Lake Chelan Hydroelectric Project
FERC Project No. 637-022

Chelan Tailrace Pump Station Findings Report DRAFT

Prepared for

CHELAN COUNTY P.U.D.

April 2007

Prepared by

CH2MHILL

P.O. Box 91500
Bellevue, WA 98009-2050

Contents

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SECTION 1

Introduction

This Geotechnical Data Report is a summary of the results of a geotechnical investigation conducted by CH2M HILL for the Chelan Tailrace Pump Station project near Chelan Falls, Washington. The general project location is shown on the Vicinity Map in Figure 1 and in the Aerial View in Figure 2, in the Figures Section. The purpose of this investigation was to explore and evaluate the subsurface conditions for the design and construction of a new pump station and related piping, and a new water canal.

1.1 Authorization

This Geotechnical Data Report was prepared under the terms of the contract (PSA No. 06-164) between CH2M HILL and Chelan County PUD (District). The contract authorizes CH2M HILL to provide geotechnical engineering services associated with the Chelan Tailrace Pump Station project (the Project) in accordance with the agreement between the District and CH2M HILL.

1.2 Purpose and Scope of Work

The purpose of this Geotechnical Data Report is to provide subsurface soils and groundwater information for the design and construction of the Project. The scope of work included the following services:

- Reviewing existing published geologic and near-surface soils information for the project area.
- Performing a site reconnaissance and identifying exploration locations.
- Excavating six (6) test pits and drilling two (2) geotechnical borings.
- Collecting soil cuttings when possible at approximately 5-foot intervals in borings and collecting soil samples at stratigraphic changes in test pits.
- Visually classifying and logging soil samples during explorations.
- Preparing this Geotechnical Data Report to summarize these tasks.

This report presents the collected data and does not provide interpretation of this data.

1.3 Project Information

The Federal Energy Regulatory Commission (FERC) requires the District to construct a pump station at the District's Lake Chelan Hydroelectric Project as part of re-licensing requirements. The pump station will be located within the tailrace of the Chelan Falls Powerhouse which is located near the confluence of the Chelan and Columbia Rivers, approximately 40 miles north of Wenatchee, WA. The project includes a pump station, approximately 1,000 feet of canal, and

an outlet structure. The pump station will deliver a maximum of 260 cfs by pumping water from the Chelan Powerhouse tailrace into Reach 4 of the Chelan River to enhance Steelhead and Chinook salmon spawning habitat. The layout of the pump station and canal are shown in Figure 3.

SECTION 2

Topographic and Geologic Conditions

This section is a summary of the existing topographic, geologic, and groundwater conditions at the project site based on published geologic, groundwater, and near-surface soils information.

2.1 Topography

The regional topography consists of hills, stream valleys, and lakes. The pump station is located on the east side of the tailrace about 100 feet south of the switchyard. The canal starts at the pump station and runs about 1,000 feet north. The regional topography is shown on the topographic map in Figure 4.

The canal is located in the gorge of the normally dry Chelan River channel. A hill drops from about 1,400 feet elevation west of the canal to about 700 feet elevation at the Columbia River east of the canal. The hill is composed of gneiss rock with a relatively thin layer of alluvium overlying the rock as observed in the cut section west of the switch yard. The canal is located in the river gorge in a relatively flat-lying area. The gorge terrain slopes gently downhill from north to south and at about 2H:1V (Horizontal:Vertical) from east to west at the proposed canal location. The pump station site is located on the east bank of the tailrace which slopes downhill from east to west into water. The tailrace bank has an approximate slope of 2H:1V.

2.2 Hydrology of Chelan River and Bypass Reach

Water from Lake Chelan flows from its southern end into the shortest river in Washington, the 4.1-mile-long Chelan River. This river falls 400 feet in its descent through a steep, rocky gorge to the Columbia River (Archibald et al., 2002). Lake Chelan waters drain into the Columbia River either through releases at the Lake Chelan Project dam into the 3.9-mile long bypassed reach of the Chelan River or through a diversion at the dam into a 2.2-mile-long power tunnel, which passes the water through the powerhouse for hydroelectric generation (FERC, 2001, sect. 5.3.2). Figure 6 shows the relationship between the Chelan River and the hydroelectric project and its diversion tunnel (from Anchor Environmental, 2000, Figure 2).

Nearly the entire Lake Chelan outflow, averaging approximately 2,000 cubic feet per second (cfs), is diverted through the penstock, which has a vertical drop of 401 feet. The bypassed reach (original Chelan River channel) is without flow during most of the year; normally, the only flow in the bypassed reach comes during the spring and early summer when snow melt raises the lake to levels requiring spill for flood control (Chelan PUD, 1998, p. E3-10). As shown in Figure 6, the bypassed reach is comprised of four distinct sections (Chelan PUD, 1999). The upper two sections, Sections 1 and 2, are relatively low gradient areas (approximately 55 ft/mi) extending a length of 3.0 miles. Section 3, referred to as the gorge, is 0.4-mile long with steep and narrow canyon walls. The gradient in this part of the channel is very steep, approximately 480 ft/mi. Waterfalls, from 5 to 20 feet high, numerous cascades, bedrock chutes, and large, deep pools characterize the stream channel in the gorge reach. Finally, Section 4 is 0.5-mile long

and characterized by a wide floodplain. This section of the bypassed reach has a relatively low gradient (22 ft/mi) and a substrate comprised of gravel, cobble, and boulders. Section 4 extends from the bottom of the gorge section downstream to the confluence with the tailrace and Columbia River (Anchor Environmental, 2000; and Archibald et al., 2002).

2.3 Area Geology

This section is a summary of the surficial regional and site geology and groundwater information based on review of published maps for the project area.

2.3.1 Regional Geology

The Chelan Tailrace Pump Station Project is located between the Cascade Mountains to the north and west, and the Columbia Plateau to the south and east. Lake Chelan and its immediate surroundings are the result of the complex interaction between two glacial masses. The lake was formed approximately 18,000 years ago during the Wisconsin glacial period. During this time, the Chelan Glacier moved down the valley from the north and the Okanogan-Columbia Valley lobe of the Cordilleran ice sheet extended upward from the south. The two glaciers approached each other and nearly met at Wapato Point and at a constriction known as "The Narrows". The approach and recession of these two glaciers caused erosion in the mid and upper portion of the lake, and geologic moraine deposits at the lower end of the lake. Together these effects created Lake Chelan (Archibald et al., 2002; Kendra and Singleton, 1987; and Hillman and Giorgi, 1999 [in] Viola and Foster, 2000).

Throughout much of Lake Chelan basin's, the soils consist of alluvial deposits (which can be more than 100 feet thick) and glacial drift. Volcanic pumice and ash from the Glacier Peak region are also present in many areas. The mountainous terrain consists mainly of large rock outcroppings and shallow soils (R. W. Beck, 1991, p. III-9; and Archibald et al., 2002). Soils typically are coarse textured, with a low percentage of fines and minimal development. Pumice and ash deposits are relatively deep on north-facing slopes, whereas erosion has removed much of this material from south-facing slopes where bedrock outcrops are common (USFS, 1998, p. 1-14; and Archibald et al., 2002).

2.3.2 Project Area Geology

The natural geology within the project vicinity is generally characterized by underlying rock formations covered by a layer of alluvial soil deposits comprised of gravel, cobble, and boulders (Schuster, 2005; and Tabor et. al. 1987). Soils typically are coarse textured, with a low percentage of fines (Archibald et al., 2002). The generalized site geology is shown in Figure 7.

Pre-Tertiary metamorphic rock in the project site is part of the Chelan Mountains tectono-stratigraphic terrain. The Chelan Mountains terrain is dominated by the Chelan Complex of Hopson and Mattinson (1971) which is composed of migmatite, gneiss and tonalite of deep-seated igneous and metamorphic rock (Waters, 1930; Hopson, 1955; Hopson and Mattinson, 1971). The massive, possibly anatectic, tonalite is also in large part late Cretaceous in age, although relict zircons in several units yield a discordant pre-Cretaceous age (Tabor et al., 1987).

Continental Glacial Drift (Qgd)

This unit consists of Holocene and Pleistocene till and alluvium. The unit comprises moderately sorted cobbles and gravels along rivers grading to poorly sorted gravelly sand on small-tributary fans. It includes some material in fans similar to the Holocene Talus deposits unit, which consists of non-sorted angular boulders and gravels.

Mesozoic Orthogneiss (Mzog)

Pre-Tertiary orthogneiss cut by tonalite dikes and sills. This unit is composed of hornblende-biotite and biotite tonalite, with minor epidote, allanite, and sphene. It is medium to coarse grained, locally with large poikiloblastic biotite plates. Rock is commonly strongly gneissic in outcrop and rich in mafic schlieren. Locally the tonalite could be cut by even lighter tonalite dikes.

Mesozoic Migmatite and Mixed Metamorphic and Igneous Rocks (Mzmi)

Tertiary and Cretaceous biotite granite and granodiorite with abundant pendants and inclusions of biotite gneiss. Similar to the $M_z$og unit, the $M_z$mi unit is composed of heterogeneous hornblende tonalite and biotite tonalite gneiss, mixed with mafic to feldspathic amphibolite, gneissic amphibolite, and blastoporphyritic feldspar gneiss. The migmatite is criss-crossed by small light-colored tonalitic to alaskitic dikes, sills, and irregular bodies, mostly with sharp contacts. Less common rocks in the migmatite are hornblende schist, biotite schist, and marble. Migmatite grades into gneiss to massive tonalite ($M_z$og) commonly rich in mafic schlieren.

2.4 Near-Surface Soil Conditions

Surficial soils for the project study area were originally mapped in 1992 by the USDA Soil Conservation Service (SCS), now referred to as the Natural Resources Conservation Service (NRCS). Typically, the NRCS maps depict conditions within 5 feet of the ground surface, and usually are not representative of conditions at greater depths. The surficial soil mapped by NRCS (2006) at the pump and canal sites is Pogue very stony fine sandy loam (PsE) as shown in Figure 8. A summary of the Pogue's surficial and engineering properties attributed by the NRCS is presented in Table 1.

2.5 Earthquakes

This section is a summary of the sources for seismic events in the region, the predicted peak firm ground acceleration and the predicted mean magnitude for the site based on United States Geological Survey (USGS) modeling, and the locations of mapped faults.

TABLE 1
Summary of Surficial Soil and Engineering Properties by NRCS

NRCS Soil Unit (Map Symbol)	Associated Geology	Topographical Area that Soils Form On	General Description (depths in inches bgs)	Slopes (%) A	Saturated Hydraulic Conductivity for upper 60 inches B (x10-4 centimeters/second)	Erosion Factor C	Hazard of Erosion D, E (limitations)	Limitations for Shallow Excavations D, F (limitations)	Upper Limit Water Table (feet bgs)
Pogue very soft fine sandy loam (PsE)	Parent material consists of glacial outwash.	Terraces and escarpments.	0 to17": Very Stony fine sandy loam 17 to 30": Very gravelly fine sandy loam 30 to 60: Extremely gravelly coarse sand	0 – 45	0 to 17": (4.00 to14.00) 17 to 30": (4.00 to14.00) 30 to 60": (141.00 to 705.00)	0 to 17": (0.20) 17 to 30": (0.20) 30 to 60": (0.05)	Severe (slope/ erodibility)	Very limited (cutbanks cave)	Available water to a depth of 60" is moderate.

Sources: Soil Conservation Service (1992), Natural Resources Conservation Service (2006), Soil Survey Staff, NRCS (2006).
Notes:

A Slope percentages are how steep the slopes generally are for that type of soil.

B Saturated hydraulic conductivity is defined by NRCS as the ease with which pores in a saturated soil transmit water. The estimates are based on soil characteristics observed in the field, particularly soil structure, porosity, and texture.

C Erosion factor is defined by NRCS as the susceptibility of a soil to sheet and rill erosion by water. The value listed in the table indicates the erodibility of the whole soil based on the percentage of silt, sand, organic matter, soil structure, and saturated hydraulic conductivity. The estimates are modified by the presence of rock fragments. The values range from 0.02 to 0.69, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

D The ratings (slight, very limited, etc.) are as classified by the NRCS based on specific criteria determined by SCS. These ratings do not necessarily reflect the opinions of CH2M HILL

E Hazard of erosion is based on the hazard of off road or off trail erosion by NRCS. These ratings are based on slope and on soil erosion factor K. The soil loss is caused by sheet or rill erosion in off-road or off-trail areas where 50 to 75 percent of the surface has been cleared of vegetation.

F Shallow excavations are excavations to a maximum of 5 or 6 feet deep.

2.5.1 Seismicity

The project area is located in the seismically active region of the Pacific Coast of Washington. Seismic events in this region result from three source mechanisms: (1) interplate events (earthquakes at plate boundaries), (2) intraplate events (earthquakes within plates), and (3) crustal events (earthquakes from faults in upper 10 t 15 miles of Earth's crust). Each of these events has a different seismogenic source, and therefore, produces earthquakes with different characteristics (i.e. peak ground acceleration, response spectra, and duration of strong shaking).

The Cascadia Subduction Zone, consisting primarily of the interface between the subducting Juan De Fuca and overriding North America tectonic plates, off the coast of Washington, provides the potential source of interplate and intraplate earthquake-induced ground motions within the study area. Interplate events occur due to movement at the interface of tectonic plates. Intraplate events originate within the subducting tectonic plate, away from its edges, when it releases built up stresses caused by its subduction under an overriding tectonic plate.

Earthquakes caused by movements along crustal faults, generally in the upper 10 to 15 miles, result in the third source mechanism. In Washington, these movements occur on the crust of the North America tectonic plate when built up stresses near the surface are released. Some of the crustal faults in the project vicinity include the Entiat fault, the Leavenworth fault zone, the Ross Lake fault, and the Wallowa Lineament. However the above mentioned faults are not considered by the USGS to be sources of significant earthquakes (that is, those of magnitude 6 or greater) during the Quaternary (the past 1,600,000 years). Quaternary crustal faults that could be sources of significant earthquakes based on the USGS are included in Section 2.5.2.

The largest historical crustal earthquake in eastern Washington occurred on 15 December 1872. Bakun and others (2002) concluded that its epicentral region was east of the Cascade Mountains near Lake Chelan, most probably near the south end of Lake Chelan, and estimated the shallow earthquake had a magnitude M6.8. Bakun and others (2002) assumed that the apparent absence of a surface scarp suggests that the 1872 earthquake may have occurred on a blind fault. Given the continuity of the deformation and seismicity along the Yakima fold belt to the south and southeast of Lake Chelan, Bakun and others (2002) inferred that events as large as M6.8 can reasonably be expected over most of south-central Washington. The information presented in the paper by Bakun and others (2002) has not been incorporated into the USGS mapping system yet.

Probabilistic seismic hazard map values have been determined from modeling conducted by the USGS and adopted by the Federal Emergency Management Agency (FEMA) and the International Building Code (IBC) (USGS, 2002; FEMA, 2001; IBC, 2003). The modeling considers all known seismic sources, the maximum credible earthquake, and the return interval associated with each source. Based upon the 2003 International Building Code (IBC), the mapped maximum considered earthquake spectral response acceleration at short periods (Ss) and at 1-second period (S1) are 0.48g and 0.15g respectively.

2.5.2 Mapped Faults

The USGS maintains a database of quaternary (time period including the past 1.6 million years) faults and folds for the United States (USGS, 2006c) that are believed to be a source of M6 or greater earthquakes. Structures (faults and folds) with noted geologic evidence of movement in

the last 10 to 15 thousand years (late Quaternary or Holocene time period) are generally considered active for seismic hazard analyses.

Table 2 and Figure 9 present the quaternary faults within the vicinity of the project site as identified by USGS (2006c). These crustal faults generally originate within the upper 10 to 15 miles of the crust. Crustal earthquakes are further categorized as occurring on *discrete fault sources* where repeated earthquakes have occurred in the geologic past, or within *areal source zones* where earthquakes have been observed and will probably occur again but have not been associated with any specific geologic features.

TABLE 2
Potentially Active Quaternary Faults within 60 Miles of the Project Site (USGS 2006c)

Fault Name	Distance to Site (miles)	USGS Fault Number[a]	Fault Type[b]	Mapped Length (miles)	Most Recent Deformation[c]	Slip Rate (mm/yr)
Pinto Fault	35	559	N	6	<1.6 Ma	<0.2
Frenchman Hills structures, Frenchman Hills fault	55	561a	T	31.7d	<1.6 Ma	<0.2
Frenchman Hills structures, Frenchman Hills uplift folds and faults	56	561c	T	56.5e	<1.6 Ma	<0.2
Kittitas Valley faults	56	560	R	17.4	<1.6 Ma	<0.2
Frenchman Hills structures, Lind Coulee fault	60	561b	T	2.5f	<1.6 Ma	<0.2
Straight Creek fault	60	553	RL	75	<1.6 Ma	<0.2

Notes:
[a] Faults are identified by number in Figure 9.
[b] Fault type notation: R (Reverse), N (Normal), LL (Left Lateral), RL (Right Lateral), T (Thrust)
[C] Deformation Age Notation: Ma (Million years before present)
[d] The total Frenchman Hills structures, Frenchman Hills fault system has a length of 56.5 miles
[e] The total Frenchman Hills structures, Frenchman Hills uplift folds and faults system has a length of 56.5 miles
[f] The total Frenchman Hills structures, Lind Coulee fault system has a length of 56.5 miles

Crustal seismic sources are mapped as Class A or B. Class A sources have geologic evidence demonstrating the existence of Quaternary movement. Class B sources have limited evidence demonstrating Quaternary movement and/or do not extend deep enough into the crust to be capable of generating significant earthquakes (moment magnitudes greater than 5.0) (USGS, 2006d). The Pinto fault is the closest mapped fault and is about 35 miles southeast of the project site. The Pinto fault is considered an active fault (USGS, 2006e) and is classified as a Class B fault. As discussed by Geomatrix Consultants Inc. (1990), the Pinto fault consists of three fault strands that may connect beneath areas of Quaternary sediments. If connected, the three strands form a generally east-striking fault that has a concave-to-the-south map pattern. The faults are only known to deform Miocene rocks of the Columbia River Basalt Group; however, the faults have not been studied in detail.

2.5.3 Ground Shaking

The ground shaking at the site of the structure was estimated using the published probabilistic seismic hazard information from the United States Geological Survey (USGS). The 2002 data set was used (USGS, 2002). The horizontal peak ground acceleration and spectral accelerations for various return intervals from the USGS (2002) are tabulated in Table 3. These data represent the shaking at a firm soil/soft rock (NEHRP B-C) boundary (FEMA, 2000).

TABLE 3
Summary of Seismic Ground Shaking, as Developed by the USGS (2002)

Probability of Exceedance	Approximate Return Interval (years)	Horizontal Peak Ground Acceleration (g)	Spectral Acceleration (g) at the following Periods (sec)	
			0.2	1.0
10% in 50 years	475	0.10	0.21	0.07
2% in 50 years	2475	0.21	0.48	0.15
1% in 50 years	4975	0.28	0.66	0.20

2.5.4 Liquefaction

Liquefaction is a phenomenon in which strong earthquake shaking causes a soil to rapidly lose its strength and behave like viscous fluid. Liquefaction typically occurs in artificial fills and in areas of loose sandy soils that are saturated with water, such as low-lying coastal areas, lakeshores, and river valleys. When soil strength is lost during liquefaction, the consequences can be catastrophic (Palmer et. al, 2004b).

According to the Washington State Department of Natural Resources, Liquefaction Susceptibility Map of Chelan County, WA, the site is moderately to highly susceptible to liquefaction as shown in Figure 10. The map provides an estimate of the likelihood that soil will liquefy as a result of earthquake shaking. The susceptibility is a measure of the physical characteristics of a soil deposit, such as grain texture, compaction, and depth of groundwater, that determine the propensity of the soil to liquefy during earthquake shaking. The map depicts the relative hazard in terms of high, moderate, low, or very low liquefaction susceptibility, and cannot be used to directly predict the severity of permanent ground deformation resulting from liquefaction.

SECTION 3

Geologically Hazardous Areas

The City of Chelan Municipal Code (CMC) 14.10.020 states that "Geologically hazardous areas include potential erosion, structural, ravine sidewall, steep slope, seismic and landslide hazard areas that are not suited to intense commercial, residential or industrial development because of susceptibility to erosion, sliding, earthquakes or other geological events hazardous to public health or safety." Based on the review of existing information, a site reconnaissance, and geotechnical explorations conducted at the project site, the primary geologic hazards for the project sites are seismic hazards related to ground shaking and liquefaction.

The CMC defines seismic hazard areas as an "area subject to a severe risk of earthquake damage as a result of seismically induced landslides, earth adjustments, settlement or soil liquefaction". A site reconnaissance and review of maps published by Washington State Department of Natural Resources (WDNR) and USGS indicate that the seismic hazards for the site inlcude potential for ground shaking and liquefaction. A low hazard of surface rupture is predicted for the site based on the distance (greater than 25 miles) of the site from the mapped fault zones. Values for the peak ground acceleration and the predicted mean magnitude associated with the ground shaking and recurrence interval for the site were previously presented in Section 2.5.1 Seismicity.

SECTION 4

Subsurface Exploration Program

Test pits and borings were conducted to provide information on subsurface conditions within the project area. This section is a summary of the exploration program including the test pit excavation methods, boring exploration methods, and soil description method used during the explorations. A summary of the results of the subsurface exploration program is presented in Section 5.0.

4.1 General

Explorations were performed by subcontractors under the oversight of CH2M HILL geotechnical engineering staff. The exploration locations were determined in the field based on proposed locations of the new project elements, equipment access, utility interference, and topographical features. Surveyed exploration locations are shown in Figure 5.

4.2 Test Pit Explorations

Test pits were excavated on January 15th and 16th 2007. The test pits were initially planned to be excavated by a CASE 580 Super K backhoe provided by the District. However, the backhoe had difficulty excavating the frozen soil at the surface, and was unable to excavate interlocked boulders larger than 3 feet in diameter encountered in the test pits. The test pits excavations were completed by KRCI of Wenatchee, WA using a CAT 312 Excavator on tracks equipped with a 24-inch wide bucket with teeth. The test pits depths ranged from 8.0 feet to 11.5 feet below ground surface (bgs). Excavation rates with the CAT 312 were slow due to significant sidewall caving and presence of large boulders.

4.3 Test Boring Explorations

Borings for this project were drilled by Environmental West Explorations, Inc. of Spokane, Washington on January 17th through 21th, 2007. The drilling process was accomplished using a 6-inch casing with a Tubex Air Rotary system and a truck-mounted Mobil B-80 drill rig. The borings were drilled to depths ranging between 52 to 60 feet bgs.

Standard Penetration Tests (SPTs) were performed in general accordance with ASTM D 1586 – *Standard Penetration Test Method for Penetration Test and Split Barrel Sampling of Soils*, in boring B-2, except that sample liners were not used. SPTs were conducted at 5-foot intervals between 10 and 35 feet using a 140-pound, automatic-trip hammer, and a free-fall of 30 inches. Because of poor recovery and heave problems, no SPTs were attempted below 35 feet on boring B-2. No SPTs were attempted in borings B-2A and Boring B-1 either. A brief description of the SPT is provided in Appendix A of this Geotechnical Data Report.

4.4 Soil Classification

At each exploration location, the soil profile was visually classified in general accordance with ASTM D 2488 - *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*. Details such as obstructions, identification of soil stratigraphy, and observation of groundwater seepage were also noted. Samples of soil were collected from the explorations, visually logged, and stored in watertight sample bags for laboratory testing. The visual field classifications were later revised as necessary based on the results of laboratory testing. Copies of the exploration logs summarizing visual field classifications, laboratory results, and other field observations are included within Appendix A.

4.5 Laboratory Soil Testing

Laboratory testing was conducted on representative soil samples recovered from the field to confirm the field visual classification of soils. GeoEngineers, Inc. of Redmond, Washington provided the geotechnical soils laboratory testing services under subcontract to CH2M HILL. The laboratory testing program consisted of:

- ASTM D 422, *Standard Test Method for Particle-Size Analysis of Soils*
- ASTM D 2216, *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock*

A summary of laboratory testing results is presented in Table 4 and copies of the laboratory results and brief descriptions of the test procedures are presented in Appendix B of this geotechnical data report.

TABLE 4
Laboratory Testing Results

Exploration Number	Depth (ft)	ASTM Classification	Natural Moisture Content (%)	Grain Size/Hydrometer Distribution		
				Percent Gravel (%)	Percent Sand (%)	Percent Fines (%)
Canal Site						
TP-1	5.0 to 5.5	GW	0.9	78.0	21.4	0.6
TP-2	9.0 to 10.0	GP-GM	1.8	75.6	16.9	7.5
TP-4	10.5 to 11.0	GP	4.0	67.0	31.4	1.6
TP-5	8.0 to 8.5	GW	1.7	70.6	27.1	2.3
TP-6	9.0 to 9.5	GW	1.7	73.1	24.7	2.2

Notes:
1. Samples consisted of material up to 3" diameter. Larger cobbles and boulders are present in parent material.
2. See exploration logs for entire sample classification.
3. ASTM classification in parentheses i.e. (SM) have not been verified by laboratory tests.

SECTION 5

Results of the Field Exploration

This section is a summary of the subsurface conditions for the project elements based on the results of field exploration and laboratory testing. The following sections are summaries of subsurface soil and groundwater conditions encountered in the exploratory test pits and borings. Surveyed boring and test pit locations are shown on the site plans in Figures 3 and 5. A summary of the laboratory testing results is presented in Table 4. The exploration logs in Appendix A provide more detailed descriptions of the soils encountered in the borings.

5.1 Surface Soil Conditions

The surface condition along the canal site generally consists of alluvium. The alluvial materials encountered during explorations are predominantly gravel, cobbles, and boulders with individual size ranging from fine sand to boulders 5 feet in diameter. Clusters of boulders are commonly present in the soils onsite and may be up to 10 feet or more in diameter. Relatively narrow access is provided to the canal site from Powerhouse Road through the powerhouse bridge. The canal can also be accessed from Chelan Falls Road through the Chelan River gorge. Some brush and small trees are present along higher elevations which slope at about 2H:1V (horizontal to vertical) on both sides of the gorge. The canal is located on a relatively flat-lying area in the river gorge. The north end of the canal which is upstream of the Chelan River is higher in elevation than the south end.

The surface conditions at the pump station site consist of alluvium and/or fill. The distinction between fill and alluvium on the tailrace bank is arbitrary because both have very similar composition. The surface soils at the pump station consist predominantly of gravel, cobbles, and boulders with sand. Individual size ranges from fine sand to boulders 5 feet or more in diameter. Some brush and small trees are present at the surface on the tailrace's east bank. Some rip rap was observed at the water level on the tailrace's east bank, adjacent to the proposed location of the pump station. Similar to the canal site, the pump station site can be accessed from Powerhouse Road and Chelan Falls Road.

5.2 Subsurface Soil Conditions

The subsurface conditions for the pump station and the canal are summarized below. These conditions are based on information recorded in the field during drilling and excavation. Test boring logs and test pit logs are contained within Appendix A of this report.

5.2.1 Pump Station

Alluvium was encountered at the pump station location at test boring B-1, B-2, and B-2A, to 54 feet, 52 feet, and 52 feet below ground surface (bgs) respectively. The alluvium consisted of sandy gravel with cobbles and well graded sand with gravel and cobbles. Large boulders up to 6 feet diameter (boring B-2, 17 to 23 feet) were also encountered in the alluvium. Sand ranged

from fine to coarse grained, with medium to coarse grains being predominant, and fines appeared to be non-plastic.

Boring B-2 was drilled first and was abandoned at 52 feet bgs due to issues with sand heave. It is very likely that the samples from the SPTs at boring B-2 are highly disturbed and that the blow counts are not representative of the soil density. Because of the struggle with heave and the very low quality in SPT samples, SPT sampling was discontinued at 35 feet bgs in boring B-2. Boring B-2 was abandoned to drill a second boring (B-2A) after the casing broke and the Tubex hammer got stuck at 52 feet. The borehole collapsed after removing the drilling rods and the casing. Water was encountered at about 11 feet bgs.

Boring B-2A was drilled about 3 feet south of B-2 to 60 feet bgs with no SPT sampling to improve the drilling rate. Alluvium was encountered in boring B-2A from the surface to 52 feet bgs. The alluvium was underlain by weathered rock between 52 and 57 feet bgs. The hole was advanced in gneiss rock from 57 to 60 feet. Water was encountered at about 11 feet bgs.

Boring B-1 was located approximately 50 feet north of boring B-2A. Boring B-1 encountered alluvium similar to B-2 and B-2A to 54 feet bgs. The alluvium was underlain by weathered rock at 56 feet bgs. The boring was advanced in rock from 56 to 56.5 feet bgs. The hole was abandoned at 56.5 feet. Water was encountered at about 12 feet bgs.

Boulders are commonly present in the soils present at the site and may be 10 feet or more in diameter. A generalized cross-section along the proposed pump station site was constructed between borings B-1 and B-2A and is presented in Figure 11.

5.2.2 Canal

All test pits (TP-1 through TP-6) excavated along the canal location encountered alluvium from the ground surface to the bottom of the test pits. Test pit depths ranged between 8 and 11.5 feet. The alluvial materials encountered were predominantly gravel, cobbles, and boulders with individual size ranging from fine sand to boulders approximately 5 feet or more in diameter. Boulders are common in this area and can be larger than 10 feet in diameter. Sand ranged from fine to coarse grained, with medium to coarse grains being predominant. Ground water seepage was observed in TP-4 at about 11 feet bgs.

5.3 Groundwater Conditions

As mentioned in the previous section groundwater was encountered at about 11 feet bgs (elevation 709 feet NGVD 1929) in the borings on the east bank of the tailrace. Water was also encountered in TP-4 at 11 feet bgs (elevation 707.7 feet NGVD 1929). During the field exploration, water in the tailrace was at elevation 709.5 feet. However fluctuation in the tailrace water level is know to vary between elevation 706.1 feet and 716.7 feet. Groundwater elevations are strongly influenced by fluctuations of tailrace water elevations.

SECTION 6

Existing Geotechnical Information

In 1926, more than 80 borings were drilled in the vicinity of the powerhouse as part of the field exploration for the existing facility and the water tunnel from Lake Chelan to the powerhouse. The borings on the east side of the powerhouse footprint (P-16, P-17, and P27) are of most interest to this project. Copies of the site plan and boring logs are included in Appendix C.

More recent geotechnical information adjacent to the project area include a 1991 report and short movie on the construction of two short bridges that connect Powerhouse Road to the switchyard through a deck at the power plant. The bridges were constructed on the west bank of the tailrace about 150 feet east of the pump station location. Two borings were advanced for exploration of subsurface conditions at the south and north bridge abutments. The borings indicated bedrock at about elevation 694 feet and 665 feet at the south and north abutments respectively. However, the geotechnical report indicates that the surface of the bedrock may be sloping steeply towards the tailrace. Copies of these boring logs along with the geotechnical report are available in Appendix C. The short movie that was put together to summarize the foundation work is available upon request.

Per personal communication with geotechnical engineer Kim de Rubertis on 3/25/2007, there is anecdotal evidence of localized subsidence on the order of six to twelve inches in the powerhouse switchyard. This information was not formally documented by the District.

SECTION 7

Limitations

This report has been prepared for the exclusive use of the Chelan Public Utility District for specific application to the Chelan Tailrace Pump Station Project, in accordance with generally accepted geotechnical engineering practice. No other warranty, express or implied, is made.

The analyses and recommendations contained in this report are based on the data obtained from collected existing information, geologic reports, and subsurface explorations conducted for this project. The boring logs and related information depict subsurface conditions only at the specific locations and times indicated and only to the depths penetrated. Subsurface conditions and water levels at other locations may differ from conditions occurring at these indicated locations. They do not necessarily reflect strata variations that may exist between such locations. The passage of time may result in a change in the conditions at these locations. Also, the depth and thickness of the subsurface strata indicated on the sections (profiles) were generalized from and interpolated between test locations. If variations in subsurface condition from those described and presented are noted during construction, recommendations in this report must be re-evaluated.

In the event that any changes in the nature, design, or location of the facilities are planned, the conclusions and recommendations contained in this report should not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing by CH2M HILL. CH2M HILL is not responsible for any claims, damages, or liability associated with interpretation of subsurface data or reuse of the subsurface data or engineering analyses without the express written authorization of CH2M HILL.

SECTION 8

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Figures

Vicinity Map

Figure 1
Vicinity Map
Chelan Tailrace Pump Station

MAPQUEST (2006).

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Aerial View

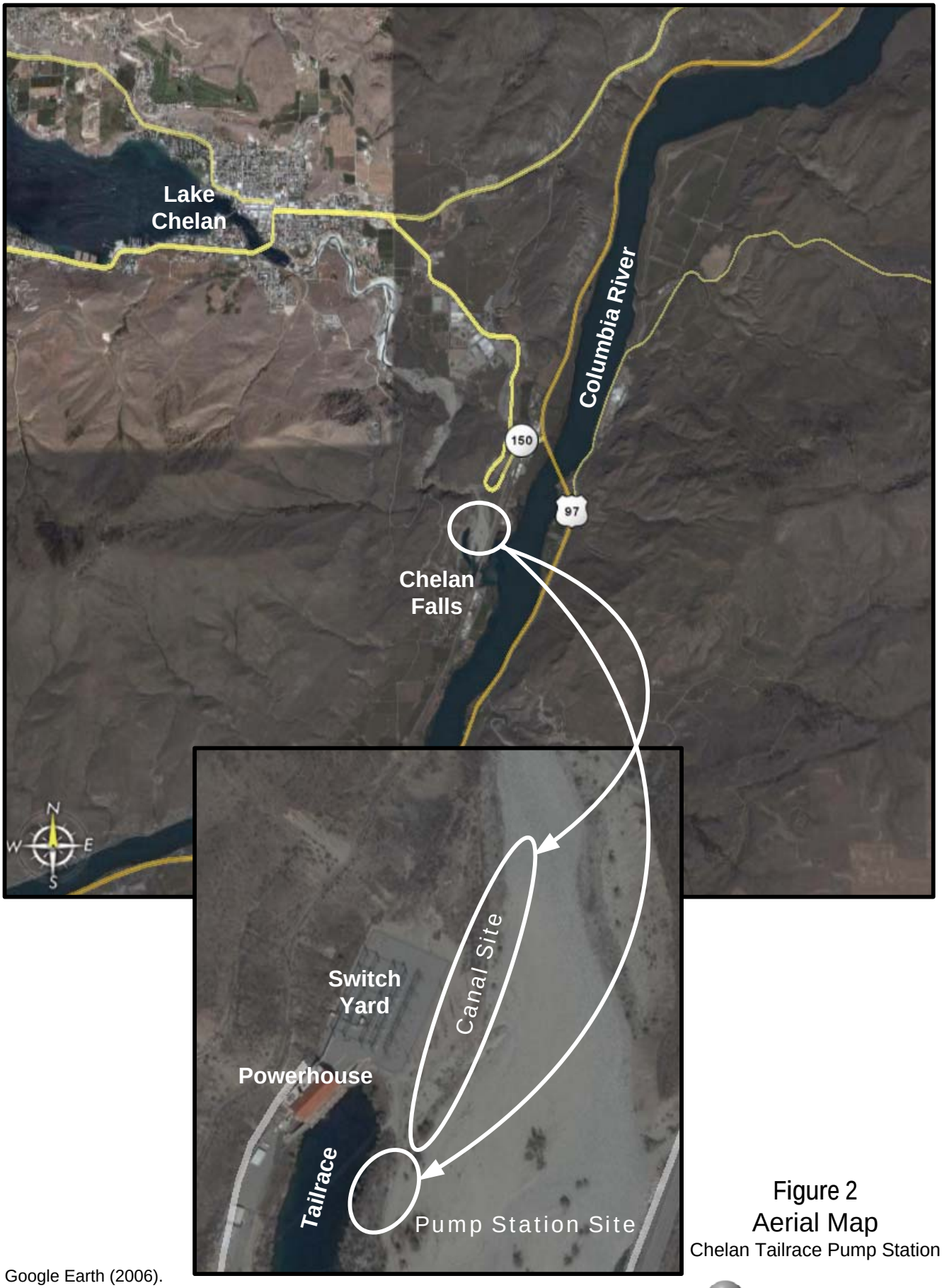

Figure 2
Aerial Map
Chelan Tailrace Pump Station

Google Earth (2006).

CH2MHILL

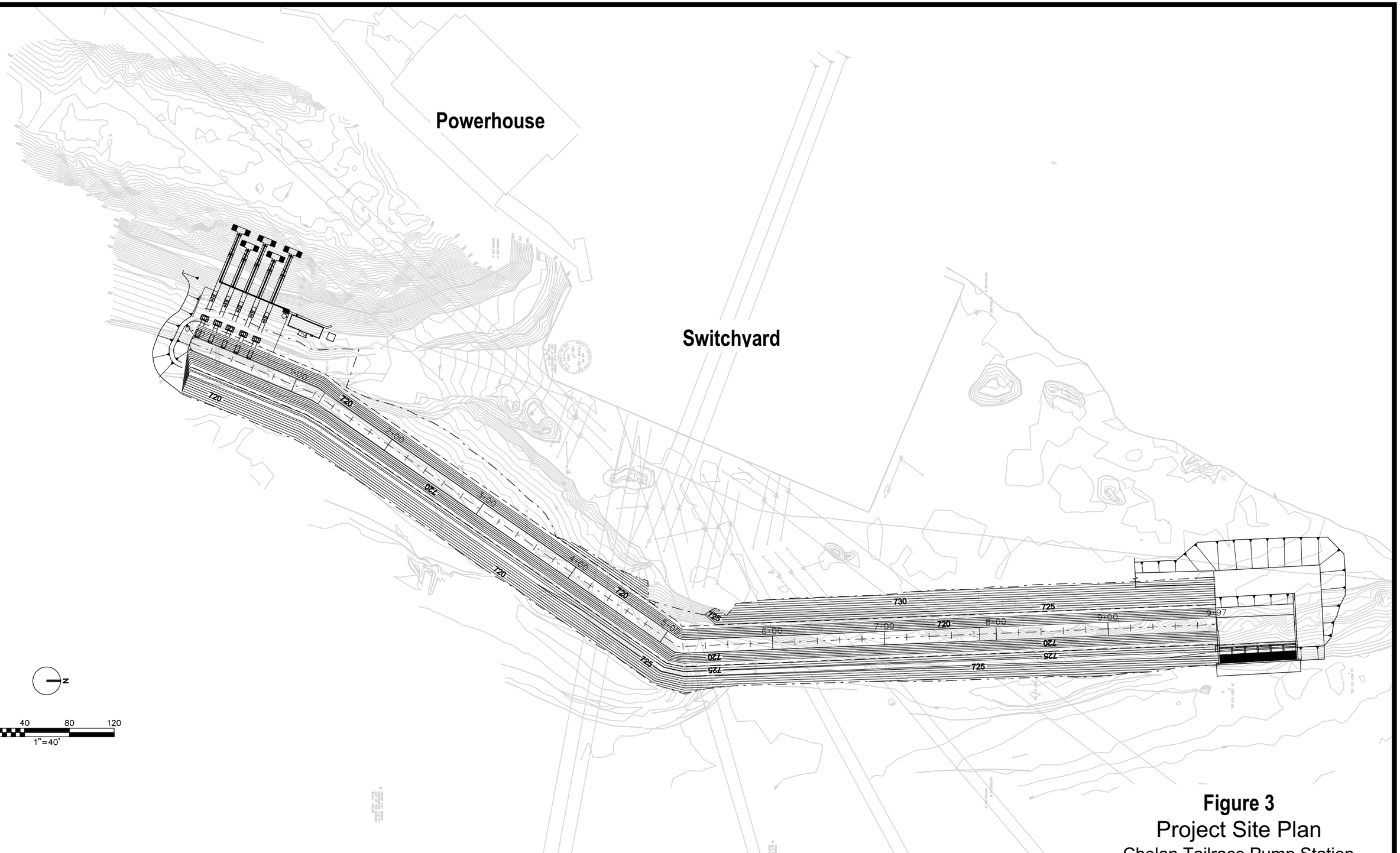

Figure 3
Project Site Plan
Chelan Tailrace Pump Station

CH2MHILL

Regional Topographic Map

USGS Chelan Falls (WA) Topo Map

View *TopoZone Pro* topographic maps, aerial photos, street maps, coordinate and elevation display

47° 48.50'N, 119° 59.21'W (NAD83/WGS84)

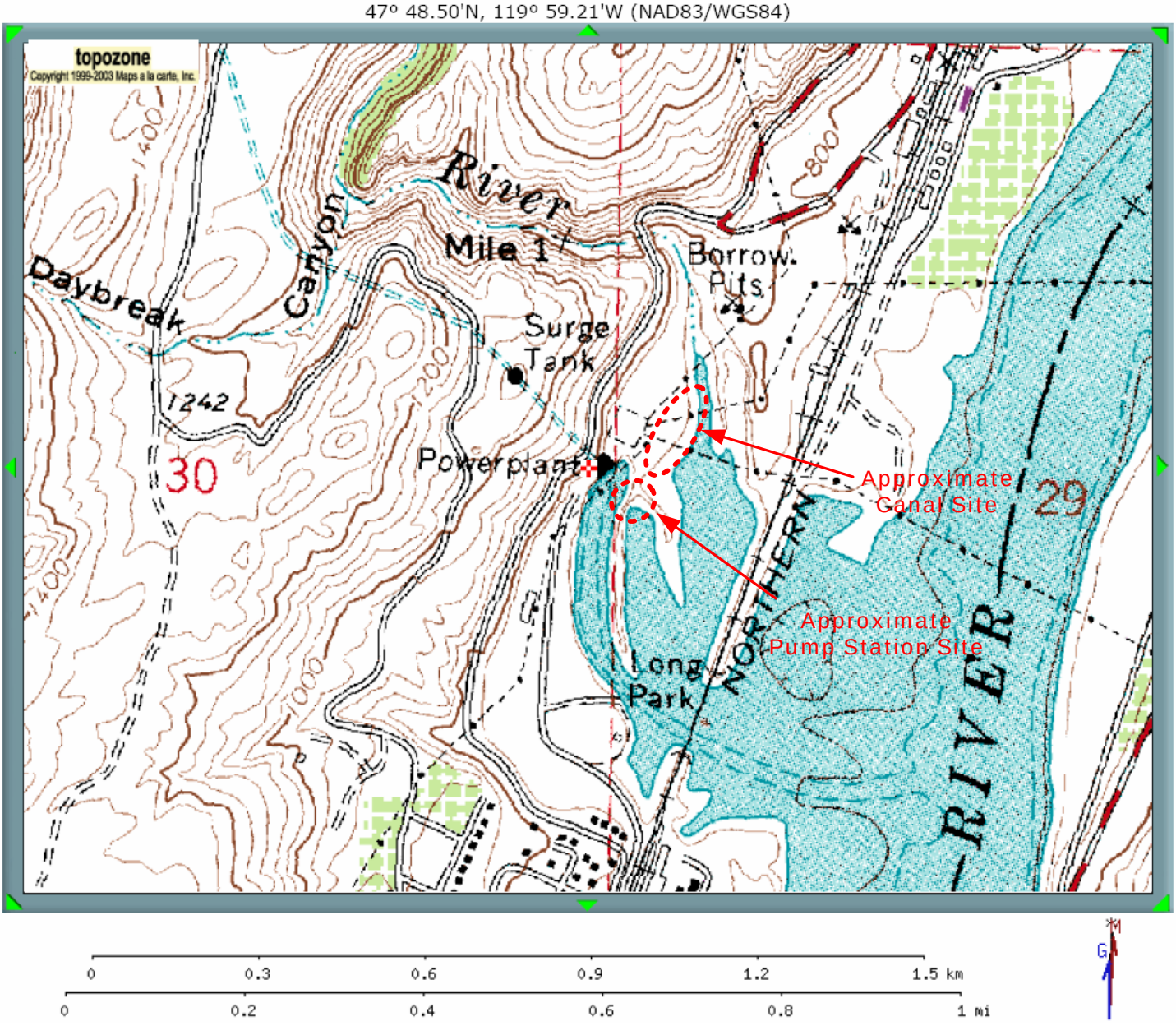

Figure 4
Regional Topographic Map
Chelan Tailrace Pump Station

USGS TopoZone (2006)

CH2MHILL

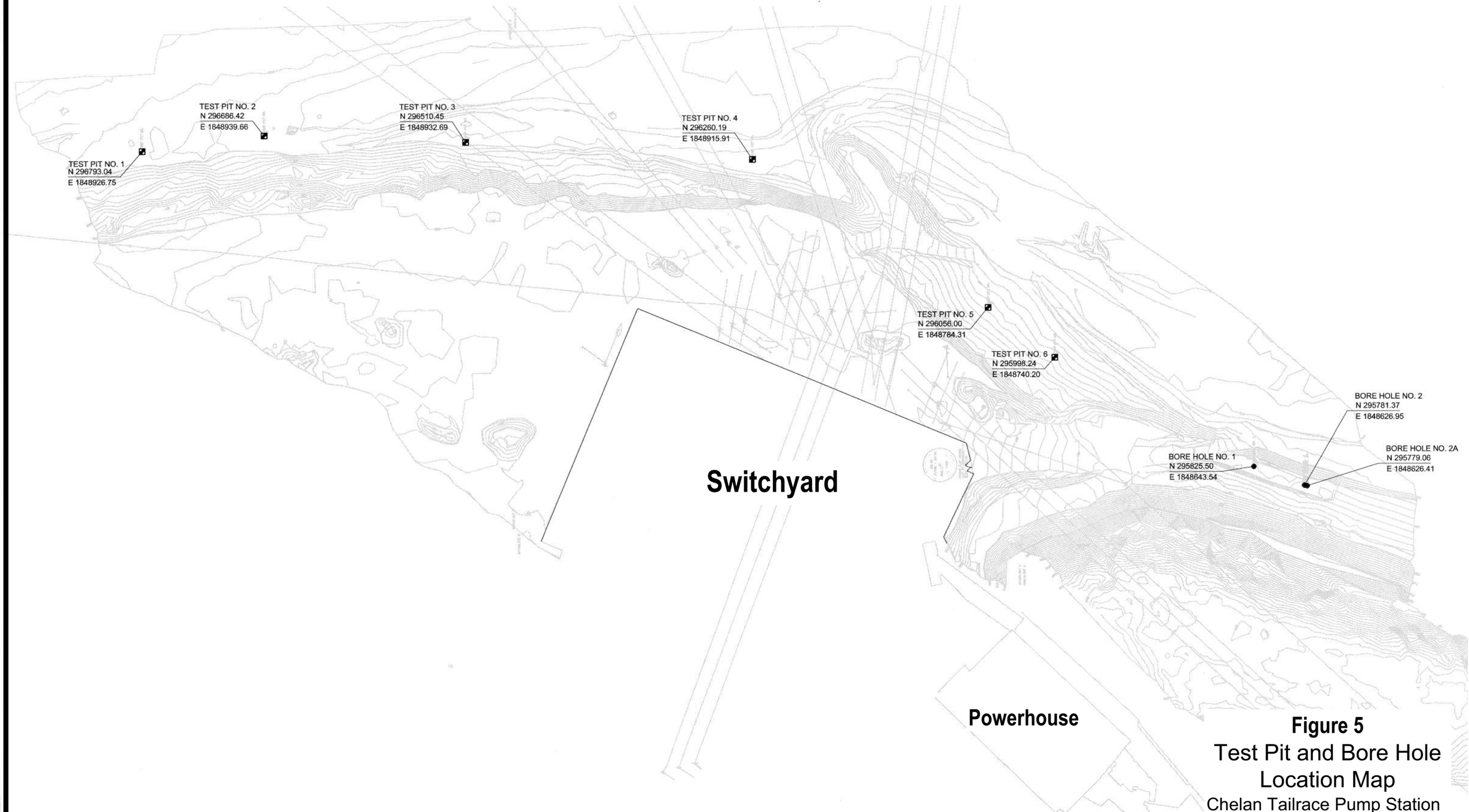

Figure 5
Test Pit and Bore Hole Location Map
Chelan Tailrace Pump Station

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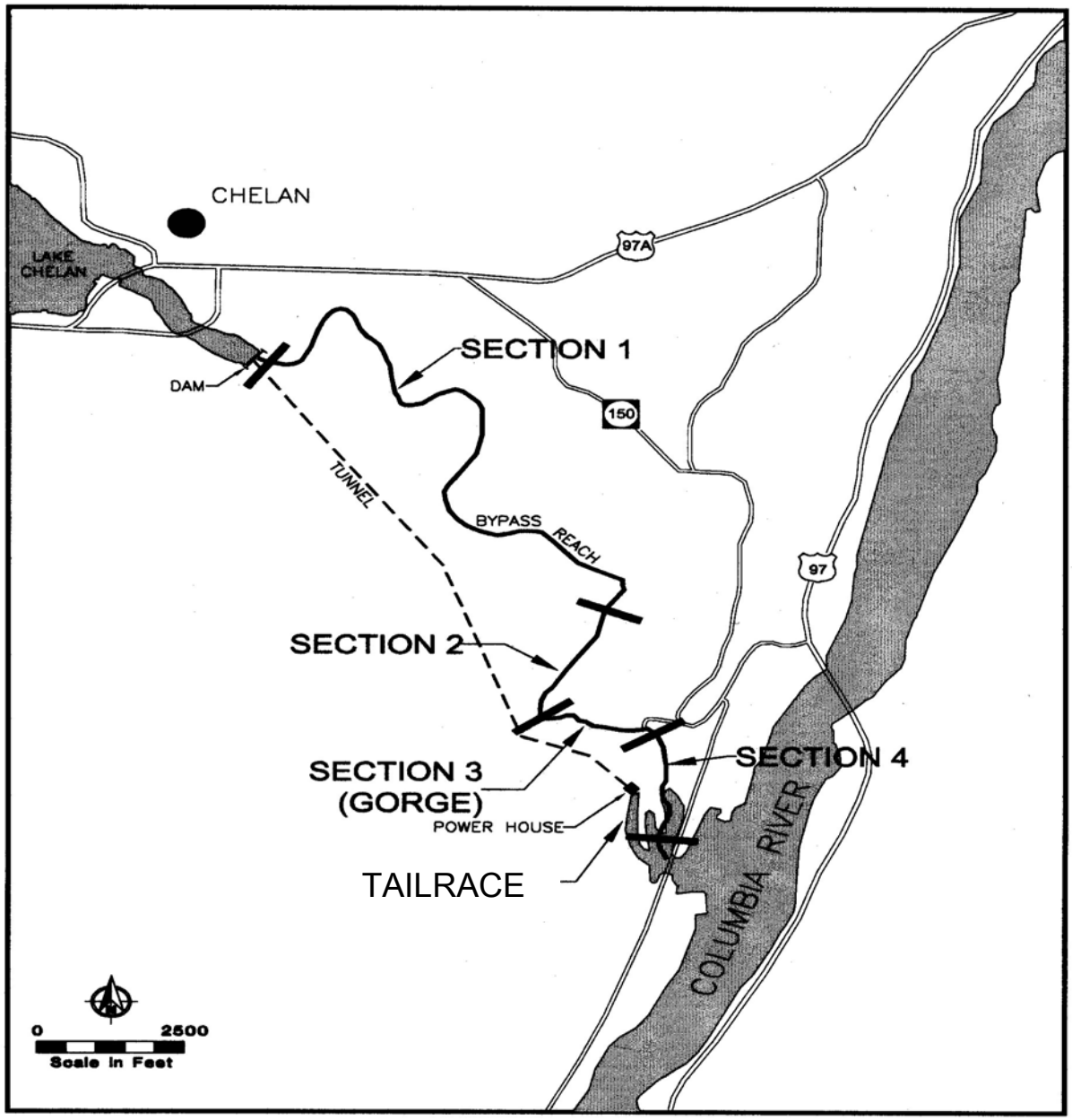
Chelan River Map

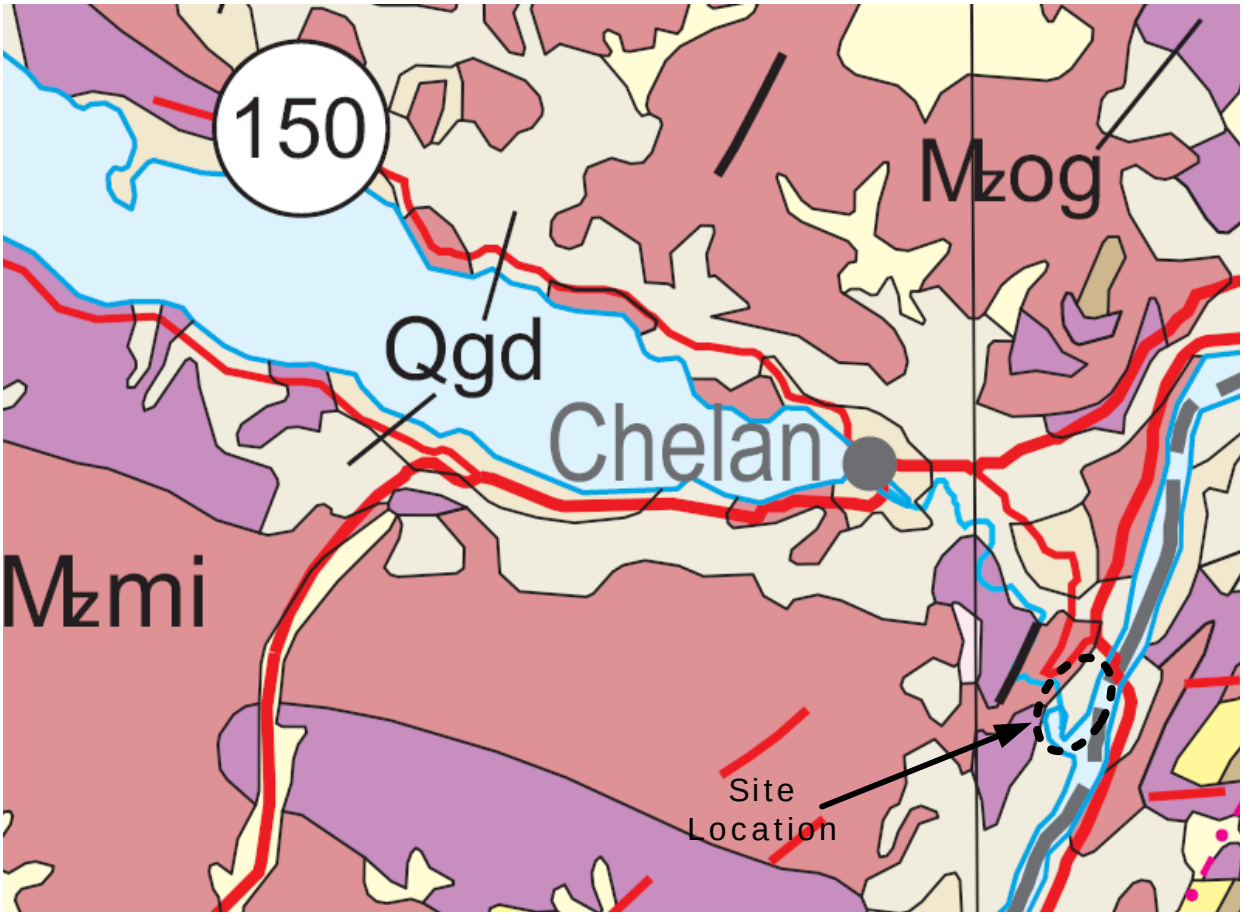


Chelan River (Bypassed Reach) by section and Lake Chelan Hydroelectric Project
(Archibald et al., 2002)

Figure 6
Chelan River Map
Chelan Tailrace Pump Station

CH2MHILL

Geologic Map



Legend

Qgd	Pleistocene continental glacial drift
$M_z$og	Mesozoic orthogneiss
$M_z$mi	Mesozoic migmatite and mixed metamorphic and igneous rocks

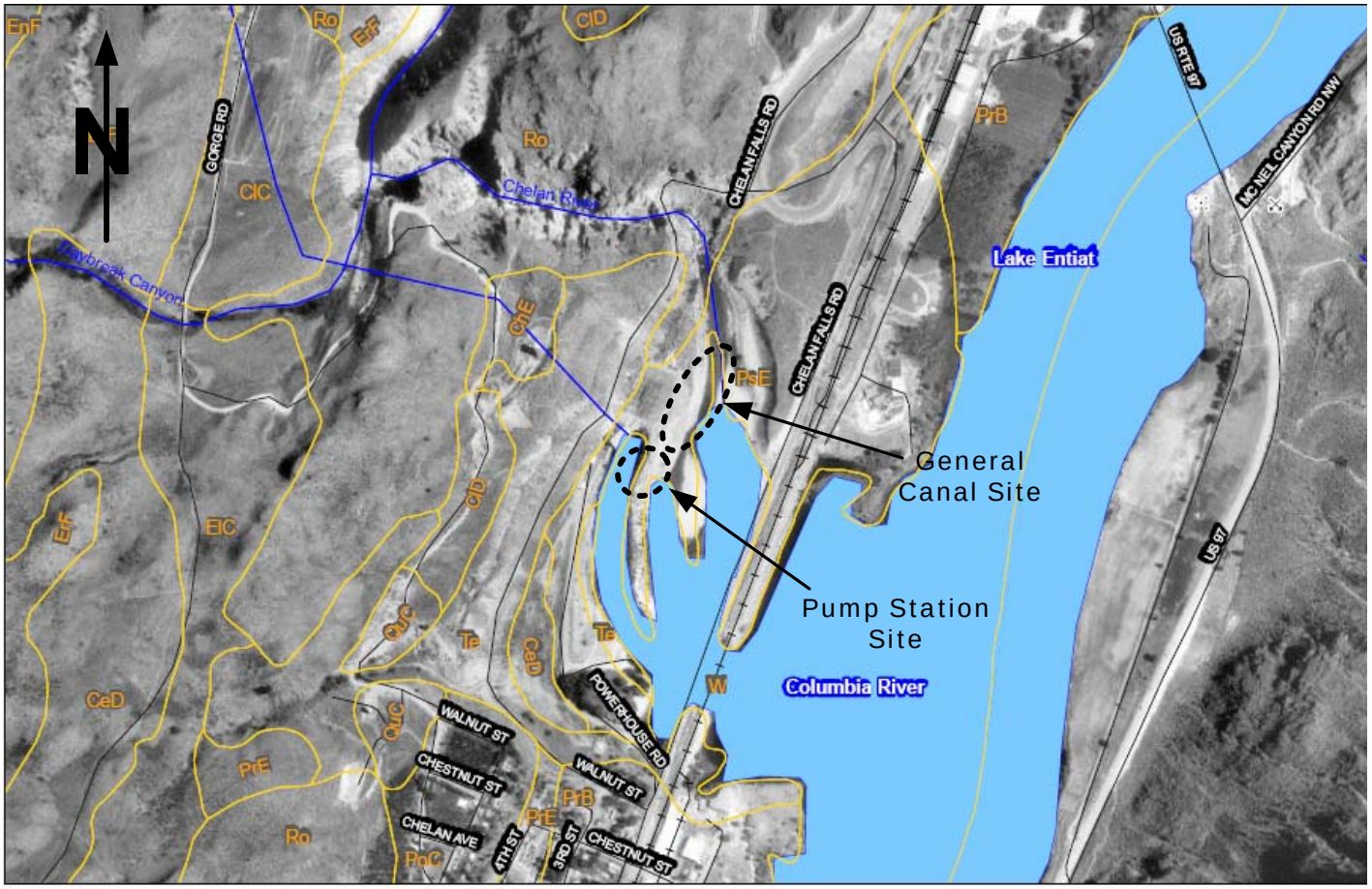
Note
Reproduce in color

Figure 7
Geologic Map
Chelan Tailrace Pump Station

After Schuster (2005). See Geotechnical Data Report for a description of the geologic units.

CH2MHILL

Surficial Soils Map



Meters
0 100 200 400

Feet
0 300 600 1,200 1,800 2,400

Legend

CeD	Cashmont stony sandy loam
ClC	Chelan gravelly sandy loam
ClD	Chelan gravelly sandy loam
EIC	Ellisforde silt loam
EnF	Entiat sandy loam
ErF	Entiat-Rock outcrop complex
PoC	Pogue fine sandy loam
PrB	Pogue gravelly fine sandy loam
PrE	Pogue gravelly fine sandy loam
PsE	Pogue very stony fine sandy loam
QuC	Quincy loamy fine sand
Ro	Rock outcrop
Te	Terrace escarpments

Note
Reproduce in color

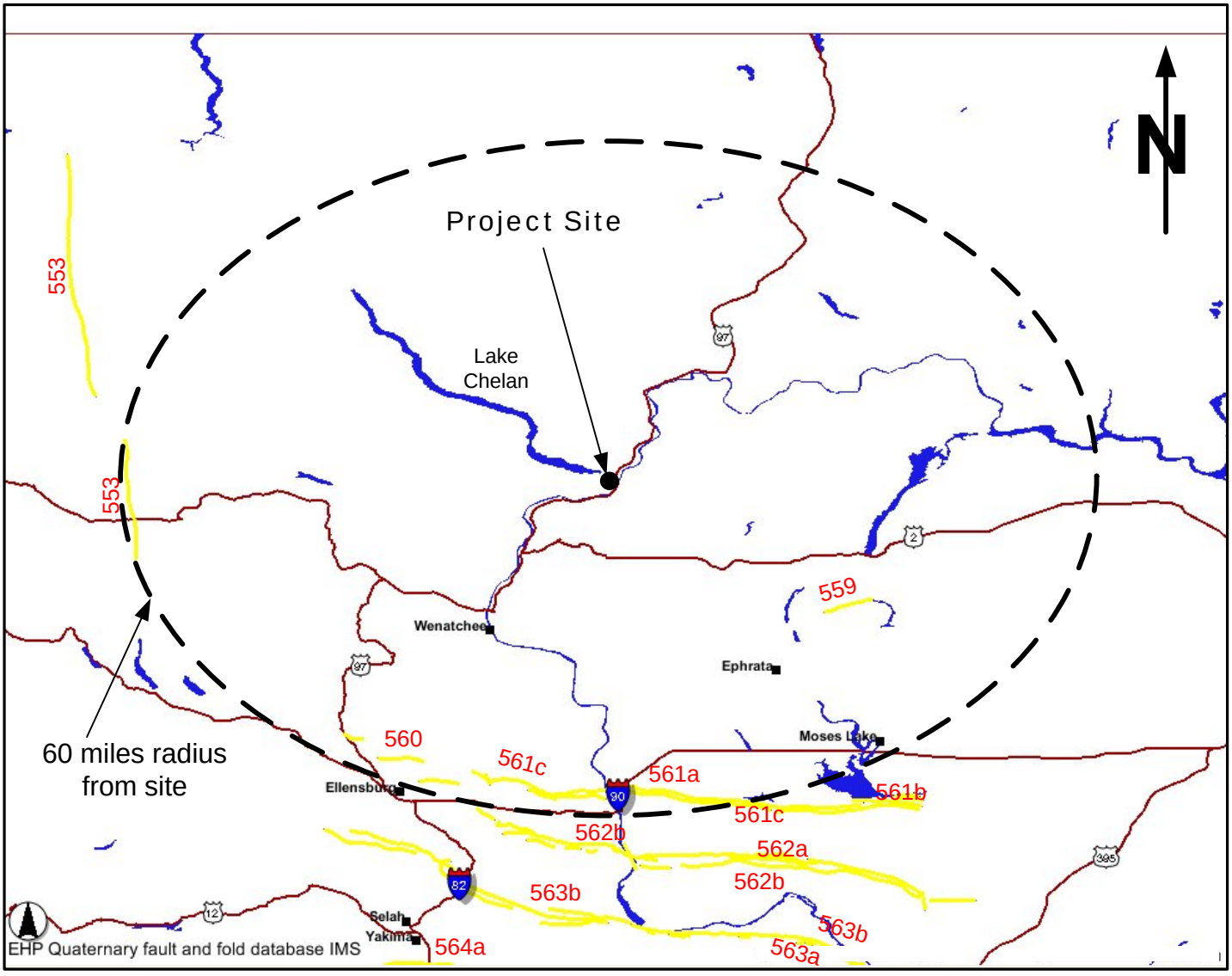
Figure 8
Surficial Soils Map
Chelan Tailrace Pump Station

USDA Natural Resources Conservation Service

Web Soil Survey 1.1
National Cooperative Soil Survey

CH2MHILL

Potentially Active Quaternary Faults



The faults shown are potential quaternary active faults from USGS Quaternary Fault and Fold Database (http://gldims.cr.usgs.gov/qfault), and are documented by number in Table 2.

Note
Reproduce in color

Legend

563b Fault number

Fault

Interstate Highways

Lakes/major rivers

Figure 9
Potentially Active Quaternary Faults
Chelan Tailrace Pump Station

CH2MHILL

Liquefaction Map

EXPLANATION

- Liquefaction susceptibility: HIGH
- Liquefaction susceptibility: MODERATE to HIGH
- Liquefaction susceptibility: MODERATE
- Liquefaction susceptibility: LOW to MODERATE
- Liquefaction susceptibility: LOW
- Liquefaction susceptibility: VERY LOW to LOW
- Liquefaction susceptibility: VERY LOW
- Bedrock
- Peat deposit — Peat is not susceptible to liquefaction but may undergo permanent displacement or loss of strength as a result of earthquake shaking.
- Water
- Ice

Note
Reproduce in color

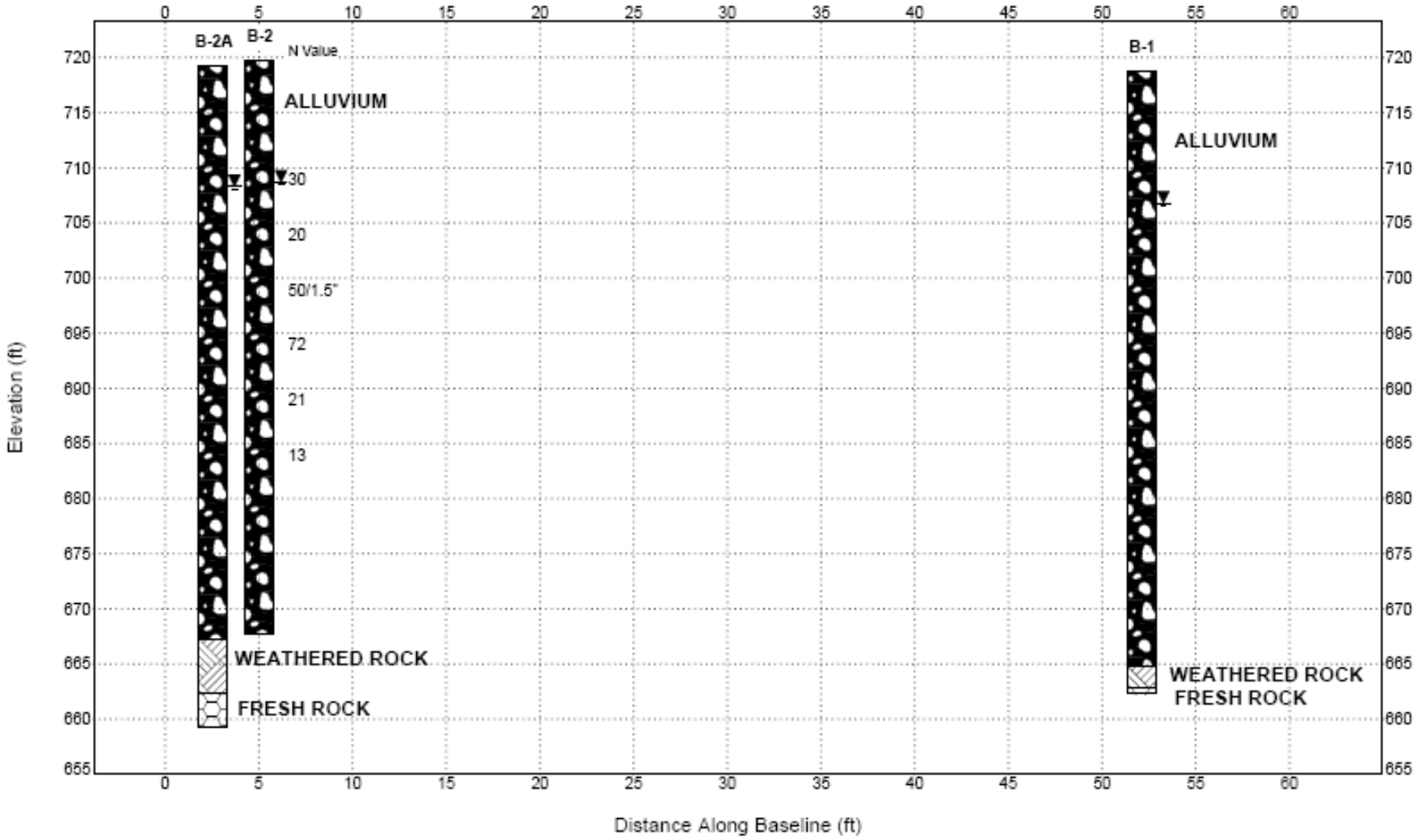
WASHINGTON STATE DEPARTMENT OF
Natural Resources
Doug Sutherland - Commissioner of Public Lands

Division of Geology and Earth Resources
Ron Teissere - State Geologist

Palmer et Al. (2004)

Figure 10
Liquefaction Map
Chelan Tailrace Pump Station

CH2MHILL



Notes:

1. The boring logs and related information depicts subsurface conditions only at the specific location and dates indicated. Subsurface conditions and water levels at other locations differ from conditions occurring at these boring locations.

2. Interpreted information is for schematic purposes only, and is not to be used for construction.

Figure 11
Geotechnical Exploration Section
Chelan Tailrace Pump Station

CH2MHILL

Appendix A
Subsurface Exploration

APPENDIX A

Boring Explorations

This appendix is a summary of the standard penetration test method during drilling, tables of the relative density of coarse grained and fine grained soils, and information noted on the borings logs such as the soil classification method and possible abbreviations noted on the boring logs.

A.1 Standard Penetration Test

The Standard Penetration Test (SPT) is performed by driving a standard split-barrel sampler 18 inches into undisturbed soil at the bottom of the borehole using a 140-pound guided hammer or ram, falling freely from a height of 30 inches. This test is conducted to obtain a measure of the resistance of the soil to penetration of the sampler and to retrieve a disturbed soil sample. The number of blows required to drive the sampler for three, 6-inch intervals, for a total of 18 inches, are observed and recorded on the soil boring log. The sum of the number of blows required to drive the sampler the second and third 6-inch intervals is considered the Standard Penetration Resistance or the SPT blowcount, N. If the sampler is driven less than 18 inches, but more than 1 foot, the SPT blowcount is that for the last 1 foot of penetration. If less than a foot is penetrated, the number of blows and the fraction of 1 foot penetrated are recorded in the boring logs.

The values of N provide a means for evaluating the relative density of granular (coarse-grained) soils and the consistency of cohesive (fine-grained) soils. Low N-values indicate soft or loose deposits, while high N-values are evidence of hard or dense materials. The criteria used for describing the relative density of coarse-grained soil and the consistency of fine-grained soils based on N-value are presented in Tables A-1 and A-2, respectively of this appendix. Field classification of the soil, based on these criteria, is incorporated in the boring logs presented in the following section.

TABLE A-1
Relative Density of Coarse Grained Soil (Developed from Sowers, 1979)

N (blows/ft)	Relative Density	Field Test
0-4	Very Loose	Easily penetrated with 1/2-in. steel rod Pushed by hand
5-10	Loose	Easily penetrated with 1/2-in. steel rod Pushed by hand
11-30	Medium Dense	Easily penetrated with 1/2-in. steel rod Driven with 5-lb hammer
31-50	Dense	Penetrated a foot with ½-in. steel rod Driven with 5-lb hammer
50+	Very Dense	Penetrated only a few inches with 1/2-in.

steel rod driven with 5-lb hammer

TABLE A-2
Consistency of Fine Grained Soil (Developed from Sowers, 1979)

N (blows/ft)	Consistency	Field Test
< 2	Very Soft	Easily penetrated several inches by fist
2-4	Soft	Easily penetrated several inches by thumb
5-8	Firm	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	Readily indented by thumb, but penetrated only with great effort
16-30	Very Stiff	Readily indented by thumbnail
30+	Hard	Indented with difficulty by thumbnail

A.2 Test Boring Logs

The boring logs are given in the following pages of this appendix. The soil classifications on the exploration logs are per the American Society for Testing and Materials (ASTM) soil classification, based on the Unified Soil Classification System (USCS). The soil group symbols are marked with parentheses when the classification is based on visual classification alone. When soil classification symbols are separated by commas, then the classification has been confirmed with laboratory testing. The lines on the boring logs do not define contacts between different soil classifications. The lines are used to separate the descriptions for legibility purposes only. The horizontal datum on the logs is Washington Coordinate System, North Zone NAD 83/91 and vertical datum is NAVD-88.

Abbreviations listed on borings logs may include the following: bgs = below ground surface

PROJECT NUMBER:	BORING NUMBER:
353102.TT.03	B-1 SHEET 1 OF 3

SOIL BORING LOG

PROJECT : Chelan Tailrace Pump Station, Chelan Falls, WA
LOCATION : North end of proposed pump station (295826.1 N, 1848647.2 E)

ELEVATION : 718.8 ft NGVD 29
DRILLING CONTRACTOR : Environmental West Exploration, SPK, WA

DRILLING METHOD AND EQUIPMENT : Mobil B-80 Truck Rig, Tubex air rotary, with 6" casing

WATER LEVELS : 12.0 ft below ground surface
START : 1/20/2007
END : 1/21/2007
LOGGER : M. Bouchedid

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION **SOIL NAME (USCS GROUP SYMBOL)** COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
					Surface is well graded gravel with sand, scattered cobbles, and boulders (alluvium/fill).	CT-xx are samples collected from drilling cuttings. Started drilling at 13:22. Driller installed checkball rod just before hammer to maintain pressure at bottom of hole.
5						
	8.5					
	10.0		CT-1 GRAB		**WELL GRADED GRAVEL WITH SAND (GW),** brown, moist, fine to coarse gravel, fine to coarse sand, estimated 10-15 % sand, estimated 5% fines, angular chipped gravel.	Driller reports angular gravel is probably chipped cobbles. 10' at 13:30.
10	12.5					
	14.0		CT-2 GRAB		**WELL GRADED GRAVEL WITH SAND (GW),** same as above, except wet, estimated <5% fines.	Water at 12' bgs. Driller reports fine sands and silts probably washed out.
15	18.0					
	20.0		CT-3 GRAB		**WELL GRADED GRAVEL WITH SAND (GW),** same as above, except, estimated 20-30% sand, estimated 5% fines.	
20						

PROJECT NUMBER:	BORING NUMBER:
353102.TT.03	B-1 SHEET 2 OF 3

SOIL BORING LOG

PROJECT : Chelan Tailrace Pump Station, Chelan Falls, WA LOCATION : North end of proposed pump station (295826.1 N, 1848647.2 E)

ELEVATION : 718.8 ft NGVD 29 DRILLING CONTRACTOR : Environmental West Exploration, SPK, WA

DRILLING METHOD AND EQUIPMENT : Mobil B-80 Truck Rig, Tubex air rotary, with 6" casing

WATER LEVELS : 12.0 ft below ground surface START : 1/20/2007 END : 1/21/2007 LOGGER : M. Bouchedid

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION **SOIL NAME (USCS GROUP SYMBOL)** COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
						20' at 13:40.
	22.0					
	24.0		CT-4 GRAB		**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM),** brown, wet, fine to coarse sand, fine to coarse gravel, subrounded to subangular gravel, sub-angular to angular gravel from chipped cobbles and boulders, predominantly medium to coarse sand, estimated 30% gravel, estimated 5-10% fines.	
25						25 at 13:50.
	27.0					
	28.0		CT-5 GRAB		**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM),** same as above.	
30						30' at 13:58.
	33.0					
	34.5		CT-6 GRAB		**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM),** similar to above, except estimated 15 % gravel, estimated 10% fines.	
35						35' at 14:07.
	38.0					
			CT-7 GRAB		**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM),** same as above.	
40	40.0					

PROJECT NUMBER:	BORING NUMBER:
353102.TT.03	B-1 SHEET 3 OF 3

SOIL BORING LOG

PROJECT : Chelan Tailrace Pump Station, Chelan Falls, WA
LOCATION : North end of proposed pump station (295826.1 N, 1848647.2 E)

ELEVATION : 718.8 ft NGVD 29
DRILLING CONTRACTOR : Environmental West Exploration, SPK, WA

DRILLING METHOD AND EQUIPMENT : Mobil B-80 Truck Rig, Tubex air rotary, with 6" casing

WATER LEVELS : 12.0 ft below ground surface
START : 1/20/2007
END : 1/21/2007
LOGGER : M. Bouchedid

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION **SOIL NAME (USCS GROUP SYMBOL)** COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
						40' at 14:16.
	43.0				**WELL GRADED GRAVEL (GW),** gray and black, wet, fine to coarse gravel, subrounded gravel, chipped angular gravel.	Driller reports more gravel and cobbles at 43', harder drilling.
			CT-8 GRAB			Driller reports sand and fines washed out from cuttings due to high water head.
45	45.0					45' at 14:23.
	47.0					
	48.0		CT-9 GRAB		**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM),** brown, wet, fine to coarse sand, fine to coarse gravel, predominantly medium to coarse sand, sub-angular to angular gravel from chipped cobbles and boulders, estimated 15-20% gravel, estimated 5-10% fines.	Driller reports casing broke at 14:33. Casing broke at 20' bgs. Pulled casing and rods out and replaced broken casing. Resumed drilling at 16:05. Driller reports hole caved in but not much resistance in redrilling hole. Redrilled hole to 20' and sopped for day at 16:20. Resumed drilling on 1/21/07 at 8:00.
50						Back at 45' at 9:00.
	53.0					
	54.0		CT-10 GRAB		**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM),** same as above.	
			CT-11 GRAB		**WEATHERED ROCK,** brown with light gray and black mottling, angular gravel cuttings.	Driller reports feels like weathered bedrock at 54'. Drilling water has a reddish color.
55	55.0					55' at 9:15.
	56.0					
	56.5		CT-12 GRAB		**GNEISS ROCK,** white and gray with black mottling, angular gravel cuttings.	Driller reports hard bedrock at 56' Drilling water is clear. Driller reports hammer broke at 56.5' at 9:30. Will take several hours to fix. M. Bouchedid tells driller to abandon hole. Hole abandonment included backfilling it with 3/4" bentonite chips.
					Bottom of Hole at 56.5 ft below ground surface	
60						

PROJECT NUMBER:	BORING NUMBER:
353102.TT.03	B-2 SHEET 1 OF 3

SOIL BORING LOG

PROJECT : Chelan Tailrace Pump Station, Chelan Falls, WA

LOCATION : South end of proposed pump station (295782.0 N, 1848630.7 E)

ELEVATION : 719.7 ft NGVD 29

DRILLING CONTRACTOR : Environmental West Exploration, SPK, WA

DRILLING METHOD AND EQUIPMENT : Mobil B-80 Truck Rig, Tubex air rotary, with 6" casing and 140 lb auto hammer

WATER LEVELS : 11.0 ft below ground surface

START : 1/17/2007

END : 1/19/2007

LOGGER : M. Bouchedid

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION **SOIL NAME (USCS GROUP SYMBOL)** COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
0					Surface is well graded gravel with sand, scattered cobbles, and boulders (alluvium/fill).	CT-xx are samples collected from drilling cuttings. Started drilling at 10:15.
5						Cuttings are brown fine to coarse subrounded to subangular gravel between 0 and 10'.
10	10.0					
	11.5	0.3	1-SS	42-15-15 (30)	**WELL GRADED GRAVEL (GW),** brown and gray, moist, medium dense, fine to coarse gravel, estimated 5% sand, 1" angular gravel stuck in tip of sampler.	SS-1 at 10:33 Driller reports water at 11' bgs.
15	15.0					
	16.5	0.3	2-SS	2-7-13 (20)	**POORLY GRADED SAND (SP),** brown, wet, medium dense, predominantly medium to coarse sand, trace fine sand, trace fine gravel, estimated <5% fines.	SS-2 at 10:51. Driller reports split spoon pushed about 4" under weight of hammer. Driller having problems advancing casing after SS-2. Driller reports low air pressure. Stopped drilling to check compressor. Resumed drilling at 11:05. Driller reports hard drilling at 17'. Feels like a boulder. Cuttings look like weathered rock. Collected cuttings and stored in bag C-1 (17' to 20'). Cuttings are grayish and angular with some sand.
20						

PROJECT NUMBER:	BORING NUMBER:
353102.TT.03	B-2 SHEET 2 OF 3

SOIL BORING LOG

PROJECT : Chelan Tailrace Pump Station, Chelan Falls, WA
LOCATION : South end of proposed pump station (295782.0 N, 1848630.7 E)

ELEVATION : 719.7 ft NGVD 29
DRILLING CONTRACTOR : Environmental West Exploration, SPK, WA

DRILLING METHOD AND EQUIPMENT : Mobil B-80 Truck Rig, Tubex air rotary, with 6" casing and 140 lb auto hammer

WATER LEVELS : 11.0 ft below ground surface
START : 1/17/2007
END : 1/19/2007
LOGGER : M. Bouchedid

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION **SOIL NAME (USCS GROUP SYMBOL)** COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	20.0					
		0.1	3-SS	50/1.5" (50/1.5")	**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM),** gray, wet, very dense, fine to coarse gravel, chipped angular gravel, fine to coarse sand, estimated 15-20% sand, estimated 5-10% fines, fractured gravel stuck in tip of sampler.	SS-3 at 11:20. Driller reports out of boulder at 23', transitioning into brownish gravel.
	21.5					
25	25.0					
		0.8	4-SS	25-35-37 (72)	**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM),** brown, wet, very dense, fine to coarse sand, fine to coarse gravel, predominantly fine to medium sand, estimated 15% gravel, estimated 5-10% fines, 1" fractured gravel stuck in tip of sampler.	SS-4 at 11:40.
	26.5					
						Fine to coarse subrounded to subangular gravel observed in cuttings between 25' and 30'.
30	30.0					
		0.8	5-SS	4-7-14 (21)	**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM),** brown, wet, medium dense, fine to coarse sand, fine to coarse gravel, predominantly medium to coarse sand, grades from coarse sand in top 2" to medium sand with gravel in middle 6" and to coarse sand with gravel in bottom 2", estimated 15% gravel, estimated 5-10% fines.	Driller reports 2.5' of heave observed after putting split spoon in hole for SS-5. Removed spoon and redrilled hole to 30'. Driller reports problems with compressor, can't get enough air pressure. Compressor needs to be fixed and driller needs to bring water pump to site to pump water into hole to control heave. Done for day at 12:30. Resumed drilling on 1/18/07 at 8:27. SS-5 at 8:45. Driller fighting heave problems after SS-5. Hammer plugged with sand and stuck in ground under coarse sand and fine to coarse gravel cuttings. Pulled hammer out of hole at 9:17. Resumed drilling at 11:45 after cleaning hammer.
	31.5					
35	35.0					
		0.3	6-SS	1-9-4 (13)	**WELL GRADED GRAVEL (GW),** brown and gray, wet, medium dense, fine to coarse gravel, subrounded to subangular gravel, estimated <5% sand, estimated <5% fines.	
	36.5					
	38.0					
			CT-1 GRAB		**POORLY GRADED SAND WITH GRAVEL (SP),** brown, wet, fine to coarse sand, fine to coarse gravel, predominantly medium to coarse sand, subrounded to subangular gravel, estimated 25% gravel, estimated 5% fines.	
40	40.0					

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
353102.TT.03	B-2 SHEET 3 OF 3

SOIL BORING LOG

PROJECT : Chelan Tailrace Pump Station, Chelan Falls, WA LOCATION : South end of proposed pump station (295782.0 N, 1848630.7 E)

ELEVATION : 719.7 ft NGVD 29 DRILLING CONTRACTOR : Environmental West Exploration, SPK, WA

DRILLING METHOD AND EQUIPMENT : Mobil B-80 Truck Rig, Tubex air rotary, with 6" casing and 140 lb auto hammer

WATER LEVELS : 11.0 ft below ground surface START : 1/17/2007 END : 1/19/2007 LOGGER : M. Bouchedid

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION **SOIL NAME (USCS GROUP SYMBOL)** COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
45	45.0					SS-6 at 12:08. Sands and fines appear to be washed out of SS-6. Driller reports blow counts for all recovered samples very likely not indicative of soil density. Blowing bottom of hole with high air pressure before every SPT to release and recover hammer in addition to heave problems impact quality of SPT. Driller says it is very hard to run SPT with air rotary in this kind of soils. Decision made to stop taking SPTs, just collect cuttings. Lunch break from 12:10 to 12:40. Sand plugged hammer again at 40' at 1:20. Resumed drilling at 3:00 after cleaning hammer and removing reemer that keeps plugging.
	46.0		CT-2 GRAB		**WELL GRADED GRAVEL WITH SAND (GW),** brown and gray, wet, fine to coarse gravel, subrounded to subangular gravel, estimated 15-20% sand, sands and silts washed out.	
50	50.0					
	52.0		CT-3 GRAB		**WELL GRADED GRAVEL WITH SAND (GW),** same as above.	Driller reports hit large boulder/rock at 52'. Will have to put reemer back on hammer to drill through boulder. Stopped for day at 5:15. Resumed drilling on 1/19/07 at 10:30 after pulling hammer out of hole and putting reemer back on hammer. Driller reports stuck at 47' at 11:30. Driller reports a lot of 2" gravel flying out of hole. Driller reports running out of ideas on how to fight hole. Driller and senior geotech engineer discuss problems on phone and decide to abandon hole. Hole abandonment included backfilling it with 3/4" bentonite chips.
55					Bottom of Hole at 52.0 ft below ground surface	
60						

PROJECT NUMBER:	BORING NUMBER:
353102.TT.03	B-2A SHEET 1 OF 3

SOIL BORING LOG

PROJECT : Chelan Tailrace Pump Station, Chelan Falls, WA

LOCATION : South end of proposed pump station (295779.6 N, 1848630.1 E)

ELEVATION : 719.3 ft NGVD 29

DRILLING CONTRACTOR : Environmental West Exploration, SPK, WA

DRILLING METHOD AND EQUIPMENT : Mobil B-80 Truck Rig, Tubex air rotary, with 6" casing

WATER LEVELS : 11.0 ft below ground surface

START : 1/20/2007

END : 1/20/2007

LOGGER : M. Bouchedid

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION **SOIL NAME (USCS GROUP SYMBOL)** COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
					Surface is well graded gravel with sand, scattered cobbles, and boulders (alluvium/fill).	CT-xx are samples collected from drilling cuttings. Started drilling at 9:15. Driller installed checkball rod just before hammer to maintain air pressure at bottom of rods. Boring B-2A is 3' south of B-2.
5						Cuttings to 5' are well graded sand with coarse sand.
10						10' at 9:23. Water at 11'.
15						15' at 9:31. Started preparing water pump to pump water into hole. Cuttings are well graded gravel with coarse sand. Water pump ready at 10:00.
20						20' at 10:10. Driller reports hard drilling from 21' to 25'. Feels like large boulder. Driller reports angular chips of gravel blown out of hole at 21'.
25						

PROJECT NUMBER:	BORING NUMBER:
353102.TT.03	B-2A SHEET 2 OF 3

SOIL BORING LOG

PROJECT : Chelan Tailrace Pump Station, Chelan Falls, WA LOCATION : South end of proposed pump station (295779.6 N, 1848630.1 E)

ELEVATION : 719.3 ft NGVD 29 DRILLING CONTRACTOR : Environmental West Exploration, SPK, WA

DRILLING METHOD AND EQUIPMENT : Mobil B-80 Truck Rig, Tubex air rotary, with 6" casing

WATER LEVELS : 11.0 ft below ground surface START : 1/20/2007 END : 1/20/2007 LOGGER : M. Bouchedid

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION **SOIL NAME (USCS GROUP SYMBOL)** COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
						25' at 10:21.
	26.0				**WELL GRADED GRAVEL WITH SAND(GW),** brown and gray, wet, fine to coarse gravel, subrounded to subangular gravel, estimated 40% sand, estimated 5% silts.	25' at 10:21. Drilling advancing smoothly and without problems.
	28.0		CT-1 GRAB			
30	32.0				**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM),** brown, wet, fine to coarse sand, fine to coarse gravel, predominantly medium to coarse sand, subrounded to subangular gravel, estimated 30% gravel, estimated 5-10% fines.	
	34.0		CT-2 GRAB			
35	37.0				**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM),** same as above.	35' at 10:45.
	39.0		CT-3 GRAB			
40	42.0				**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM),** same as above, except less fines.	40' at 11:04.
	44.0		CT-4 GRAB			Driller reports high water head causing fine sands and silts to get washed out.
45	48.0				**WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM),** same as above.	
50	50.0		CT-5 GRAB			

PROJECT NUMBER:	BORING NUMBER:
353102.TT.03	B-2A SHEET 3 OF 3

SOIL BORING LOG

PROJECT : Chelan Tailrace Pump Station, Chelan Falls, WA LOCATION : South end of proposed pump station (295779.6 N, 1848630.1 E)

ELEVATION : 719.3 ft NGVD 29 DRILLING CONTRACTOR : Environmental West Exploration, SPK, WA

DRILLING METHOD AND EQUIPMENT : Mobil B-80 Truck Rig, Tubex air rotary, with 6" casing

WATER LEVELS : 11.0 ft below ground surface START : 1/20/2007 END : 1/20/2007 LOGGER : M. Bouchedid

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)	RECOVERY (ft)	#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION **SOIL NAME (USCS GROUP SYMBOL)** COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
						50' at 11:24.
	52.0				**WEATHERED ROCK,** brown with light gray and black mottling, angular gravel cuttings.	Driller reports harder drilling at 52'. Feels like weathered rock. Flushed water is getting cleaner.
			CT-6 GRAB			
55	55.0					
	56.0		CT-7 GRAB		**WEATHERED ROCK,** similar to above.	55' at 11:45.
						Driller reports fresh rock at 57'
	58.5					
	59.0		CT-8 GRAB		**GNEISS ROCK,** white and gray with black mottling, angular gravel cuttings.	
60	60.0					
					Bottom of Hole at 60.0 ft below ground surface	60' at 12:10. Hole abandonment included backfilling it with 3/4" bentonite chips.
65						
70						
75						

CH2MHILL

PROJECT NUMBER: 353102.TT.03 **TEST PIT NUMBER:** TP-1

TEST PIT LOG

PROJECT: Chelan Tailrace Pump Station **LOCATION:** North end of proposed canal

CONTRACTOR: KRCI, Wenatchee, WA **DATE EXCAVATED:** 1/15/07

EXCAVATION EQUIPMENT: CAT 312 Excavator w/ 2' wide bucket

WATER LEVEL: Not encountered **SURFACE ELEVATION:** 720.9' **LOGGER:** M. Bouchedid

DEPTH BELOW	SAMPLE NUMBER	SAMPLE TYPE	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DIFFICULTY IN EXCAVATION, RUNNING GRAVEL CONDITION, COLLAPSE OF WALLS, SAND HEAVE, DEBRIS ENCOUNTERED, WATER SEEPAGE, GRADATIONAL CONTACTS, TESTS, INSTRUMENTATION
0			Ground Surface	
			Surface is covered with rocks, boulders, cobbles, gravel and sand (alluvium). Rocks up to 5' diameter scattered all over site.	Note: cobbles and boulders not included in samples. Started excavation at 13:20 with a CASE 580 Super K backhoe provided by Chelan PUD.
1			**WELL GRADED GRAVEL (GW),** brown and gray, slightly moist, very hard, fine to course gravel, rounded to subrounded gravel, several boulders up 3' diameter, estimated 5% sand.	Top 1' is frozen. Backhoe operator reports very hard excavation.
2				
3				
4				Operator reports hit large boulder at 5' at 14:00. Can not go deeper. Need larger equipment. Started excavating from 5' bgs with CAT 312 excavator at 14:40.
5	1	GRAB	**WELL GRADED GRAVEL WITH SAND, GW,** brown and gray, slightly moist to moist, very hard, fine to course gravel, rounded to subrounded gravel from 2' to 6' bgs, subrounded to subangular gravel from 6' to 9' bgs, scattered cobbles and boulders up to 5' diameter.	M.C.=0.9% Gravel=78% Sand=21.4% Fines=0.6% Side walls caving in at 6' depth. Large 3' diameter boulder extends from 4.5' to 7.5 bgs on east side of hole. 2.5' boulder on west side of hole at 6.5'. Operator reports hard excavation at 15:00. Not confident can go to 12' bgs.
6				
7				
8				Operator reports large boulder at 9'. Can't go through it. Done backfilling test pit at 15:15.
9			Bottom of test pit at 9'. End of Excavation	No water seepage observed during excavation. Heavy caving observed during excavation below 6'. Final test pit dimensions before backfilling: Length=16', Width=5.5', Depth=9'
10				

CH2MHILL

PROJECT NUMBER: 353102.TT.03 **TEST PIT NUMBER:** TP-2

TEST PIT LOG

PROJECT: Chelan Tailrace Pump Station **LOCATION:** North end of proposed canal

CONTRACTOR: KRCI, Wenatchee, WA **DATE EXCAVATED:** 1/15/07

EXCAVATION EQUIPMENT: CAT 312 Excavator w/ 2' wide bucket

WATER LEVEL: Not encountered **SURFACE ELEVATION:** 721.6' **LOGGER:** M. Bouchedid

DEPTH BELOW	SAMPLE NUMBER	SAMPLE TYPE	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DIFFICULTY IN EXCAVATION, RUNNING GRAVEL CONDITION, COLLAPSE OF WALLS, SAND HEAVE, DEBRIS ENCOUNTERED, WATER SEEPAGE, GRADATIONAL CONTACTS, TESTS, INSTRUMENTATION
0			Ground Surface Surface is covered with rocks, boulders, cobbles, gravel and sand (alluvium). Rocks up to 5' diameter scattered all over site.	Note: cobbles and boulders not included in samples. Started excavation at 14:10 with a CASE 580 Super K backhoe provided by Chelan PUD.
1			**WELL GRADED GRAVEL (GW),** brown and gray, slightly moist, very hard, fine to course gravel, rounded to subrounded gravel, several boulders up 3' diameter, estimated 5% sand, estimated <5% fines.	Top 1' is frozen. Backhoe operator reports large boulder at 2' at 14:30. Can't go deeper.
2				Started excavating with CAT 312 excavator at 15:15 at 2' bgs.
3				
4				
5				
6				
7				Side walls caving in from all sides below 7' depth
8				
9			**POORLY GRADED GRAVEL WITH SILT AND SAND, GP-GM,** brown and gray, slightly moist to moist, very hard, fine to course gravel, rounded to subrounded gravel from 2' to 6' bgs, subrounded to subangular gravel from 6' to 10.5' bgs, scattered cobbles and boulders up to 3' diameter.	M.C.=1.8% Gravel=75.6% Sand=16.9% Fines=7.5%
10	1	GRAB		

CH2MHILL

PROJECT NUMBER: 353102.TT.03 **TEST PIT NUMBER:** TP-2
Sheet: 2 of 2

TEST PIT LOG

PROJECT: Chelan Tailrace Pump Station **LOCATION:** North end of proposed canal
CONTRACTOR: KRCI, Wenatchee, WA **DATE EXCAVATED:** 1/15/07
EXCAVATION EQUIPMENT: CAT 312 Excavator w/ 2' wide bucket
WATER LEVEL: Not encountered **SURFACE ELEVATION:** 721.6' **LOGGER:** M. Bouchedid

DEPTH BELOW	SAMPLE NUMBER	SAMPLE TYPE	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DIFFICULTY IN EXCAVATION, RUNNING GRAVEL CONDITION, COLLAPSE OF WALLS, SAND HEAVE, DEBRIS ENCOUNTERED, WATER SEEPAGE, GRADATIONAL CONTACTS, TESTS, INSTRUMENTATION
11			Bottom of test pit at 10.5'. End of Excavation	Done backfilling hole at 15:45. No water seepage observed during excavation. Heavy caving observed during excavation below 7'. Final test pit dimensions before backfilling: Length=14', Width=6', Depth=10.5'
12				
13				
14				
15				
16				
17				
18				
19				
20				

CH2MHILL

PROJECT NUMBER: 353102.TT.03 **TEST PIT NUMBER:** TP-3
Sheet: 1 of 1

TEST PIT LOG

PROJECT: Chelan Tailrace Pump Station **LOCATION:** Middle of proposed canal
CONTRACTOR: KRCI, Wenatchee, WA **DATE EXCAVATED:** 1/15/07
EXCAVATION EQUIPMENT: CAT 312 Excavator w/ 2' wide bucket
WATER LEVEL: Not encountered **SURFACE ELEVATION:** 720.0' **LOGGER:** M. Bouchedid

DEPTH BELOW	SAMPLE NUMBER	SAMPLE TYPE	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DIFFICULTY IN EXCAVATION, RUNNING GRAVEL CONDITION, COLLAPSE OF WALLS, SAND HEAVE, DEBRIS ENCOUNTERED, WATER SEEPAGE, GRADATIONAL CONTACTS, TESTS, INSTRUMENTATION
0			Ground Surface	
			Surface is covered with rocks, boulders, cobbles, gravel and sand (alluvium). Rocks up to 5' diameter scattered all over site.	Note: cobbles and boulders not included in samples. Started excavation at 15:50.
1			**WELL GRADED GRAVEL (GW),** brown and gray, slightly moist, very hard, fine to course gravel, rounded to subrounded gravel, several boulders up 3' diameter, estimated 5% sand, estimated <5% fines.	Top 1' is frozen.
2				
3				
4				Large 4' diameter boulder at 6' bgs.
5				
6				Side walls caving in from all sides below 6' depth.
	1	GRAB	**WELL GRADED GRAVEL WITH SAND (GW),** brown and gray, slightly moist to moist, very hard, fine to course gravel, rounded to subrounded gravel to 6' bgs, subrounded to subangular gravel from 6' to 8' bgs, scattered cobbles and boulders up to 4' diameter, estimated 20% sand, estimated <5% fines.	
7				
8			Bottom of test pit at 8'.	Done backfilling hole at 16:20 No water seepage observed during excavation. Heavy caving observed during excavation below 6'.
			End of Excavation	Final test pit dimensions before backfilling: Length=15', Width=10', Depth=8'
9				
10				

CH2MHILL

PROJECT NUMBER: 353102.TT.03 **TEST PIT NUMBER:** TP-4
Sheet: 1 of 2

TEST PIT LOG

PROJECT: Chelan Tailrace Pump Station **LOCATION:** Middle of proposed canal
CONTRACTOR: KRCI, Wenatchee, WA **DATE EXCAVATED:** 1/16/07
EXCAVATION EQUIPMENT: CAT 312 Excavator w/ 2' wide bucket
WATER LEVEL: 11' bgs **SURFACE ELEVATION:** 718.7' **LOGGER:** M. Bouchedid

DEPTH BELOW	SAMPLE NUMBER	SAMPLE TYPE	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DIFFICULTY IN EXCAVATION, RUNNING GRAVEL CONDITION, COLLAPSE OF WALLS, SAND HEAVE, DEBRIS ENCOUNTERED, WATER SEEPAGE, GRADATIONAL CONTACTS, TESTS, INSTRUMENTATION
0			Ground Surface Surface is covered with rocks, boulders, cobbles, gravel and sand (alluvium). Rocks up to 5' diameter scattered all over site.	Note: cobbles and boulders not included in samples. Started excavation at 8:50.
1			**WELL GRADED GRAVEL (GW),** brown and gray, slightly moist, very hard, fine to course gravel, rounded to subrounded gravel, several boulders up 3' diameter, estimated 5% sand, estimated <5% fines.	Top 1' is frozen.
2				
3				
4				2.5' diameter boulder at 4'.
5			**WELL GRADED GRAVEL WITH SAND (GW),** brown and gray, slightly moist to moist, very hard, fine to course gravel, rounded to subrounded gravel from 2' to 6' bgs, subrounded to subangular gravel from 6' to 11.5' bgs, scattered cobbles and boulders up to 5' diameter, estimated 15-20% sand, estimated <5% fines.	
6				Side walls caving in from all sides starting at 6' depth. 3' diameter boulder at 6'.
7				5' diameter rock on side wall between 2' and 7'.
8				
9				
10				Soils are sandier starting at 10'.

CH2MHILL

PROJECT NUMBER: 353102.TT.03 **TEST PIT NUMBER:** TP-4
Sheet: 2 of 2

TEST PIT LOG

PROJECT: Chelan Tailrace Pump Station **LOCATION:** Middle of proposed canal
CONTRACTOR: KRCI, Wenatchee, WA **DATE EXCAVATED:** 1/16/07
EXCAVATION EQUIPMENT: CAT 312 Excavator w/ 2' wide bucket
WATER LEVEL: 11' bgs **SURFACE ELEVATION:** 718.7' **LOGGER:** M. Bouchedid

DEPTH BELOW	SAMPLE NUMBER	SAMPLE TYPE	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DIFFICULTY IN EXCAVATION, RUNNING GRAVEL CONDITION, COLLAPSE OF WALLS, SAND HEAVE, DEBRIS ENCOUNTERED, WATER SEEPAGE, GRADATIONAL CONTACTS, TESTS, INSTRUMENTATION
11	1	GRAB	**POORLY GRADED GRAVEL WITH SAND, GP,** brown and gray, slightly moist to moist, very hard, fine to course gravel, predominantly coarse gravel, subrounded to subangular gravel, fine to coarse snad.	M.C.=4.0% Gravel=67% Sand=31.4% Fines=1.6% Water seeping from bottom of test pit at 11' (water table at 11' bgs).
12			Bottom of test pit at 11.5'. End of Excavation	Done backfilling hole at 9:28. Water seepage observed during excavation at 11' bgs. Heavy caving observed during excavation below 6'. Final test pit dimensions before backfilling: Length=15', Width=7', Depth=11.5'
13				
14				
15				
16				
17				
18				
19				
20				

CH2MHILL

PROJECT NUMBER: 353102.TT.03 **TEST PIT NUMBER:** TP-5
Sheet: 1 of 2

TEST PIT LOG

PROJECT: Chelan Tailrace Pump Station **LOCATION:** South end of proposed canal
CONTRACTOR: KRCI, Wenatchee, WA **DATE EXCAVATED:** 1/16/07
EXCAVATION EQUIPMENT: CAT 312 Excavator w/ 2' wide bucket
WATER LEVEL: Not encountered **SURFACE ELEVATION:** 721.7' **LOGGER:** M. Bouchedid

DEPTH BELOW	SAMPLE NUMBER	SAMPLE TYPE	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DIFFICULTY IN EXCAVATION, RUNNING GRAVEL CONDITION, COLLAPSE OF WALLS, SAND HEAVE, DEBRIS ENCOUNTERED, WATER SEEPAGE, GRADATIONAL CONTACTS, TESTS, INSTRUMENTATION
0			Ground Surface	Note: cobbles and boulders not included in samples. Started excavation at 9:31.
			Surface is covered with rocks, boulders, cobbles, gravel and sand (alluvium).	Top 1' is frozen.
1				
2				
3				
4				
5				Side walls caving in from all sides below 5' depth
6				
7				
8	1	GRAB	**WELL GRADED GRAVEL WITH SAND, GW,** brown and gray, slightly moist to moist, very hard, fine to course gravel, rounded to subrounded gravel, scattered cobbles and boulders up to 2' diameter.	M.C.=1.7% Gravel=70.6% Sand=27.1% Fines=2.2%
9				
10				

CH2MHILL

PROJECT NUMBER: 353102.TT.03 **TEST PIT NUMBER:** TP-5
Sheet: 2 of 2

TEST PIT LOG

PROJECT: Chelan Tailrace Pump Station **LOCATION:** South end of proposed canal
CONTRACTOR: KRCI, Wenatchee, WA **DATE EXCAVATED:** 1/16/07
EXCAVATION EQUIPMENT: CAT 312 Excavator w/ 2' wide bucket
WATER LEVEL: Not encountered **SURFACE ELEVATION:** 721.7' **LOGGER:** M. Bouchedid

DEPTH BELOW	SAMPLE NUMBER	SAMPLE TYPE	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DIFFICULTY IN EXCAVATION, RUNNING GRAVEL CONDITION, COLLAPSE OF WALLS, SAND HEAVE, DEBRIS ENCOUNTERED, WATER SEEPAGE, GRADATIONAL CONTACTS, TESTS, INSTRUMENTATION
11			Bottom of test pit at 11'. End of Excavation	Done backfilling hole at 10:00. No water seepage observed during excavation. Heavy caving observed during excavation below 5'. Final test pit dimensions before backfilling: Length=15', Width=8.5', Depth=11'
12				
13				
14				
15				
16				
17				
18				
19				
20				

CH2MHILL

PROJECT NUMBER: 353102.TT.03 **TEST PIT NUMBER:** TP-6
Sheet: 1 of 1

TEST PIT LOG

PROJECT: Chelan Tailrace Pump Station **LOCATION:** South end of proposed canal
CONTRACTOR: KRCI, Wenatchee, WA **DATE EXCAVATED:** 1/16/07
EXCAVATION EQUIPMENT: CAT 312 Excavator w/ 2' wide bucket
WATER LEVEL: Not encountered **SURFACE ELEVATION:** 721.2' **LOGGER:** M. Bouchedid

DEPTH BELOW	SAMPLE NUMBER	SAMPLE TYPE	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DIFFICULTY IN EXCAVATION, RUNNING GRAVEL CONDITION, COLLAPSE OF WALLS, SAND HEAVE, DEBRIS ENCOUNTERED, WATER SEEPAGE, GRADATIONAL CONTACTS, TESTS, INSTRUMENTATION
0			Ground Surface	
			Surface is covered with rocks, boulders, cobbles, gravel and sand (alluvium).	Note: cobbles and boulders not included in samples. Started excavation at 10:05.
1				Top 1' is frozen.
2				
3				
4				
5				Stopped excavation at 5' at 10:15. Excavator had to excavate another urgent test pit for another contractor. Resumed drilling at 11:05.
6				Side walls caving in from all sides below 6' depth.
7				
8			**WELL GRADED GRAVEL WITH SAND, GW,** brown and gray, slightly moist to moist, very hard, fine to course gravel, rounded to subrounded gravel, scattered cobbles and boulders up to 2' diameter.	M.C.=1.7% Gravel=73.1% Sand=24.7% Fines=2.2% Done backfilling hole at 11:35. No water seepage observed during excavation. Heavy caving observed during excavation below 6'.
9	1	GRAB		
			Bottom of test pit at 9.5'.	Final test pit dimensions before backfilling: Length=16', Width=9', Depth=9.5'
10			End of Excavation	

Appendix B
Laboratory Test Results

APPENDIX B

Laboratory Testing Program

GeoEngineers, of Redmond, Washington performed laboratory testing that included natural moisture content and grain size analyses. A summary of the laboratory testing results is presented in Table 3 and the results are also incorporated in the soil boring logs in Appendix A of this Geotechnical Data Report. Brief descriptions of the various laboratory tests follow.

B.1 Visual Description

The visual description of soils allows convenient and consistent comparison of soils using a standard method for describing the soil. The use of this method of classification provides a basis for comparison of soils from widespread geographic areas. Visual classification of soils was performed in general accordance with ASTM D 2488.

B.2 Natural Moisture Content Test

The natural moisture content test determines the weight of water contained in a given weight of soil. The results are usually presented as the weight of water divided by the weight of dry solids, expressed as a percentage. Moisture content (along with unit weight and specific gravity of solids) provides the basis for determining the phase relationships of a soil and may be useful in estimating soil consistency, compressibility, and strength. Natural moisture content was determined in general accordance with ASTM D 2216.

B.3 Grain Size (Sieve) Analyses

Grain size, or sieve, analyses were conducted in general accordance with ASTM D 422, Standard Method for particle Size Analysis of Soils. The lab procedure includes (a) mechanical sieve analysis for samples estimated to contain less than 50 percent fines (material passing the No. 200 sieve), and (b) combined (sieve and hydrometer) analysis for samples estimated to have at least 50 percent fines content. The sieve analysis consists of shaking soil through a stack of progressively smaller opening screens, each with known opening size and determining the portion (by weight) of particles retained on each sieve. They hydrometer analysis is based on Stoke's law for the velocity of a freely falling sphere. The method involves determining the settling rate of soil particles by measuring the density of the soil water solution and calculating the particle size in suspension at particular time intervals.

B.4 Soil Classification Systems

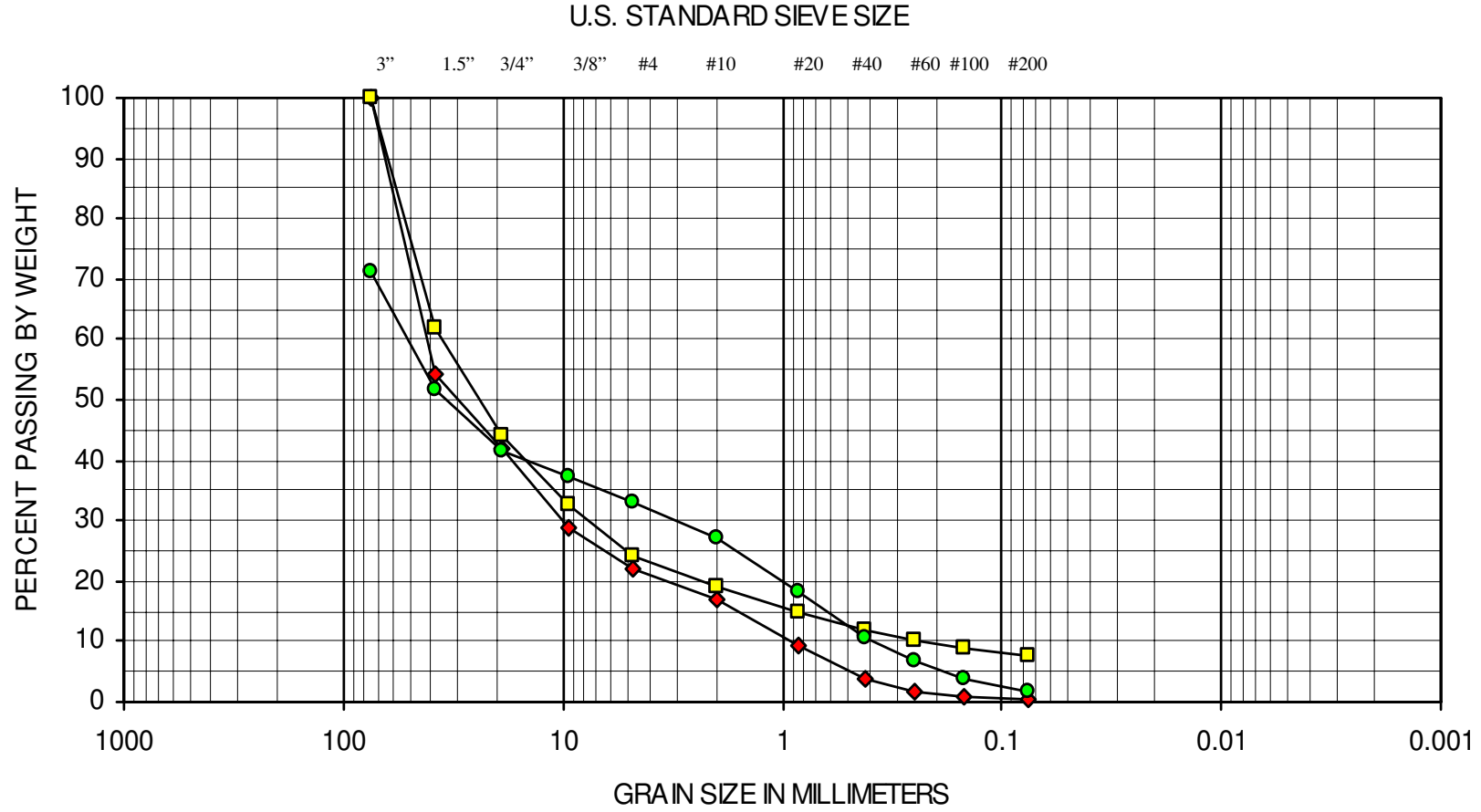
Soil classification systems attempt to group soil with similar engineering behavior based on index tests. A number of classification systems have been developed, usually for a specific application. The system most generally accepted for a wide range of engineering application is the ASTM soil classification system, based on the Unified Soil Classification System (USCS).

Soil classification systems generally use index test methods (particle size analysis and Atterberg limits) to permit rational grouping of the soil. Laboratory classification of soil was performed in general accordance with ASTM D 2487. The corrected soil classifications can be identified from the exploration logs as those not enclosed in parenthesis.

GEOENGINEERS

FIGURE

SIEVE ANALYSIS RESULTS



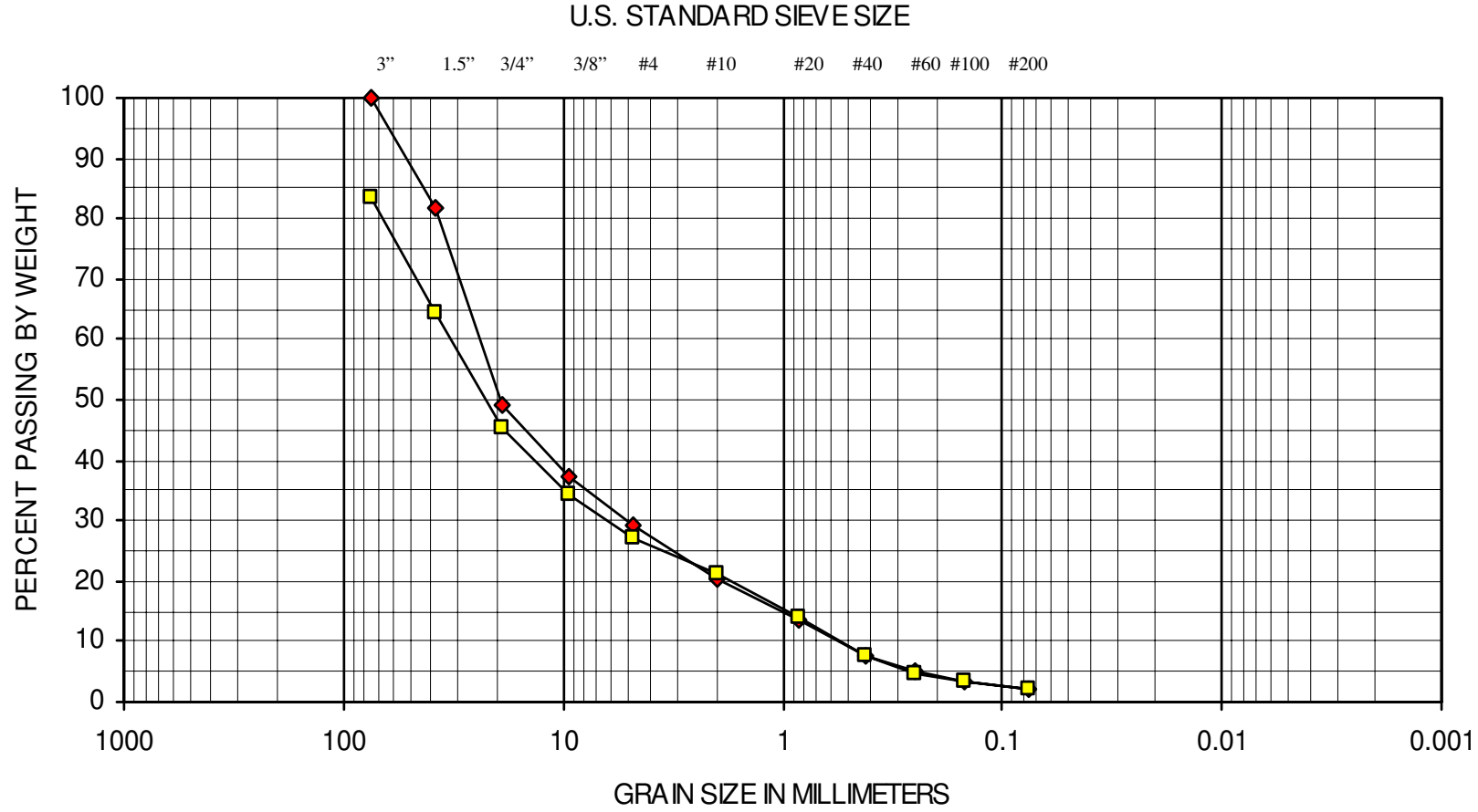
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	DEPTH (ft)	SOIL CLASSIFICATION
◆	TP-1	5-5.5	Gray well graded gravel with sand (GW)
□	TP-2	9-10	Gray poorly graded gravel with silt and sand (GP-GM)
○	TP-4	10.5-11	Gray poorly graded gravel with sand (GP)

GEOENGINEERS

FIGURE

SIEVE ANALYSIS RESULTS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	DEPTH (ft)	SOIL CLASSIFICATION
◆	TP-5	8-8.5	Gray well graded gravel with sand (GW)
■	TP-6	9-9.5	Gray well graded gravel with sand (GW)

Appendix C
Existing Geotechnical Information

APPENDIX C

Existing Geotechnical Information

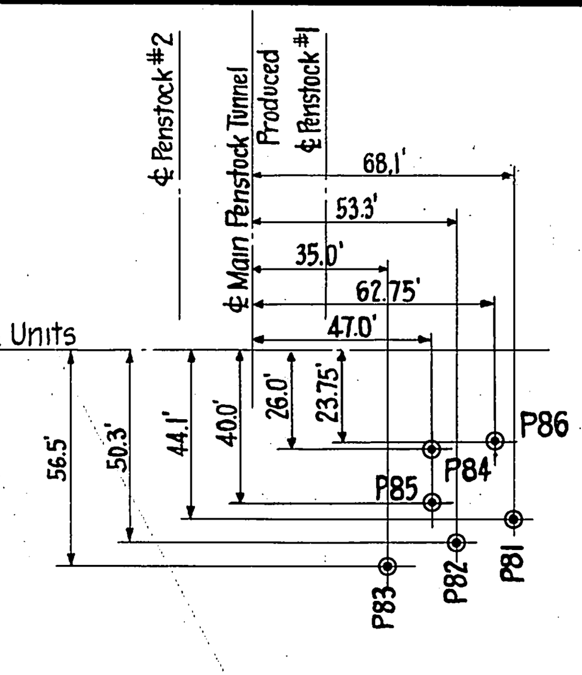
This appendix consists of a copy of borings performed in 1926 for the construction of the powerhouse and a geotechnical report that was prepared for the construction of a bridge on the west bank of the tailrace. A short movie summarizing the work that was done on the bridge foundations is available upon request.

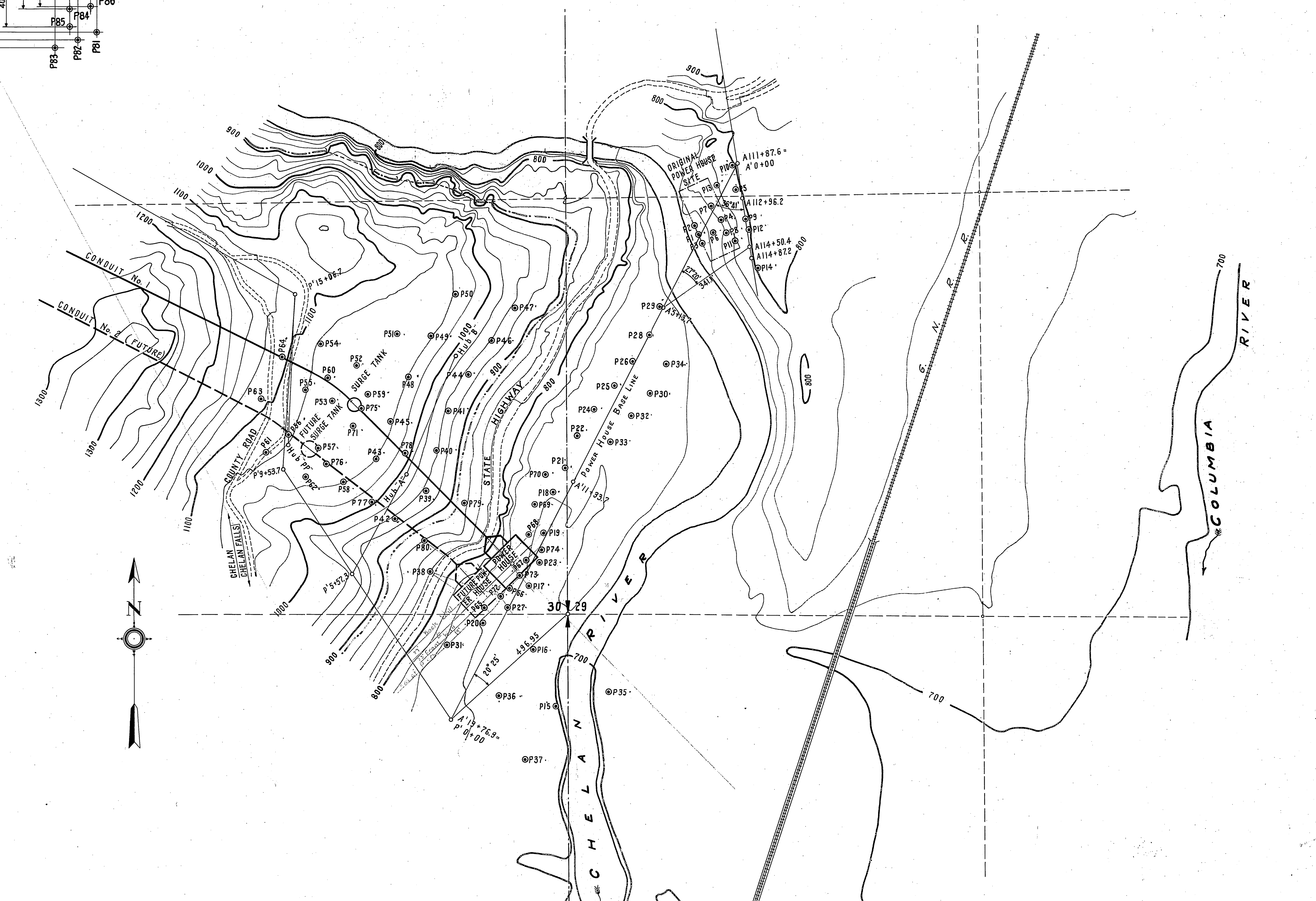
E 2777

TIES TO TEST HOLES P1 TO P80 INCL.
IN VICINITY OF
ORIGINAL AND FINAL POWER HOUSE SITES AND FINAL SURGE TANK SITE

HOLE NO.	TRANSIT AT STA.	FORESIGHT	DEFLECTION ANGLE RIGHT	DEFLECTION ANGLE LEFT	DISTANCE (CHAINED)	DISTANCE (COMPUTED)	ELEVATION	REMARKS
P1	A112+96.2	A114+87.0	59°44'				725.0	Holes P1 to P8 incl., P11
"	A114+87.0	A112+96.2		56°21'		183.47	"	and P35 computed for dis-
P2	A112+96.2	A114+50.4	69°35½'				723.2	tance, from intersections
"	A114+50.4	A112+96.2		60°12'		188.08	"	shown.
P3	A112+96.2	A114+50.4	51°05'				725.3	Located but not drilled
"	A114+50.4	A112+96.2		76°14'		150.86	"	
P4	A112+96.2	A114+50.4	54°07'				745.3	
"	A114+50.4	A112+96.2		36°36'		124.94	"	
P5	A112+96.2	A111+31.0		27°24'		36.67	797.2	
"	A111+31.0	A112+96.2	7°15'				"	
P6	A112+96.2	A114+50.4	50°01'				730.1	
"	A114+50.4	A112+96.2		58°00'		124.24	"	
P7	A112+96.2	A114+50.4	86°00'				750.0	
"	A114+50.4	A112+96.2		33°48'		177.27	"	
P8	A112+96.2	A114+50.4	34°15'				748.8	
"	A114+50.4	A112+96.2		49°22'		87.32	"	
P9	Hole N°P	9 is located	on the "A"	Line at	Sta. A113+61.0		799.0	
P10	A112+96.2	A114+50.4	171°30'		108.00		797.6	
P11	A112+96.2	A114+50.4	18°04'					Located but not drilled.
"	A114+50.4	A112+96.2		56°53'		49.53		
P12	A114+50.4	A112+96.2	4°10'		53.00		799.03	
P13	A111+87.6	A112+96.2	52°47'		92.50		776.5	
P14	A114+50.4	A112+96.2	168°38'		67.00		807.9	
P15	West ¼ Cor. Sec. 29	NW. Cor.–S.W. ¼ of S.W. ¼ Sec. 29	8°05		297.00		702.9	See below for location of
P16	A'19+76.9	A'11+33.7	22°25'		342.00		711.7	West ¼ Cor. Sec. 29
P17	A'11+33.7	A'19+76.9		3°52'	357.00		714.6	
P18	A'11+33.7	A'19+76.9	3°52'		71.00		725.9	
P19	A'11+33.7	A'19+76.9	2°28'		187.00		718.5	
P20	A'19+76.9	A'11+33.7		9°40'	321.00		725.3	
P21	A'11+33.7	A'5+13.7		54°15'	49.70		729.6	
P22	A'11+33.7	A'5+13.7		21°40'	147.00		730.3	
P23	A'11+33.7	A'19+76.9		3°11'	277.00		716.3	
P24	A'11+33.7	A'5+13.7		11°09'	240.00		730.3	
P25	A'11+33.7	A'5+13.7		3°52'	332.00		732.0	
P26	A'5+13.7	A'11+33.7	0°53'		195.00		733.0	
P27	A'19+76.9	A'11+33.7		0°35'	395.00		718.1	
P28	A'5+13.7	A'11+33.7		1°39'	94.00		735.4	
P29	A'5+13.7	A'11+33.7	90°00'		6.30		737.4	
P30	A'5+13.7	A'19+76.9		19°07'	273.00		733.21	
P31	A'19+76.9	A'5+13.7		31°15'	236.00		747.55	
P32	A'11+33.7	A'5+13.7	13°56'		277.00		731.3	
P33	A'11+33.7	A'5+13.7	15°21'		172.00		727.5	
P34	A'11+33.7	A'5+13.7	11°15'		47.50		734.46	
P35	A'19+76.9	A'5+13.7	52°27'			503.60	715.0	
"	A'5+13.7	A'19+76.9		19°03'			"	
P36	A'19+76.9	A'5+13.7	35°10'		165.00		723.4	
P37	A'19+76.9	A'5+13.7	91°37'		261.00		707.7	
P38	A'19+76.9	A'11+33.7		34°41'	472.00		819.6	
P39	P'5+57.3	P'9+53.7	74°52'		348.00		950.5	
P40	Hole N° P39	P'5+57.3	152°05'		131.00		950.7	
P41	Hub "B"	Hub "A"		15°00'	173.80		950.9	See below for location
P42	P'5+57.3	P9+53.7	70°16'		217.00		950.3	of Hub "A" and Hub "B"
P43	Hub "A"	P'5+57.3	88°15'		107.30		1050.7	"
P44	Hub "B"	Hub "A"		56°20'	74.20		952.7	"
P45	Hub "A"	P'5+57.3	135°28'		174.00		1052.6	"
P46	Hub "B"	Hub "A"		134°41'	124.70		955.36	"
P47	Hub "B"	Hub "A"		151°00'	246.00		954.9	"
P48	Hub "A"	P'5+57.3	152°30'		306.30		1053.6	"
P49	P'15+06.7	P'9+53.7		77°07'	442.50		1059.34	Located but not drilled
P50	P'15+06.7	P'9+53.7		94°05'	501.80		1048.9	
P51	P'15+06.7	P'9+53.7		72°42'	342.00		1063.62	Located but not drilled
P52	P'15+06.7	P'9+53.7		44°11'	293.00		1065.0	
P53	P'15+06.7	P'9+53.7		22°50'	355.70		1064.25	
P54	P'15+06.7	P'9+53.7		30°43'	173.30		1072.33	
P55	P'15+06.7	P'9+53.7		8°35'	303.30		1071.64	
P56	P'9+53.7	P'15+06.7	4°19'		111.00		1075.7	
P57	P'9+53.7	P'15+06.7	55°20'		131.00		1063.6	
P58	P'9+53.7	P'5+57.3		44°52'	194.40		1051.6	
P59	P'15+06.7	P'9+53.7		39°36'	387.90		1070.1	Located but not drilled
P60	P'15+06.7	P'9+53.7		24°53'	282.40		1062.7	
P61	Hub "PP"	P'15+06.7		107°14'	74.70		1079.0	For location Hub "PP"
P62	Hub "PP"	P'15+06.7	152°45'		106.20		1059.9	see below
P63	Hub "PP"	P'15+06.7		32°46'	177.00		1103.0	
P64	Hub "PP"	P'15+06.7		6°59'	285.40		1111.6	
P65	A'19+76.9	A'11+33.7		10°41'	371.00		733.7	
P66	A'11+33.7	A'19+76.9	3°53'		388.00		734.5	
P67	A'19+76.9	A'11+33.7		2°11'	557.00		735.3	
P68	A'19+76.9	A'11+33.7		4°34'		636.39	735.2	For tie see below
P69	A'11+33.7	A'19+76.9	33°06'		138.00		734.5	
P70	A'11+33.7	A'19+76.9	80°20'		90.00		735.5	Located but not drilled
P71	Hub "PP"	P'15+06.7	69°15'		213.00		1068.22	For Hub "PP" see below.
P72	A'11+33.7	A'19+76.9	5°33'		426.00		734.9	
P73	A'11+33.7	A'19+76.9	3°11'		336.00		734.1	
P74	A'11+33.7	A'19+76.9		1°50'	233.00		717.2	
P75	Hub "PP"	P'15+06.7	59°27'		258.00		1071.0	For Hub "PP" see below
P76	Hub "PP"	P'15+06.7	111°46'		128.00		1064.75	"
P77	P'5+57.3	P'0+00		130°40'	233.90		1001.1	P'0+00 = A'19+76.9
P78	P'5+57.3	P'0+00		122°20'	411.10		1002.6	"
P79	P'5+57.3	P'0+00		88°03'	415.50		884.5	"
P80	P'5+57.3	P'0+00		80°30'	252.40		881.8	"
P81-86								NE Corner of P.H. - See Sketch
P66	A'11+33.7	A'19+76.9	3°53'		388.00		734.5	Field tie to test
	Distance from	P66	to P68		180.00			hole No. P68
P68	A'19+76.9	A'11+33.7		4°34			735.2	
Hub "PP"	P'15+06.7	P110+45.2		117°10'	481.25			
Hub "A"	P'5+57.3	P'9+53.7	61°41'		353.80			
Hub "B"	Hub "A"	P'5+57.3	173°47'		403.90			
W. ¼ Cor. Sec. 29	A'19+76.9	A'11+33.7	20°25'		496.95			
P93	P'9+53.7	P'15+06.7	31°36'		136.9'		1064.8	
P94	P'9+53.7	P'15+06.7	23°57'		189.6'		1067.09	

DRAWN: C.J. Maddox CHECKED: D.W. Howe NOTED:
TRACED: C.J. Maddox CORRECT: H.C. Bender NOTED:





LEGEND

○ ······ Station on traverse or control hub.

⊙P40 ···· Test Hole and number.

½ Section Corner

¼ Section Corner

The Geo. Brown Pipe. (24" Wood Stave)

NOTES

Map covers portion of Sec. 29 and Sec. 30 T.27N. R.23E. W.M.

Contour interval 25 feet.

See E2785 for log & definite location of holes P87-94

See S2718 (1"=50') for location of holes 2A, 6A, P15-80, P87-92, & P94

See S2730 (1"=50') for location of holes P15-38 & P87-92

CHELAN STATION
POWER HOUSE SITES
LOCATION OF EXPLORATION HOLES

SCALE 1 IN. = 200 FT. DATE: SEPT. 20, 1926

THE WASHINGTON WATER POWER COMPANY
SPOKANE, WASHINGTON

APPROVED [signature] CHIEF ENGINEER DATE Sept. 20, 1926

SHEET 1 OF 8 SHEETS

E 2777

CHELAN STATION
POWER HOUSE SITE NO. 1
LOG OF DIAMOND DRILL HOLES

SCALE NONE DATE: SEPT. 20, 1926

THE WASHINGTON WATER POWER COMPANY
SPOKANE, WASHINGTON

APPROVED [signature] CHIEF ENGINEER DATE Sept. 20 1926

SHEET 2 OF 8 SHEETS

E 2778

DRAWN C. J. Maddox CHECKED D. W. Howe NOTED
TRACED C. J. Maddox CORRECT [signature] NOTED

E 2779

CHELAN PROJECT
POWER HOUSE SITE NO. 2
LOG OF DIAMOND DRILL HOLES

SCALE: NONE DATE: MAR 23, 1926

THE WASHINGTON WATER POWER COMPANY
SPOKANE, WASHINGTON

APPROVED [signature] CHIEF ENGINEER DATE Mar. 23, 1926

SHEET 3 OF 8 SHEETS

E 2779

E 2780

	P30	P31	P32	P33	P34	P35	P36	P37	P38	P39	P40	P41	P42	P43	P44
Start	W.D. Mar 3, 1926	Mar 3, 1926	Mar 10, 1926	Mar 22, 1926	Mar 16, 1926	Mar 20, 1926	Mar 25, 1926	Mar 27, 1926	Mar 29, 1926	April 2, 1926	April 5, 1926	April 10, 1926	April 11, 1926	April 13, 1926	April 16, 1926 W.D.
Finish	Mar 9, 1926	Mar 13, 1926	Mar 15, 1926	Mar 25, 1926	Mar 20, 1926	Mar 28, 1926	Mar 27, 1926	Mar 31, 1926	April 1, 1926	April 8, 1926	April 11, 1926	April 19, 1926	April 16, 1926	April 21, 1926	April 22, 1926 D.D.
Start	D.D.	Mar 15, 1926												May 8, 1926	Start
Finish		Mar 19, 1926												May 16, 1926	Finish
	740								840	960	960	960	960	1060	960
	730								830						950
	720														940
	710														930
	700														920
	690														910
	680														900
	670								760						890
	660														880
	650														870
	640														860
	630										940				850
	620											830			840
	610														830
	600														820

~P43~

NOTE:- 3" Casing was driven to El 947.00 the casing became too tight. Casing was pulled and replaced by 4½" casing.

DRAWN: C.E. Peterson, CHECKED: O.M. Horn, NOTED:

TRACED: C.E. Peterson, CHECKED: W.P. Strandberg, NOTED:

CHELAN PROJECT
POWER HOUSE SITE NO. 2
LOG OF DIAMOND DRILL HOLES

SCALE: NONE DATE: MAR 23, 1926

THE WASHINGTON WATER POWER COMPANY
SPOKANE, WASHINGTON

APPROVED W.H. Grouser CHIEF ENGINEER DATE Mar. 23 1926

SHEET 4 OF 8 SHEETS

E 2780

CHELAN STATION
POWER HOUSE SITE NO. 2
LOG OF DIAMOND DRILL HOLES

SCALE: NONE DATE: SEPT. 20, 1926

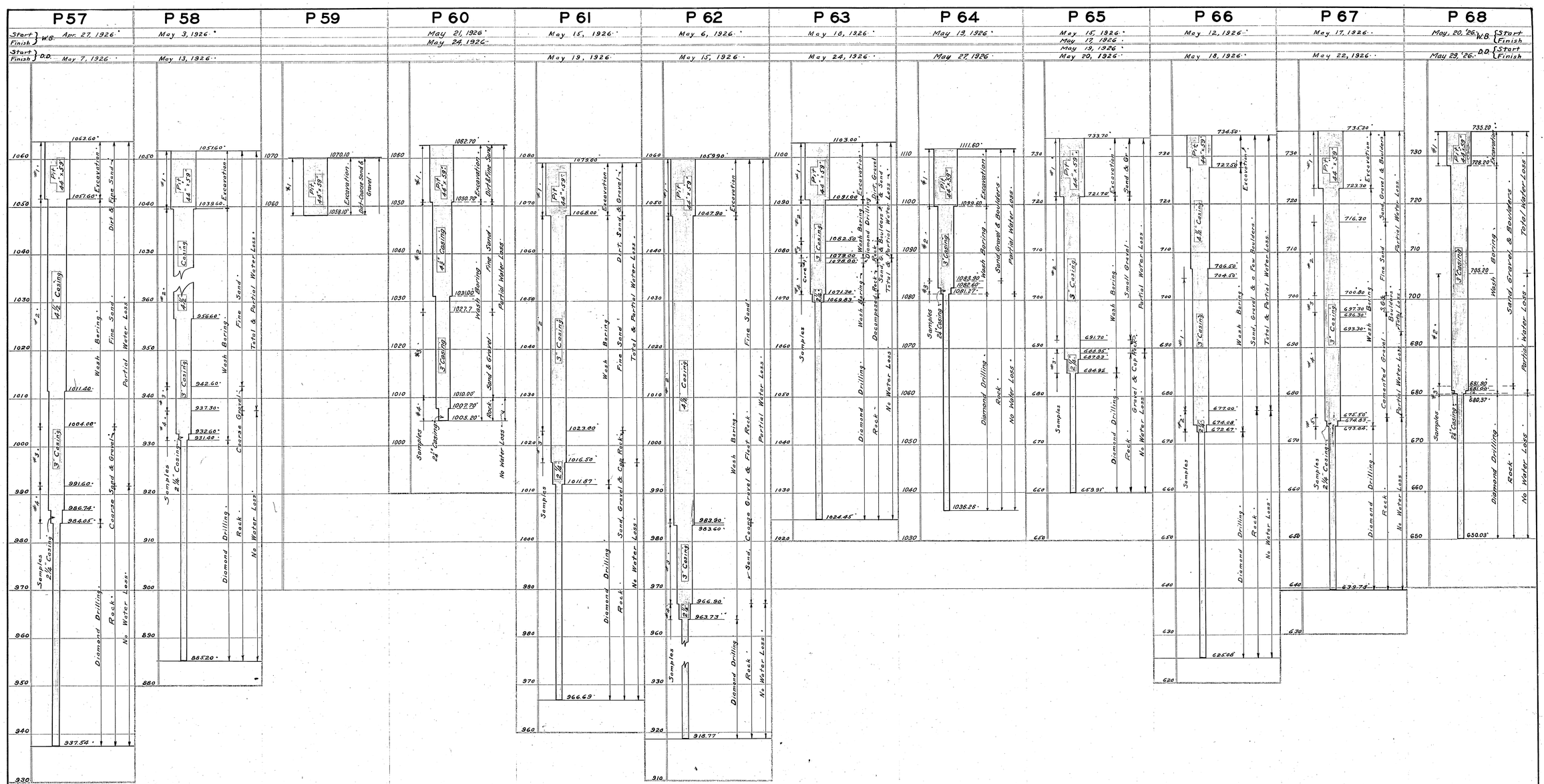
THE WASHINGTON WATER POWER COMPANY
SPOKANE, WASHINGTON

APPROVED: V.H. Greisser, CHIEF ENGINEER DATE: Sept. 20, 1926

SHEET 5 OF 8 SHEETS

E 2781

DRAWN: C.E. Peterson CHECKED: D.W. Howe NOTED:
TRACED: C.E. Peterson CORRECT: NOTED:



DRAWN D.W. Howe CHECKED C.E. Peterson NOTED
TRACED D.W. Howe CORRECT A.Monsen NOTED

CHELAN STATION
POWER HOUSE SITE NO. 2
LOG OF DIAMOND DRILL HOLES

SCALE NONE DATE SEPT. 20, 1926

THE WASHINGTON WATER POWER COMPANY
SPOKANE, WASHINGTON

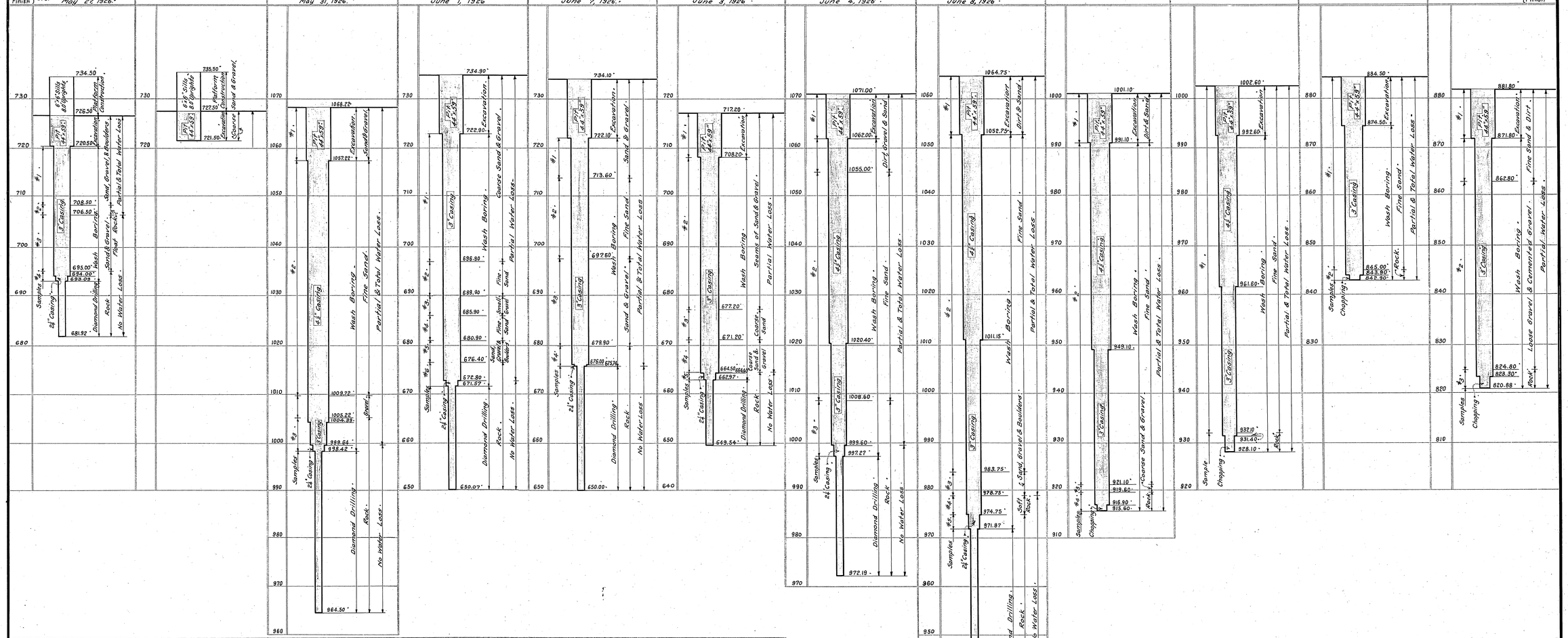
APPROVED V.M. Brown CHIEF ENGINEER DATE Sept. 20.1926

SHEET 6 OF 8 SHEETS

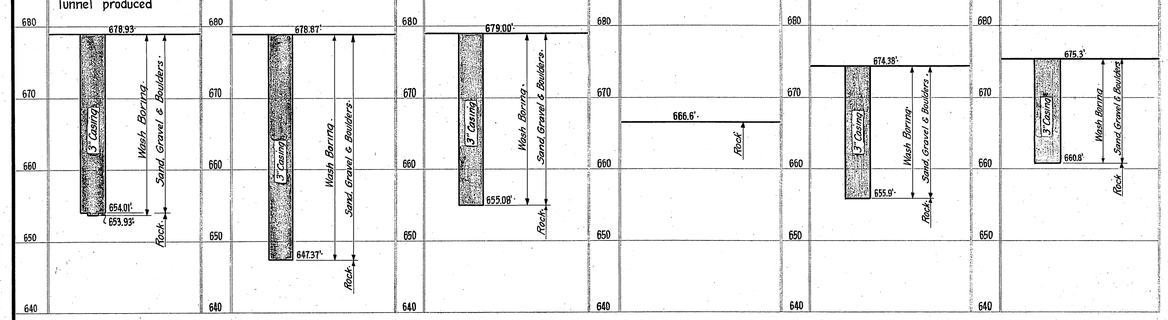
E 2782

E 2783

	P69	P70	P71	P72	P73	P74	P75	P76	P77	P78	P79	P80
Start W.B.	May 22, 1926.	May 15, 1926.	May 25, 1926.	May 26, 1926.	May 28, 1926.	May 31, 1926.	May 28, 1926.	May 31, 1926.	June 3, 1926.	June 10, 1926.	June 11, 1926.	June 8, 1926.
Finish W.B.	May 22, 1926.	May 16, 1926.	May 31, 1926.	June 1, 1926.	June 7, 1926.	June 3, 1926.	June 4, 1926.	June 8, 1926.	June 7, 1926.	June 12, 1926.	June 14, 1926.	June 10, 1926.
Start D.D.												
Finish D.D.	May 27, 1926.		May 31, 1926.	June 1, 1926.	June 7, 1926.	June 3, 1926.	June 4, 1926.	June 8, 1926.	June 7, 1926.	June 12, 1926.	June 14, 1926.	June 10, 1926.



	P81	P82	P83	P84	P85	P86
Start W.B.	Oct. 29, 1926.	Oct. 30, 1926.	Oct. 31, 1926.		Nov. 6, 1926.	Nov. 7, 1926.
Finish W.B.	Oct. 30, 1926.	Oct. 31, 1926.	Nov. 1, 1926.		Nov. 6, 1926.	Nov. 7, 1926.
	44.1' E, 68.1' N of Intersection of ℄ Units & ℄ Main Penstock Tunnel produced	50.3' E, 53.3' N of Same	56.5' E, 35.0' N of Same	26.0' E, 47.0' N. of Same	40.0' E, 47.0' N. of Same	23.75' E, 62.75' N. of Same



DRAWN C. J. Madden CHECKED D. W. Howe NOTED
TRACED C. J. Madden CORRECT A. H. Bowden NOTED

CHELAN STATION
POWER HOUSE SITE NO. 2
LOG OF DIAMOND DRILL HOLES

SCALE NONE DATE: SEPT. 20, 1926

THE WASHINGTON WATER POWER COMPANY
SPOKANE, WASHINGTON

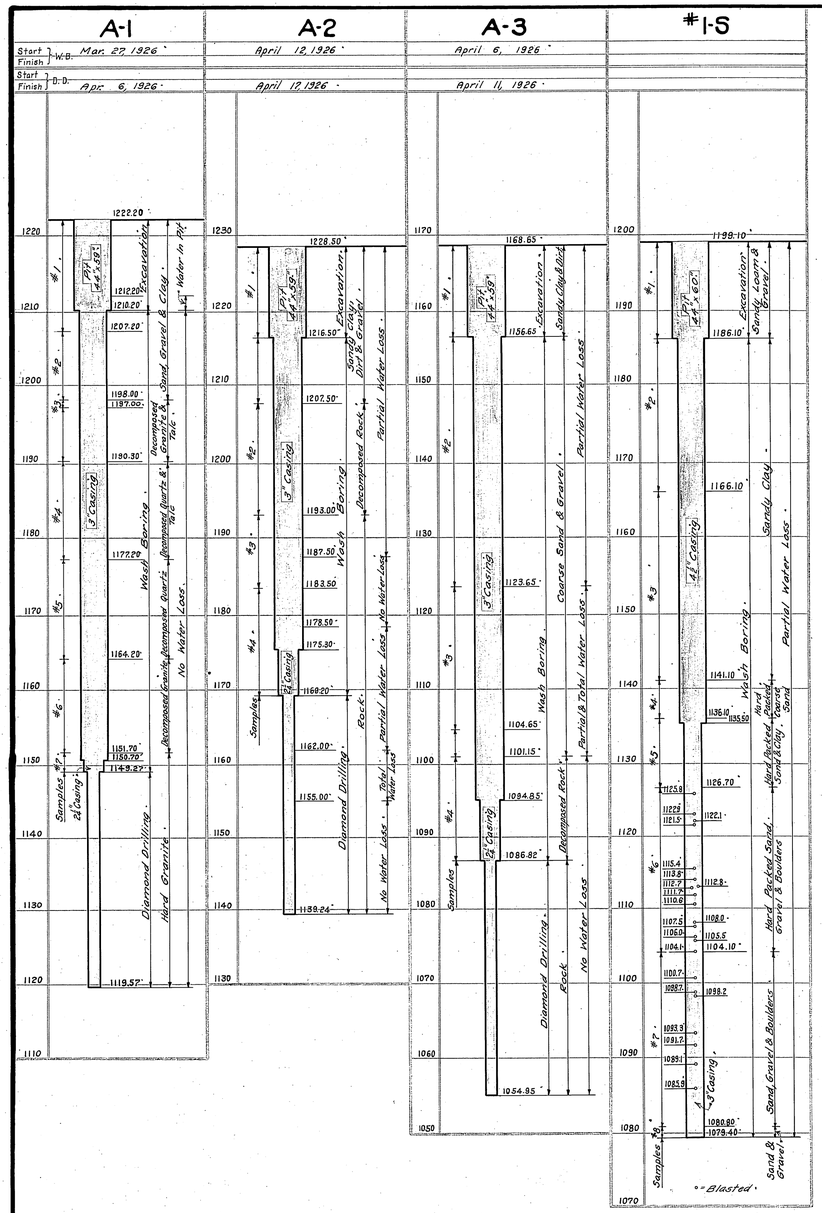
DATE	REVISION	BY	CHECKED
4-17-28	W.B. HOLES P81-86 ADDED	M.F. Murphy	A.H. Bowden

SHEET 7 OF 8 SHEETS

APPROVED W. G. Swasey CHIEF ENGINEER DATE Sept 20 1926

E 2783

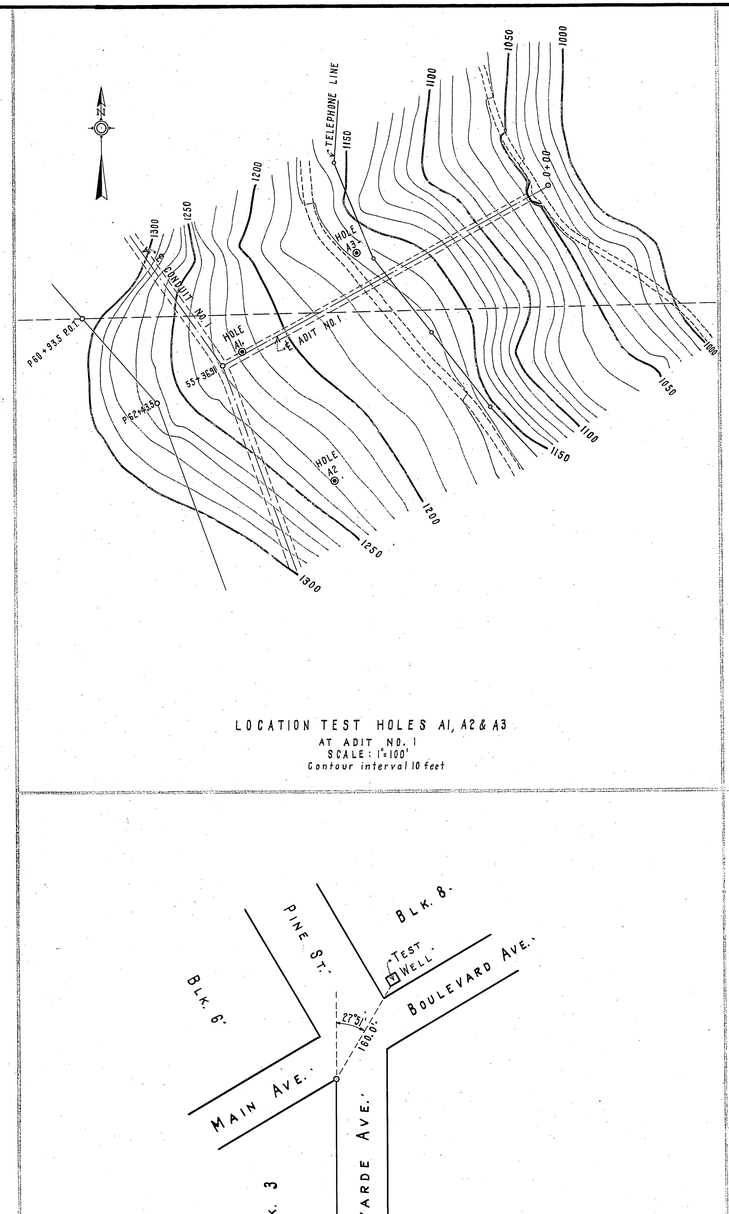
E 2784



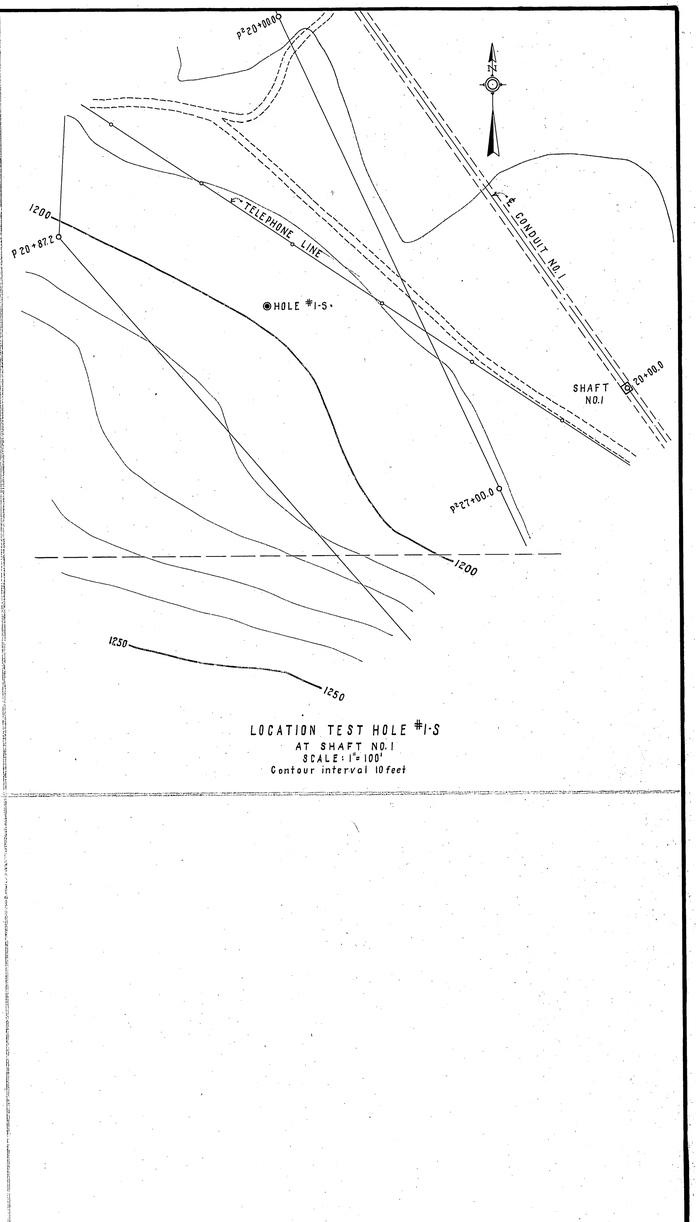
TIES TO MISCELLANEOUS TEST HOLES
IN VICINITY OF
ADIT NO. 1, SHAFT NO. 1 AND AT LAKE

HOLE	TRANSIT AT STA.	FORESIGHT	DEFLECTION ANGLE RIGHT	DEFLECTION ANGLE LEFT	DISTANCE (CHAINED)	DISTANCE (COMPUTED)	ELEVATION	REMARKS
A1	C 43+00.0	C 45+51.0		35° 00'			1083.2	At Adit No.1 Computed
"	C 46+51.0	C 43+00.0	109°45'			348.83	"	from intersections shown
A2	P 62+43.5	P 68+72.6		46°12'	261.00		1228.5	At Adit No.1
A3	P 60+93.5	P 35+00.0	117°40'		378.50		1168.7	"
A1	P 62+43.5	P 60+93.5	100°40'		134.00		1222.2	Tie above incorrect.
#1-S							1199.1	At Shaft No.1
Test Well	S 53+50.4	S 60+45.25	7°12'		181.50		1086.6	In Lake Park Addition to
"	See Sketch	See Sketch	27°51'		160.00		"	Lakeside

DRAWN C.J. Maddox CHECKED D.W. Howe NOTED
TRACED C.J. Maddox CORRECTED Richards NOTED



LOCATION TEST HOLES A1, A2 & A3
AT ADIT NO. 1
SCALE: 1"=100'
Contour interval 10 feet



LOCATION TEST HOLE #1-S
AT SHAFT NO. 1
SCALE: 1"=100'
Contour interval 10 feet

LOCATION OF TEST WELL FOR WATER SUPPLY
IN LAKE PARK ADDITION TO LAKESIDE.
NOT TO SCALE.

CHELAN STATION
LOG & LOCATION OF
MISCELLANEOUS EXPLORATION HOLES

SCALE AS SHOWN DATE: SEPT. 20, 1926

THE WASHINGTON WATER POWER COMPANY
SPOKANE, WASHINGTON

APPROVED V.M. Goodwin CHIEF ENGINEER DATE Sept. 20.1926

SHEET 8 OF 8 SHEETS

E 2784

September 28, 1991

MEMORANDUM

TO: Dan Garrison
FROM: Kim de Rubertis
SUBJECT: Chelan Falls Powerhouse
Draft Tube Deck Extension
Foundation Design

The purposes of this memo are to present the results of the field investigation, to outline the findings, to made a preliminary evaluation, and to suggest next steps to be taken.

Investigations.

Previous. The site was investigated in the 20's in connection with the original design and construction. Numerous borings were made, and copies of the boring logs and the location plan showing where the borings were made were examined. In general, the borings found alluvium consisting of sand, gravel, cobbles, and boulders overlying bedrock. The closest borings to the planned draft tube deck extension were P-19, P-65, P-72 and P-74. The logs from those borings were plotted on the present-day topography (attached) and used to estimate the depths to rock at the foundations for the deck extensions.

Present. To confirm the anticipated subsurface conditions, especially the feasibility of constructing drilled piers, two holes were drilled. One was drilled at the location for the south abutment, and one for the north abutment. The holes were drilled on September 19-21, 1991 by the Longyear Company. The rig used was a truck-mounted HC-44. The holes were drilled vertically with HQ wireline tools. The holes were advanced using mud as a drilling fluid and by reaming 4-in casing down as the hole advanced. Samples were taken in the overburden with the core barrel. Continuous cores were taken in rock. Water pressure tests were conducted in both holes in bedrock. Upon completion, both holes were backfilled and abandoned. The samples and cores were logged. Logs are attached. Samples and cores are stored in the garage near the powerhouse. Outcrops on

the north and south side of the powerhouse were examined to establish stratigraphic control and joint orientation and spacing.

Findings.

Both holes revealed the following subsurface conditions:

FILL consisting of sand, gravel, cobbles, and boulders up to at least 24 in, overlying

ALLUVIUM consisting of sand, gravel, cobbles, and boulders up to at least 18 in, overlying

BEDROCK consisting of banded, hard, dense gneiss.

The distinction between fill and alluvium is somewhat arbitrary because both are similar in composition; however, the alluvium contains considerably more sand.

Core recovery in both holes was essentially 100%. Rock Quality Designation (RQD) in both holes was excellent, ranging from 82% to 100%. No water loss was experienced in water pressure tests in the rock sections of both holes. Static water levels in both drill holes were pool level, about El 708.

The slope and orientation of the bedrock surface is concealed on both abutments.

Project personnel related that the south abutment slope failed and that failure was followed by construction of the sheet pile wall. Also related was an account of flooding on the north abutment (from a broken water pipe), giving rise to sinkhole formation in the switchyard. One sinkhole was observed in the switchyard during this investigation.

Preliminary Evaluation.

The purpose of this investigation was to characterize the subsurface conditions in the abutments in sufficient detail to evaluate the feasibility of

constructing deep foundations by drilled piers and to estimate the engineering properties of overburden and rock.

Constructing deep foundations by drilled piers is technically feasible. The boulders encountered, up to at least 24 in, can be handled during construction without great difficulty.

The fill does not possess suitable engineering properties for constructing a shallow foundation to support the 350-kip bridge loads because the fill is poorly consolidated and because, on the north abutment especially, temporary cuts in the fill would prejudice the stability of existing structures. A shallow foundation to support the bridge loads could experience up to one inch of settlement, even if care is observed in design and construction.

Shallow foundations for the abutment retaining and wingwalls can be founded in the fill provided that the following precautions are observed:

1. Establish a footing elevation at or above El 715 to avoid submergence after the pool raise,
2. Overexcavate about 12 in
3. Sluice the excavated surface with copious amount of water
4. Place 12 in of select (well graded 3-in minus, no fines) fill in two equal lifts each lift compacted by at least four passes of a 10-ton smooth-wheel vibratory roller (basically 95% of ASTM D-1557).
5. Limit foundation pressures to 2.0 ksf

Not knowing the configuration of the bedrock surface and knowing that it could be sloping steeply toward the tailrace mitigates against deep foundations *on* the bedrock surface, i. e. piles or piers founded directly on the bedrock surface may not make full contact with hard rock. Piers or piles socketed into rock are preferred. A minimum socket depth of 5 ft will reduce the risk of a "pop-out" along joints forming a wedge at the bedrock surface.

The design for a drilled pier should consider the following:

1. Assume that the presumptive bearing capacity of the bedrock is not less than 100 TSF.
2. Assume an allowable bearing capacity of the bedrock of not less than 25 TSF.
3. Design the pier so that the rock in the socket is exposed (not cased), and assume an allowable adhesion between the concrete and rock = $0.05f'_c$.
4. Assume that the pier can sustain an allowable horizontal load equal to the passive earth pressure acting on an equivalent wall with the depth six times the pile diameter and the width three times the pile diameter. For estimating passive earth pressure, assume a friction angle of 35°, $K_p = 3.7$, and a dry unit weight of soil = 130 pcf.

Next Steps. Prospective contractors should be given an opportunity to review the logs and view the cores and the site, if possible, so that the design team might gain additional information on constructability and cost. This memo should be reviewed for completeness and reasonableness of design recommendations.

LAKE CHELAN HYDROELECTRIC PROJECT
CHELAN FALLS POWERHOUSE DRAFT TUBE DECK EXTENSION
LOG OF SOUTH ABUTMENT DRILL HOLE

ELEV	DEPTH	REC / RQD	GRAPHIC LOG	DESCRIPTION	REMARKS
	5			Run 1	Vertical hole
	10			Run 2	HQWL core Reamed 4-in casing to 32 ft
	15			Gray and brown, sand, gravel, cobbles and boulders, FILL, one 15-in (min) boulder at 13 ft Run 3 approx SWL	drill water return red at 31 ft
704	20			Run 4 Run 5	
	25			Sand, gray, medium to coarse, ALLUVIUM	
694	30			Run 6	TOP OF ROCK
		90/40		Banded, gray and white, quartz, biotite GNEISS broken and weathered along joints inclined 60° to horizontal and vertical fracture Run 7	

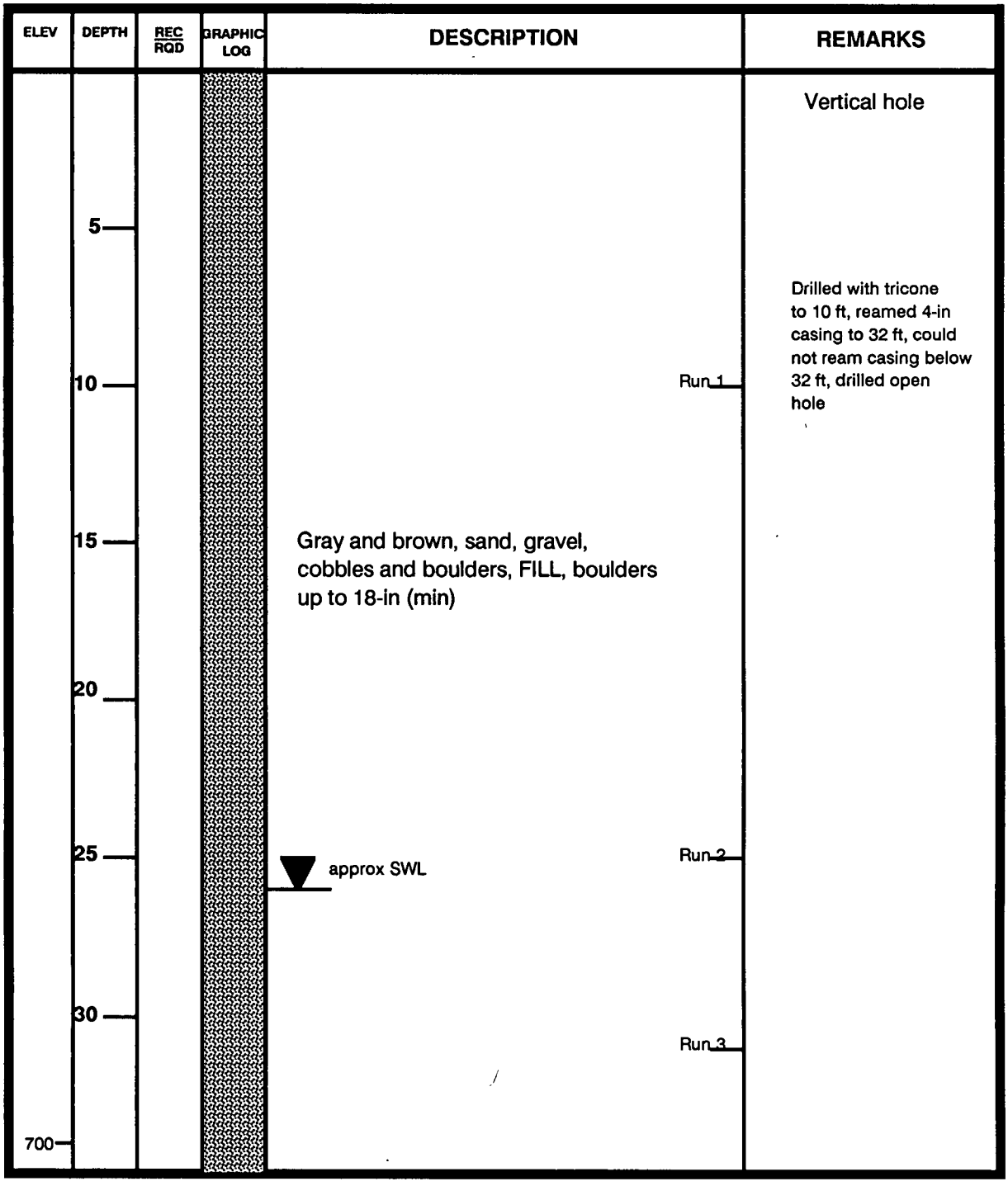
KIM DE RUBERTIS * CONSULTING ENGINEER * CASHMERE, WASHINGTON

LAKE CHELAN HYDROELECTRIC PROJECT
CHELAN FALLS POWERHOUSE DRAFT TUBE DECK EXTENSION
LOG OF SOUTH ABUTMENT DRILL HOLE

ELEV	DEPTH	REC / RQD	GRAPHIC LOG	DESCRIPTION	REMARKS
		100 / 100		Run 8	
		100 / 86		Banded, gray and white, quartz,biotite GNEISS fresh, near vertical fractures healed with calcite, joints with rough faces inclined 60° to horizontal, oxidized, and coated with brown clay infilling	
	40			Run 9	
		100 / 87		Becoming more massive @ 41 ft, joints 40°-45° to horizontal, joint inclined 60° to horizontal and filled with 1/4-in of clay from 43 to 45 ft	
	45			Run 10	Pressure test 10 min @ 30 psig took 2 gal
		100 / 90		Darker and more massive, foliation less distinct. Hornblende replaces biotite. Clay stain on fracture @ 52 ft	
	50	100 / 100		Run 11	
674	52			Run 12	
				BOTTOM OF HOLE	
				Entire hole drilled with mud. Casing pulled and hole plugged and abandoned 9/20/91	

KIM DE RUBERTIS * CONSULTING ENGINEER * CASHMERE, WASHINGTON

LAKE CHELAN HYDROELECTRIC PROJECT
CHELAN FALLS POWERHOUSE DRAFT TUBE DECK EXTENSION
LOG OF NORTH ABUTMENT DRILL HOLE



KIM DE RUBERTIS * CONSULTING ENGINEER * CASHMERE, WASHINGTON

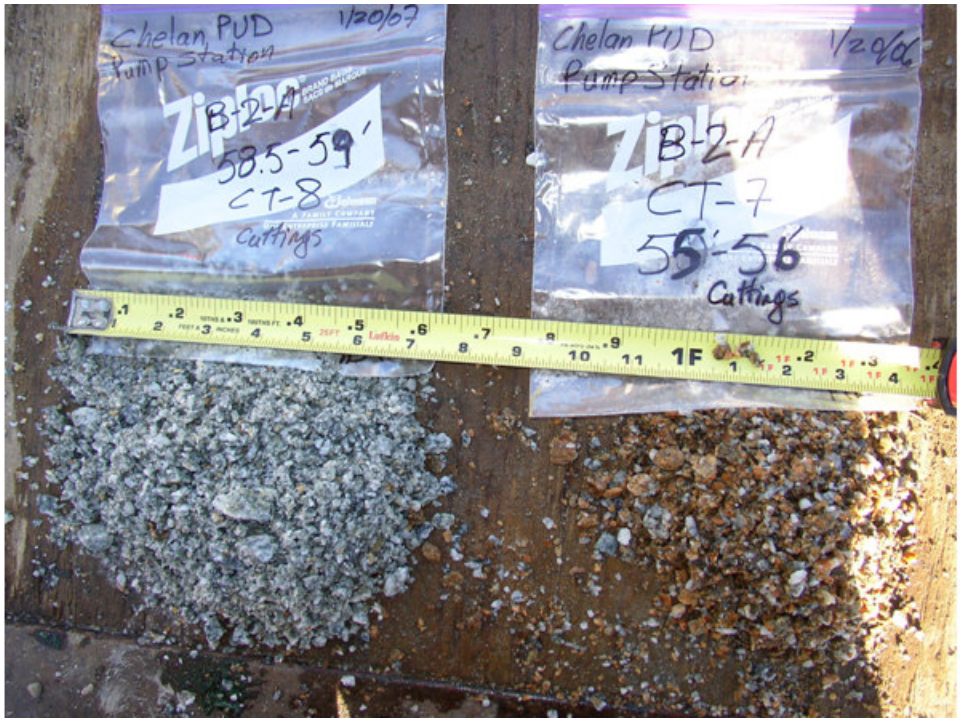
LAKE CHELAN HYDROELECTRIC PROJECT
CHELAN FALLS POWERHOUSE DRAFT TUBE DECK EXTENSION
LOG OF NORTH ABUTMENT DRILL HOLE

ELEV	DEPTH	REC / RQD	GRAPHIC LOG	DESCRIPTION	REMARKS
	40			Gray sand, gravel, cobbles, and boulders, FILL, boulders up to 15-in (min) Run 4	
690	45 50			Gray medium to coarse sand with occasional gravel and cobbles, ALLUVIUM Run 5	
666	55 60 65			Gray sand, gravel, cobbles, and boulders, ALLUVIUM, boulders up to 15-in (min) grading sandy at 60 ft Run 6	TOP OF ROCK
					HQWL core

LAKE CHELAN HYDROELECTRIC PROJECT
CHELAN FALLS POWERHOUSE DRAFT TUBE DECK EXTENSION
LOG OF NORTH ABUTMENT DRILL HOLE

ELEV	DEPTH	REC / RQD	GRAPHIC LOG	DESCRIPTION	REMARKS
		100 / 100		Banded, mottled gray and white, quartz, biotite GNEISS, fresh foliation 45° to horizontal, widely spaced (>1 ft) joints parallel to foliation, tight 45° cross joints healed with calcite	
	75	100 / 82		Run 7	
				Closely spaced (4-in) joints at 76 ft inclined 30°-45° to horizontal with thin, brown clay coating	
				Run 8	Pressure test 10 min @ 30 psig took 1 gal
	80	100 / 96		60°-70° joints 78-83 ft rough joint faces	
				Run 9	
	85	100 / 100		Massive, rough near vertical joint 83-84.2, one 50° joint at 86 ft	
646					
				BOTTOM OF HOLE	
	90			Entire hole drilled with mud. Casing pulled and hole plugged and abandoned 9/21/91	

Appendix D
Geotechnical Exploration Photographs



Top Left: Drilling boring B-1. Looking north. Stakes indicating locations of borings B-2A and B-2 visible in front of truck.

Top Right: Cuttings from boring B-2A.

Bottom Left: Drilling boring B-2. Looking south.

GEOTECHNICAL EXPLORATION PHOTOS

GEOTECHNICAL DATA REPORT
Chelan Tailrace Pump Station
JANUARY 2007

CH2MHILL

Top Left: Excavating TP-2 with a CASE 80 Super K backhoe. Looking west.

Top Right: TP-2 before backfilling it.

Bottom Left: Excavating TP-1 with a CAT 312 excavator. Looking southeast.

GEOTECHNICAL EXPLORATION PHOTOS

GEOTECHNICAL DATA REPORT
Chelan Tailrace Pump Station
JANUARY 2007

CH2MHILL

Top Left: Excavating TP-3 with a CAT 312 excavator. Looking north.

Top Right: Water seeping in at 11' bgs in TP-4.

Bottom Left: Excavated material from TP-4. Looking southeast.

GEOTECHNICAL EXPLORATION PHOTOS

GEOTECHNICAL DATA REPORT
Chelan Tailrace Pump Station
JANUARY 2007

CH2MHILL

Top Left: Excavating TP-5 with a CAT 312 excavator. Looking east.

Top Right: TP-6 backfilled. Looking west.

Bottom Left: Soil caving in TP-6. Top 1' of soil was frozen.

GEOTECHNICAL EXPLORATION PHOTOS

GEOTECHNICAL DATA REPORT
Chelan Tailrace Pump Station
JANUARY 2007

CH2MHILL

Lake Chelan Hydroelectric Project
FERC Project No. 637-022

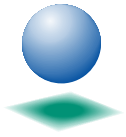
Chelan Tailrace Pump Station Hydrologic and Hydraulic Findings DRAFT

Prepared for

CHELAN COUNTY

April 2007

Prepared by



CH2MHILL

P.O. Box 91500
Bellevue, WA 98009-2050

Contents

Attachments

Tables

Figures

CHELAN TAILRACE PUMP STATION

Draft Hydrologic and Hydraulic Findings

General

This report provides basic hydrologic and hydraulic information developed to support the design of the Chelan Tailrace Pump Station. The documentation includes information related to the vertical survey datum, tailrace water surface elevations, powerhouse draft tube exit velocities, and flows in the Chelan River.

Vertical Survey Datum

The design of the Chelan Tailrace Pump Station project is based on the Rocky Reach vertical datum (National Geodetic Vertical Datum [NGVD] 1,929). All previous drawings of the project site and site hydraulic information have historically been reported on the Lake Chelan Datum. The conversion between the two datums is as follows:

Lake Chelan Datum elevation – (minus) 1.6 feet = Rocky Reach Datum (NGVD 1929)

Additional information is included as Attachment A.

Tailrace Water Surface Elevations

A stage-duration curve for the Chelan powerhouse tailrace was prepared using average daily data from the float gage located on the tailrace deck of the powerhouse. Data was evaluated for the years 2001 to 2005 for the period of anticipated pump station operation (i.e., March 15 to May 15 and October 15 to November 30). Figure 1 presents the stage-duration curve.

The pump station design water surface elevations were developed using the stage-duration curve and are presented in Table 1. All elevations are on the Rocky Reach Vertical Datum, NGVD 1,929.

TABLE 1
Pump Station Design Water Surface Elevations

Description	Elevation (feet)
Normal low (99 percent exceedence)	706.1
Design (50 percent exceedence)	707.7
Normal high (2 percent exceedence)	709.5
Design flood (maximum hourly stage from June 12, 1997)	716.7

Powerhouse Draft Tube Exit Velocity

Flows exit the Chelan powerhouse via rectangular draft tubes openings. There are two openings per unit, for a total of four openings. The openings are approximately 168 inches wide by 113.75 inches high at a location measured just upstream of the bulkhead gate slot. As a result, the draft tubes have a total area of 530.8 square feet (ft^2). The openings have an invert elevation of 667.4 feet, and the total powerhouse design flow is approximately 2,200 cubic feet per second (cfs).

Exit velocities from the Chelan powerhouse draft tubes were calculated by dividing the total powerhouse flow by the total draft tube exit area. Velocities in the tailrace were calculated by dividing the total powerhouse flow by the cross section available for conveyance at the design water surface elevation. This approach is an approximation only and does not consider the jet flow properties of the draft tube discharge which may result in higher velocities as some locations. Table 2 presents the draft tube velocities, and Figure 2 shows the draft tube exit velocity curve.

TABLE 2
Powerhouse Draft Tube Exit Velocities

Tailrace Location	Velocity (feet per second)
Draft tube exit	4.1
Immediately upstream of pump station site	0.5
Immediately downstream of pump station site	0.5

Chelan River

The flow of the 4.5-mile-long Chelan River is controlled by the Public Utility District No. 1 of Chelan County (the District) via operation of the Lake Chelan Dam. Spills typically occur during May, June, and July, when inflows exceed the hydraulic capacity of the powerhouse (2,200 cfs) or when generation is curtailed. The flood-of-record is 20,600 cfs. Flows may periodically inundate the lower portion of the Chelan River.

Erlandsen
SURVEYING | PLANNING | ENGINEERING | GIS

250 Simon Street SE
East Wenatchee, WA 98802

Phone: 509.884.2562
Fax: 509.884.2814

www.erlandsen.com

February 15, 2006

Mr. James G. Kapla, P.E.
CH2M Hill
100 112th Avenue NE., Suite 400
Bellevue, WA 98004

DRAFT

Re: P.U.D. No. 1 of Chelan County (the District) – Reach 4 Pump Station
Project: Bathymetric and Topographic Survey

Mr. Kapla:

Enclosed herewith please find the following:

- Sealed and signed hard copy of the topographic survey including control monuments and data as well as the additional mapping items (6 test pits, 2 bore holes, Benchmark at SE. corner of switchyard, Beebe irrigation line valves).
- Hard copy of the DTM point file
- Sealed and signed hard copy of Survey control and data sheet.

The elevation of the float gage reference mark (shown in picture provided) is 736.23 feet NGVD 1929 vertical datum. The elevation noted in the photo (737'-101/4") appears to be on the Lake Chelan vertical datum.

The conversion of between NGVD 1929 datum and Lake Chelan Datum is thus:

- NGVD 29 elevation + (plus) 1.6 feet = Lake Chelan Datum elevation or;
- Lake Chelan Datum Elevation – (minus) 1.6 feet = NGVD 1929 datum elevation.

Feel free to contact me with questions and/or additional needs you may have regarding this project.

Thank you for this opportunity to provide our services.

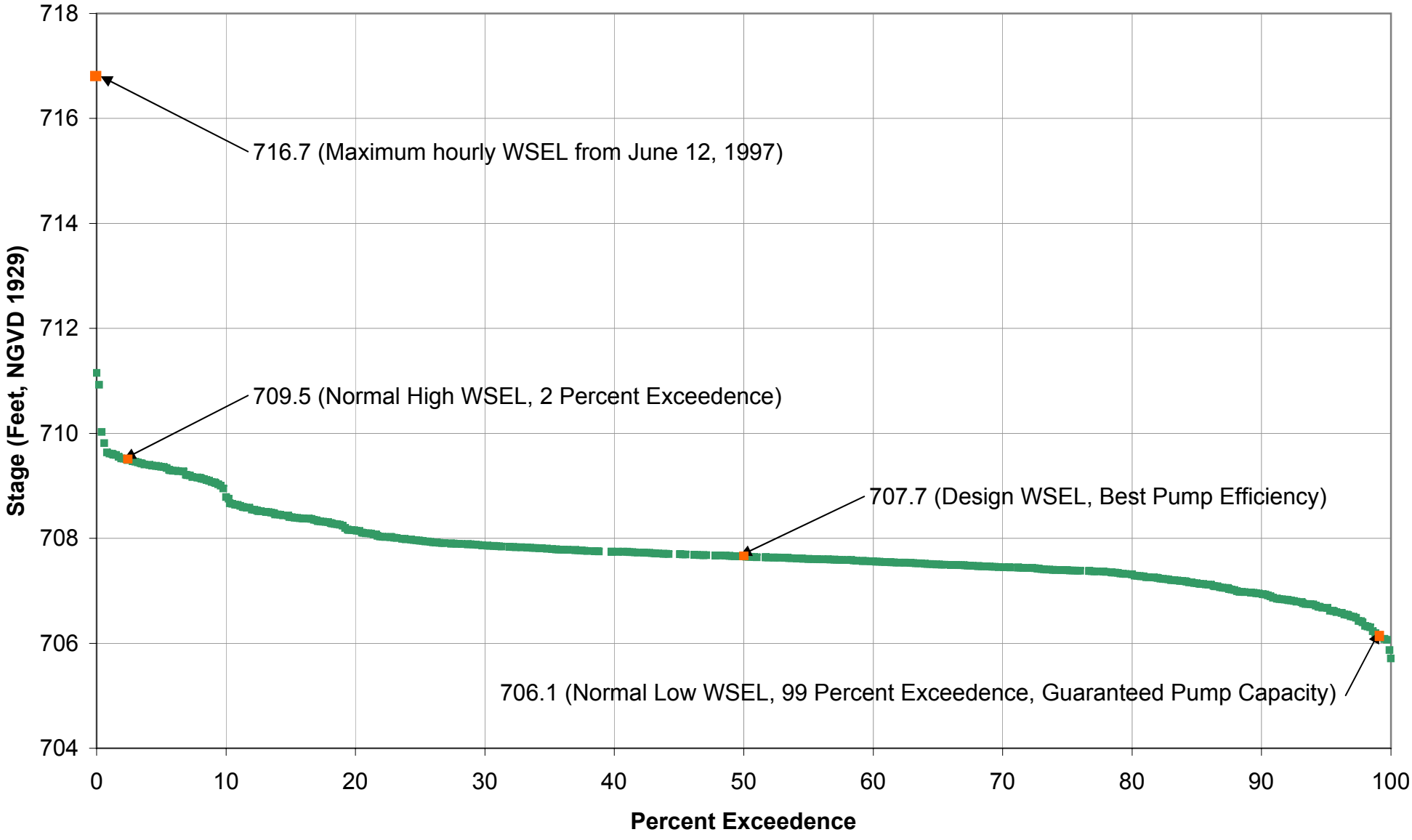
Sincerely,

Erik B. Gahringer, PLS
East Wenatchee Branch/Project Manager

DRAFT

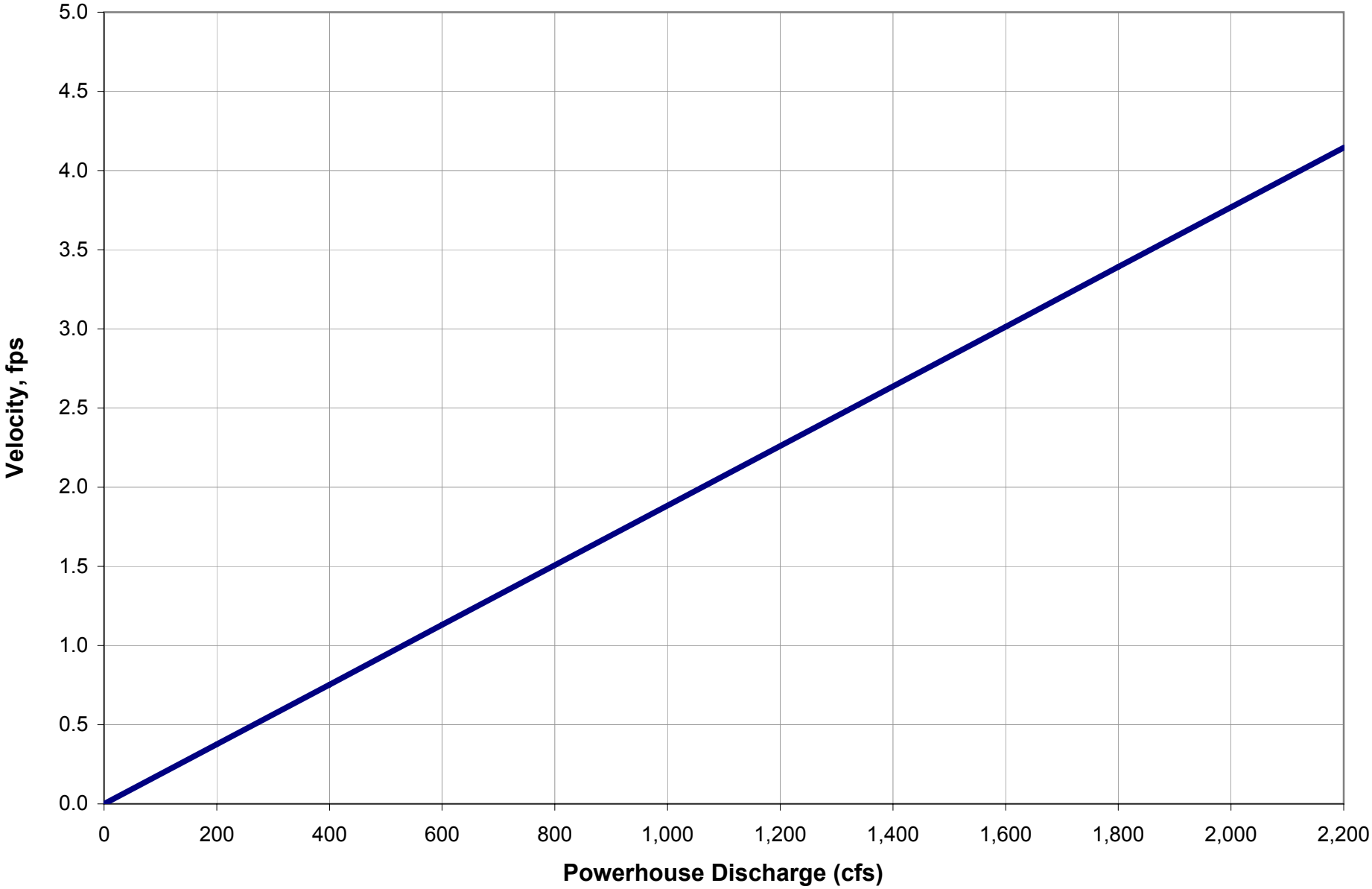
EBG:eg
Enclosures

Figure 1: Chelan Powerhouse Tailrace Stage-Duration Curve (Average Daily Data from 2001-2005 for period of PS operation: March 15 - May 15 and October 15 - November 30)



4/20/2007

Figure 2: Chelan Powerhouse Draft Tube Exit Velocity



4/20/2007

Lake Chelan Hydroelectric Project
FERC Project No. 637-022

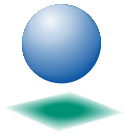
Chelan Tailrace Pump Station Record Drawings DRAFT

Prepared for

CHELAN COUNTY

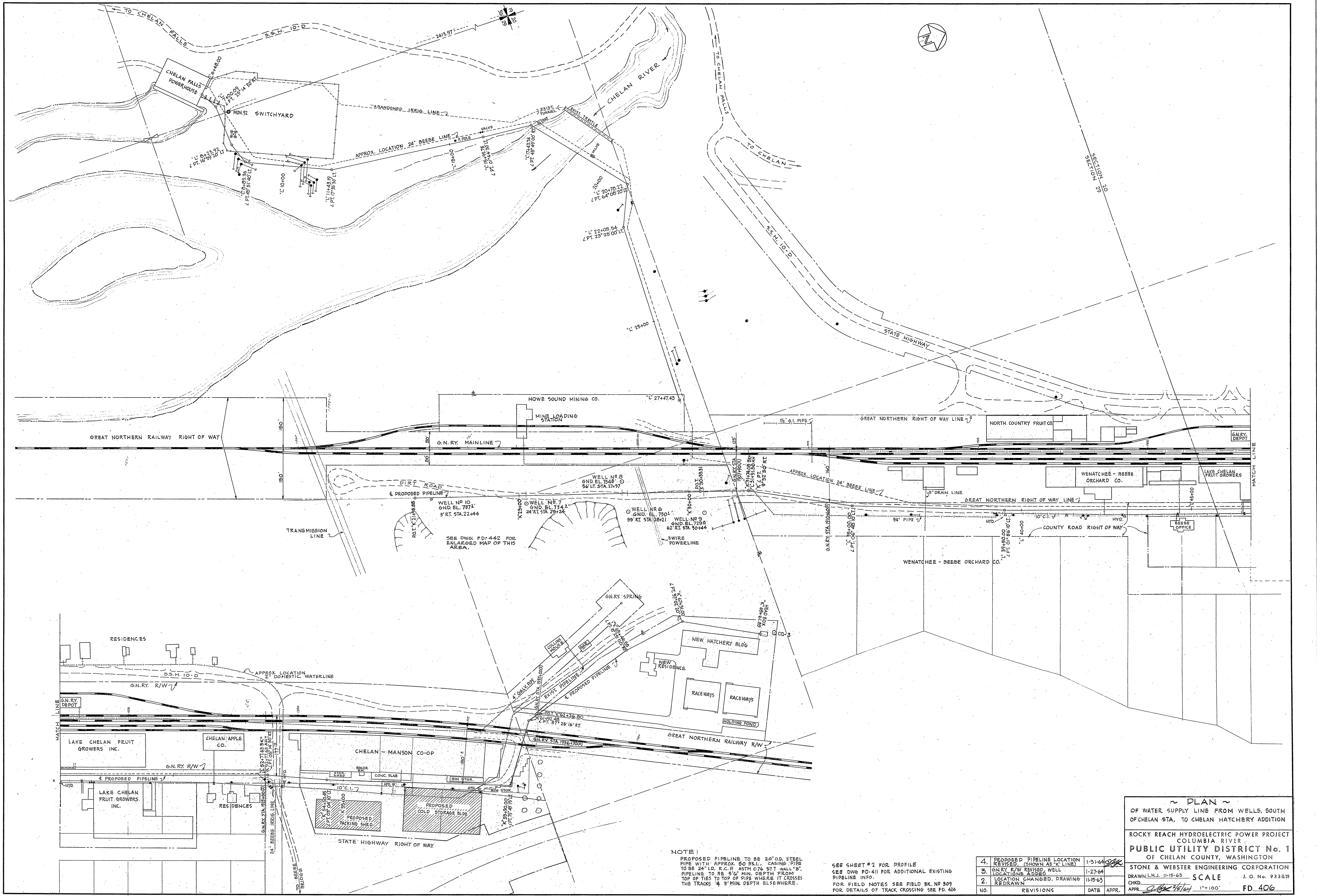
April 2007

Prepared by



CH2MHILL

P.O. Box 91500
Bellevue, WA 98009-2050



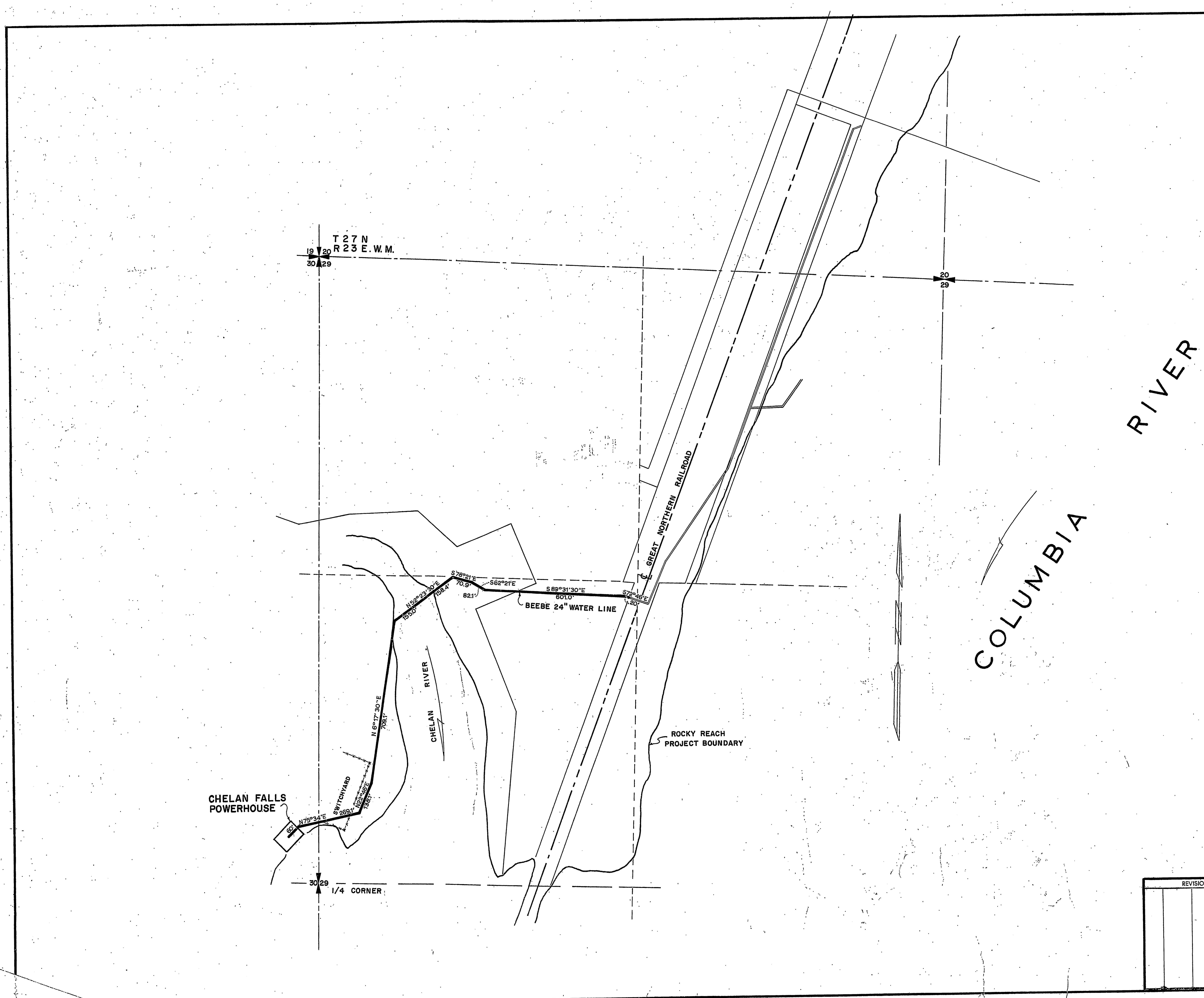
NOTE:
PROPOSED PIPELINE TO BE 20" O.D. STEEL PIPE WITH APPROX. 50 P.S.I.. CASING PIPE TO BE 24" I.D. R.C.P. ASTM C-76 57T WALL "B". PIPELINE TO BE 5'6" MIN. DEPTH FROM TOP OF TIES TO TOP OF PIPE WHERE IT CROSSES THE TRACKS & 3' MIN. DEPTH ELSEWHERE.

SEE SHEET #2 FOR PROFILE
SEE DWG FD-411 FOR ADDITIONAL EXISTING PIPELINE INFO.
FOR FIELD NOTES SEE FIELD BK. No 309
FOR DETAILS OF TRACK CROSSING SEE FD. 424

NO.	REVISIONS	DATE	APPR.
4.	PROPOSED PIPELINE LOCATION REVISED. (SHOWN AS "K" LINE)	1-31-64	
3.	G.N.RY. R/W REVISED, WELL LOCATIONS ADDED	1-27-64	
2.	LOCATION CHANGED, DRAWING REDRAWN	11-15-63	

~ PLAN ~
OF WATER SUPPLY LINE FROM WELLS, SOUTH OF CHELAN STA. TO CHELAN HATCHERY ADDITION

ROCKY REACH HYDROELECTRIC POWER PROJECT
COLUMBIA RIVER
PUBLIC UTILITY DISTRICT No. 1
OF CHELAN COUNTY, WASHINGTON
STONE & WEBSTER ENGINEERING CORPORATION
DRAWN L.N.J. 11-15-63 SCALE J. O. No. 9330.15
CHKD.
APPR. 1" = 100' FD 406
SHEET 1



NOTE:

LOCATION OF PIPELINE TAKEN FROM DRAWING DATED 6-28-61 AND SKETCH DRAWING FROM SURVEY OF PIPELINE DATED 11-19-62 BY JOHN W. EMERSON, LICENSED PROFESSIONAL LAND SURVEYOR.

EXHIBIT A

REVISIONS	PUBLIC UTILITY DISTRICT NO. 1 of Chelan County, Washington
	TITLE WENATCHEE – BEEBE ORCHARDS IRRIGATION WATER LINE

Date: 3-12-65	Drawn	Checked	Approved	Drawing No.
Scale 1" = 200'	D.A.			LC-147