides an excellent example of rapid tephra dispersal in the Columbia River. Hubbel and others (1983), estimated that 27.5 x 10^6 m^3 of sediment was contributed in the first 24 hours after the eruption. This pulse of sediment input reduced the 12.2 m deep navigation channel to 4.3 m at the mouth of the Cowlitz River.

In most instances of the Mazama ash occurrence, there are abrupt, distinct contact at both the upper and lower surfaces of the ash layer. In some instances there is a thin interbedding of fine sand, silt and/or clay at the contacts, usually the upper contact (K.C. Robbins, Personal Communication, 1992). The ash layer itself is quite homogenous and free from contamination by other flood plain materials.

The ash occurs as a very firm layer when thicknesses of six inches or more are encountered. Sample blow counts are commonly as much as three times those for the flood plain deposits occurring above and below the ash layer. The ash layer is characteristically light gray to pale purplish gray when wet and dries to a very light gray to chalky white. Laboratory tests indicate the following physical properties: grain Size: generally 95 to 100% passes # 200 sieve (0.074mm); shear strength: non-cohesive with average phi=31° (K.C. Robbins, unpublished data, 1992).

Considering the small (silt) size of the ash particles, the environments of sediment deposition would indicate quiet low energy settings of channel sloughs and floodplains. Some of the large isopach deposits probably represent channel deposits such as point bars (M.H. Beeson, personal communication, 1994).

The Mazama ash deposits in the lower Willamette River basin were derived from ash fluvially transported down the Willamette River, as opposed to backflooding from the Columbia

River. The U.S. Department of Agriculture Soil Surveys from Lane County, Linn County, and Clackamas County, all state that pyroclastic material occurs in the sifton soils of the Winkle surface in the Willamette Valley. The Winkle surface is an early to mid Holocene (10,850 ±240 yr to 5,280 ±270 yr) alluvial surface deposited in the floodplain of the Willamette River (Reckendorf, 1992). Generally, the ash occurs as fine grained material in the intersticial spaces of coarser grained deposits of gravel (Reckendorf, 1992). The extensive deposits of ash in the upper portions of the Willamette Valley indicate that the deposits found in the lower Willamette River basin were derived from the Willamette River.

GEOCHEMICAL ANALYSIS OF THE TARGET ASH LAYER

The target ash samples that I analyzed were irradiated for INAA in the Oregon State University TRIGA MARK II Reactor. Gamma Ray spectra were obtained at Portland State University. Thirty tephra samples were previously prepared and analyzed by various investigators.

The geochemical data for the sample sets (Appendix A, Tables A-1 and Table A-2) used for tephra source analysis were collected by four different analysts from five separate experiments. Sample set NG-1 through NG-9 (Appendix A, Table A-2) are all ash samples from drill cores located along the southern margin of the Columbia River estuary. Sample sites (Appendix A, Table A-3) range from Warrenton, Oregon, west of

Astoria to the Fernhill/Burnside road area about 8 miles east of Astoria. The sampled horizons range from -48.5 to -69.4 ft msl. The gamma ray spectra for these nine samples were obtained by the author. This set of nine samples is collectively referred to as "Astoria ash" on the odd numbered graphs presented in Appendix A.

Sample sets L-1 through L-7 (Longview, Washington) and P-1 through P-13, P-16 and P-16-1.5, (Portland area) (Table A-3) are all samples of suspect ash (except for P-16-1.5 which is sediment from 1.5 ft beneath the ash layer basal contact in sample P-16). These samples are from drill cores located in the Longview, Washington and Portland, Oregon areas. For the Portland area samples both Willamette and Columbia River sites are represented. The element concentration numbers for these samples were obtained by Dr. Marvin H. Beeson, at Portland State University.

Sample sets StH-JB through StH-UGG are all Mt. St. Helens tephra. These samples are from tephra unit set S and set J (Tables A-1 and Table A-3) and represent multiple layers within each set. The samples were submitted by Dr. Paul E. Hammond of Portland State University to Dr. Marvin H. Beeson and were part of the same irradiation batch as the Longview and Portland sets. Sample set MAZ-1 through MAZ-3 (Tables A-1 and A-3) are all known Mazama ash samples from locations in central Oregon (Beeson, unpublished data). Samples MAZ-4 (CFP-AVG-1) and MAZ-5 (CFP-154) are also known Mazama tephra

samples. The geochemical data for these two samples is from Bacon and Druitt (1988). It should be noted the Bacon and Druitt (1988) did not report geochemical concentrations for Cobalt. The Phelps Creek sample represents tephra from Phelps Creek, near Trinity, Washington. This tephra has been attributed to one of the two eruptions of Glacier Peak 11,200 ka (Randle, Goles, and Kittleman, 1971). The geochemical data point from this sample is labeled "Glacier Peak tephra" in figures A-1 through A-16 of Appendix A.

All the graphs in Appendix A (graphs A-1 through A-16) are arranged in pairs. Odd numbered plots represent two elements plotted against each other for the Longview and Astoria area ash samples. The even numbered plots are for the suspect ash occurrence from the Portland area (both Willamette and Columbia Rivers) tephra samples. This style of plotting was used for two reasons: first, to prevent the graphed points from appearing too cluttered; second, to delineate any differences between the Portland basin samples and the samples from below the Cowlitz and Lewis Rivers because these two tributaries have delivered large amounts of reworked Mount St. Helens tephra to the lower Columbia River basin.

LITHOLOGIC DISTRIBUTION

During Holocene time the lower Columbia basin sedimentation has been influenced by marine transgression

along with infilling of terrigenous and volcanic sediments. Sea level rise has the same general sedimentologic effect as damming a river. The river responds by aggrading its bed in an upstream direction. Alluvial sands were found at least 90-100 meters depth in Cathlamet channel (Abby, 1989) providing direct evidence that the lower Columbia River has accumulated substantial volumes of sediment due to the effect of sea level rise.

Generally the Holocene sediments for the LCRB are dominantly fine sands. Fine sands are apparent in all of the borehole records (Appendix B) extending from Cape Disappointment, Washington and Warrenton, Oregon, up river to the Sandy River near the eastern extent of the study area, about 120 miles in river distance. While lenses and layers of both coarser sands and gravels, along with finer silts and clays, occur locally, fine sands are shown to be distributed throughout the entire lower Columbia River basin.

The results of the data analysis are plotted in a series of two dimensional cross sections that display the vertical and lateral lithologic distribution for the Holocene sedimentary deposits. The cross section locations are generally at bridge sites and developed port industrial areas where the data density is sufficient for both vertical and lateral characterization of the sedimentary fill. The basal contact for the Holocene fill is incorporated into the cross sections only in areas where it can be accurately determined.

In the estuary region, The cross-sections for the Astoria bridge shows that fine sands occur from the base of the Holocene deposits at subsurface elevations greater than -275 feet (-84 meters) msl, up to the modern river deposits. I have estimated the basal contact for the unconsolidated late Pleistocene/Holocene sedimentary deposits to occur at about -393 feet msl (-120 meters). This subsurface contact elevation is based on the occurrence of a seismic reflector present at about -430 feet (-130 meters) elevation about 10 miles downriver of the cross-section location. The seismic survey was located near the mouth of the Columbia river south of Peacock Spit. The survey was performed by Geo-Recon Inc. The seismic profile was observed by the author but unavailable for reproduction. The location of the Astoria bridge cross-section appears in Figure 11. By comparison, grain size decreases in the peripheral areas off the main channel axis of the Astoria bridge cross-section (Figure 12). The deposit sorting is also more variable towards the valley margins, as shown by the presence of stratified sands and silts, and sandy silt deposits. These subsurface results are consistent with the findings of the CREDDP study that showed modern fine sediment (silts and muds) to be distributed in the peripheral bays and off channel axis bars (Figure 4).

The Puget Island cross-section (Figure 13 and Figure 14) shows a better record of the isolated lithologic lenses of channel cut and fill structures. This cross-section probably

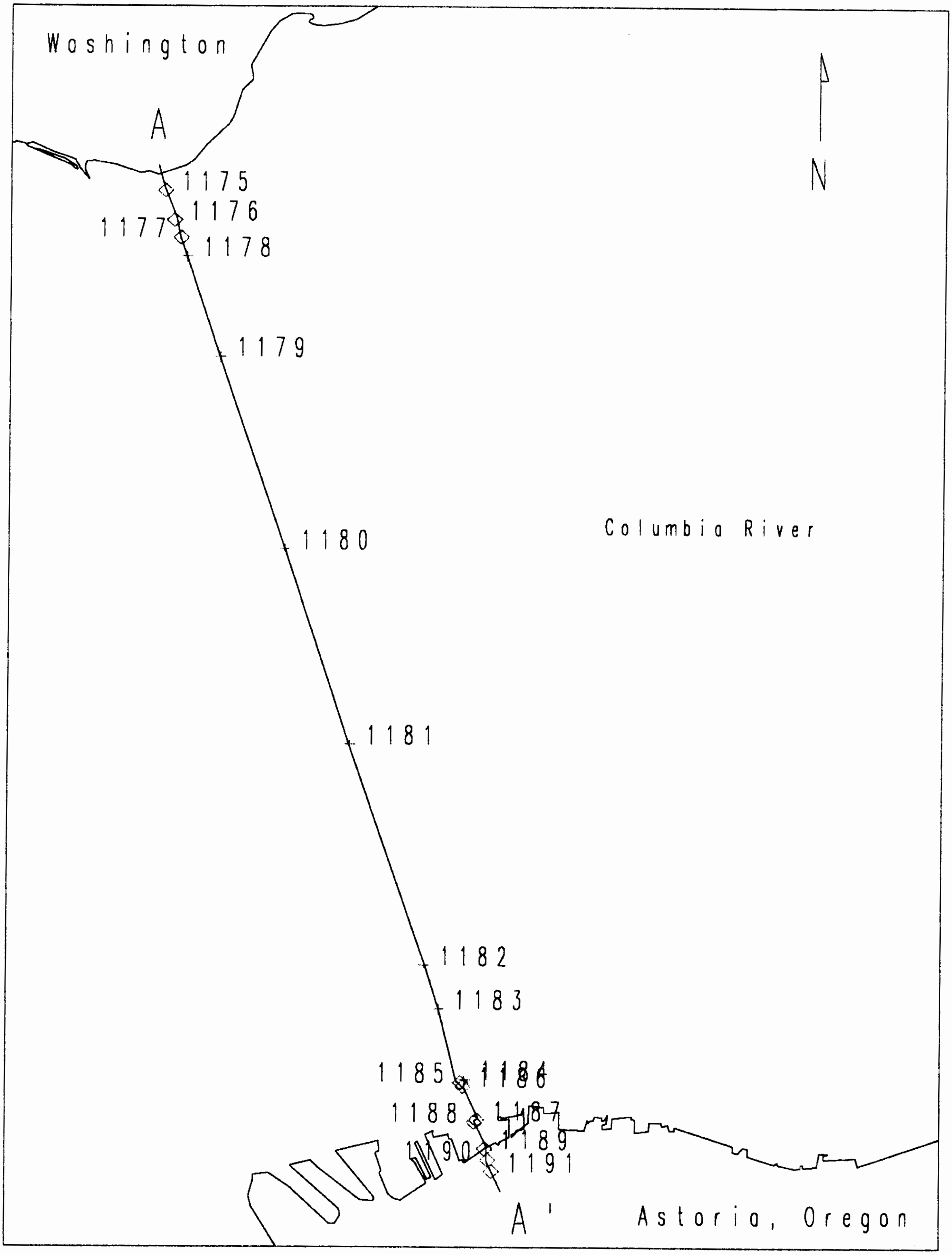

Figure 11. Location of Astoria bridge cross-section.

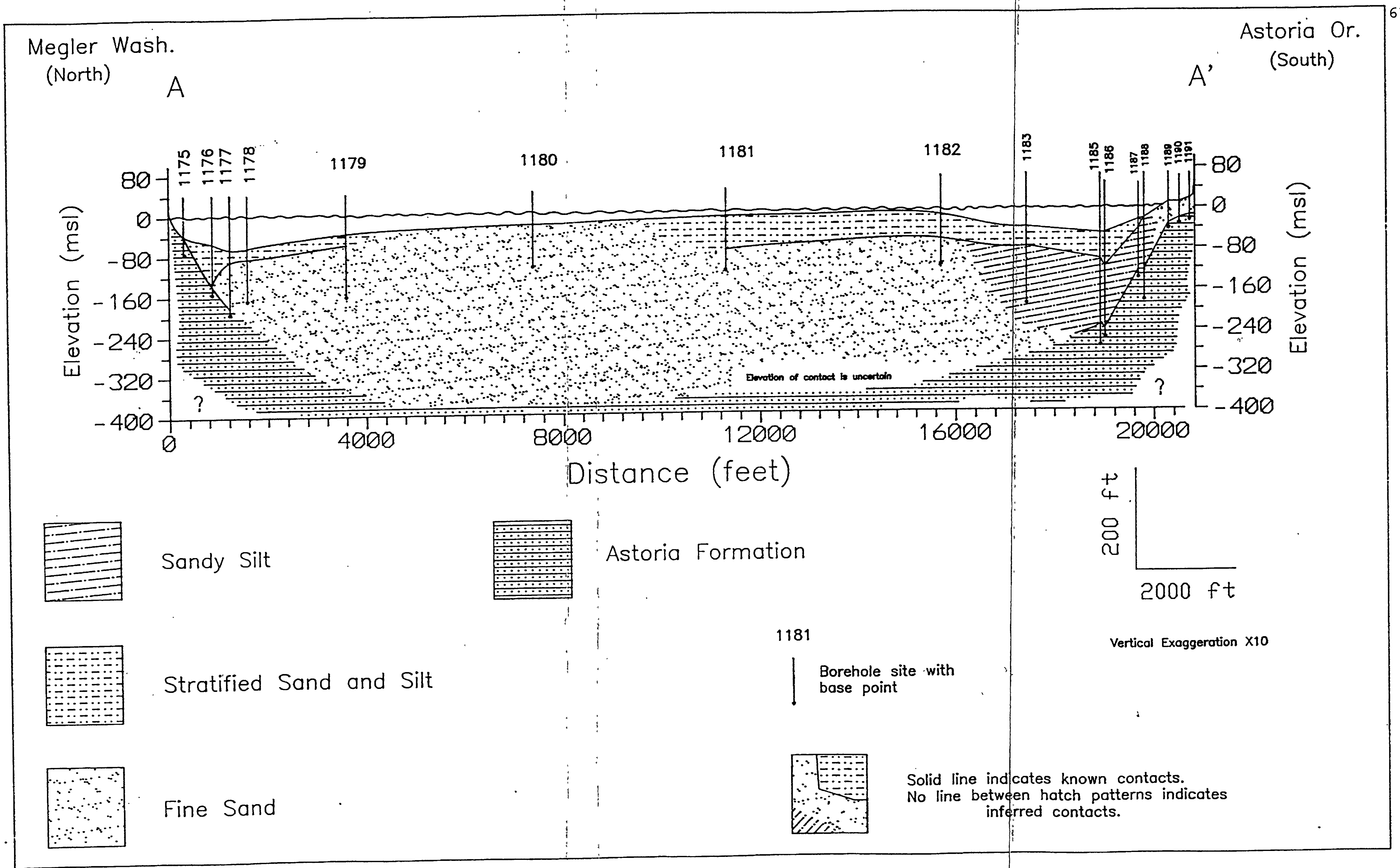

Figure 12. Astoria bridge cross-section.

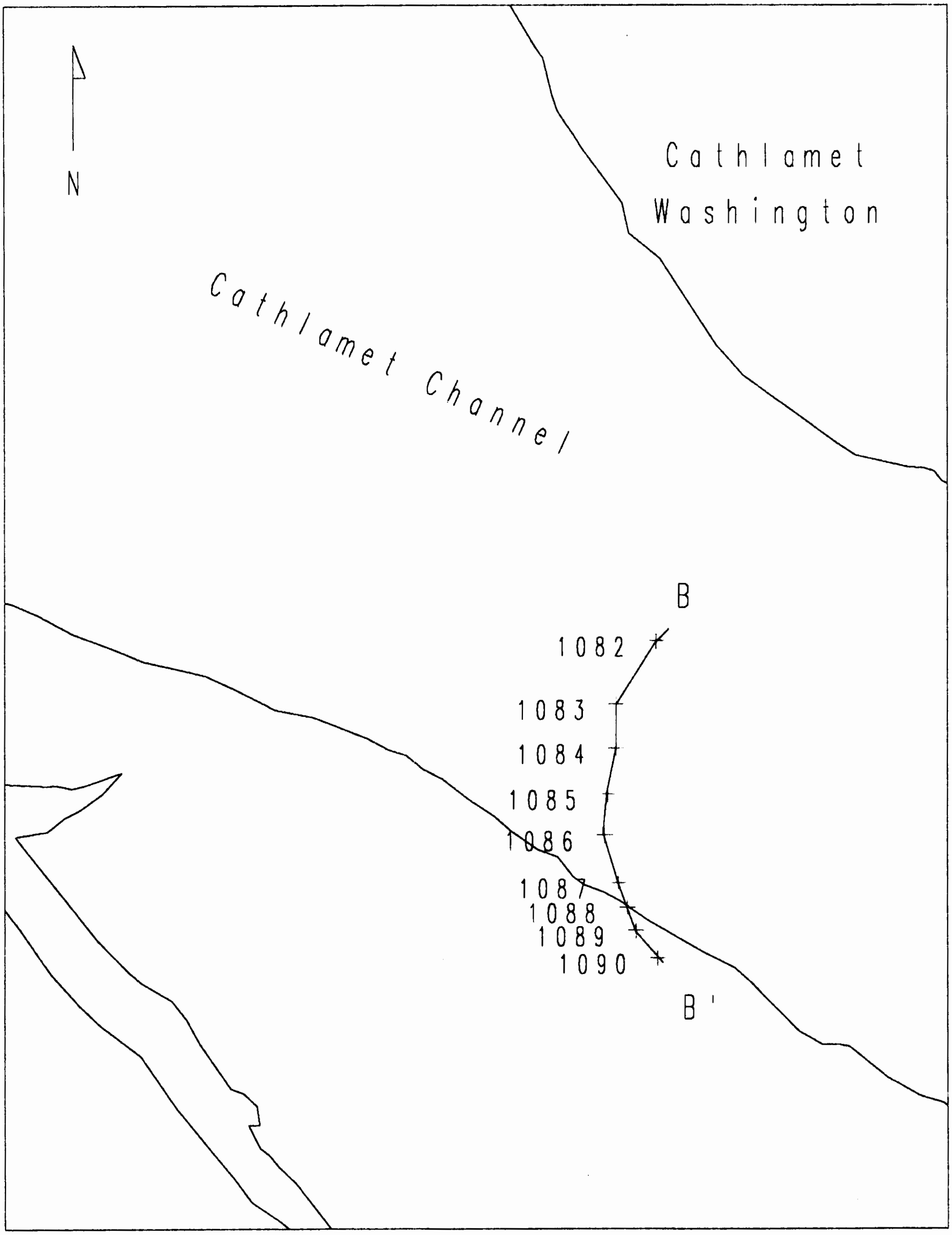

Figure 13. Location of Puget Island bridge cross-section.

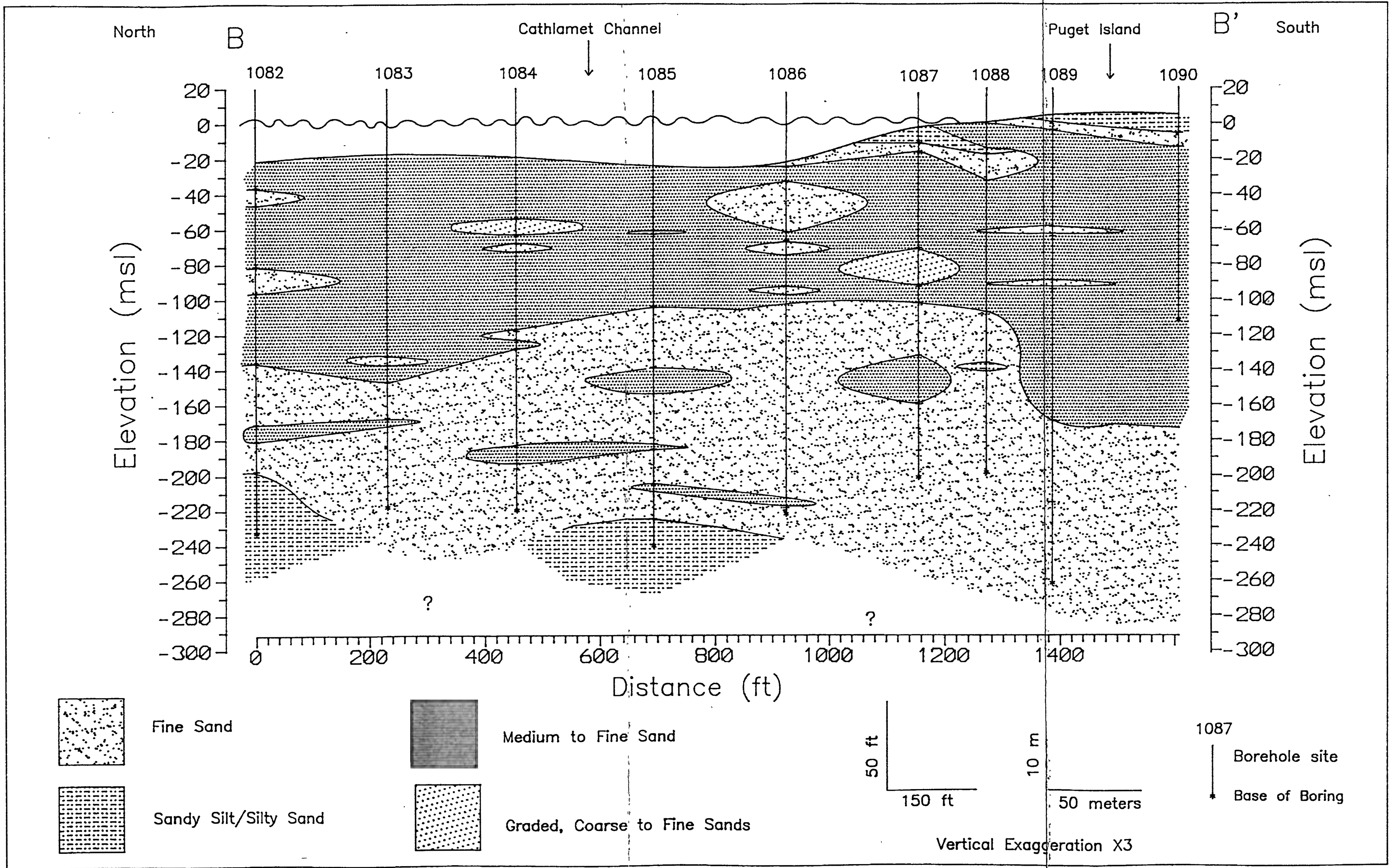

Figure 14. Puget Island bridge cross-section.

best exemplifies the distribution of the local lenses and cut and fill sedimentary structures because it used the shortest length compared to the other cross-sections. At depth none of the borings penetrated the pre-Holocene deposits. Generally, the dominant grain size distribution increases from fine sand to medium sands above the -120 feet (-37 meters) msl elevation. Both the sedimentary structures and coarsening upward trend most likely record a shift in the main channel axis (and subsequent higher energy regime) to the north side of the valley in this particular stretch of the river.

The cross-section (Figure 15 and Figure 16) from Oak Point, Washington to Locoda Oregon, near River mile 54, represents the deepest measured penetration for late Quaternary (post-catastrophic flood) sedimentary alluvium. The primary feature of note in this cross-section is the occurrence of the contact between the Holocene Columbia River alluvium and the underlying coarse-grained deposits. This contact is based on waterwell data from hole number 1154 and a geophysical contact near hole 1156. The contact at -286 feet msl (-87.2 meters) in hole 1154 was described as unconsolidated gravels by the water well driller and is interpreted by the author as catastrophic flood deposits. The deeper geophysical contact beneath the modern south channel axis is found near drillhole 1156.

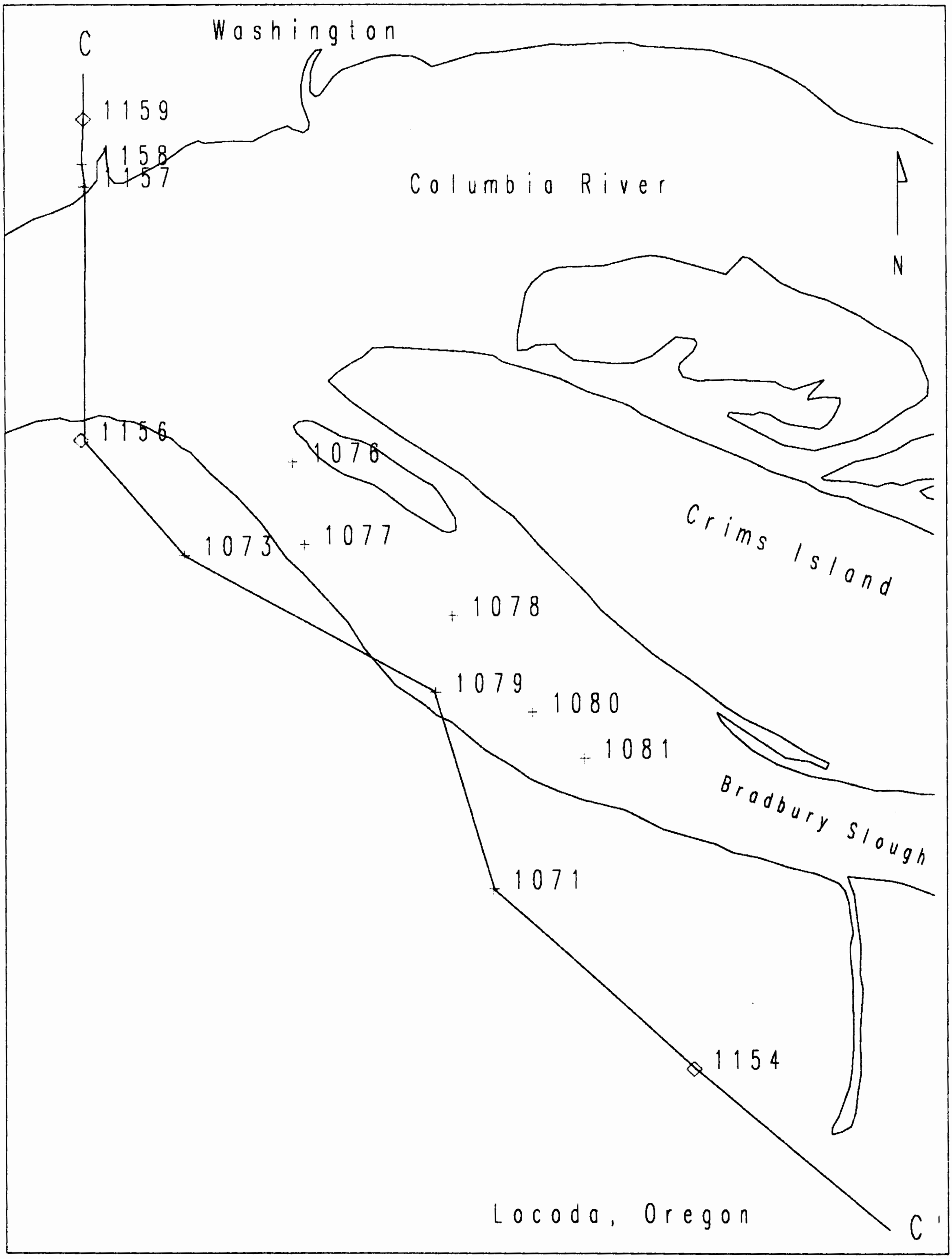

Figure 15. Location of Oak Point, Washington to Locoda, Oregon cross-section.

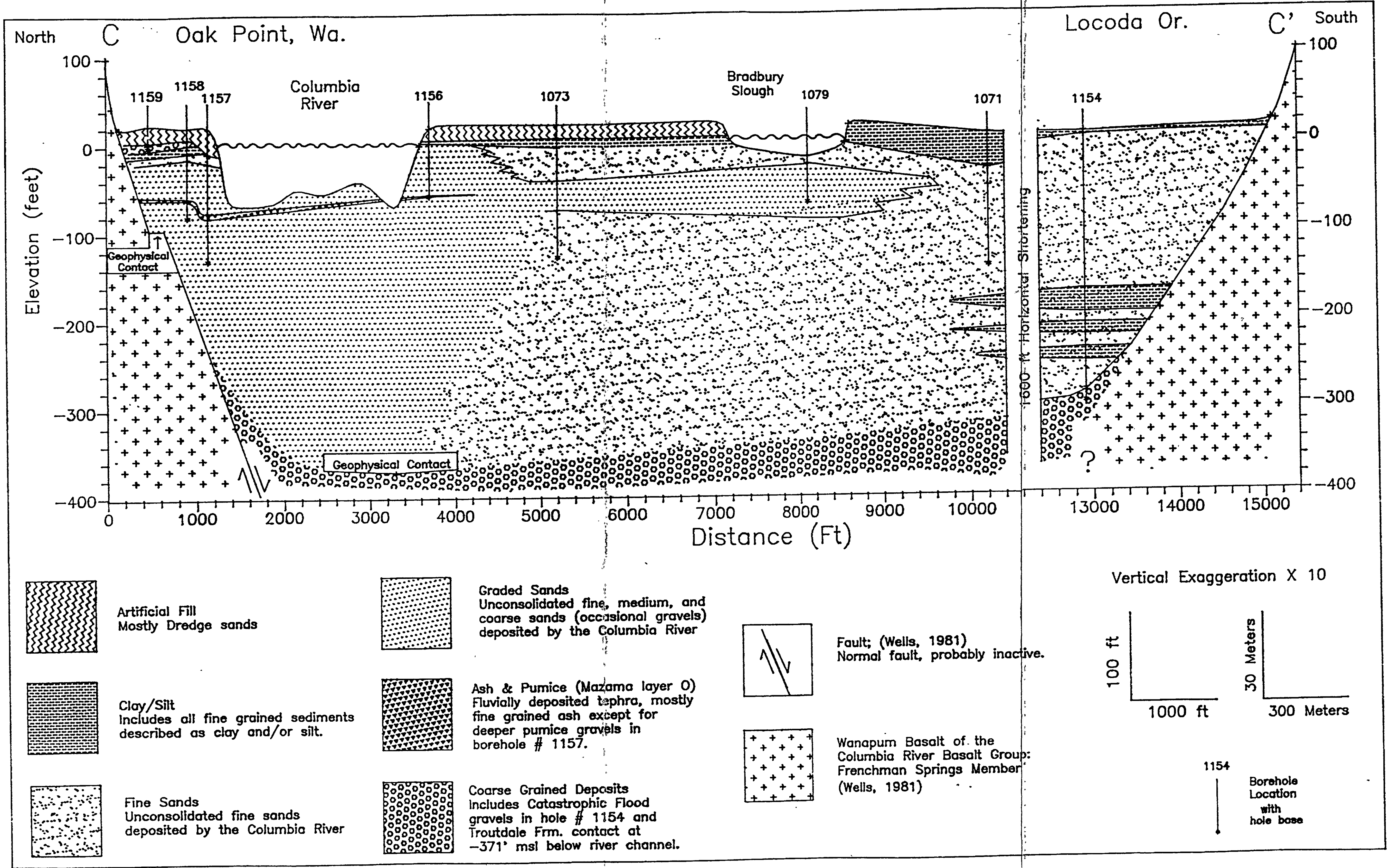

Figure 16. Oak Point, Washington to Locoda, Oregon cross-section.

This geophysical contact, at -371 feet (-113 meters), is based on a seismic reflector from an acoustic survey performed by Geo-Recon Inc. for a local utility company (data observed by the author but unavailable for reproduction). The contact is based on a one way travel time of .075 seconds (75 milliseconds) at a rate of 5000 ft/s as modeled in the survey for the subbottom overlying sedimentary alluvium. The presence of a sub-bottom reflector indicates the underlying strata has a significant density contrast with the overlying sediments. Also, nearby, the catastrophic flood deposits occur at -300 feet msl (-91.4 meters) in the Champlin well (Hole #1292) approximately 5 miles (8 kilometers) downriver. Therefore, this reflector at -371 feet (113 meters), is most likely the contact with the underlying flood deposits or the Pleistocene Troutdale Formation.

The seismic survey on the north shore of the river near Oak Point, Washington at the mouth of Mill Creek (RM 54) indicated that hard rock was present at -97 feet msl (-30 meters). Rock was found 16 feet south of hole # 1178, to 171 feet south of hole # 1178 at a depth of 118 feet (36 meters). No rock was found further south of this point. The rock velocity was estimated to be approximately 10,000 feet/s. I have interpreted this rock stratum to be weathered basalt of the Columbia river Basalt Group. This interpretation is based on the observation that Wells (1981) mapped from surface outcrops at least two horizontal flows of the Wanapum Basalt

in excess of 15 miles along the steep north slope of the Columbia River in this area. The basalt at depth could be Grande Ronde Basalt of the CRBG because these basalts normally occur relatively lower in the Miocene stratigraphic section.

A normal fault has been interpreted to form the steep northern slope of the river basin in this area. This interpretation is based on the occurrence of the CRBG at the surface and near subsurface (-97 feet, -30 meters) along the northern basin margin, yet the basalt is absent 3000 feet to the south and 275 feet (84 meters) lower under the southern river channel. Also, Wells (1981) mapped an ENE-WSW trending strike slip fault offset by a NW-SE trending normal fault only 2000 feet (610 meters) west of the cross-section axis. The fault is assumed to be inactive with the Holocene sediments in depositional contact. The Mazama ash horizon occurs in drillholes 1156, 1157, and 1158.

The cross-section of the Longview Bridge (Figure 17 and Figure 18) shows the late Pleistocene and Holocene stratigraphy beneath the southern Longview basin. The cross-section extends from Rainier, Oregon in the south north to Industrial Way along the waterfront in the industrial section of the town of Longview. The profile shows lithified sands and gravels under a water well (hole #227) interpreted by the author to be the Troutdale Formation. These deposits are assumed to extend under the Longview basin but none of the other drill holes penetrated this lithified strata. Drill

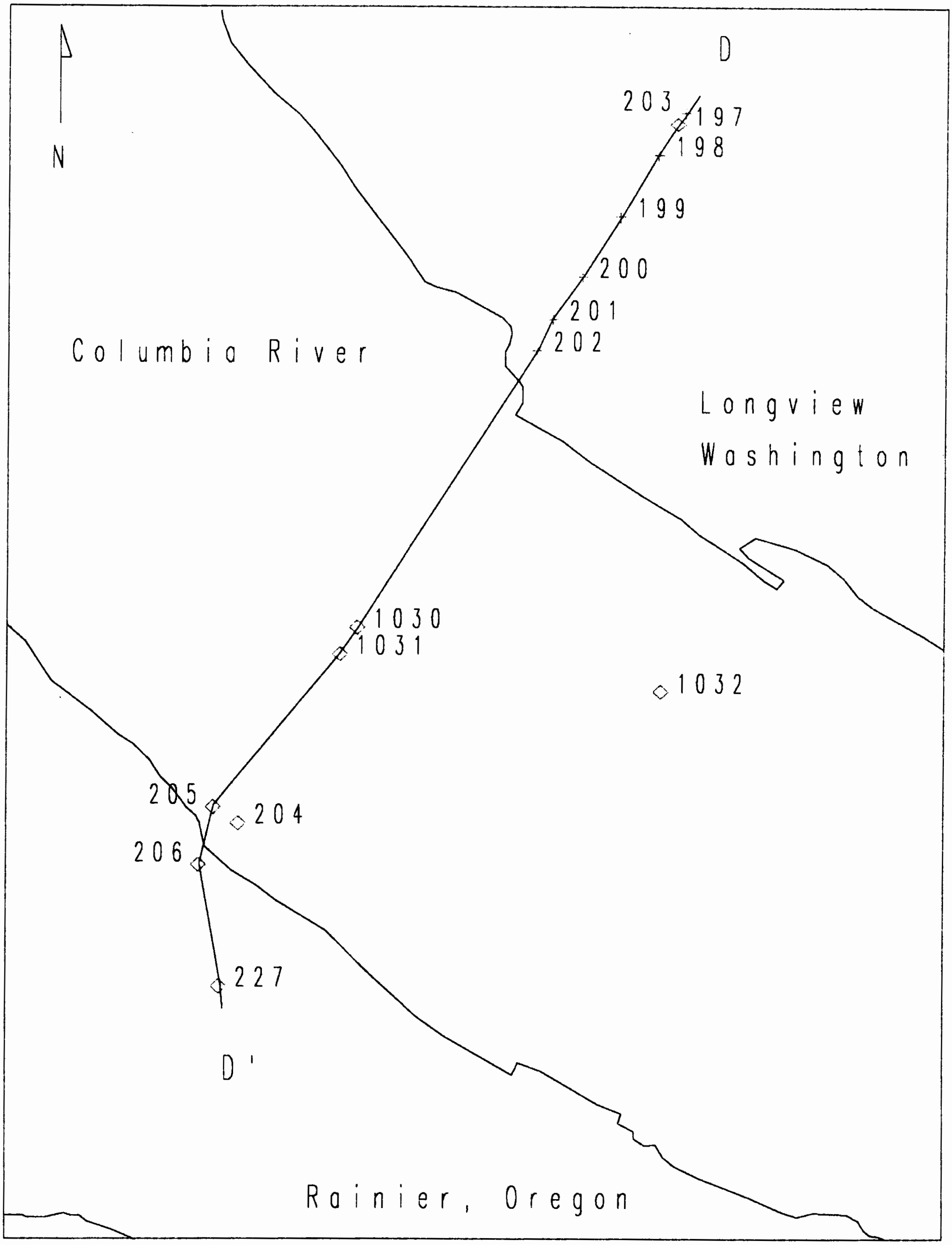

Figure 17. Location of Longview bridge cross-section.

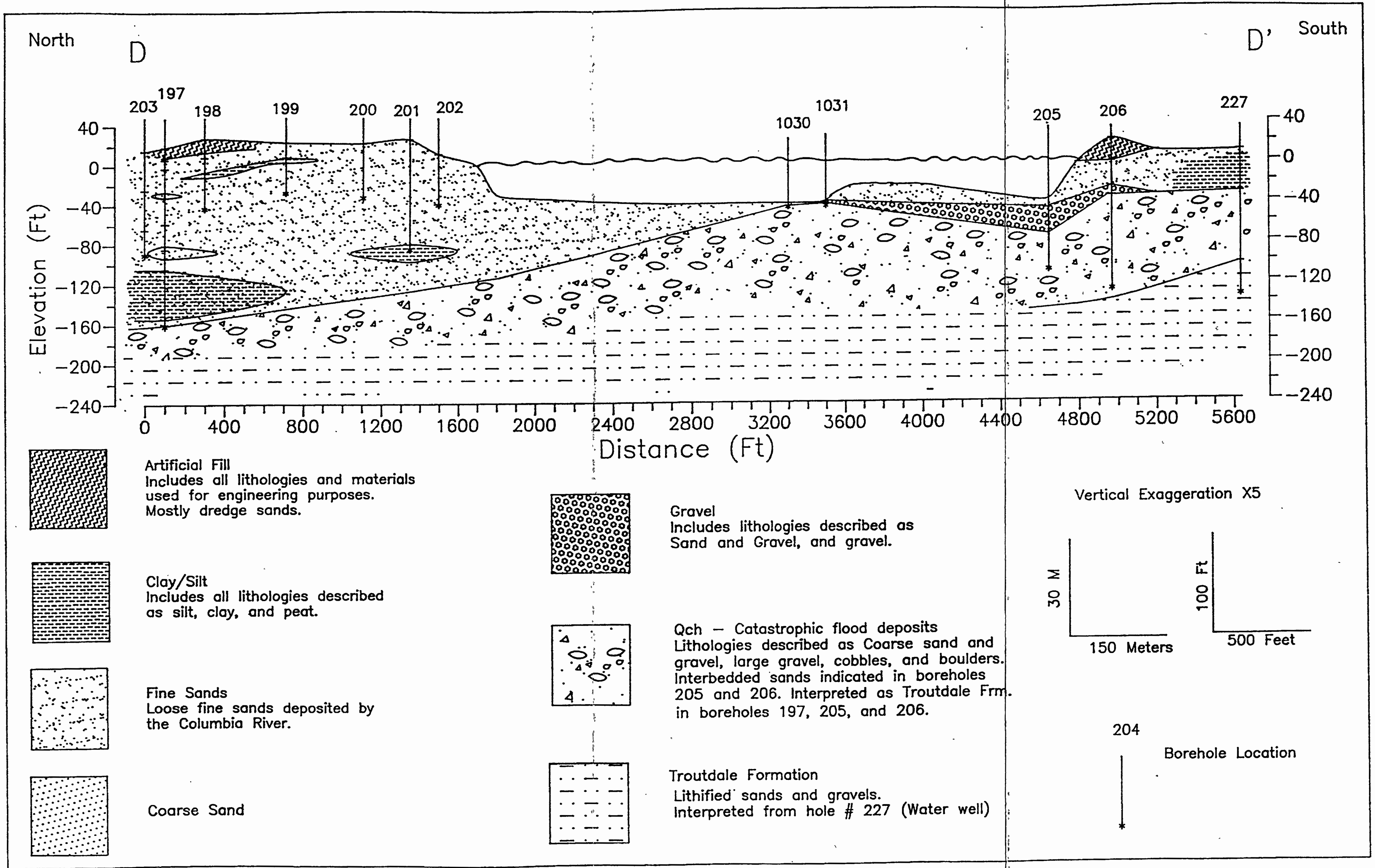

Figure 18. Longview bridge cross–section.

holes 206, 205, 1031, and 1030 all penetrated "cobbles, boulders, and coarse sands" at shallow levels (-15 to -42 feet) along the southern portion of the river and increased in depth to -160 feet at hole 197. This stratigraphic horizon was interpreted to be of catastrophic flood origin, based on the coarse grain size. The original borehole records indicated that this stratum was the Troutdale Formation in holes 205,206, and 197. Holes 205 and 206 indicated the presence of some thin layers of interbedded sands. Coarse gravels overlie the flood deposits along the modern southern channel while fine sands and lenses of fine grained sediments (silt, clay, and peat) occur throughout the rest of the cross section. Modern artificial fill deposits (dredge material ?) associated with the bridge construction occur at the surface.

The cross-section from Burlington, Oregon to Vancouver, Washington displays the lithologic distribution of sedimentary deposits and the position of the underlying medium-grained versus coarse-grained contact surface beneath Sauvie Island and the confluence region of the Willamette and Columbia Rivers. Figure 19 shows the location for the cross-section that appears in Figure 20. Fine-grained deposits of silty sand occur beneath the flood plains of Sauvie Island and Vancouver, Washington. Medium-grained deposits of sands occur beneath the area of the confluence of the Willamette and Columbia Rivers and, beneath Multnomah Channel near the western margin of the cross-section. The Portland Hills fault defines the western

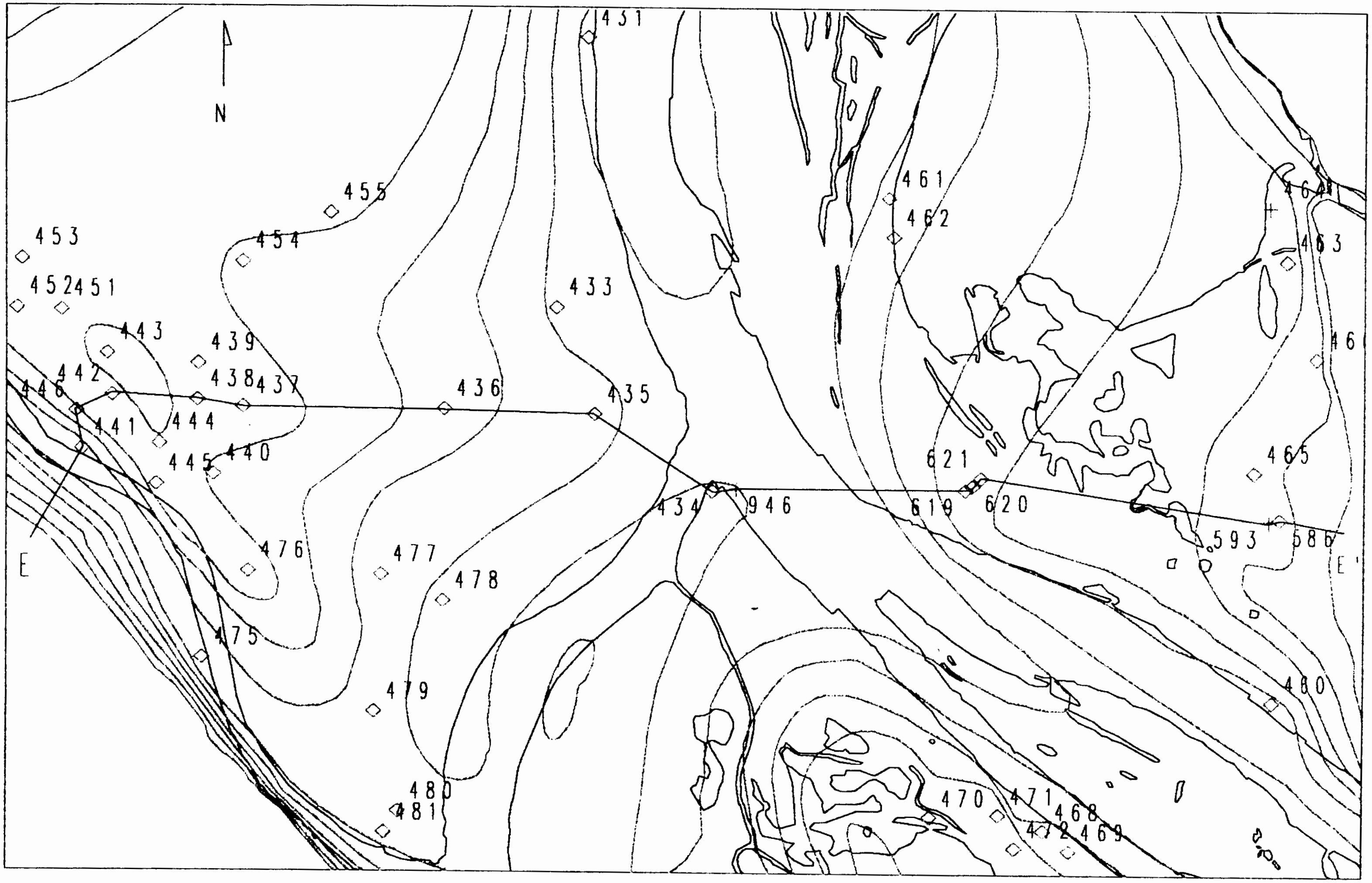

Figure 19. Burlington, Oregon to Vancouver, Washington cross-section location. Contour lines represent 10 meter isopach on Holocene and late Pleistocene fine-grained deposits.

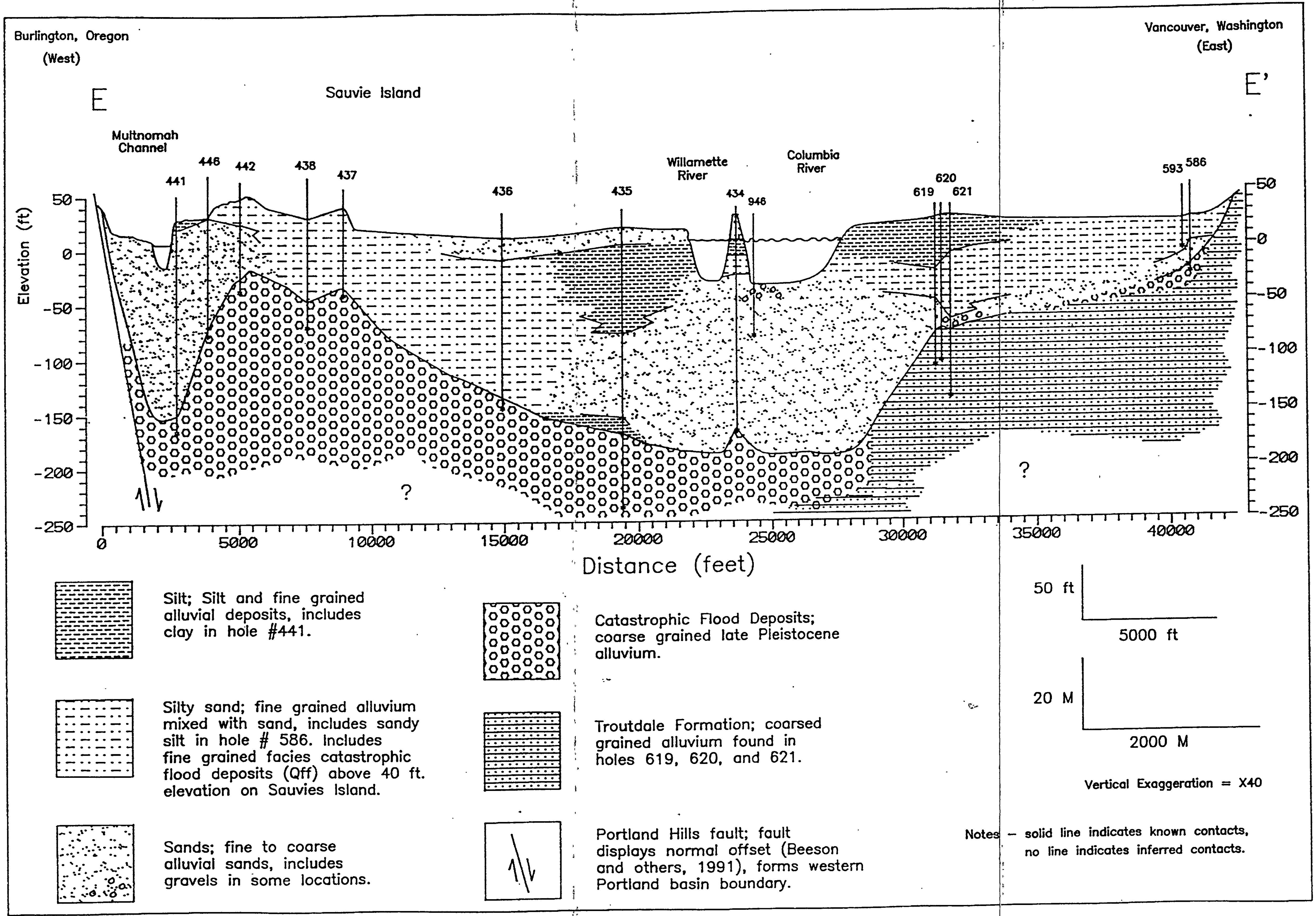

Figure 20. Burlington, Oregon to Vancouver, Washington cross-section.

boundary of the alluvial deposits just west of Multnomah Channel at the base of the Tualatin Mountains. The Portland Hills fault displays normal offset (Beeson and others, 1991). Beneath the medium and fine-grained deposits are extensive coarse-grained deposits of cobbles and gravels derived from the catastrophic floods that swept through the area during late Pleistocene time. Note that some of the fine-grained deposits overlying the coarse-grained deposits may have also been derived from the catastrophic floods, especially the areas above the 40′ elevation on Sauvie Island. Further discussion of these upper Sauvie Island late Pleistocene deposits appears later in the text. The position of the contact surface between the fine-grained deposits of the late Pleistocene deposits versus the Holocene fine-grained alluvial deposits is uncertain. The Troutdale Formation underlies much of the eastern portion of the lithologic profile. The Troutdale Formation has been mapped at the surface at the eastern end of the cross-section and was also identified in borings 619, 620, and 621, beneath the floodplain of west Vancouver, Washington.

In the Portland area, the two major Freeway bridges (I-5 and I-205) provide the best locations for cross-sectional profiles because of the continuity of the data. Both profiles show Holocene deposits of fine sands and lesser amounts of local coarse sands, gravels, and silts deposited on the underlying Troutdale Formation. In both cross-sections the

Troutdale Formation occurs at about -160 feet (-49 meters) msl on the south side of the river and extends beyond the limits of the profiles underneath the modern floodplain. To the north of the modern channel axis the Troutdale conglomerates rise to near surface elevations.

At the I-5 bridge site (Figures 21 and Figure 22) the contact with the late Pleistocene catastrophic flood deposits is at -150 feet (-46 meters) msl beneath Hayden Island. Fine sands are the dominant lithology of the Holocene fill throughout the entire cross-section. Coarse-grained sands and scattered gravels can be found just above the flood deposits beneath both the modern main channel and the Oregon Slough channel immediately south of Hayden Island. Fine-grained silts and clays with interbedded fine sands have been deposited throughout the Holocene under the former site of the city of Vanport on the southern floodplain.

The I-205 bridge cross-section location appears in Figure 23. The I-205 bridge cross-section (Figure 24) is quite similar to the I-5 bridge lithologic profile. Generally, the Troutdale Formation contact ranges from -80 feet (-24 meters) msl beneath the northern main channel to -180 feet (-55 meters) msl beneath the southern floodplain, in the vicinity of the Portland Airport, where the conglomerate pinches out, exposing a window of the Sandy River Mudstone Formation. Overlying the Troutdale conglomerate is a deposit of fine

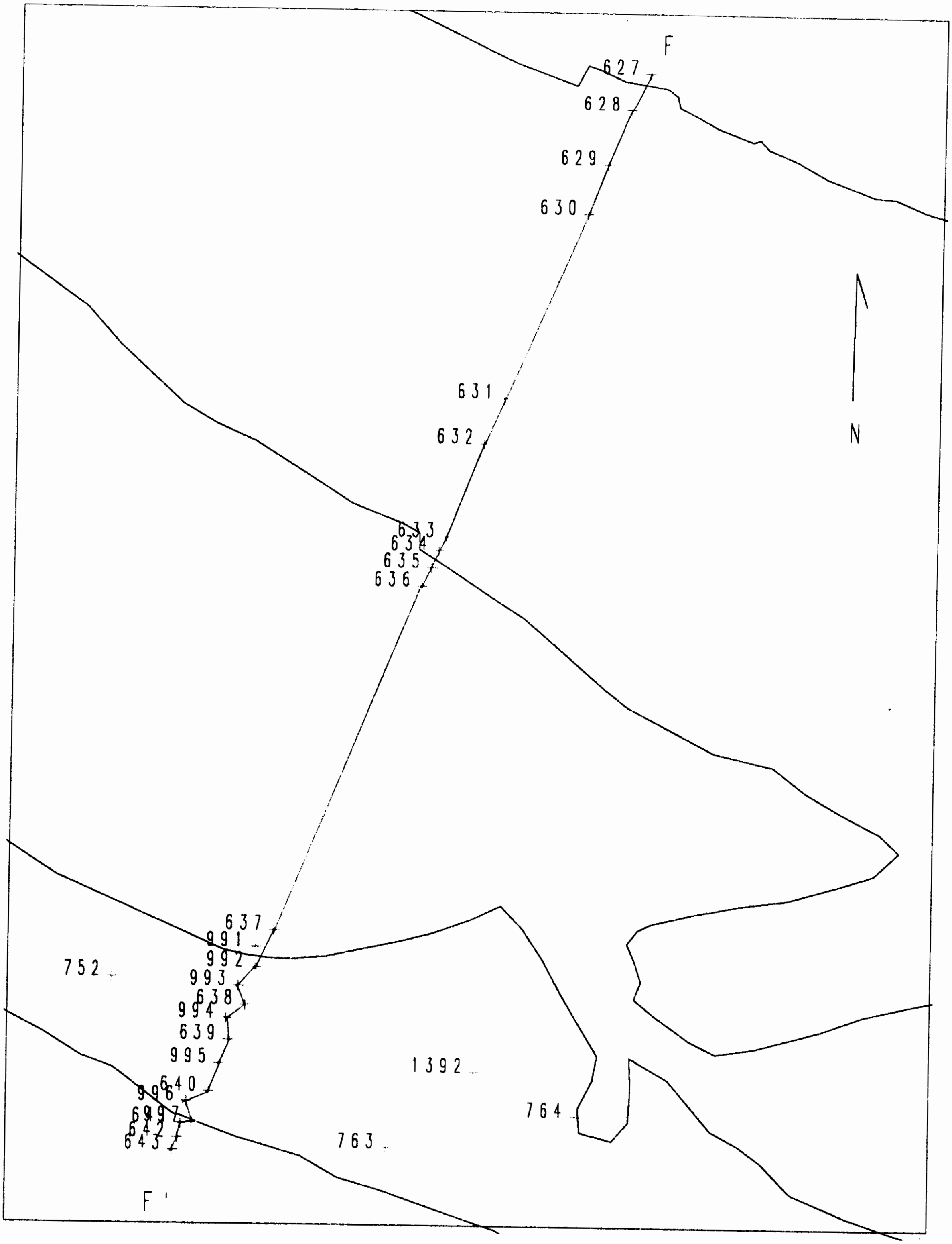

Figure 21. Location of I-5 and Oregon Slough bridges cross-section.

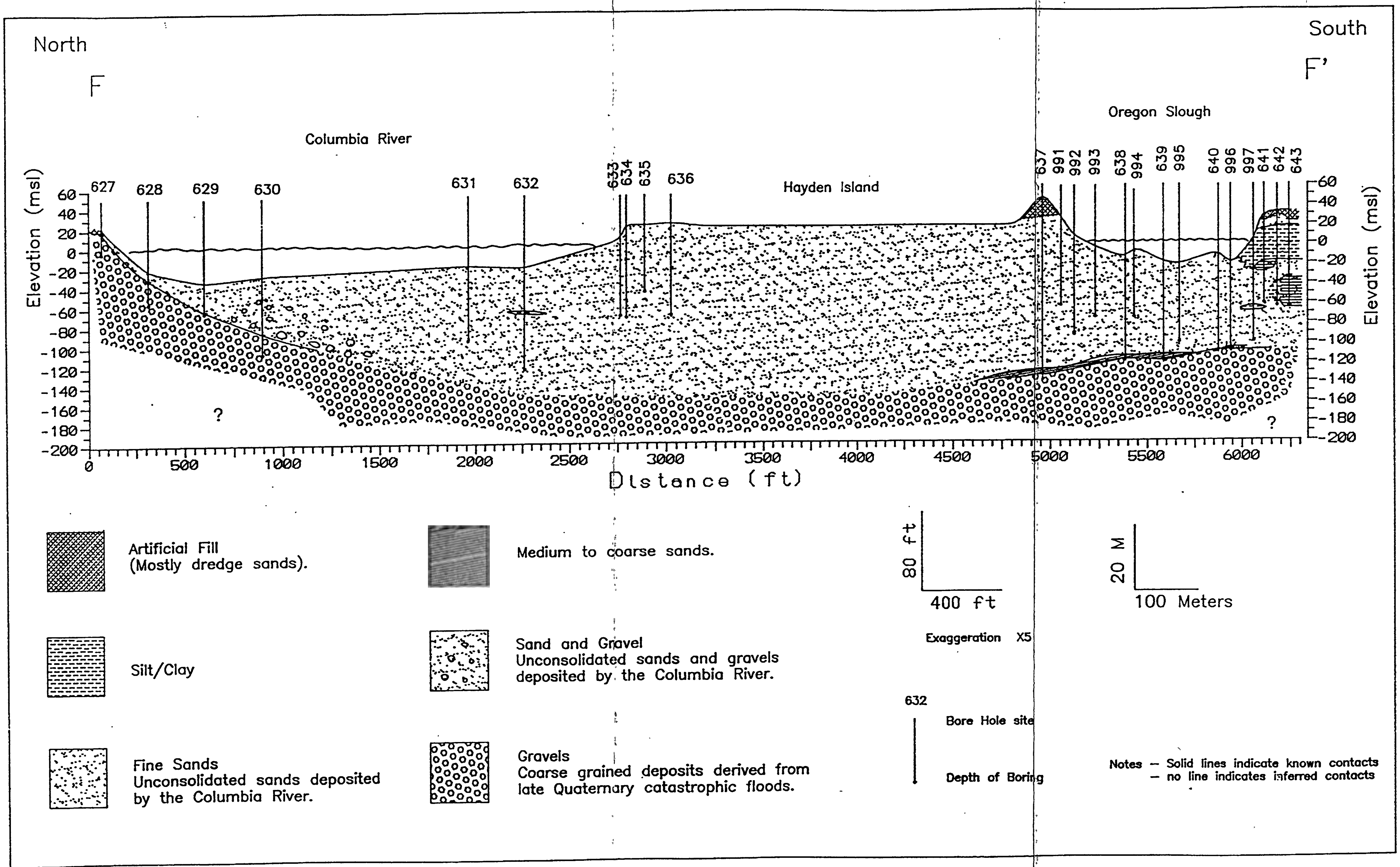

Figure 22. I–5 and Oregon Slough bridges cross–section.

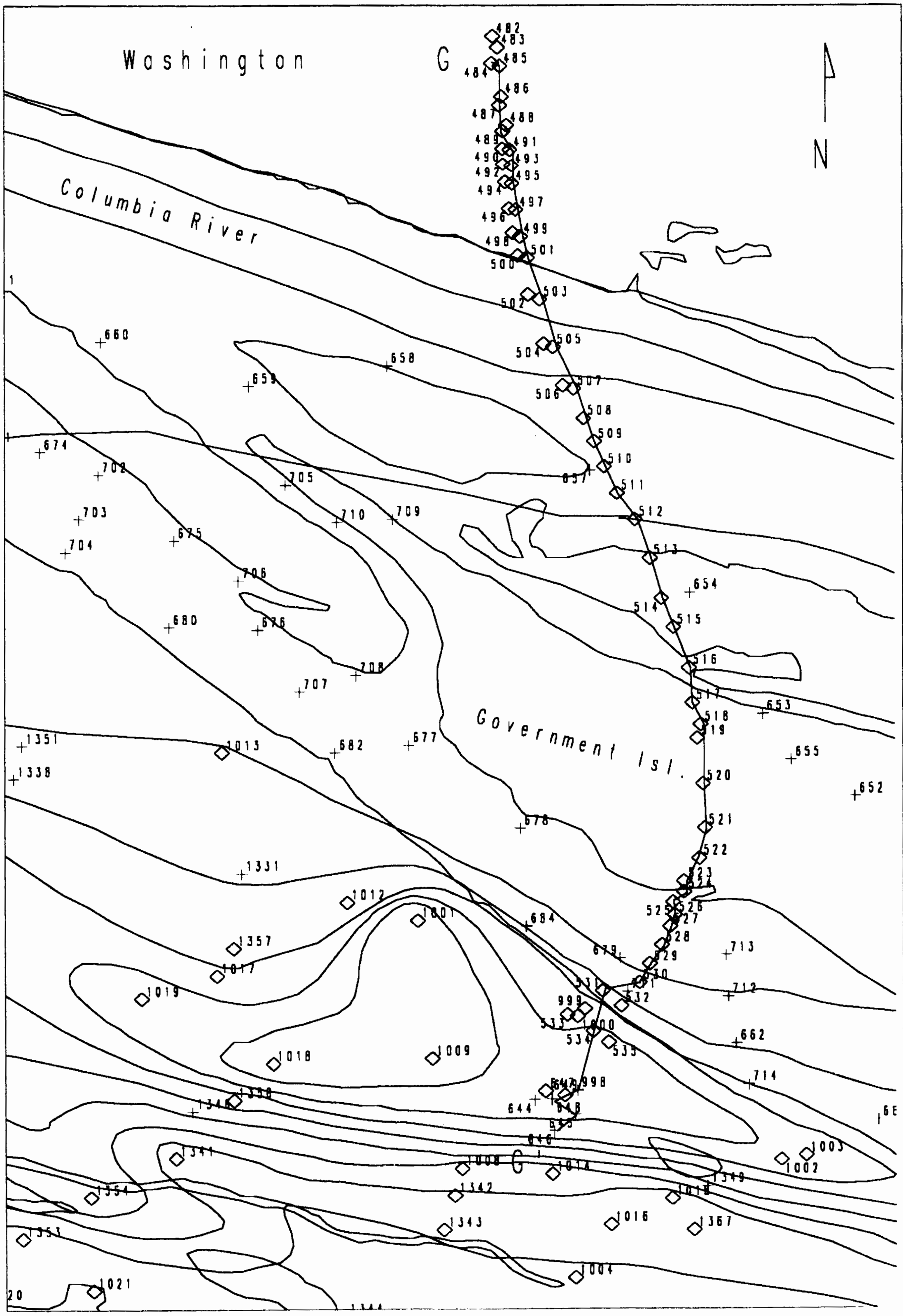

Figure 23. Location of I-205 bridge cross-section. Contour lines represent 10 meter isopach on Holocene alluvial deposits.

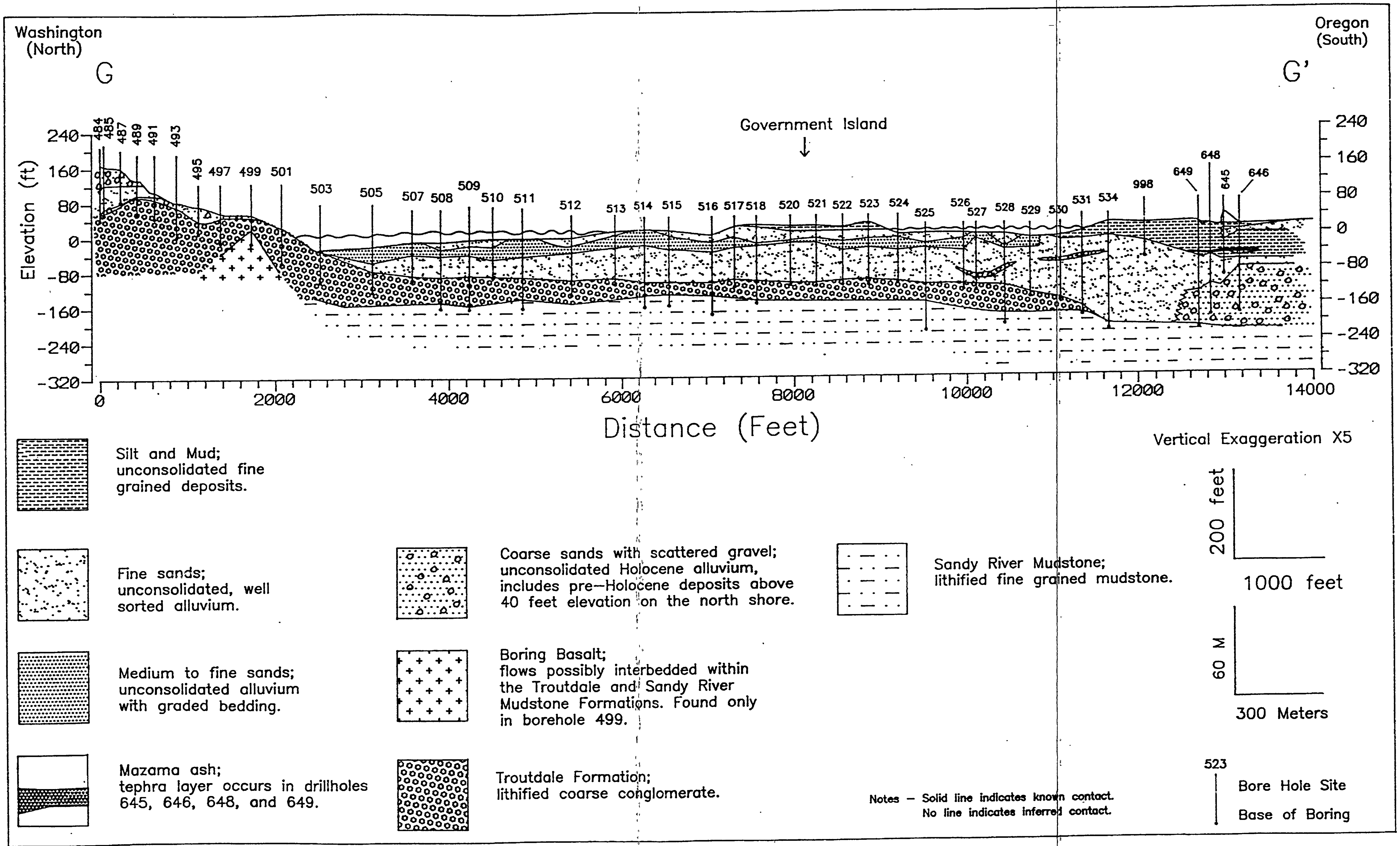

Figure 24. I-205 bridge cross-section.

sands the extends across the entire cross section. A 500 foot long gravel lens up to 10 feet in thickness is deposited within the fine sands beneath the modern southern channel just south of Government Island. Also notable is a sheet of medium sands that extends from 0 feet msl to about -40 feet msl all along the profile until it pinches out underneath the southern channel near Marine Drive. Silts and interbedded fine sands occur on the floodplain from Marine Drive south to the southern limit of the cross section. The Mazama ash horizon forms a thin deposit at -51 feet (-15.5 meters) msl beneath (borings 645, 646, 648, and 649) the southern floodplain sediments.

LITHOLOGIC GRAIN SIZE DATA

Analysis of grain size partitioning was performed for 54 of the borehole records in an attempt to delineate how much sand, silty sand, sandy silt, and silt, was distributed throughout the Holocene fill of the LCRB. Also, did grain size distribution change with respect to subsurface elevation within the basin? The data presented in Appendix D allows us to examine the percentages of sand, silty sand, sandy silt, and silt distributed for the length of each core log, and further partitioning of the sediments into elevation intervals allows us to inspect the lithologic variations with subsurface elevation. The results indicate that 54.7 % of the total LCRB sediments are sand size (or larger) sediments (> 0.075 mm);

17.5 % are silty sands; 14.8 % are sandy silt; and 13.0 % are silt size or finer (< 0.075 mm). The grain size distribution does not increase or decrease appreciably with respect to changes in subsurface elevation. Throughout the entire elevation range the sand sized grains are the dominant component of the infilling sediments. The percentage of silty sand, sandy silt, and silt, generally ranged from 5% to 25% for the respective subsurface elevation interval for each lithologic component. Never did the percentage of any one of the three finer components exceed the percentage of sand within the respective interval. Also, the percentage of sand was usually greater then 50 percent. The combined total of the other three components only exceeded the percentage of sand for the 0 to -33 feet (0 to -10 m), -164 to -197 feet (-50 to -60 m), and -197 to -230 feet (-60 to -70 m) intervals, and in these intervals the amount exceeded was minimal. This suggests that the Columbia River has had sufficient energy to transport and bypass sands and finer grained sediments through the LCRB throughout Holocene time. This also suggests that the Columbia River has functioned as a source of sands to the littoral zone rather than a sink during the Holocene period.

VOLUME OF BASIN FILL

The volume of Holocene fill in the LCRB was calculated for twelve depth intervals from the isopach maps. The

resulting sedimentary volumes for each interval appear in Table V.

Figure 25 is a plot of the cumulative volume of sedimentary fill (Km^3) plotted against the average depth below present sea level (in meters) for each depth interval. Also plotted is a best fit line that displays the volume increase with decreasing depth. The total volume of fill is calculated to be 74.57 Km^3 in the LCRB. This total volume of sediment infilling is most likely a conservative estimate because the western boundary for the isopach map was derived from extending a line from the southern tip of Cape Disappointment, across the main channel axis to Clatsop Spit, then projecting the line south, southeast through Warrenton Oregon where the boundary line intersects the most northwestern extent of the older Pleistocene terraces (Neim and Neim, 1985) in northwest Clatsop County. This southwest boundary intersection coincides with the 3500 year old shoreline of Rankin (1983) and nearly eliminates the Clatsop dunes region from being incorporated into the volume of fill estimate. Also, a seismic profile located at the mouth of the river suggests that the depth of sedimentary fill may be 130 meters as previously mentioned. The plot of cumulative volume of fill vs. depth below sea level (Figure 25) displays a nearly linear relationship. The above discussion of sedimentary infilling is primarily based on the cumulative volume of fill calculations and general observations from borehole records. To accurately assess the

TABLE V

HOLOCENE SEDIMENT VOLUME CALCULATIONS

Depth Interval m	Area (KM^3) Per Interval	Volume (KM^3) of total fill	Cumulative fill Volume (KM^3)
0-10	121.3	0.61	74.57
10-20	104.8	1.57	61.71
20-30	134.4	3.36	49.99
30-40	151.4	5.30	39.46
40-50	145.1	6.53	30.36
50-60	121.5	6.68	22.74
60-70	113.7	7.39	16.45
70-80	102.3	7.68	11.35
80-90	85.4	7.26	7.32
90-100	83.9	7.97	4.23
100-110	75.3	7.91	1.98
110-120	107.1	12.32	0.54
	1346.3	74.57	

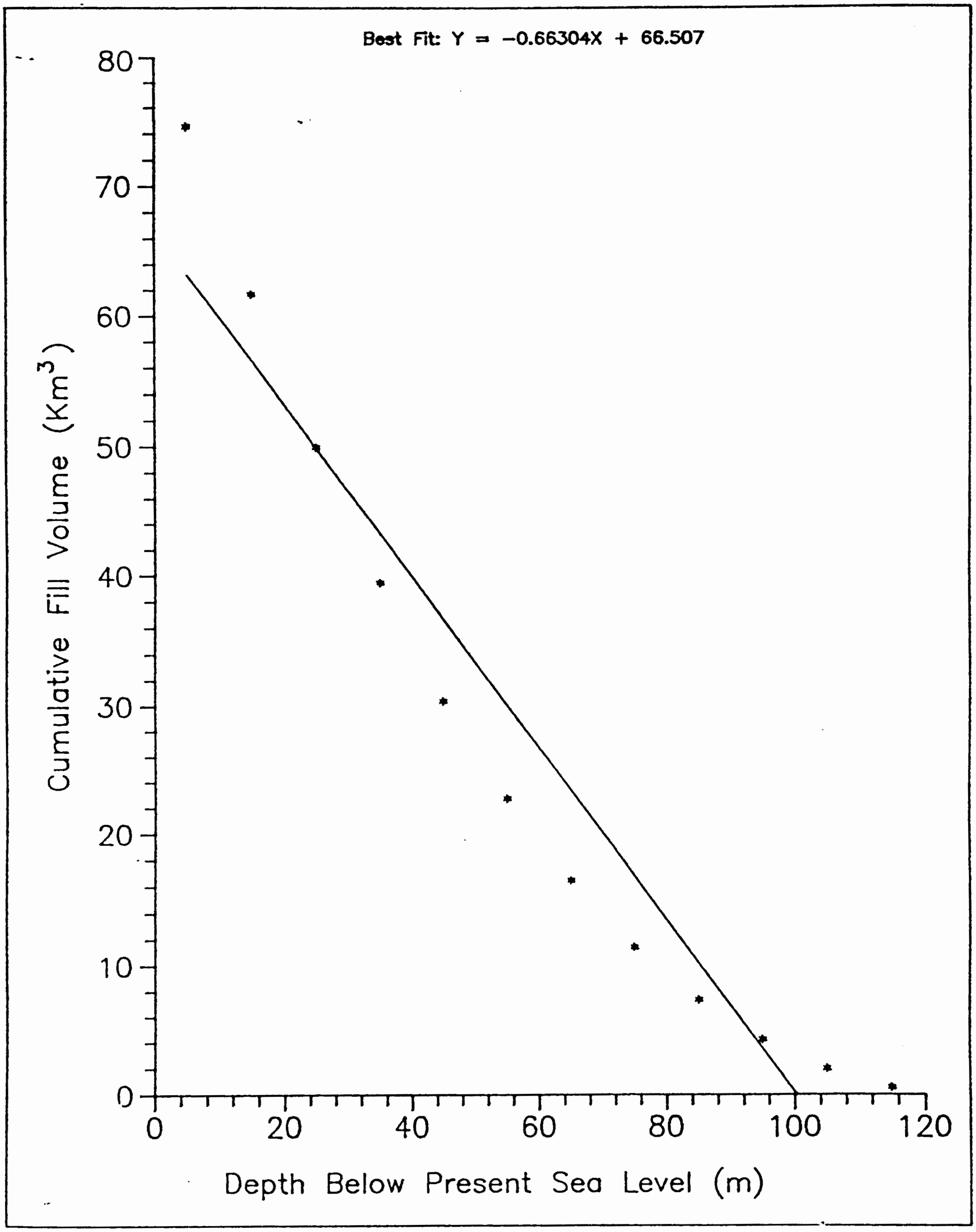

Figure 25. Volume of sedimentary fill vs depth for the lower Columbia River basin.

ratio of sediment accumulation through time in the LCRB it is necessary to address the rate of sediment accumulation.

RATE OF SEDIMENT ACCUMULATION

A total volume of 74.57 km^3 (7.457×10^{10} m^3) of sediment has accumulated in the LCRB since the time of the catastrophic floods, about 12 - 13 ka. This volume estimate gives us a useful measure for characterizing the rate of sediment infilling of the LCRB during the latest Pleistocene and Holocene time. These sediment accumulation rates allow us to address some important questions about the Columbia River fluvial system. (1) Do modern estimates of sediment discharge reflect the past records of sediment discharge? (2) What are the effects of flow regulation (dams, channelization, etc.) on the sediment discharge rate? (3) How might changes in sediment retention rate in the Columbia River have affected sediment supply to coastal areas adjacent to the Columbia River during the Holocene period?

A comparison of past retention rates versus present discharge rates can be calculated and compared in the LCRB. Table VI shows the calculated values for the comparison of present discharge rates verses depositional volume. A total volume of 7.457×10^{10} m^3 of sediment has been deposited in the LCRB since the last of the catastrophic floods. Waitt (1985) estimated the last flood event at 12,700 years bp. This corresponds to an annual depositional rate of 5.87×10^6 m^3/yr

TABLE VI

MODERN DISCHARGE RATES HINDCAST TO PAST DEPOSITIONAL RATES

	Discharge Annual Rates $10^6\ m^3\ yr^{-1}$	Deposition Annual Rates# $10^6\ m^3\ yr^{-1}$	Total Volume of Deposition $10^{10}\ m^3$
<u>CREDDP</u>			
1868-1934*	14.0	1.4	1.78
sand fraction*	7.0	0.7	0.89
1864-1981	11.8	1.18	1.50
sand fraction	5.5	0.55	0.70
<u>This Study</u>			
Total (12,700 yrs)	58.7	5.87	7.457
Pre Mazama (5855 yrs)	85.4	8.54	4.999
Post Mazama (6845 yrs)	35.9	3.59	2.458

Assumes 10% bedload, with 100% of bedload deposited within the system.

* Does include contributions from the Willamette, but not Cowlitz, Lewis, and other tributaries below Vancouver Washington. Willamette River contribution uses an average of 1.2 million tons yr^{-1} (based on USGS, unpublished data, WY 1963-1964 (Sherwood and others, 1990).

through the last 12,700 thousand years. Assuming that 10% of the total sediment load is bedload and 100% of the bedload is deposited in the LCRB system, this corresponds to an annual total (including suspended load) sediment discharge rate of 5.87×10^{7} m^{3}/yr. To further characterize the late Quaternary sedimentary deposition rates we can use the Mazama ash layer marker to partition the LCRB sedimentary fill into pre-mazama and post-mazama time periods. For example, we use the date of 6845 years bp (Bacon, 1988) as the time marker, and the 20 meter (65.6 feet) depth interval as the depth of the ash bed, (Appendix C) as the pre versus post Mazama fill volume depth horizon. For the pre-mazama time period the annual rate of deposition is $8.54 \times 10^{6} m^{3} yr^{-1}$. For the post mazama period the rate is $3.59 \times 10^{6} m^{3} yr^{-1}$ of sediment deposition. This shows a decrease in depositional volume by a factor of 2.38 from the pre-Mazama to post-Mazama time intervals. Peterson and Phipps (1992) performed a similar study at Grays Harbor, Washington. They calculated a four-fold decrease in average basin sediment accumulation rate between the early and late Holocene period for Grays Harbor. This study (Columbia River) calculated a 2.38 times decrease in sediment deposition rate for the late Holocene (post-Mazama) period.

In the CREDDP study Sherwood and others (1990) estimated the modern total sediment discharge rate (within historic

time, 1868-1981) for the Columbia River to be 1.13 X $10^7 m^3/yr$ (Tables II and Table III). The pre-regulation (1868-1934) sediment discharge rate is estimated to be 1.4 X $10^7 m^3 yr^{-1}$ (Table III). The sediment discharge rate from my basin fill calculation (5.87 x 10^7 m^3/yr) suggests that the prehistoric rate is larger by a factor of 4.97 times (relative to the CREDDP historic value) and 4.19 times (relative to the pre-regulation value). Factors of 4.97 and 4.19 times are substantial differences and these values show a major discrepancy between the reported modern discharge rates compared to the discharge rate derived from the geologic record. How can these differences in depositional rate be explained?

To address the differences between the modern discharge rate calculation and the geologic record calculation we need to look at the factors that influence each estimate. The CREDDP study (Sherwood and others, 1990) based its calculation on a heuristic model for predicting sediment discharge from riverflow measurements, and from direct measurements of sediment discharge along the Columbia River. Their value of 11.8 X $10^6 m^3$ yr^{-1} was calculated from hindcast measurements from water years 1878 to 1981 (see Table III). The estimate of 5.87 X $10^7 m^3/yr$ from this study is based on a total volume of 74.28 X $10^{10} m^3$ deposited over a period of 12,700 years and assumes that bedload is only 10% of the total sediment load

and that 100% of the bedload is deposited in the system. Both calculations have their strengths and weaknesses.

The primary strength of CREDDP's discharge rate calculation is that it incorporated direct measurements to augment their model. A major weakness is that the direct measurements were performed for a short period of time (1964-1970) and then incorporated into a model to project a longer period of time. Also, these measurements of sediment discharge rate and riverflow were performed during the historic period which has been a time of major river modifications such as irrigation removal, flow regulation, and dam construction for both the main stem of the Columbia River and along many of its tributary river systems. I note that the CREDDP values were not designed for projecting past prehistoric discharge rates. One of the major problems this study encountered is that the discharge rates reported for the Columbia River are barely sufficient to fill the known volume of the LCRB. To fill the basin using CREDDP values we need to assume amounts of deposition greater then 60% of the total discharge for the pre-Mazama period and amounts of deposition greater than 30% for the post-Mazama period. The lack of silt and clay in the Holocene fill argues against such large percentages of total sediment load deposition.

The primary strength of the discharge rate calculation from this study is that it incorporates the known volume of fill and sediment grain size distribution for the post

catastrophic flood period, therefore negating the short time interval used by the CREDDP study.

There are multiple possibilities for the discrepancies in discharge rate value for the brief historic record (CREDDP) value versus the longterm geologic record value (this study). The engineered features such as dam construction, flow regulation, and irrigation withdrawal could dampen the historic value. Flow regulation in modern times has reduced peak flow rates (floods) along the Columbia River and its tributaries when the river is capable of transporting the greatest amount of sediment. Conversely, flow regulation has increased the discharge rate during low flow periods. The geologic record discharge rate value suggests that past sediment discharge was most likely greater. Waitt (1985) noted that while the last catastrophic "large" flood was estimated to occur about 12,700 years ago, the 11,250 $\pm$ 250 Glacier Peak ash layer G (Table I) was overlain by smaller late stage floods that followed deglaciation of the Columbia River drainage basin. These late stage floods were capable of transporting and depositing sediment in the LCRB. However, back filling of the LCRB occurred in response to marine transgression, which did not significantly influence the LCRB until after 11,000 bp (Figures 7 and 8).

Another potentially major contributing sediment source to the LCRB that is accounted for in the volumetric analysis from this study, but not accounted for in the CREDDP estimates,

involves the contributions of infrequent yet catastrophic input of the Cascade volcanic eruptions and lahars. All of the values reported in Table III are measurements from Vancouver, Washington. This measuring station essentially records the eastern sub-basin sediment contributions, yet essentially eliminates the contributions from the Cowlitz, Lewis, and other tributaries down river from this station. The CREDDP study did use data (1963-1964 -one water year) for the Willamette River and projected that single year's data back in time for the cumulative time periods calculations. Simenstad and others (1990) reported that "although the coastal sub-basin (of the Columbia River, west of the Cascade Range) occupies 8% of the total drainage basin, it contributes 24% of the total riverflow due to the large excess of precipitation over evaporation, and the mild, wet winters." If sediment discharge yields are proportional to riverflow, the coastal sub-basin certainly contributes a significant, and partially unaccounted for, amount of sediment to the LCRB.

The May 18, 1980, eruption of Mount St. Helens shows how volcanic events can supply substantial amounts of sediment to the LCRB from these volcanic arc tributaries. Fairchild and Wigmosta (1983) estimated the amount of sediment in the mudflows that reached the Toutle and Cowlitz River confluence to approach nearly 100 X $10^6 m^3$ in volume. Schuster (1981) reported that 34 X $10^6 m^3$ of sediment accumulated in the Columbia River adjacent to the mouth of the Cowlitz River

immediately after the eruption, and the Cowlitz continues to contribute an unusually high rate of sediment to the LCRB. Table VII (Abby, 1989) lists the sediment discharge rate for the Cowlitz River following the 1980 eruption of Mount St. Helens.

The disproportionately high volume of sediment input to the LCRB following the 1980 eruption shows how past volcanic events can influence the sediment supply to the LCRB. Throughout the Holocene period many volcanic events have input large amounts of sediment to the LCRB, as shown by the Mazama ash bed occurrence. Table I lists past late Quaternary volcanic events that have erupted "large volumes" of tephra. Certainly, even lesser eruptive events, not listed in Table I, from local Cascade volcanos have input substantial amounts of sediments into the basin. Also these large amounts of sediment influx can most likely endure for decades (or longer through reworking) before the local fluvial system returns to its normal sediment discharge level.

An alternative hypothesis for the large discrepancy in the modern versus geologic records based discharge rate values is that the LCRB functioned as a sink and received substantial amounts of sediment from the marine environment during the early stages of the marine transgression. However, evidence for this hypothesis is not substantial. The dominance of sand sized sediments throughout all depths of the LCRB suggests

TABLE VII

SEDIMENT CONTRIBUTION OF THE COWLITZ RIVER TO THE COLUMBIA RIVER AFTER THE 1980 ERUPTION OF MOUNT ST. HELENS

Sediment yield (10^6 m^3)

Water Year	Total	Bed Material	Bed % of Total
1980	30.6	N/A	N/A
1981	N/A	N/A	N/A
1982	17.59	0.76	4.3
1983	16.06	2.29	14.3
1984	7.65	1.53	20.0
1985	4.59	1.53	33.3
1986	3.82	1.53	40.0
1987	3.82	1.53	40.0

Where bed material is grains larger than very fine sand (>0.125 mm, excluding very fine sand).

that sufficient energy for fluvial depositional processes has allowed for throughflow of river sediments to the marine side throughout the Holocene marine transgression.

The effects of past and present sediment supply from the Columbia River system to the adjacent marine environment can also be assessed independently. Rankin (1983) showed that the shoreline along the northern Oregon coast at 3500 years b.p. had moved eastward with the marine transgression and was up against the uplifted Pleistocene terraces. Since that time the shoreline has prograded westward to form Clatsop Spit. This shoreline progradation shows that there has been a sufficient amount of Columbia River sediment to supply the adjacent coastline since 3500 years bp. Also, Peterson and Phipps (1992) indicated that the barrier spit in Grays Harbor, Washington, is supplied by Columbia River sands and has been accreting vertically for the last 9000 years. This further supports the idea that the Columbia River has been a source of sands to nearby coastal areas rather than a sink.

To accurately assess the rate of sediment accumulation a sediment level verses age curve needs to be constructed.

A preliminary late Holocene sediment level curve for the LCRB appears in figure 26. Table VIII lists the dates used in figure 26. Note that the two oldest dates are based on the age of geologic occurrence as opposed to radio-carbon dates.

Three trends are plotted in figure 26. The curved line

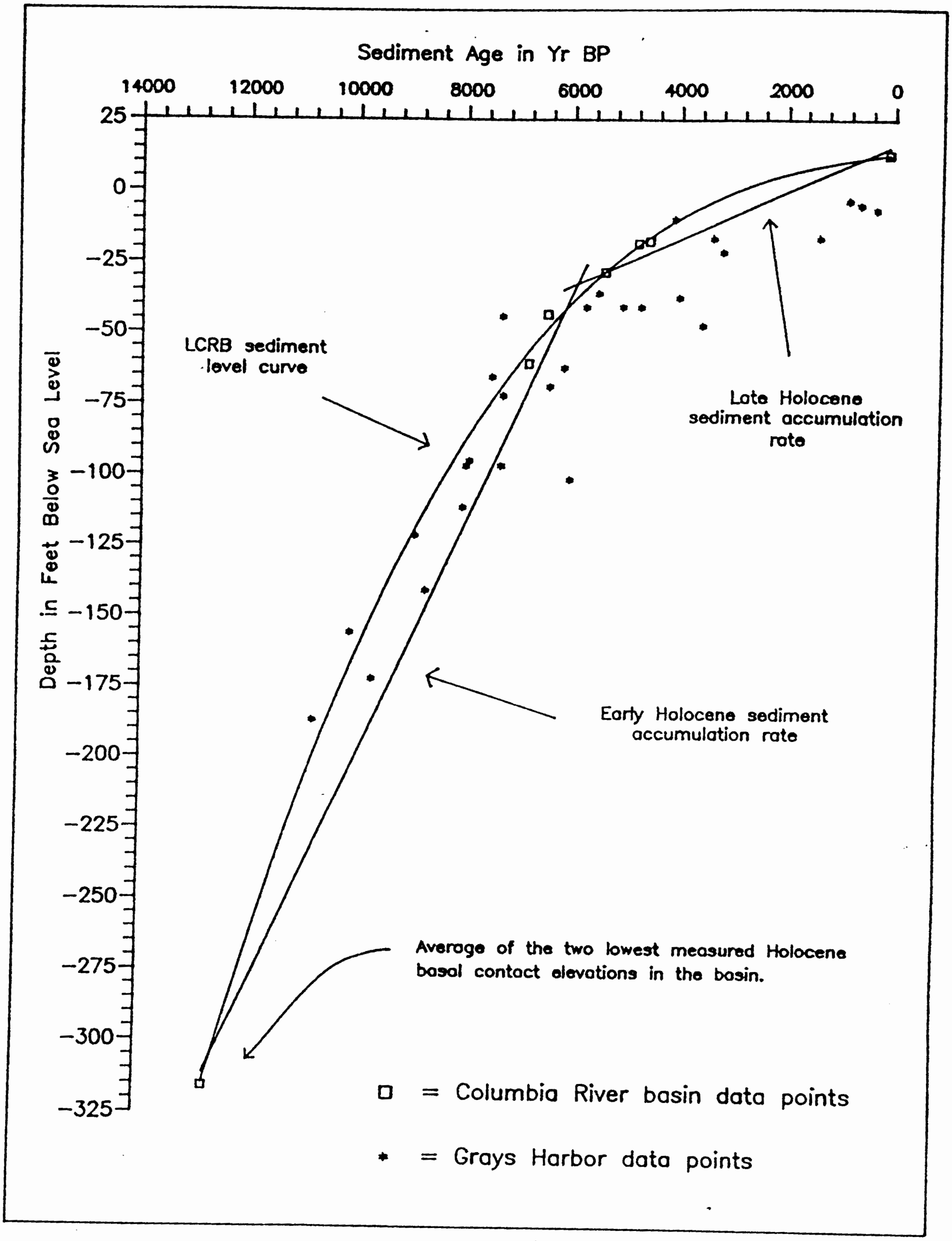

Figure 26. Predicted sediment age-level curve for the lower Columbia River basin (boxes) compared to Grays Harbor sediment depth-age data (asterisks).

TABLE VIII

SEDIMENT AGE ELEVATIONS

Site	Date (RCYBP)	Elevation ft (msl)
564[a]	100 ±70	+12.87
564[a]	4590 ±70	-17.58
*	4800 ±90	-18.5
*	5420 ±100	-28.5
*[b]	6490 ±100	-43.5
Mazama[c]	6845	-60.96
262&260[d]	12,700	-316.0

* Data from P.E. Hammond (1975). Samples from two different boreholes on the west bank of the Willamette River north of Linnton Oregon.

[a] Sample from borehole near N. Marine drive, Portland, Oregon.

[b] Sample from carbonized wood within a Mazama ash layer.

[c] Average elevation for all of the Mazama ash data points. RCYBP from Bacon, 1983.

[d] Elevation is an average from these two boreholes and represents the two lowest known contact elevations. RCYBP date from Waitt, 1985.

that extends through the boxed points is the apparent sediment level curve for the LCRB. The lower straight line segment represents the slope of sediment accumulation rate for the pre-Mazama time period. The upper straight line segment represents the sediment accumulation rate slope for the post-Mazama time period. The square boxes are data points from the Portland basin area of the LCRB. The smaller points (asterisks) are data points from Grays Harbor that Peterson and Phipps (1992) used to construct a similar sediment level curve for that estuary. Note that generally the Columbia River points (boxes, 0-7 ka) plot at a slightly higher elevation for a given depth, than the Grays Harbor estuary points. This relation is likely due to higher average elevation of the fluvial flood plain in the upper reaches of the LCRB, as compared to the tidally dominated depositional system of the Grays Harbor estuary. As previously mentioned, the upper five points of the LCRB data points were determined by radio-carbon dating methods. The second to lowest box point is plotted from the average elevation of all the Mazama ash points (Appendix C) versus the age of the Mazama eruption at 6845 years ago (Bacon and Druitt, 1988). The lowest boxed point at -316 feet (-96.3 m) and 12,700 years bp, is an average from the two lowest elevations in boreholes 260 and 262 (Appendix B) in Longview, Washington and near Kalama, Washington respectively, and represents the lowest elevation occurrence for the Holocene contact in the upper basin of the LCRB. This point

was used as a reference marker for the Columbia River base level at the onset of the Holocene marine transgression in the LCRB. Note, these two base level points are greater then 60 miles (97 km) inland from the modern river mouth location. Most likely the base level was lower in the lower river reaches.

The shape of the sediment level curve for the LCRB closely resembles some eustatic sea-level curves reported for the Holocene (Atwater and others, 1977; Glenn, 1978; Kraft, 1971; Peterson and Phipps, 1992; Figures 7, 8 and 9). The curve shows a steep rise during the early Holocene period followed by a significant decline in the sedimentation rate during the late Holocene. The lower line segment (early Holocene) slope corresponds to an accumulation rate of 12.6 mm/yr. Peterson and Phipps (1992) calculated a similar 12 mm/yr accumulation rate for the Grays Harbor estuary. The upper line segment represents the late Holocene sediment accumulation rate. The slope of this line corresponds to a rate of 2.5 mm/yr. A comparison of the two sediment accumulation rates shows that the post-Mazama (late Holocene) sediment accumulation rate declined by a factor of five times versus the pre-Mazama, early Holocene, rate in the LCRB.

There is still much uncertainty as to the level of fluvial-esturine deposition throughout the LCRB. Additional C^{14} age data needs to be collected for the sediment levels within the LCRB, especially in the lower reaches of the estuary, and

throughout the basin below the depth of the Mazama ash layer. These data are needed to further evaluate the predicted sediment level curve from this study and to constrain sedimentation rates in the different portions of the basin.

DISCUSSION

Within the Columbia River estuary Holocene fill, the Mazama ash layer provides a regional key stratigraphic interval that roughly divides the sedimentary deposits into early and late Holocene time. This time interval, about 6845 years bp, is particularly important as it roughly corresponds to a major change in rate of sea level rise (fast: greater than 7000 years bp, slow: less than 7000 years bp).

The primary chronostratigraphic marker bed is the Mazama ash layer. No previous literature for the ash bed has been published. Geochemical analysis of the ash layer has been compiled by Dr. Marvin Beeson (Portland State University), Dr. Larry Kittleman (University of Oregon), and by the author for this study.

MAZAMA ASH GEOCHEMISTRY

The results of the tephra source analysis shows that the suspect Mazama ash horizon is indeed derived from the climatic eruption(s) of Mount Mazama 6845 years ago. Appendix A contains the geochemical data tables (Tables A-1 and A-2) and graphs (Figures A-1 through A-16) used for analysis. The circled fields labeled "Mazama Ash" and "Mt. St. Helens tephra" in Figures A-1 through A-16 (Appendix A) are for the

samples known to have been derived from these two potential source volcanos.

Rare earth elements are normally somewhat concentrated in glass relative to co-existing crystals, and it is unlikely their abundances would be significantly modified by weathering processes (Randle, and others, 1971). Therefore, La, Ce, and Sm should be good discriminants judging from the distinctive ranges in tables A-I and A-II. One should note that to a first approximation the elements of this group are coherent. Plots A-1 through A-6 (La vs Sm, Ce vs Sm, and La vs Ce) of Appendix A clearly display that both the Portland area and Longview/Astoria area ash occurrences are distributed around known Mazama ash points. Clearly these points were not derived from Mount St. Helens or Glacier Peak tephras because they all contain higher concentrations of Lanthanum, Samarium, and Cerium, yet the rare earth elements do not distinguish the suspect ash samples from the sediment found in the Portland basin.

Thorium is also a useful discriminant in ash samples. Th is also concentrated in glass relative to co-existing crystalline phases. Unlike the situation in holocrystalline rocks, where this element may be located at grain boundary sites and readily removed during weathering, Th in these ash samples would probably not be leached out easily due to its low geochemical mobility (Randle, and others, 1971). Its abundances vary from one group of ashes to another but the

ranges in a particular set are narrow. The thorium contents of the Mt. St. Helens and Glacier Peak sample provide a clear distinction between these two sets and the Mazama ash in our data (plots A-7 & A-8).

Hafnium (plots A-9 & A-10) also seems to be useful. Like Thorium, it is concentrated in glass and would not be expected to be mobilized during weathering. Hafnium is also useful for distinguishing the ash samples from the Portland area sediment and Glacier Peak tephra because all of the ash samples show a higher concentration of Hafnium compared to the sediment and Glacier Peak tephra. The Hafnium vs Thorium ratios also show a coherent grouping around the known Mazama points.

The transition metals Co, Fe, and Sc are all concentrated in crystalline phases relative to glass. Therefore, these elements best distinguish the separation of the ash samples from the sediment sample and the near source Mount St. Helens sample set. Plots A-11 through A-16 display that the ash samples had generally lower concentrations of iron, cobalt, and scandium. On the basis of transition metal element concentrations the Portland, Longview, and Astoria area ash occurrences can be distinguished from the Mount St. Helens set of ashes and also suggest that these samples were not derived from the reworking of previously deposited sediments.

Based on the above observations the ash samples from the borings in the Portland, Longview, and Astoria regions were

certainly derived from Mt. Mazama as opposed to either a Mt. St. Helens or Glacier Peak source.

Analysis of the target ash layer indicates that it was derived from the climatic eruption of Mount Mazama 6845 years ago. The data in Appendix A show little geochemical variability between the data points from individual sample sets. Also, there is little variability between sample sets from the different analysts. This lack of variability indicates that results show good geochemical correlation between multiple analysts in independent experiments. The significance of identifying the geochemical character of the ash bed in the LCRB allows it to be used as a marker horizon. Combined with its widespread distribution and known age of deposition, it can be used as a key chronostratigraphic marker within the Holocene deposits of the Columbia River basin.

ANCESTRAL RIVER VALLEY MORPHOLOGY AND BASIN FILL

The basin isopach maps (Maps 1 through 4) display the sedimentary infilling and subsequent morphology of the LCRB and the adjacent tributaries. The maps (especially Map 1) illustrate the generally narrow river valley and steep incised slopes along the lateral margins of the valley. This narrow channel axis form suggests that the Columbia River has been confined to its present incised canyon with only minor lateral migration.

The isopach maps show some very intriguing subsurface features. Depths below the 110 meter contour represents the maximum thickness and lowest elevation occurrences for the Holocene alluvium. The base elevation of nearly -120 meters is consistent with pre-Holocene lower global sea level stands during the late Pleistocene (Bloom, 1983). Also, known late Pleistocene contacts from boreholes at nearly -100 meters msl occurring more then 60 and 70 miles upriver (Longview and Kalama, Washington) give supporting evidence for a Holocene base level near -120 meters msl in the lowest portions of the LCRB. The isopach contours also show that the Columbia river has excavated a deep valley with steep lateral margins prior to deposition of the Holocene alluvium.

In the vicinity of Longview, Washington, the Cowlitz River is a major tributary of the Mount St. Helens area, capable of transporting large volumes of primary or reworked volcanic debris to the Columbia River system. The Cowlitz River delta at Longview shows evidence of progradation out into the Longview basin. The isopach contours (Map 2) show that the former Columbia River channel axis flowed beneath the present site of Longview on the modern Cowlitz River delta. The timing of the Columbia River channel shift to the southern margin of the Longview basin is uncertain but probably coincided with the eruptive sequences (Table III) that deposited the Set J (8300 $\pm$ 300 bp) tephras or during the Set

Y (3350 - 3510 $\pm$ 240 bp) and/or Set P (2580 - 2930 $\pm$ 250 bp) eruptive sequences.

Also of note in the vicinity of Longview, Washington, the drill holes penetrated a series of small basalt knobs. The knobs trend in a northwest to southeast alignment which suggests the presence of a structural trend, possibly a fault. The knobs appear to have a streamlined form with their long axis parallel to the direction of riverflow. The streamlined form is likely the result of scouring by lower river elevations (down cutting) and/or the catastrophic flood events that swept through the Longview basin during the late Pleistocene. Also of note is the deep (>60 m) channel just north of Mount Solo in Longview. This channel could represent the presence of a bifurcation of the main channel axis around Mount Solo caused by either the catastrophic floods or subsequent flow of the early Holocene Columbia River.

Similar to the Cowlitz River system in Longview, the Lewis River delta near Woodland, Washington has also prograded out into the Columbia River valley. Map 3 shows that the present position of the Columbia River channel occupies the western margin of the valley. But, the isopach contours suggest that the Columbia River formerly occupied the central valley axis flowing underneath the present location of the modern Lewis River delta. Timing for this lateral channel shift is uncertain but it most likely occurred during progradation of the Lewis River delta during the Mount St.

Helens eruptive Set J, Set Y, or Set P, eruptive sequences as stated above.

In the Portland area the isopach data (Map 4) suggests both scouring and depositional features. Along the western margin of Sauvie Island (Maps 3 and 4) the isopach contours show a shallow (10-20 meters beneath the surface) gravel bar aligned in a northwest direction parallel to Multnomah channel that curves northeast near the middle of the island. The drill holes all penetrated coarse grained sediment described as "gravel, cobbles" and occasionally "boulders". This gravel bar may represent an extension of Alameda Ridge in north Portland, a deposition remnant from the catastrophic Bretz flood events. The isopach data indicate a deep channel (greater than 50 meters) beneath the modern Multnomah Channel near the southwest shoreline of Sauvie Island. This channel combined with the gravel bar immediately north (and parallel) to the channel suggests that a portion of the Willamette River may have occupied this deep channel either during, or immediately following, the catastrophic floods and subsequently breached the gravel bar to occupy its present channel shortly thereafter. Also, the sediments deposited upon the Sauvie Island gravel ridge could possibly represent late Quaternary fine grain facies sediments deposited by the winnowing flood events. Evidence for this idea is suggested by the high topographic position of the sediments. The finer sediments deposited on the gravel bar reach elevations exceeding 50 feet

(15 meters) above modern msl, peak island elevations reach 70 feet (21 meters) msl. Previous geologic mapping in the Portland basin area has mapped the upper Sauvie Island surface as "Qal" (Trimble, 1963), but historic flood data from the U.S. Army Corps of Engineers indicates that flood elevations have only reached 32.8 feet (1948) and slightly greater during the 1894 flood event. The presence of alluvial sediments above the 50 foot elevation suggests that either pre-historic floods in the Portland Basin have reached above this elevation, or that the sediments deposited on the Sauvie Island gravel bar may actually represent fine-grained facies (Qff) deposits from the late Pleistocene floods. Archeological evidence from recovered artifacts suggests that native Americans were present at least 4,500 years ago on the upper elevations of Sauvie Island. This evidence is based on "artifact form and technology" (Ken Ames, Personal Communication). This archeological evidence further supports my interpretation is that these deposits represent the fine-grained facies deposits from the catastrophic floods. These deposits also show how difficult it is to distinguish between modern flood alluvium and catastrophic flood alluvium based on grain size alone. This example gives a surface analog to a potential problem that may be occurring at depth; how, and where, does one define the Holocene boundary when coarser grained deposits are not present. I should also note that this area is the only

region within the study area where the upper isopach surface exceeds 40 feet in elevation.

Map 4 also shows the presence of another shallow gravel bar beneath the present location Smith and Bybee lakes in north Portland. The gravel ridge is about 20 to 30 meters below the modern surface level and is aligned parallel to Alameda ridge. This gravel bar is most likely a depositional feature left by the catastrophic floods. The occurrence of coarse-grained facies deposits beneath Sauvie Island and north Portland illustrate the potential for possible large volume aquifers buried beneath the Holocene sediments. Yet, the question of water quantity and quality from these potential aquifers awaits further investigation.

Map 4 shows the presence of two deep (greater than 60 M) channels beneath the Rivergate area of North Portland extending up the Willamette River drainage system. Either or both of these channels may represent the location where the Willamette River breached the northwestern extension of Alameda ridge.

In the area near the southern extension of the I-205 Bridge the isopach contours indicate the presence of a deep (80+ m) scour channel. This channel extends from the borings immediately east from the south end of the bridge and extends westward underneath the Portland Airport where it broadens out and shallows to the level of the main valley floor. Whether this channel is an erosional remnant from the catastrophic

floods or was formed by the early Holocene Columbia River awaits further investigation. But this feature does suggest a break in slope for the incised lower Columbia River valley because the isopach data indicate that upriver from the scour channel the sediment thickness only reaches depths to 40 meters.

Inspection of the cross sections and sediment partition data (Appendix D) shows that fine sands have been the dominant grain size deposited throughout the lower, middle, and upper portions of the drill core logs. This trend is fairly uniform for the cross sections and is independent of their position relative to the eastern and western portions of the study area. This uniform grain size partitioning suggests that the finer silt and clay size sediments have almost entirely bypassed the lower Columbia River system throughout the Holocene transgression. While local deposits of fine-grained silt and clay size sediments are apparent, their distribution as lenses and thin beds suggests that subsequent channel migrations may have scoured them out during subsequent lateral channel migrations. Sediment bypassing also supports the idea that the lower Columbia River has remained in a nearly stable energy regime and that during Holocene sea level rise. The valley was not a quiet standing body of water dominantly influenced by rapid sea level rise but, rather, an energetic system capable of continuously transporting sediment into and through the lower river basin. If sea level had outpaced

fluvial infilling, there should be extensive deposits of fine sediments at depth in the lower river valley, but that is not indicated by the drill hole logs, or the sediment partition data. Furthermore, the dominance of sand throughout the length of the lower Columbia River valley indicates that fine sand has also been bypassed through the system' throughout Holocene time. These results are consistent with reports of the Clatsop spit progadation (Rankin, 1983) after a decrease in the rate of sea level rise after 7,000 years b.p.. The indications that the Columbia River has been bypassing sands to the marine environment throughout the Holocene is also consistent with the development and vertical growth of the barrier spits at Grays Harbor (Peterson and Phipps, 1992).

The rate of LCRB infilling decreased by more than 50% from the pre-Mazama to post-Mazama time interval (Table VI). The depth vs fill volume plot displays a near linear relation, suggesting that sediment deposition rate changes were not due to non linear trends of basin volume with depth. Two primary factors could cause the dramatic decrease in sediment depositional rate after 7,000 years bp: (1) a decrease in sediment supply rate or (2) a change in sediment retention rate. A major climatic change in the Pacific Northwest should have closely followed the end of glaciation in the latest Pleistocene-early Holocene time possibly supplying more sediment at the end of glaciation. However, a major decrease in the rate of eustatic sea level rise occurred in the early-

middle Holocene time at about 7,000 years ago (Bloom, 1983). A decreasing rate of sea level rise could have resulted in a shallowing of the LCRB and bypassing of bedload sediments through the LCRB to the coastal zone. Although additional sediment-level/age curves are needed for the LCRB to discriminate between these two possibilities, the latter is presumed here, primarily due to the predominance of bed load (sand) deposited throughout the Holocene period. Bypassing has apparently been occurring throughout the Holocene period. Therefore, the controls on sediment throughflow appear to dominate sediment deposition rather then variable sediment input. In any case, the sediment accumulation rates are likely to underestimate the sand supply to the LCRB. The dominance of river sand throughout the length of the basin implies significant throughflow of this size fraction throughout the Holocene. The lack of accumulated silts and clays shows that these finer fractions were never effectively trapped in the fluvially dominated LCRB. Estimates of prehistoric total discharge, based on an assumed 10% bedload, are also likely to under represent actual total sediment discharge, unless bedload accounts for more then 10% of the total sediment discharge.

The apparent sediment bypassing through the LCRB through Holocene time indicates that the lower Columbia River is not similar to the tidally dominated depositional systems that occur in Grays Harbor and Tillamook Bay. The lower Columbia

River basin has been a fluvially dominated system throughout the Holocene. The relative base level for fluvial deposition has kept close pace with the rise of the Holocene marine transgression and continued to bypass fine grained sediments. The rate of sediment bypassing has increased in reciprocal proportion to the decrease in sea level rise.

CONCLUSIONS

The lower Columbia River basin Holocene sedimentary deposits record the post catastrophic flood stratigraphic development of the river basin during the Holocene marine transgression in the Pacific northwest. From the infilled sedimentary deposits I have recorded the following information: 1) the occurrence of a key chronostratigraphic marker horizon, the Mazama ash bed, and measurements of its thickness and stratigraphic position. 2) A database (Appendix B) of 1487 borehole records has been compiled. This database gives adequate control for construction of four isopach maps that record the depth and volume of infilled sediments for the LCRB. 3) Information derived from this database gives an image of the subsurface basin morphology and the position of the underlying pre Holocene contact surface. 4) Borehole sediment grain-size partitioning has been performed to delineate the general overall vertical grain-size distribution within the LCRB sedimentary deposits. 5) A sediment age-level curve has been constructed, and rates of infilling have been calculated. Finally, 6) we can use the above information to comment on the sediment supply and retention rate, and how these inputs have been affected by the marine transgression during Holocene time.

The Mazama ash bed occurrence has been identified in 197 boreholes from throughout the LCRB. The ash bed appears in the floodplain sediments of both Oregon and Washington, and extends from Troutdale, Oregon downriver to Warrenton, Oregon. Sedimentary characteristics indicate the ash bed was deposited by fluvial processes in a floodplain environment. The borehole records indicate that the average elevation for the basal contact is -61.0 feet (-18.6 meters).

INAA geochemical data from multiple analysts in separate experiments identifies the source of the suspect ash bed. The comparisons indicate the suspect ash to be derived from the climax eruption of Mount Mazama 6845 years ago. Identification of this key marker bed gives a time horizon that allows us to partition the LCRB sedimentary deposits into two distinct time intervals; the pre-Mazama and post-Mazama time periods. This ash bed indicates the average floodplain elevation at the time of deposition.

A comprehensive database (Appendix B) of 1487 borehole records from throughout the LCRB has been compiled. This database gives us sufficient control for delineating the depth and extent of subsurface lithologic contacts for the Mazama ash bed and the Holocene basal contact.

The database was used to construct four isopach maps that show the widespread distribution of the boreholes and resulting isopach contours. The isopach maps display some intriguing subsurface features. The Columbia River valley

morphology reveals that the river was capable of down cutting a deep incised valley with steep walls prior to the deposition of Holocene sediments during the subsequent marine transgression. The erosional process responsible for downcutting the pre Holocene surface must have been the late Pleistocene Columbia River and culminated about 12,700 years ago with the catastrophic floods. On a local scale, some of the prominent subsurface features displayed by the isopach maps are as follows: 1) The shallow basaltic bedrock knobs that occur beneath the western floodplain of Longview, Washington. These knobs are probably erosional remnants (similar to Mount Solo) formed by the catastrophic floods that swept through the area during latest Pleistocene time. The linear northwest to southeast alignment suggest the possibility of a structural trend (fault?) that runs parallel to these bedrock knobs. 2) The Cowlitz River is one of two major tributaries that originate near Mount St. Helens. It enters the Columbia River at Longview, Washington. The isopach contours indicate that the voluminous sedimentary discharge from the Cowlitz river has prograded outwards the Cowlitz delta and subsequently infilled the early Holocene Columbia River channel, forcing the modern channel to the south side of the valley. 3) Similarly, The Lewis River delta about 20 miles further upriver has also prograded outwards infilling the early Holocene Columbia River channel. 4) Further upriver near the confluence of the Willamette River deep subsurface

channels suggest that this area has been influenced by an early Holocene/late Pleistocene shift in channel structure. A deep 50 meter channel is present along the southwestern portion of Sauvie Island. This channel is probably a former Willamette River channel that was wholly or partially restricted to this position either during or immediately following the deposition of Alameda ridge during the catastrophic flood events. Also, near the confluence of the Willamette River with the Columbia River, two 60+ meter channels are present. These channels were probably formed during or soon after the late Pleistocene flood events. Further upriver in the east Portland area near the I-205 bridge site, the Columbia River has excavated a deep 80+ meter channel. This event also was most likely the result of late Pleistocene scouring.

A total volume of 74.57 cubic kilometers ($7.457 \times 10^{10} m^3$) of sediment has accumulated in the LCRB since the catastrophic floods, about 12,700 years ago. This corresponds to an average annual depositional rate of $5.87 \times 10^6 m^3 yr^{-1}$. Using the Mazama ash layer occurrence as a time line the Holocene sedimentary fill can be partitioned into two distinct time intervals. For the pre-Mazama time period the average annual LCRB sediment deposition volume is $8.54 \times 10^6 m^3 yr^{-1}$. For the post-Mazama time period the average annual LCRB sediment accumulation volume is $3.59 \times 10^6 m^3 yr^{-1}$. These two volumes show that the average annual sediment depositional volume has decreased by a factor

of 2.38 from the early to late Holocene time. The nearly linear volume of fill versus depth trend indicates that the base level of the LCRB fluvial system has closely kept pace with the Holocene sea level rise.

The volume of fill value can also be used to calculate the past sediment discharge rates. Based on the assumption that 10% of the sediment in transport is bedload and that 100% of the bedload is deposited within the system, this study hindcasts an annual fluvial sediment discharge rate of 58.7 X $10^6 m^3 yr^{-1}$. For the pre and post Mazama time periods the corresponding discharge rates are 85.3 X $10^6 m^3 yr^{-1}$ and 35.9 X $10^6 m^3 yr^{-1}$ respectively. These values are much greater than the modern sediment discharge rates reported by previous investigators. A portion of this large discrepancy can be attributed to the infrequent yet substantial volumes of sediment derived from LCRB tributaries that drain from the nearby Cascade volcanos following eruptive events. These volcanic contributions were essentially unaccounted for by the previous investigators. Also, previous investigations have used discharge calculations from historic times to augment their models. Dam construction and flow regulations on the main stem of the Columbia and many of its tributaries has dampened peak flows when the river is capable of transporting its largest loads. Therefore, the previous investigators may have under estimated the fluvial sediment discharge rates. The remainder of the large sediment volume discrepancy can be

accounted for by the mid-Holocene adjustment in sediment retention rate attributed to the increased rate of sediment bypassing.

Grain size distribution partition data were recorded from the borehole records. The results indicate that 54.7% of the total infilled sediments are sands, 17.5% are silty sands, 14.8% are sandy silts, and 13.0% are silt size or smaller. The grain size distribution did not change appreciably with respect to increased subsurface elevation. Throughout the entire elevation range sand size grains are the primary component of the alluvial sedimentary deposits. This homogeneous grain size distribution shows that throughout Holocene time the Columbia River has had sufficient energy to transport sand sized sediments into and through the LCRB. This also shows that the river has functioned as a source of sands to the adjacent nearshore environment rather than a sink for littoral sands during Holocene time.

A Holocene sediment age-level curve for the LCRB has been constructed from chronologic markers (radiocarbon dates and contact elevations) within the unconsolidated sedimentary deposits. The sediment level curve (Figure 26) closely resembles eustatic sea level curves reported from other Pacific coast estuaries. The curve shows a steep rise during the early Holocene followed by a pronounced decline during late Holocene time. The slope of the early Holocene line and late Holocene sediment level line shows the rate of sediment

accumulation for these two respective time intervals. The early Holocene sediment accumulation rate is 12.6 mm per year, and the late Holocene accumulation rate is 2.5 mm per year. These rates correspond to a decline in sediment level accumulation of 5 times. This decreasing sediment accumulation rate indicates that fine grained sediments are not being retained in the basin but are continuing to be transported through the LCRB. It also clearly displays the adjustment in sediment deposition rate that occurred in mid-Holocene time.

A nearly linear trend in volume of sedimentary fill versus depth combined with a significant decrease in the rate of sediment accumulation levels shows that the sedimentary deposits of the LCRB have closely kept pace with the Holocene sea level rise. This demonstrates that the Columbia River has been a fluvially dominated depositional system throughout the Holocene marine transgression. As the sea level rise decreased during mid-Holocene time the fluvial system responded by increasing its throughput of fine grained sediments. Fine-grained sediments continue to be transported through the lower river basin and deposited offshore.

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APPENDIX A

GEOCHEMICAL DATA AND ELEMENT CONCENTRATION PLOTS

TABLE A-1 ELEMENT CONCENTRATIONS FOR TEPHRA SAMPLES (ALL VALUES ARE ppm EXCEPT WHERE NOTED)
(Samples Analyzed by previous investigators)

Sample (Concentration / Uncertainty)

Sample	Na %		La		Sm		Sc		Ba		Ce		Eu	
ASH L-1	3.55	0.06	26.2	1.4	5.17	0.10	7.66	0.17	1000	400	45.0	4.0	1.06	0.11
ASH L-2	3.28	0.06	25.2	1.5	5.33	0.12	8.68	0.19	1100	400	55.0	4.0	1.03	0.11
ASH L-3	3.61	0.06	22.3	1.4	4.93	0.11	7.15	0.16	1000	400	38.0	4.0	0.96	0.11
ASH L-4	3.27	0.06	25.5	1.4	4.95	0.12	8.62	0.18	1100	400	41.0	4.0	1.27	0.12
ASH L-5	3.22	0.06	24.0	1.3	4.75	0.11	7.46	0.16	1000	400	49.0	4.0	0.96	0.11
ASH L-6	3.49	0.06	26.1	1.4	5.32	0.10	7.64	0.16	1200	400	45.0	4.0	1.21	0.11
ASH L-7	3.23	0.06	23.3	1.4	5.02	0.10	8.22	0.17	900	400	45.0	4.0	1.16	0.11
ASH P-1	3.48	0.06	22.4	1.4	5.05	0.10	7.10	0.16	1100	400	45.0	4.0	0.97	0.10
ASH P-2	3.61	0.06	22.3	1.3	4.85	0.10	6.98	0.15	600	400	35.0	4.0	0.96	0.10
ASH P-4	3.16	0.06	25.4	1.4	5.43	0.12	9.06	0.18	1000	400	52.0	4.0	1.05	0.11
ASH P-5	3.26	0.06	24.1	1.4	4.82	0.12	8.88	0.18	700	400	44.0	4.0	1.02	0.11
ASH P-6	2.91	0.06	23.2	1.4	4.80	0.11	11.10	0.20	1100	400	48.0	5.0	1.30	0.12
ASH P-8	3.57	0.08	23.5	1.4	5.04	0.12	7.61	0.16	1200	400	41.0	4.0	1.13	0.11
ASH P-9	3.56	0.06	21.9	1.4	4.93	0.11	6.97	0.16	1300	400	44.0	4.0	1.16	0.11
ASH P-10	3.13	0.06	21.3	1.4	4.95	0.11	9.71	0.18	1200	400	43.0	4.0	1.05	0.11
ASH P-11	3.24	0.06	20.6	1.3	5.04	0.10	9.68	0.18	700	400	39.0	4.0	1.11	0.11
ASH P-12	3.53	0.06	21.9	1.4	4.86	0.11	6.93	0.16	900	400	45.0	4.0	1.17	0.11
ASH P-13	3.53	0.06	24.0	1.3	5.30	0.11	7.76	0.16	900	400	42.0	4.0	1.06	0.11
STH JB	1.94	0.04	9.9	1.0	3.38	0.09	12.50	0.20	700	400	23.0	4.0	0.81	0.11
STH JY	2.89	0.06	9.5	1.1	2.98	0.08	8.39	0.18	400	300	24.0	4.0	0.72	0.09
STH 4	3.36	0.06	11.7	1.2	2.76	0.08	7.49	0.16	800	300	20.0	4.0	0.89	0.09
STH 3	3.14	0.06	13.3	1.2	3.56	0.09	7.33	0.16	700	300	27.0	4.0	0.81	0.10
STH UG	3.25	0.06	13.4	1.2	3.30	0.10	13.30	0.20	600	400	31.0	4.0	0.91	0.11
STH LG	3.19	0.06	14.8	1.2	3.47	0.11	12.10	0.20	1100	400	34.0	4.0	1.15	0.11
STH UGG	3.16	0.07	17.5	1.4	3.25	0.10	8.14	0.19	800	400	28.0	5.0	0.92	0.12
BCR-1-3	2.43	0.03	26.1	0.6	6.60	0.07								
BCR-1-4	2.46	0.04	27.3	0.9	6.69	0.10								
O-16-1	3.20	0.04	41.5	0.8	6.60	0.07	3.84		500	200		3.0	0.37	0.06
O-16-2	3.19	0.05	40.1	1.1	6.62	0.09	3.92		340	160	60.0	2.0	0.27	0.04
GSP-1-1	2.16	0.03	191.0	1.7	28.10	0.20								
GSP-1-2	2.26	0.05	188.0	2.0	27.40	0.30								
GSP-1							6.36	0.11	1300	300	394.0	7.0	1.86	0.13
BCR-1-2							33.00	0.30	1300	400	59.0	4.0	1.94	0.14
O-16-3							4.04	0.11	600	300	70.0	4.0	0.33	0.08
O-16-4							3.90		330	120	0.0	0.0	0.35	0.07
P-16	3.43	0.05	27.6	1.6	4.96	0.09	8.15	0.17	500	300	43.0	3.0	1.27	0.10
P-16G	3.35	0.05	27.3	1.6	5.01	0.11	7.00	0.17	500	300	46.0	3.0	1.18	0.10
P-16-1.5	2.11	0.03	24.0	1.3	5.25	0.09	20.90	0.30	500	400	49.0	4.0	1.48	0.12
K104 (P-12)	3.87	0.05	26.7	1.7	5.09	0.10	6.52	0.16	800	300	42.0	3.0	1.13	0.10
K107 (P-11)	3.40	0.05	25.9	1.7	4.07	0.10	6.73	0.16	700	300	44.0	3.0	1.09	0.10
MAZ 1	3.71	0.05	25.1	1.4	4.66	0.08	7.46	0.15	600	200	42.0	3.0	1.16	0.09
MAZ 2	3.39	0.06	32.0	2.0	4.79	0.16	6.80	0.20	600	400	47.0	4.0	0.91	0.12
MAZ 3	3.23	0.05	22.7	1.7	4.79	0.11	6.75	0.06	560	200	46.3	1.1	1.06	0.05
CFP-154	5.27		23.0		5.00		6.73		766		44.0		0.95	
CFP-AVE-1	5.23		22.0		4.80		6.59		771		43.0		0.92	
Phelps Crk			13.5	0.7	2.56	0.15	7.54	0.14	220	50	30.7	0.8	0.82	0.03

TABLE A-1 (continued) ELEMENT CONCENTRATIONS FOR TEPHRA SAMPLES (ALL VALUES ARE ppm EXCEPT WHERE NOTED) (Samples Analyzed by previous investigators)

	Lu		Th		Hf		Co		Fe %	
ASH L-1	0.18	0.12	5.3	0.6	5.1	1.10	7.60	0.90	2.03	0.11
ASH L-2	0.14	0.12	4.5	0.7	8.0	1.20	12.20	1.20	2.12	0.11
ASH L-3	0.16	0.11	4.2	0.6	6.6	1.10	6.70	0.80	1.84	0.09
ASH L-4	0.26	0.13	3.9	0.6	5.1	1.10	9.70	1.10	2.39	0.11
ASH L-5	0.22	0.11	5.6	0.6	7.3	1.10	7.50	0.90	1.94	0.10
ASH L-6	0.15	0.11	5.2	0.6	9.1	1.10	7.30	0.80	2.04	0.10
ASH L-7	0.21	0.12	5.3	0.6	6.3	1.10	9.40	1.00	2.40	0.11
ASH P-1	0.24	0.11	5.6	0.6	6.3	1.00	7.30	0.90	1.71	0.09
ASH P-2	0.21	0.11	4.7	0.6	6.3	1.00	5.40	0.70	1.88	0.09
ASH P-4	0.15	0.12	4.6	0.7	4.7	1.10	10.50	1.10	2.51	0.11
ASH P-5	0.36	0.14	5.9	0.6	7.8	1.10	9.00	1.00	2.14	0.10
ASH P-6	0.27	0.14	5.0	0.7	6.0	1.30	14.70	1.40	2.87	0.13
ASH P-8	0.34	0.13	5.2	0.6	5.6	1.10	7.40	0.90	2.04	0.10
ASH P-9	0.28	0.13	5.3	0.6	7.0	1.10	6.60	0.80	2.05	0.10
ASH P-10	0.31	0.14	4.1	0.7	7.4	1.20	11.30	1.20	2.77	0.12
ASH P-11	0.25	0.13	4.3	0.6	7.4	1.10	12.50	1.10	2.56	0.11
ASH P-12	0.16	0.12	4.6	0.6	7.5	1.10	6.00	0.80	1.89	0.09
ASH P-13	0.15	0.12	6.0	0.6	5.9	1.10	8.80	0.90	1.89	0.10
STH JB	0.24	0.14	1.8	0.7	4.3	1.20	19.40	1.40	4.68	0.16
STH JY	0.20	0.12	2.5	0.6	4.7	1.10	11.30	1.20	3.10	0.13
STH 4	0.20	0.12	2.5	0.6	4.9	1.00	10.70	1.00	2.72	0.12
STH 3	0.22	0.12	2.7	0.6	5.1	1.00	11.00	1.10	2.68	0.12
STH UG	0.22	0.14	0.7	0.7	3.4	1.20	20.80	1.50	4.13	0.15
STH LG	0.06	0.14	1.4	0.7	4.3	1.20	22.40	1.50	3.95	0.15
STH UGG	0.12	0.14	1.9	0.7	3.2	1.20	12.80	1.20	2.99	0.14
BCR-1-3										
BCR-1-4										
O-16-1	0.39	0.11	10.2	0.4	9.4	0.80	2.30	0.40	1.12	0.05
O-16-2	0.31	0.08	9.1	0.3	6.9	0.60	1.80	0.30	1.13	0.04
GSP-1-1										
GSP-1-2										
GSP-1	0.09	0.09	104.0	1.3	15.9	1.20	10.60	0.90	3.04	0.09
BCR-1-2	0.55	0.18	6.6	0.7	8.4	1.30	53.90	1.80	9.37	0.19
O-16-3	0.39	0.13	8.8	0.6	7.9	1.00	2.10	0.60	1.15	0.08
O-16-4	0.25	0.07	9.1	0.2	7.4	0.50	1.90	0.20	1.13	0.03
P-16	0.55	0.13	5.7	0.5	7.2	0.90	7.70	0.80	1.99	0.10
P-16G	0.38	0.12	5.5	0.6	7.6	0.90	5.50	0.80	1.80	0.10
P-16-1.5	0.49	0.16	4.3	0.7	3.1	1.20	24.40	1.30	5.27	0.15
K104 (P-12)	0.32	0.12	5.1	0.5	7.3	0.90	4.30	0.60	1.61	0.09
K107 (P-11)	0.34	0.12	6.3	0.5	6.4	0.90	4.00	0.70	1.77	0.09
MAZ 1	0.49	0.12	4.9	0.5	6.1	0.80	4.70	0.60	2.20	0.09
MAZ 2	0.55	0.16	6.4	0.7	6.5	1.20	4.50	0.80	1.79	0.12
MAZ 3	0.41	0.07	5.6	0.19	7.0	0.40	3.90	0.30	1.87	0.04
CFP-154	0.35		5.3		5.9				1.61	
CFP-AVE-1	0.34		5.1		5.7				1.66	
Phelps Crk	0.20	0.03	5.6	0.13	3.1	0.09	9.80	0.20	2.29	0.02

TABLE A-2 INAA ANALYSIS; 1ST & 2ND COUNT DATA FOR SAMPLES ANALYZED FOR THIS STUDY

ELEMENT CONCENTRATIONS FOR ASTORIA AREA ASH SAMPLES - 1ST COUNT DATA

SAMPLE (Concentration / Uncertainty) (All concentrations in ppm except where noted)

SAMPLE	As		Ga		Na %		K		Sc		Cr		Fe %	
NG-1	16.35	0.00	11.13	0.00	3.35	0.25	2.03	9.96	7.79	4.44	134.83	0.00	2.41	28.06
NG-2	7.10	9.57	11.20	22.75	1.46	0.22	1.57	5.79	16.24	2.65	109.61	0.00	6.37	16.58
NG-3	5.87	24.73	29.96	40.93	3.27	0.25	2.65	14.04	7.87	5.08	0.00	0.00	3.56	0.00
NG-4	4.02	25.41	49.96	0.00	3.16	0.26	2.40	14.57	7.80	6.23	0.00	0.00	2.42	19.15
NG-5	7.19	26.08	16.20	0.00	3.40	0.26	2.22	13.58	8.66	5.65	0.00	0.00	2.10	27.81
NG-6	8.34	25.66	0.00	0.00	3.45	0.30	2.45	0.00	8.91	6.56	0.00	0.00	3.13	24.89
NG-7	3.28	37.41	32.24	37.31	3.25	0.28	2.93	15.71	8.36	4.43	0.00	0.00	2.51	15.52
NG-8	6.41	24.37	0.00	0.00	3.23	0.30	2.91	14.87	7.96	5.52	78.53	0.00	2.88	0.00
NG-9	12.39	0.00	181.36	0.00	3.05	0.28	2.41	19.15	7.21	5.45	0.00	0.00	2.81	0.00
MAG-1									6.10	1.27	0.00	0.00	1.86	5.10
JR-1									3.84	3.14	0.00	0.00	4.22	0.00
JB-2									54.00	0.53			9.89	3.08
1633a														
NG-4*	23.40	0.00			3.04	0.38	2.74	21.69	8.03	6.05	0.00	0.00	2.20	0.00
MAG-1*	10.05	0.00			2.81	0.28	2.89	9.74	16.98	1.42	0.00	0.00	5.37	6.59

SAMPLE	Co		Sb		Hf		La		Sm		Yb		Lu		Th	
NG-1	37.22	0.0	0.80	34.46	7.70	0.00	25.18	3.32	4.54	1.78	3.07	26.72	0.40	33.38	0.00	0.0
NG-2	28.89	0.0	0.81	30.18	6.67	0.00	31.07	2.30	5.33	1.18	2.59	26.14	0.34	43.18	16.24	0.0
NG-3	34.51	0.0	0.80	37.85	5.63	0.00	23.68	5.11	5.11	1.78	2.62	0.00	0.58	20.99	10.23	0.0
NG-4	12.02	0.0	0.61	38.10	6.15	29.48	24.30	4.70	5.03	1.68	2.21	27.32	0.30	0.00	15.39	0.0
NG-5	0.00	0.0	1.44	27.80	6.87	0.00	24.36	6.02	5.27	1.54	7.16	0.00	0.37	37.28	0.00	0.0
NG-6	3.12	0.0	7.13	0.00	7.90	45.38	26.36	5.55	4.74	1.69	3.24	24.91	0.30	28.08	14.74	0.0
NG-7	22.53	49.5	1.16	49.04	6.85	39.93	25.00	4.21	5.35	1.55	4.52	23.11	0.43	0.00	14.87	0.0
NG-8	17.08	0.0	0.92	0.00	7.68	27.45	24.99	5.51	5.22	1.56	3.87	22.42	0.44	0.00	16.71	0.0
NG-9	27.42	0.0	0.92	0.00	6.87	42.98	21.63	4.26	4.13	1.76	2.91	31.73	0.31	0.00	17.61	0.0
MAG-1	11.37	0.0			1.56	44.74	7.64	1.70	0.00	0.00			0.05	0.00	130.21	0.0
JR-1	10.80	0.0			1.25	41.34	3.66	2.89	0.00	0.00			5.08	0.00	103.39	0.0
JB-2	39.80	17.1											0.00	0.00		
1633a																
NG-4*	14.83	39.6			0.00	0.00	26.83	4.53	0.00	0.00			1.15	0.00	6.50	0.0
MAG-1*	20.59	10.4			6.53	39.43	45.72	1.67	0.00	0.00			0.20	0.00	11.21	0.0

* Replicate analysis

TABLE A-2 (continued) ASTORIA AREA ASH SAMPLES - 2ND COUNT DATA

SAMPLE CONCENTRATION (ppm) UNCERTAINTY (%)

SAMPLE	Rb		Cs		Sr		Ba		Sc		Cr		Fe %	
NG-1	82.03	14.40	3.38	7.37	245.85	29.03	761.37	5.43	7.44	1.01	10.72	19.94	2.06	1.52
NG-2	77.31	14.97	5.59	8.96	657.87	0.00	579.83	7.19	15.69	0.76	72.22	6.42	4.03	0.96
NG-3	64.61	11.18	3.46	8.82	229.26	24.95	781.05	5.10	6.87	1.07	7.51	21.26	1.91	1.51
NG-4	61.29	11.40	3.77	11.10	231.95	25.63	689.36	5.41	6.54	1.02	10.43	17.96	1.83	1.48
NG-5	51.61	14.24	3.69	10.37	408.36	35.33	757.37	5.54	7.33	1.02	12.44	16.39	2.08	1.49
NG-6	61.11	17.26	4.65	9.98	275.61	28.95	791.11	5.64	7.87	0.67	11.82	17.91	2.14	1.47
NG-7	52.60	26.13	3.82	8.03	0.00	0.00	741.19	6.26	7.46	1.10	12.81	16.23	2.28	1.38
NG-8	77.83	15.59	4.12	9.89	271.18	23.35	728.70	5.98	7.19	1.28	12.27	16.99	2.24	1.33
NG-9	53.96	18.29	3.84	10.74	231.41	23.01	626.10	6.75	6.05	1.13	7.69	23.50	1.73	1.55
MAG-1	152.00	6.54	8.30	2.60	156.00	30.47	490.00	4.78	17.00	0.39	105.00	1.64	4.86	0.51
JB-2	19.57	33.69	2.91	31.92	492.65	0.00	208.03	10.48	54.01	0.22	27.40	13.31	9.89	0.38
JR-1	257.00	2.55	20.20	1.03	0.00	0.00	273.99	0.00	5.20	0.74	2.75	26.62	0.62	2.46
1633a	160.46	10.17	11.81	2.78	514.79	25.58	138.41	2.70	35.83	0.22	208.99	1.11	9.21	0.37
NG-4*	60.94	15.16	3.11	7.44	228.52	26.61	728.81	5.72	6.48	1.07	6.99	27.20	1.86	1.39
MAG-1*	149.41	4.87	7.94	2.32	115.29	38.22	548.33	4.52	16.14	0.41	113.41	1.47	4.88	0.48

SAMPLE	Co		Zn		Ce		Nd		Sm		Eu		Tb	
NG-1	4.88	5.09	186.50	14.64	49.58	2.43	25.15	0.00	4.76	2.28	1.15	5.50	0.68	0.00
NG-2	14.84	2.93	98.41	34.51	62.11	2.10	0.00	0.00	5.63	1.29	1.50	4.56	0.81	16.41
NG-3	4.31	4.46	69.88	27.87	47.54	2.44	27.25	0.00	4.80	2.07	1.10	10.84	0.61	10.27
NG-4	4.08	7.53	51.02	45.74	45.62	2.50	23.27	0.00	4.40	2.26	1.02	6.71	0.55	10.11
NG-5	5.00	6.51	57.22	44.84	52.21	2.36	26.04	34.36	4.94	2.21	1.18	10.23	0.62	11.59
NG-6	5.41	6.51	55.80	47.12	52.95	2.44	30.13	0.00	5.32	2.86	1.18	5.06	0.66	9.97
NG-7	4.62	5.32	0.00	0.00	51.61	2.34	27.13	19.17	4.92	3.12	1.15	12.66	0.56	0.00
NG-8	4.53	4.48	0.00	0.00	48.96	2.40	26.97	0.00	4.81	3.21	1.14	6.17	0.62	0.00
NG-9	4.10	5.38	47.49	47.03	41.38	2.65	25.57	35.54	4.20	3.32	0.98	5.88	0.64	27.91
MAG-1	20.00	1.48	126.00	16.29	94.00	0.94	44.00	26.58	78.00	0.64	1.60	7.62	0.88	0.00
JB-2	39.81	1.13	110.01	16.27	7.99	10.68			2.30	1.47				
JR-1	0.84	12.63	15.76	34.68	49.00	1.29	25.50	20.62	6.20	1.07	0.31	8.19	1.10	4.48
1633a	38.56	1.01	219.08	13.16	178.15	0.67	79.80	5.99	16.72	0.56	3.75	4.32	2.15	2.74
NG-4*	4.02	5.19	52.51	44.50	46.71	2.47	24.81	28.84	4.44	3.35	1.09	9.51	0.54	9.39
MAG-1*	19.53	1.37	121.78	16.01	93.65	0.94	43.53	0.00	7.87	1.41	1.68	2.94	0.91	4.36

SAMPLE	Tm		Yb		Lu		Zr		Sb		Hf		Ta	
NG-1	0.00	0.00	2.90	11.90	0.38	7.16	241.79	23.90	0.00	0.00	5.65	4.21	1.12	17.39
NG-2	0.00	0.00	2.84	16.41	0.40	12.44	498.31	43.42	21.89	0.00	4.61	5.50	1.49	17.20
NG-3	0.00	0.00	2.61	10.64	0.37	7.02	206.20	22.65	0.76	26.98	5.54	3.78	0.99	16.15
NG-4	0.00	0.00	2.86	13.97	0.34	6.46	274.81	37.93	0.00	0.00	5.66	3.71	0.94	0.00
NG-5	0.00	0.00	3.24	10.32	0.39	6.55	210.90	43.62	0.00	0.00	5.98	5.31	1.19	12.06
NG-6	0.00	0.00	3.10	12.06	0.39	8.29	402.52	41.49	0.00	0.00	6.20	3.97	0.68	0.00
NG-7	0.00	0.00	3.03	11.37	0.39	7.31	198.54	41.90	1.03	0.00	5.90	4.14	0.75	21.50
NG-8	0.70	35.46	3.03	9.99	0.36	8.18	0.00	0.00	0.00	0.00	5.69	4.13	0.94	20.82
NG-9	0.44	49.25	2.52	12.48	0.33	7.97	184.91	0.00	0.00	0.00	4.98	4.23	0.78	0.00
MAG-1	0.52	37.22	3.00	9.28	0.40	10.35	92.34	47.70	1.65	23.61	3.60	4.42	1.75	12.08
JB-2			2.50	8.39	0.40	9.93	50.88	0.00	6.22	0.00	1.69	11.66		
JR-1	0.73	23.16	4.60	3.73	0.68	4.17	102.00	22.05	1.75	11.45	4.70	2.74	1.90	4.01
1633a	1.25	19.85	8.01	5.11	1.15	4.91	306.89	19.66	6.80	10.16	7.41	3.10	5.38	6.95
NG-4*	0.00	0.00	2.61	12.80	0.36	7.66	197.75	22.52	0.00	0.00	5.70	3.95	0.90	24.23
MAG-1*	0.71	24.69	3.12	8.24	0.42	8.62	137.36	0.00	1.32	0.00	3.77	3.94	2.31	4.00

TABLE A-2 (continued) ASTORIA AREA ASH SAMPLES - 2ND COUNT DATA

	Th		La	
NG-1	6.34	3.21	29.21	6.00
NG-2	7.56	2.48	34.40	3.68
NG-3	5.80	2.87	27.69	5.20
NG-4	5.41	2.95	25.33	5.71
NG-5	5.92	2.89	26.24	5.66
NG-6	6.42	3.04	38.27	7.73
NG-7	6.05	3.34	29.13	6.95
NG-8	5.93	2.90	31.31	7.79
NG-9	5.12	3.17	25.40	8.04
MAG-1	12.80	1.12	46.00	1.75
JB-2	0.30	48.19	1.96	18.71
JR-1	26.50	0.55	21.00	3.59
1633a	25.49	0.68	89.36	1.96
NG-4*	5.64	2.95	31.96	7.02
MAG-1*	12.77	0.99	53.74	4.31

* Replicate Analysis

TABLE A-3 LOCATIONS FOR SAMPLES USED IN INAA ANALYSIS

SAMPLE	LOCATION		
NG-1	John Day River Bridge	Astoria	
NG-2	John Day River Bridge	Astoria	
NG-3	Fernhill/Burnside Pasture	Astoria	
NG-4	Duplicate of NG-3	Astoria	
NG-5	John Day River Bridge	Astoria	
NG-6	Duplicate of NG-5	Astoria	
NG-7	Holbrook Slough	Warrenton	
NG-8	Duplicate of NG-8	Warrenton	
NG-9	John Day River Bridge	Astoria	
MAG-1	USGS Standard	Marine Mud	
JR-1	USGS Standard	Japanese Rhyolite	
JB-2	USGS Standard	Japanese Basalt	
1633a	USGS Standard	Coal Fly Ash	
L-1	Longview Wash, Port Industrial sites		
L-2	Longview Wash, Port Industrial sites		
L-3	Longview Wash, Port Industrial sites		
L-4	Longview Wash, Port Industrial sites		
L-5	Longview Wash, Port Industrial sites		
L-6	Longview Wash, Port Industrial sites		
L-7	Longview Wash, Port Industrial sites		
P-1	Portland Area	Columbia River	
P-2	Portland Area	Columbia River	
P-4	Portland Area	Columbia River	
P-5	Portland Area	Willamette River	
P-6	Portland Area	Willamette River	
P-7	Portland Area	Willamette River	
P-8	Portland Area	Willamette River	
P-9	Portland Area	Columbia River	
P-10	Portland Area	Willamette River	
P-11	Portland Area	Willamette River	
P-12	Portland Area	Willamette River	
P-13	Portland Area	Columbia River	Troutdale
P-16	Portland Area, Willamette River - Swan Isl.		
P-16-1.5	Portland area - sediment 1.5 ft below the tephra layer in sample P-16		
MAZ-1	Mazama Tephra, Pumice Point Overlook - Crater Lake Or.		
MAZ-2	Mazama Tephra, Odell Butte - glass separate		
MAZ-3	Mazama Tephra, La Pine Or.		
CFP-154#	Mazama tephra - Climatic Pumice Fall		
CFP-AVG-1#	Mazama tephra - Climatic Pumice Fall		
Phelps Crk**	Pumice from Phelps Crk. Trinity Wash. - Glacier Peak		

\# Data from C.R. Bacon and T.H. Druitt, 1988
** Data from Randal, Goles, and Kittleman, 1971

TABLE A-3 (continued) LOCATIONS FOR SAMPLES USED IN INAA ANALYSIS

MOUNT SAINT HELENS SAMPLES

STH-JB	Upper of two discrete beds of set J tephra
STH-JY	Main bed of set J tephra, below JB
STH-4	Upper most layer of set S tephra
STH-3	Lower of 2 main beds at top of set S
STH-UG	Upper part of layer G
STH-LG	Lower part of layer G
STH-UGG	Layer G

USGS STANDARDS

BCR-1-2	Columbia River Basalt - 2nd replicate analysis
BCR-1-3	Columbia River Basalt - 3rd replicate analysis
BCR-1-4	Columbia River Basalt - 4th replicate analysis
GSP-1	Quartz Monzonite
GSP-1-1	Quartz Monzonite - 2nd replicate analysis
GSP-1-2	Quartz Monzonite - 3rd replicate analysis
0-16-1	Rhyolite Obsidian
0-16-2	Rhyolite Obsidian - 2nd replicate analysis
0-16-3	Rhyolite Obsidian - 3rd replicate analysis
0-16-4	Rhyolite Obsidian - 4th replicate analysis

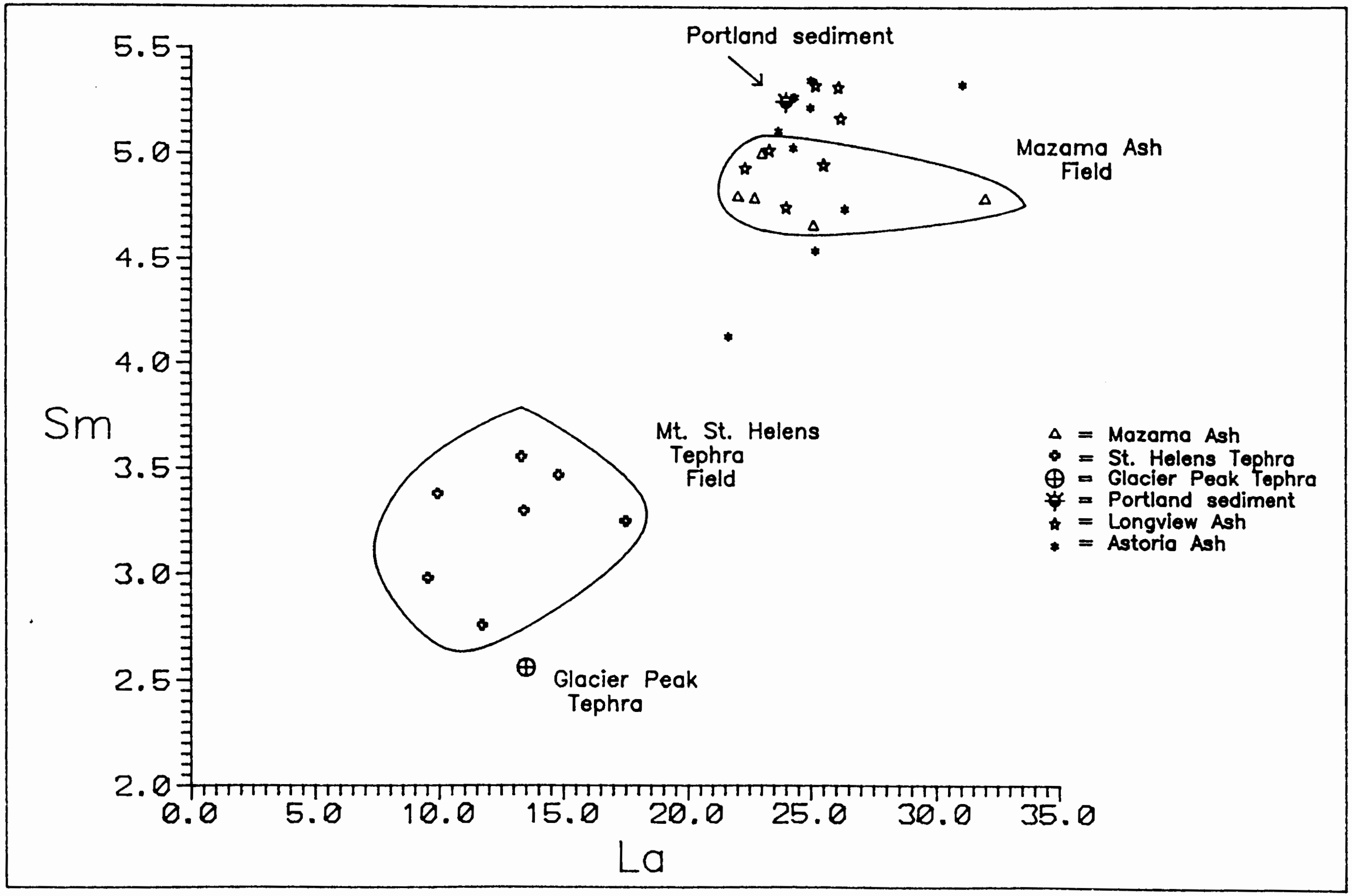

Figure A-1. Lanthanum vs. Samarium; Astoria and Longview area sample sites.

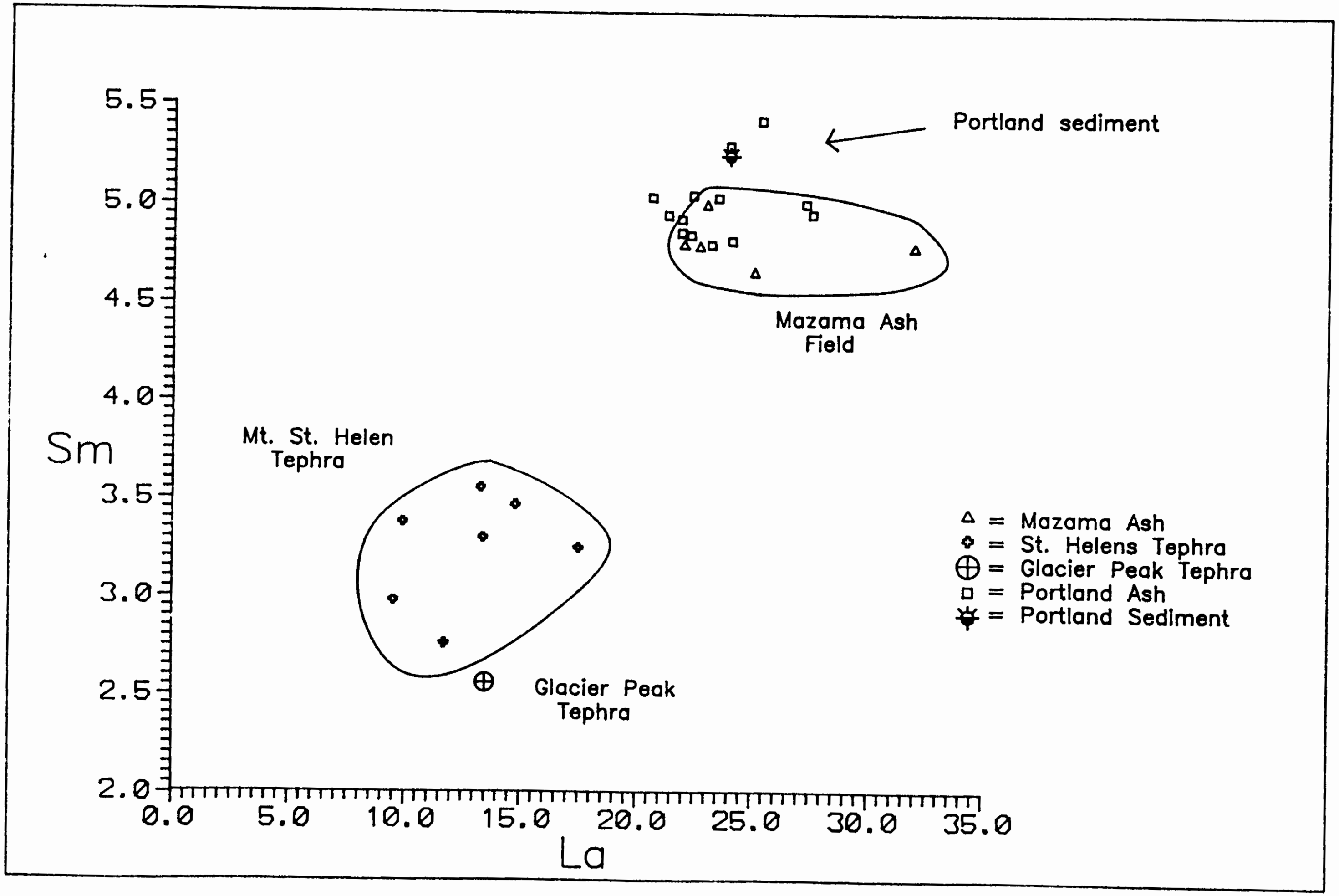

Figure A-2. Lanthanum vs. Samarium; Portland area sample sites.

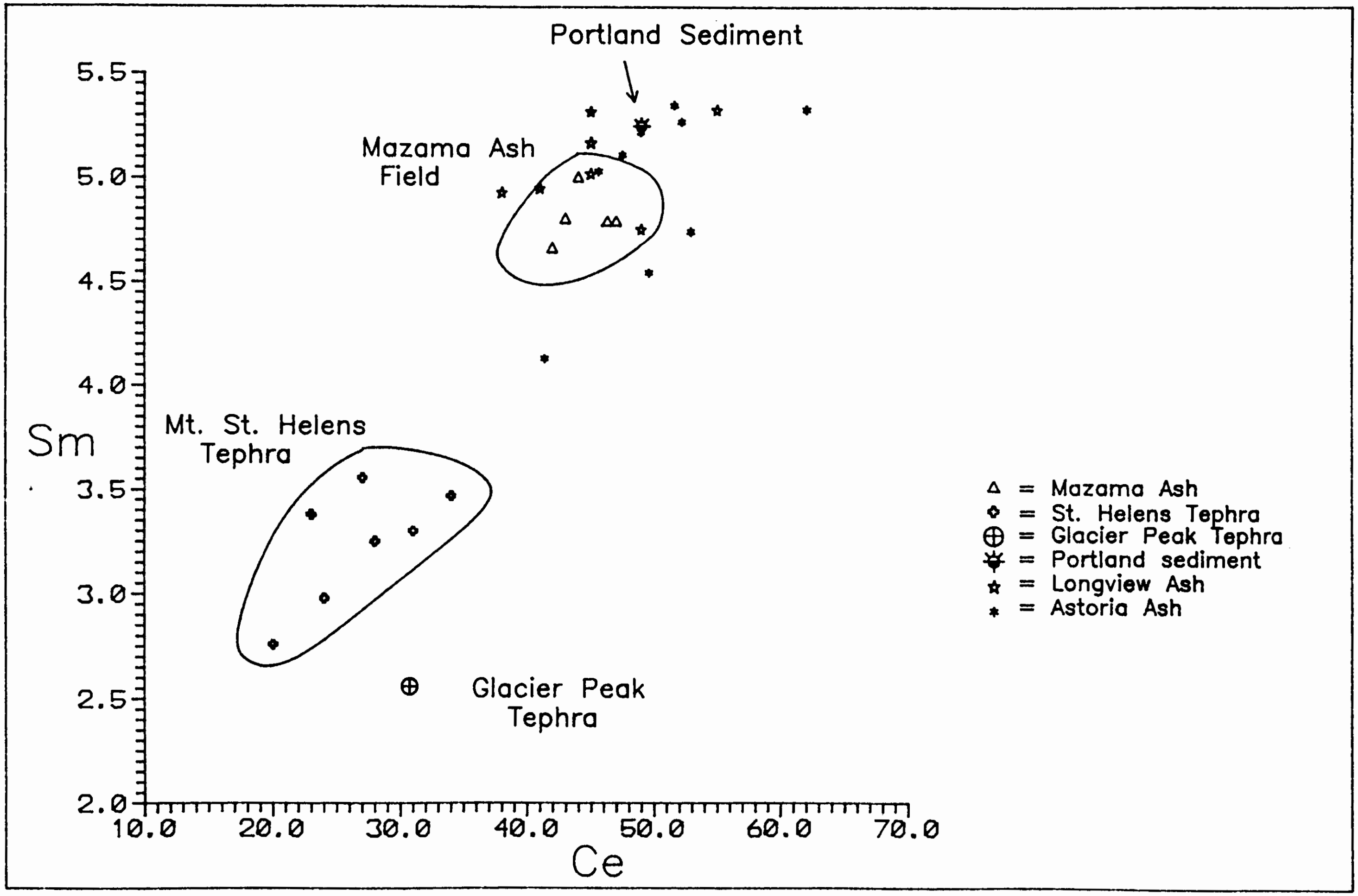

Figure A-3. Cerium vs. Samarium; Longview and Astoria area sample sites.

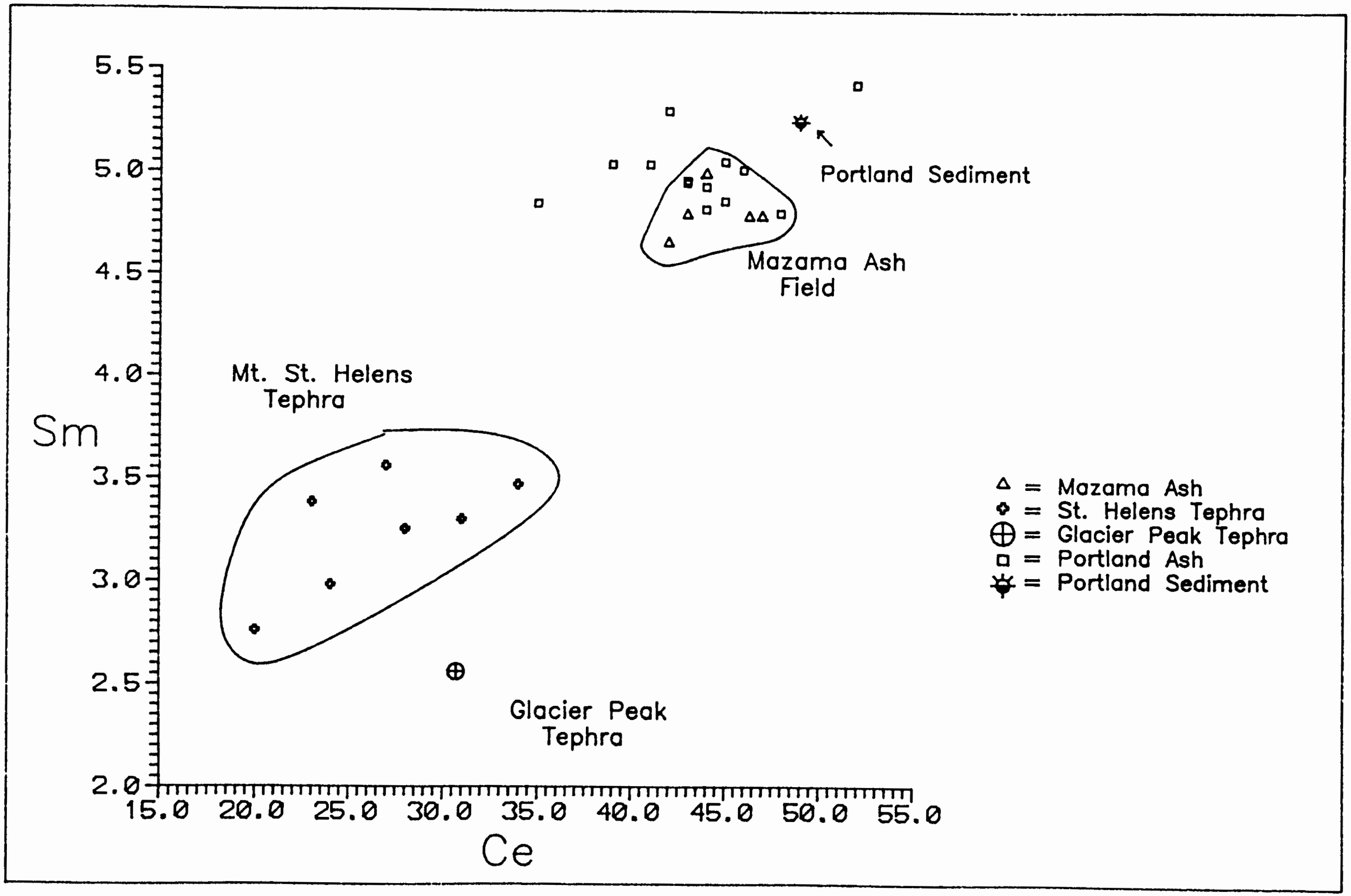

Figure A-4. Cerium vs. Samarium; Portland area sample sites.

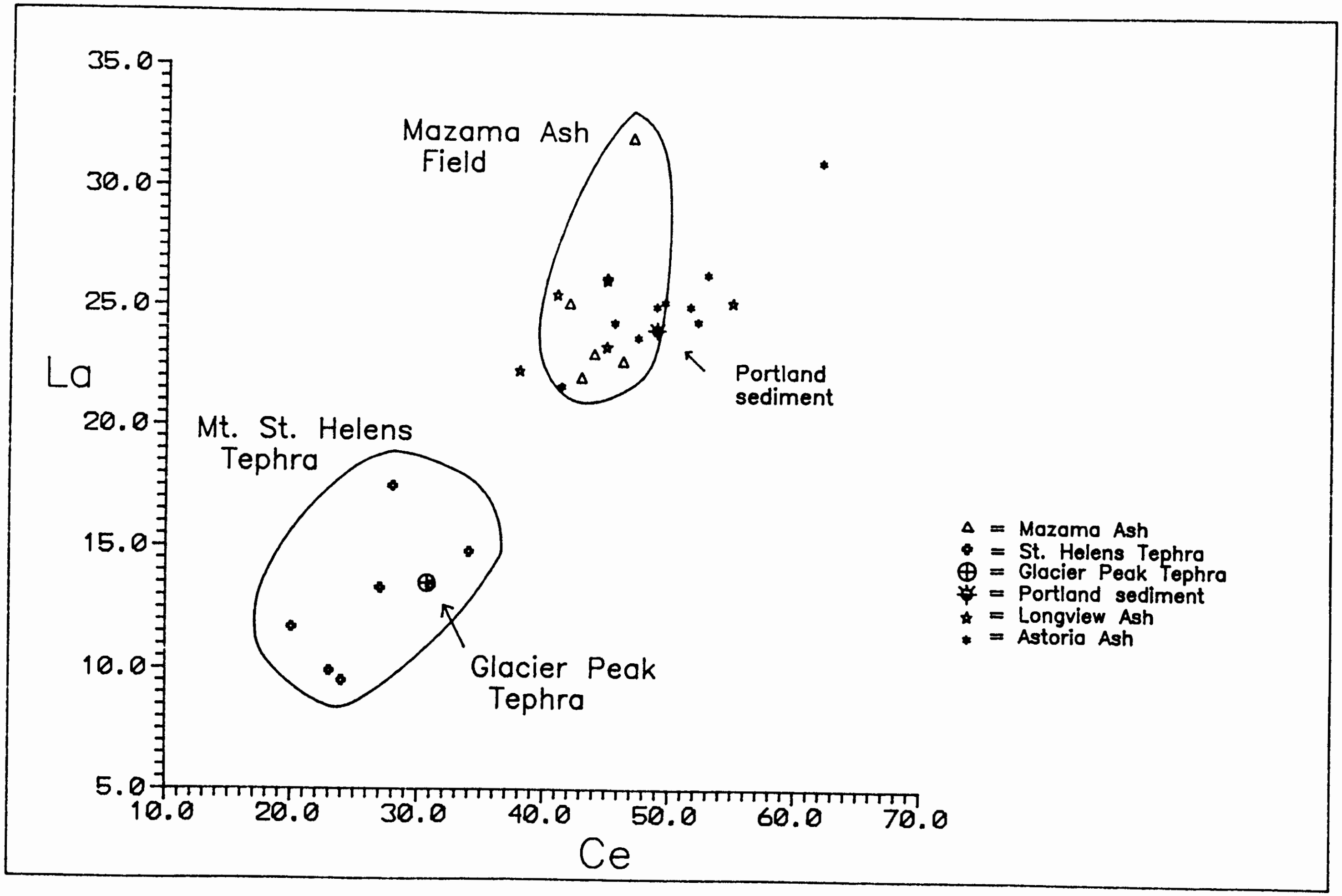

Figure A-5. Cerium vs. Lantanum; Longview and Astoria area sample sites.

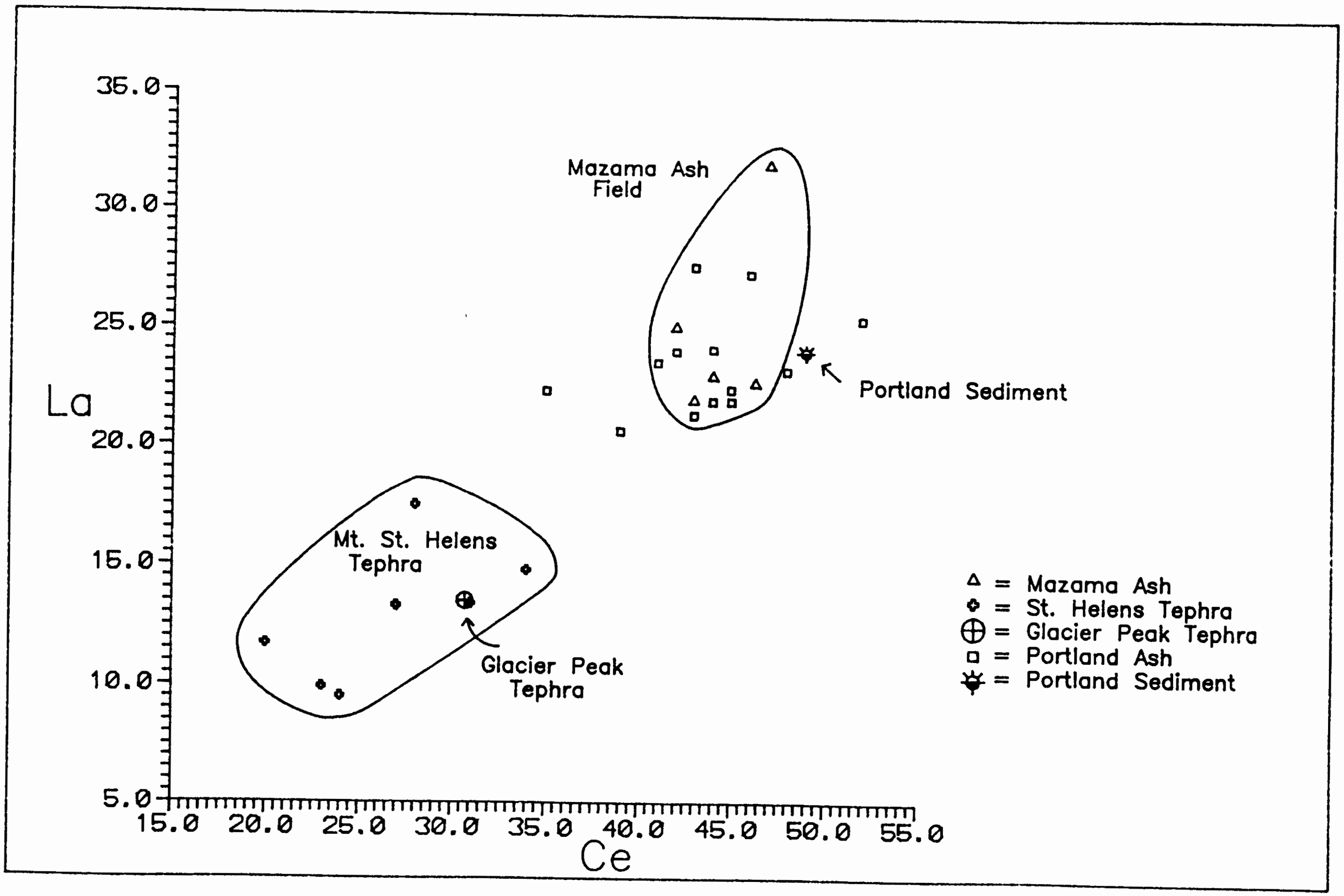

Figure A-6. Cerium vs. Lantanum; Portland area sample sites.

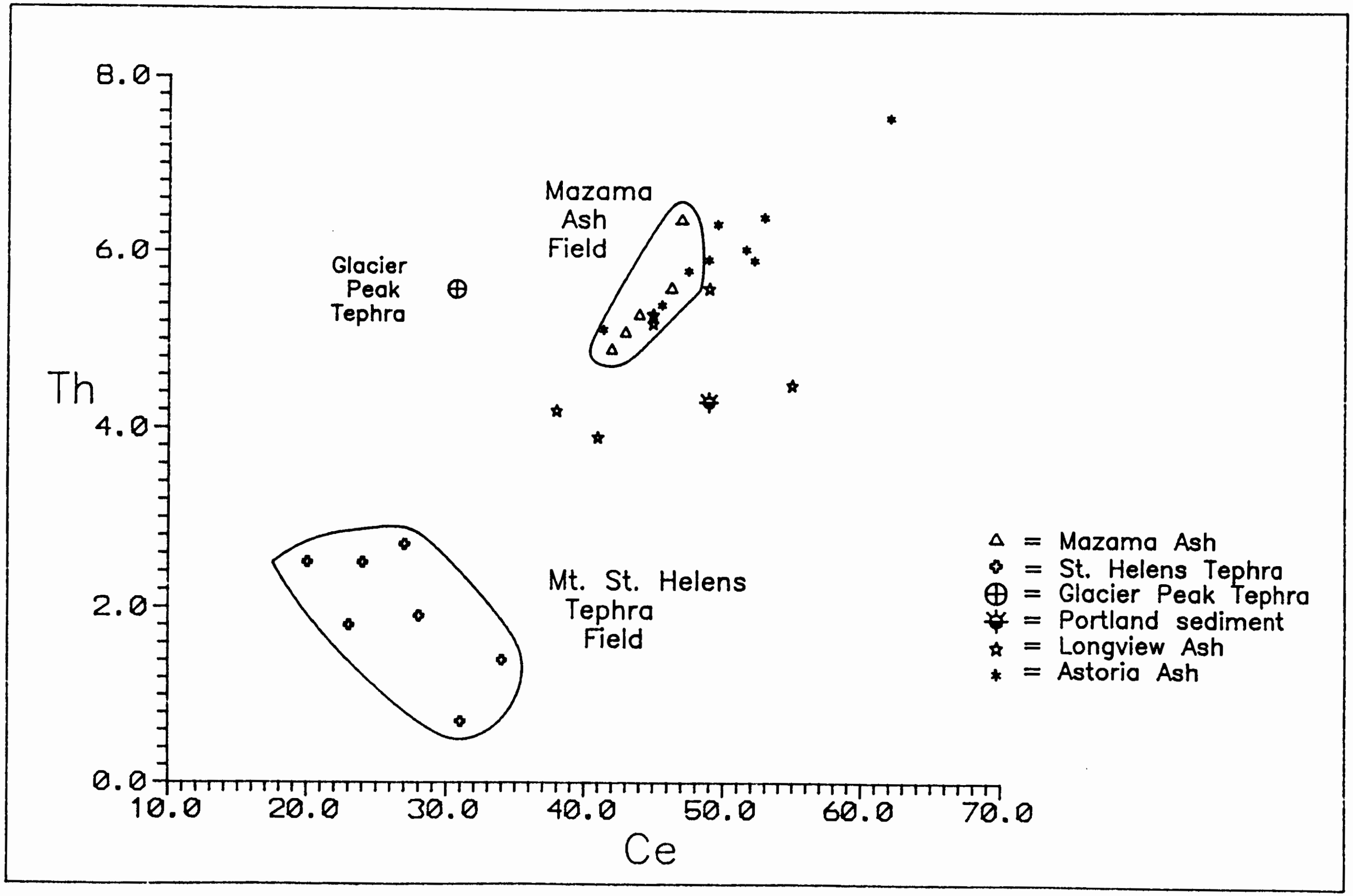

Figure A-7. Cerium vs. Thorium; Longview and Astoria area sample sites.

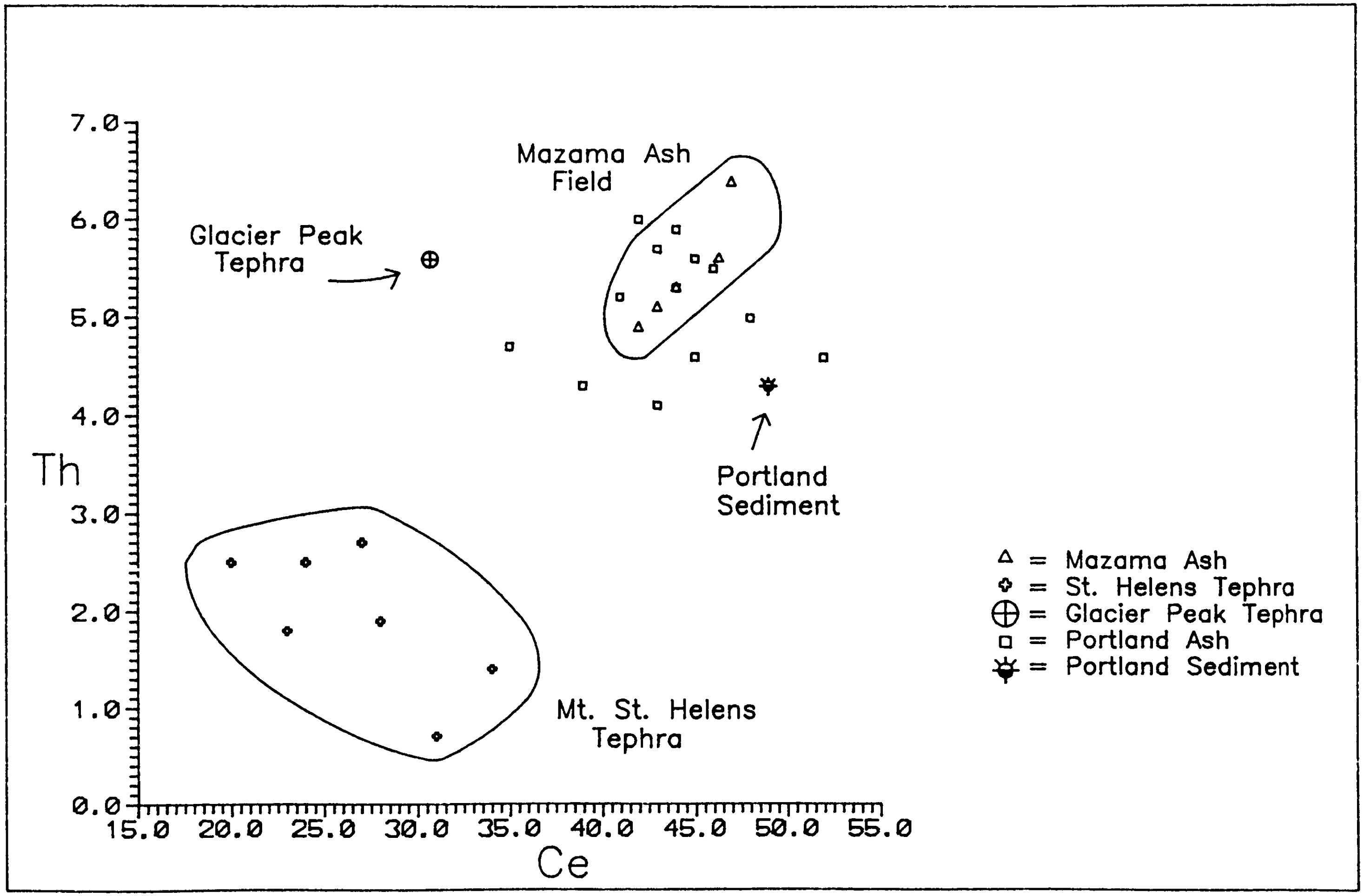

Figure A-8. Cerium vs. Thorium; Portland area sample sites.

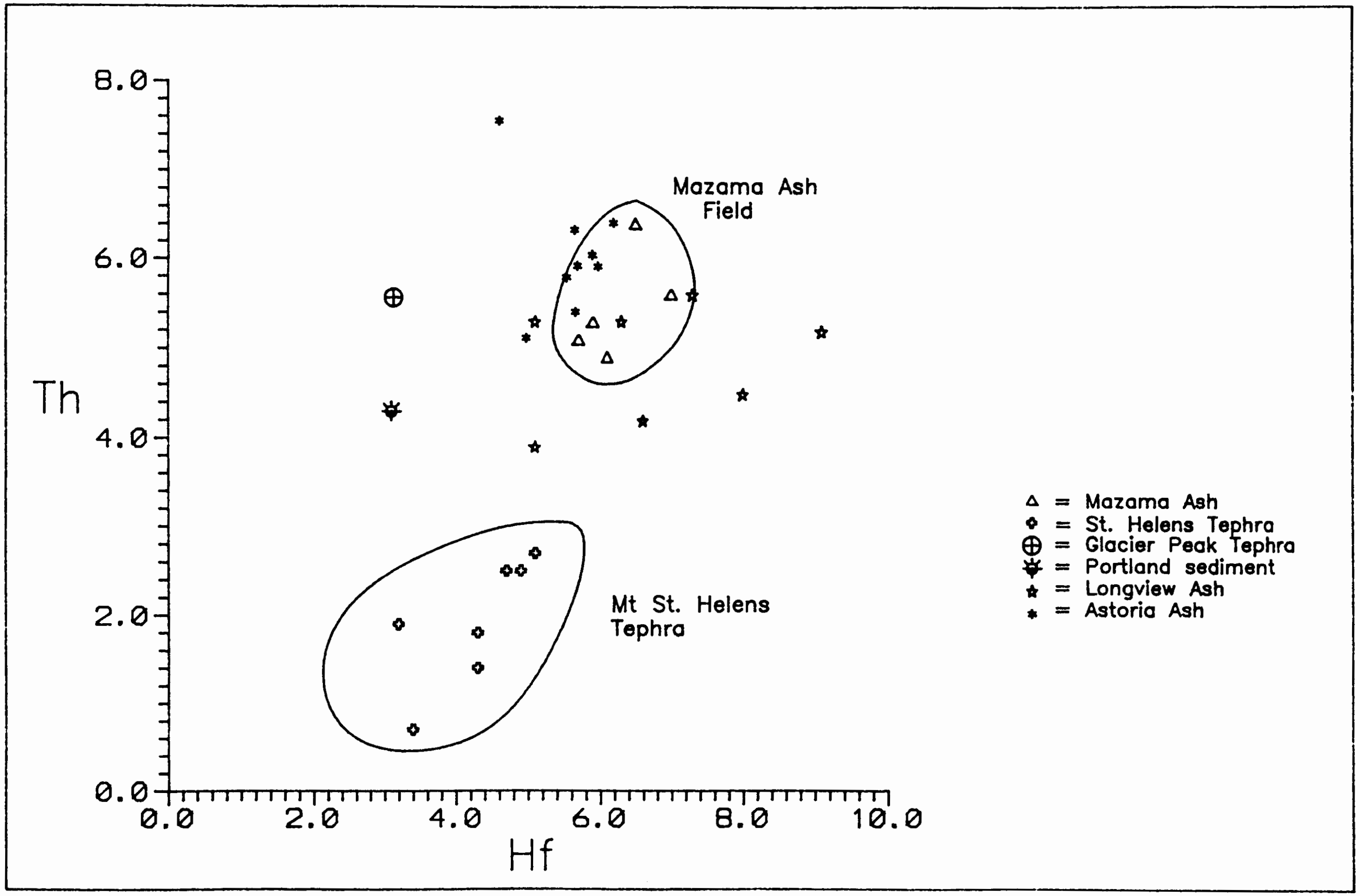

Figure A-9. Hafnium vs. Thorium; Longview and Astoria area sample sites.

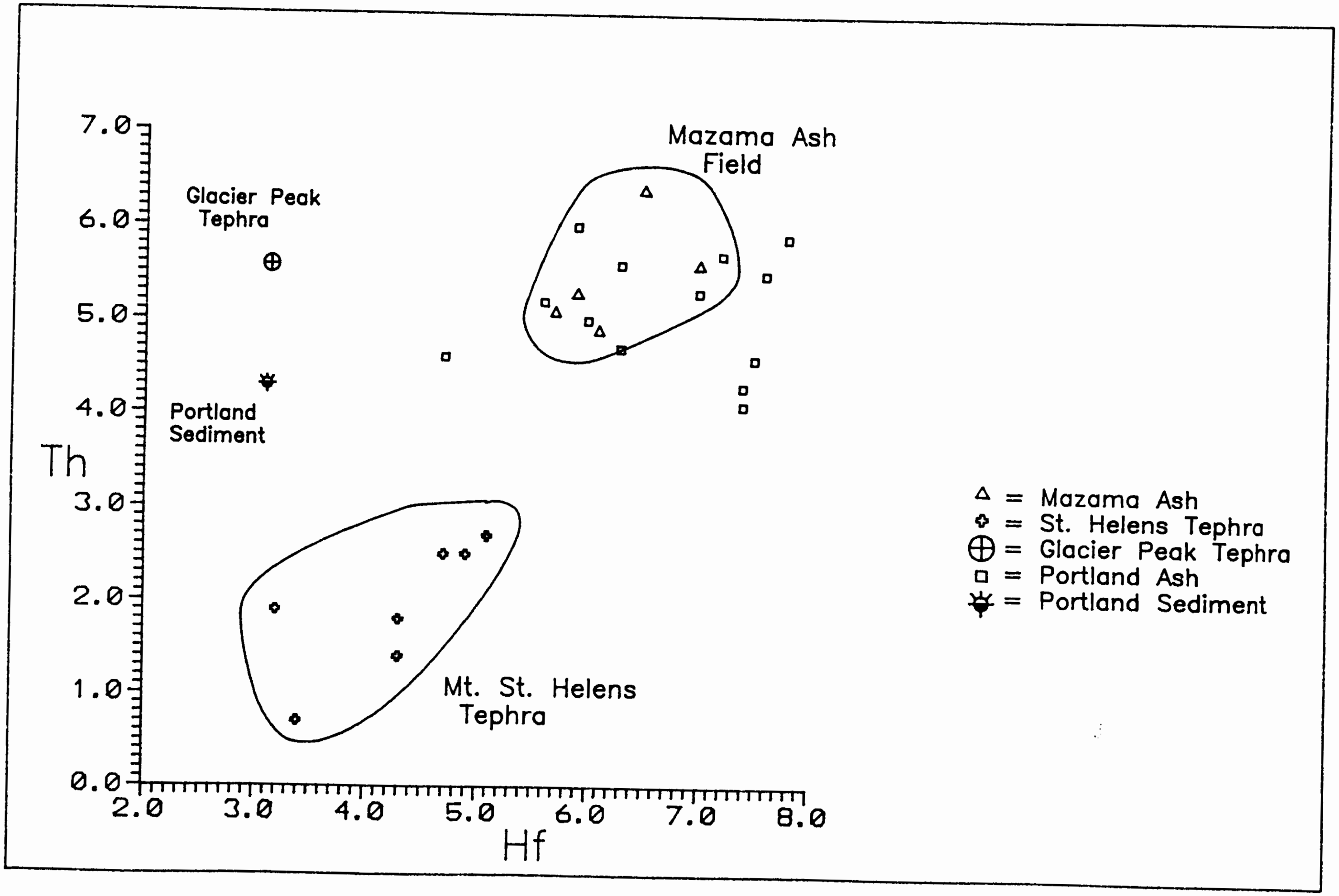

Figure A-10. Hafnium vs. Thorium; Portland area sample sites.

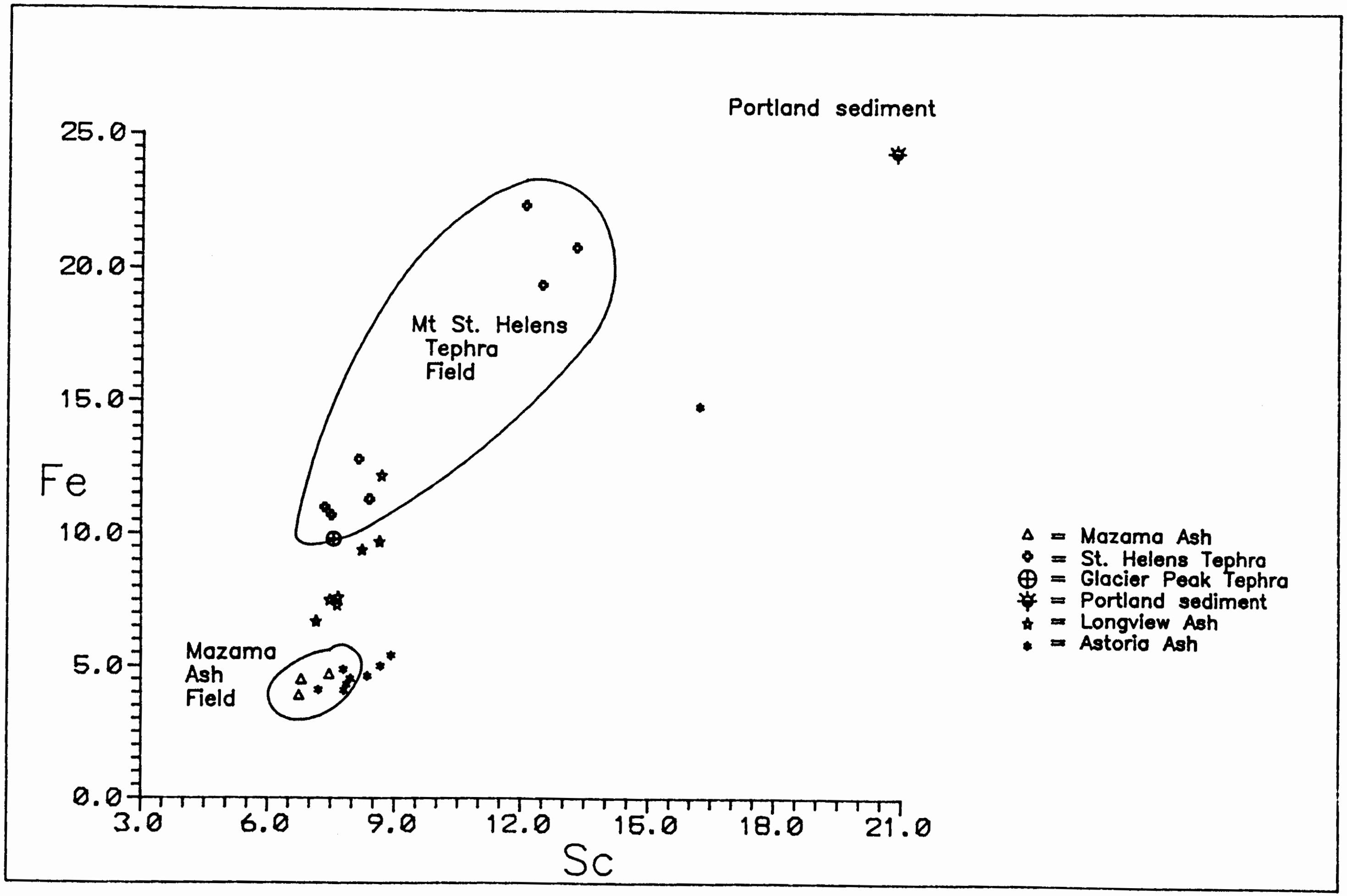

Figure A-11. Scandium vs. Cobalt; Longview and Astoria area sample sites.

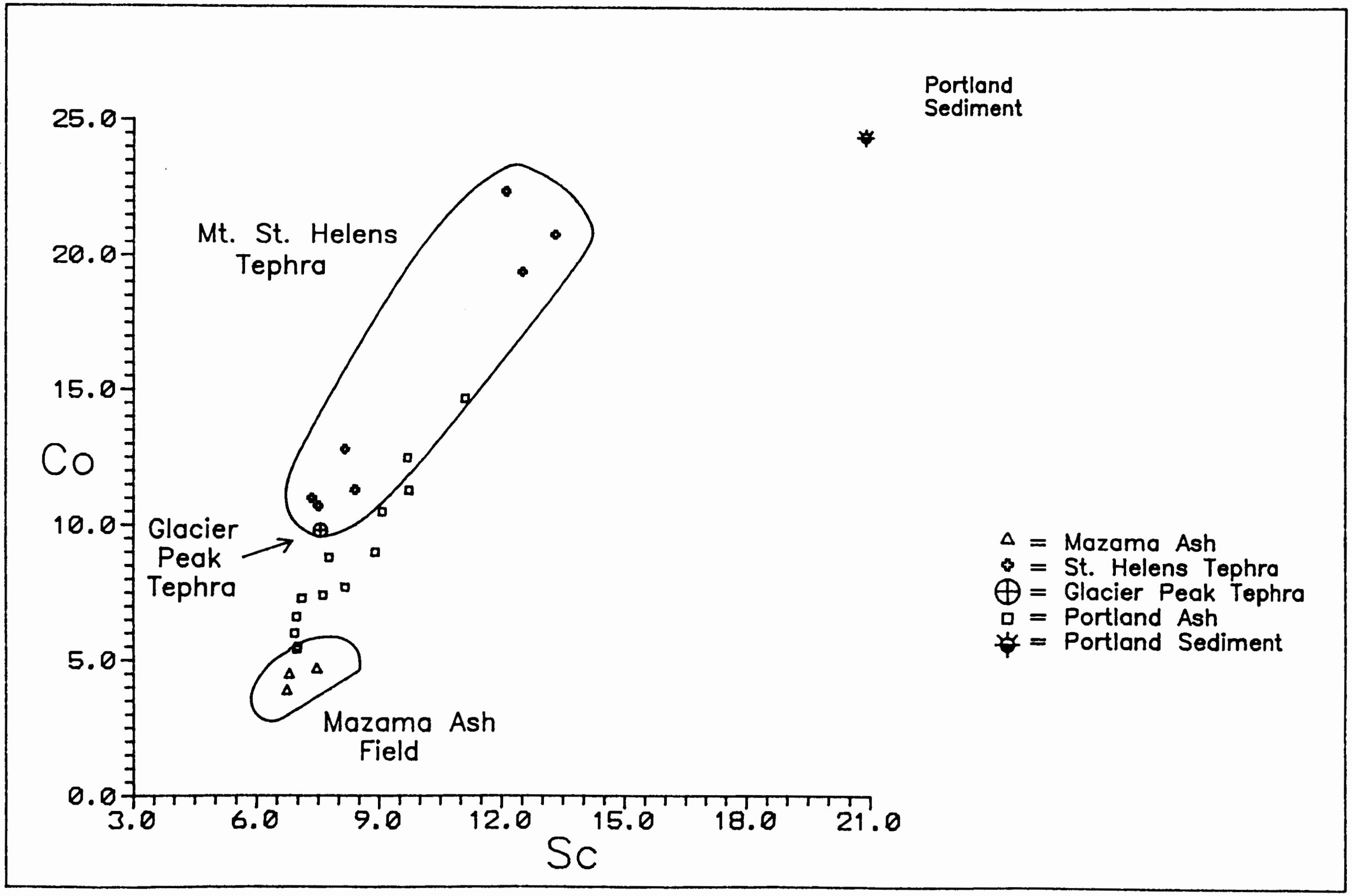

Figure A-12. Scandium vs. Cobalt; Portland area sample sites.

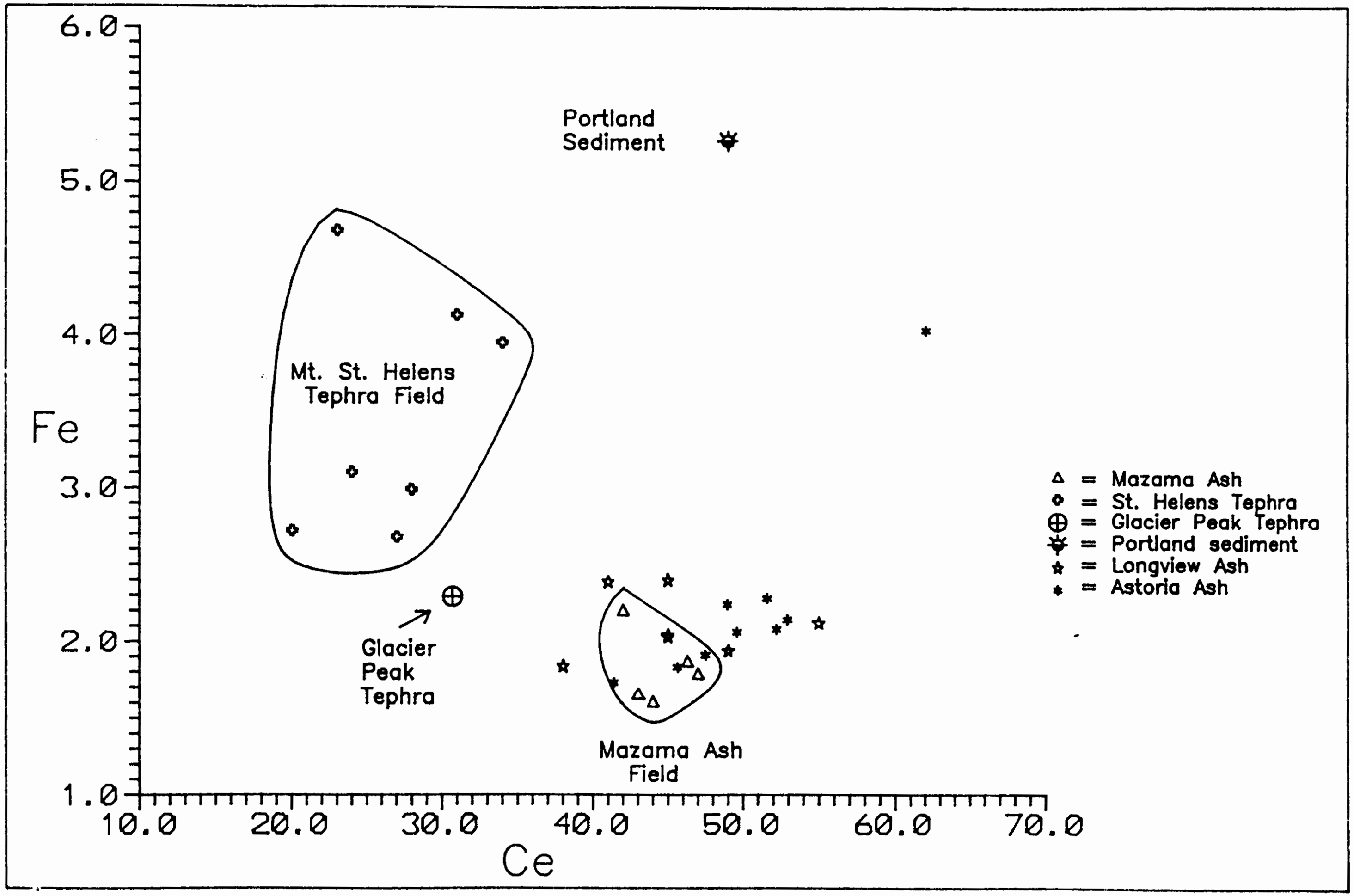

Figure A-13. Cerium vs. Iron; Longview and Astoria area sample sites.

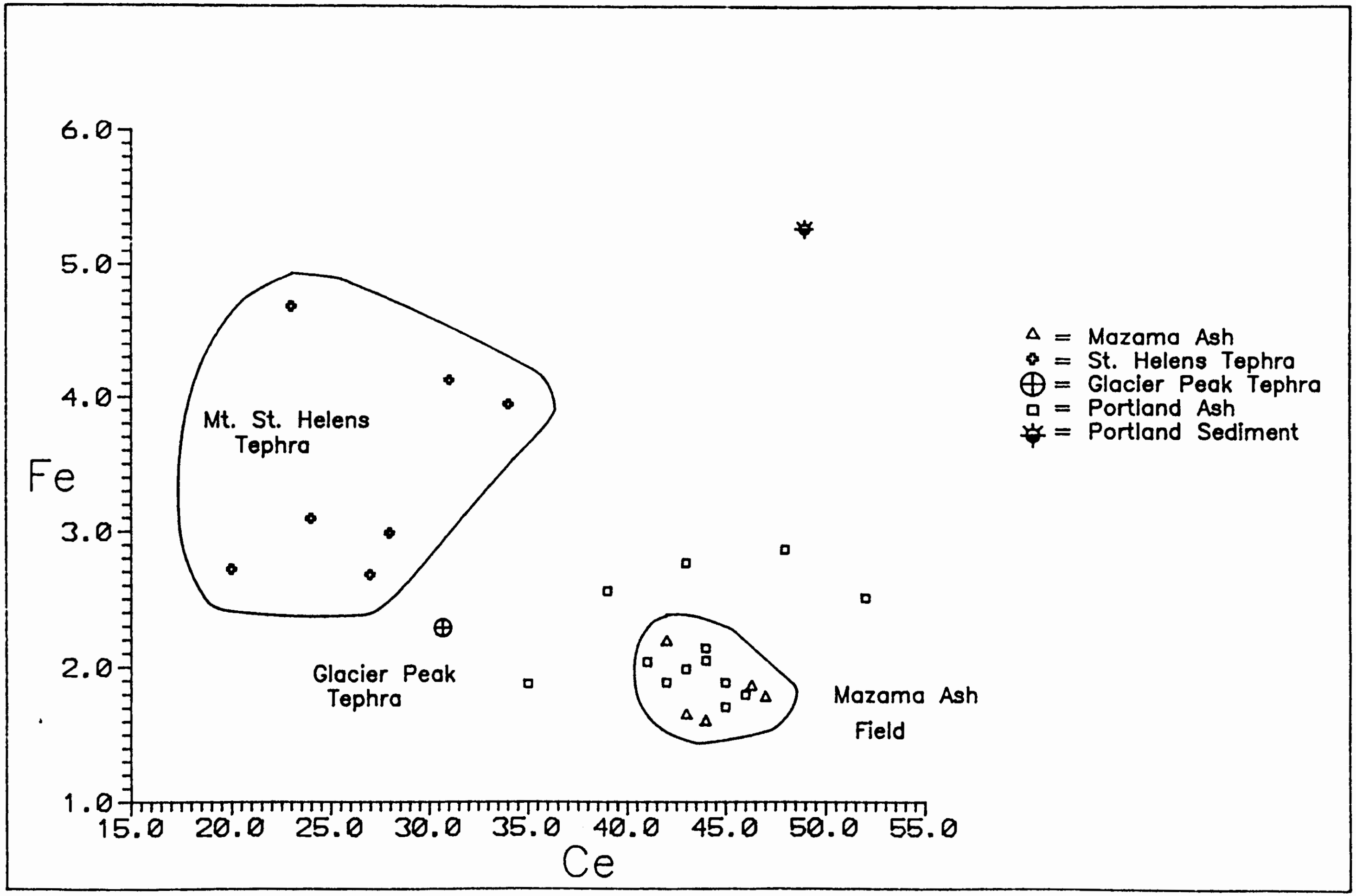

Figure A-14. Cerium vs. Iron; Portland area sample sites.

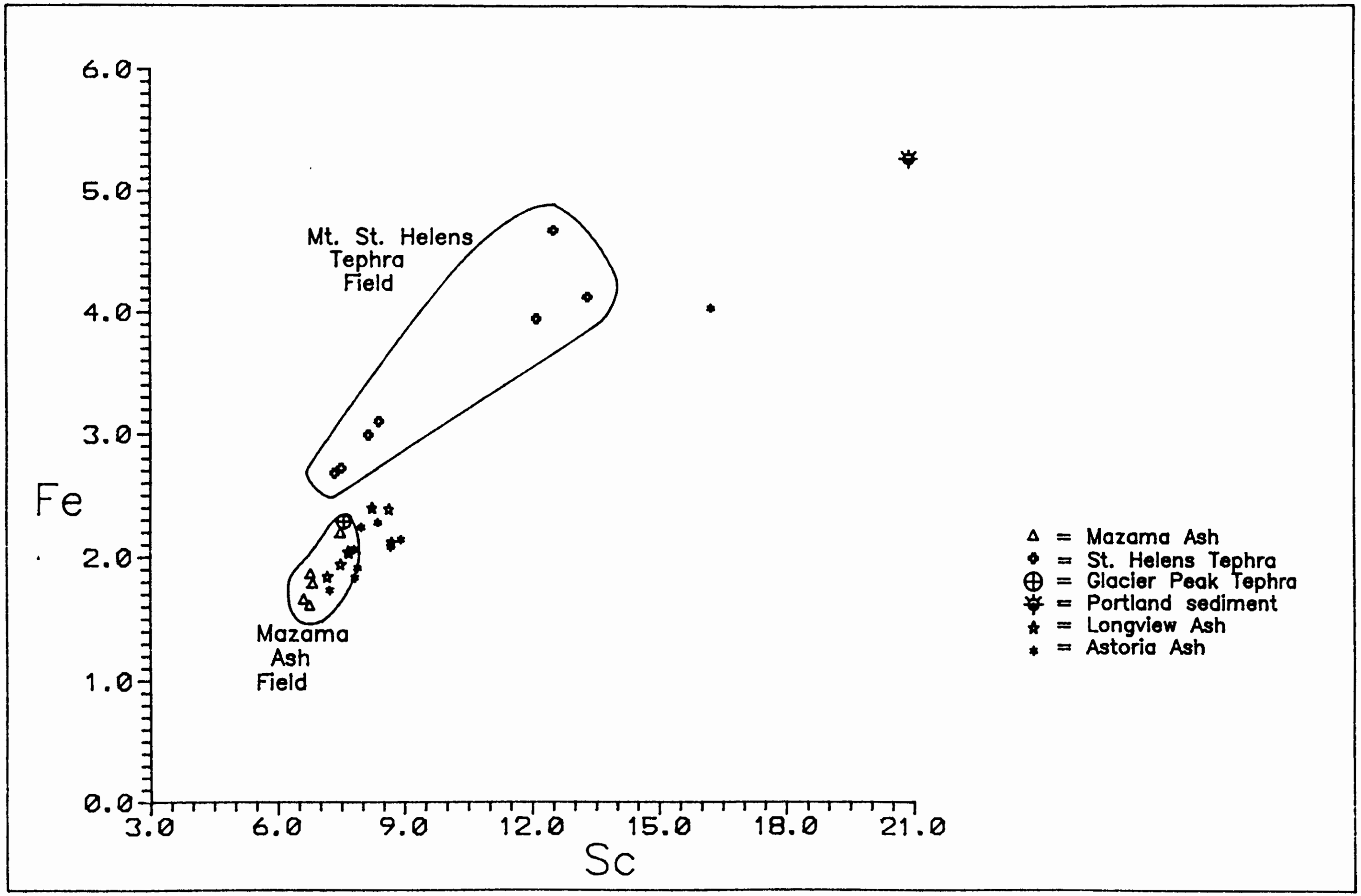

Figure A-15. Scandium vs. Iron; Longview and Astoria area sample sites.

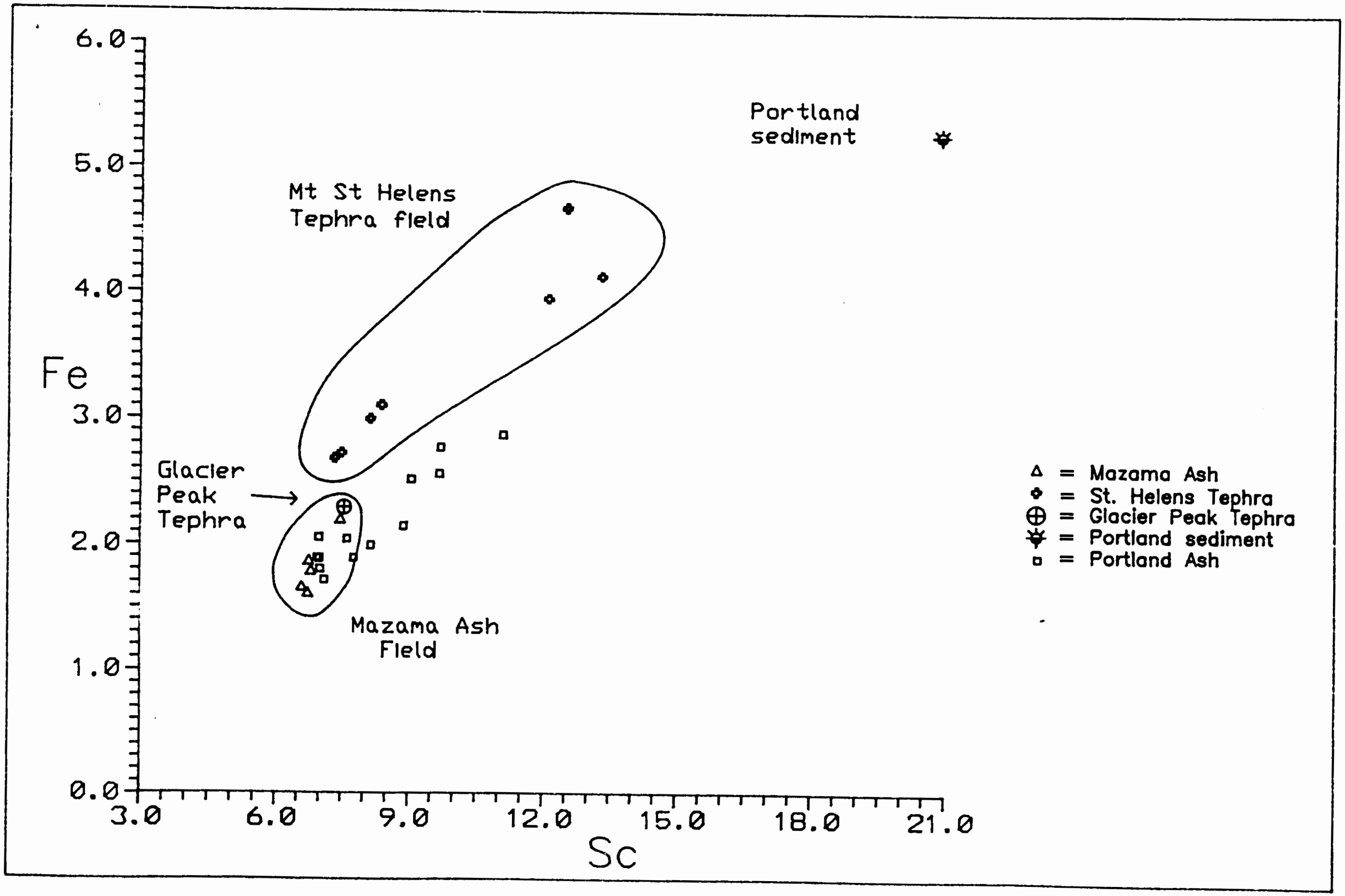

Figure A-16. Scandium vs. Iron; Portland area sample sites.

APPENDIX B

DATA BASE OF BOREHOLE RECORDS

Listed below is an explanation of how this data base was constructed including the methods used for interpretation.

Data for the last 163 records (Pt # 1324 through Pt # 1487) were taken from DOGAMI's Portland area seismic database. The database was compiled by Ian Maiden and generously donated by DOGAMI. Only those points from the DOGAMI database that fell within the floodplain boundaries and were not from duplicate borehole logs already compiled by the author were used.

<u>Column 1</u> - Location: General description of the borehole location. Water well designations are based on the official system for rectangular subdivision of public lands, referenced to the Willamette Base Line and Meridian. Many of the water wells were located in the center of their respective grid section if the well log did not indicate a quarter section reference. Also, for the sections that had multiple well occurrences without any quarter section reference, only one well log was chosen to represent that particular section; generally the well chosen was one that penetrated the underlying strata below the Holocene alluvium. This location designation was common for the Sauvie Island water wells and some of the wells on the Lewis River delta.

<u>Column 2</u> - Map ID#: Map identification Number that represents the unique designation for each borehole log incorporated into the data set and displayed on all maps in the thesis.

<u>Column 3</u> - UTM EAST: Universal Transverse Mercator grid position in zone 10. All values are in meters and increase eastward.

<u>Column 4</u> - UTM NORTH: Universal Transverse Mercator grid position north of the equator. All values are in meters and increase northward.

<u>Column 5</u> - Surface Elev Ft: Surface Elevation in feet from sea level (USC&GS datum) indicated on the borehole records. For the water wells where no surface elevation was given, the elevation was estimated from the nearest reference point (contour line or benchmark) indicated from the corresponding USGS 7.5 series topographic map. For boreholes in the Longview Washington area that indicated surface elevations from the Slaughters Bar datum, elevations were corrected to the USC&GS datum by adding 0.98 feet.

<u>Column 6</u> - Hole Depth Ft: Depth of the borehole in feet.

<u>Column 7</u> - Hole Base Ft: Hole Base Elevation in Feet; Base elevation in feet of the borehole.

<u>Column 8</u> - QalBasal Contact ft: Qal Base Elevation in Feet; Elevation of the basal contact between the overlying unconsolidated Quaternary Alluvium (Qal) and the underlying Formation. The contact was interpreted by the author as the boundary between the fine-grained (Qal and Qff) unconsolidated deposits and the underlying (Qfc, QMc, Tt, CRBG, or Ta) lithologies. The boundary was based on either a partition in grainsize, cementation, or density (interpreted from SPT blowcounts, or geophysical measurements) contrast. For boreholes that did not penetrate the underlying strata a value of zero appears for that data record.

Column 9 - QalBasal ContactM: Qal Base Elevation in meters; Same as column G in meters. These values were used to estimate isopach of Qal and Qff for all of the maps that appear in the thesis.

Column 10 - GIS Code: Binary code used for all borehole logs to indicate if the borehole penetrated any formation or lithologic unit beneath the unconsolidated Quaternary alluvium. 0 = no; 1 = yes.

Column 11 - Basal Lithol: Lithology of the underlying strata below the unconsolidated alluvium, used as the boundary for the Holocene contact. Abbreviations for the lithologies listed on the borehole records are as follows: Rock = local basin pre-Holocene strata of unidentified lithology; Qls = landslide deposits; S&G(&C) = sand and gravel (and cobbles); Grvl = gravel; G&Cobbles= gravel and cobbles; Bouldr = boulders; Qff = fine grained facies of the late Quaternary catastrophic flood deposits; Qfc = coarse grained facies of the late Quaternary catastrophic flood deposits; Tt = Troutdale Formation; SRM = Sandy River mudstone; Bslt = Basalt; Claystn = Claystone; Ast Frm = Astoria Formation; Gobel V. = Gobel volcanics.

Column 12 - Isopach feet: Isopach in feet; Thickness of Qal and Qff in feet. Includes fill material in some areas.

Column 13 - Isopach Meters: Isopach in meters; Thickness of Qal and Qff in meters. Includes fill material in some areas.

Column 14 - Ash Code: Binary code used to indicate the presence of the Mazama Ash occurrence. 1 = yes; 0 = no.

Column 15 - SPT Min/Max: Standard Penetration test values reported as the minimum and maximum number of blows reported within the unconsolidated Quaternary alluvium. SPT is defined as the number of blows required to drive a 2 inch outer diameter sampler one foot using a 140 pound weight free falling 30 inches per blow. The asterisk (*) indicates the number of blows required to drive a Dames and Moore inc. type U sampler one foot with 800 pound weight falling 24 inches per blow (also used to drive casing, personal communication with Dames and Moore inc.).

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
Weyerhauser	1	500775	5108222	-16	6.5	-22.5	-22	-6.7	1	Rock	6	1.8	0		
Longview	2	500801	5108183	-18	38	-56			0		38	0.3	0		
Mt Coffin	3	500828	5108152	-20.5	35.5	-56			0		35.5	2.3	1		
Site	4	500868	5108110	-12.5	16.5	-29	-28	-8.5	1	Rock	15.5	4.7	0		
	5	500789	5108201	-19	34	-53	-52	-15.8	1	Rock	33	10.1	0		
	6	500838	5108218	20	36.5	-16.5	-16	-4.9	1	Rock	36	11.0	0		
Weyerhauser	7	501141	5108509	15.5	93	-77.5	0	0.0	0		93	28.3	1		
Longview	8	501183	5108557	15.5	76.5	-61	0	0.0	0		76.5	23.3	0		
	9	501358	5108168	15.5	62	-46.5	0	0.0	0		62	18.9	0		
	10	501491	5108310	15.5	60	-44.5	0	0.0	0		60	18.3	0		
	11	501455	5108261	15.5	60	-44.5	0	0.0	0		60	18.3	0		
	12	501368	5108364	15.5	80	-64.5	0	0.0	0		80	24.4	1		
	13	501304	5108416	17	205	-188	0	0.0	0		205	62.5	1	2	60 *
	14	501331	5108448	16	152	-136	0	0.0	0		152	46.3	1	2	40 *
	15	501324	5108443	16	212	-196	-193	-58.8	1	Grvl	209	63.7	0		
	16	501328	5108433	16	164	-148	0	0.0	0		164	50.0	1		
	17	501307	5108421	17	155	-138	0	0.0	0		155	47.2	1		
	18	501273	5108345	15	151	-136	0	0.0	0		151	46.0	0		
	19	500907	5108720	16.5	72	-55.5	0	0.0	0		72	21.9	0	2	26 *
	20	500910	5108801	12.5	71.5	-59	0	0.0	0		71.5	21.8	0	2	30 *
	21	500966	5108864	11.5	100.5	-89	0	0.0	0		100.5	30.6	1	0	11 *
	22	501058	5108801	12	80.5	-68.5	0	0.0	0		80.5	24.5	1	1	64 *
	23	501005	5108778	15	71.5	-56.5	0	0.0	0		71.5	21.8	0	2	32 *
	24	501144	5108789	15	71.5	-56.5	0	0.0	0		71.5	21.8	0	0	18 *
	25	500836	5108815	17	30	-13	0	0.0	0		30	9.1	0	4	14 *
	26	500789	5108663	23.5	75.5	-52	0	0.0	0		75.5	23.0	0		
	27	501108	5108589	16	148.5	-132.5	0	0.0	0		148.5	45.3	1	2	31 *
	28	501410	5108523	13	117	-104	0	0.0	0		117	35.7	1	2	22 *
	29	501074	5108859	15	102.5	-87.5	0	0.0	0		102.5	31.2	1		
	30	501120	5108727	15	100.5	-85.5	0	0.0	0		100.5	30.6	1		
	31	501093	5108772	15	181	-166	0	0.0	0		181	55.2	0		
	32	500894	5108871	15	101	-86	0	0.0	0		101	30.8	1		
	33	500927	5108840	15	155	-140	0	0.0	0		155	47.2	1		
	34	500962	5108702	15	100.5	-85.5	0	0.0	0		100.5	30.6	1		
	35	501003	5108915	15	100	-85	0	0.0	0		100	30.5	1		
	36	500857	5108765	17	161	-144	0	0.0	0		161	49.1	0		
	37	501480	5108596	15	192.5	-177.5	0	0.0	0		192.5	58.7	1		
	38	500859	5108704	18	60.5	-42.5	0	0.0	0		60.5	18.4	0		
	39	500805	5108792	19.5	74	-54.5	0	0.0	0		74	22.6	0		
	40	500876	5108827	15	70	-55	0	0.0	0		70	21.3	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
	41	500906	5108757	17	81	-64	0	0.0	0		81	24.7	0		
	42	500966	5108774	14.5	70	-55.5	0	0.0	0		70	21.3	0		
	43	500973	5108802	14.5	70	-55.5	0	0.0	0		70	21.3	0		
	44	501004	5108732	18	85.5	-67.5	0	0.0	0		85.5	26.1	0		
	45	501073	5108746	15	89	-74	0	0.0	0		89	27.1	1		
	46	501041	5108783	14	70	-56	0	0.0	0		70	21.3	0		
	47	500797	5108732	21.5	61	-39.5	0	0.0	0		61	18.6	0		
	48	500914	5108635	19.5	60.5	-41	0	0.0	0		60.5	18.4	0		
	49	500867	5108872	13	70	-57	0	0.0	0		70	21.3	0		
	50	501064	5108719	15	70	-55	0	0.0	0		70	21.3	0		
	51	501013	5108812	12.5	50	-37.5	0	0.0	0		50	15.2	0		
Weyerhauser	52	501275	5108619	10	71.5	-61.5	0	0.0	0		71.5	21.8	0	1	15
	53	501226	5108608	10	101.5	-91.5	0	0.0	0		101.5	30.9	0	1	10
	54	501348	5108519	10	50	-40	0	0.0	0		50	15.2	0	1	21
	55	501363	5108542	10	86.5	-76.5	0	0.0	0		86.5	26.4	1	1	80
	56	501321	5108567	10	50	-40	0	0.0	0		50	15.2	0	1	21
	57	500844	5108332	24	152	-128	0	0.0	0		152	46.3	1		
	58	500907	5108313	25	76.5	-51.5	0	0.0	0		76.5	23.3	0		
	59	500864	5108369	25	71.5	-46.5	0	0.0	0		71.5	21.8	0		
	60	501799	5107826	16	118	-102	-101	-30.8	1	Bslt	117	35.7	0	0	20 *
	61	502046	5107711	17	105.5	-88.5	0	0.0	0		105.5	32.2	0	4	32 *
	62	500692	5108426	17.5	161	-143.5	0	0.0	0		161	49.1	1		
	63	500593	5108557	17.5	173.5	-156	0	0.0	0		173.5	52.9	1		
	64	500518	5108667	26.5	200.5	-174	0	0.0	0		200.5	61.1	1		
	65	501695	5108004	17	109	-92	-84	-25.6	1	Grvl	101	30.8	1		
	66	501848	5107920	16.5	54.5	-38	-38	-11.6	1	Bslt	54.5	16.6	0		
	67	501929	5107847	15	179	-164	-164	-50.0	1	Bslt	179	54.6	0		
	68	501749	5108014	16	100	-84	-84	-25.6	1	Grvl	100	30.5	0		
	69	501786	5107937	16.5	20.5	-3.5	-3.5	-1.1	1	Bslt	20	6.1	0		
	70	501854	5107851	16.5	127	-110.5	-107.5	-32.8	1	Bslt	124	37.8	0		
	71	501774	5107981	16.5	61	-44.5	-43.5	-13.3	1	Grvl	60	18.3	0		
	72	501838	5107789	16	118	-102	-102	-31.1	1	Bslt	118	36.0	0		
	73	501907	5107693	16.5	110	-93.5	0	0.0	0		110	33.5	0		
	74	501960	5107788	16	112	-96	0	0.0	0		112	34.1	0		
	75	502017	5107674	16.5	197	-180.5	0	0.0	0		197	60.0	0		
	76	502107	5107649	15.5	110	-94.5	0	0.0	0		110	33.5	0		
	77	502166	5107688	15	177.5	-162.5	-162.5	-49.5	1	Bslt	177.5	54.1	0		
	78	501293	5108499	15.5	156.5	-141	0	0.0	0		156.5	47.7	1		
	79	501793	5107908	16.5	17	-0.5	-0.5	-0.2	1	Bslt	17	5.2	0	0	4 *
	80	501786	5107846	15.5	70.5	-55	0	0.0	0		70.5	21.5	0	0	14 *
	81	501917	5107809	15.5	70.5	-55	0	0.0	0		70.5	21.5	0	2	16 *

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
	82	502003	5107741	16.5	70.5	-54	0	0.0	0		70.5	21.5	0		
	83	502061	5107800	15.5	70	-54.5	0	0.0	0		70	21.3	0	1	21 *
	84	501818	5107977	16.5	36	-19.5	-19.5	-5.9	1	Bslt	36	11.0	0		
	85	501839	5107951	16.5	21.5	-5	-5	-1.5	1	Bslt	21.5	6.6	0		
	86	501752	5107859	16.5	70.5	-54	0	0.0	0		70.5	21.5	0		
	87	501900	5107753	16.5	70.5	-54	0	0.0	0		70.5	21.5	0		
	88	501983	5107844	15	70.5	-55.5	0	0.0	0		70.5	21.5	0		
	89	502114	5107748	16.5	70.5	-54	0	0.0	0		70.5	21.5	0		
Reynolds	90	500467	5109223	14	81	-67	0	0.0	0		81	24.7	1		
Metals	91	500191	5109175	13	256	-243	-190	-57.9	1	Tt	203	61.9	0		
Longview	92	499967	5109292	12.3	250	-237.7	-196.7	-60.0	1	Grvl	209	63.7	0		
	93	500273	5109091	11	292	-281	-201	-61.3	1	Tt	231	70.4	0		
	94	500137	5109842	5.1	97	-91.9	0	0.0	0		97	29.6	1	1	14 *
	95	500060	5109742	5.3	151.5	-146.2	0	0.0	0		151.5	46.2	1	2	36 *
	96	499997	5109648	6.5	98	-91.5	0	0.0	0		98	29.9	1		
	97	499857	5109510	9.7	126	-116.3	0	0.0	0		126	38.4	0		
	98	500234	5109761	5.2	100	-94.8	0	0.0	0		100	30.5	1		
	99	500149	5109653	7.4	100	-92.6	0	0.0	0		100	30.5	1	0	18 *
	100	500071	5109555	9.6	102.5	-92.9	0	0.0	0		102.5	31.2	1		
	101	499961	5109432	9.3	63	-53.7	0	0.0	0		63	19.2	0		
	102	500326	5109688	5.4	225	-219.6	0	0.0	0		225	68.6	1		
	103	500236	5109584	9.6	100	-90.4	0	0.0	0		100	30.5	1		
	104	500144	5109485	9.1	152	-142.9	0	0.0	0		152	46.3	1		
	105	500059	5109375	9.5	101.5	-92	0	0.0	0		101.5	30.9	1		
	106	500021	5109322	11.3	100	-88.7	0	0.0	0		100	30.5	0		
	107	499988	5109268	12.3	103	-90.7	0	0.0	0		103	31.4	1		
	108	500220	5109490	10	100	-90	0	0.0	0		100	30.5	1		
	109	500415	5109655	4.3	80	-75.7	0	0.0	0		80	24.4	0		
	110	500469	5109605	3.7	82	-78.3	0	0.0	0		82	25.0	0		
	111	500319	5109500	9.5	88	-78.5	0	0.0	0		88	26.8	1		
	112	500386	5109474	9.1	88	-78.9	0	0.0	0		88	26.8	1		
	113	500335	5109244	12.2	100	-87.8	0	0.0	0		100	30.5	1		
	114	500265	5109159	14.1	100	-85.9	0	0.0	0		100	30.5	0		
	115	500465	5109634	4	32	-28	0	0.0	0		32	9.8	0		
	116	500505	5109606	3.6	32	-28.4	0	0.0	0		32	9.8	0		
	117	500436	5109603	4	32	-28	0	0.0	0		32	9.8	0		
	118	500475	5109572	3.6	32	-28.4	0	0.0	0		32	9.8	0		
	119	500420	5109680	4	32	-28	0	0.0	0		32	9.8	0		
	120	500448	5109661	4.3	32	-27.7	0	0.0	0		32	9.8	0		
	121	500388	5109649	4.1	32	-27.9	0	0.0	0		32	9.8	0		
	122	500411	5109621	4	32	-28	0	0.0	0		32	9.8	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
	123	499911	5109469	10.2	103	-92.8	0	0.0	0		103	31.4	0	1	16 *
	124	499873	5109360	11.4	92	-80.6	0	0.0	0		92	28.0	1	2	8 *
	125	499955	5109316	11	117	-106	0	0.0	0		117	35.7	0	2	21 *
	126	500022	5109217	12.2	135	-122.8	0	0.0	0		135	41.1	0	1	31 *
	127	500100	5109314	10.4	132	-121.6	0	0.0	0		132	40.2	1	2	35 *
	128	500192	5109380	8.9	101.5	-92.6	0	0.0	0		101.5	30.9	1	1	15 *
	129	500038	5109530	6	73	-67	0	0.0	0		73	22.3	0		
	130	500037	5109499	6	70	-64	0	0.0	0		70	21.3	0		
	131	500094	5109632	6	70	-64	0	0.0	0		70	21.3	1		
	132	500068	5109606	6	70	-64	0	0.0	0		70	21.3	1		
	133	500046	5109436	6	71	-65	0	0.0	0		71	21.6	0		
	134	499992	5109472	6	40	-34	0	0.0	0		40	12.2	0		
	135	499930	5109589	7.5	72.5	-65	0	0.0	0		72.5	22.1	1		
	136	499894	5109556	6.5	70	-63.5	0	0.0	0		70	21.3	1		
	137	499768	5109374	12	223	-211	0	0.0	0		223	68.0	1	2	30 *
	138	499781	5109431	12	80	-68	0	0.0	0		80	24.4	1	2	26 *
	139	499820	5109386	12	215	-203	0	0.0	0		215	65.5	1	2	22 *
	140	499917	5109327	10	211	-201	-200	-61.0	1	Grvl	210	64.0	1	2	24 *
	141	499930	5109263	10	92	-82	0	0.0	0		92	28.0	1	4	20 *
	142	499876	5108957	-26	100	-126	0	0.0	0		100	30.5	1		
	143	499988	5108855	-36	90	-126	0	0.0	0		90	27.4	1		
	144	500086	5108776	-51.5	48	-99.5	0	0.0	0		48	14.6	1		
	145	499842	5109967	6.1	100	-93.9	0	0.0	0		100	30.5	1		
	146	499916	5110097	4.8	80	-75.2	0	0.0	0		80	24.4	1		
	147	499922	5108887	-40.5	127	-167.5	0	0.0	0		127	38.7	1		
	148	499980	5108821	-44.5	136	-180.5	-178.5	-54.4	1	Grvl	134	40.8	0		
	149	500010	5108807	-40.5	140.5	-181	-179.5	-54.7	1	Grvl	139	42.4	0		
	150	499635	5110007	11	74.5	-63.5	0	0.0	0		74.5	22.7	1		
	151	499688	5109968	11	62	-51	0	0.0	0		62	18.9	0		
	152	499717	5109934	10.5	87.5	-77	0	0.0	0		87.5	26.7	0		
	153	499677	5110006	11	70	-59	0	0.0	0		70	21.3	0		
	154	499725	5109966	11	67	-56	0	0.0	0		67	20.4	0		
	155	499661	5110120	4	25.5	-21.5	0	0.0	0		25.5	7.8	0		
	156	499779	5110074	7	23.5	-16.5	0	0.0	0		23.5	7.2	0		
	157	499829	5110029	7	25.5	-18.5	0	0.0	0		25.5	7.8	0		
	158	499883	5110000	7.5	25.5	-18	0	0.0	0		25.5	7.8	0		
	159	499671	5110170	5	109.5	-104.5	0	0.0	0		109.5	33.4	0		
	160	499700	5110096	6.5	96.5	-90	0	0.0	0		96.5	29.4	1		
	161	499735	5110136	5	98.5	-93.5	0	0.0	0		98.5	30.0	1		
	162	499763	5110104	5	103	-98	0	0.0	0		103	31.4	1		
	163	499820	5110053	5.5	106	-100.5	0	0.0	0		106	32.3	0		
	164	499866	5110020	9	113.5	-104.5	0	0.0	0		113.5	34.6	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
	165	499835	5109936	8	90.5	-82.5	0	0.0	0		90.5	27.6	0		
	166	499870	5110124	6.2	100.2	-94	0	0.0	0		100.2	30.5	1		
	167	499700	5110147	5.5	53.5	-48	0	0.0	0		53.5	16.3	0		
	168	499571	5110187	5	69.5	-64.5	0	0.0	0		69.5	21.2	0		
	169	499837	5110042	4.4	46.4	-42	0	0.0	0		46.4	14.1	0		
	170	499732	5110063	5.1	62.1	-57	0	0.0	0		62.1	18.9	0		
	171	499563	5110136	5.1	61.1	-56	0	0.0	0		61.1	18.6	0		
	172	499783	5109980	3.3	49.3	-46	0	0.0	0		49.3	15.0	0		
	173	499691	5110039	5.6	42.6	-37	0	0.0	0		42.6	13.0	0		
	174	499554	5110061	2.3	41.8	-39.5	0	0.0	0		41.8	12.7	0		
	175	499609	5109946	4.2	50.2	-46	0	0.0	0		50.2	15.3	0		
	176	499772	5109867	4.5	50.5	-46	0	0.0	0		50.5	15.4	0		
	177	499672	5109841	6	52	-46	0	0.0	0		52	15.8	0		
	178	499537	5109935	5	51	-46	0	0.0	0		51	15.5	0		
Newsprint	179	505076	5107947	18	90	-72	0	0.0	0		90	27.4	1	1	28 *
Plant	180	505115	5107992	16	72	-56	0	0.0	0		72	21.9	0	1	26 *
Longview	181	505106	5108053	15	51.5	-36.5	0	0.0	0		51.5	15.7	0	2	31 *
Retirement Home	182	504603	5109899	16.5	81.5	-65	0	0.0	0		81.5	24.8	0		
Longview Wa.	183	504618	5109859	16.5	72	-55.5	0	0.0	0		72	21.9	0		
	184	504591	5109795	14.5	37	-22.5	0	0.0	0		37	11.3	0		
Longview Bank	185	505079	5109091	19	98.5	-79.5	0	0.0	0		98.5	30.0	0	2	42
	186	505108	5109038	18	56.5	-38.5	0	0.0	0		56.5	17.2	0	2	40
	187	505062	5109056	18	55	-37	0	0.0	0		55	16.8	0	4	35
	188	505069	5109014	18	55	-37	0	0.0	0		55	16.8	0	3	31
	189	505086	5109063	18.5	54	-35.5	0	0.0	0		54	16.5	0	2	26
Longview Fibre	190	506300	5105497	14	122.5	-108.5	0	0.0	0		122.5	37.3	1		
	191	506221	5105292	14	122	-108	0	0.0	0		122	37.2	0		
	192	506561	5105311	15.6	137.1	-121.5	0	0.0	0		137.1	41.8	1	5	39 *
	193	506569	5105433	15.6	171.2	-155.6	0	0.0	0		171.2	52.2	1	2	37 *
	194	506493	5105267	15.5	171.5	-156	0	0.0	0		171.5	52.3	1	5	42 *
	195	506523	5105381	15.5	151.5	-136	0	0.0	0		151.5	46.2	1	3	38 *
Internat. Paper	196	504729	5104969	-24	48.5	-72.5	0	0.0	0		48.5	14.8	0	3	20 *
Longview Bridge	197	503565	5106291	18.5	182	-163.5	-159.5	-48.6	1	Grvl	178	54.3	0		
	198	503533	5106238	27	70	-43	0	0.0	0		70	21.3	0		
	199	503469	5106135	23.6	50	-26.4	0	0.0	0		50	15.2	0		
	200	503407	5106033	22.5	55	-32.5	0	0.0	0		55	16.8	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
	201	503358	5105962	21.6	111	-89.4	0	0.0	0		111	33.8	0		
	202	503331	5105910	12	52	-40	0	0.0	0		52	15.8	0		
	203	503579	5106312	15	105	-90	0	0.0	0		105	32.0	0		
	204	502840	5105114	-37.5	46	-83.5	-83.5	-25.5	1	Bouldr	46	14.0	0		
	205	502798	5105141	-38.1	64.8	-102.9	-90.5	-27.6	1	Grvl	52.4	16.0	0		
	206	502773	5105044	22	151	-129	-35	-10.7	1	Grvl	57	17.4	0		
WASHDOT SR-432	207	505596	5106982	14.8	142	-127.2	0	0.0	0		142	43.3	1		
Trojan	208	508756	5098235	22.8	133.5	-110.7	-106.2	-32.4	1	Gobel V.	129	39.3	0	2	28
	209	508663	5098237	22.6	160.5	-137.9	0	0.0	0		160.5	48.9	1	1	47
	210	508701	5098307	20	66	-46	0	0.0	0		66	20.1	1		
	211	508719	5098160	20	52.5	-32.5	0	0.0	0		52.5	16.0	0		
	212	508731	5097741	18	77	-59	0	0.0	0		77	23.5	1		
	213	508691	5097788	18	142	-124	0	0.0	0		142	43.3	0		
	214	508720	5097696	18	77.5	-59.5	0	0.0	0		77.5	23.6	1		
	215	508787	5097776	18	100	-82	0	0.0	0		100	30.5	0		
Water Well	216	508982	5097227	12	327	-315	-281	-85.6	1	Grvl	293	89.3	0		
T7NR2W3Ad	217	506958	5107185	13	101	-88	0	0.0	0		101	30.8	0		
T7NR2W4Aa	218	505405	5107737	10	20	-10	0	0.0	0		20	6.1	0		
T7NR2W9Caa	219	504682	5105358	15	215	-200	-163	-49.7	1	Tt	178	54.3	0		
T7NR2W10Bc	220	505887	5105669	15	61.5	-46.5	0	0.0	0		61.5	18.7	0		
T7NR2W11Bd	221	507748	5105691	20	96.5	-76.5	0	0.0	0		96.5	29.4	0		
T7NR2W13Abc	222	509646	5104374	14	297	-283	-174	-53.0	1	Claystn	188	57.3	0		
T7NR2W7Dc	223	501754	5105066	10	163	-153	-41	-12.5	1	S&G	51	15.5	0		
T7NR2W7Db	224	501836	5105406	10	36	-26	-16	-4.9	1	Grvl	26	7.9	0		
T7NR2W7Cb	225	501032	5105443	10	166	-156	-36	-11.0	1	Grvl	46	14.0	0		
T7NR2W7Ca	226	501420	5105439	10	119	-109	-67	-20.4	1	S&G	77	23.5	0		
T7NR2W8Cc	227	502808	5104841	10	145	-135	-35	-10.7	1	Grvl	45	13.7	0		
T7NR3W12Ba	228	499790	5106248	7	130	-123	-92	-28.0	1	Grvl	99	30.2	0		
BPA Crossing	229	497781	5107701	12	152	-140	0	0.0	0		152	46.3	1		
	230	498064	5108164	11	150	-139	0	0.0	0		150	45.7	0		
	231	498474	5108834	14	98.5	-84.5	0	0.0	0		98.5	30.0	0		
	232	498922	5109585	8	78.5	-70.5	0	0.0	0		78.5	23.9	0		
BPA Longview	233	498774	5109651	10	41	-31	0	0.0	0		41	12.5	0	2	38
	234	498822	5109655	10	41.5	-31.5	0	0.0	0		41.5	12.6	0	4	7

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
CERRO Corp	235	497937	5111132	4	135.5	-131.5	-128	-39.0	1	Bslt	132	40.2	1		
	236	497640	5111014	3	187	-184	0	0.0	0		187	57.0	1		
	237	497174	5110817	11	150	-139	0	0.0	0		150	45.7	1		
Proposed Grain	238	498639	5109682	10.7	147.7	-137	0	0.0	0		147.7	45.0	1	2	83
Storage Fac.	239	498514	5109658	13.2	141.2	-128	0	0.0	0		141.2	43.0	1	4	30
Longview	240	498551	5109766	5.4	76.4	-71	0	0.0	0		76.4	23.3	1	3	17
	241	498772	5109600	15.4	142.4	-127	0	0.0	0		142.4	43.4	1	8	75
	242	498807	5109701	5.4	101.4	-96	0	0.0	0		101.4	30.9	1	2	180
	243	498618	5109624	14.2	141.2	-127	0	0.0	0		141.2	43.0	1	4	105
	244	498418	5109676	15.7	141.7	-126	0	0.0	0		141.7	43.2	1	5	50
	245	498448	5109788	6	142	-136	0	0.0	0		142	43.3	1	4	33
Willow Grove	246	493205	5114389	10	99.5	-89.5	0	0.0	0		99.5	30.3	0	0	24 *
Island	247	492833	5113587	10	148.5	-138.5	0	0.0	0		148.5	45.3	0	1	30 *
	248	493406	5113805	10	152	-142	0	0.0	0		152	46.3	0	0	37 *
	249	492644	5114213	10	137	-127	0	0.0	0		137	41.8	0		
T8NR3W17Cb	250	493393	5113436	10	105	-95	0	0.0	0		105	32.0	0		
T8NR3W26	251	498485	5110492	20	200	-180	0	0.0	0		200	61.0	1		
T8NR3W26Bd	252	498514	5110441	20	35	-15	0	0.0	0		35	10.7	0		
T8NR3W24	253	500047	5112151	20	230	-210	-188	-57.3	1	Grvl	208	63.4	0		
T8NR2W26Dcad	254	508281	5109811	12	361	-349	-153	-46.6	1	Grvl	165	50.3	0		
T8NR2W31Cdac	255	501418	5108079	15	201.5	-184.5	-179	-54.6	1	Grvl	194	59.1	0		
T8NR3W36Baab	256	499882	5109452	10	410	-400	-295	-89.9	1	Grvl	305	93.0	0		
T8NR3W36Adb	257	500524	5108964	10	261	-251	-197	-60.0	1	Grvl	207	63.1	0		
T8NR3W25Dcbb	258	500052	5109886	10	353	-343	-302	-92.1	1	S&G	312	95.1	0		
T8NR3W25Dcd	259	500350	5109704	10	339	-329	-289	-88.1	1	S&G	299	91.1	0		
T8NR3W25Cdba	260	499788	5109858	10	395	-385	-317	-96.6	1	Grvl	327	99.7	0		
T8NR2W34Cd	261	506040	5108041	10	111	-101	0	0.0	0		111	33.8	0		
T7NR2W36D	262	509993	5098664	10	331	-321	-315	-96.0	1	Claystn	325	99.1	0		
T7NR2W36Dc	263	509770	5098436	13	101.5	-88.5	0	0.0	0		101.5	30.9	0		
T7NR1W31Dd	264	511557	5098434	32	115	-83	-70	-21.3	1	S&G	102	31.1	0		
	265	511230	5099083	18	29	-11	0	0.0	0		29	8.8	0		
Kalama Coal	266	509813	5098666	9.5	65	-55.5	0	0.0	0		65	19.8	0	1	28
Shipment Fac.	267	510192	5098530	12	71.5	-59.5	0	0.0	0		71.5	21.8	0	1	52
	268	510571	5099040	10	71.5	-61.5	0	0.0	0		71.5	21.8	0	1	33

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min Max
Dow Chemical	269	510586	5096664	11	53.5	-42.5	0	0.0	0		53.5	16.3	0	
Kalama Wa.	270	510911	5096731	9	50	-41	0	0.0	0		50	15.2	0	
	271	511000	5096817	10	50	-40	0	0.0	0		50	15.2	0	
	272	510958	5096528	14	52	-38	0	0.0	0		52	15.8	0	
	273	511160	5096576	10	76.5	-66.5	0	0.0	0		76.5	23.3	0	
	274	510888	5096318	18	50	-32	0	0.0	0		50	15.2	0	
	275	510890	5096293	18	23	-5	0	0.0	0		23	7.0	0	
	276	511098	5096244	14.5	50	-35.5	0	0.0	0		50	15.2	0	
	277	511298	5096325	12	72	-60	0	0.0	0		72	21.9	0	
	278	510622	5096549	14	86	-72	0	0.0	0		86	26.2	0	
	279	510702	5096549	14	86	-72	0	0.0	0		86	26.2	0	
	280	510641	5096476	20	32.5	-12.5	0	0.0	0		32.5	9.9	0	
	281	510714	5096495	18	32.5	-14.5	0	0.0	0		32.5	9.9	0	
	282	510561	5096585	18	31.5	-13.5	0	0.0	0		31.5	9.6	0	
	283	510647	5096614	14	31	-17	0	0.0	0		31	9.4	0	
	284	510769	5096386	19	51	-32	0	0.0	0		51	15.5	0	
	285	510818	5096322	18.5	52	-33.5	0	0.0	0		52	15.8	0	
	286	510922	5096206	19	52	-33	0	0.0	0		52	15.8	0	
	287	510893	5096393	17	50	-33	0	0.0	0		50	15.2	0	
	288	511011	5096385	13.5	52	-38.5	0	0.0	0		52	15.8	0	
	289	511022	5096266	16.5	54	-37.5	0	0.0	0		54	16.5	0	
	290	511069	5096338	14.5	60	-45.5	0	0.0	0		60	18.3	0	
	291	510900	5096440	13	48.5	-35.5	0	0.0	0		48.5	14.8	0	
	292	511016	5096462	11.5	60	-48.5	0	0.0	0		60	18.3	0	
	293	511060	5096508	10	49	-39	0	0.0	0		49	14.9	0	
	294	510806	5096460	14.5	52	-37.5	0	0.0	0		52	15.8	0	
	295	509655	5097711	-30	15	-45	0	0.0	0		15	4.6	0	
	296	509773	5097390	-30	16	-46	0	0.0	0		16	4.9	0	
	297	509957	5097102	-30	13	-43	0	0.0	0		13	4.0	0	
	298	510126	5096902	-30	20	-50	0	0.0	0		20	6.1	0	
	299	510359	5096690	-30	14	-44	0	0.0	0		14	4.3	0	
Sand Exploration	300	509783	5097606	-10	42	-52	0	0.0	0		42	12.8	0	
Kalama Wa.	301	509910	5097310	-15	33	-48	0	0.0	0		33	10.1	0	
	302	510009	5097087	-20	10	-30	0	0.0	0		10	3.0	0	
	303	510267	5096825	-10	37	-47	0	0.0	0		37	11.3	0	
	304	509804	5097797	-1.5	49	-50.5	0	0.0	0		49	14.9	0	
	305	509921	5097434	0	20	-20	0	0.0	0		20	6.1	0	
	306	510098	5097214	-2	46	-48	0	0.0	0		46	14.0	0	
	307	510161	5097000	-5	40	-45	0	0.0	0		40	12.2	0	
	308	509867	5097215	-30	19	-49	0	0.0	0		19	5.8	0	
	309	509848	5097537	-1	42	-43	0	0.0	0		42	12.8	0	

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
Proposed Mill	310	510188	5097140	-5	74.5	-79.5	0	0.0	0		74.5	22.7	0		
Kalama Wa.	311	510255	5097051	-0.5	71.5	-72	0	0.0	0		71.5	21.8	0		
	312	510321	5096865	-17	72	-89	0	0.0	0		72	21.9	0		
	313	510937	5097636	9.7	15	-5.3	0	0.0	0		15	4.6	0		
	314	510372	5097280	10.3	21	-10.7	0	0.0	0		21	6.4	0		
	315	510389	5097624	12.9	24	-11.1	0	0.0	0		24	7.3	0		
	316	510297	5097933	8.5	15	-6.5	0	0.0	0		15	4.6	0		
	317	510115	5098011	10.6	17	-6.4	0	0.0	0		17	5.2	0		
	318	510384	5098093	10.2	16	-5.8	0	0.0	0		16	4.9	0		
	319	510190	5097709	9.9	16	-6.1	0	0.0	0		16	4.9	0		
	320	510608	5097433	13.6	20	-6.4	0	0.0	0		20	6.1	0		
	321	510584	5097658	10.3	16	-5.7	0	0.0	0		16	4.9	0		
	322	510549	5097778	10.2	16	-5.8	0	0.0	0		16	4.9	0		
	323	511065	5097471	8.6	45	-36.4	0	0.0	0		45	13.7	0		
	324	511001	5097313	10.9	26	-15.1	0	0.0	0		26	7.9	0		
	325	510753	5097253	10.2	20	-9.8	0	0.0	0		20	6.1	0		
	326	510739	5096940	9.1	25	-15.9	0	0.0	0		25	7.6	0		
	327	510484	5097072	11.4	26	-14.6	0	0.0	0		26	7.9	0		
	328	510300	5097662	9.4	10	-0.6	0	0.0	0		10	3.0	0		
	329	510727	5097561	5.4	10	-4.6	0	0.0	0		10	3.0	0		
	330	510584	5097565	10.8	10	0.8	0	0.0	0		10	3.0	0		
	331	510809	5097544	11.5	17	-5.5	0	0.0	0		17	5.2	0		
	332	510867	5097311	10	50	-40	0	0.0	0		50	15.2	0		
	333	510973	5097173	10	23	-13	0	0.0	0		23	7.0	0		
	334	510376	5096788	16	85	-69	0	0.0	0		85	25.9	0		
	335	510581	5097132	12	18	-6	0	0.0	0		18	5.5	0		
	336	510197	5097292	10	89.5	-79.5	0	0.0	0		89.5	27.3	0		
	337	510036	5096999	-27.5	22.5	-50	0	0.0	0		22.5	6.9	0		
	338	510140	5097090	-2.5	48.5	-51	0	0.0	0		48.5	14.8	0		
	339	509973	5097355	-2	48	-50	0	0.0	0		48	14.6	0		
	340	510122	5097295	-2.5	49	-51.5	0	0.0	0		49	14.9	0		
	341	509747	5097516	-23.5	26	-49.5	0	0.0	0		26	7.9	0		
Port of Kalama	342	511922	5094805	3.5	43.5	-40	0	0.0	0		43.5	13.3	0		
	343	511962	5094699	1	35.5	-34.5	0	0.0	0		35.5	10.8	0		
	344	511992	5094594	4.5	39	-34.5	0	0.0	0		39	11.9	0		
	345	511940	5094513	4	31.5	-27.5	0	0.0	0		31.5	9.6	0		
Kalama Wa.	346	513243	5092026	27	65	-38	-37.5	-11.4	1	Bslt	64.5	19.7	0		
South 2 miles	347	513202	5092095	27.5	43.5	-16	-13.5	-4.1	1	Bslt	40	12.2	0		
	348	513157	5092180	28	68	-40	-40	-12.2	1	Bslt	68	20.7	0	10	24

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
	349	513277	5092045	29	45.5	-16.5	-16.5	-5.0	1	Bslt	45.5	13.9	0		
	350	513234	5092110	30.5	17.5	13	15.5	4.7	1	Bslt	15	4.6	0		
	351	513191	5092198	29	70	-41	-21	-6.3	1	Bslt	50	15.2	0	18	24
Virginia Chem Co	352	512372	5093244	29	85	-56	-51	-15.5	1	Bslt	80	24.4	0		
Kalama Wa.	353	512272	5093365	8.2	112	-103.8	-98	-29.9	1	Bslt	106.2	32.4	0		
	354	512225	5093497	32	49	-17	-13	-4.0	1	Bslt	45	13.7	0		
	355	512336	5093332	36.8	44	-7.2	4	1.2	1	Bslt	32.8	10.0	0	2	26 *
	356	512601	5092889	21.3	56.3	-35	-33.5	-10.2	1	Bslt	54.8	16.7	0	4	13 *
	357	512688	5092601	21.3	37	-15.7	-14	-4.3	1	Bslt	35.3	10.8	0	4	12 *
	358	512783	5092658	27.1	58	-30.9	-29	-8.8	1	Bslt	56.1	17.1	0	4	17 *
	359	512880	5092644	28.4	69	-40.6	0	0.0	0		69	21.0	0	5	16 *
Grain Terminal	360	513022	5091956	12	110	-98	-94	-28.7	1	Grvl	106	32.3	0		
Kalama Wa.	361	512943	5092133	9.5	97	-87.5	-73.5	-22.4	1	Grvl	83	25.3	0		
	362	512861	5092308	12.5	65	-52.5	-50.5	-15.4	1	Rock	63	19.2	0		
	363	512986	5092060	10.5	102	-91.5	-71.5	-21.8	1	Grvl	82	25.0	0		
	364	512934	5092242	14	79	-65	-58	-17.7	1	Grvl	72	21.9	0		
	365	513119	5092038	18	78	-60	-59	-18.0	1	Rock	77	23.5	0		
	366	512950	5092312	25	68	-43	-42	-12.8	1	Rock	67	20.4	0		
	367	512789	5092441	11.1	39	-27.9	-27.9	-8.5	1	Rock	39	11.9	0		
	368	512886	5092484	26.4	26	0.4	2.4	0.7	1	Rock	24	7.3	0		
	369	513073	5092185	20	65	-45	-44	-13.4	1	Rock	64	19.5	0		
	370	512958	5092389	25	49.5	-24.5	-23.5	-7.2	1	Rock	48.5	14.8	0		
	371	512684	5092400	-32	43	-75	0	0.0	0		43	13.1	0		
	372	512767	5092259	-33	44	-77	0	0.0	0		44	13.4	0		
	373	512862	5092090	-42	33	-75	0	0.0	0		33	10.1	0		
	374	512950	5091914	-43	34	-77	0	0.0	0		34	10.4	0		
	375	512981	5092136	12	88	-76	-67	-20.4	1	Grvl	79	24.1	0		
	376	513029	5092046	12	99	-87	-69	-21.0	1	Grvl	81	24.7	0		
	377	512993	5092170	12	77	-65	-63	-19.2	1	Rock	75	22.9	0		
	378	513019	5092123	16	87	-71	-60	-18.3	1	Grvl	76	23.2	0		
	379	513034	5092085	15	91	-76	-64	-19.5	1	Grvl	79	24.1	0		
	380	512904	5092311	26	71	-45	0	0.0	0		71	21.6	0		
Woodland Wa.	381	519213	5083895	-2.5	80.5	-83	0	0.0	0		80.5	24.5	0	0	21 *
	382	519221	5083816	-3.5	80	-83.5	0	0.0	0		80	24.4	0	2	22 *
	383	519169	5083866	-2.5	90.5	-93	0	0.0	0		90.5	27.6	0		
	384	519178	5083783	-3	80	-83	0	0.0	0		80	24.4	0	0	17 *
Non Developed	385	513690	5090945	45	120.8	-75.8	45	13.7	1	Rock	120.8	36.8	0		
Industrial Site	386	513596	5091045	30	105.8	-75.8	30	9.1	1	Rock	105.8	32.2	0		
	387	513670	5091095	14	86	-72	14	4.3	1	Rock	86	26.2	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min Max
T5NR1W10	388	516303	5085707	10	43	-33	0	0.0	0		43	13.1	0	
T5NR1W11Bd	389	517212	5086350	8	198	-190	0	0.0	0		198	60.4	0	
T5NR1W15Cd	390	515623	5084604	10	202	-192	-136	-41.5	1	G&Clay	146	44.5	0	
T5NR1W14Cb	391	517465	5084433	15	51	-36	0	0.0	0		51	15.5	0	
T5NR1W14Bd	392	517080	5084840	10	40	-30	0	0.0	0		40	12.2	0	
T5NR1W14Bdda	393	517689	5084778	10	38	-28	0	0.0	0		38	11.6	0	
T5NR1W14Aa	394	518283	5085251	10	30	-20	0	0.0	0		30	9.1	0	
T5NR1W13Bc	395	518685	5084836	10	51.5	-41.5	0	0.0	0		51.5	15.7	0	
T5NR1W13Bb	396	518668	5085255	10	56	-46	0	0.0	0		56	17.1	0	
T5NR1W13Cc	397	518683	5084050	20	45	-25	0	0.0	0		45	13.7	0	
T5NR1W16Cc	398	513956	5084117	15	160	-145	-88	-26.8	1	S&G	103	31.4	0	
T5NR1W8A	399	513302	5087034	15	70	-55	0	0.0	0		70	21.3	0	
Fertilizer Plant	400	514351	5084293	0.7	61	-60.3	0	0.0	0		61	18.6	0	
St. Helens Or.	401	514451	5084311	-12.3	55	-67.3	0	0.0	0		55	16.8	1	
Boise Cascade	402	515389	5076933	23	104.7	-81.7	0	0.0	0		104.7	31.9	1	
St. Helens Or.	403	515373	5076893	23.5	116.6	-93.1	0	0.0	0		116.6	35.5	0	
	404	515362	5076858	23.5	94.4	-70.9	0	0.0	0		94.4	28.8	1	
Lewis River Site	405	518155	5077917	10	72.5	-62.5	0	0.0	0		72.5	22.1	0	
	406	518401	5077927	10	53.5	-43.5	0	0.0	0		53.5	16.3	0	
	407	518046	5077334	10	94.4	-84.4	0	0.0	0		94.4	28.8	1	
Campbell Lake	408	518720	5068119	20	80	-60	0	0.0	0		80	24.4	0	
Site	409	518773	5068125	15.5	77.5	-62	0	0.0	0		77.5	23.6	0	
T4NR1W14Ba	410	517682	5075614	0	321	-321	-82	-25.0	1	Grvl	82	25.0	0	
T4NR1W17Bdd	411	512622	5074826	28	372	-344	1	0.3	1	Bslt	27	8.2	0	
T3NR1W7	412	510929	5066872	20	60	-40	14	4.3	1	Grvl	6	1.8	0	
T3NR1W5	413	512837	5068577	20	92	-72	5	1.5	1	Grvl	15	4.6	0	
T3NR1W4Bdbb	414	514120	5068847	15	43	-28	0	0.0	0		43	13.1	0	
T3NR1W19	415	510784	5064070	10	120	-110	-88	-26.8	1	Tt	98	29.9	0	
T3NR1W18	416	511489	5065164	10	119	-109	-63	-19.2	1	S&G	73	22.3	0	
T3NR1W23	417	517655	5063725	10	151	-141	-138	-42.1	1	Grvl	148	45.1	0	
T3NR1W26	418	517615	5061995	12	169	-157	-135	-41.1	1	Tt	147	44.8	1	
T3NR1W30	419	511207	5062195	10	127	-117	-114	-34.7	1	Grvl	124	37.8	0	
T3NR1W30Cc	420	510654	5061469	20	127	-107	-107	-32.6	1	S&G	127	38.7	0	
T3NR1W31Cd	421	511063	5059884	10	120	-110	-102	-31.1	1	S&G	112	34.1	0	
T3NR1W31Bd	422	511002	5060707	10	83	-73	0	0.0	0		83	25.3	0	
T3NR1W32	423	512758	5060307	10	80	-70	-25	-7.6	1	Grvl	35	10.7	0	
T3NR1W33Bc	424	513848	5060689	10	80	-70	-33	-10.1	1	Grvl	43	13.1	0	

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
T3NR1W34	425	516233	5060271	20	100	-80	-70	-21.3	1	S&G	90	27.4	0		
T3NR1W35Cc	426	517168	5060060	20	220	-200	-156	-47.5	1	Grvl	176	53.6	0		
T2NR1W6B	427	510953	5059464	10	110	-100	0	0.0	0		110	33.5	0		
T2NR1W6Ab	428	511344	5059488	20	157	-137	-126	-38.4	1	S&G	146	44.5	0		
T2NR1W2Ac	429	511395	5059076	20	45	-25	-11	-3.4	1	S&G	31	9.4	0		
T2NR1W6Da	430	511794	5058687	20	55	-35	-29	-8.8	1	S&G	49	14.9	0		
T2NR1W2Bd	431	517315	5059129	20	247	-227	-220	-67.1	1	Grvl	240	73.2	0		
T2NR1W2Bb	432	517088	5059390	20	212	-192	-181	-55.2	1	S&G	201	61.3	0		
T2NR1W11Cc	433	517040	5056686	20	232	-212	-181	-55.2	1	Grvl	201	61.3	0		
T2NR1W13Cc	434	518477	5055048	30	196	-166	-165	-50.3	1	Bouldr	195	59.4	0		
T2NR1W14	435	517395	5055733	20	257	-237	-169	-51.5	1	Grvl	189	57.6	0		
T2NR1W15	436	516031	5055774	10	155	-145	-135	-41.1	1	Grvl	145	44.2	0		
T2NR1W16Bd	437	514201	5055787	40	81	-41	-33	-10.1	1	S&G	73	22.3	0		
T2NR1W16Bc	438	513794	5055846	30	100	-70	-46	-14.0	1	S&G&C	76	23.2	0		
T2NR1W16Bb	439	513801	5056173	20	98	-78	-66	-20.1	1	S&G	86	26.2	0		
T2NR1W16Cd	440	513939	5055183	50	101	-51	-50	-15.2	1	S&G	100	30.5	0		
T2NR1W17Cad	441	512740	5055406	30	185	-155	-150	-45.7	1	Grvl	180	54.9	0		
T2NR1W17Ac	442	513018	5055886	48	85	-37	-26	-7.9	1	S&G	74	22.6	0		
T2NR1W17Ab	443	512973	5056264	20	104	-84	-34	-10.4	1	Grvl	54	16.5	0		
T2NR1W17Da	444	513448	5055455	30	72	-42	-37	-11.3	1	S&G	67	20.4	0		
T2NR1W17Dd	445	513425	5055090	30	85	-55	-55	-16.8	1	Grvl	85	25.9	0		
T2NR1W17Bd	446	512689	5055743	30	107	-77	-71	-21.6	1	S&G	101	30.8	0		
NWTL Sauvie Isl.	447	510640	5058142	10	165	-155	-155	-47.2	1	Grvl	165	50.3	0	1	66
T2NR1W7Ba	448	511064	5057961	40	94	-54	-51	-15.5	1	Grvl	91	27.7	0		
T2NR1W7Ca	449	511180	5057158	20	100	-80	-71	-21.6	1	Grvl	91	27.7	0		
T2NR1W7Ac	450	511403	5057507	30	97	-67	-64	-19.5	1	Grvl	94	28.7	0		
T2NR1W8Cd	451	512555	5056651	40	91	-51	-38	-11.6	1	Grvl	78	23.8	0		
T2NR1W8Cc	452	512153	5056669	50	106	-56	-24	-7.3	1	Grvl	74	22.6	0		
T2NR1W8Cb	453	512200	5057104	30	86	-56	-45	-13.7	1	Grvl	75	22.9	0		
T2NR1W9Ca	454	514198	5057082	15	112	-97	-87	-26.5	1	Tt	102	31.1	0		
T2NR1W9Ad	455	514987	5057523	15	98	-83	-79	-24.1	1	Grvl	94	28.7	0		
T3NR1W25Ca	456	519077	5061918	10	293	-283	-217	-66.1	1	Grvl	227	69.2	0		
T3NR1W25Dcb	457	519542	5061649	10	460	-450	-213	-64.9	1	Grvl	223	68.0	0		
T3NR1E18Bc	458	520176	5063978	10	78	-68	-53	-16.2	1	Tt	63	19.2	0		
T3NR1E19A(W1/2)	459	521026	5064156	29.5	260	-230.5	-44.5	-13.6	1	Tt	74	22.6	0		
T2NR1E28Ba	460	523585	5053159	30	407	-377	-108	-32.9	1	Tt	138	42.1	0		
T2NR1E7Bcb	461	520077	5057684	10	214	-204	-185	-56.4	1	Grvl	195	59.4	0		
T2NR1E7Cbb	462	520110	5057328	20	176	-156	-148	-45.1	1	S&G	168	51.2	0		
T2NR1E9Cad	463	523707	5057131	26	120	-94	-62	-18.9	1	Tt	88	26.8	0		
T2NR1E9Bc	464	523552	5057615	20	76	-56	0	0.0	0		76	23.2	0		
T2NR1E16Cc	465	523416	5055243	25	70	-45	-14	-4.3	1	S&G	39	11.9	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min Max
T2NR1E16Bad	466	523991	5056266	35	211	-176	-8	-2.4	1	Grvl	43	13.1	0	
T2NR1E36Ada	467	529579	5051212	30	260	-230	28	8.5	1	S&G	2	0.6	0	
Smith & Bybee	468	521511	5051971	16	119	-103	-103	-31.4	1	Grvl	119	36.3	0	
Lakes	469	521747	5051786	22	114	-92	-92	-28.0	1	Grvl	114	34.7	0	
Dutch Cones	470	520480	5052090	22	89	-67	-65	-19.8	1	Grvl	87	26.5	0	
	471	521109	5052114	14	88	-74	-72	-21.9	1	Grvl	86	26.2	0	
	472	521257	5051808	15	84	-69	-68	-20.7	1	Grvl	83	25.3	0	
Buffalo Elec #6	473	527109	5051175	31	168	-137	5	1.5	1	Grvl	26	7.9	0	
	474	527223	5051486	29	160	-131	20	6.1	1	Grvl	9	2.7	0	
T2NR1W21Cc	475	513840	5053522	20	200	-180	-176	-53.6	1	Grvl	196	59.7	0	
T2NR1W21Bd	476	514251	5054308	15	86	-71	-60	-18.3	1	S&G	75	22.9	0	
T2NR1W22Bc	477	515461	5054282	10	205	-195	-176	-53.6	1	Grvl	186	56.7	0	
T2NR1W22	478	516027	5054047	10	207	-197	-193	-58.8	1	S&G	203	61.9	0	
T2NR1W27Bb	479	515403	5053037	10	198	-188	-182	-55.5	1	S&G	192	58.5	0	
T2NR1W27C	480	515627	5052121	15	195	-180	-170	-51.8	1	S&G	185	56.4	0	
T2NR1W28	481	515499	5051927	15	202	-187	-170	-51.8	1	Grvl	185	56.4	0	
ODOT	482	535044	5050157	181.9	87.5	94.4	181.9	55.4	1	S&G	0	0.0	0	
I205 Bridge	483	535061	5050116	172.4	131.5	40.9	172.4	52.5	1	Qff	0	0.0	0	
	484	535040	5050058	168.9	127	41.9	168.9	51.5	1	Qff	0	0.0	0	
	485	535070	5050049	165.9	111	54.9	165.9	50.6	1	Grvl	0	0.0	0	
	486	535076	5049941	160.3	61.5	98.8	160.3	48.9	1	Grvl	0	0.0	0	
	487	535068	5049909	161.1	76	85.1	161.1	49.1	1	Grvl	0	0.0	0	
	488	535094	5049836	133.3	96	37.3	133.3	40.6	1	Qff	0	0.0	0	
	489	535080	5049814	137.6	81	56.6	137.6	41.9	1	S&G	0	0.0	0	
	490	535079	5049749	106.1	61	45.1	106.1	32.3	1	Qff	0	0.0	0	
	491	535106	5049745	105.8	60	45.8	105.8	32.2	1	Tt	0	0.0	0	
	492	535081	5049689	82.7	80	2.7	82.7	25.2	1	Tt	0	0.0	0	
	493	535112	5049683	82.6	82	0.6	82.6	25.2	1	Tt	0	0.0	0	
	494	535090	5049623	71.7	80	-8.3	71.7	21.9	1	Tt	0	0.0	0	
	495	535114	5049616	71.8	62	9.8	71.8	21.9	1	Qfc	0	0.0	0	
	496	535103	5049525	58.1	60	-1.9	58.1	17.7	1	Qfc	0	0.0	0	
	497	535127	5049520	55.2	67	-11.8	55.2	16.8	1	Tt	0	0.0	0	
	498	535116	5049437	53.4	60	-6.6	53.4	16.3	1	Qfc	0	0.0	0	
	499	535143	5049423	52.4	65	-12.6	52.4	16.0	1	Qfc	0	0.0	0	
	500	535136	5049354	24.9	78	-53.1	12.9	3.9	1	Tt	12	3.7	0	
	501	535169	5049346	23.4	81	-57.6	11.4	3.5	1	Tt	12	3.7	0	
	502	535172	5049212	-29.6	79	-108.6	-32.1	-9.8	1	Qfc	2.5	0.8	0	
	503	535213	5049195	-28.1	73.6	-101.7	-31.1	-9.5	1	Qfc	3	0.9	0	

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	504	535228	5049036	-22	71	-93	-80	-24.4	1	Tt	58	17.7	0	13	46
	505	535262	5049024	-21.1	104	-125.1	-78.1	-23.8	1	Tt	57	17.4	0	7	33
	506	535298	5048887	-11.5	110	-121.5	-80	-24.4	1	Tt	68.5	20.9	0	10	41
	507	535336	5048875	-10.6	87	-97.6	-89.6	-27.3	1	Tt	79	24.1	0	7	34
	508	535373	5048769	-10.5	151	-161.5	-91	-27.7	1	Tt	80.5	24.5	0	4	46
	509	535411	5048685	-5.5	158	-163.5	-92.5	-28.2	1	Tt	87	26.5	0	8	39
	510	535447	5048593	-2.5	89.5	-92	-91.5	-27.9	1	Tt	89	27.1	0	4	49
	511	535494	5048497	-2.5	159	-161.5	-92.5	-28.2	1	Tt	90	27.4	0	8	48
	512	535560	5048401	-2.7	131	-133.7	-101.2	-30.8	1	Tt	98.5	30.0	0	5	48
	513	535614	5048261	12.4	120	-107.6	-95.6	-29.1	1	Tt	108	32.9	0	6	112
	514	535656	5048116	15	175.5	-160.5	-104	-31.7	1	Tt	119	36.3	0	6	115
	515	535699	5048011	12.5	169.5	-157	-104.5	-31.9	1	Tt	117	35.7	0	6	84
	516	535756	5047865	2	180	-178	-107	-32.6	1	Tt	109	33.2	0	12	69
	517	535768	5047738	20.8	136.5	-115.7	-98.2	-29.9	1	Tt	119	36.3	0	11	68
	518	535799	5047659	24.8	178	-153.2	-102.2	-31.2	1	Tt	127	38.7	0	5	66
	519	535786	5047609	21.8	130	-108.2	-108.2	-33.0	1	Tt	130	39.6	0	15	63
	520	535807	5047443	21.8	133	-111.2	-106.2	-32.4	1	Tt	128	39.0	0	8	67
	521	535814	5047284	22.3	135.8	-113.5	-107.7	-32.8	1	Tt	130	39.6	0	6	59
	522	535793	5047175	18.5	130	-111.5	-101.5	-30.9	1	Tt	120	36.6	0	4	66
	523	535737	5047093	28.8	141	-112.2	-99.2	-30.2	1	Tt	128	39.0	0	4	60
	524	535737	5047055	1.9	110.3	-108.4	-103.1	-31.4	1	Tt	105	32.0	0		
	525	535696	5047018	3.5	221	-217.5	-111.5	-34.0	1	Tt	115	35.1	0	5	81
	526	535702	5046971	3.2	126.5	-123.3	-111.8	-34.1	1	Tt	115	35.1	0	10	94
	527	535685	5046929	1.3	127	-125.7	-113.7	-34.7	1	Tt	115	35.1	0	5	87
	528	535655	5046863	-0.1	203.5	-203.6	-130.1	-39.7	1	Tt	130	39.6	0	5	106
	529	535611	5046793	-8.6	133.5	-142.1	-131.6	-40.1	1	Tt	123	37.5	0	10	91
	530	535573	5046725	-6	142.2	-148.2	-146	-44.5	1	Tt	140	42.7	0	10	79
	531	535437	5046694	4.8	189	-184.2	-165.2	-50.4	1	Tt	170	51.8	0	3	81
	532	535506	5046639	2.9	246	-243.1	-182.1	-55.5	1	Tt	185	56.4	0	5	97
	533	535309	5046606	24	225.3	-201.3	-186	-56.7	1	Tt	210	64.0	0	1	82
	534	535403	5046547	25	241.5	-216.5	-205	-62.5	1	SRM	230	70.1	0	2	85
	535	535459	5046506	26	246.5	-220.5	-208	-63.4	1	SRM	234	71.3	0	2	111
Vancouver	536	530408	5050963	34	52.9	-18.9	-2.5	-0.8	1	Grvl	36.5	11.1	0	4	27
East Side	537	530446	5050940	31	48.7	-17.7	-5	-1.5	1	S&G	36	11.0	0	4	23
Treatment	538	530394	5050934	36	48.3	-12.3	-0.5	-0.2	1	Grvl	36.5	11.1	0	5	33
Plant	539	530383	5050906	33	44	-11	-1.5	-0.5	1	Grvl	34.5	10.5	0	3	23
	540	530436	5050893	29	34	-5	-2	-0.6	1	Grvl	31	9.4	0	2	18
Smith & Bybee	541	521501	5051518	20	87	-67	-67	-20.4	1	Grvl	87	26.5	0		
Dutch Cones	542	521231	5051212	23	97	-74	-72	-21.9	1	Grvl	95	29.0	0		
2nd project	543	520228	5052651	23	92	-69	-66	-20.1	1	Grvl	89	27.1	0		

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	544	520551	5052503	19	101	-82	-80	-24.4	1	Grvl	99	30.2	0		
	545	520997	5052334	14	93	-79	-76	-23.2	1	Grvl	90	27.4	0		
	546	519945	5052777	12	84	-72	-70	-21.3	1	Grvl	82	25.0	0		
PDX	547	530600	5047448	8.82	40	-31.18	0	0.0	0		40	12.2	0		
AIR FORCE	548	530644	5047448	8.82	80	-71.18	0	0.0	0		80	24.4	0		
	549	530687	5047450	8.82	40	-31.18	0	0.0	0		40	12.2	0		
PDX	550	523163	5043659	27.6	81.5	-53.9	0	0.0	0		81.5	24.8	0	3	35
Terminal II	551	523187	5043703	27.4	18	9.4	0	0.0	0		18	5.5	0		
	552	523178	5043683	27.2	28.5	-1.3	0	0.0	0		28.5	8.7	0		
	553	523186	5043644	28.1	26.5	1.6	0	0.0	0		26.5	8.1	0	5	28
	554	523203	5043681	26.1	83.5	-57.4	0	0.0	0		83.5	25.5	0	8	65
Fremont	555	525024	5042790	32.6	91	-58.4	-3.4	-1.0	1	Grvl	36	11.0	0		
Bridge	556	525047	5042770	32.4	91	-58.6	-3	-0.9	1	Grvl	35.4	10.8	0		
	557	525000	5042716	14.7	122	-107.3	-8	-2.4	1	Grvl	22.7	6.9	0		
	558	524964	5042715	8.4	66	-57.6	-7	-2.1	1	Grvl	15.4	4.7	0		
	559	524979	5042695	8.6	66	-57.4	-28	-8.5	1	Grvl	36.6	11.2	0		
	560	524705	5042414	24.2	150	-125.8	-87	-26.5	1	Grvl	111.2	33.9	0		
	561	524730	5042392	31.6	173	-141.4	-90	-27.4	1	Grvl	121.6	37.1	0		
N Marine Dr	562	523189	5050908	29.42	127.5	-98.08	-87.6	-26.7	1	Grvl	117	35.7	0	3	54
RR Bridge	563	523231	5050930	28.72	132.2	-103.48	-93.3	-28.4	1	Grvl	122	37.2	0	2	59
N Marine Dr	564	521969	5051372	33.17	100.8	-67.63	-66.3	-20.2	1	Grvl	99.5	30.3	1	3	40
Highway Bridge	565	522064	5051363	28.62	111.5	-82.88	-71.38	-21.8	1	Grvl	100	30.5	0	3	28
	566	522161	5051381	32.18	119	-86.82	-74.52	-22.7	1	Grvl	106.7	32.5	1	2	40
	567	522277	5051390	25.87	113.3	-87.43	-82.63	-25.2	1	Grvl	108.5	33.1	1	2	47
Vancouver	568	528586	5051163	29	23.5	5.5	6.5	2.0	1	Grvl	22.5	6.9	0		
Shipyards	569	528615	5051050	27.5	24	3.5	10	3.0	1	Grvl	17.5	5.3	0		
	570	528586	5050888	27	44	-17	24.5	7.5	1	Grvl	2.5	0.8	0		
1966	571	525264	5052026	33	35	-2	3	0.9	1	G&Cobls	30	9.1	0		
	572	525270	5051994	30	37	-7	-5	-1.5	1	Grvl	35	10.6	0		
	573	525284	5051958	29.5	43	-13.5	-10	-3.0	1	G&Cobls	39.5	12.0	0		
	574	525237	5051978	31	42	-11	-9	-2.7	1	Grvl	40	12.2	0		
	575	525301	5052005	29.5	30	-0.5	1.5	0.5	1	Grvl	28	8.5	0		
1963	576	525085	5052033	32	45	-13	-6	-1.8	1	S&G	38	11.6	0		
	577	525136	5052071	32	33	-1	5	1.5	1	S&G	27	8.2	0		
	578	525135	5052035	27.4	42	-14.6	-11.6	-3.5	1	Grvl	39	11.9	0		
	579	525098	5052067	27.4	34.5	-7.1	0.4	0.1	1	G&Cobls	27	8.2	0		

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Water Wells	580	524904	5052150	35	127.5	-92.5	35	10.7	1	Grvl	0	0.0	0		
	581	524881	5052158	27	184	-157	2	0.6	1	G&Cobls	102	31.1	0		
BPA Hayden I	582	522103	5053134	13	39	-26	0	0.0	0		39	11.9	0	7	15
	583	522113	5053107	13	38.5	-25.5	0	0.0	0		38.5	11.7	0	5	15
BPA Vancouver	584	522551	5054018	20	42	-22	0	0.0	0		42	12.8	0	2	16
	585	522537	5054049	20	41	-21	0	0.0	0		41	12.5	0	1	20
Vancouver	586	523647	5054816	24.5	51.5	-27	-19.5	-5.9	1	Grvl	44	13.4	0	5	39
Waste Water	587	523615	5054667	22.5	26.5	-4	0	0.0	0		26.5	8.1	0	5	44
Plant	588	523564	5054438	24	36.5	-12.5	0	0.0	0		36.5	11.1	0	5	38
	589	523485	5054451	22	26.5	-4.5	0	0.0	0		26.5	8.1	0	5	43
	590	523441	5054500	18	26.5	-8.5	0	0.0	0		26.5	8.1	0	8	27
	591	523453	5054658	23.5	31.5	-8	0	0.0	0		31.5	9.6	0	5	33
	592	523513	5054891	22	31.5	-9.5	0	0.0	0		31.5	9.6	0	3	39
	593	523551	5054799	21.5	26.5	-5	0	0.0	0		26.5	8.1	0	6	39
City of	594	523522	5054122	22.7	39.5	-16.8	-3.3	-1.0	1	Grvl	26	7.9	0	3	16
Vancouver	595	523542	5054350	26.9	41	-14.1	2.4	0.7	1	Grvl	24.5	7.5	0	7	27
Waste	596	523427	5054183	22.7	40.5	-17.8	-8.8	-2.7	1	Grvl	31.5	9.6	0	9	24
Lagoon	597	523396	5054362	21.7	41.5	-19.8	-4.3	-1.3	1	Grvl	26	7.9	0	13	33
	598	523418	5054281	23.1	40.3	-17.2	-6.4	-2.0	1	Grvl	29.5	9.0	0	10	26
	599	523477	5054270	22.8	38.3	-15.5	-1.2	-0.4	1	Grvl	24	7.3	0	8	30
	600	523523	5054227	23.7	38.5	-14.8	0.2	0.1	1	Grvl	23.5	7.2	0	7	45
Sewage Plant	601	524049	5055911	36	56.5	-20.5	-19	-5.8	1	Grvl	55	16.8	0		
	602	524084	5053213	30	44	-14	0	0.0	0		44	13.4	0		
	603	524567	5052626	47.5	31.5	16	47.5	14.5	1	S&G	0	0.0	0		
	604	524692	5052497	42	26.5	15.5	42	12.8	1	S&G	0	0.0	0		
	605	525441	5052317	42	26.5	15.5	42	12.8	1	S&G	0	0.0	0		
	606	523471	5058204	1.9	7.5	-5.6	0	0.0	0		7.5	2.3	0		
Vancouver	607	522273	5056785	2.1	15.5	-13.4	0	0.0	0		15.5	4.7	0		
Lake	608	520442	5057371	2.6	15	-12.4	0	0.0	0		15	4.6	0		
	609	520791	5058987	1.9	15	-13.1	0	0.0	0		15	4.6	0		
	610	521848	5060117	4.6	14	-9.4	0	0.0	0		14	4.3	0		
	611	522020	5058015	1.9	7.5	-5.6	0	0.0	0		7.5	2.3	0		
	612	522674	5058975	2	7.5	-5.5	0	0.0	0		7.5	2.3	0		
Alcoa Vancouver	613	521017	5054713	28.33	136	-107.67	-81.7	-24.9	1	S&G	110	33.5	0		
	614	521115	5054855	28.84	111	-82.16	-62.2	-19.0	1	S&G	91	27.7	0		

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	615	520986	5054728	27.7	136	-108.3	-81.3	-24.8	1	S&G	109	33.2	0		
	616	521132	5054717	30.16	119	-88.84	-63.8	-19.4	1	Grvl	94	28.7	0		
	617	521094	5054650	28.44	130	-101.56	-72.6	-22.1	1	Grvl	101	30.8	0		
	618	521058	5054702	29.24	146	-116.76	-73.8	-22.5	1	S&G	103	31.4	0		
	619	520790	5055069	26.14	135	-108.86	-79.9	-24.4	1	Tt	106	32.3	0		
	620	520855	5055106	28.26	133	-104.74	-75.7	-23.1	1	Tt	104	31.7	0		
	621	520931	5055181	28.71	166	-137.29	-77.3	-23.6	1	Tt	106	32.3	0		
Scappoose RR	622	509943	5058473	15	48	-33	-20	-6.1	1	Tt	35	10.7	0	3	23
	623	509967	5058580	10	49	-39	-25	-7.6	1	Tt	35	10.7	0	1	11
	624	509934	5058377	14	49	-35	-11	-3.4	1	Tt	25	7.6	0	2	7
	625	509956	5058531	15	58.2	-43.2	-24	-7.3	1	Tt	39	11.9	0		
	626	509929	5058266	19.5	42	-22.5	-5.5	-1.7	1	Tt	25	7.6	0	1	7
ODOT	627	525574	5051853	22	26	-4	17.5	5.3	1	Grvl	4.5	1.4	0		
I-5 Bridge	628	525545	5051792	-22	34	-56	-31	-9.4	1	Grvl	9	2.7	0		
	629	525509	5051702	-34.5	21.5	-56	-63.5	-19.4	1	Grvl	29	8.8	0		
	630	525478	5051622	-29	79	-108	-86.5	-26.4	1	S&G	57.5	17.5	0		
	631	525351	5051324	-19.5	75.5	-95	0	0.0	0		75.5	23.0	0		
	632	525319	5051251	-21	103.5	-124.5	0	0.0	0		103.5	31.5	0		
	633	525261	5051101	10	80	-70	0	0.0	0		80	24.4	0		
	634	525250	5051079	21	93	-72	0	0.0	0		93	28.3	0		
	635	525239	5051051	22	68	-46	0	0.0	0		68	20.7	0		
	636	525225	5051021	23.5	93.5	-70	0	0.0	0		93.5	28.5	0		
ODOT	637	525001	5050464	48	186	-138	-127	-38.7	1	S&G	175	53.3	0		
Oregon Slough	638	524956	5050345	-12.5	104.75	-117.25	-117	-35.7	1	Qfc	104.5	31.9	0		
Bridge	639	524930	5050289	-18.6	100	-118.6	-118.6	-36.1	1	Qfc	100	30.5	0		
	640	524900	5050205	-11.5	97	-108.5	-108.5	-33.1	1	Qfc	97	29.6	0		
	641	524855	5050154	28.4	61.6	-33.2	0	0.0	0		61.6	18.8	0		
	642	524851	5050131	32	96.5	-64.5	0	0.0	0		96.5	29.4	0		
	643	524843	5050111	32.5	98	-65.5	0	0.0	0		98	29.9	0		
ODOT	644	535190	5046301	18.1	127.5	-109.4	0	0.0	0		127.5	38.9	0		
I205	645	535338	5046248	41.2	139	-97.8	0	0.0	0		139	42.4	1		
Airport	646	535262	5046190	16	199.5	-183.5	0	0.0	0		199.5	60.8	1		
Interchange	647	535229	5046332	19.6	241	-221.4	-212.4	-64.7	1	SRM	232	70.7	0		
	648	535254	5046304	16.6	205	-188.4	0	0.0	0		205	62.5	1		
	649	535300	5046317	18.6	253.5	-234.9	-214.9	-65.5	1	SRM	233.5	71.2	1		
POP	650	537315	5046551	23	55	-32	0	0.0	0		55	16.8	0		
Govt. Isl	651	536636	5047101	26	53.5	-27.5	0	0.0	0		53.5	16.3	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min Max
Columbia R.	652	536367	5047397	17	55	-38	0	0.0	0		55	16.8	0	
	653	536028	5047698	17	55	-38	0	0.0	0		55	16.8	0	
	654	535760	5048138	6	55	-49	0	0.0	0		55	16.8	0	
	655	536132	5047530	16	50.5	-34.5	0	0.0	0		50.5	15.4	0	
	656	537117	5047329	23	50.5	-27.5	0	0.0	0		50.5	15.4	0	
	657	535396	5048581	-2.5	28.5	-31	0	0.0	0		28.5	8.7	0	
	658	534659	5048957	-5	26.5	-31.5	0	0.0	0		26.5	8.1	0	
	659	534156	5048883	3	32.5	-29.5	0	0.0	0		32.5	9.9	0	
	660	533620	5049043	-6	26	-32	0	0.0	0		26	7.9	0	
	661	533205	5049238	-18	16	-34	0	0.0	0		16	4.9	0	
	662	535928	5046503	-8.5	23	-31.5	0	0.0	0		23	7.0	0	
	663	536450	5046228	-8.5	23	-31.5	0	0.0	0		23	7.0	0	
	664	537022	5045984	-3.5	27	-30.5	0	0.0	0		27	8.2	0	
	665	532457	5049389	-27.5	19	-46.5	0	0.0	0		19	5.8	0	
	666	532019	5049461	-16	26	-42	0	0.0	0		26	7.9	0	
	667	531850	5049602	-25	17.5	-42.5	0	0.0	0		17.5	5.3	0	
	668	532040	5049829	-19.5	21.5	-41	0	0.0	0		21.5	6.6	0	
	669	532188	5050070	-11	15.5	-26.5	0	0.0	0		15.5	4.7	0	
	670	531920	5050155	-10	21	-31	0	0.0	0		21	6.4	0	
	671	531525	5049391	-20	32	-52	0	0.0	0		32	9.8	0	
	672	532219	5049328	-3	31	-34	0	0.0	0		31	9.4	0	
	673	532891	5049027	-5	35	-40	0	0.0	0		35	10.7	0	
	674	533396	5048645	-5	30	-35	0	0.0	0		30	9.1	0	
	675	533885	5048322	-13	30	-43	0	0.0	0		30	9.1	0	
	676	534188	5048002	-3	38	-41	0	0.0	0		38	11.6	0	
	677	534737	5047583	-13.5	30.5	-44	0	0.0	0		30.5	9.3	0	
	678	535140	5047282	-13.5	45	-58.5	0	0.0	0		45	13.7	0	
	679	535501	5046815	-17	29	-46	0	0.0	0		29	8.8	0	
	680	533867	5048011	-11	47.5	-58.5	0	0.0	0		47.5	14.5	0	
	681	532834	5048648	-5	57	-62	0	0.0	0		57	17.4	0	
	682	534469	5047556	-14	37	-51	0	0.0	0		37	11.3	0	
	683	532147	5049096	-18	44	-62	0	0.0	0		44	13.4	0	
	684	535162	5046931	-7	53	-60	0	0.0	0		53	16.2	0	
	685	531025	5049492	-8	51.5	-59.5	0	0.0	0		51.5	15.7	0	
	686	531177	5049564	-13	51.5	-64.5	0	0.0	0		51.5	15.7	0	
	687	531202	5049427	-4.5	51.5	-56	0	0.0	0		51.5	15.7	0	
	688	531338	5049470	-13.5	43	-56.5	0	0.0	0		43	13.1	0	
	689	531674	5049336	-18	16.5	-34.5	0	0.0	0		16.5	5.0	0	
	690	531676	5049244	-15.5	37.5	-53	0	0.0	0		37.5	11.4	0	
	691	531965	5049271	-14	41.5	-55.5	0	0.0	0		41.5	12.6	0	
	692	531962	5049134	-15.5	39.5	-55	0	0.0	0		39.5	12.0	0	
	693	532265	5049144	-7	46	-53	0	0.0	0		46	14.0	0	

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	694	532542	5049030	-5	59	-64	0	0.0	0		59	18.0	0	
	695	532478	5048931	-5	50	-55	0	0.0	0		50	15.2	0	
	696	532870	5048850	-4	49.5	-53.5	0	0.0	0		49.5	15.1	0	
	697	532861	5048769	-5	33	-38	0	0.0	0		33	10.1	0	
	698	532834	5048749	-5	33	-38	0	0.0	0		33	10.1	0	
	699	532861	5048722	-4.5	36.5	-41	0	0.0	0		36.5	11.1	0	
	700	532892	5048750	-4.5	24	-28.5	0	0.0	0		24	7.3	0	
	701	533190	5048671	-5.5	53.5	-59	0	0.0	0		53.5	16.3	0	
	702	533610	5048562	-13	37.5	-50.5	0	0.0	0		37.5	11.4	0	
	703	533540	5048400	-11	46.5	-57.5	0	0.0	0		46.5	14.2	0	
	704	533489	5048280	-9	33	-42	0	0.0	0		33	10.1	0	
	705	534290	5048525	0	54	-54	0	0.0	0		54	16.5	0	
	706	534119	5048180	-11	42	-53	0	0.0	0		42	12.8	0	
	707	534340	5047777	-14	26	-40	0	0.0	0		26	7.9	0	
	708	534545	5047837	-2	55	-57	0	0.0	0		55	16.8	0	
	709	534679	5048401	1	49.5	-48.5	0	0.0	0		49.5	15.1	0	
	710	534476	5048389	-7	47	-54	0	0.0	0		47	14.3	0	
	711	535529	5046691	-12	40.5	-52.5	0	0.0	0		40.5	12.3	0	
	712	535898	5046673	-1	47.5	-48.5	0	0.0	0		47.5	14.5	0	
	713	535890	5046826	-3	47	-50	0	0.0	0		47	14.3	0	
	714	535973	5046356	-6	47	-53	0	0.0	0		47	14.3	0	
	715	537073	5045781	-5	59	-64	0	0.0	0		59	18.0	0	
	716	538304	5046163	-2	57	-59	0	0.0	0		57	17.4	0	
	717	538305	5045621	0	59.5	-59.5	0	0.0	0		59.5	18.1	0	
	718	538292	5045721	-2	27	-29	0	0.0	0		27	8.2	0	
	719	536698	5046032	-3	20.5	-23.5	0	0.0	0		20.5	6.2	0	
	720	532436	5049125	-7.5	42.5	-50	0	0.0	0		42.5	13.0	0	
	721	532756	5048884	-7.5	42.5	-50	0	0.0	0		42.5	13.0	0	
POP	722	530158	5048621	7.2	52.5	-45.3	0	0.0	0		52.5	16.0	0	
Airport	723	529593	5048937	9.1	59.5	-50.4	0	0.0	0		59.5	18.1	0	
	724	529969	5048722	7.2	60	-52.8	0	0.0	0		60	18.3	0	
	725	529803	5048811	10.7	63	-52.3	0	0.0	0		63	19.2	0	
	726	530317	5047849	15	60	-45	0	0.0	0		60	18.3	0	
	727	530104	5047630	13	59	-46	0	0.0	0		59	18.0	0	
	728	530375	5047664	12.3	61.1	-48.8	0	0.0	0		61.1	18.6	0	
	729	530141	5047476	15	52	-37	0	0.0	0		52	15.8	0	
Reynolds	730	546585	5044708	28.6	71.6	-43	0	0.0	0		71.6	21.8	0	
Troutdale	731	546469	5044895	23.2	51.9	-28.7	0	0.0	0		51.9	15.8	0	
	732	546531	5044856	24.3	66.6	-42.3	0	0.0	0		66.6	20.3	0	
	733	546471	5044810	22.7	56.4	-33.7	0	0.0	0		56.4	17.2	0	

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	734	546533	5044781	23.7	53.5	-29.8	0	0.0	0		53.5	16.3	0	
	735	546478	5044727	20	56	-36	0	0.0	0		56	17.1	0	
	736	546539	5044665	21.8	54.8	-33	0	0.0	0		54.8	16.7	0	
	737	546484	5044597	20.5	67	-46.5	0	0.0	0		67	20.4	0	
	738	546540	5044544	19.4	76.8	-57.4	0	0.0	0		76.8	23.4	0	
	739	546475	5044504	18.5	75	-56.5	0	0.0	0		75	22.9	0	
	740	546539	5044428	17.7	68.7	-51	0	0.0	0		68.7	20.9	0	
	741	546752	5044566	24	60.5	-36.5	0	0.0	0		60.5	18.4	0	
	742	546784	5044536	22	75.5	-53.5	0	0.0	0		75.5	23.0	0	
	743	546807	5044572	24.5	74.5	-50	0	0.0	0		74.5	22.7	0	
	744	546680	5044525	22	57.5	-35.5	0	0.0	0		57.5	17.5	0	
PGE Towers	745	546492	5045151	20	33.5	-33.5	0	0.0	0		53.5	16.3	0	
Sundial Rd	746	546048	5045189	22	51.5	-29.5	0	0.0	0		51.5	15.7	0	
	747	545488	5044935	20	75.5	-55.5	0	0.0	0		75.5	23.0	0	
	748	544677	5044930	21	89.5	-68.5	-67	-20.4	1	Grvl	88	26.8	1	
	749	543973	5044926	17	55.5	-38.5	-33	-10.1	1	Grvl	50	15.2	0	
PP&L Camas	750	545812	5046410	13	65	-52	-49	-14.9	1	Bslt	62	18.9	0	
Crossing	751	545828	5045552	15	58.5	-43.5	0	0.0	0		58.5	17.8	0	
Delta Park	752	524742	5050388	-23	23.5	-46.5	0	0.0	0		23.5	7.2	0	
Sand Explor.	753	524388	5050496	-25	15	-40	0	0.0	0		15	4.6	0	
	754	524272	5050613	-19	31	-50	0	0.0	0		31	9.4	0	
	755	524064	5050612	-16	18.5	-34.5	0	0.0	0		18.5	5.6	0	
	756	524002	5050752	-15	30	-45	0	0.0	0		30	9.1	0	
	757	523801	5050735	-14	27.5	-41.5	0	0.0	0		27.5	8.4	0	
	758	523843	5050957	-16	28	-44	0	0.0	0		28	8.5	0	
	759	523717	5050907	-10.5	35.5	-46	0	0.0	0		35.5	10.8	0	
	760	523566	5050864	-16	27	-43	0	0.0	0		27	8.2	0	
	761	523646	5051094	-9	36.5	-45.5	0	0.0	0		36.5	11.1	0	
	762	523001	5051321	-13.5	33.5	-47	0	0.0	0		33.5	10.2	0	
	763	525183	5050117	-15	30.5	-45.5	0	0.0	0		30.5	9.3	0	
	764	525481	5050170	-16.5	27.5	-44	0	0.0	0		27.5	8.4	0	
	765	525630	5049933	-22	23	-45	0	0.0	0		23	7.0	0	
	766	525902	5049904	-18	25	-43	0	0.0	0		25	7.6	0	
	767	526219	5049792	-20	24	-44	0	0.0	0		24	7.3	0	
Vanport	768	523976	5050082	7.5	91.5	-84	-83	-25.3	1	Grvl	90.5	27.6	0	
Site	769	523447	5050282	11	91	-80	-79	-24.1	1	Grvl	90	27.4	1	
	770	523061	5050416	6.7	83.7	-77	-76	-23.2	1	Grvl	82.7	25.2	0	
	771	522898	5050031	5	75	-70	-69	-21.0	1	Grvl	74	22.6	0	
	772	522799	5049647	14.2	91.2	-77	-76	-23.2	1	Grvl	90.2	27.5	1	

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	773	523346	5049385	8.8	93.8	-85	0	0.0	0		93.8	28.6	0		
	774	523711	5049213	11.6	102.6	-91	-89	-27.1	1	Grvl	100.6	30.7	1		
	775	523823	5049566	15.8	97.3	-81.5	-80.5	-24.5	1	Grvl	96.3	29.4	1		
	776	524463	5048845	14.3	121.3	-107	-106	-32.3	1	Grvl	120.3	36.7	1		
N Marine Dr	777	523454	5050634	28	113	-85	-84	-25.6	1	Grvl	112	34.1	0	2	14 *
Crown Z.	778	523540	5050703	26	117	-91	-90	-27.4	1	Grvl	116	35.4	1	0	10 *
	779	523369	5050506	11	97	-86	-84	-25.6	1	Grvl	95	29.0	1	0	14 *
	780	523303	5050531	10	93	-83	-83	-25.3	1	Grvl	93	28.3	1	1	12 *
	781	523212	5050572	8	91	-83	-82	-25.0	1	Grvl	90	27.4	1	0	15 *
	782	523343	5050542	12.5	46.5	-34	0	0.0	0		46.5	14.2	0	2	12 *
	783	523323	5050480	7.5	39.5	-32	0	0.0	0		39.5	12.0	0	1	10 *
	784	523176	5050512	8	45	-37	0	0.0	0		45	13.7	0	0	6 *
	785	523238	5050648	26.5	27.5	-1	0	0.0	0		27.5	8.4	0	6	7 *
Delta Park	786	524351	5050102	18.7	120.2	-101.5	-82	-25.0	1	Grvl	100.7	30.7	1	3	20 *
West	787	524152	5050020	22.9	117.9	-95	-84	-25.6	1	Grvl	107	32.6	1	1	12 *
	788	524410	5050024	12.3	115.3	-103	-84	-25.6	1	Grvl	96.3	29.4	0	2	15 *
	789	524256	5050012	16.2	116.2	-100	-85.5	-26.1	1	Grvl	101.7	31.0	1	4	12 *
	790	524020	5050107	7.5	101.5	-94	-92.5	-28.2	1	Grvl	100	30.5	0		
Delta Park	791	526340	5048704	10.5	35.5	-25	0	0.0	0		35.5	10.8	0	0	8 *
East	792	526446	5048745	10.5	38	-27.5	0	0.0	0		38	11.6	0	0	2 *
	793	526400	5048698	8	78	-70	0	0.0	0		78	23.8	1	0	15 *
	794	526363	5048642	9.5	35.5	-26	0	0.0	0		35.5	10.8	0	0	3 *
	795	526465	5048678	8.5	36.5	-28	0	0.0	0		36.5	11.1	0	0	1 *
POP	796	519821	5051947	10	71	-61	-54	-16.5	1	Grvl	64	19.5	0		
Rivergate	797	521123	5051358	13	83	-70	-64	-19.5	1	Grvl	77	23.5	0		
	798	521324	5052131	25	150	-125	-113	-34.4	1	Grvl	138	42.1	0		
	799	520162	5051168	8	44	-36	-32	-9.8	1	Grvl	40	12.2	0		
	800	522062	5051487	20	120	-100	-84	-25.6	1	Grvl	104	31.7	1		
	801	521821	5050255	7	75	-68	-63	-19.2	1	Grvl	70	21.3	1		
Crown Z.	802	520405	5045533	20	122	-102	-95	-29.0	1	Grvl	115	35.1	0		
Front Ave	803	520538	5045397	27	132	-105	0	0.0	0		132	40.2	0		
	804	520713	5045209	30.5	99	-68.5	0	0.0	0		99	30.2	0		
	805	520630	5045527	-5.5	99.5	-105	-101.5	-30.9	1	Grvl	96	29.3	0		
	806	520750	5045577	-4	106	-110	0	0.0	0		106	32.3	0		
	807	520672	5045604	-7.7	91.3	-99	-96	-29.3	1	Grvl	88.3	26.9	0		
	808	520923	5045380	-16.7	94.3	-111	-107.5	-32.8	1	Grvl	90.8	27.7	0		
	809	520808	5045445	2.5	101.5	-99	0	0.0	0		101.5	30.9	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
	810	520717	5045518	35.9	91.5	-55.6	-54.35	-16.6	1	Bslt	90.25	27.5	0	4	53 *
	811	520767	5045427	35.4	93	-57.6	-55.1	-16.8	1	Grvl	90.5	27.6	0	2	12 *
	812	520567	5045522	27.6	80	-52.4	-46.9	-14.3	1	Bslt	74.5	22.7	0	1	17 *
	813	520647	5045469	35.7	80.5	-44.8	-43.3	-13.2	1	Bslt	79	24.1	0	3	28 *
	814	520707	5045382	35.8	77.5	-41.7	-41.2	-12.6	1	Bslt	77	23.5	0	3	14 *
	815	520792	5045299	33.4	78.5	-45.1	-44.6	-13.6	1	Bslt	78	23.8	0	4	28 *
	816	520729	5045683	-4.8	77.2	-82	-78.5	-23.9	1	Bslt	73.7	22.5	1	1	28 *
	817	520803	5045618	-8.3	94.7	-103	-91.5	-27.9	1	Grvl	83.2	25.4	1	1	24 *
	818	520890	5045552	-8.3	94.7	-103	-82	-25.0	1	G&Cobls	73.7	22.5	1	0	10 *
	819	520951	5045439	2.2	92.2	-90	-68	-20.7	1	G&Cobls	70.2	21.4	0	1	12 *
East Swan Isl	820	521912	5045874	31.5	80	-48.5	0	0.0	0		80	24.4	0		
	821	521929	5045903	31.5	184.5	-153	-143	-43.6	1	Grvl	174.5	53.2	1		
	822	522089	5045744	31.5	80.5	-49	0	0.0	0		80.5	24.5	0		
	823	522091	5045772	31.5	173.5	-142	-131	-39.9	1	Grvl	162.5	49.5	1		
	824	522244	5045632	30.6	80.6	-50	0	0.0	0		80.6	24.6	0		
	825	522243	5045663	31.6	167.6	-136	-124	-37.8	1	Grvl	155.6	47.4	1		
	826	522479	5045445	30.6	80.6	-50	0	0.0	0		80.6	24.6	0		
	827	522509	5045462	31.5	170.5	-139	-124	-37.8	1	Grvl	155.5	47.4	0		
	828	522722	5045290	31.7	151.7	-120	-118	-36.0	1	Grvl	149.7	45.6	0		
	829	522865	5045172	31.5	136	-104.5	-90	-27.4	1	Grvl	121.5	37.0	0		
	830	521736	5045705	31.4	80.4	-49	0	0.0	0		80.4	24.5	0		
	831	521641	5045741	31.6	184.6	-153	-142.5	-43.4	1	Grvl	174.1	53.1	0		
West Swan Isl	832	522652	5044809	31.8	130.8	-99	0	0.0	0		130.8	39.9	0		
	833	522338	5045047	30.8	164.8	-134	-121	-36.9	1	Grvl	151.8	46.3	0		
	834	522213	5045144	30.9	160.9	-130	-127	-38.7	1	Grvl	157.9	48.1	0		
	835	522751	5044611	-35	38	-73	0	0.0	0		38	11.6	0		
	836	522578	5044689	-34.2	103.8	-138	-118	-36.0	1	S&G	83.8	25.5	1		
	837	522437	5044836	-22.5	49.5	-72	0	0.0	0		49.5	15.1	1		
	838	522202	5045011	-27.4	121.6	-149	-135.5	-41.3	1	Grvl	108.1	32.9	0		
	839	522131	5045057	-28.1	53.4	-81.5	0	0.0	0		53.4	16.3	0		
	840	521955	5045202	-30.2	123.3	-153.5	-140	-42.7	1	Grvl	109.8	33.5	0		
	841	521780	5045330	-32	49	-81	0	0.0	0		49	14.9	0		
Mocks Bottom	842	521951	5046365	34	126	-92	0	0.0	0		126	38.4	1		
North	843	522021	5046413	34	101.5	-67.5	0	0.0	0		101.5	30.9	1		
	844	522280	5046521	28	111	-83	0	0.0	0		111	33.8	1		
	845	522501	5046448	26	95	-69	0	0.0	0		95	29.0	1		
	846	522110	5046425	35	112	-77	0	0.0	0		112	34.1	1		
Swan Isl	847	521319	5045698	-45.6	88.9	-134.5	-126	-38.4	1	Grvl	80.4	24.5	0		
Dry Dock	848	521476	5045565	-31.5	102.5	-134	-129	-39.3	1	Grvl	97.5	29.7	0		
	849	521719	5045402	-14.2	126.3	-140.5	-131	-39.9	1	Grvl	116.8	35.6	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
POP	850	521736	5044978	-39	34	-73	0	0.0	0		34	10.4	0		
Willamette River	851	521625	5045199	-38.7	36.8	-75.5	0	0.0	0		36.8	11.2	0		
	852	521391	5045309	-38.1	27.4	-65.5	0	0.0	0		27.4	8.4	0		
	853	521178	5045831	-48.5	30	-78.5	0	0.0	0		30	9.1	0		
	854	520877	5045840	-44.5	36	-80.5	0	0.0	0		36	11.0	0		
	855	520555	5046242	-50	31.5	-81.5	0	0.0	0		31.5	9.6	0		
	856	520288	5046572	-35.5	27.5	-63	0	0.0	0		27.5	8.4	0		
	857	520330	5046331	-43.8	33.2	-77	0	0.0	0		33.2	10.1	0		
	858	523307	5045860	24	105	-81	0	0.0	0		105	32.0	0		
	859	523125	5046174	20	102	-82	0	0.0	0		102	31.1	0		
	860	523013	5046030	22	100	-78	0	0.0	0		100	30.5	1		
	861	522905	5045816	27	145	-118	-112.5	-34.3	1	Grvl	139.5	42.5	0	0	34 *
	862	522938	5045890	32	149	-117	-113	-34.4	1	Grvl	145	44.2	0	2	29 *
	863	523513	5044377	17.5	110.5	-93	-85	-25.9	1	Grvl	102.5	31.2	0		
	864	523236	5044498	28.9	109.9	-81	-76	-23.2	1	Grvl	104.9	32.0	0		
	865	523345	5044421	22.7	104.7	-82	-77.5	-23.6	1	Grvl	100.2	30.5	0		
	866	523275	5044680	31	127.5	-96.5	-93	-28.3	1	Grvl	124	37.8	0		
	867	523494	5044661	31.5	127	-95.5	-94	-28.7	1	Grvl	125.5	38.3	0		
	868	523755	5044401	21.5	125.5	-104	-101	-30.8	1	Grvl	122.5	37.3	0		
	869	523683	5044521	24	96	-72	0	0.0	0		96	29.3	0		
	870	523704	5044449	27	131	-104	0	0.0	0		131	39.9	0		
	871	523441	5045008	31.5	101.5	-70	0	0.0	0		101.5	30.9	0		
Coliseum	872	525946	5042009	93.4	38.9	54.5	93.4	28.5	1	Qfc	0	0.0	0		
Gasco	873	518978	5047025	22	84	-62	0	0.0	0		84	25.6	0		
NW Portland	874	518785	5047043	26.6	41.1	-14.5	-14	-4.3	1	Bslt	40.6	12.4	0		
	875	518825	5046965	34.5	80	-45.5	-45.5	-13.9	1	Bslt	80	24.4	0		
	876	518905	5047059	10.7	154.2	-143.5	-143.5	-43.7	1	Bslt	154.2	47.0	1		
	877	518839	5047093	18.3	90.3	-72	-72	-21.9	1	Bslt	90.3	27.5	0		
	878	518924	5046990	20.2	95.2	-75	-74	-22.6	1	Bslt	94.2	28.7	0		
	879	518807	5047057	26.1	59.2	-33.1	-33.1	-10.1	1	Bslt	59.2	18.0	0		
	880	518686	5047046	34	51	-17	-16	-4.9	1	Bslt	50	15.2	0		
	881	518713	5047065	34	59	-25	-24.5	-7.5	1	Bslt	58.5	17.8	0		
	882	518740	5047075	34	51	-17	-16.5	-5.0	1	Bslt	50.5	15.4	0		
	883	518758	5047108	34	71.5	-37.5	-35.5	-10.8	1	Bslt	69.5	21.2	0		
	884	518660	5047067	34	39.5	-5.5	0	0.0	0		39.5	12.0	0		
	885	518688	5047094	34	51	-17	0	0.0	0		51	15.5	0		
	886	518702	5047114	34	44	-10	-10	-3.0	1	Bslt	44	13.4	0		
	887	518653	5047087	34	41.5	-7.5	0	0.0	0		41.5	12.6	0		
	888	518720	5047124	34	50	-16	0	0.0	0		50	15.2	0		
	889	518647	5047118	34	47	-13	-12.5	-3.8	1	Bslt	46.5	14.2	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
	890	518682	5047135	34	42.5	-8.5	0	0.0	0		42.5	13.0	0		
	891	518681	5047164	34	47.5	-13.5	-13.5	-4.1	1	Bslt	47.5	14.5	0		
	892	518797	5047145	34	92	-58	-58	-17.7	1	Bslt	92	28.0	0		
	893	518748	5047150	34	84	-50	-50	-15.2	1	Bslt	84	25.6	0	4	27 *
	894	518771	5047205	34	102	-68	-67	-20.4	1	Bslt	101	30.8	0	3	20 *
	895	518731	5047197	34	89.5	-55.5	-55.5	-16.9	1	Bslt	89.5	27.3	0		
	896	518662	5047232	36	60	-24	0	0.0	0		60	18.3	0		
	897	518729	5047272	34	106.5	-72.5	0	0.0	0		106.5	32.5	0	4	22 *
	898	518704	5047232	34	91.5	-57.5	-57	-17.4	1	Bslt	91	27.7	0		
	899	519005	5047072	25	201.5	-176.5	-176	-53.6	1	Bslt	201	61.3	0	1	29 *
	900	518941	5047047	26	105	-79	0	0.0	0		105	32.0	0		
	901	518724	5047219	19	75	-56	-56	-17.1	1	Bslt	75	22.9	0		
	902	518707	5047203	35	84	-49	-49	-14.9	1	Bslt	84	25.6	0		
PGE	903	516747	5051327	21.94	99	-77.06	0	0.0	0		99	30.2	0		
Willamette	904	516176	5050968	18.97	98	-79.03	0	0.0	0		98	29.9	1		
Linnton	905	515968	5050849	17	44	-27	-23	-7.0	1	Bslt	40	12.2	0		
Harborton	906	516145	5051053	25.5	135	-109.5	-108.5	-33.1	1	Bslt	134	40.8	0		
	907	516170	5051019	29	134	-105	-103.5	-31.5	1	Bslt	132.5	40.4	1		
	908	515919	5050910	-3	43.5	-46.5	-46.5	-14.2	1	Grvl	43.5	13.3	0		
	909	515942	5050887	-2.5	31.5	-34	0	0.0	0		31.5	9.6	0		
	910	515951	5050936	0	35.5	-35.5	0	0.0	0		35.5	10.8	0		
	911	515978	5050907	1	70	-69	-68	-20.7	1	Grvl	69	21.0	0		
	912	516077	5051063	22.5	52	-29.5	-29	-8.8	1	Bslt	51.5	15.7	0	1	32
	913	516054	5051038	22.6	71	-48.4	-47.9	-14.6	1	Bslt	70.5	21.5	0	0	17
	914	516025	5051010	22.7	91.5	-68.8	-68.3	-20.8	1	Bslt	91	27.7	0	2	5
	915	516078	5051001	23.7	65.5	-41.8	-41.3	-12.6	1	Bslt	65	19.8	0	3	46
	916	516023	5050979	23.6	56	-32.4	-32.4	-9.9	1	Bslt	56	17.1	0	4	24
	917	516054	5050989	23.9	57.5	-33.6	-33.6	-10.2	1	Bslt	57.5	17.5	0	4	60
	918	516056	5050961	23.7	58.5	-34.8	-34.8	-10.6	1	Bslt	58.5	17.8	0	5	58
Union Pacific RR	919	517423	5051954	16	31	-15	0	0.0	0		31	9.4	0		
St. Johns	920	517449	5051468	15	80	-65	0	0.0	0		80	24.4	1		
	921	517766	5051394	13	56	-43	0	0.0	0		56	17.1	0		
	922	518372	5051267	23	61	-38	0	0.0	0		61	18.6	0		
	923	518071	5051335	13	65	-52	0	0.0	0		65	19.8	1		
Ramsay&Lombard	924	517637	5052094	37	126.5	-89.5	0	0.0	0		126.5	38.6	0	5	31 *
Morr&Knudsen	925	517923	5051050	21	130	-109	0	0.0	0		130	39.6	1	2	12 *
	926	517269	5050977	27.5	167.5	-140	0	0.0	0		167.5	51.1	1		
	927	516999	5050962	27	101	-74	0	0.0	0		101	30.8	1	3	42 *

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min Max
POP RIVERGATE	928	518696	5051786	13	138.5	-125.5	0	0.0	0		138.5	42.2	1	
	929	519298	5050937	25	147.5	-122.5	-107	-32.6	1	Grvl	132	40.2	1	
	930	517683	5048496	-38	21.5	-59.5	-59.5	-18.1	1	Bouldrs	21.5	6.6	0	
	931	517563	5049244	-38	45	-83	0	0.0	0		45	13.7	0	
	932	516294	5051389	-23	59	-82	0	0.0	0		59	18.0	1	
	933	516180	5051713	-7	25	-32	0	0.0	0		25	7.6	0	
	934	516588	5052447	-46	39	-85	0	0.0	0		39	11.9	0	
	935	516238	5052747	-26	61	-87	0	0.0	0		61	18.6	1	
	936	516940	5053386	-25	52	-77	0	0.0	0		52	15.8	0	
	937	516683	5053631	-26	55.5	-81.5	0	0.0	0		55.5	16.9	1	
	938	517554	5054180	-37	45	-82	0	0.0	0		45	13.7	1	
	939	517724	5054054	-27	55	-82	0	0.0	0		55	16.8	0	
	940	517955	5054733	-29	55	-84	0	0.0	0		55	16.8	1	
	941	518271	5054867	-41	41.5	-82.5	0	0.0	0		41.5	12.6	0	
	942	516358	5052413	-43	40.5	-83.5	0	0.0	0		40.5	12.3	1	
POP RIVERGATE	943	516796	5053429	-42	38	-80	0	0.0	0		38	11.6	0	
	944	519228	5054477	-23	56.5	-79.5	0	0.0	0		56.5	17.2	0	
	945	519075	5054928	-39	39.5	-78.5	0	0.0	0		39.5	12.0	0	
	946	518692	5055075	-34	46	-80	0	0.0	0		46	14.0	0	
	947	517291	5052916	20	126	-106	0	0.0	0		126	38.4	0	
	948	517775	5053881	15	100	-85	0	0.0	0		100	30.5	0	
	949	517821	5053163	10	140	-130	0	0.0	0		140	42.7	1	
	950	518498	5055001	40	90.5	-50.5	0	0.0	0		90.5	27.6	0	
	951	518762	5052666	15	95	-80	0	0.0	0		95	29.0	1	
	952	519244	5053381	20	132	-112	0	0.0	0		132	40.2	1	
	953	518175	5053789	30	160	-130	0	0.0	0		160	48.8	1	
	954	518211	5053655	29	103.5	-74.5	0	0.0	0		103.5	31.5	0	
	955	518065	5053728	30.5	85	-54.5	0	0.0	0		85	25.9	0	
	956	517978	5053671	32	81.5	-49.5	0	0.0	0		81.5	24.8	0	
	957	518042	5053600	33	125	-92	0	0.0	0		125	38.1	0	
	958	517935	5053583	35.5	115	-79.5	0	0.0	0		115	35.1	0	
	959	517856	5053564	35.5	23.5	12	0	0.0	0		23.5	7.2	0	
	960	517912	5053468	34	160	-126	0	0.0	0		160	48.8	1	
	961	517860	5053706	33	22.5	10.5	0	0.0	0		22.5	6.9	0	
	962	517631	5053689	29	60	-31	0	0.0	0		60	18.3	0	
	963	517507	5053540	27	65	-38	0	0.0	0		65	19.8	0	
	964	517273	5053375	33	93	-60	0	0.0	0		93	28.3	0	
	965	518789	5053463	12.2	99.5	-87.3	0	0.0	0		99.5	30.3	1	
	966	518333	5054011	23.2	52	-28.8	0	0.0	0		52	15.8	0	
	967	518213	5054114	19.4	42	-22.6	0	0.0	0		42	12.8	0	
	968	518810	5053867	22	82	-60	0	0.0	0		82	25.0	0	
	969	518492	5053839	18	79	-61	0	0.0	0		79	24.1	0	

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
	970	517509	5052632	35	173	-138	-135.5	-41.3	1	Grvl	170.5	52.0	0	0	56 *
	971	517523	5052572	35	128	-93	0	0.0	0		128	39.0	0		
	972	517584	5052629	33	130	-97	0	0.0	0		130	39.6	0		
	973	517612	5052567	33	130	-97	0	0.0	0		130	39.6	0		
Grain Terminal	974	518046	5054123	30	120	-90	0	0.0	0		120	36.6	1	2	30 *
	975	518076	5054074	30	156	-126	0	0.0	0		156	47.5	0	3	44 *
	976	518114	5054034	31	124	-93	0	0.0	0		124	37.8	0	0	36
	977	517910	5054139	-28.5	144.5	-173	0	0.0	0		144.5	44.0	0	0	100 *
	978	517957	5054187	-28	131	-159	0	0.0	0		131	39.9	0	0	70 *
	979	517129	5053285	35.5	162	-126.5	-124.5	-37.9	1	Grvl	160	48.8	0	2	50
	980	517207	5053250	35.5	157.5	-122	-121.5	-37.0	1	Grvl	157	47.9	0	1	34 *
	981	517281	5053217	35.5	161	-125.5	0	0.0	0		161	49.1	0	2	40 *
Oregon	982	516759	5052567	32.1	101.1	-69	0	0.0	0		101.1	30.8	1		
Steel Mills	983	517097	5052434	32	113	-81	0	0.0	0		113	34.4	1		
	984	516737	5052435	30	82	-52	0	0.0	0		82	25.0	0		
	985	517059	5052350	30	106	-76	0	0.0	0		106	32.3	0		
PP&L Suavies Isl	986	515479	5052733	10	40	-30	0	0.0	0		40	12.2	0		
P. of Portland	987	520324	5052268	22	58	-36	0	0.0	0		58	17.7	0		
	988	520400	5053055	24	82	-58	0	0.0	0		82	25.0	0		
	989	519606	5053008	14	101	-87	0	0.0	0		101	30.8	0		
	990	519758	5053630	20	75.5	-55.5	0	0.0	0		75.5	23.0	0		
Oreg-Slough	991	524971	5050437	28	90	-62	0	0.0	0		90	27.4	0		
Old Borings	992	524972	5050406	9	101	-92	0	0.0	0		101	30.8	0		
ODOT	993	524945	5050376	-3	71	-74	0	0.0	0		71	21.6	0		
	994	524927	5050324	-7	67	-74	0	0.0	0		67	20.4	0		
	995	524916	5050251	-21	79	-100	0	0.0	0		79	24.1	0		
	996	524864	5050189	-20	89	-109	-107	-32.6	1	S&G	87	26.5	0		
	997	524874	5050156	4	104	-100	0	0.0	0		104	31.7	0		
I205 & Airport	998	535346	5046335	21.7	74.5	-52.8	0	0.0	0		74.5	22.7	0		
T1NR2E15Badd3	999	535373	5046628	22.14	640	-617.86	-198.86	-60.6	1	Tt	221	67.4	0		
T1NR2E15Badd1	1000	535346	5046600	22.05	228	-205.95	-197.95	-60.3	1	S&G	220	67.1	0		
T1NR2E15Bbac1	1001	534768	5046951	22	364	-342	-267	-81.4	1	Tt	289	88.1	0		
T1NR2E15Daad1	1002	536092	5046084	21.63	448	-426.37	-204.37	-62.3	1	Tt	226	68.9	0		
T1NR2E15Daaa2	1003	536183	5046100	21.63	270	-248.37	-202.37	-61.7	1	Qfc	224	68.3	0		
T1NR2E15Cdaa1	1004	535335	5045656	21.86	457	-435.14	-9.14	-2.8	1	Tt	31	9.4	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min Max
T1NR2E14Cc1	1005	536325	5045397	20	440	-420	-5	-1.5	1	Qfc	25	7.6	0	
T1NR2E14Ddb1	1006	537680	5045485	20	600	-580	-23	-7.0	1	Grvl	43	13.1	0	
T1NR2E14Dddb2	1007	537678	5045484	20	585	-565	-21	-6.4	1	S&G	41	12.5	0	
T1NR2E15Cbaa1	1008	534926	5046053	16	460	-444	-60	-18.3	1	Grvl	76	23.2	0	
T1NR2E15Bcac1	1009	534820	5046448	23.9	328	-304.1	-253.1	-77.1	1	Grvl	277	84.4	0	
T1NR2E13Cdcc2	1010	538276	5045393	20	568	-548	-37	-11.3	1	Grvl	57	17.4	0	
T1NR2E5Cda	1011	532025	5048901	15	205	-190	-88	-26.8	1	Tt	103	31.4	0	
T1NR2E9Dddc1	1012	534513	5047016	29.18	250	-220.82	-141.82	-43.2	1	Grvl	171	52.1	0	
T1NR2E9Dbdb1	1013	534059	5047555	19	423	-404	-113	-34.4	1	S&G	132	40.2	0	
T1NR2E15Caac1	1014	535254	5046033	16.3	85	-68.7	-59.7	-18.2	1	Grvl	76	23.2	0	
T1NR2E15Dbdb1	1015	535691	5045943	22	68	-46	-40	-12.2	1	Grvl	62	18.9	0	
T1NR2E15Dbcb1	1016	535465	5045849	20	360	-340	-35	-10.7	1	Grvl	55	16.8	0	
T1NR2E16Abac1	1017	534040	5046748	23.2	345	-321.8	-176.8	-53.9	1	Tt	200	61.0	0	
T1NR2E16Adbc1	1018	534242	5046430	14.56	400	-385.44	-251.44	-76.6	1	S&G	266	81.1	0	
T1NR2E16Acac1	1019	533766	5046665	7	399	-392	-236	-71.9	1	Grvl	243	74.1	0	
T1NR2E16Cc1	1020	533189	5045575	40	243	-203	36	11.0	1	Bouldrs	4	1.2	0	
T1NR2E16Cd1	1021	533588	5045614	40	125	-85	40	12.2	1	Grvl	0	0.0	0	
T1NR2E17Daa	1022	532973	5045935	21	80	-59	3	0.9	1	Tt	18	5.5	0	
T1NR2E24Bdbd2	1023	538370	5044842	17.6	375	-357.4	0.6	0.2	1	Tt	17	5.2	0	
T1NR2E24Adcb2	1024	539085	5044729	20.1	538	-517.9	10.1	3.1	1	Grvl	10	3.0	0	
Fremont Bridge	1025	524561	5042300	30.9	110.9	-80	-6	-1.8	1	Grvl	36.9	11.2	0	
Smith & Bybee	1026	520035	5052570	22	91	-69	-68	-20.7	1	Grvl	90	27.4	0	
Dutch Cones	1027	520289	5052255	13	79	-66	-64	-19.5	1	Grvl	77	23.5	0	
3rd project	1028	518735	5053686	20	138	-118	0	0.0	0		20	6.1	0	
Troutdale Airport	1029	547668	5044122	34	778	-744	-61	-18.6	1	Tt	95	29.0	0	
Longview Bridge	1030	503036	5105444	-40	4	-44	-43	-13.1	1	Bouldrs	3	0.9	0	
Clam Shell	1031	503007	5105399	-38	5	-43	-42	-12.8	1	Bouldrs	4	1.2	0	
Exploration	1032	503540	5105338	-40	8	-48	-48	-14.6	1	Bouldrs	8	2.4	0	
JDR Cow Pasture	1033	442812	5112569	9.5	80.5	-71	0	0.0	0		80.5	24.5	1	
John Day River	1034	442084	5112587	7.3	132.5	-125.2	-105.2	-32.1	1	Ast Frm	112.5	34.3	1	
Bridge	1035	442136	5112590	9.1	127	-117.9	-96.9	-29.5	1	Ast Frm	106	32.3	1	
	1036	442138	5112561	19.8	98	-78.2	0	0.0	0		98	29.9	1	
ODOT	1037	442667	5114141	-1	131	-132	-119.5	-36.4	1	Ast Frm	118.5	36.1	1	
Tongue Pt. to	1038	442835	5114293	-3	99	-102	-73	-22.3	1	Ast Frm	70	21.3	0	
Burnside	1039	447230	5113314	0	36.5	-36.5	-7	-2.1	1	Ast Frm	7	2.1	0	
	1040	447263	5113286	0	13.5	-13.5	-14.5	-4.4	1	Ast Frm	14.5	4.4	0	

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ODOT	1041	444562	5113043	12.4	99.5	-87.1	-75.6	-23.0	1	Ast Frm	88	26.8	0		
Astoria Bypass	1042	444324	5112938	33	68.4	-35.4	-17	-5.2	1	Ast Frm	50	15.2	0		
	1043	445337	5112992	20	58.3	-38.3	-19.7	-6.0	1	Ast Frm	39.7	12.1	0		
	1044	445125	5113099	-3	48.5	-51.5	-10	-3.0	1	Ast Frm	7	2.1	0		
	1045	444903	5113078	0	47.5	-47.5	-12.2	-3.7	1	Ast Frm	12.2	3.7	0		
	1046	444708	5113051	-11	34.8	-45.8	-18.8	-5.7	1	Ast Frm	7.8	2.4	0		
	1047	444392	5113040	-4	70.2	-74.2	-21.5	-6.6	1	Ast Frm	17.5	5.3	0		
	1048	444190	5113010	2	51.5	-49.5	-5.5	-1.7	1	Ast Frm	7.5	2.3	0		
ODOT	1049	448121	5112885	48.5	65	-16.5	48	14.8	1	Ast Frm	0	0.0	0		
Marys Creek	1050	448158	5112871	5	80	-75	-42	-12.8	1	Ast Frm	47	14.3	1		
Bridge	1051	448214	5112852	5	98	-93	-51	-15.5	1	Ast Frm	56	17.1	1		
	1052	448253	5112845	30	98	-68	-40	-12.2	1	Ast Frm	70	21.3	0		
ODOT	1053	450121	5112287	5	95	-90	-24	-7.3	1	Ast Frm	29	8.8	0		
Ferris Creek	1054	450055	5112301	4	68	-64	-26	-7.9	1	S&G	30	9.1	0		
Bridge	1055	449977	5112319	3	58	-55	-28	-8.5	1	S&G	31	9.4	0		
	1056	449923	5112338	5	70	-65	-23	-7.0	1	S&G	28	8.5	0		
	1057	449870	5112354	5	70	-65	0	0.0	1	Bslt	5	1.5	0		
Gnat Creek	1058	458797	5114927	10	61.5	-51.5	-23	-7.0	1	Ast Frm	33	10.1	0		
Bridge	1059	458825	5114911	1	111	-110	-103	-31.4	1	Ast Frm	104	31.7	1		
Blind Slough	1060	458239	5116536	0	144.3	-144.3	-143.3	-43.7	1	Ast Frm	143.3	43.7	0		
Bridge	1061	458236	5116428	0	96.5	-96.5	0	0.0	0		96.5	29.4	1		
	1062	458235	5116467	0	111.3	-111.3	-111.3	-33.9	1	Ast Frm	111.3	33.9	1		
	1063	458237	5116502	0	139.5	-139.5	0	0.0	0		139.5	42.0	1		
Crown Z	1064	468630	5111686	15	108.1	-93.1	-92	-28.0	1	Bslt	107	32.6	0	1	27
Wauna Or.	1065	468877	5111411	10	26.5	-16.5	-5	-1.5	1	Qls	15	4.6	0		
	1066	468973	5111049	10	31.6	-21.6	-7.3	-2.2	1	Grvl	17.3	5.3	0		
	1067	469304	5110756	10	41.5	-31.5	-11.5	-3.5	1	Grvl	21.5	6.6	0	1	7
	1068	468667	5111311	23	101.5	-78.5	11	3.4	1	Qls	12	3.7	0		
	1069	468490	5111499	11	156	-145	-14	-4.3	1	Qls	25	7.6	0		
Westport Ferry Slip	1070	470891	5109100	11	70	-59	0	0.0	0		70	21.3	0	1	23
Bradbury Slough	1071	487718	5112627	9	150	-141	0	0.0	0		150	45.7	0		
	1072	486001	5112164	9	150	-141	0	0.0	0		150	45.7	1		
	1073	486769	5113666	22	150	-128	0	0.0	0		150	45.7	0		
	1074	485656	5113509	23	149.5	-126.5	0	0.0	0		149.5	45.6	0		
	1075	485575	5113264	23	74.5	-51.5	0	0.0	0		74.5	22.7	0		
	1076	487103	5113957	0	81.5	-81.5	0	0.0	0		81.5	24.8	0		

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	1077	487139	5113700	0	78.5	-78.5	0	0.0	0		78.5	23.9	0		
	1078	487592	5113480	0	73.5	-73.5	0	0.0	0		73.5	22.4	0		
	1079	487541	5113240	0	67.5	-67.5	0	0.0	0		67.5	20.6	0		
	1080	487838	5113177	0	88.5	-88.5	0	0.0	0		88.5	27.0	0		
	1081	487997	5113034	0	62.5	-62.5	0	0.0	0		62.5	19.1	0		
WASHDOT	1082	470389	5115571	-21	212	-233	0	0.0	0		212	64.6	0	1	126
Puget Isl	1083	470331	5115479	-17	201.5	-218.5	0	0.0	0		201.5	61.4	0	4	108
Bridge	1084	470331	5115414	-19	201.5	-220.5	0	0.0	0		201.5	61.4	0	4	78
	1085	470318	5115347	-24	216.5	-240.5	0	0.0	0		216.5	66.0	0	1	108
	1086	470314	5115287	-22	200.25	-222.25	0	0.0	0		200.25	61.0	0	2	129
	1087	470334	5115218	-2	200	-202	0	0.0	0		200	61.0	0	1	91
	1088	470347	5115182	1	200	-199	0	0.0	0		200	61.0	0	1	76
	1089	470360	5115148	5	267	-262	0	0.0	0		267	81.4	0	4	62
	1090	470391	5115108	5	117	-112	0	0.0	0		117	35.7	0	3	27
WASHDOT	1091	445796	5131456	8.4	41.5	-33.1	0	0.0	0		41.5	12.6	0		
Deep River	1092	445904	5131401	31	36.5	-5.5	0	0.0	0		36.5	11.1	0		
Bridge	1093	445949	5131378	16.9	91	-74.1	-48.1	-14.7	1	Ast Frm	65	19.8	0	2	37
	1094	445951	5131380	16	110	-94	-59	-18.0	1	Ast Frm	75	22.9	0	2	90
	1095	445995	5131360	6	115	-109	-76.5	-23.3	1	Ast Frm	82.5	25.1	0	1	20
	1096	446023	5131340	4	129	-125	-96	-29.3	1	Ast Frm	100	30.5	1	1	68
	1097	446062	5131321	5	189	-184	-162	-49.4	1	Ast Frm	167	50.9	1	5	34
	1098	446101	5131310	7	248	-241	-215	-65.5	1	Ast Frm	222	67.7	0	1	61
	1099	446141	5131296	-8	214.5	-222.5	-214.5	-65.4	1	Grvl	214.5	65.4	0	2	65
	1100	446171	5131282	-8	221.33	-229.33	-188	-57.3	1	Ast Frm	180	54.9	0	3	67
	1101	446202	5131283	8.8	240.33	-231.53	-211.2	-64.4	1	Ast Frm	220	67.1	1	2	55
	1102	446211	5131267	4	245	-241	-211	-64.3	1	Ast Frm	215	65.5	1	3	71
	1103	446250	5131249	4	255	-251	-215.5	-65.7	1	Ast Frm	219.5	66.9	0	2	24
	1104	446284	5131234	5	257	-252	-222	-67.7	1	Ast Frm	227	69.2	0	1	28
	1105	446325	5131215	6	253.5	-247.5	-217	-66.1	1	Ast Frm	223	68.0	0	2	19
	1106	446339	5131231	7	180	-173	0	0.0	0		180	54.9	0	3	40
	1107	446352	5131210	3	245	-242	-215	-65.5	1	Ast Frm	218	66.4	0	1	68
Ranglia Slough	1108	446642	5130958	4	245	-241	-206	-62.8	1	Ast Frm	210	64.0	1	2	48
Bridge	1109	446645	5130939	-8	244	-252	-221	-67.4	1	Ast Frm	213	64.9	0	1	38
	1110	446648	5130917	9	236	-227	-214	-65.2	1	Ast Frm	223	68.0	0	3	37
	1111	446650	5130896	8.8	91.5	-82.7	0	0.0	0		91.5	27.9	1	2	50
Port Westward	1112	486145	5113179	13.5	135	-121.5	0	0.0	0		135	41.1	1		
Beaver Site	1113	486269	5113227	14	111	-97	0	0.0	0		111	33.8	0		
	1114	486422	5113284	12.5	114	-101.5	0	0.0	0		114	34.7	1		

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	1115	486289	5113044	10	121	-111	0	0.0	0		121	36.9	0	2	49
	1116	486444	5113151	13.5	121	-107.5	0	0.0	0		121	36.9	0	8	69
	1117	486541	5113155	13	121	-108	0	0.0	0		121	36.9	0	2	75
	1118	486273	5112973	14	121	-107	0	0.0	0		121	36.9	0	2	34
	1119	486453	5113044	12.5	121	-108.5	0	0.0	0		121	36.9	0	6	57
	1120	486358	5112771	5	151	-146	0	0.0	0		151	46.0	0	2	130
	1121	486613	5112953	13.5	131	-117.5	0	0.0	0		131	39.9	0	11	50
	1122	486601	5113156	10	121	-111	0	0.0	0		121	36.9	0	2	44
	1123	486505	5113101	11	121	-110	0	0.0	0		121	36.9	0		
	1124	486616	5113108	14	121	-107	0	0.0	0		121	36.9	0		
	1125	486521	5113054	12	121	-109	0	0.0	0		121	36.9	0		
	1126	486353	5113009	14	121	-107	0	0.0	0		121	36.9	0		
	1127	486189	5113042	10	121	-111	0	0.0	0		121	36.9	0		
	1128	486541	5113016	6.5	121	-114.5	0	0.0	0		121	36.9	0		
	1129	486641	5113054	6.5	121	-114.5	0	0.0	0		121	36.9	0		
	1130	486570	5113001	15	60	-45	0	0.0	0		60	18.3	0		
	1131	486586	5113024	15.5	60	-44.5	0	0.0	0		60	18.3	0		
	1132	486550	5112967	14.8	152	-137.2	0	0.0	0		152	46.3	0		
	1133	486515	5112953	15.2	67	-51.8	0	0.0	0		67	20.4	0		
	1134	486482	5112942	15	60	-45	0	0.0	0		60	18.3	0		
	1135	486379	5112906	14.9	71.5	-56.6	0	0.0	0		71.5	21.8	0		
	1136	486459	5112898	14.9	91	-76.1	0	0.0	0		91	27.7	0		
	1137	486538	5113135	15.8	97.5	-81.7	0	0.0	0		97.5	29.7	0		
	1138	486509	5113132	15.6	98.5	-82.9	0	0.0	0		98.5	30.0	0		
	1139	486522	5113120	16.4	98.5	-82.1	0	0.0	0		98.5	30.0	0		
	1140	486540	5113121	16	98.5	-82.5	0	0.0	0		98.5	30.0	0		
	1141	486266	5113119	15	60.5	-45.5	0	0.0	0		60.5	18.4	0		
	1142	486172	5113075	15.5	61	-45.5	0	0.0	0		61	18.6	0		
	1143	486299	5112972	14.5	108	-93.5	0	0.0	0		108	32.9	1		
	1144	486549	5113120	13	151	-138	0	0.0	0		151	46.0	0		
	1145	486556	5113086	9	165	-156	0	0.0	0		165	50.3	0		
	1146	486574	5113048	12	150	-138	0	0.0	0		150	45.7	0		
	1147	486147	5113028	9.5	105	-95.5	0	0.0	0		105	32.0	0		
	1148	486188	5113008	8.5	102	-93.5	0	0.0	0		102	31.1	0		
	1149	486248	5113003	11	105	-94	0	0.0	0		105	32.0	1		
	1150	486223	5112959	14	102	-88	0	0.0	0		102	31.1	1		
	1151	486364	5112966	14	102	-88	0	0.0	0		102	31.1	1		
	1152	486319	5112991	17.5	102	-84.5	0	0.0	0		102	31.1	0		
	1153	486262	5112931	14	100	-86	0	0.0	0		100	30.5	1		
T8NR4W23Cb	1154	488335	5112067	9	306	-297	-286	-87.2	1	Grvl	295	89.9	0		
McClean Bridge	1155	484027	5108044	10.6	152.5	-141.9	0	0.0	0		152.5	46.5	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min Max
Oak Pt/Locoda	1156	486450	5114026	19.2	76.5	-57.3	-371.2*	-113.1*	1	Qfc/Tt?	375	114.3	1	
PGE Crossing	1157	486461	5114815	21.3	151.5	-130.2	0	0.0	0		151.5	46.2	1	
	1158	486455	5114886	20.8	101.5	-80.7	0	0.0	0		101.5	30.9	1	
* Geophysical Contact	1159	486459	5115031	23.8	25	-1.2	-95*	-28.9*	1	Qfc/Tt?	119	36.2	0	
T8NR4W27Ad	1160	487916	5110714	15	128	-113	-1	-0.3	1	Ast Frm	16	4.9	0	
Powers Slough	1161	428364	5114162	5	142.5	-137.5	-136	-41.5	1	S&G	141	43.0	0	
Bridge	1162	428361	5114103	5	83.5	-78.5	0	0.0	0		83.5	25.5	0	
Skippanon Bridge	1163	429023	5112601	10.5	102	-91.5	0	0.0	0		102	31.1	1	
Warrenton Or	1164	428939	5112593	9.8	99.5	-89.7	0	0.0	0		99.5	30.3	1	
Holbrook Slough	1165	430600	5112084	5	120.5	-115.5	0	0.0	0		120.5	36.7	1	
Warrenton Or.	1166	430547	5112038	5	91.5	-86.5	0	0.0	0		91.5	27.9	0	
Astoria Pier 3	1167	433380	5115032	10	55	-45	0	0.0	0		55	16.8	0	
	1168	433370	5114980	10	79	-69	0	0.0	0		79	24.1	0	
	1169	433276	5115053	10	97.5	-87.5	0	0.0	0		97.5	29.7	0	
	1170	433319	5115022	10	201.3	-191.3	-155	-47.2	1	Ast Frm	165	50.3	0	
Astoria Pier 2	1171	433506	5115276	-14	151.5	-165.5	0	0.0	0		151.5	46.2	0	
	1172	433662	5115185	-20.5	125.5	-146	0	0.0	0		125.5	38.3	0	
	1173	433762	5115093	-14.5	30.7	-45.2	0	0.0	0		30.7	9.4	0	
	1174	433666	5115109	16	86.5	-70.5	0	0.0	0		86.5	26.4	0	
ODOT	1175	432686	5120876	-38	36	-74	-46	-14.0	1	Ast Frm	8	2.4	0	
Astoria-Megler	1176	432742	5120706	-55	99	-154	-149	-45.4	1	Ast Frm	94	28.7	0	
Bridge	1177	432779	5120604	-67	127.5	-194.5	-204	-62.2	1	Ast Frm	127.5	38.9	0	
	1178	432815	5120496	-64	102	-166	0	0.0	0		102	31.1	0	
	1179	433011	5119921	-37.5	122.5	-160	0	0.0	0		122.5	37.3	0	
	1180	433382	5118815	-23	84	-107	0	0.0	0		84	25.6	0	
	1181	433761	5117691	-10.5	107.5	-118	0	0.0	0		107.5	32.8	0	
	1182	434189	5116420	-10.5	98.5	-109	0	0.0	0		98.5	30.0	0	
	1183	434276	5116170	-36	148	-184	0	0.0	0		148	45.1	0	
	1184	434426	5115764	-47	151	-198	0	0.0	0		151	46.0	0	
	1185	434401	5115749	-48	224	-272	-230	-70.1	1	Ast Frm	182	55.5	0	
	1186	434417	5115725	-47	209	-256	-238	-72.5	1	Ast Frm	191	58.2	0	
	1187	434497	5115533	-23	114	-137	-123	-37.5	1	Ast Frm	100	30.5	0	
	1188	434479	5115522	-21	159	-180	-123	-37.5	1	Ast Frm	102	31.1	0	
	1189	434542	5115369	12	54	-42	-29	-8.8	1	Ast Frm	41	12.5	0	

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min Max
	1190	434561	5115304	11.5	46.5	-35	-20	-6.1	1	Ast Frm	31.5	9.6	0	
	1191	434582	5115239	18.5	43.5	-25	-16	-4.9	1	Ast Frm	34.5	10.5	0	
John Day River Bridge	1192	442086	5112598	4.2	121	-116.8	-125.8	-38.3	1	Ast Frm	121	36.9	1	
	1193	441979	5112673	4	112	-108	-72	-21.9	1	Ast Frm	76	23.2	0	
	1194	441929	5112702	-22	82	-104	-88	-26.8	1	Ast Frm	66	20.1	0	
	1195	441957	5112684	-16	84	-100	-68	-20.7	1	Ast Frm	52	15.8	0	
	1196	441881	5112744	11	80	-69	-54	-16.5	1	Ast Frm	65	19.8	0	
	1197	441870	5112758	11	70	-59	-47	-14.3	1	Ast Frm	58	17.7	0	
	1198	441855	5112777	11	53	-42	-37	-11.3	1	Ast Frm	48	14.6	0	
	1199	441836	5112802	16	68	-52	-51	-15.5	1	Ast Frm	67	20.4	0	
	1200	441811	5112826	16	63	-47	-42	-12.8	1	Ast Frm	58	17.7	0	
	1201	441888	5112716	6.51	96	-89.49	-43.49	-13.3	1	Ast Frm	50	15.2	0	
	1202	442036	5112609	4.6	121	-116.4	-80.4	-24.5	1	Ast Frm	85	25.9	1	
T8NR10W9Bb1	1203	427428	5116140	10	369	-359	-278	-84.7	1	Ast Frm	288	87.8	0	
T8NR10W9Cb1	1204	428565	5115448	10	1539	-1529	-252	-76.8	1	Ast Frm	262	79.9	0	
T8NR10W7Ad	1205	425763	5116334	23	800	-777	-258	-78.6	1	Ast Frm	281	85.6	0	
Col. Co. School	1206	479015	5106204	32	125	-93	30	9.1	1	Grvl	2	0.6	0	
T7NR5W3	1207	477858	5106449	14	42	-28	-27	-8.2	1	Ast Frm	41	12.5	0	
Woodson Bridge	1208	474911	5106741	3	65	-62	0	0.0	0		65	19.8	0	
	1209	474933	5106794	4	65	-61	0	0.0	0		65	19.8	0	
Tennasille Island	1210	463845	5120263	11.5	38.5	-27	0	0.0	0		38.5	11.7	0	
	1211	463768	5120251	11.5	29.5	-18	0	0.0	0		29.5	9.0	0	
	1212	463604	5120141	11.5	38.5	-27	0	0.0	0		38.5	11.7	0	
	1213	463600	5120091	11.5	28.5	-17	0	0.0	0		28.5	8.7	0	
	1214	463628	5120177	11.5	30.5	-19	0	0.0	0		30.5	9.3	0	
	1215	463400	5119981	11.5	31.5	-20	0	0.0	0		31.5	9.6	0	
T9NR6W26Cca	1216	469376	5119732	14	40	-26	0	0.0	0		40	12.2	0	
T9NR6W26Ad	1217	470565	5120382	10	64	-54	-48	-14.6	1	Grvl	58	17.7	0	
T9NR6W26Cb	1218	469703	5119879	10	59	-49	0	0.0	0		59	18.0	0	
T9NR6W18Aa	1219	464398	5123902	10	120	-110	-110	-33.5	1	Bslt	120	36.6	1	
T9NR6W5Ad	1220	465884	5126567	20	130	-110	-100	-30.5	1	Grvl	120	36.6	0	
T10NR11W26Ba	1221	422645	5130908	20	17	3	0	0.0	0		17	5.2	0	
T10NR11W26Ca	1222	422496	5130071	20	93.5	-73.5	0	0.0	0		93.5	28.5	0	

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
New England	1223	429351	5113081	7	65	-58	0	0.0	0		65	19.8	0		
Fish Co.	1224	429440	5113094	7	57	-50	0	0.0	0		57	17.4	0		
	1225	429410	5113169	10	62	-52	0	0.0	0		62	18.9	0		
NW Aluminum	1226	429963	5113788	0	111	-111	0	0.0	0		111	33.8	0	78	170
Warrenton Or.	1227	429993	5112862	5	101	-96	0	0.0	0		101	30.8	0		
	1228	429895	5112141	10	101	-91	0	0.0	0		101	30.8	1		
	1229	429928	5111575	10	75	-65	-58	-17.7	1	Ast Frm	68	20.7	0		
	1230	428753	5111298	10	52	-42	-31	-9.4	1	Ast Frm	41	12.5	0		
	1231	428658	5112030	10	102	-92	0	0.0	0		102	31.1	1		
	1232	429526	5112456	10	102	-92	0	0.0	0		102	31.1	1		
	1233	429513	5111827	10	101	-91	0	0.0	0		101	30.8	1		
	1234	429804	5113284	5	101	-96	0	0.0	0		101	30.8	0		
	1235	430548	5113370	0	101	-101	0	0.0	0		101	30.8	0		
Astoria Pier 3	1236	433269	5115246	-19	125	-144	0	0.0	0		125	38.1	0	0	100
2nd project	1237	433018	5115146	-20	126	-146	0	0.0	0		126	38.4	0	0	110
	1238	432892	5115147	-29.5	119	-148.5	0	0.0	0		119	36.3	0	16	128
Tongue Point	1239	441386	5115987	15	59.5	-44.5	0	0.0	0		59.5	18.1	0		
	1240	441365	5116028	15	56.5	-41.5	0	0.0	0		56.5	17.2	0		
	1241	441221	5115956	15	21.5	-6.5	0	0.0	0		21.5	6.6	0		
	1242	441164	5116446	15	31.5	-16.5	0	0.0	0		31.5	9.6	0		
	1243	441240	5116356	15	36.5	-21.5	0	0.0	0		36.5	11.1	0		
	1244	441285	5116259	15	32	-17	0	0.0	0		32	9.8	0		
	1245	441311	5116159	15	35	-20	0	0.0	0		35	10.7	0		
	1246	441266	5116041	15	31.5	-16.5	0	0.0	0		31.5	9.6	0		
	1247	441227	5116095	15	20	-5	0	0.0	0		20	6.1	0		
	1248	441064	5116502	15	25	-10	0	0.0	0		25	7.6	0		
	1249	441333	5115975	15	35	-20	0	0.0	0		35	10.7	0		
	1250	441393	5115838	15	31.5	-16.5	0	0.0	0		31.5	9.6	0		
Tongue Point	1251	441248	5116554	-15.5	17	-32.5	0	0.0	0		17	5.2	0		
2nd project	1252	441542	5116486	-10	19.5	-29.5	0	0.0	0		19.5	5.9	0		
	1253	441436	5116582	-11.5	20.5	-32	0	0.0	0		20.5	6.2	0		
	1254	441678	5116574	-11.5	18	-29.5	0	0.0	0		18	5.5	0		
	1255	441299	5116381	-15	13	-28	0	0.0	0		13	4.0	0		
	1256	441434	5116421	-13.5	14	-27.5	0	0.0	0		14	4.3	0		
	1257	441473	5116263	-13.5	19	-32.5	0	0.0	0		19	5.8	0		
Tongue Point	1258	441290	5116466	-12.5	48	-60.5	-21	-6.4	1	Ast Frm	8.5	2.6	0		
3rd project	1259	441382	5116497	-16	47.5	-63.5	-29	-8.8	1	Ast Frm	13	4.0	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
	1260	441586	5116555	-17	46.5	-63.5	0	0.0	0		46.5	14.2	0		
	1261	441343	5116305	-18	46	-64	-24	-7.3	1	Ast Frm	6	1.8	0		
	1262	441409	5116328	-17	46.5	-63.5	-23	-7.0	1	Ast Frm	6	1.8	0		
	1263	441510	5116359	-16	47.5	-63.5	0	0.0	0		47.5	14.5	0		
	1264	441420	5116151	-16.5	47	-63.5	-48.5	-14.8	1	Ast Frm	32	9.8	0		
	1265	441521	5116179	-15.5	48	-63.5	0	0.0	0		48	14.6	0		
Trojan	1266	509006	5097881	15	255	-240	-35	-10.7	1	Bslt	50	15.2	0		
Nuclear Plant	1267	509050	5097490	18	53	-35	0	0.0	0		53	16.2	0		
Site	1268	509154	5097489	10	27	-17	0	0.0	0		27	8.2	0		
	1269	508697	5097813	12	278	-266	-257	-78.3	1	Grvl	269	82.0	0		
	1270	509173	5097700	-11.1	53.9	-65	-29.1	-8.9	1	Bslt	18	5.5	0		
	1271	509133	5097762	18	89	-71	-38	-11.6	1	Grvl	56	17.1	0		
	1272	509085	5097815	15	125	-110	-73	-22.3	1	Bslt	88	26.8	0		
	1273	508815	5098338	11	38	-27	-13	-4.0	1	Tuff	24	7.3	0		
	1274	509122	5098350	-6	29	-35	-30	-9.1	1	Grvl	24	7.3	0		
	1275	509099	5098339	2	42	-40	-20	-6.1	1	Tuff	22	6.7	0		
	1276	508645	5098297	4	56	-52	0	0.0	0		56	17.1	0		
	1277	508681	5098135	12	153	-141	0	0.0	0		153	46.6	0		
	1278	508876	5097773	15	102	-87	0	0.0	0		102	31.1	0		
	1279	508821	5097141	15	27	-12	0	0.0	0		27	8.2	0		
	1280	508928	5097060	16	81	-65	0	0.0	0		81	24.7	1		
	1281	509192	5097845	6	116	-110	-95	-29.0	1	Bouldrs	101	30.8	0		
	1282	509088	5098326	6.5	27.5	-21	-12	-3.7	1	Bslt	18.5	5.6	0		
	1283	509116	5098269	11.6	61.6	-50	-37	-11.3	1	Grvl	48.6	14.8	0		
	1284	508889	5098216	18	45	-27	-14	-4.3	1	Tuff	32	9.8	0		
	1285	509144	5097835	17.4	99.4	-82	-39.6	-12.1	1	S&G	57	17.4	0		
	1286	509166	5097856	18	38	-20	-5	-1.5	1	Bslt	23	7.0	0		
	1287	509124	5097824	18	69	-51	-38	-11.6	1	Bslt	56	17.1	0		
	1288	508354	5097973	10.1	151.5	-141.4	0	0.0	0		151.5	46.2	0	8	41
	1289	508283	5097964	22	24.5	-2.5	0	0.0	0		24.5	7.5	0		
	1290	508296	5097879	22	102	-80	0	0.0	0		102	31.1	1	3	38
	1291	508366	5097886	22	27	-5	0	0.0	0		27	8.2	0		
Champlin Well	1292	480415	5108444	0	5720	-5720	-300	-91.4	1	Bslt&Grvl	300	91.4	0		
Ash Grove	1293	516784	5052044	33	97	-64	0	0.0	0		97	29.6	0		
Lime & Cement	1294	516986	5051992	33	96	-63	0	0.0	0		96	29.3	0		
	1295	516781	5051892	32	97	-65	0	0.0	0		97	29.6	0		
	1296	517027	5051882	32	93	-61	0	0.0	0		93	28.3	0		
	1297	516650	5051895	10	110	-100	0	0.0	0		110	33.5	0		
	1298	516654	5051946	8	110	-102	0	0.0	0		110	33.5	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
	1299	516662	5051991	8	91	-83	0	0.0	0		91	27.7	0		
	1300	516869	5051981	34	76	-42	0	0.0	0		76	23.2	0		
	1301	516935	5051972	34	71	-37	0	0.0	0		71	21.6	0		
Ash Grove Well	1302	516781	5051966	32.0	212.0	-180.0	-158.0	-48.2	1	Tt	190.0	57.9	0		
Crown Z.	1303	517003	5051801	31	32	-1	0	0.0	0		32	9.8	0	0	8 *
N Portland	1304	517008	5051693	32	31	1	0	0.0	0		31	9.4	0	4	10 *
	1305	516907	5051741	32	110	-78	0	0.0	0		110	33.5	0	4	35 *
	1306	516821	5051792	32	33	-1	0	0.0	0		33	10.1	0	4	9 *
	1307	516828	5051700	31.5	34.5	-3	0	0.0	0		34.5	10.5	0	5	12 *
	1308	516733	5051747	33	84	-51	0	0.0	0		84	25.6	0	6	39 *
Carnation Co	1309	518299	5053887	29.4	151.0	-121.6	0.0	0.0	0		151.0	46.0	1		
	1310	518363	5053835	28.2	141.5	-113.3	0.0	0.0	0		141.5	43.1	0		
	1311	518331	5053821	29.2	111.5	-82.3	0.0	0.0	0		111.5	34.0	0		
	1312	518327	5053728	30.5	106.5	-76.0	0.0	0.0	0		106.5	32.5	0		
	1313	518344	5053873	28.5	174.0	-145.5	0.0	0.0	0		174.0	53.0	0		
	1314	518384	5053871	29.5	194.0	-164.5	0.0	0.0	0		194.0	59.1	0		
	1315	518435	5053754	27.0	124.0	-97.0	0.0	0.0	0		124.0	37.8	0		
	1316	518386	5053746	29.5	115.5	-86.0	0.0	0.0	0		115.5	35.2	0		
	1317	518414	5053822	29.0	125.0	-96.0	0.0	0.0	0		125.0	38.1	0		
	1318	518395	5053794	27.8	114.5	-86.7	0.0	0.0	0		114.5	34.9	0		
	1319	518307	5053849	29.0	115.5	-86.5	0.0	0.0	0		115.5	35.2	0		
	1320	518274	5053923	29.0	114.3	-85.3	0.0	0.0	0		114.3	34.8	0		
USACE	1321	521484	5053911	-30.0	61.5	-91.5	0.0	0.0	0		61.5	18.7	0	2	86
PP&L Ione Reef	1322	546149	5046081	5.7	30.7	-25.0	5.7	1.7	1	Bslt	0.0	0.0	0		
	1323	546097	5046063	7.7	32.2	-24.5	7.7	2.3	1	Bslt	0.0	0.0	0		
<u>DOGAMI DATA</u>															
162nd xSandy	1324	539430	5044065	30	680	-650	18	5.5	1	Qlg?	12	3.7	0		
162nd X AirportWy	1325	539460	5044960	20	28	-8	2	0.6	1	Tt? Qlg?	18	5.5	0	1	11
Marine x 158th	1326	539100	5045230	20	490	-470	-36	-11.0	1	Tt Qlg?	56	17.1	0	1	15
158th X Columbia Slu	1327	539120	5044260	17	320	-303	4	1.2	1	Qlg? Tt?	13	4.0	0		
Hemlock	1328	539730	5044710	15	22	-7	-1	-0.3	1	Qlg? Tt?	16	4.9	0	2	11
PIA	1329	531490	5049020	24	84	-60	0	0.0	0		84	25.6	0	4	29
PIA	1330	533000	5047785	15	80	-65	0	0.0	0		80	24.4	0	0	48
PIA	1331	534130	5047120	20	70	-50	0	0.0	0		70	21.3	0	2	40
PIA	1332	530240	5047780	14	59	-45	0	0.0	0		59	18.0	0		

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Ft	Hole Base Ft	QalBasal ContactFt	QalBasal ContactM	GIS Code	Basal Lithol	Isopach Feet	Isopach Meters	Ash Code	SPT Min	SPT Max
PIA Terminal	1333	531810	5048290	17	117	-100	0	0.0	0		117	35.7	0	1	38
PIA	1334	530560	5049130	20	75	-55	0	0.0	0		75	22.9	0	1	11
PIA	1335	532170	5048070	22	117	-95	0	0.0	0		117	35.7	0	0	21
PIA	1336	533000	5047530	17	80	-63	0	0.0	0		80	24.4	0		
Portland AFB	1337	531150	5047220	10	95	-85	0	0.0	0		95	29.0	0	1	29
PIA	1338	533300	5047460	40	90	-50	0	0.0	0		90	27.4	0	14	51
PIA	1339	532880	5046790	18	39	-21	0	0.0	0		39	11.9	0	3	34
PIA	1340	532020	5048170	20	126	-106	-102	-31.1	1	Tt? Qlg?	122	37.2	0	2	56
PIA SE	1341	533890	5046090	24	47	-30	-23	-7.0	1	Tt Qlg?	47	14.3	0	2	39
I-205 X Holman	1342	534900	5045955	18	60	-60	-42	-12.8	1	Qlgu	60	18.3	0	2	13
I-205 X 105th	1343	534860	5045830	22	50	-50	-13	-4.0	1	Qlgu	35	10.7	0	2	6
I-205 at Johnson Lk	1344	534500	5045520	16	25	-25	10	3.0	1	Qlg	6	1.8	0	4	10
AirportWay x 138	1345	537480	5045350	15	28	-13	-5	-1.5	1	Qlg? Tt?	20	6.1	0	3	11
Lombard X Airport	1346	533950	5046260	20	80	-60	0	0.0	0		80	24.4	0	1	26
Marx x 105th	1347	534860	5045350	18	20	-20	6	1.8	1	Qlg	12	3.7	0	4	11
Marx x 105th	1348	535370	5045195	28	13	15	23	7.0	1	Qlg Tt?	5	1.5	0	9	12
	1349	535820	5045990	20	60	-40	0	0.0	0		60	18.3	0		
Airport	1350	531545	5048500	20	216	-196	0	0.0	0		216	65.8	0		
UAL, PIA	1351	533330	5047580	20	110	-90	0	0.0	0		110	33.5	0		
13211 NE Marine	1352	537340	5045650	20	122	-102	-100	-30.5	1	Qal? Tt?	120	36.6	0		
Marx x 87	1353	533330	5045800	20	10	10	10	3.0	1	Tt? Qlg?	10	3.0	0		
90th x Col. Slough	1354	533580	5045950	15	125	-110	-103	-31.4	1	Qlg	118	36.0	0		
11555 NE Sumner	1355	535690	5045250	15	418	-403	4	1.2	1	Qlg	9	2.7	0		
5131 NE 148th	1356	538350	5044500	25	280	-255	-9	-2.7	1	Qlg	34	10.4	0		
Lombard x 96th	1357	534100	5046850	25	355	-320	-175	-53.3	1	Qlg? Tt?	175	53.3	0		
Saratoga x 96th	1358	534100	5046300	7	399	-392	-167	-50.9	1	Tt? Qls/lg	174	53.0	0		
138th X Columbia Slu	1359	537390	5045130	20	365	-345	-14	-4.3	1	Tt Qlg?	34	10.4	0		
122nd X UPRR	1360	536260	5044850	28	50	-22	24	7.3	1	Qlg	4	1.2	0		
82nd x Columbia Slu	1361	533100	5045930	25	61	-38	-35	-10.7	1	Qlg? Tt	60	18.3	0		
Whitaker x 138th	1362	537200	5045020	15	15	-15	5	1.5	1	Qlg Tt?	10	3.0	0	1	9
PIA Military	1363	531900	5047100	20	54	-34	0	0.0	0		54	16.5	0	2	9
Sandy x 142	1364	537920	5044480	35	23	12	31	9.4	1	Qlg	4	1.2	0		
PIA	1365	532520	5047790	20	51	-31	0	0.0	0		51	15.5	0	1	20
Invernees Dr.	1366	535900	5045440	22	33	-11	-10	-3.0	1	Qlg? Tt?	32	9.8	0	8	28
Ainsworth CircxAirpt	1367	535770	5045830	25	51	-26	-25	-7.6	1	Qlg Tt?	50	15.2	0	3	15
4200 Columbia Way	1368	529700	5051350	35	260	-225	34	10.4	1	Qmc?	1	0.3	0		
Doane lake	1369	519580	5045870	50	60	-10	0	0.0	0		60	18.3	0		
I-5 X Columbia Sloug	1370	524970	5048160	10	80	-70	-35	-10.7	1	Tt? Qlg?	45	13.7	0		
Yeon X 26th	1371	522940	5043460	35	140	-105	-100	-30.5	1	Tt	135	41.1	0	3	25
Elrod X 21st.	1372	527820	5047540	20	70	-50	-40	-12.2	1	Tt?	60	18.3	0	5	18

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Vanport City	1373	523480	5049670	10	152	-142	-80	-24.4	1	Tt? Qlg?	90	27.4	0		
	1374	523250	5049630	12	92	-80	-80	-24.4	1	Tt?	92	28.0	0		
	1375	524080	5049350	12	97	-85	-85	-25.9	1	Tt	97	29.6	0		
	1376	520030	5046305	30	27	3	0	0.0	0		27	8.2	0		
	1377	528500	5049500	30	60	-30	0	0.0	0		60	18.3	0		
	1378	524480	5042200	38	78	-40	15	4.6	1	Tt? Qlg?	23	7.0	0		
	1379	527260	5047490	35	45	-10	0	0.0	0		45	13.7	0		
	1380	527260	5047380	20	28	-8	-8	-2.4	1	Tt? Qlg?	28	8.5	0		
	1381	527660	5048600	20	40	-20	0	0.0	0		40	12.2	0		
	1382	522790	5046000	20	135	-115	-115	-35.1	1	Tt?	135	41.1	0		
	1383	523000	5043430	30	30	0	0	0.0	0		30	9.1	0		
	1384	524560	5042480	30	140	-110	0	0.0	0		140	42.7	0		
	1385	522500	5042670	35	70	-35	-35	-10.7	1	Tt?	70	21.3	0		
	1386	521910	5042990	50	20	30	0	0.0	0		20	6.1	0		
	1387	523080	5043540	30	105	-75	-75	-22.9	1	Tt	105	32.0	0		
	1388	520330	5045080	37	45	-8	-8	-2.4	1	Tcr	45	13.7	0		
	1389	520540	5046650	10	166	-156	0	0.0	0		166	50.6	0		
	1390	527880	5047200	20	963	-943	-28	-8.5	1	Tt	48	14.6	0		
	1391	528230	5047670	10	130	-120	-110	-33.5	1	Tt	120	36.6	0		
	1392	525320	5050240	10	140	-130	0	0.0	0		140	42.7	0		
26th X Yeon	1393	521750	5045970	10	175	-165	-165	-50.3	1	Tt?	175	53.3	0		
26th X Yeon	1394	521530	5044835	-10	127	-137	-137	-41.8	1	Tt?	127	38.7	0		
26th X Yeon	1395	521270	5045700	-20	105	-125	-125	-38.1	1	Tt?	105	32.0	0		
	1396	521850	5045450	30	135	-105	-105	-32.0	1	Tt?	135	41.1	0		
	1397	521935	5045280	0	140	-140	-140	-42.7	1	Tt?	140	42.7	0		
	1398	522460	5045100	30	159	-129	-129	-39.3	1	Tt	159	48.5	0		
	1399	522810	5044760	30	175	-145	-145	-44.2	1	Tt?	175	53.3	0		
	1400	522720	5044680	-20	98	-118	-118	-36.0	1	Tt?	98	29.9	0		
Quimby X 12th	1401	524760	5042120	25	65	-40	-25	-7.6	1	Tt? Qlg?	50	15.2	0	3	8
Front x 35th	1402	522230	5044250	32	157	-125	-113	-34.4	1	Tt? Qlg?	145	44.2	0	5	70
NW Portland	1403	523930	5042890	32	26	6	9	2.7	1	Qlg? Tt?	23	7.0	0		
NW Portland	1404	524025	5043170	30	62	-32	0	0.0	0		62	18.9	0		
12th X Pettygrove	1405	524690	5042050	35	60	-25	2	0.6	1	Qlg Tt?	33	10.1	0	3	15
Jubitz Truck Stop	1406	526000	5049150	10	108	-98	-94	-28.7	1	Qlg? Tt?	104	31.7	1		
NE 21st x Columbia	1407	527910	5046930	30	42	-12	12	3.7	1	Qlg Tt?	18	5.5	0	12	35
Col Slu x PortlandRD	1408	522050	5049400	30	82	-52	-52	-15.8	1	Qlg? Tt?	82	25.0	0	1	30
Col Slu x PortlandRD	1409	522330	5049830	32	114	-82	-82	-25.0	1	Qlg? Tt?	112	34.1	0		
Col Slu x PortlandRD	1410	522570	5050120	28	97	-69	-67	-20.4	1	Qlg? Tt?	95	29.0	0	2	64
Col Slu x PortlandRD	1411	522105	5051060	26	106	-80	-79	-24.1	1	Tt? Qlg?	105	32.0	0	1	8
Col Slu x PortlandRD	1412	523620	5051740	21	150	-129	0	0.0	0		150	45.7	0	4	66

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6135 N. Basin	1413	522700	5045740	25	172	-147	-120	-36.6	1	Qmc?	145	44.2	0		
NWNicolai X Willam R	1414	523995	5043200	25	100	-75	0	0.0	0		100	30.5	0	7	43
NW Front X Doane	1415	520175	5045420	37	35	2	0	0.0	0		35	10.7	0	7	19
Swan Island	1416	521780	5045785	30	173	-143	-138	-42.1	1	Tt	168	51.2	0	18	69
NW Industrial X 28th	1417	522800	5042930	37	90	-53	-47	-14.3	1	Tt	84	25.6	0	4	14
St Helens Rd X Kittr	1418	521025	5044640	35	93	-58	-49	-14.9	1	Tcr	84	25.6	0		
NW Front X Doan	1419	520380	5045415	35	368	-333	-55	-16.8	1	Tcr	90	27.4	0		
NW Front X Kittredge	1420	521040	5044795	35	400	-365	-30	-9.1	1	Tcr	65	19.8	0		
NW Front X 25th	1421	523340	5043380	31	69	-38	6	1.8	1	Qmc? Tt?	25	7.6	0	6	20
W end Fremont Bridge	1422	524335	5042350	45	85	-40	10	3.0	1	Qlgu	35	10.7	0		
NW Front X Kittredge	1423	521350	5044700	36	61	-25	-12	-3.7	1	Tt? Qlgu	48	14.6	0	9	42
NW Kittredge X Front	1424	521475	5045000	-12	71	-83	-45	-13.7	1	Tt	33	10.1	0	0	8
NW Front X Kittredge	1425	520980	5045165	32	82	-50	-45	-13.7	1	Tcr	77	23.5	0	5	10
3366 NW Yeon	1426	522230	5043700	33	669	-646	-71	-21.6	1	Qlg?Qal?Tt	104	31.7	0		
8200 NE Union	1427	526520	5047500	45	82	-37	5	1.5	1	Qlgu	40	12.2	0		
8443 N Kerby	1428	525655	5047780	43	95	-52	-3	-0.9	1	Qlg/Qls	46	14.0	0		
8300 N Vancouver	1429	526040	5047720	30	97	-67	-14	-4.3	1	Qlgu, Tt?	44	13.4	0		
320 NE Gertz	1430	526400	5048360	15	189	-174	-115	-35.1	1	Qlgu? Tt	130	39.6	0		
2239 NE Elrod	1431	527930	5047675	10	144	-134	-70	-21.3	1	Tt? Qal?	80	24.4	0		
720 NE Marine Dr	1432	526790	5049550	20	217	-197	-108	-32.9	1	Tt	128	39.0	0		
Col. Edgwtr GolfClub	1433	527885	5049175	12	172	-160	-128	-39.0	1	Qlgu Tt?	140	42.7	0		
Col. EdgwtrGolfClub	1434	527405	5049090	10	137	-127	-100	-30.5	1	Qlgu, Qal?	110	33.5	0		
Ne Marine XC union	1435	525220	5049850	20	250	-230	-90	-27.4	1	Qlgu	110	33.5	0		
N Marine X Union Ct	1436	524950	5049355	5	177	-172	-104	-31.7	1	Qlg? Qal?	109	33.2	0		
N Columbia XUnionPac	1437	522565	5048900	20	87	-57	-31	-9.4	1	Qlg? Qal?	51	15.5	0		
6900 N edgewater	1438	520425	5047170	38	130	-92	-46	-14.0	1	Tt, Qlg	84	25.6	0		
N Columbia X Denver	1439	524240	5048100	35	75	-40	0	0.0	1	Qlg	35	10.7	0		
3200 NW Yeon	1440	519900	5045980	30	302	-272	-42	-12.8	1	Tcr	72	21.9	0		
Terminal 1	1441	524370	5042830	27	123	-96	-90	-27.4	1	Tt	117	35.7	0	12	40
Terminal 1	1442	523985	5042900	33	26	7	10	3.0	1	Tt	23	7.0	0	9	24
Terminal 2	1443	523350	5043820	30	150	-120	-85	-25.9	1	Tt Qal?	115	35.1	0		
Terminal 1	1444	524130	5042870	30	127	-97	-90	-27.4	1	Tt	120	36.6	0		
Swan Island	1445	521945	5045650	25	195	-170	-140	-42.7	1	Tt	165	50.3	0	7	40
MocksBottom	1446	523000	5045770	30	148	-118	-115	-35.1	1	Tt	145	44.2	0	6	43
I-5 X NE Union	1447	524830	5049835	20	100	-80	-80	-24.4	1	Tt? Qlg?	100	30.5	0		
N Union X Marine	1448	525305	5049780	10	61	-51	0	0.0	0		61	18.6	0	1	31
I-5 X Vanport Dr.	1449	524310	5048740	11	71	-60	0	0.0	0		71	21.6	0	2	35
Portland Meadows	1450	525150	5048700	12	131	-119	-116	-35.4	1	Qlgu? Tt?	128	39.0	0	1	32
HaydenMdwsX Kerby	1451	525600	5049020	12	101	-89	0	0.0	0		101	30.8	0	1	22

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Delta Park Fairgrnds	1452	525250	5048900	10	132	-122	-120	-36.6	1	Qlgu Tt?	130	39.6	0		
2300 N Columbia	1453	524190	5048220	35	35	0	6	1.8	1	Qlgu Tt?	29	8.8	0	3	18
NEVancouverXSchmeer	1454	526130	5047940	20	52	-32	0	0.0	0		52	15.8	0	2	30
NE Gertz X 13th	1455	527100	5048290	6	56	-50	0	0.0	0		56	17.1	0	1	42
NE Columbia Ct	1456	526640	5047780	20	15	5	7	2.1	1	Qlgu Tt?	13	4.0	0	9	25
Mocks Bottom	1457	522345	5045870	1	82	-81	0	0.0	0		82	25.0	0	18	32
Mocks Bottom	1458	523090	5046440	45	114	-69	0	0.0	0		114	34.7	0	2	38
East end Smith Lake	1459	522740	5050400	25	100	-75	-70	-21.3	1	Tt Qlg?	95	29.0	0	2	81
N end smith Lake	1460	522200	5051260	13	88	-75	-70	-21.3	1	Tt? Qlg?	83	25.3	0	2	20
N Columbia X Portlan	1461	521980	5049140	32	57	-25	-4	-1.2	1	Tt Qlgu?	36	11.0	0	11	40
Going St Warehouse	1462	525055	5043210	35	50	-15	0	0.0	0		50	15.2	0		
26th X Yeon	1463	522995	5043500	35	145	-110	-105	-32.0	1	Tt	140	42.7	0	3	30
Foot of Nicolai	1464	523945	5043180	30	105	-75	0	0.0	0		105	32.0	0	0	50
St. Helensx 31st	1465	522375	5042730	30	90	-60	-60	-18.3	1	Tt	90	27.4	0	6	56
Frmnt Br x Front	1466	524820	5042270	32	84	-52	0	0.0	0		84	25.6	0	5	70
N River x Clark	1467	525200	5042650	30	50	-20	-7	-2.1	1	Tt Qlg?	37	11.3	0		
NW 35th x Luzon	1468	522050	5043060	32	102	-70	0	0.0	0		102	31.1	0		
Industrial X 26th	1469	523040	5043000	30	85	-55	-45	-13.7	1	Tt? Qal?	75	22.9	0	3	34
26th x Front	1470	523090	5043660	30	125	-95	-90	-27.4	1	Tt	120	36.6	0	3	20
Luzon X 31st	1471	522300	5043150	37	105	-68	-10	-3.0	1	Tt?	47	14.3	0		
20th X Wilson	1472	524100	5042580	36	31	5	12	3.7	1	Qlg Tt	24	7.3	0	6	29
31st X Yeon	1473	522560	5043460	34	149	-115	-10	-3.0	1	Tt? Qlg	44	13.4	0		
30 X St.Johns Bridge	1474	519050	5046940	26	400	-374	-24	-7.3	1	Tcr	50	15.2	0		
N ColumbiaXLombard	1475	518560	5051180	16	99	-83	0	0.0	0		99	30.2	0	3	40
LinntonPlywoodPlant	1476	517095	5049100	40	80	-40	-10	-3.0	1	Tcr	50	15.2	0	7	41
Mobil Oil	1477	517400	5048640	30	65	-35	-35	-10.7	1	Tcr	65	19.8	0	2	42
Terminal 4	1478	517660	5050130	30	205	-175	-160	-48.8	1	Tt?	190	57.9	0		
Terminal 4 Slip 1	1479	517560	5049870	-20	127	-147	-147	-44.8	1	Tt	127	38.7	0	15	38
Termninal 4	1480	517680	5049190	-30	145	-175	-155	-47.2	1	Tt? Qal?	125	38.1	0	13	48
N ramsey X Rivergate	1481	516700	5051930	10	115	-105	0	0.0	0		115	35.1	0		
Rivergate	1482	516740	5052140	32	187	-155	-153	-46.6	1	Tt	185	56.4	0	4	32
Rivergate	1483	518005	5051600	30	205	-175	-170	-51.8	1	Tt	200	61.0	0	2	41
Terminal 4	1484	517800	5048980	-20	150	-170	-165	-50.3	1	Tt	145	44.2	0	3	78
International Term.	1485	518060	5050380	28	68	-40	-40	-12.2	1	Qfc? Tt?	68	20.7	0		
W end St Johns Brdge	1486	518150	5047790	30	61	-31	-30	-9.1	1	Tcr	38	11.6	0	5	45
W tower, St. JohnsBr	1487	518375	5047670	-9	19	-28	-14	-4.3	1	Tcr	5	1.5	0		

APPENDIX C

MAZAMA ASH DATA

APPENDIX C MAZAMA ASH OCCURRENCE DATA

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Feet	Ash isopach Feet	Elevation of basal contact Feet	Elevation of basal contact Meters
Weyerhauser Longview	3	500828	5108152	-20.5	35.5	4.0	-54.5	-16.6
	7	501141	5108509	15.5	93	streaks	-73.5	-22.4
	12	501368	5108364	15.5	80	4.0	-57.5	-17.5
	13	501304	5108416	17	205	4.5	-59	-18.0
	14	501331	5108448	16	152	3.5	-57.5	-17.5
	16	501328	5108433	16	164	3.5	-56	-17.1
	17	501307	5108421	17	155	3.5	-57	-17.4
	21	500966	5108864	11.5	100.5	3.0	-64	-19.5
	22	501058	5108801	12	80.5	5.0	-65.5	-20.0
	27	501108	5108589	16	148.5	5.0	-71	-21.6
	28	501410	5108523	13	117	3.5	-62	-18.9
	29	501074	5108859	15	102.5	3.5	-54	-16.5
	30	501120	5108727	15	100.5	3.0	-60.5	-18.4
	32	500894	5108871	15	101	3.0	-59	-18.0
	33	500927	5108840	15	155	3.0	-59	-18.0
	34	500962	5108702	15	100.5	3.5	-63	-19.2
	35	501003	5108915	15	100	4.5	-58.5	-17.8
	37	501480	5108596	15	192.5	2.5	-61	-18.6
	45	501073	5108746	15	89	3.0	-74	-22.6
Weyerhauser	55	501363	5108542	10	86.5	1.5	-61.5	-18.7
	57	500844	5108332	24	152	4.5	-58.5	-17.8
	62	500692	5108426	17.5	161	5.0	-64.5	-19.7
	63	500593	5108557	17.5	173.5	3.0	-61	-18.6
	64	500518	5108667	26.5	200.5	2.0	-62.25	-19.0
	65	501695	5108004	17	109	3.8	-56.75	-17.3
	78	501293	5108499	15.5	156.5	3.0	-61.25	-18.7
Reynolds Metals Longview	90	500467	5109223	14	81	3.0	-63	-19.2
	94	500137	5109842	5.1	97	4.0	-63.9	-19.5
	95	500060	5109742	5.3	151.5	4.0	-63.7	-19.4
	96	499997	5109648	6.5	98	NG	-75.5	-23.0
	98	500234	5109761	5.2	100	5.0	-65.8	-20.1
	99	500149	5109653	7.4	100	4.0	-60.6	-18.5
	100	500071	5109555	9.6	102.5	4.0	-63.4	-19.3
	102	500326	5109688	5.4	225	3.5	-59.1	-18.0
	103	500236	5109584	9.6	100	6.0	-61.4	-18.7

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Feet	Ash isopach Feet	Elevation of basal contact Feet	Elevation of basal contact Meters
	104	500144	5109485	9.1	152	3.0	-65.1	-19.8
	105	500059	5109375	9.5	101.5	4.0	-61	-18.6
	107	499988	5109268	12.3	103	3.0	-42.7	-13.0
	108	500220	5109490	10	100	9.0	-66.5	-20.3
	111	500319	5109500	9.5	88	11.5	-69.5	-21.2
	112	500386	5109474	9.1	88	12.5	-75.9	-23.1
	113	500335	5109244	12.2	100	2.0	-59.8	-18.2
	124	499873	5109360	11.4	92	2.0	-62.6	-19.1
	127	500100	5109314	10.4	132	4.0	-64.1	-19.5
	128	500192	5109380	8.9	101.5	5.5	-65.1	-19.8
	131	500094	5109632	6	70	3.5	-59	-18.0
	132	500068	5109606	6	70	4.0	-61	-18.6
	135	499930	5109589	7.5	72.5	4.0	-63	-19.2
	136	499894	5109556	6.5	70	3.0	-58.5	-17.8
	137	499768	5109374	12	223	3.5	-65	-19.8
	138	499781	5109431	12	80	3.5	-65	-19.8
	139	499820	5109386	12	215	3.0	-64.5	-19.7
	140	499917	5109327	10	211	4.5	-64	-19.5
	141	499930	5109263	10	92	3.0	-59.5	-18.1
	142	499876	5108957	-26	100	5.0	-62	-18.9
	143	499988	5108855	-36	90	2.0	-62	-18.9
	144	500086	5108776	-51.5	48	5.0	-74	-22.6
	145	499842	5109967	6.1	100	6.0	-64.9	-19.8
	146	499916	5110097	4.8	80	streaks	-66.2	-20.2
	147	499922	5108887	-40.5	127	4.5	-61.5	-18.7
	150	499635	5110007	11	74.5	1.0	-62.5	-19.1
	160	499700	5110096	6.5	96.5	3.0	-86.5	-26.4
	161	499735	5110136	5	98.5	3.0	-87.5	-26.7
	162	499763	5110104	5	103	5.5	-88	-26.8
	166	499870	5110124	6.2	100.2	5.0	-63	-19.2
	179	505076	5107947	18	90	2.5	-63.5	-19.4
Longview Fibre	190	506300	5105497	14	122.5	2.5	-56	-17.1
	192	506561	5105311	15.6	137.1	8.5	-60.8	-18.5
	193	506569	5105433	15.6	171.2	5.0	-61.1	-18.6
	194	506493	5105267	15.5	171.5	3.5	-59	-18.0
	195	506523	5105381	15.5	151.5	5.0	-59.5	-18.1
WASHDOT SR-43	207	505596	5106982	14.8	142	1.0	-60.2	-18.3
BPA Crossing	229	497781	5107701	12	152	1.5	-56.5	-17.2

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Feet	Ash isopach Feet	Elevation of basal contact Feet	Elevation of basal contact Meters
CERRO Corp	235	497937	5111132	4	135.5	7.0	-68	-20.7
	236	497640	5111014	3	187	4.0	-56	-17.1
	237	497174	5110817	11	150	6.0	-70	-21.3
Proposed Grain Storage Facility Longview	238	498639	5109682	10.7	147.7	1.0	-74	-22.6
	239	498514	5109658	13.2	141.2	3.0	-65	-19.8
	240	498551	5109766	5.4	76.4	3.0	-62.5	-19.1
	241	498772	5109600	15.4	142.4	1.0	-60	-18.3
	242	498807	5109701	5.4	101.4	11.0	-75	-22.9
	243	498618	5109624	14.2	141.2	17.0	-88	-26.8
	244	498418	5109676	15.7	141.7	1.5	-60.5	-18.4
	245	498448	5109788	6	142	2.5	-64.5	-19.7
T8NR3W26	251	498485	5110492	20	200	NG	-47*	-14.3
Beaver Plant	1112	486145	5113179	13.5	135	3.0	-84.5	-25.8
	1114	486422	5113284	12.5	114	5.0	-43.5	-13.3
	1143	486299	5112972	14.5	108	5.0	-60.5	-18.4
	1149	486248	5113003	11	105	3.0	-57.5	-17.5
	1150	486223	5112959	14	102	3.0	-58.5	-17.8
	1151	486364	5112966	14	102	3.5	-62	-18.9
	1153	486262	5112931	14	100	3.0	-59	-18.0
Dames & Moore PGE Crossing	1156	486450	5114026	19.2	76.5	1.5	-57.3	-17.5
	1157	486461	5114815	21.3	151.5	TL	-81.7	-24.9
	1158	486455	5114886	20.8	101.5	TL	-59.2	-18.0
Bradbury Slough	1072	486001	5112164	9	150	2.0	-53	-16.2
Longview basin averages						3.82	-62.87	-19.2
Trojan	209	508663	5098237	22.6	160.5	5.0	-56.9	-17.3
	210	508701	5098307	20	66	0.5	-46	-14.0
	212	508731	5097741	18	77	<3.0	-59	-18.0
	214	508720	5097696	18	77.5	3.5	-59.5	-18.1
	1280	508928	5097060	16	81	1.0	-47	-14.3
	1290	508296	5097879	22	102	4.0	-58	-17.7

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Feet	Ash isopach Feet	Elevation of basal contact Feet	Elevation of basal contact Meters
FertilizerPlant	401	514451	5084311	-12.3	55	NG	-62.3*	-19.0
Boise Cascade	402	515389	5076933	23	104.7	1.0	-57	-17.4
St Helens Or	404	515362	5076858	23.5	94.4	0.5	-53.5	-16.3
Lewis Riv. Site	407	518046	5077334	10	94.4	5.5	-54.1	-16.5
T3NR1W26	418	517615	5061995	12	169	7.0	-61	-18.6
N Marine Dr	564	521969	5051372	33.17	100.8	5.5	-48.33	-14.7
	566	522161	5051381	32.18	119	3.0	-46	-14.0
	567	522277	5051390	25.87	113.3	6.5	-51.1	-15.6
ODOT	645	535338	5046248	41.2	139	<2	-47.8	-14.6
I-205	646	535262	5046190	16	199.5	streaks	-50	-15.2
Airport	648	535254	5046304	16.6	205	<2	-52.9	-16.1
Interchange	649	535300	5046317	18.6	253.5	<1.5	-50.8	-15.5
PGE Sundial Rd	748	544677	5044930	21	89.5	2.5	-45.5	-13.9
Vanport	769	523447	5050282	11	91	2.5	-51.5	-15.7
Site	772	522799	5049647	14.2	91.2	6.0	-55.5	-16.9
	774	523711	5049213	11.6	102.6	9.0	-56	-17.1
	775	523823	5049566	15.8	97.3	2.5	-49.5	-15.1
	776	524463	5048845	14.3	121.3	0.5	-56.5	-17.2
Crown Z.	778	523540	5050703	26	117	3.5	-52.5	-16.0
N Marine Dr	779	523369	5050506	11	97	1.5	-52	-15.8
	780	523303	5050531	10	93	2.5	-54	-16.5
	781	523212	5050572	8	91	3.0	-54.5	-16.6
Delta Park	786	524351	5050102	18.7	120.2	2.5	-50.5	-15.4
West	787	524152	5050020	22.9	117.9	5.5	-56.5	-17.2
	789	524256	5050012	16.2	116.2	4.0	-54	-16.5
Delta Park East	793	526400	5048698	8	78	3.5	-51	-15.5
POP	800	522062	5051487	20	120	1.0	-44	-13.4
Rivergate	801	521821	5050255	7	75	6.0	-52	-15.8

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Feet	Ash isopach Feet	Elevation of basal contact Feet	Elevation of basal contact Meters
Crown Z.	816	520729	5045683	-4.8	77.2	0.2	-50	-15.2
Front Ave	817	520803	5045618	-8.3	94.7	0.2	-53	-16.2
	818	520890	5045552	-8.3	94.7	0.1	-53.5	-16.3
E Swan Isl	821	521929	5045903	31.5	184.5	TL	-82	-25.0
	823	522091	5045772	31.5	173.5	TL	-76	-23.2
	825	522243	5045663	31.6	167.6	TL	-68	-20.7
W Swan Isl	836	522578	5044689	-34.2	103.8	3.0	-86	-26.2
	837	522437	5044836	-22.5	49.5	streaks	-43.5	-13.3
Mocks Bottom	842	521951	5046365	34	126	0.5	-62	-18.9
North	843	522021	5046413	34	101.5	0.2	-58	-17.7
	844	522280	5046521	28	111	NG	-62	-18.9
	845	522501	5046448	26	95	2.5	-60.5	-18.4
	846	522110	5046425	35	112	streaks	-56.5	-17.2
POP Willamette	860	523013	5046030	22	100	TL	-60	-18.3
Gasco	876	518905	5047059	10.7	154.2	1.5	-92	-28.0
PGE Willamette	904	516176	5050968	18.97	98	2.5	-51	-15.5
Linnton/Harbor	907	516170	5051019	29	134	0.8	-44.25	-13.5
St. Johns	920	517449	5051468	15	80	2.0	-55	-16.8
	923	518071	5051335	13	65	3.0	-52	-15.8
Morr&Knudsen	925	517923	5051050	21	130	1.0	-48	-14.6
	926	517269	5050977	27.5	167.5	streaks	-83	-25.3
	927	516999	5050962	27	101	streaks	-64	-19.5
POP RIVERGATE	928	518696	5051786	13	138.5	9.0	-60	-18.3
	929	519298	5050937	25	147.5	8.0	-64	-19.5
	932	516294	5051389	-23	59	2.5	-57	-17.4
	935	516238	5052747	-26	61	7.5	-58.5	-17.8
	937	516683	5053631	-26	55.5	5.5	-52.5	-16.0
	938	517554	5054180	-37	45	22.0	-63.5	-19.4
	940	517955	5054733	-29	55	35.5	-79.5	-24.2
	942	516358	5052413	-43	40.5	0.8	-52.75	-16.1
	949	517821	5053163	10	140	3.5	-54.5	-16.6
	951	518762	5052666	15	95	1.0	-45	-13.7
	952	519244	5053381	20	132	streaks	-50	-15.2

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Feet	Ash isopach Feet	Elevation of basal contact Feet	Elevation of basal contact Meters
	953	518175	5053789	30	160	2.0	-79.5	-24.2
	960	517912	5053468	34	160	5.5	-54	-16.5
	965	518789	5053463	12.2	99.5	NG	-83.8	-25.5
Grain Terminal	974	518046	5054123	30	120	NG	-60	-18.3
Oregon	982	516759	5052567	32.1	101.1	NG	-69	-21.0
Steel Mills	983	517097	5052434	32	113	1.0	-66	-20.1
Upper basin averages						3.15	-56.77	-17.3
JDR Cow Pasture	1033	442812	5112569	9.5	80.5	4.0	-48.5	-14.8
John Day River	1034	442084	5112587	7.3	132.5	6.0	-58.7	-17.9
Bridge	1035	442136	5112590	9.1	127	3.0	-52.9	-16.1
	1036	442138	5112561	19.8	98	4.5	-56.2	-17.1
ODOT TngPt-Br	1037	442667	5114141	-1	131	1.0	-70	-21.3
Marys Crk	1050	448158	5112871	5	80	NG	-41	-12.5
Bridge	1051	448214	5112852	5	98	NG	-80	-24.4
Gnat Crk Bdg	1059	458825	5114911	10	120	6.6	-62.6	-19.1
Blind Slough	1061	458236	5116428	18	114.5	<1.5	-82.5	-25.1
Bridge	1062	458235	5116467	20.2	131.5	0.5	-71.3	-21.7
	1063	458237	5116502	20.5	160	0.5	-53	-16.2
WASHDOT	1096	446023	5131340	4	129	1.5	-57.5	-17.5
Deep River	1097	446062	5131321	5	189	2.5	-61	-18.6
Bridge	1101	446202	5131283	8.8	240.33	5.0	-61.2	-18.7
	1102	446211	5131267	4	245	1.5	-59.5	-18.1
Ranglia Slough	1108	446642	5130958	4	245	3.0	-64	-19.5
	1111	446650	5130896	8.8	91.5	2.5	-63.7	-19.4
Skippanon Bridge	1163	429023	5112601	10.5	102	1.5	-66.5	-20.3
Warrenton Or	1164	428939	5112593	9.8	99.5	1.0	-62.7	-19.1
Holbrook Slough	1165	430600	5112084	5	120.5	1.0	-60.5	-18.4

Location	Map ID#	UTM EAST	UTM NORTH	Surface Elev Ft	Hole Depth Feet	Ash isopach Feet	Elevation of basal contact Feet	Elevation of basal contact Meters
John Day River Bridge	1192	442086	5112598	4.2	121	0.9	-62.7	-19.1
	1202	442036	5112609	4.6	121	1.5	-66.9	-20.4
T9NR6W19Aa Skamokowa Park	1219	464398	5123902	10	120	NG	-58*	-17.7
NW Aluminum Warrenton Or	1228	429895	5112141	10	101	1.0	-55	-16.8
	1231	428658	5112030	10	102	4.5	-63.5	-19.4
	1232	429526	5112456	10	102	3.0	-64	-19.5
	1233	429513	5111827	10	101	3.0	-55	-16.8
Lower basin averages						2.27	-59.27	-18.1
Entire LCRB totals						Average = 3.36	-60.96	-18.58
						Standard deviation = 3.66		

NG = Not Given (usually indicates ash or pumice noted on log but no thickness given)
TL = Thin Layer
* Top Contact Elevation
All isopachs indicated as NG, TL, or streaks were assigned a thickness of 0.1 feet for the calculations.
All values listed as less than (<) assumed the maximum isopach indicated for the calculations.

APPENDIX D

SEDIMENT GRAIN SIZE DISTRIBUTION DATA

SEDIMENT GRAIN SIZE DISTRIBUTION DATA

HOLE#	ISOPACH	SAND FEET	SILTYSAND FEET	SANDYSILT FEET	SILT FEET	%SAND	%SILTYSND	%SANDYSLT	%SILT
1203	288	282	0	0	6	97.9	0.0	0.0	2.1
1226	111	103.5	2.5	4	1	93.2	2.3	3.6	0.9
1161	142.5	126	12.5	0	4	88.4	8.8	0.0	2.8
1171	151.5	20	131.5	0	0	13.2	86.8	0	0
1170	150	4	49	77	20	2.7	32.7	51.3	13.3
1186	191	35.5	0	120	35.5	18.6	0.0	62.8	18.6
1179	122.5	111.25	0	0	11.25	90.8	0.0	0.0	9.2
1181	107.5	73.75	0	0	33.75	68.6	0.0	0.0	31.4
1109	213	0	69	142	2	0.0	32.4	66.7	0.9
1104	227	0	107	120	0	0.0	47.1	52.9	0.0
1060	143.3	7	7.15	7.15	122	4.9	5.0	5.0	85.1
1089	267	0	245	22	0	0.0	91.8	8.2	0.0
1085	216.5	0	197	19.5	0	0.0	91.0	9.0	0.0
1070	61	52	0	9	0	85.2	0.0	14.8	0.0
1292	250	35	145	25	45	14.0	58.0	10.0	18.0
1120	151	98	31	13	9	64.9	20.5	8.6	6.0
1154	295	236	4	0	55	80.0	1.4	0.0	18.6
1157	119.5	70	49.5	0	0	58.6	41.4	0.0	0.0
1071	150	90	20	10	30	60	13.3	6.7	20
1073	138	127	4.5	4.5	2	92	3.3	3.3	1.4
246	99.5	80	0	7	12.5	80.4	0.0	7.0	12.6
247	148.5	139	0	4	5.5	93.6	0.0	2.7	3.7
248	152	111	11	15.5	14.5	73.0	7.2	10.2	9.6
249	137	109	0	22.5	5.5	79.6	0.0	16.4	4.0
260	320	255	0	0	65	79.7	0.0	0.0	20.3
258	308	161	61	78	8	52.3	19.8	25.3	2.6
137	223	45	7	159	12	20.2	3.1	71.3	5.4
102	225	20	14	34	157	8.9	6.2	15.1	69.8
15	209	50	15	50	94	23.9	7.2	23.9	45.0
31	181	122	21.5	0	37.5	67.4	11.9	0.0	20.7
197	178	49	78.5	0	50.5	27.5	44.1	0.0	28.4
193	149	96.5	7.5	28.5	16.5	64.8	5	19.1	11.1
194	153.5	95.5	7.5	50.5	0	62.2	4.9	32.9	0.0
1269	269	154	0	0	115	57.2	0	0	42.8
216	290	143	37	55	55	49.3	12.8	19.0	19.0
262	325	96	117	112	0	29.5	36.0	34.5	0.0
353	106.2	84.7	21.5	0	0	79.8	20.2	0.0	0.0
401	55	55	0	0	0	100.0	0.0	0.0	0.0
1302	190	149	0	0	41	78.4	0.0	0.0	21.6
1314	194	130	5	0	59	67.0	2.6	0.0	30.4
977	144.5	127.5	16	1	0	88.2	11.1	0.7	0.0
970	170.5	82.5	26.5	59.5	2	48.4	15.5	34.9	1.2

HOLE#	ISOPACH	SAND FEET	SILTYSAND FEET	SANDYSILT FEET	SILT FEET	%SAND	%SILTYSND	%SANDYSLT	%SILT
632	103.5	103.5	0	0	0	100.0	0.0	0.0	0.0
637	175	175	0	0	0	100.0	0.0	0.0	0.0
926	149	125	0	9.5	14.5	83.9	0.0	6.4	9.7
831	150.5	96.5	54	0	0	64.1	35.9	0.0	0.0
834	142	80	23	39	0	56.3	16.2	27.5	0.0
899	177	145.5	19	0	12.5	82.2	10.7	7.1	0.0
512	98.5	94.5	4	0	0	95.9	4.1	0.0	0.0
528	130	130	0	0	0	100.0	0.0	0.0	0.0
533	210	167	9	34	0	79.5	4.3	16.2	0.0
535	234	173	18	43	0	73.9	7.7	18.4	0.0
747	75.5	51	2	2	20.5	67.6	2.6	2.6	27.2
748	87.5	5.5	6	26	50	6.3	6.9	29.7	57.1
Borehole Percent						58.8	15.4	13.4	12.4
Isopach Percent						54.70	17.51	14.84	12.95

APPENDIX D SEDIMENT GRAIN SIZE DISTRIBUTION FOR SUBSURFACE ELEVATION INTERVALS

HOLE#	0-33 METER INTERVAL				33-66 METER INTERVAL				66-99 METER INTERVAL			
	%SAND	%SILTYSND	%SANDYSLT	%SILT	%SAND	%SILTYSND	%SANDYSLT	%SILT	%SAND	%SILTYSND	%SANDYSLT	%SILT
1203	93.9	0.0	0.0	6.1	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1226	94.0	3.0	0.0	3.0	84.8	0.0	15.2	0.0	86.3	7.6	6.1	0.0
1161	100.0	0.0	0.0	0.0	87.9	0.0	0.0	12.1	100.0	0.0	0.0	0.0
1171	27.3	72.7	0	0	0	100	0	0	0	100	0	0
1170	0	33.3	33.4	33.3	0	33.3	33.4	33.3	12.1	84.8	3.1	0
1186					50.0	0.0	0.0	50.0	50.0	0.0	0.0	50.0
1179					60.6	0.0	0.0	39.4	100.0	0.0	0.0	0.0
1181	50.0	0.0	0.0	50.0	50.0	0.0	0.0	50.0	81.8	0.0	0.0	18.2
1109	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	27.3	72.7	0.0
1104	0.0	100.0	0.0	0.0	0.0	39.4	60.6	0.0	0.0	100.0	0.0	0.0
1060	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0
1089	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0
1085					0.0	93.9	6.1	0.0	0.0	100.0	0.0	0.0
1070	75.8	0.0	24.2	0.0	100.0	0.0	0.0	0.0				
1292									12.1	87.9	0.0	0.0
1120	66.7	9.1	3.0	21.2	97.0	3.0	0.0	0.0	66.6	16.7	16.7	0.0
1154	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1157	72.7	27.3	0.0	0.0	100.0	0.0	0.0	0.0	71.8	28.2	0.0	0.0
1071	0	0	30	70	39.4	60.6	0	0	100	0	0	0
1073	87.8	6.1	6.1	0	100	0	0	0	100	0	0	0
246	71.2	0.0	21.2	7.6	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
247	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
248	6.1	33.3	47.0	13.6	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
249	45.5	54.5	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
260	60.6	0.0	0.0	39.4	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
258	0.0	93.9	0.0	6.1	9.1	90.9	0.0	0.0	84.8	0.0	15.2	0.0
137	36.4	0.0	63.6	0.0	0.0	0.0	90.9	9.1	0.0	0.0	100.0	0.0
102	0.0	0.0	86.1	13.9	0.0	18.1	17.0	64.9	0.0	0.0	0.0	100.0
15	0.0	0.0	54.5	45.5	0.0	0.0	33.3	66.7	0.0	0.0	0.0	100.0
31	43.9	24.2	0.0	31.8	100.0	0.0	0.0	0.0	22.7	40.9	0.0	36.3
197	25.8	74.2	0.0	0.0	0.0	100.0	0.0	0.0	33.3	66.7	0.0	0.0
193	100	0	0	0	19.7	22.7	7.6	50	21.2	0	78.8	0
194	87.9	12.1	0.0	0.0	13.6	10.6	75.8	0.0	22.7	0.0	77.3	0.0
1269	0	0	0	100	0	0	0	100	0	0	0	100
216	0.0	0.0	39.4	60.6	0.0	0.0	0.0	100.0	0.0	0.0	93.9	6.1
262	27.3	15.2	57.6	0.0	18.2	81.8	0.0	0.0	48.5	0.0	51.5	0.0
353	85.8	14.2	0.0	0.0	82.4	17.6	0.0	0.0	66.7	33.3	0.0	0.0
401	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0				
1302	27.3	0.0	0.0	72.7	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0

HOLE#	0-33 METER INTERVAL				33-66 METER INTERVAL				66-99 METER INTERVAL			
	%SAND	%SILTYSND	%SANDYSLT	%SILT	%SAND	%SILTYSND	%SANDYSLT	%SILT	%SAND	%SILTYSND	%SANDYSLT	%SILT
1314	31.8	0.0	0.0	68.2	43.9	0.0	0.0	56.1	68.2	0.0	0.0	31.8
977					63.6	33.3	3.0	0.0	100.0	0.0	0.0	0.0
970	0.0	0.0	100.0	0.0	0.0	80.3	18.2	1.5	65.2	0.0	34.8	0.0
632					100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
637	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
926	54.5	0.0	28.8	16.7	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
831	87.9	12.1	0.0	0.0	100.0	0.0	0.0	0.0	54.5	45.5	0.0	0.0
834	87.9	12.1	0.0	0.0	100.0	0.0	0.0	0.0	44.0	0.0	56.0	0.0
899	60.6	39.4	0.0	0.0	81.8	18.2	0.0	0.0	86.4	0.0	0.0	13.6
512	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	87.9	12.1	0.0	0.0
528	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
533	42.4	27.3	30.3	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
535	9.1	39.4	51.5	0.0	100.0	0.0	0.0	0.0	84.8	15.2	0.0	0.0
747	86.3	6.1	6.1	1.5	100.0	0.0	0.0	0.0				
748	16.7	31.8	6.1	45.4	0.0	10.6	25.8	63.6				
TOTALS	49.2	17.5	16.4	16.8	58.5	17.3	9.2	15.0	59.4	17.3	12.1	11.1

APPENDIX D SEDIMENT GRAIN SIZE DISTRIBUTION FOR SUBSURFACE ELEVATION INTERVALS
(continued)

HOLE#	99-131 METER INTERVAL				131-164 METER INTERVAL				164-197 METER INTERVAL			
	%SAND	%SILTYSND	%SANDYSLT	%SILT	%SAND	%SILTYSND	%SANDYSLT	%SILT	%SAND	%SILTYSND	%SANDYSLT	%SILT
1203	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
1226												
1161	62.1	37.9	0.0	0.0								
1171	0	100	0	0	0	100	0	0				
1170	0	0	100	0	0	0	100	0				
1186	29.7	0.0	40.6	29.7	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0
1179	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0				
1181	100.0	0.0	0.0	0.0								
1109	0.0	59.4	34.4	6.2	0.0	0.0	100.0	0.0	0.0	51.5	48.5	0.0
1104	0.0	18.8	81.2	0.0	0.0	0.0	100.0	0.0	0.0	6.1	93.9	0.0
1060	21.9	30.0	30.0	18.1								
1089	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0
1085	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0
1070												
1292	0.0	31.3	68.7	0.0	0.0	0.0	12.1	87.9	0.0	51.5	0.0	48.5
1120	9.4	46.8	43.8	0.0	100.0	0.0	0.0	0.0				
1154	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	18.2	0.0	0.0	81.8
1157	0.0	100.0	0.0	0.0								
1071	100	0	0	0								
1073	100	0	0	0								
246												
247	100.0	0.0	0.0	0.0								
248	100.0	0.0	0.0	0.0								
249	100.0	0.0	0.0	0.0								
260	36.4	0.0	0.0	63.6	42.4	0.0	0.0	57.6	63.6	0.0	0.0	36.4
258	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	75.8	0.0	24.2	0.0
137	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	39.4	21.2	30.3	9.1
102	0.0	0.0	0.0	100.0	54.5	7.6	0.0	37.9	0.0	9.1	0.0	90.9
15	0.0	15.1	0.0	84.9	78.8	21.2	0.0	0.0	54.5	9.1	36.4	0.0
31	68.7	0.0	0.0	31.3	100.0	0.0	0.0	0.0				
197	0.0	20.3	0.0	79.7	0.0	30.3	0.0	69.7				
193	100	0	0	0	100	0	0	0				
194	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0				
1269	87.5	0	0	12.5	100	0	0	0	100	0	0	0
216	0.0	93.9	6.1	0.0	78.8	21.2	0.0	0.0	100.0	0.0	0.0	0.0
262	0.0	90.6	9.4	0.0	90.9	9.1	0.0	0.0	78.8	0.0	21.2	0.0
353												
401												
1302	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0				

HOLE#	99-131 METER INTERVAL				131-164 METER INTERVAL				164-197 METER INTERVAL			
	%SAND	%SILTYSND	%SANDYSLT	%SILT	%SAND	%SILTYSND	%SANDYSLT	%SILT	%SAND	%SILTYSND	%SANDYSLT	%SILT
1314	84.4	15.6	0.0	0.0	100.0	0.0	0.0	0.0				
977	100.0	0.0	0.0	0.0								
970	87.9	0.0	7.6	4.5								
632	100.0	0.0	0.0	0.0								
637	100.0	0.0	0.0	0.0								
926												
831	15.6	84.4	0.0	0.0								
834	17.9	53.4	28.7	0.0								
899	81.2	0.0	0.0	18.8	94.0	0.0	0.0	6.0				
512												
528	100.0	0.0	0.0	0.0								
533	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
535	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
747												
748												
TOTALS	53.4	22.2	14.5	10.0	56.5	13.4	21.1	8.9	46.1	19.4	19.7	14.8

APPENDIX D (continued) SEDIMENT GRAIN SIZE DISTRIBUTION FOR SUBSURFACE ELEVATION INTERVALS

HOLE#	197-230 METER INTERVAL				230-262 METER INTERVAL				262-295 METER INTERVAL				295-328 METER INTERVAL			
1203	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0				
1226																
1161																
1171																
1170																
1186	0.0	0.0	100.0	0.0												
1179																
1181																
1109	0.0	100.0	0.0	0.0												
1104	0.0	69.7	30.3	0.0												
1060																
1089	0.0	100.0	0.0	0.0	0.0	33.3	66.7	0.0								
1085	0.0	78.8	21.2	0.0												
1070																
1292	0.0	100.0	0.0	0.0	30.3	69.7	0.0	0.0	15.2	84.8	0.0	0.0				
1120																
1154	60.6	0.0	0.0	39.4	54.5	0.0	0.0	45.5	100.0	0.0	0.0	0.0				
1157																
1071																
1073																
246																
247																
248																
249																
260	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
258	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
137																
102	40.9	7.6	0.0	51.5												
15																
31																
197																
193																
194																
1269	100	0	0	0	100	0	0	0								
216	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0				
262	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0
353																
401																
1302																
1314																
977																
970																
632																
637																
926																
831																
834																
899																
512																
528																
533																
535																
747																
748																
TOTALS	43.0	32.6	18.0	6.5	65.0	11.4	18.5	5.1	73.6	26.4	0.0	0.0	66.7	33.3	0.0	0.0