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FOUNDATION REPORT

WYNOOCHEE DAM

US Army Corps
of Engineers
Seattle District

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19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

Report was prepared in accordance with ER 1110-1-1801, dated 15 December 1981, which requires as-built foundation reports for major construction projects. The purpose of this report is to insure the preservation for future use of complete records of foundation conditions encountered during construction and of methods used to adapt structures to these conditions. The overall condition of the dam foundation is excellent.

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SUBJECT: Wynoochee Dam Foundation Report, 1988

CDR, US Army Corps of Engineers, North Pacific Division, P.O. Box 2870;
Portland, OR 97208-2870 27 February 1989

FOR Commander, Seattle District (CENPS-EN-GT-GE)

Your replies are considered satisfactory and the report is approved.

FOR THE COMMANDER:

Gary G
for ROBERT P. FLANAGAN, P.E.
Chief, Engineering Division

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DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX C-3755
SEATTLE, WASHINGTON 98124

CENPS-EG-G (415-10f) 8 July 1988

MEMORANDUM FOR: Commander, North Pacific Division, U.S. Army Corps of Engineers, ATTN: Chief, Engineering Division (CENPD-EN), P.O. Box 2946, Portland, Oregon 97208-2946

SUBJECT: Wynoochee Dam Foundation Report, June 1988

Enclosed you will find 3 copies of the above report for your review and approval as required by ER1110-1-1801. Wynoochee Dam construction was completed in 1972 and the dam has been in operation for 16 years.

FOR THE COMMANDER:

Encl (3 copies)

R. P. SELLEVOLD, P.E.
Chief, Engineering Division

CENPD-EN-G(CENPS-EG-G/8Jul88)(1130-2-320b) 1st End Sager 503-221-3867
SUBJECT: Wynochee Dam Foundation Report, June 1988

DA, US Army Corps of Engineers, North Pacific Division, P.O. Box 2870,
Portland, OR 97208-2870 14 December 1988

TO: Commander, Seattle District (CENPS-EG-G)

1. The report is approved subject to the incorporation of the minor changes and additions listed below.

2. The following comments are provided for your action:

a. Page 12, para. 3.03.3, 5th line from the top of the page; the word "spilitic" is a rarely used and highly technical geologic term that should be defined.

b. Pages 25 and 26, para. 4.08; the first two sentences should be rewritten to correct and clarify the following points. The design shear strength for the mass concrete could not have been 2500 psi (this was probably the unconfined compressive strength and the shear strength was 250 psi). The concrete/rock interface shear strength assumption of 500 psi is considered non-conservative. A sentence on the rationale behind this value is appropriate here.

c. Page 44, Section 7; one of the most important purposes for a Foundation Report is to identify any potential foundation problems or concerns that could affect future dam safety or performance. There apparently are no items or concerns of this nature at Wynoochee. If that is correct, it should be stated here.

d. There are no plates that show "as mapped" geologic sections, such as a centerline profile or abutment slope mapping sections. If such data exists, it should be added to the report.

e. There are no plates that show excavation drawings for the structure, other than monoliths 6 and 7 (Plates 11 and 12). If this information is available, it should also be added to the report.

FOR THE COMMANDER:

Gary L. [illegible]

for ROBERT P. FLANAGAN, P.E.
Chief, Engineering Division

CENPS-EN-GT-GE (CENPS-EG-G/8Jul88) (1130-2-320b) 2nd End Gembala/mw/
206-764-3711
SUBJECT: Wynoochee Dam Foundation Report, 1988

DE, Seattle District, U.S. Army Corps of Engineers, ATTN: CENPS-EN-GT-GE,
P.O. Box C-3755, Seattle, WA 98124-2255

FEB 14 198~~8~~9

FOR DA, U.S. Army Corps of Engineers, North Pacific Division, P.O. Box 2870,
Portland, OR 97208-2870

1. The following provides information or describes action taken on the comments in endorsement 1. (Answers are numbered as in the endorsement.)

a. Concur

b. A shear strength of 500 psi was used in analysis. The 2,500 psi shown was a typographical error. The word "conservative" pertains to the shear strength for the foundation rock not the concrete/rock interface. The shear strength at the interface was also assumed to be 500 psi, however, no rationale for selection of this value is available.

c. Concur

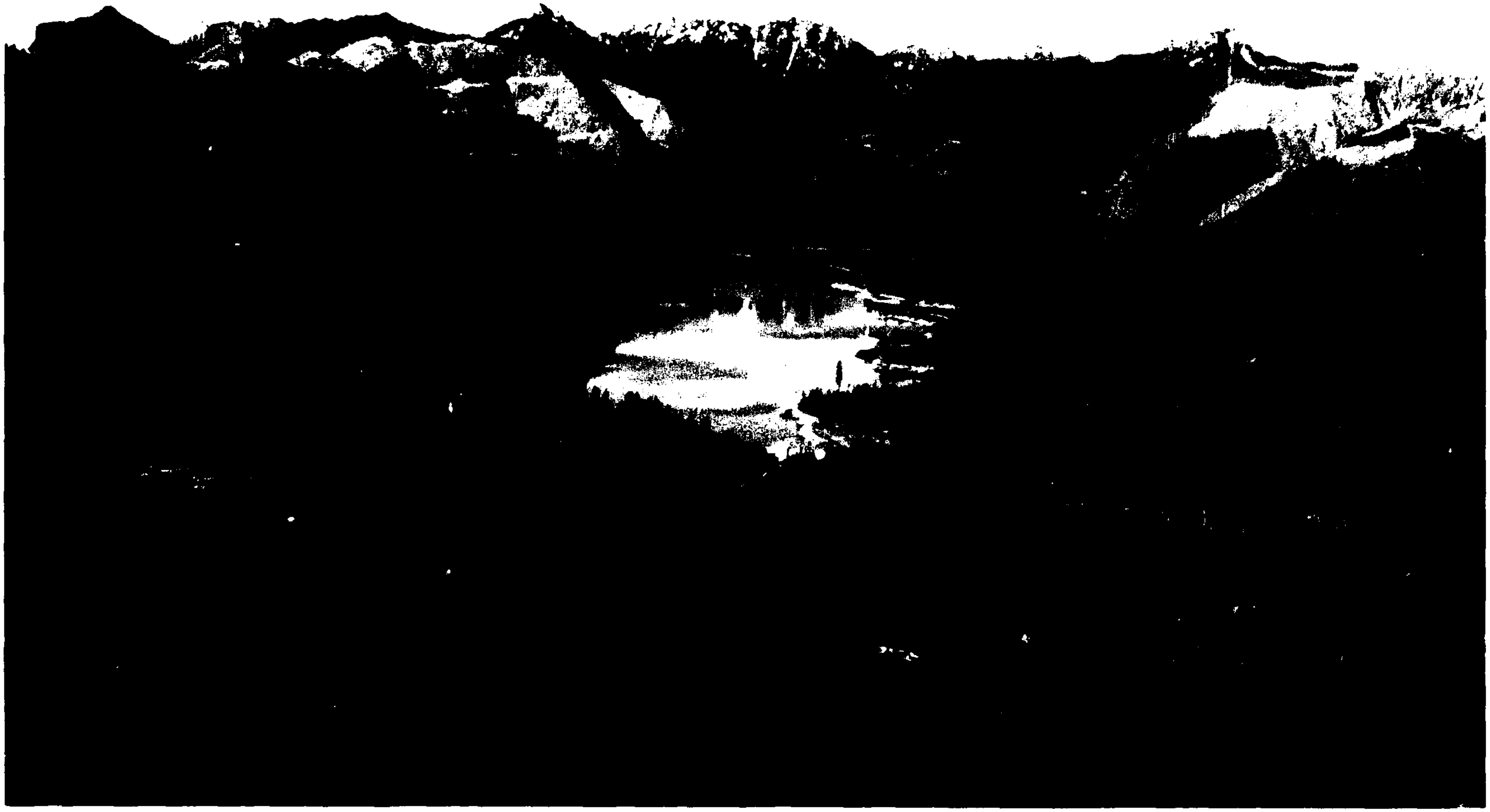
d. There are no plates available that show "as mapped" geologic sections. Plate 14 in Appendix B presents geologic and embankment sections that have been compiled using data interpreted from other drawings in this appendix.

e. There are no available plates that show as-built excavation drawings for the structure other than what is already included in the foundation report.

2. Please contact Mr. David D. Gembala, (206) 764-3711, CENPS-EN-GT-GE, for any information or comments concerning the foundation report. The report has been prepared for final printing.

FOR THE COMMANDER:

R. P. SELLEVOLD, P.E.
Chief, Engineering Division



FRONTISPIECE — VIEW NORTHEAST OF WYNOOCHEE DAM AND WEATHERWAX BASIN

WYNOOCHEE DAM

FOUNDATION REPORT

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

1988

WYNOOCHEE DAM FOUNDATION REPORT

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APPENDIX B

PLATES

TABLE 1-1

PERTINENT DATA

General:

Stream miles from confluence with Chehalis River	51.8
Drainage area, square miles	41
Reservoir length, miles	4.4
Reservoir capacity, acre feet	70,000
Maximum normal pool elevation, feet (feet above sea level)	800
Minimum pool	700

Dam:

Maximum crest elevation, feet	805
Length of dam (concrete) at top, feet	672
Length of dam (earthfill) at top, feet	1,028
Height, maximum section, feet (bedrock to top)	175
Height above streambed (hydraulic height), feet	175
Volume of concrete, cubic yards (c.y.)	92,800
Volume of embankment, c.y.	461,000

Spillway:

Type of gates	Tainter
Number of bays	2
Bay width, feet	32
Height above sill, feet	39
Height above crest, feet	38.08
Radius, feet	37
Trunnion anchorage type	Prestressed

TABLE 1-2

PREVIOUSLY ISSUED DESIGN MEMORANDA

No.	Title	Date
1	Site Selection	Jul 65
2	Construction Materials	Apr 66
3	General Design Memorandum	Apr 66
3 (Supp 1)	Revisions to Outlet Works	Oct 66
4	Spillway Design Flood	Jun 66
5A	Preliminary Master Plan	Aug 66
6	Real Estate	Sep 66
6 (Supp 1)	Additional Real Estate Requirements	Oct 67
6 (Ltr Supp 2)	Mitigation of Wildlife Lands	Apr 71
6 (Ltr Supp 4)	Highway and Road Relocation and Public Access - Wynoochee Lake Boundary Marking	Feb 73
7	Reservoir Clearing	Aug 66
8	Road Relocations	Oct 66
9	Fish and Wildlife	Jul 67
9 (Supp 1)	Facilities for Upstream Fish Passage	Aug 67
10	Dam - Basis of Design	May 67
10 (Supp 1)	Multilevel Low Flow Outlet Works	Jul 68
10 (Ltr Supp 2)	River Diversion	Feb 68
10 (Ltr Supp 4)	Beautification Aspects of Spillway	Apr 68
10 (Ltr Supp 5)	Dam - Basis of Design (Garage)	May 72
10 (Ltr Supp 6)	Reservoir Bank Storage and Turbidity	Aug 72
10 (Ltr Supp 7)	Sluice Repair	Feb 77
10 (Ltr Supp 8)	Project Housing	Jul 77
10 (Ltr Supp 9)	Restroom	Nov 77
10 (Ltr Supp 10)	Equipment Storage Building	Mar 78
11	Cost Allocation	Jun 67
12	Hydrologic and Communication Facilities	Apr 70
15	Sedimentation Ranges	Jan 70
16	Landscape Development Plan	Jan 73
17	Earthquake Analysis of Wynoochee Dam	Sep 83

WYNOOCHEE DAM
FOUNDATION REPORT

SECTION 1. INTRODUCTION

1.01 Location and Description of Project.

1.01.1 The multipurpose Wynoochee Lake project is located on the Wynoochee River in the southern Olympic Mountains about 28 air miles north of Montesano, Washington, and 51.8 river miles above the confluence with the Chehalis River (figure 1-1). The project consists of a dam, reservoir, outlet works, and fish facilities and provides industrial water supply, flood control, recreation, irrigation and enhancement of fisheries. Wynoochee Dam spans a narrow, near vertical-walled rock canyon and rises 50 feet above the canyon lip, impounding a reservoir 4.4 miles long at normal full pool elevation 800 feet. The 175-foot-high concrete gravity section of the dam is founded on basaltic bedrock. The flanking zoned earth and rockfill embankments on each side (figure 1-2) generally are founded on granular materials with their central, semi-impervious cores keyed to bedrock. The right embankment section joins an impervious clay blanket that extends upstream to follow the reservoir shoreline for 1,000 feet. The clay blanket serves to lengthen the seepage path around the right abutment of the dam. On the left abutment, the left embankment transitions into a zoned upstream slope treatment section which extends to a point approximately 700 feet beyond the end of the concrete dam. Approximately 400 feet of the section has a cutoff core to rock, with the remainder bottoming in a cutoff on top of the natural clay layer. A gravel filter blanket and a seepage collection pipe to control seepage, prevent erosion, and increase the stability of the left bank downstream seepage-emergence area are provided between 700 and 1,700 feet downstream from the dam on the left abutment (plate 17 in appendix B).

1.01.2 Wynoochee Lake project was proposed in House Document 601 and authorized by Public Law 87-974, 87th Congress, 2d Session, as a part of the Flood Control Act of 1962. Preliminary investigations began in 1964 and final siting was made in 1965. Detailed foundation investigation was completed in 1967. Pertinent data for the project are summarized in table 1-1.

1.02 Purpose and Scope. This report is prepared in accordance with ER-1110-1-1801, dated 15 December 1981, as amended by changes 1 and 2 dated 30 June 1982 and 1 April 1983, which requires as-built foundation reports for major construction projects. The purpose of this report is to insure the preservation for future use of complete records of foundation conditions encountered during construction and of methods used to adapt structures to these conditions.

1.03 Acknowledgements. This report was originally drafted by Dennis Larson, Project Geologist, Portland District, on temporary assignment to Wynoochee Lake Project. The report was substantially modified by Richard Eckerlin, Staff Geologist, Seattle District under the supervision of David Gembala,

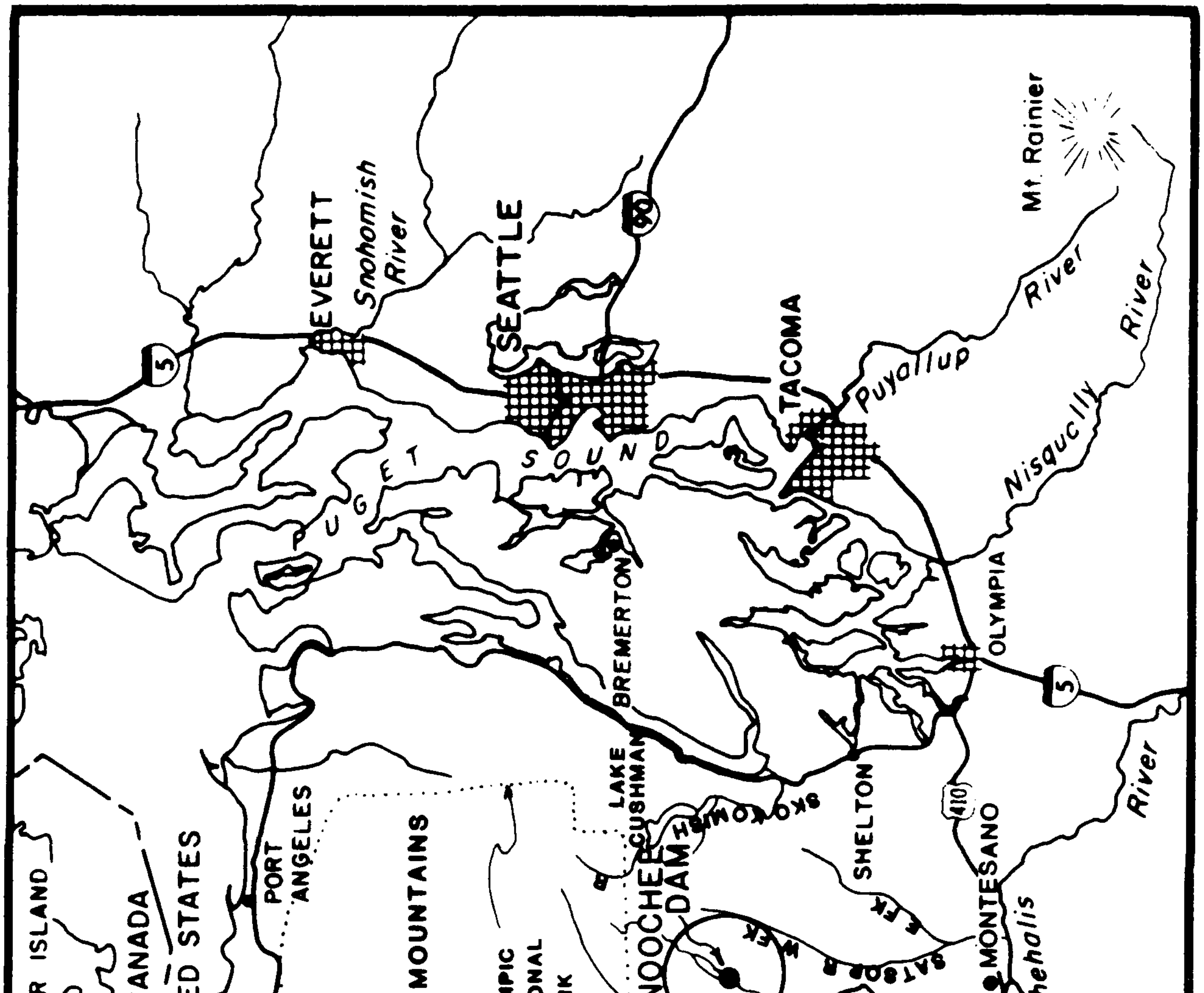

VICINITY MAP
SCALE IN MILES
10
0
10
20
N
PACIFIC OCEAN
STRAIT OF JUAN DE FUCA
VANCOUVER ISLAND
CANADA
UNITED STATES
PORT ANGELES
101
OLYMPIC MOUNTAINS
OLYMPIC NATIONAL PARK
LAKE QUINAULT
WYNOOCHEE DAM
LAKE CUSHMAN
SKOKOMISH R
BREMERTON
SHELTON
E FK
SATSOP R
W FK
WYNOOCHEE R
HUMPTULIPS R
ABERDEEN
HOQUIAM
MONTESANO
Chehalis River
410
101
OLYMPIA
5
PUGET SOUND
TACOMA
Puyallup River
Nisqually River
SEATTLE
90
EVERETT
Snohomish River
5
Mt. Rainier

FIGURE 1-1

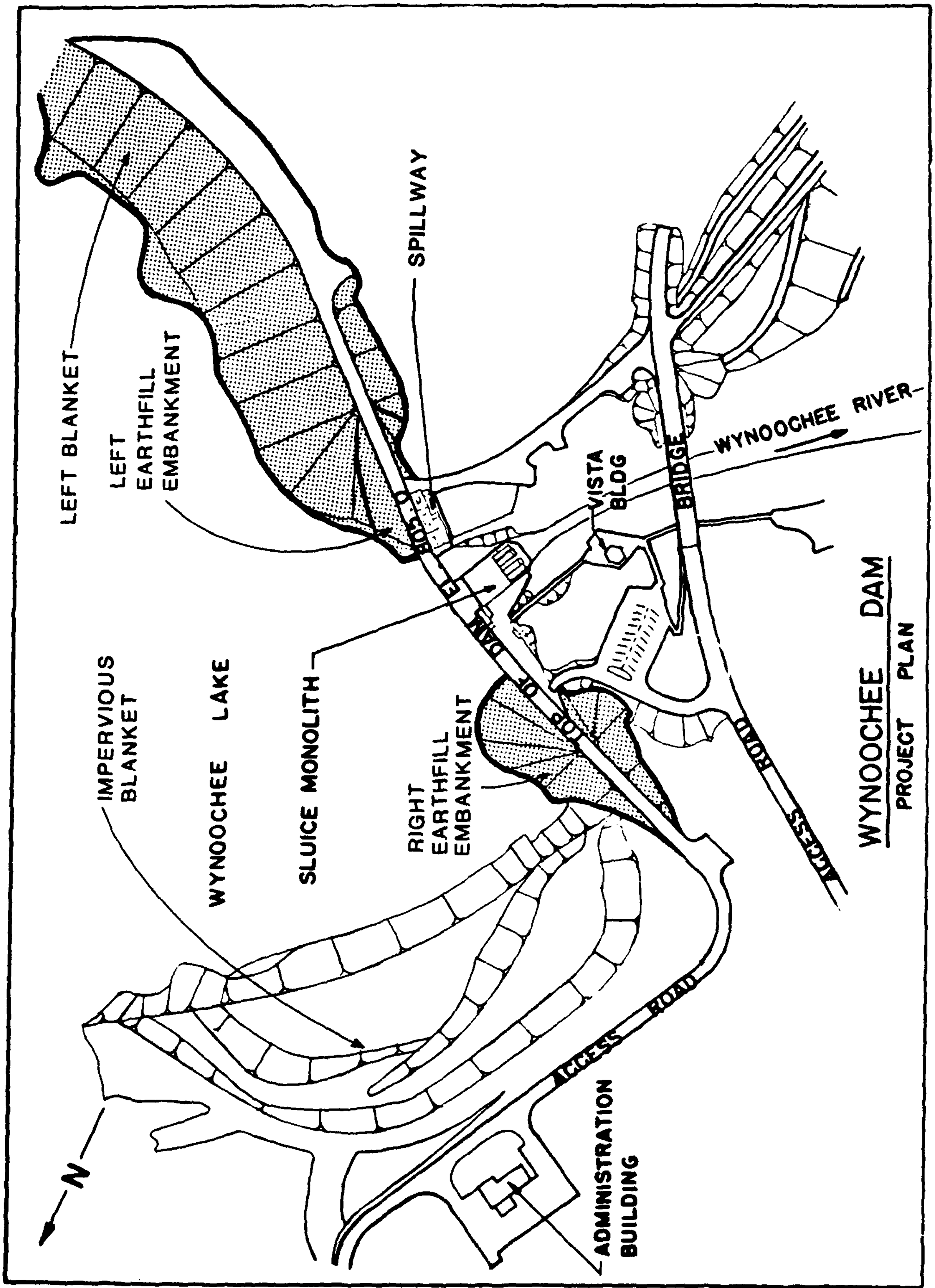

LEFT BLANKET
LEFT EARTHFILL EMBANKMENT
SPILLWAY
IMPERVIOUS BLANKET
WYNOOCHEE LAKE
SLUICE MONOLITH
RIGHT EARTHFILL EMBANKMENT
TOP OF DAM EL 80
VISTA BLDG
BRIDGE
WYNOOCHEE RIVER
ACCESS ROAD
ACCESS ROAD
ADMINISTRATION BUILDING
N
WYNOOCHEE DAM
PROJECT PLAN

FIGURE 1-2

Chief, Geology Section, and general supervision of Charles Perry, Chief, Geotechnical Branch, Seattle District. Mr. R. Boyd Kramer was Resident Engineer. Much of the basic preconstruction geological investigations were accomplished by John Nelson, Staff Geologist, Seattle District. Mr. Richard Galster, former Chief, Geology Section, provided a formal comprehensive review of this report.

1.04 Construction History. Wynoochee Dam was designed by the Seattle District, U.S. Army Corps of Engineers. The prime construction contract (DACW67-70-C-0005) was awarded to Dravo Corporation of Bellevue, Washington. Construction of the dam commenced in August 1969 and was completed in October 1972.

1.04.1 Work in 1969. Clearing and grubbing for the left and right abutments were started in August and completed in October. Rock excavation for left bank monoliths commenced in September. By the end of 1969, all common excavation of foundations for the left and right embankments and for the concrete section was complete, spillway rock excavation was to grade, and drilling for rock bolt reinforcement in the spillway was in progress.

1.04.2 Work in 1970. In January 1970, rock excavation was started for the river diversion. By April, most of the drain holes and rock bolts were installed on the left side of the spillway chute and excavation was complete for the upstream right bank cutoff trench. By the end of June, foundation excavation was complete for monoliths 12, 13, and 14 and placement of clay was in progress in the right bank cutoff trench. By September, rock excavation was 98 percent complete; concrete had been placed in monoliths 12, 13, and 14; and installation of the river diversion pipe was in progress. By the end of the year, the diversion pipe installation was complete and foundation concrete had been placed in monoliths 1, 2, 3, 6, 10, 11, 12, 13, and 14.

1.04.3 Work in 1971. By February 1971, rock excavation for the monolith 7 foundation was in progress. By April, concrete had been placed in all monoliths, except monoliths 5, 8, and 9, and by June, concrete had been placed in all monoliths. In July, placement of the right embankment and tie to the upstream clay blanket was in progress, and the spillway chute slab was completed. In August, monolith 7 foundation grouting was completed and placement of the left embankment was in progress. By the end of October, all foundation drilling and grouting were complete, plugging of the diversion pipe was complete, and contractor was completing riprap, rockfill, and topsoil work. All work, except on the elevator, was suspended on 17 December due to funding problems.

1.04.4 Work in 1972. The contractor resumed work on 20 March and completed final grading, road surfacing, concrete finishing, riprap dressing, and cleanup by September 1972.

1.04.5 Initial Pool Raise in 1973. The reservoir was initially raised from March through June 1973. Foundation leakage and abutment seepage were monitored daily through April 1973 and then weekly through June. The dam was determined safe for reservoir raising to elevation 800 feet.

1.05 Construction Photographs. Refer to appendix A for selected construction photographs.

SECTION 2. INVESTIGATIONS

2.01 Site Selection: Geologic reconnaissance mapping was conducted during the general investigation in 1958 through 1961 on the Wynoochee River. Four possible damsites at river miles 16, 42.5, 43.1, and 51.8 were examined. Two sites were found adaptable to construction of a project. The site at river mile 42.5 was determined suitable for a power dam; however, studies indicated that hydroelectric power could not be produced economically. Storage and other purposes could best be met by a dam at river mile 51.8. Investigations consisting of geologic mapping and subsurface drilling began in 1964. The final site was selected in 1965. Detailed foundation investigation was completed in 1967.

2.02 *Investigations Prior to Construction*. Approximately 45 exploratory borings were drilled using diamond drill, rotary drill, cable tool, and bucket auger methods. In addition to drilling, exploration included nine backhoe pits, five backhoe trenches, and eight dozer cuts. See plates 1 through 7 in appendix B. In several drill borings fine grained soils were drive sampled using 3-inch-diameter Shelby tubes, and selected tubes were tested in the laboratory. Triaxial shear and consolidation tests were conducted on representative undisturbed Shelby-tube samples of foundation clays. Gradation, Atterberg limits, moisture content, triaxial shear, and permeability tests were conducted on selected disturbed samples of foundation materials. See Appendix C, Laboratory Analyses and Appendix D, Boring Logs. Field dye tests provided additional data on ground water conditions. No rock testing was completed on the foundation rock. Since the nature of the rock was characterized by numerous discontinuous, randomly oriented joints, testing of unjointed specimens would not give strengths representative of the jointed rock mass. It was assumed that the compressive strength of the confined rock at the base of the dam would be equal to or greater than the compressive strength of the mass concrete in the dam (Corps of Engineers, DM10, 1967).

2.03 Investigations During Construction. Three NX rotary drill borings were drilled into the downstream right side slope beyond the toe of monolith 6 to examine the possible open condition of several 50 to 90 degree dipping relief joints located behind the natural slope. Also, holes were drilled where the slope was to be excavated for the river diversion pipe. On the right bank in the foundations of monoliths 1 through 5, six shallow holes were drilled with a 2-1/2-inch-diameter track drill to determine characteristics of a hard glacial till deposit. The drilling showed that the material was unsatisfactory for the foundation and was later removed. The concrete monolith foundations were mapped intermittently in 1970 and 1971 by temporary duty personnel from Portland District. The monolith 5 foundation was concealed by debris from foundation preparation of monolith 4 and the monolith 9 foundation was concealed beneath a haul road fill while a geologist was at the project and neither were mapped. The spillway foundation was not mapped.

SECTION 3. GEOLOGY

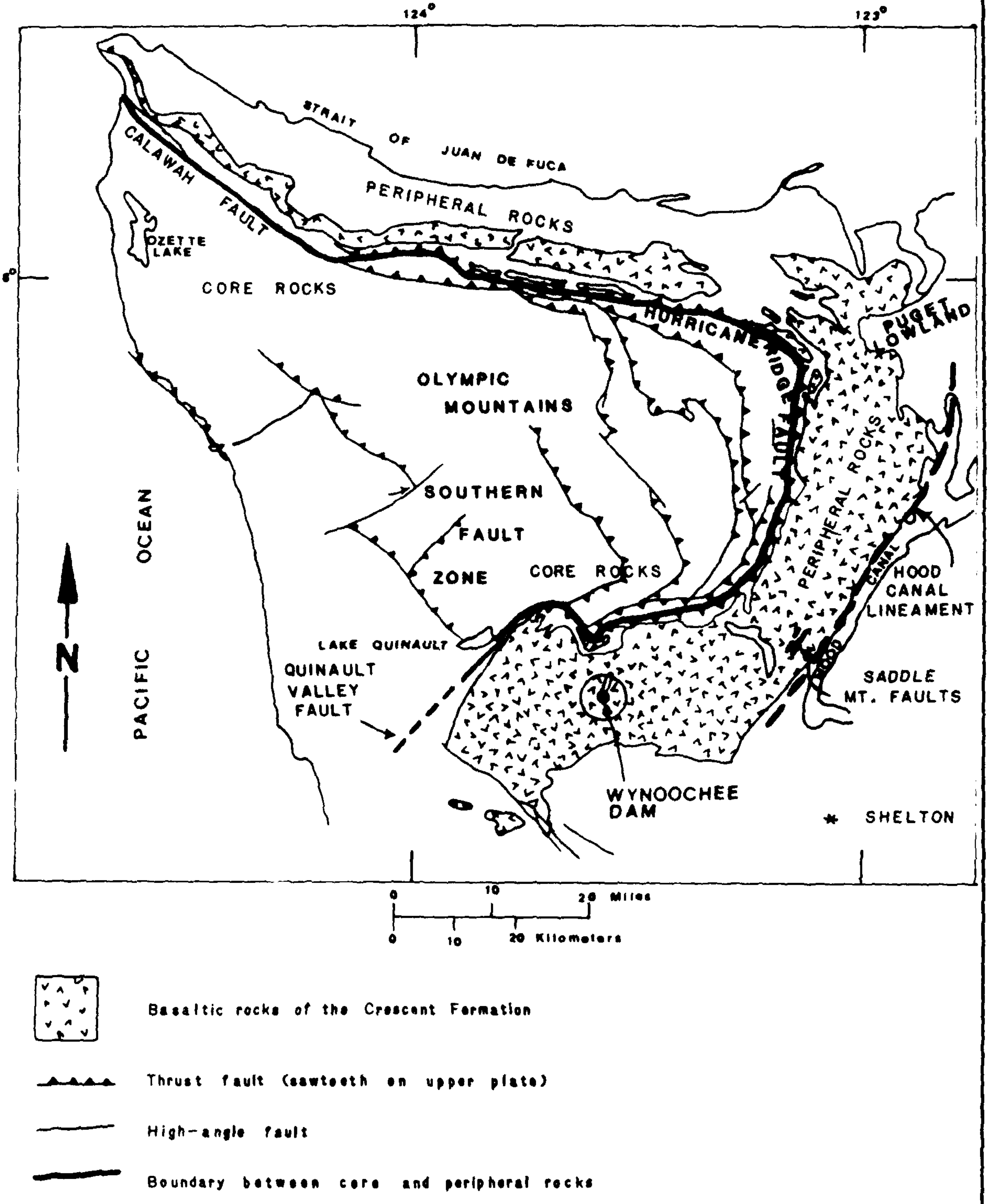
3.01 Areal Geology.

3.01.1 The project lies on the south flank of the Olympic Mountains. The Olympics consist of thrust-faulted, Tertiary, clastic, marine metasediments flanked on the north, east, and on the south by early Tertiary volcanic rocks and sediments that dip away from the core (Tabor and Cady, 1978). Core and peripheral rocks constitute two major geologic terraces as shown on figure 3-1. Core rocks are divided into an eastern terrane and a western terrane (Stewart, 1974). Western core rocks are mostly sandstone, siltstone, and minor conglomerate with scattered volcanic rocks in major shear zones. Western core rocks are nonslaty, while eastern core rocks consist of sedimentary rocks locally metamorphosed to slate, semischist, and phyllite. The eastern core rocks are sheared and broken. Ages of core rocks progress from oldest to youngest westward. Core rocks are separated from the peripheral rocks by steeply dipping thrust faults. The oldest peripheral rocks belong to the Blue Mountain unit which consists of argillite, conglomerate, and sandstone. These rocks underlie and are interbedded with early and middle Eocene volcanic rocks of the Crescent Formation. The Crescent Formation, named after exposures around Lake Crescent, consists of unmetamorphosed and metamorphosed tholeiitic basalt, diabase, volcaniclastic, and associated sediments. From 8 miles upstream to 10 miles downstream from the dam the rocks are dominantly basaltic lava flows striking west to northwest and dipping to the south.

3.01.2 Most of the central parts of the Olympics have been modified by glaciation with cirques at the heads of deep U-shaped main valleys. River valleys in the southern Olympics have been repeatedly glaciated during the Pleistocene by movement of ice outward from the interior of the Olympic Mountains. The repetitive glacial deposition combined with interglacial stream erosion has left complex valleys characterized by highly irregular rock surfaces with mid-valley bedrock knobs protruding through the present terraced valley configurations. In the Wynoochee Valley, three depositional stages significant to the project occur in the reservoir area. Each is represented by terrace remnants composed of both granular and clay materials. The lowest stage is represented by deposits between elevations 700 and 750 feet, an intermediate stage occurs between elevations 750 and 850 feet, and an upper stage occurs between elevations of 900 and 1,000 feet.

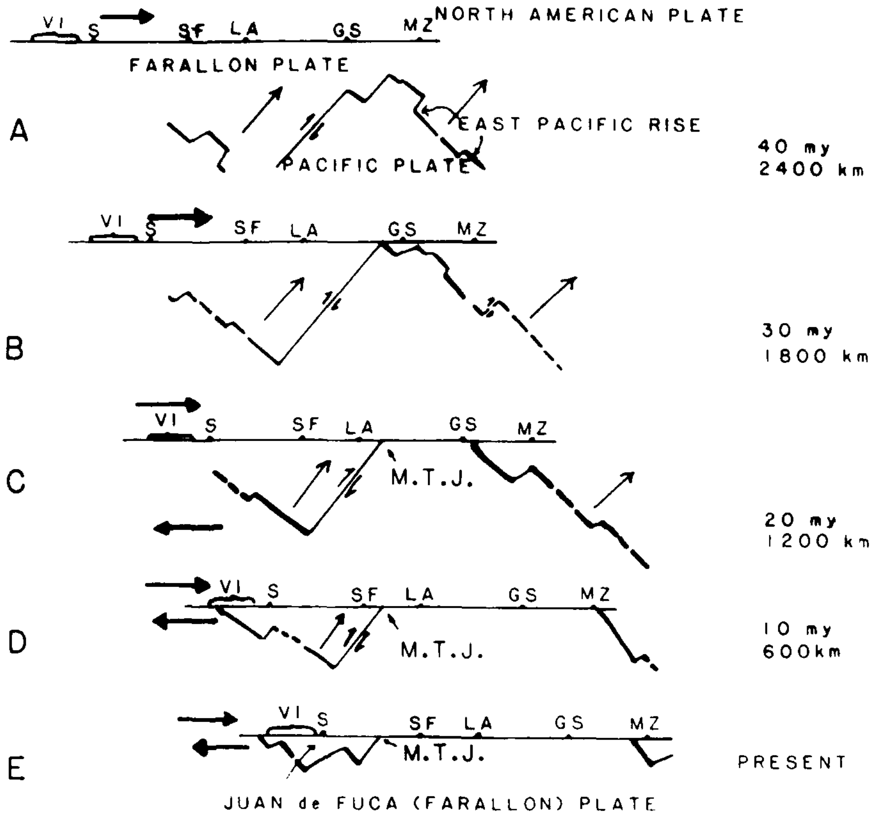
3.02 Tectonic and Seismic Setting.

3.02.1 The arcuate structure pattern observed in the Olympics is considered to be related to a subducting lithospheric plate (figure 3-2). Interaction between the North American, Farallon (Juan de Fuca), and Pacific plates produced the structural patterns of the region. Eastward dipping subduction of the Juan de Fuca plate beneath the North American plate generated isoclinal folds and imbricate thrusts in the Olympic Peninsula. From the onset of imbricate thrusting, the region was dominated by northeast-southwest compression. East or northeast high angle normal faults and north to northwest oriented



MAJOR GEOLOGICAL TERRANES OF THE OLYMPIC PENINSULA
(Modified from Tabor and Cady, 1978)

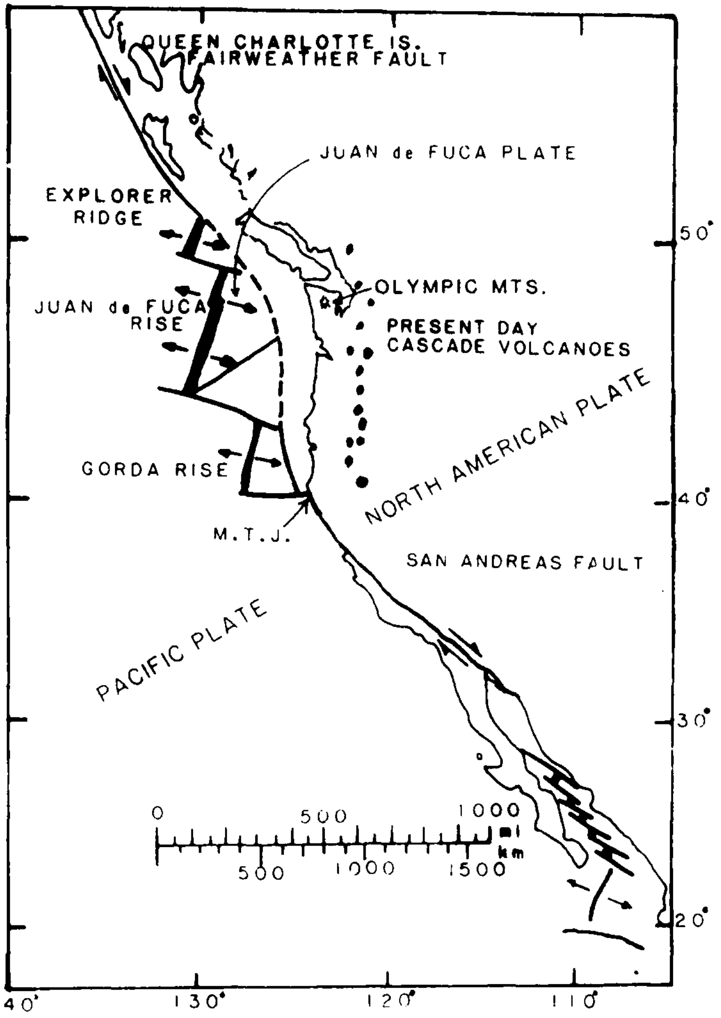
FIGURE 3-1



SCHEMATIC MODEL OF PLATE INTERACTIONS (Atwater, 1970)

VI-Vancouver Is.; S-Seattle; SF-San Fransico; LA-Los Angeles; GS-Guaymas; MZ-Matation; and M.T.J.-Mendocino Triple Junction.

Large arrows denote relative plate motions.



SOME TECTONIC ELEMENTS NEAR THE NORTHEAST PACIFIC AND WESTERN NORTH AMERICAN PLATE BOUNDARIES (Silver, 1971)

FIGURE 3-2

fold axes and reverse faults formed in response to this northeastward compression of the crust. During Pliocene to Holocene time, the regional stress system evolved to the present north-south compressional system. The present regional stress field is associated with the movement of the North American plate with respect to the Pacific plate as defined by dextral slip on the San Andreas and Queen Charlotte-Fairweather fault systems.

3.02.2 The structure of the Olympics is characterized by a series of major structural blocks separated from each other by major thrust and shear zones (figure 3-1). The Calawah fault separates highly deformed core rocks from peripheral rocks. Eastward, the Calawah fault splays into several faults separating slaty units of the eastern core (Tabor and Cady, 1978). West-northwest structural trends characterize most of the northern peninsula. The concentric Hurricane Ridge fault separates rocks of contrasting lithologies in the north. The fault wraps around into the southern Olympic Mountains and merges with the southern fault zone, a zone of intense deformations. Near Lake Quinault faults that bound the core merge to form the southern fault zone. Within the southern Olympics the only active known fault is the Saddle Mountain's East fault (figure 3-1) located between Hood Canal and Lake Cushman (Wilson, et al., 1979). This fault lies within 22 miles of the dam. It is a reverse fault, 1 mile in length, strikes N26°E and dips 75°E. The fault displaces Pleistocene gravels 9 feet vertically. Last movement on the Saddle Mountains East fault appears to have occurred about 1,200 years ago. The Saddle Mountains East and West faults cover a distance of about 2.5 miles and are believed to be Holocene features developed within an older northeast trending zone of fracturing. These faults may be surface branching of a deeper boundary fault manifest in the Hood Canal lineament.

3.02.3 A sparse earthquake record exists for the southern Olympic Mountains probably due to the low population density, and until recently, the lack of instrumentation. The limited historic seismicity record of the southern Olympics indicates that moderate earthquakes can be expected while the adjacent Puget Lowland to the east has experienced major earthquakes. For the earthquake analysis of Wynoochee Dam (in Design Memorandum 17) three models of possible seismic disturbance are considered most appropriate to the project: (a) a subcrustal zone beneath the western margin of the Puget Lowland; (b) a crustal source also in the vicinity of the western margin of the Lowland; and (c) a crustal source in the Quinault Valley. Estimated magnitudes for the three models are as follows:

> Model (a) is a Magnitude 7.5 earthquake, 22 to 37 miles deep, with an epicenter northwest of Shelton. Attenuation distance from the hypocenter is 35 miles.
>
> Model (b) is a Magnitude 6.9 earthquake, 26 miles east of the dam on the border of the Puget Lowland and is based on a half length (21 miles) of the largest possible causative normal fault; the Hood Canal lineament.

Model (c) is a Magnitude 6.0 earthquake on the Quinault Valley fault, 12 miles from the dam. The steep northwestern flank of Quinault Ridge is 12 miles long and assumed to be the potentially active segment along the fault. The magnitude is based on less than one-half length rupture.

Models (a) and (b) are generally accepted as portraying the seismic climate presently understood for the Puget Lowland. The surface rupture model (b) is based on the 42-mile length of the gravity expression of the structure.

3.03 Site Geology.

3.03.1 In the region of the dam, Wynoochee Valley is a 2-mile-wide U-shaped, glaciated valley (known as Weatherwax Basin) bounded by rock ridges which rise 2,000 feet above the valley floor (frontispiece). The dam spans a narrow canyon cut through the high point of a midvalley rock hill mostly covered by glacial drift. The glacial sequence includes an upper sandy and locally silty gravel, a central unit of varved silty clay, and a lower unit of variable glacial till with lenses of sand, silt, and gravel. The narrow basalt bedrock canyon extends from several hundred feet upstream to over 800 feet downstream from the dam. Extrusive igneous rocks constitute most of the bedrock in the area and consist of south dipping black to dark greenish gray basalt flows. Submarine pillow basalt flows (spilites) comprise most of the bedrock at the site. The rock is closely jointed and finely crystalline with carbonate veinlets and zones of palagonite. Palagonite (hydrous glass) forms 1-inch rinds on pillows and occurs in zones up to 1 foot thick at flow contacts and along zones of internal shear in a flow. Most joint surfaces are coated with unweathered dark chlorite. Thin clay and fine sandy interbeds are occasionally present at flow contacts. Locally, the basalt is cut by dark gray, moderately jointed diabase dike rock.

3.03.2 All of the concrete dam is founded on bedrock (figure 3-3). Basalt forms the right abutment, diabase forms the left, and a contact zone between the two rock types occurs in the valley bottom beneath the dam (plate 8). Generally, basalt occurs downstream of a diagonal vertical plane extending from the downstream end of the spillway chute along a N20°W bearing through the heel of monolith 5. Diabase is exposed in the foundations of monoliths 5, 6, and 7 and in all left abutment monolith foundations. The contact zone rock occurs with irregular near vertical boundaries and crosses the foundation along a diagonal zone ranging from 1 to 20 feet wide. The zone enters the dam area at the downstream end of the spillway chute, enters the dam foundation at the toe of monolith 7, and passes out of the foundation in the heel of monolith 5.

3.03.3 Bedrock beneath the dam and forming the canyon walls is characterized by many discontinuous randomly oriented joints. On plate 8 major joints are labeled alphabetically for location convenience. Contraction (cooling) joints, stress relief joints, and joints along flow contacts cause a highly variable degree of rock competency. Flow contacts are irregular, strike northwest, and dip between 30-80°SW. Stress relief joints with uneven

PRECONSTRUCTION WYNOOCHEE CANYON — VIEW UPSTREAM SHOWING WYNOOCHEE RIVER CANYON BEFORE CONSTRUCTION OF WYNOOCHEE DAM (1969)

FIGURE 3-3

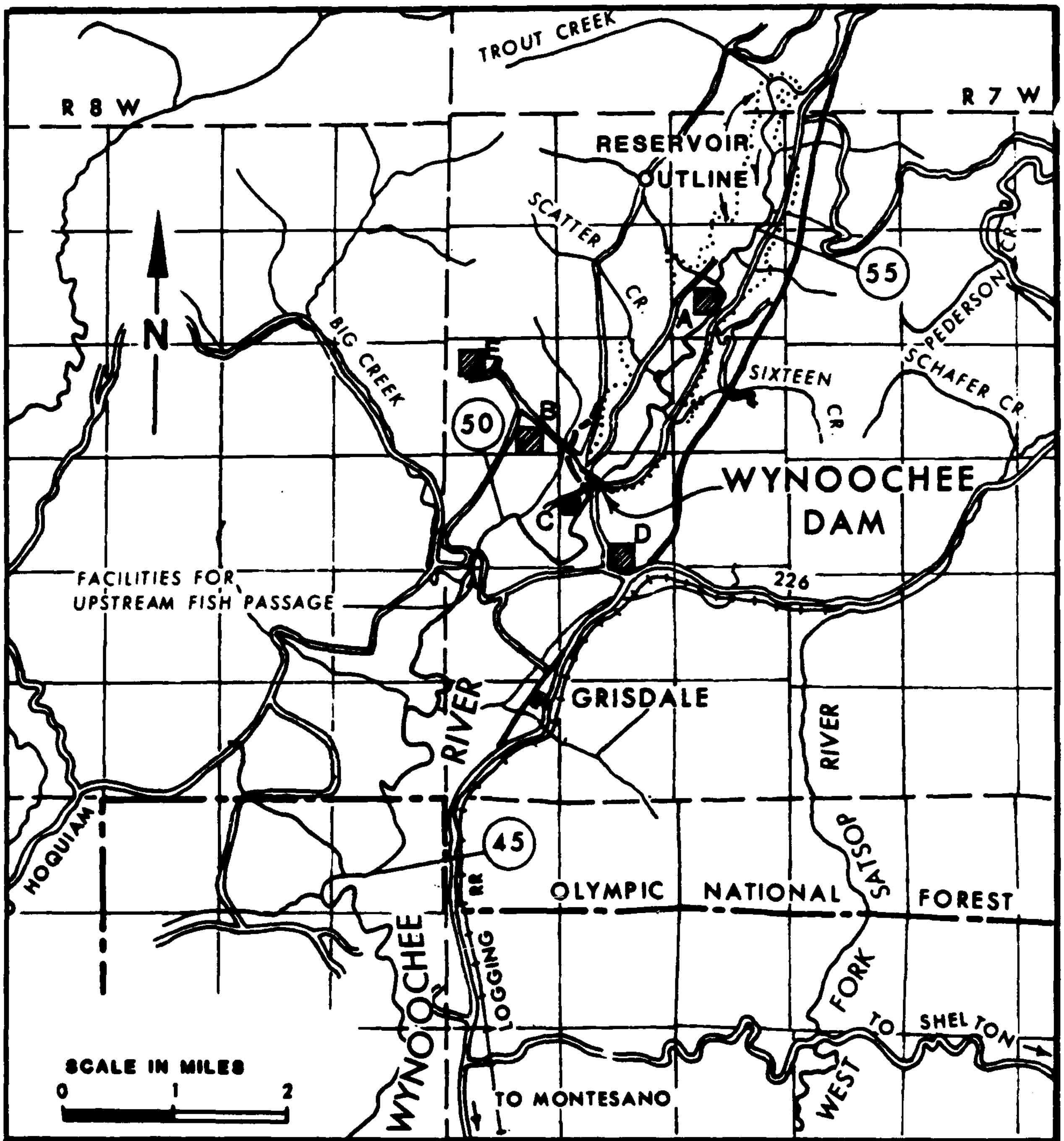
and rough surfaces dip toward the river in both canyon walls. The right bank basalt contains numerous open, intersecting joints with chlorite coatings and pockets of brown and gray clay. The degree of openness in individual joints or flow contacts in the basalt ranges from rock surfaces in contact to a zone 3-feet thick filled with weathered rock materials and clay. A spilitic basalt body occurs in the toe area of monoliths 1 and 2. Spilites are altered basaltic rocks that characteristically have a high albite feldspar content. This body trends N35°W and dips 55°SW, and is well defined with sharp boundaries. Prior to final foundation preparation, the spilitic basalt contained open joints filled with gray plastic clay paralleling both margin contacts and dipping 55°S. The left bank diabase foundation bedrock exhibits numerous three-dimensional, intersecting systems of open joints. Details of the joints are discussed in section 4. Prior to foundation preparation, the open joints in the diabase contained films of damp to moist plastic clay. The diabase was typically stained brown to depths of less than 0.2 foot. Basalt is generally weathered to greater depth than the diabase, primarily due to the more broken nature of the basalt caused during rapid submarine cooling during deposition. Before final excavation the basalt surface typically was partially decomposed and weathered brown. Locally weathered slabs and pockets of brown clay occurred to several feet of depth. Pockets and lenses of clay are common along open joints and flow contacts in the project area.

3.03.4 Numerous joints on both abutments served as conduits for ground water transmission during construction. Water which was used to moisten the monolith 12 foundation passed through a three-dimensional network of open joints in the diabase and emerged along various joints in the monolith 8 cut slope above the elevation 680 berm. Water also drained from the monolith 7 cut slope just below elevation 645 at 123 feet downstream from the dam axis. Prior to sealing operations in the foundations of monoliths 4 and 5, the water which ponded during rainy periods would drain after about 24 hours. Water flowed from open joints on the layback slope of monolith 6. Six to 8 hours after the start of rain, flow was first observed between elevations 670 and 700 feet. After 24 hours, seeps were observed at elevation 650 feet, though not in the dam foundation.

3.04 Geology of Construction Materials.

3.04.1 Satisfactory materials of sufficient volume for concrete aggregate, embankment construction, and for the right abutment impervious blanket were located within a reasonable haul distance of the project. Figure 3-4 shows the material source locations.

3.04.2 Concrete aggregate was excavated from a gravel pit located within the boundary of the reservoir about 2 miles northeast of the dam (location A on figure 3-4). These reservoir gravels are mostly graywacke and basalt rock types. The Wynoochee gravels are derived from an upstream area of hard graywacke and from a middle-reach belt of moderately altered basaltic rocks. Pleistocene stream gravels partly filled the valley and formed a high terrace approximately 300 feet above the present stream level. Subsequently, the stream cut down through the valley fill to produce an inner terraced valley.



LOCATION OF MATERIAL SOURCES

A ----CONCRETE AGGREGATE
B ----EMBANKMENT GRAVEL SHELL
C ----IMPERVIOUS BLANKET
D ----EMBANKMENT CORE
E ---- RIPRAP AND ROCKFILL

FIGURE 3-4

Gravels in the Pleistocene valley fill tend to show a weathered rind and are commonly silt coated. By contrast, the Holocene river gravels are both fresher and cleaner. Gravels downstream from the dam are dominantly altered basalt and those upstream are dominantly hard graywacke. The concrete aggregate gravels contained numerous wood fragments which led to a contractor claim for excessive processing. The wood fragments were hand picked from the aggregate at the feed and discharge ends of the processing plant in combination with a contractor-designed hydraulic sluicing tank. Wood fragments were reduced to negligible quantity. A total of 92,780 cubic yards (c.y.) of concrete were placed during construction of the main dam and spillway.

3.04.3 Sources B and D on figure 3-4 provided gravel for the embankments with source B providing clean gravel for the embankment filter and source D providing a somewhat more silty gravel (GP-GM) for the semi-impervious core and left abutment slope treatment.

3.04.4 Clay for the right abutment impervious blanket was borrowed from a glacio-lacustrine clay unit, location C, about 1/4 mile downstream from the dam on the right bank.

3.04.5 The riprap and rockfill for the embankments were obtained from a quarry at location E. The source is a massive diabase dike 1.5 miles northwest of the dam. The dike is about 120 feet thick and dips nearly vertical. Maximum available rock size is about 2 feet cubed. The petrographic analysis of the rock riprap is given in appendix C.

SECTION 4. FOUNDATION EXCAVATION AND TREATMENT

4.01 General.

4.01.1 Common Excavation. Clearing and grubbing for the left and right abutments were started in August 1969. Common materials were excavated using assorted types of heavy equipment, including scrapers, dragline, clamshell, whirly crane, dozers, backhoes, front-end loaders, and track drills. Between dam axis stations 1+55 and 4+46 (lip of canyon) on the right bank, approximately 28,000 c.y. of common materials were excavated in the foundation areas of monoliths 1, 2, 3, 4 and 5. Between axis stations 5+58 (lip of canyon) and 9+00 on the left bank, approximately 26,500 c.y. of common materials covering the foundations of monoliths 8, 9, 10, 11, 12, 13 and 14 were excavated. Approximately 160,000 c.y. of common materials were excavated for placement of both embankments and the right bank cutoff trench.

4.01.2 Rock Excavation. Rock excavation by drilling and blasting was required for shaping the foundations to achieve design grades. Blasting operations included line (presplit), production, and cushion blasts. Rock excavation for the left bank monoliths commenced in September 1969 and project blasting continued through February 1971.

4.02 Blast Vibration Monitoring.

4.02.1 A Geo Recon (later Slope Indicator) model S-2 blast monitor was used by Government personnel to monitor blasting for excavation in the spillway and right bank canyon wall. Two vibration detectors were placed on the Wynoochee River Bridge approximately 400 feet downstream from the blasting. One detector was placed midbridge on the walkway and the other on top of the left bank (east side) downstream abutment pier. On 27 October 1969, the largest blast, a 2,650 pound shot was detonated in 0 to 10 delays (250 milliseconds (ms) total time). The footing experienced a peak particle velocity of slightly less than 0.1 inch per second in the transverse mode at 24 cycles per second (c.p.s.). The bridge deck showed a peak particle velocity of 0.15 inch per second in a vertical mode at 22 c.p.s. The vibrations recorded during this and other shots were below the accepted damage threshhold for normal concrete structures.

4.02.2 The combination of rock fracture orientation and spacing on the right canyon wall act to decrease the tensile strength of the rock mass. In order to protect against rock mass instability, the initial blasting was monitored on the right canyon wall. One detector was positioned on rock within 50 feet of each blast and a second detector was placed on the right bank footing for the Contractor's temporary trestle bridge. Contract specifications had no requirements to control blasting procedures. As a result of blast monitoring in March 1970, blast procedures were modified by the Seattle District Geology Section. Procedures are summarized as follows:

- Production shots were held to maximum of 50 pounds of Gelamite II per delay with all delays a minimum of 25 ms apart.

- Cushion or presplit shots were held to a maximum of 35 pounds of Gelamite II per delay, plus primacord, with each delay a minimum of 25 ms apart.

- Cushion portion of a shot began a minimum of 250 ms following detonation of the final production delay.

- Adequate relief was given for each shot and each delay within a shot.

Total rock excavation by blasting was 35,455 c.y. between September 1969 and February 1971. Blasting events are summarized in table 4-1. Plates 9 through 12 in appendix B show excavation details. The photographs in appendix A may aid the reader in visualizing the following foundation discussions.

4.03 Right Bank Monoliths.

4.03.1 In monoliths 1 and 2, following initial stripping of the common material and the weathered, partly decomposed basalt surface, the exposed rock surface still contained weathered pockets and slabs. Slabs were underlain by open joints filled with brown plastic clay and similarly, pockets of weathered basalt contained broken rock debris and wet brown clay. Additional ripping and dozing with a D-9 dozer equipped with two 48-inch shank rippers removed the unacceptable materials up to 3 additional feet of depth. The spilitic basalt in the monolith toe areas contained a concentration of rock debris averaging 1/2 foot in diameter in a soft, wet, gray clay matrix (figure 4-2). This material was excavated to elevation 732 feet and backfilled with 474 c.y. of mass concrete to elevation 745 feet.

4.03.2 Monoliths 3 and 4 are founded on basalt bedrock (figure 4-2). The shape of the foundation is controlled by joints dipping 15° to 20° upstream (north). These joints daylight in local depressions and are relatively tight. After initial stripping of the monolith 4 foundation an area containing significantly large pockets of broken and weathered basalt was discovered under the heel area along with hard glacial till over much of the foundation surface. These discoveries occurred near the scheduled 1970 winter shut-down period. Construction efforts were focused on excavating and cleaning the materials prior to shutdown. Concrete placement was delayed until the following spring.

4.03.3 Monolith 5 is founded on basalt, a contact zone, and diabase as shown on plate 8. Detailed foundation structures were never mapped.

4.04 Diversion Excavation.

4.04.1 On 11 March 1970, the contractor detonated the first excavation blast along the right canyon wall, downstream from the concrete foundations in monolith 6. This blast exposed the N-relief joint (figure 4-3 and plates 8 and 11), along with several other open joints. Subsequent blasting and excavation

TABLE 4-1

BLASTING DATA

Date	*Shot Location	Shot Type	Powder Factor	Blast Holes	Depth Blast Holes (ft.)	Pattern In Feet
24 Sep 69	Left Abutment	Production	0.50	130	3 to 9	--
3 Oct 69	Spillway (6+35 to 7+10)	Line	--	130	12 to 29	2 x 2
27 Oct 69	Left Abutment	Production	0.25	350	12	5 x 7
31 Oct 69	Vista	Line	--	42	--	--
7 Nov 69	Manhole	Line	--	20	--	--
7 Nov 69	Manhole	Production	--	10	--	4 x 4
12 Nov 69	Left Abutment	Production	0.40	350	12	5 x 7
18 Nov 69	Left Abutment	Production	0.45	225	8	5 x 5
5 Dec 69	Spillway Chute	Production	0.50	400	11	5 x 5
Dec 69	Spillway Chute	Production	0.50	75	12	5 x 5
29 Dec 69	Spillway Chute	Production	0.40	150	2 to 11	4 x 4
31 Dec 69	Left Abutment	Production	0.40	160	2 to 10	5 x 5
14 Jan 70	Left Abutment	Line	--	75	13 to 32	2' Centers
20 Jan 70	Spillway	Production	0.26	60	20	6 x 6
23 Feb 70	Left Abutment	Presplit	--	39	10	2' Centers
23 Feb 70	Left Abutment	Line	0.56	265	10	4 x 4
3 Mar 70	Right Abutment	Production	--	--	20	5 x 5
11 Mar 70	Right Abutment	Line	--	--	20	--
11 Mar 70	Right Abutment	Production	--	--	20	5 x 5
23 Mar 70	Right Abutment	Line	--	29	--	--
23 Mar 70	Right Abutment	Production	--	9	--	--
23 Mar 70	Left Abutment	Production	0.50	200	10	--
23 Mar 70	Left Abutment	Production	0.50	200	10	--
30 Apr 70	D.S. 5+61 to 6+02	Line	--	--	20	--
30 Apr 70	D.S. 5+61 to 6+02	Production	--	00	20	--
4 May 70	D.S. 6+80 to 7+02	Line	0.40	35	14 to 18	--
7 May 70	Left Abutment	Production	0.34	73	15 to 20	5 x 5
7 May 70	Left Abutment	Production	0.42	70	15 to 20	5 x 5
13 May 70	Left Abutment	Line	--	24	15 to 20	2' Centers
13 May 70	Left Abutment	Production	0.38	78	15 to 20	5 x 5
13 May 70	Right Abutment	Line	--	59	7 to 15	2' Centers
13 May 70	Right Abutment	Production	0.40	100	7 to 15	5 x 5
14 May 70	Right Bank	Line	--	70	--	--
14 May 70	D/S Skewback	Production	0.15	10	10	5 x 5

Table 4-1. Blasting Data (con.)

Date	*Shot Location	Shot Type	Powder Factor	Blast Holes	Depth Blast Holes (ft.)	Pattern In Feet
20 May 70	Diversion Slope	Line	--	38	20	2' Centers
20 May 70	Diversion Slope	Production	0.10	8	20	Random
20 May 70	Rt. Abut. u/s Skewback	Line	--	10	10	2' Centers
20 May 70	Rt. Abut. u/s Skewback	Production	0.25	5	10	Random
21 May 70	Rt. Abut. d/s Skewback	Line	--	14	17	2' Centers
21 May 70	Rt. Abut. d/s Skewback	Production	0.33	6	17	Random
28 May 70	Lt. Abut. d/s Skewback	Line	--	23	20 to 33	2' Centers
28 May 70	Lt. Abut. d/s Skewback	Production	0.60	70	2 to 10	3x3, 4x4
8 Jun 70	Lt. Abut. d/s Skewback	Production	0.40	12	15 to 30	Variable
8 Jun 70	Right Abutment	Line	--	45	20	3' Centers
8 Jun 70	Right Abutment	Production	0.45	125	20	5 x 5
18 Jun 70	Div. Slope Layback	Line	--	37	20	2' Centers
18 Jun 70	Div. Slope Layback	Production	0.50	18	20	Random
19 Jun 70	Div. Slope Layback	Line	--	17	30	2' Centers
19 Jun 70	Div. Slope Layback	Production	0.53	13	20	Random
19 Jun 70	Div. Slope Layback	Line	--	16	30	2' Centers
19 Jun 70	Div. Slope Layback	Production	0.50	12	20	Random
24 Jun 70	Lt. Abut. 680 Berm	Line	--	32	20	2' Centers
24 Jun 70	Lt. Abut. 680 Berm	Production	0.33	15	20	5 x 5
24 Jun 70	Lt. Abut. 680 Berm	Line	--	32	20	2' Centers
24 Jun 70	Lt. Abut. 680 Berm	Production	0.24	18	20	5 x 5
30 Jun 70	Lt. Abut. 680 Berm	Line	--	21	20	2' Centers
30 Jun 70	Lt. Abut. 680 Berm	Production	0.40	6	20	Random
7 Jul 70	Div. Slope Layback	Line	--	8	20	2' Centers
7 Jul 70	Div. Slope Layback	Production	0.40	15	20	Random
7 Jul 70	Lt. Abut. 680 Berm	Line	--	32	20	2' Centers
7 Jul 70	Lt. Abut. 680 Berm	Production	0.22	15	20	7 x 7
11 Jul 70	Rt. Abut. Layback	Line	--	24	20	2' Centers
11 Jul 70	Rt. Abut. Layback	Production	0.70	43	20	Random
13 Jul 70	Left Bank	Line	1.00	10	8 to 10	Random
15 Jul 70	Left Abut. 680 Berm	Line	--	14	20	2' Centers
15 Jul 70	Left Abut. 680 Berm	Production	0.50	34	20	5 x 5
22 Jul 70	Div. Slope Layback	Line	--	7	20	2' Centers
22 Jul 70	Div. Slope Layback	Production	0.30	24	20	Varies

Table 4-1. Blasting Data (con.)

Date	*Shot Location	Shot Type	Powder Factor	Blast Holes	Depth Blast Holes (ft.)	Pattern In Feet
29 Jul 70	Div. Slope Layback	Line	--	13	20	--
29 Jul 70	Div. Slope Layback	Production	0.46	15	20	Variable
29 Jul 70	D/S Left Bank	Line	--	5	29	--
29 Jul 70	D/S Left Bank	Production	--	2	20	Variable
12 Aug 70	Div. Slope Layback	Line	--	12	20	2' Centers
12 Aug 70	Div. Slope Layback	Production	0.80	24	20	4 x 4
13 Aug 70	Pipe Tr. Wedge Cut	Line	--	24	43	2' Centers
19 Aug 70	Div. Slope Layback	Line	--	15	3 to 18	2' Centers
19 Aug 70	Div. Slope Layback	Production	0.75	34	3 to 18	Random
27 Aug 70	D/S Left Bank	Line	--	20	2 to 30	2' Centers
27 Aug 70	D/S Left Bank	Line	--	22	30	2' Centers
27 Aug 70	Div. Slope Layback	Production	0.15	9	20	Random
3 Sep 70	Div. Slope Layback	Line	--	22	3 to 10	2' Centers
3 Sep 70	Div. Slope Layback	Production	0.80	55	20 to 30	Random
3 Sep 70	D/S Left Bank	Cushion	0.50	33	3 to 14	Random
18 Sep 70	Div. Slope Layback	Line	--	21	10 to 17	2' Centers
18 Sep 70	Div. Slope Layback	Production	0.70	17	5 to 15	Random
3 Dec 70	Low Flow Conduit	Line	--	17	10 to 12	0.7'Centers
6 Jan 71	Low Flow Conduit	Line	--	11	18	0.7'Centers

*Shot-Location Abbreviations:

a. D.S. - Dam Axis Stationing (Stationing is shown on Plate 8 Appendix B)
b. D/S (d/s) - Downstream
c. U/s (u/s) - Upstream
d. Div. Slope - Diversion Slope
e. Lt. Abut. - Left Abutment
f. Rt. Abut. - Right Abutment
g. Pipe Tr. - Pipe Trench

progressed to approximately elevation 700 feet adjacent to the dam and to elevation 720 feet near the downstream end. During the course of the excavation, the slope became unstable arising from the N-relief joint. The N-joint contained springs and damp zones along its trace as well as a coating of plastic fines to 1 inch thick. On 30 April 1970, the contractor was notified to halt his excavations on the slope and to allow core drilling exploration. Between 4 and 8 May 1970 three NX size core borings were drilled into the slope to establish the limits of the N-joint. Examination of the geologic structure showed that the design rock excavation on the right abutment was stable; however, steepening of the rock slope to accommodate the contractor's diversion pipe would remove most of the support for the rock mass in the upper slope. On 19 May 1970, the Government notified the contractor that unstable rock extending from 50 to 160 feet downstream of the dam axis should be rock bolted on 5-foot centers or should be removed. The contractor removed the wedge of rock between the diversion cut line and the relief joint. On 18 June 1970, the contractor detonated the first cushion blast on the layback diversion slope. Three-inch-diameter line holes spaced on 2-foot centers were drilled along a new cutline to elevation 640 feet. During blast hole drilling the contractor had trouble with bits sticking in weathered and broken rock. The batter and alinement of some of the line holes deviated from the contractor's indicated design and in general the bottom of the drill holes did not fall along the contractor's designed toe of slope. The main blasting along the layback excavation slope was completed on 18 September 1970. The diversion pipe was completed on 5 November 1970 after delays due to high water. River diversion through the diversion pipe was made on 5 December 1970 after construction of the Z pile cofferdam (plates 9 and 10).

4.04.2 Solid core, 1-inch-diameter expansion shell rock bolts were installed in the right abutment in the area covered by monolith 6 concrete. Bolt lengths range from 15 to 40 feet in length with patterns and locations shown on figure 4-3. A total of 2,055 lineal feet of solid core, nongroutable bolts were installed. Groutable, 1-inch-diameter expansion shell rock bolts are installed in the slope downstream from the dam face. Bolt lengths range from 15 to 40 feet for a total lineal footage of 4,405. No progressive opening of major joints or evidence of mass instability have been observed in the exposed right bank rock excavation areas since the bolts were installed. The rock bolts were physically checked in 1982 and found to have proper seating. The bolt heads are monitored annually with a telescope. A shallow cave in the right wall of the canyon beneath the vista structure was filled with concrete to reinforce the slope during dam construction.

4.05 Canyon Monoliths.

4.05.1 Monolith 6, the right canyon monolith, is founded on basalt, diabase, and the contact zone between the two rock units. The bench originally excavated for the diversion pipe (figure 4-4) averages 25 feet in width, and 136 feet in length. This bench provided the foundation for the 13-foot diameter steel diversion pipe. The monolith 6 bench surface is irregular with frequent 1-foot-high "steps" that face both upstream and downstream. As-built grades range from elevation 632 to 640 feet along the right (west) side of the bench and from 637 feet in the upstream area to 630 feet on the downstream left (east) side. The shaped right rock wall against which the monolith was placed is shown on figure 4-3 and was excavated on 0.75 H to 1 V between elevations 640 and 720 feet. The 0-joint is a significant feature that is exposed in both the cut slope and bench. It strikes N55°E and dips 70°SE in the cut slope and dips near vertical across the bench. The 0-joint is generally open from 1 to 3 feet with white and gray mineralization filling the cavity. Several prominent joint systems in the bench are: a set trending N to N10°W with vertical dips; a set trending N55°W, dipping 10-30°S; a set trending N55-65°E with vertical dips paralleling the 0-joint; and a set trending N25-40°W with dips varying 20-35°S. All joints in the basalt are coated with chlorite. This condition caused progressive loosening of blocks and fragments requiring constant washing and hand picking just before concrete placement. During slope excavation on the right canyon wall several steeply dipping joints were encountered which produced unstable rock masses. The most troublesome was the N-relief joint which created a large unstable rock wedge above the diversion pipe alignment (see paragraph 4.04).

4.05.2 Monolith 7, is located in the center of the canyon and is the tallest monolith. It is founded on a combination bench and cut slope. The bench is approximately 43 feet wide and extends from 15 feet upstream to 140 feet downstream from the dam axis. The open 0-joint shown on figures 4-3 and 4-4 continues into the monolith bench foundation from monolith 6. The open L-joint trends N55°E, dips approximately vertical and occurs in the downstream side of the low flow conduit excavation (figure 4-5 and plate 12). The T-joint strikes N55°W, dips 35°S and is a prominent joint with associated parallel open joints occurring above and below, spaced 4 to 6 feet apart. This area of parallel joints occurs under the heel of the dam and extends as much as 25 feet downstream. The T-joint and parallel joints responded to unloading during excavation blasting in the low flow conduit area. This joint system is reinforced by two rows of four each solid core 1-inch-diameter rock bolts varying in length from 15 to 25 feet. The bolts were inclined down 60° and aligned normal to the strike of the T-joint (figure 4-5). The intersection of open joints trending N55°E and dipping 35°NW with the T-joint system and L-joint produces blocks and slabs ranging in size from 1 foot to about 3 feet. Four horizontal rows of 1-inch-diameter solid core rock bolts were installed on 10-foot centers in the area covered by monolith 7 concrete. Rock bolt lengths range from 10 to 25 feet with a total installation of 840 lineal feet. When it was evident that the slope would remain uncovered for more than 8 months, this standard bolt pattern was supplemented with an additional 840 lineal feet of ungrouted bolts to produce a 5- by 5-foot pattern over the wall surface adjacent to the low flow conduit. These rock bolts range from 10 to 15 feet in length and are located from 15 feet upstream of the dam axis to 55 feet downstream to control progressive loosening of the N55°E trending vertical joints. The additional bolts include seven 15-foot-long reset bolts along the periphery of the low flow conduit excavation to help prevent opening of the L-joint and the N55°E vertical set of open joints.

4.05.3 Monolith 8, the left canyon monolith is founded on a combination bench and cut slope in the diabase bedrock (figures 4-6 and 4-7). The 45-foot-high cut slope is variable and ranges from 0.62 H - 1 V at the dam axis to 0.55 H - 1 V about 50 feet downstream. A three dimensional system of intersecting open joints occurs in the foundation and cut slope. The R-joint is a prominent joint in the cut slope ranging in strike from N10^{o}W to N55^{o}W with dips from 35-50^{o}SW. The R-joint is open to ground water and surface water movement. A second prominent system strikes approximately N55^{o}E and dips 40-50^{o}NW. Spacing between joints averages about 1.5 feet. A series of discontinuous and irregular joints striking N25^{o}E to N55^{o}E and dipping from vertical to 60^{o}SE locally cause overhanging slabs of bedrock. The cut slope is reinforced with solid core, 1-inch-diameter rock bolts on 10-foot centers (figure 4-7). The open J-joint and associated parallel joints are exposed in the monolith 8 wall surface from 50 feet to over 150 feet downstream from the dam axis. The joint zone strikes N45^{o}W and dips 10-35^{o}SW and ranges in thickness from 1 to 3 inches. Joint filling consists of partly decomposed rock fragments and brown, wet, stiff, plastic clay (CL).

4.05.4 Solid core, 1-inch-diameter expansion shell rock bolts were installed in the areas covered by concrete on the left abutment. A total of 840 lineal feet of nongroutable bolts were installed between elevations 690 and 710 feet in two rows of 40-foot-long bolts and one row of 30-foot-long bolts on a 10- by 10-foot pattern as shown on figure 4-7. Rock bolts inclined down at 60^{o} were installed in the monolith 8 bench foundation at the upstream end. The 1-inch-diameter solid core bolts are in two rows of four each ranging in length from 15 to 25 feet for a total length of 170 lineal feet. These bolts were installed to control inflation of joints associated with the T-joint system. The inflation response was due to natural processes of unloading which were accelerated by blasting in the adjacent low flow conduit excavation.

4.05.5 Grouted 1-inch-diameter rock bolts were installed on the slope below the downstream right side of the spillway between elevations 690 and 730 feet. Forty-five rock bolts amounting to 980 lineal feet were installed in four phases to reinforce, pin, and support the natural slope condition. Bolts range from 10 to 40 feet in length with the 20- and 40-foot bolts passing through the J-joint into competent rock. Later vibrations from blasting at lower elevations opened joints in an area below elevation 730 feet at the downstream right corner of the spillway. Additional scaling from behind the rock bolt plate at elevation 723 feet exposed a joint dipping 35^{o} toward the river and at lower elevations an 8-foot-thick rock slab dipping 70^{o} toward the river. Rock bolts, 20 and 30 feet in length, on 5-foot centers, extend through the slab into competent rock behind the J-joint. Rock bolts were installed on 10-foot centers at elevations 710 and 720 feet immediately downstream of the face of the dam. These 25-foot-long bolts reinforce the natural slope along 50^{o} to 70^{o} open joints which dip toward the river. To provide additional support for the foundation under the right wall of the spillway, additional rock bolts were installed between elevations 660 and 730 feet.

4.06 Left Bank Monoliths.

4.06.1 Monoliths 9, 10, and 11 are entirely founded on diabase bedrock (figure 4-8). The continuous open J-joint, described under monolith 8, extends across the downstream toe of monoliths 9, 10 and 11 and into the monolith 11 cut slope. The J-joint was excavated from upstream areas in the foundations for monoliths 9, 10 and 11 because the feature was above the fixed design grade. A three dimensional interconnected system of open joints forms blocks and slabs of rock in the monolith 10 foundation. A prominent set of open joints ranges from N55°E to N65°E with dips from vertical to 50°SE and occasional 50°NW dips. A N to N10°W set with 20-45°E dips produces a pronounced vertical relief averaging about 1 foot high.

4.06.2 The monolith 11 foundation is a combination bench (figure 4-8) and cutslope (figure 4-9). Extensions of joint systems in the monolith 8 cut slope and monoliths 9 and 10 foundations produce a network of intersecting joints in monolith 11. The J-joint varies in dip from 15-35°SW (downstream) and averages about 25° in the cut slope face. A N50°W set paralleling, but not directly adjacent to the J-zone dips from 20° downstream to 50° upstream. Surfaces of the J-joint and joints striking N50°W contained discontinuous films and pockets of brown, stiff, wet, clay (CL) before removal. Another prominent set, with tight planes in rock to rock contact, strike N65°E and dip from vertical to 50°NW. The 20° to 50° upstream and downstream dipping joints responded to blasting by loosening below grade and required removal during foundation preparation. Twenty-five number 11 "J" bars were set 10 feet deep, each with 4-foot stick-up above the rock surface. The bars are spaced on 5-foot centers and four rows of bars continue under the grouting gallery area from monoliths 9 and 10.

4.06.3 Production blasting was used for foundation rock excavation in monoliths 9, 10, and 11. Three-inch-diameter blast holes were drilled on 4- by 4- and 5- by 5-foot staggered and parallel patterns depending on depth of cuts. Holes were loaded with 45 percent Gelamite II powder in 2 by 16 (2.09 lbs. each) sticks. Four to five sticks were column loaded in each hole with stemming and a 7- to 10-foot collar. Dynamite ranged from 150 to 900 pounds per blast with most shots 400 to 500 pounds. Powder factors ranged from 0.25 to 0.55 for all major blasts in the monolith foundations. From six to twelve delays with 25 to 80 millisecond intervals were used in parallel patterns to relieve blast forces away from final surfaces.

4.06.4 Overdrilled blast holes occur in the final foundation surfaces of monoliths 10 and 11. Radial cracks surround a number of holes indicating the holes were loaded and detonated below grade. Locations of these holes are shown on figure 4-8. In monolith 10, the 10-35°SW dipping joints paralleling the J-joint and the N to N10°E joint set with dips 20-45°E inflated due to blast forces below grade. The inflation led to overexcavation of foundation rock. In monolith 11, the 20° to 50° upstream dipping joints and 20° to 35° downstream dipping joints responded to blasting by loosening below grade and required removal during foundation preparation.

Twenty-five number 11 "J" bars were set 10 feet deep with 4 feet "stick-up" above the rock surface. The bars are spaced on 5-foot centers and a continuation of four rows of bars under the grouting gallery extended into monoliths 9 and 10.

4.06.5 Monoliths 12, 13, and 14 are founded on the diabase bedrock (figure 4-10). The open three-dimensional intersecting joint system exposed in the left cut slope of monolith 11 extends into the monolith 12 foundation. The N50°W trending set of joints which dip 20° to 35° upstream were coated with medium to very stiff, brown, moist, plastic clay (CL). The N65°E set dipping from vertical to the north are open in monolith 12 and contained moist, plastic clay before removal. The third set strike N50°W and dip 20° to 50° downstream. Intersection of these joints along the monolith 11-12 joint line resulted in considerable foundation preparation effort. The open joints dipping toward monolith 11 daylight in the cut slope. In particular, the N65°E, 50°NW set caused the most difficulty. Five number 11 dowels 5 feet 7 inches long were grouted full depth into the foundation, 7 feet upstream of the dam axis between stations 7+49 and 7+65. The dowels were installed through a tight surface slab with 30° upstream dip and through at least one lower plane. A row of eight number 11 "J" bars 17 feet long were grouted 15 feet into the foundation, 15 feet downstream from the axis between stations 7+45 and 7+80. The vertically installed bars penetrate a clay coated succession of joints dipping 20° to 35° upstream. The N50°W joint set that dips 20° to 35° upstream continues to station 8+20 in monolith 13. Removal of some of these tight slabs during foundation preparation did not improve the condition of the foundation. Therefore, two rows of four each, number 11 dowels, 8.5 feet long, were grouted vertical for full depth into the foundation. Installed on 5-foot centers between stations 7+90 and 8+05, one row is 3 feet upstream and the other is 2 feet downstream from the dam axis. The most prominent features visible in monolith 13, between stations 8+20 and 8+33, are N50°E to N65°E trending, near vertical dipping white mineral seams. These seams caused no problems during foundation preparation. The west half of monolith 14 foundation contains no open joints except for a 15° downstream dipping joint with E-W strike. Open joints in the east half exhibit a two dimensional intersecting system with E-W and N-S strikes. The E-W set dip from 20° to 40°S and the N-S set dips from 60°E to vertical. The continuous open P-joint crosses the foundation diagonally trending E-W with dips ranging 20-45°S. Paralleling open joints contained clay (CL) which was removed prior to concrete placement.

4.06.6 In portions of monoliths 12, 13 and 14, concrete beneath the downstream gutter of the drainage and grouting gallery is a minimum of 3.5 feet thick. Design specifications stated there would be a 5-foot minimum; however, due to the nature of the wedges involved, a 3.5-foot minimum was allowed for about 8 feet in monolith 12; 32 feet in monolith 13; and 35 feet in monolith 14. Minor jackhammering was used to remove projections of the rock surface extending inside the 3.5-foot clearance minimum.

4.07 Spillway Chute.

4.07.1 Presplitting was accomplished before any production blasting. On 3 October 1969, the contractor presplit the left and right sides of the spillway. Total charge of this shot was 800 pounds. The 3-inch-diameter line (presplit) holes were drilled on 2-foot centers and loaded with Hercosplit WR 7/8- by 24-inch, 25 percent powder and primacord. Considerable damage occurred outside the excavation limits from the 3 October shot indicating that the shot was overloaded. Overbreak occurred along the top left wall area and a ridge of rock along the right wall area broke out along an open joint structure. On the left wall the shot vented through the foundation, rather than forming a face. At the extreme downstream end of the spillway chute, venting followed joints up to 7 feet away from the planned face. In the area where the spillway excavation is closest to the service road the shot vented through the roadway. On the riverward (right) side of the spillway, part of the rock rib that was supposed to stand between the spillway and canyon apparently shifted 1 to 2 feet riverward. Several joints dipping 50° to 60° toward the river were exposed. Original design called for using the rib of rock as lateral support for the right spillway wall. Successive blasting caused further loosening of the rib and the rib was finally removed with a D-9 dozer with ripper necessitating design of a free standing right spillway wall. Production (fragmentation) blasts consisted of 3-inch-diameter holes on 4- by 4-foot and 5- by 7-foot parallel patterns. Holes were loaded with 1-1/2 to 2 sticks of Gelamite II dynamite in 2 by 16 stick size. Parallel and chevron delay sequences were used to relieve blast forces upstream and downstream. Dynamite ranged from 400 to 2,650 pounds per blast and 6 to 12 delays were used with 25 to 40 millisecond intervals. Cushion blasting was not used in the spillway.

4.07.2 The H-joint occurs in the left spillway wall and J-joint occurs in the spillway chute foundation. The spillway foundation was never mapped by a geologist. The H-joint strikes N15°W, dips downstream 15° to 25° and is open from 0.1 to 1.0 foot. The H-joint daylights at the downstream end of the chute. The J-joint is exposed in the cut slope below the right wall and extends from the downstream end of the monolith 9 foundation to under the spillway structure. The joint zone strikes N45°W, dips 15°-35°SW and ranges in thickness from 0.5 to 3.0 feet. A three dimensional interconnected system of joints forms irregular blocks and slabs in the foundation. One set crosses diagonally trending N60°E with dips ranging from 45° to 70°SE. Another set strikes N60°E and dips 45° to 50° toward the river. One joint striking N60°W and dipping 10°E intersects the J-joint and forms a large rock wedge in the right wall area. This wedge is keyed against the J-joint and presents no stability problem. Also a system of joints trending N10°W to N50°W dip 20°-30°SW. A system of white mineral filled joints in the left wall strike N60°E and dip from vertical to 70°NW. Joint spacing averages about 1 foot apart.

4.08 Concrete on Rock Foundations. Laboratory testing was not performed on the foundation rock. It was assumed that the compressive strength of the confined rock at the base of the dam would not be greatly affected by joints and, therefore, would be equal or greater than the compressive strength of the mass concrete in the dam. A conservative shear strength of 500 p.s.i. was assumed for the foundation rock. The design shear strength of the mass concrete was 500 p.s.i. and the shear strength between the rock and concrete was assumed to be 500 p.s.i. (Corps of Engineers, DM10, 1967). Contract specifications required concrete to be placed on clean rock surfaces, free from oil, standing or running water, ice, mud, drummy rock, coating, debris and loose, semidetached or unsound fragments. To comply with specifications, all faults or seams were cleaned to a satisfactory depth and to firm rock on the sides. Foundation preparation and cleanup were accomplished by jetting with high pressure air and water to remove loose surface debris. Clay seams, scale and deteriorated mineral coatings were removed by such methods as sandblasting, hand wire brushing and dental excavation with pick and shovel. Despite suggestions that the contractor use a sandblasting machine he relied heavily on wire brushing methods for some of the leveling placement foundations, especially in monolith 12. All rock surfaces were kept continuously wet for at least 24 hours immediately prior to concrete placing. Horizontal rock surfaces were covered (broomed) with a layer of mortar, immediately before the concrete was placed. Several scheduled concrete placements were delayed or rescheduled because of unacceptable preparation of the final foundation surfaces.

4.09 Right and Left Embankment Foundations.

4.09.1 By April 1970, all common excavation of foundations for the left and right embankments and for the upstream right bank cutoff trench was complete. These foundations were never mapped; however, they were photographed and selected photographs are in appendix A. Foundation materials discussed in the text and shown on plates 13 and 14 are interpreted from construction photographs, preconstruction drill boring logs, and logs of exploration pits in the area.

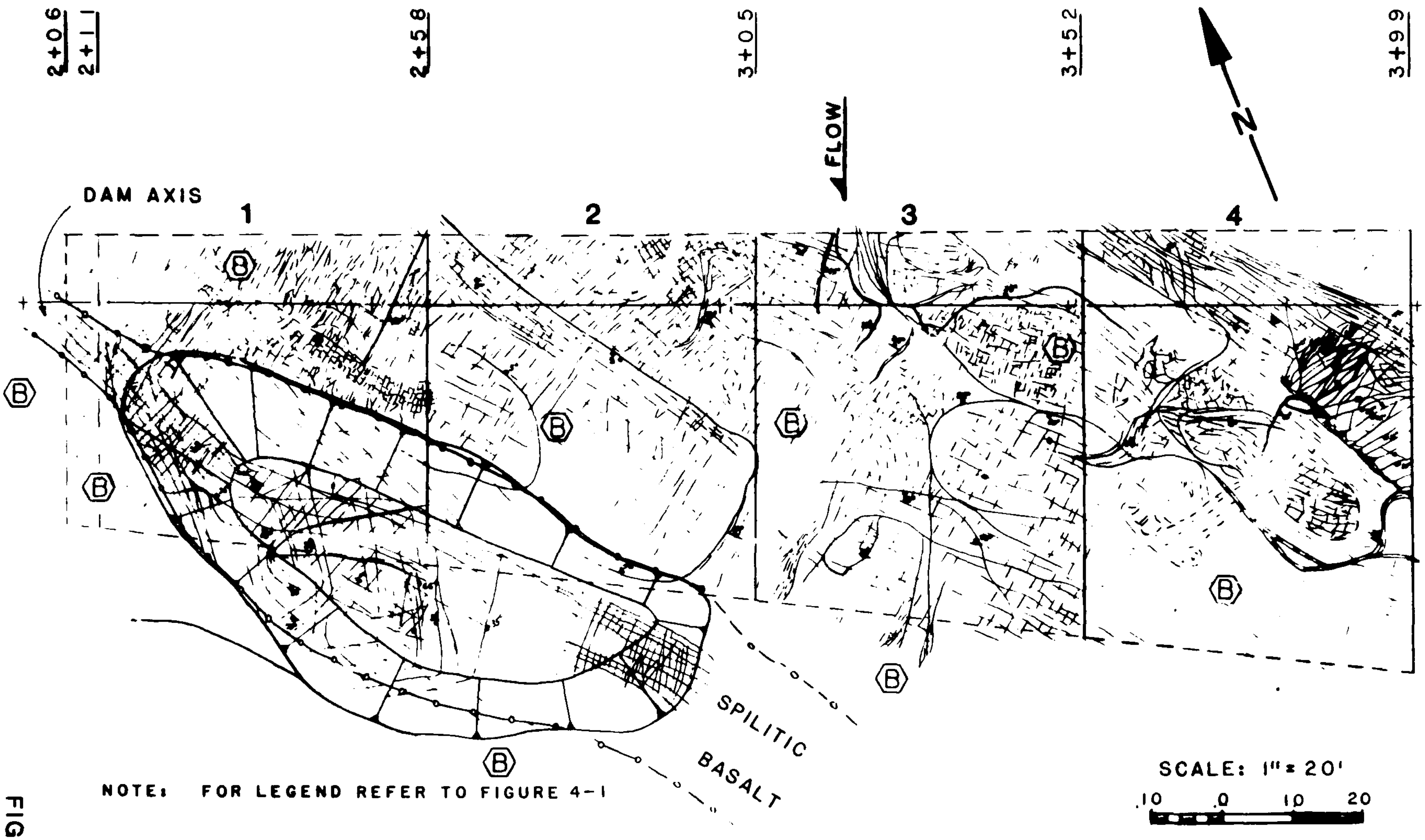
4.09.2 The left embankment is founded on granular materials consisting of discontinuous beds and lenses of sandy gravel, medium to gravelly sand, and silty sandy gravel. The semi-impervious core of the embankment is keyed into diabase bedrock between the concrete section of the dam and 400 feet to the east as shown on plate 13. Approximately 450 to 650 feet east of monolith 14 the embankment core is keyed into lean blue-green sandy clay.

4.09.3 The right embankment is founded on granular materials similar to that in the left embankment foundation. The semi-impervious core of the right embankment is keyed to basaltic bedrock. From dam axis station 1+00, a cutoff core trench extends upstream at a right angle to follow the reservoir shoreline for approximately 1,000 feet. The trench, shown on plate 13, varies in depth from 5 feet at its northern end to over 20 feet at station 6+00 (control line A). On control line A from station 0+80 to 4+75, the trench is keyed to hard glacial till composed of clayey gravel. From station 4+40 to 7+00, the trench is keyed to stiff lean clay. From station 7+00 to 10+00, the trench is keyed to granular sediments deposited as discontinuous beds of silty sandy cobble gravel and gravelly sand. Sides of the cutoff trench between stations 0+80 and 10+00 are composed of granular materials. The clay core for the upstream right bank cutoff trench was placed in June and July 1970. In July 1971, the impervious right abutment blanket was placed and joined to the core in the cutoff trench.

FIGURE 4-1

LEGEND FOR FIGURES 4-2 THROUGH 4-10

30 ◢╱	Trace of dipping joint with angle and direction of dip.
—■—	Trace of vertical joint.
50 ●—●—●—●	Dipping contact between rock units with angle and direction of dip.
———	Trace of open joint.
~ ~ ~	Trace of joint with slickensides.
≈ ≈ ≈	Open zone with weathering and plastic fines.
⟨B⟩ ⟨C⟩ ⟨D⟩	Foundation rock unit B-Basalt, C-Chilled Zone, D-Diabase.
Ⓝ	Major joint, designated by circled alphabet letter.
♀ 0.5	Seepage with quantity of water estimated in g.p.m.
⊗ 30	Ungrouted rock bolt and length in feet.
● 25	Grouted rock bolt and length in feet.
△ 40	Drain hole and length in feet.



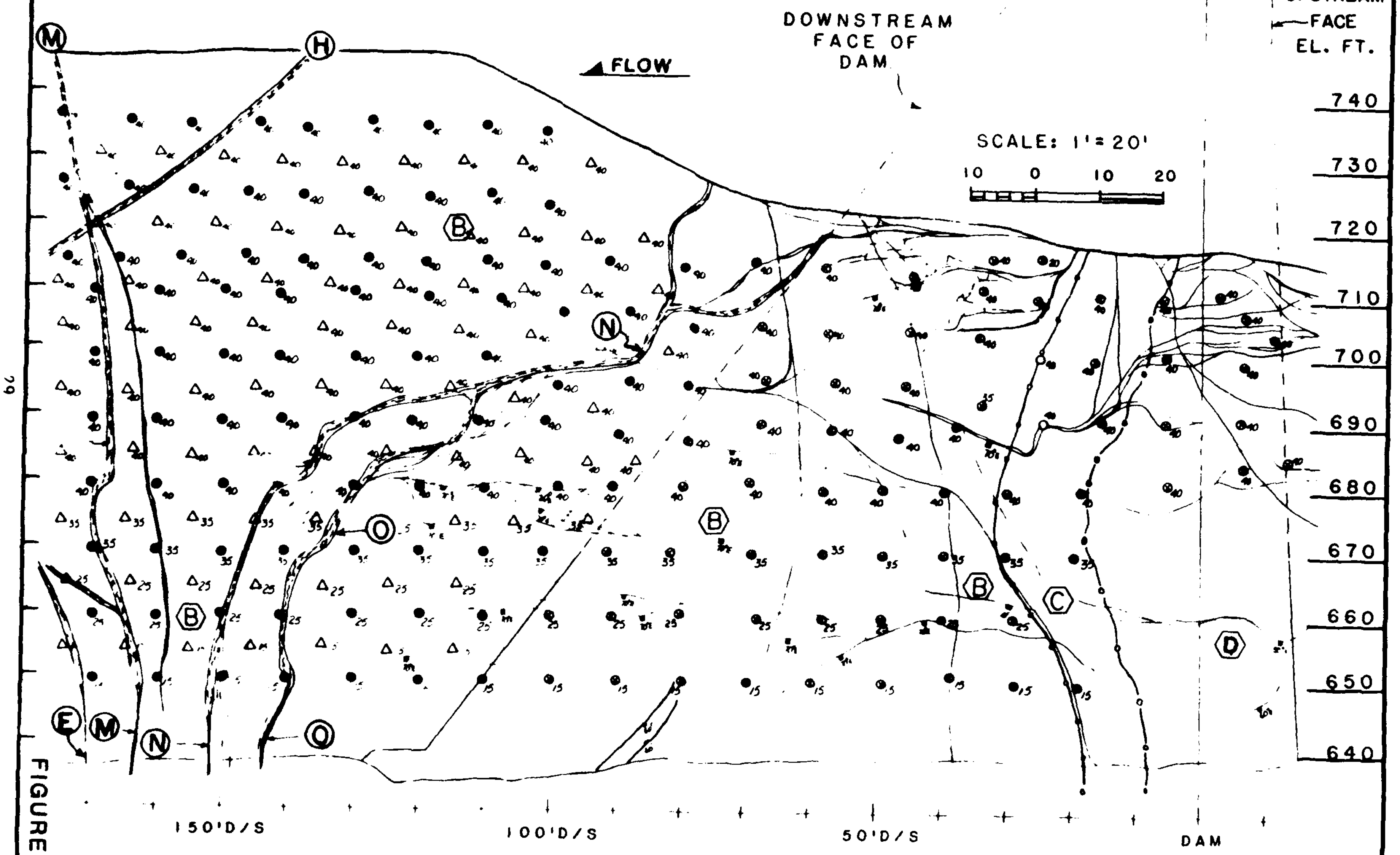
NOTE: FOR LEGEND REFER TO FIGURE 4-1

FIGURE 4-2

GEOLOGICAL PLAN-MONOLITHS 1,2,3 AND 4

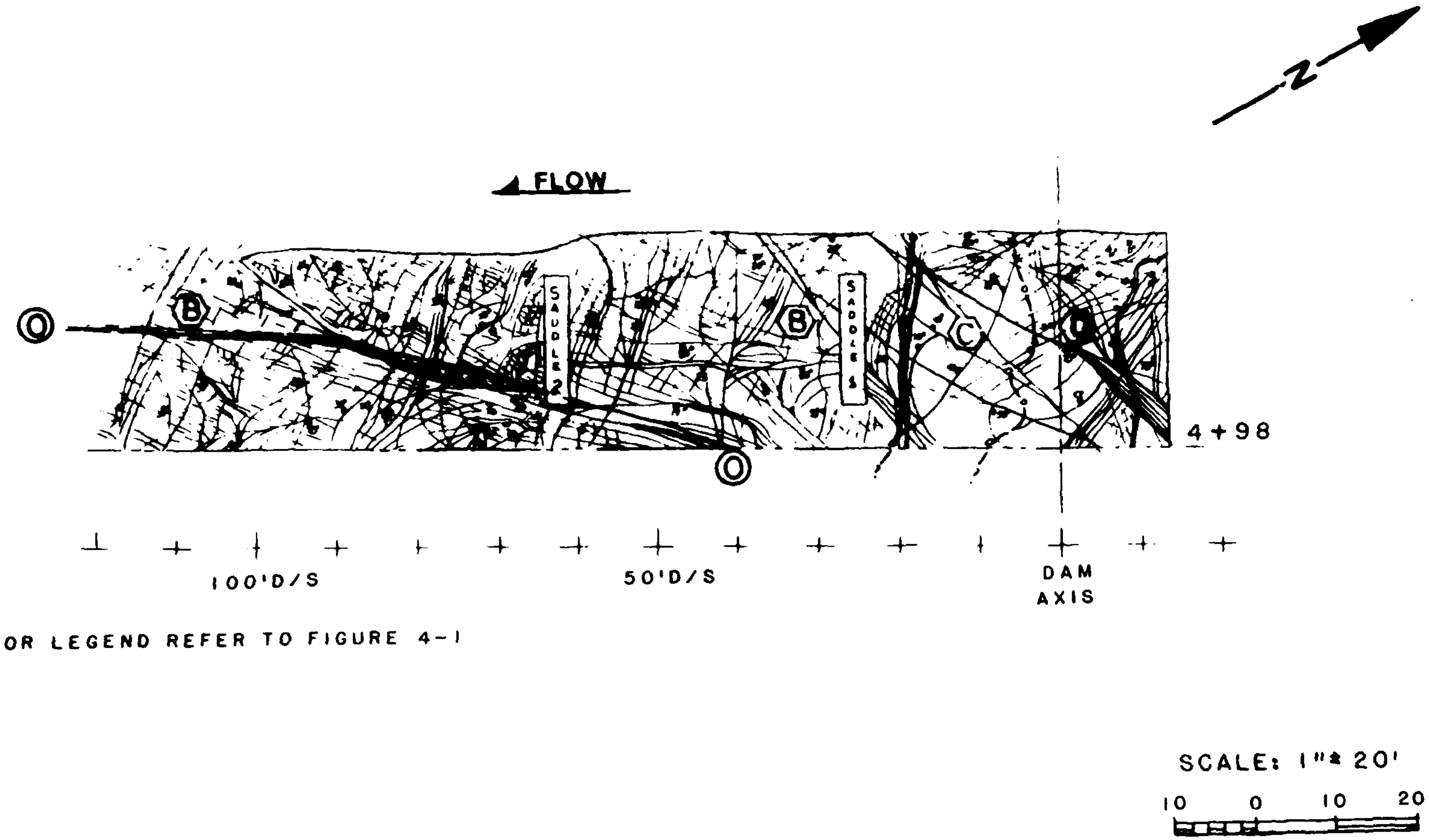
WYNOOCHEE DAM FOUNDATION REPORT

NOTE: FOR LEGEND REFER TO FIGURE 4-1



GEOLOGICAL SECTION-MONOLITH 6 WALL SURFACE
WYNOOCHEE DAM FOUNDATION REPORT

FIGURE 4-3

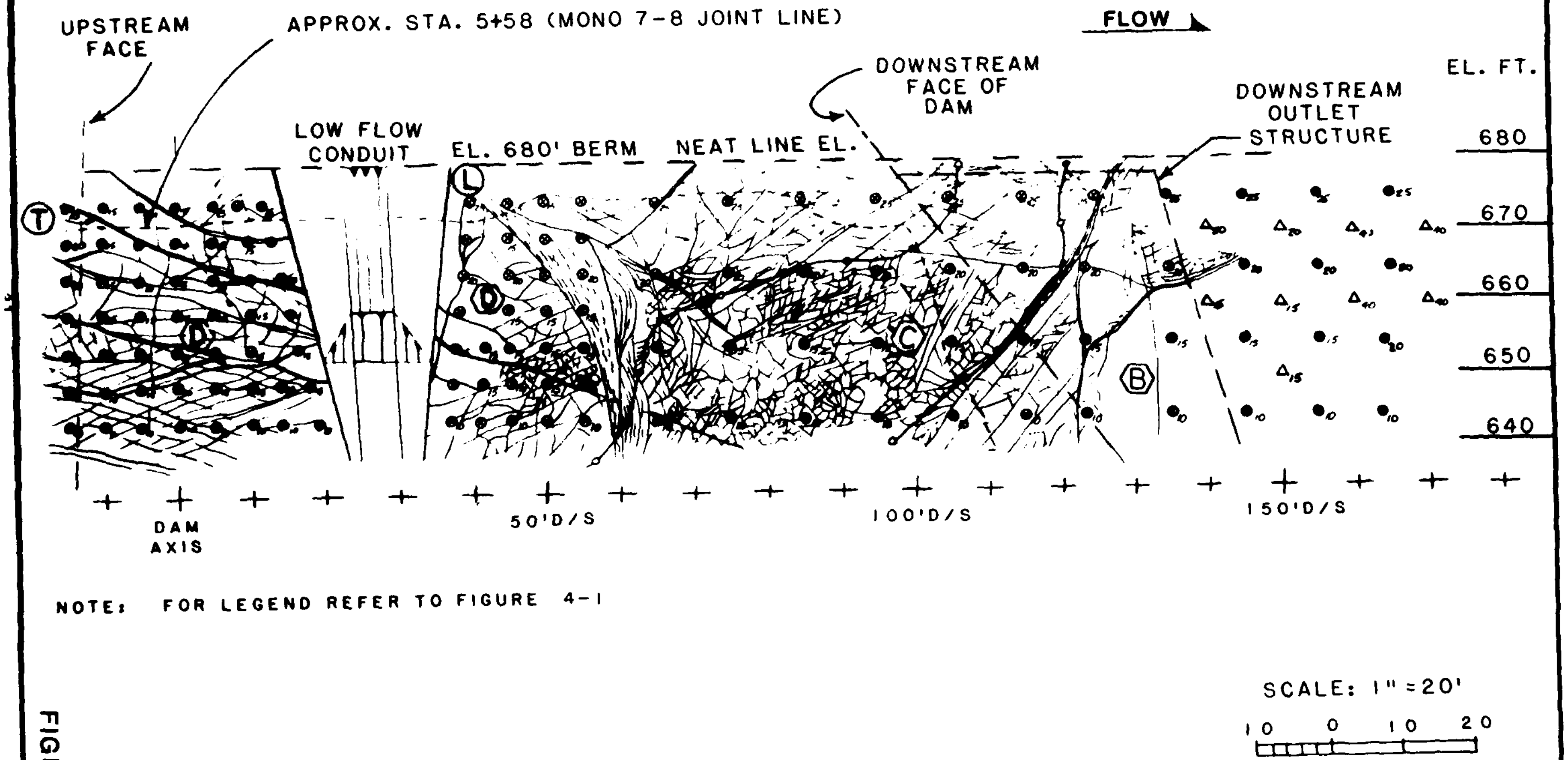


NOTE: FOR LEGEND REFER TO FIGURE 4-1

GEOLOGIC PLAN - MONOLITH 6 (BENCH SECTION)

WYNOOCHEE DAM FOUNDATION REPORT

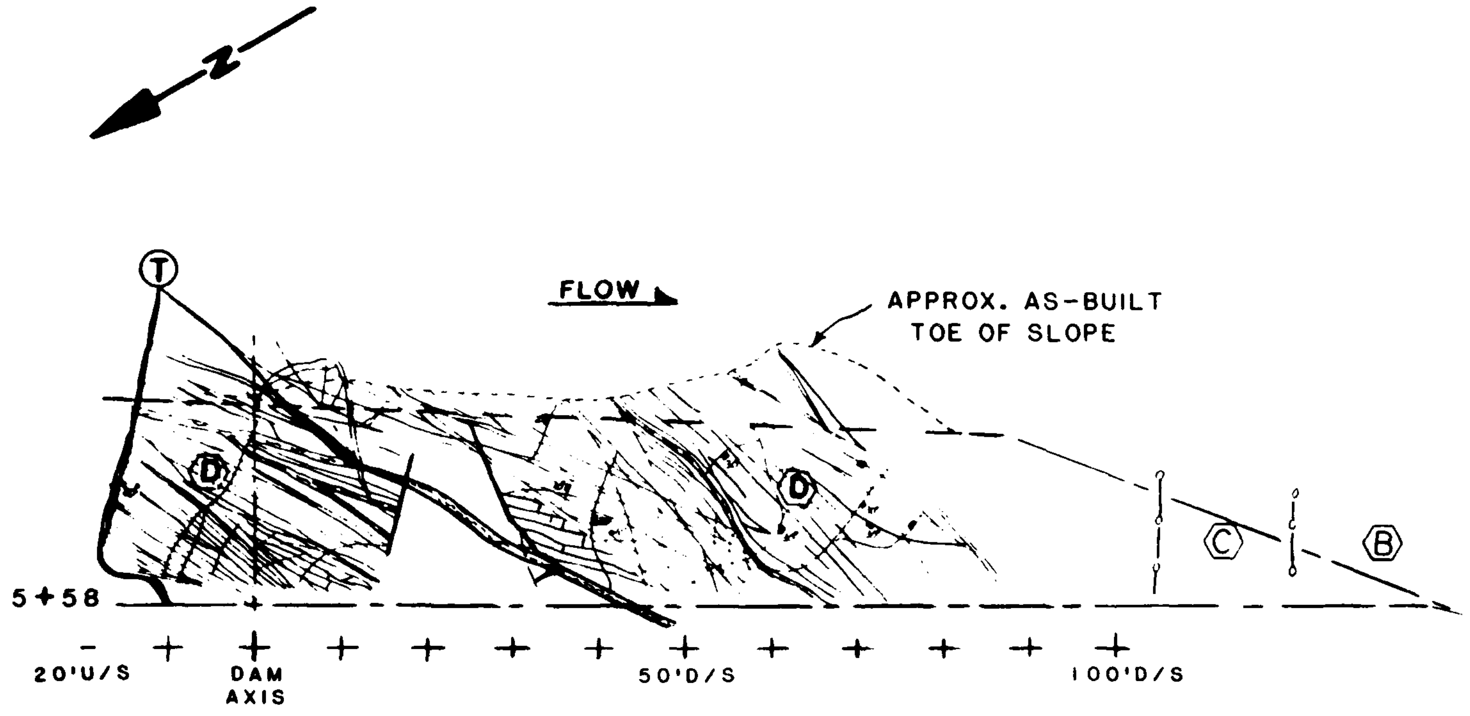
FIGURE 4-4



NOTE: FOR LEGEND REFER TO FIGURE 4-1

FIGURE 4-5

GEOLOGICAL SECTION-MONOLITH 7 WALL SURFACE
WYNOOCHEE DAM FOUNDATION REPORT



NOTE: FOR LEGEND REFER TO FIGURE 4-1

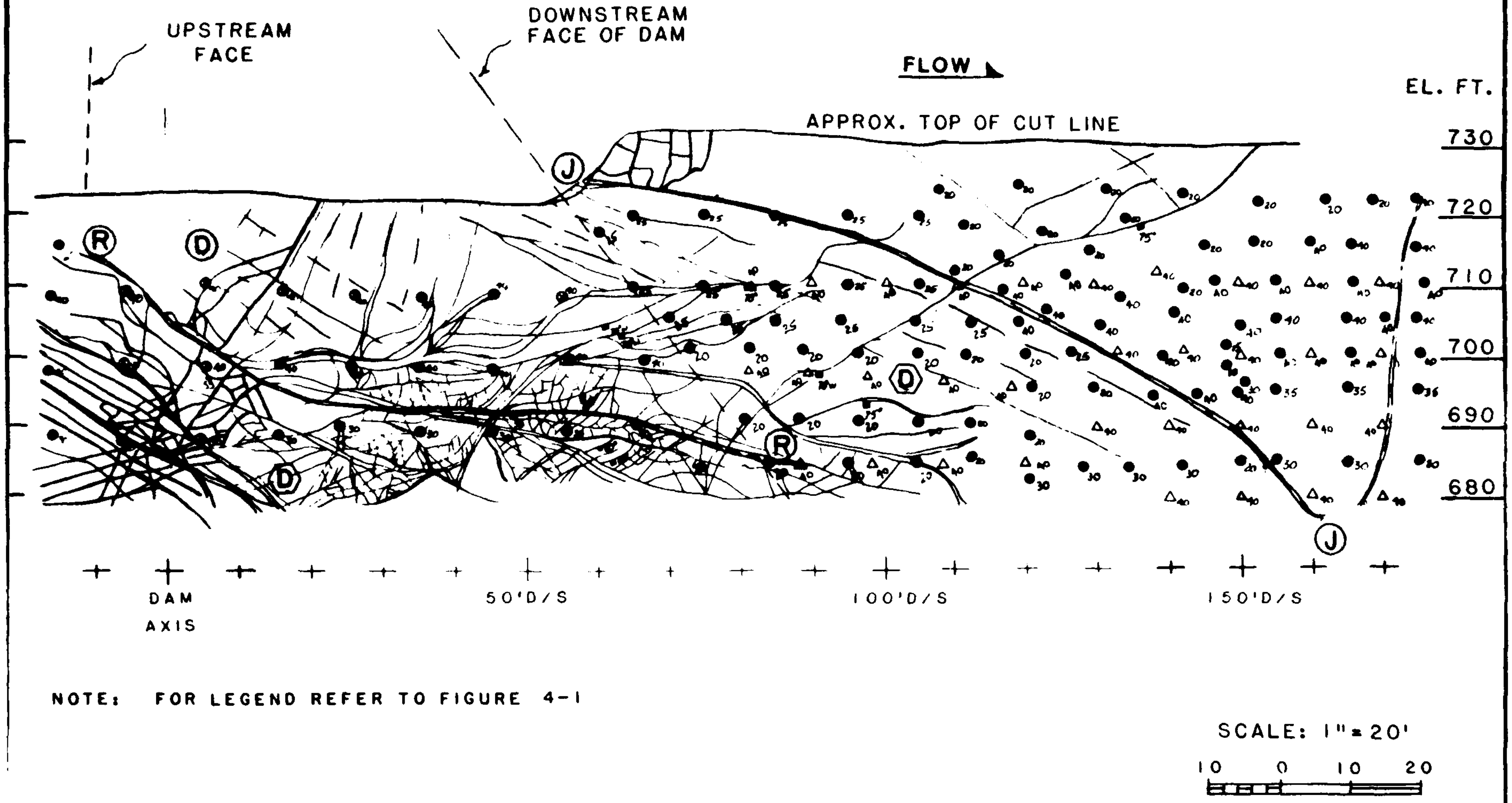
SCALE: 1" = 20'

10 0 10 20

GEOLOGICAL PLAN –MONOLITH 8 EL.680 BERM

WNOOCHEE DAM FOUNDATION REPORT

FIGURE 4-6

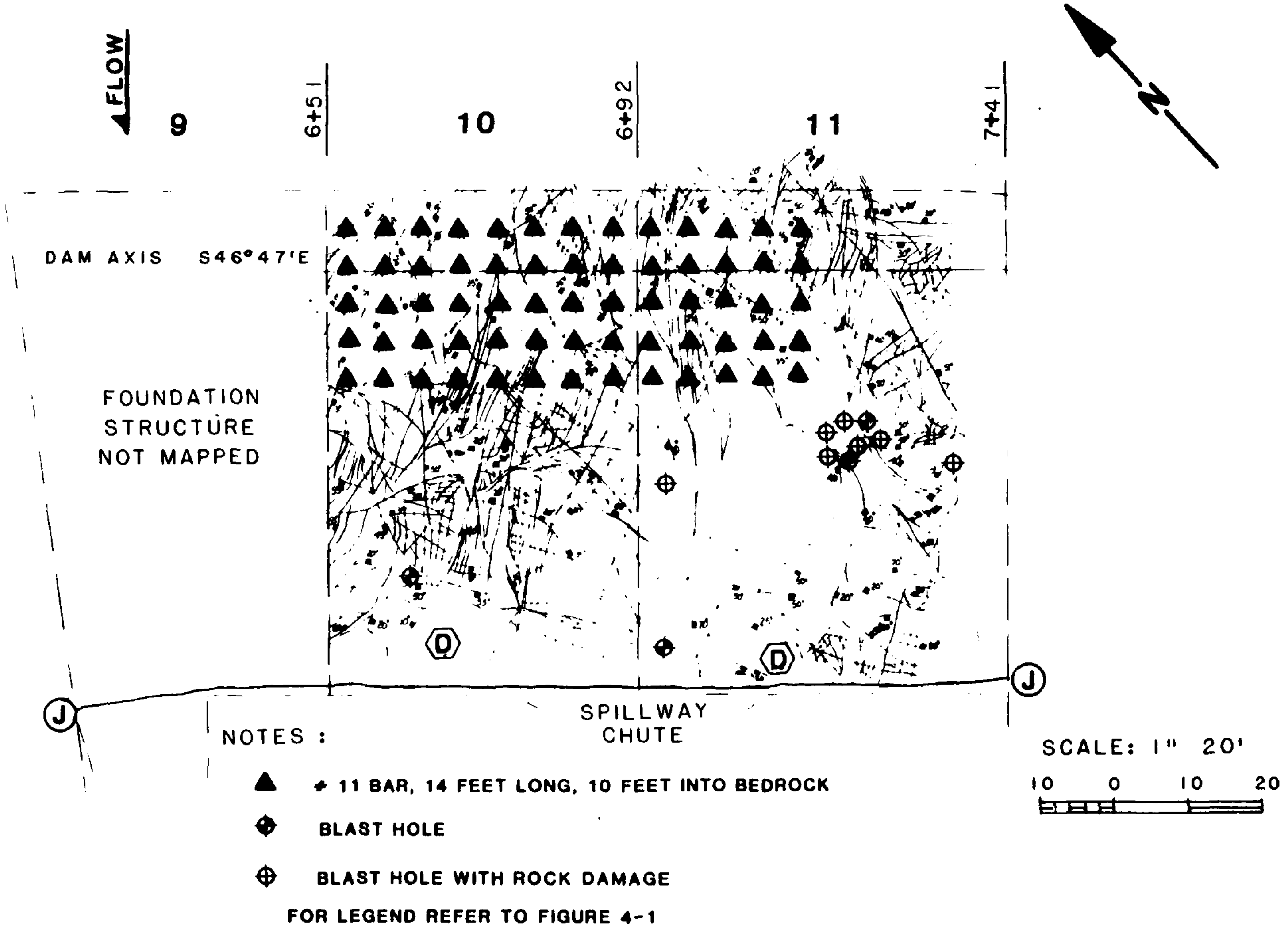


NOTE: FOR LEGEND REFER TO FIGURE 4-1

FIGURE 4-7

GEOLOGICAL SECTION–MONOLITH 8 WALL SURFACE

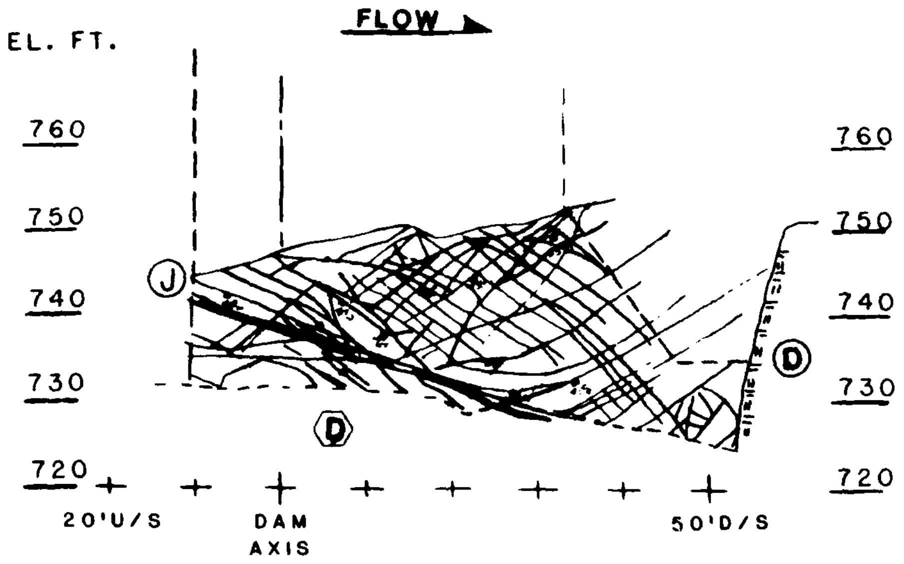
WYNOOCHEE DAM FOUNDATION REPORT



GEOLOGICAL PLAN–MONOLITHS 10 AND 11

WYNOOCHEE DAM FOUNDATION REPORT

FIGURE 4-8



NOTE: FOR LEGEND REFER TO FIGURE 4-1

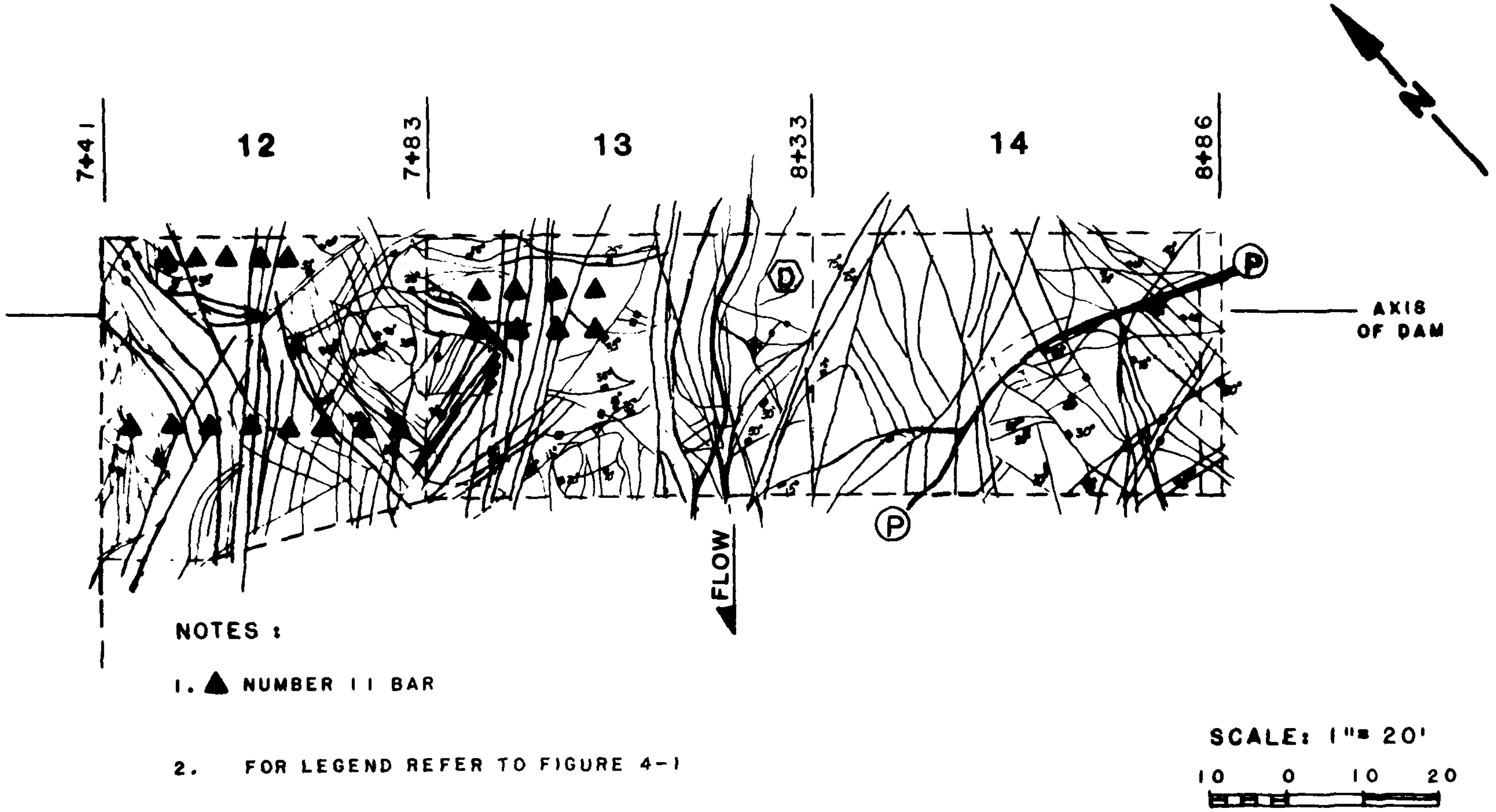
SCALE: 1" 20'

10 0 10 20

FIGURE 4-9

GEOLOGICAL SECTION–MONOLITH 11 WALL SURFACE

WYNOOCHEE DAM FOUNDATION REPORT



NOTES :

1. ▲ NUMBER 11 BAR

2. FOR LEGEND REFER TO FIGURE 4-1

GEOLOGICAL PLAN-MONOLITHS 12, 13, AND 14

WYNOOCHEE DAM FOUNDATION REPORT

FIGURE 4-10

SECTION 5. FOUNDATION DRAINAGE AND GROUTING

5.01 Grouting.

5.01.1 Foundation grouting was performed under the main construction contract. All drilling and grouting were performed by Continental Drilling Company, a subcontractor to Dravo Corporation. The grout curtain extends the full length of the concrete structure and is composed of two zones: a secondary zone varying from 40 to 90 feet in rock and a primary zone generally 25 feet in rock (plate 15). Grout holes were inclined 15° upstream from vertical except in monolith 5, between stations 4+28 and 4+46, the holes are inclined only 2°. In monoliths 6 and 7 the upstream batter of the grout holes was gradually varied between 2° and 15° to form a continuous warped grout curtain. Combined drilling footages through rock and concrete are listed in table 5-1.

5.01.2 Drilling and grouting were done using the split spacing, stage grouting method. Stage grouting involves the placement of the grout curtain by drilling and grouting in successive operations. A complete cycle consists of drilling, washing, pressure testing and grouting of any portion of a hole within a given zone. All grouted primary holes are located on 10-foot centers to the bottom of the first zone and secondary holes are spaced midway between two grouted primary holes. Prior to starting the deeper second area zone, all primary holes within 100 feet were grouted. After the grout holes were drilled to the final predetermined depths the holes were washed, pressure tested, and grouted. During the grouting operation grout was injected at 80 p.s.i., allowed to remain in the holes until initial set, and then removed by washing. Grout holes, as necessary, were backfilled with a 1:1 neat cement grout, nipples were removed and nipple holes were dry packed. Grout takes per monolith are summarized in table 5-2. Plan and profile of grout holes and grout takes for each hole are indicated on plate 15.

5.02 Drainage.

5.02.1 One segmented drainage curtain is used to intercept seepage and relieve possible hydraulic pressures downstream from the grout curtain. Drain holes are 2-1/2 inches in diameter and are drilled in two vertical planes parallel to the dam axis. The upstream plane of holes occurs 6.5 feet downstream of the dam axis in monoliths 1 through 5 and monoliths 8 through 14. Hole collars for the downstream plane are 12.5 feet downstream of the axis in monolith 6 at elevations 686 and 677 feet and in monolith 7 at elevations 667 and 641 feet. A profile of drain holes is shown on plate 16.

5.02.2 Total leakage from foundation drains and monolith joint and face drains is measured by weirs placed in the gallery gutters as shown on figure 5-1. Drains that show appreciable flow, 1 gallon per minute or greater, are measured independently of the weir measurements. The reservoir initially was raised in spring 1973. On 20 June 1973, total leakage flow was 18.4 g.p.m. (see table 5-3). The reservoir was at elevation 795.2 feet

TABLE 5-1

GROUT HOLE FOOTAGE OF ROCK AND CONCRETE DRILLED FOR MONOLITH

Mono	Secondary (ft)	Primary (ft)	Total (ft)
1	355	170	525
2	285	165	450
3	235	190	425
4	240	170	410
5	710	135	845
6	735	*	735
7	3,054	*	3,065
8	225	*	225
9	410	150	560
10	200	120	320
11	285	165	450
12	267	171	438
13	210	130	340
14	307	107	414
	7,529	1,673	9,202

TABLE 5-2

GROUT TAKE IN SACKS OF CEMENT PER MONOLITH

Mono	Secondary (Sacks)	Primary (Sacks)	Total (Sacks)
1	1.25	2.00	3.25
2	1.50	36.00	37.50
3	1.25	1.00	2.25
4	1.25	2.50	3.75
5	26.25	4.75	31.00
6	10.00	*	10.00
7	149.50	*	149.50
8	53.25	*	53.25
9	7.25	1.50	8.75
10	21.75	6.75	28.50
11	0.75	2.75	3.50
12	36.00	4.50	40.50
13	30.25	4.75	35.00
14	43.75	0.25	44.00
Total	379.75	66.75	446.50

*No primary zone.

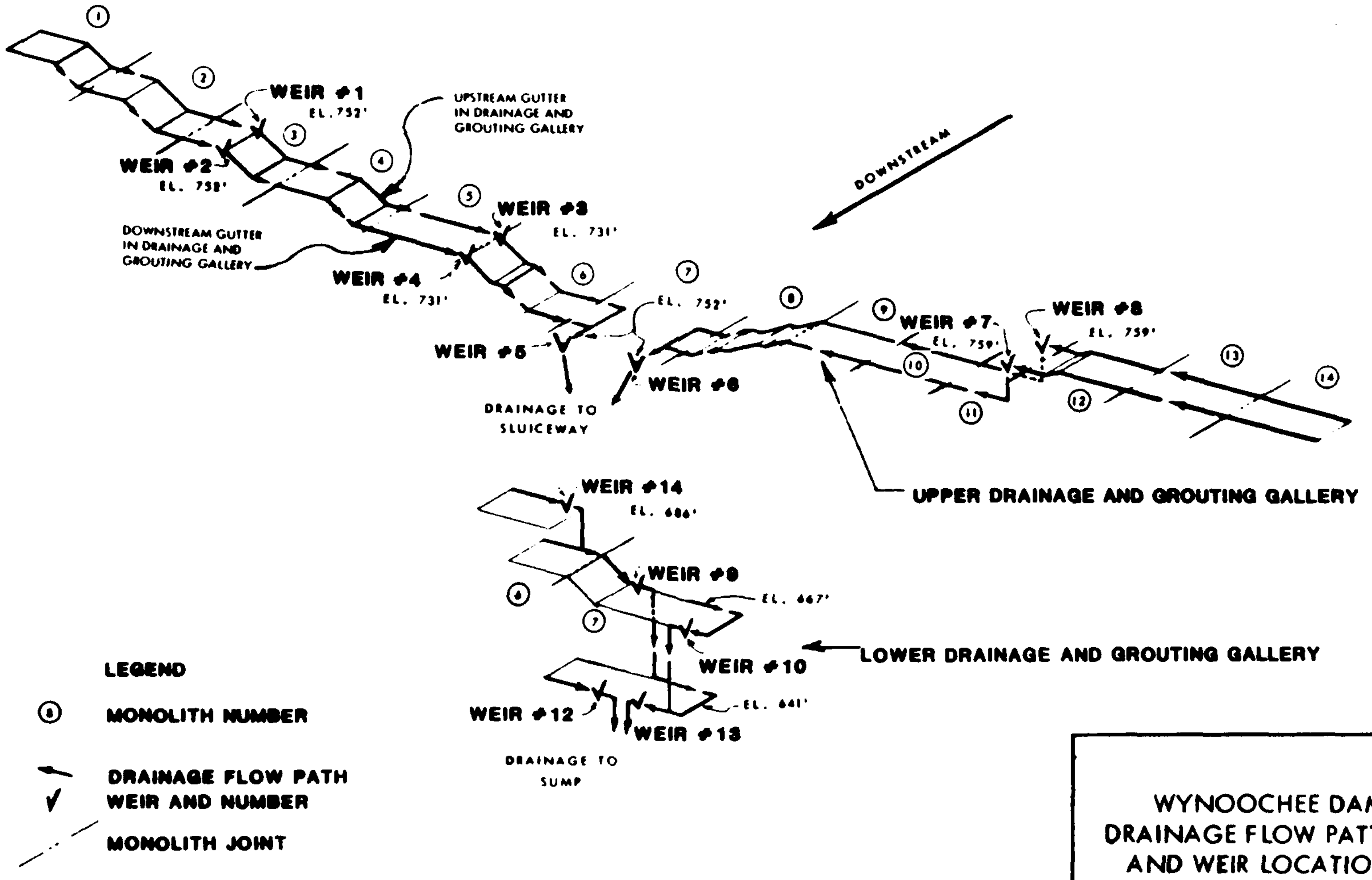
See plate 15 for grout holes section.

TABLE 5-3

DAM DRAINAGE

Date	Total Leakage Weirs 5, 6, 12, 13 (gpm)	Reservoir Elevation (ft)
June 1973	18.4	795.2
June 1974	20.5	800.0
June 1975	19.5	795.5
June 1976	18.0	799.3
June 1977	14.8	799.7
June 1978	12.9	795.7
June 1979	21.2	788.5
June 1980	14.3	791.3
June 1981	30.4	795.3
June 1982	18.0	796.2
June 1983	20.4	797.1
June 1984	25.7	798.9
June 1985	34.2	799.2
June 1986	46.8	796.9
June 1987	43.5	799.9

NOTE: Total drainage into the dam includes leakage through foundation drains and monolith face and joint drains.



WYNOOCHEE DAM
DRAINAGE FLOW PATTERN
AND WEIR LOCATIONS

FIGURE 5-1

(4.8 feet below maximum pool). Maximum flows ranged between 1 and 2.5 gallons per minute in the lower gallery drains in monoliths 6 and 7. Negligible to minor seepage occurred in all other foundation drains during the pool raise and during the following reservoir drawdown. In June 1977, total leakage decreased to 14.8 g.p.m. This decrease in leakage was believed to be caused by a buildup of calcareous deposits within the drain holes. In January 1978 the drains were first cleaned by project personnel using an air pressure centrifugal type drill. This drill enlarged the diameter of the borings and subsequently disturbed the walls of the boring causing the brittle bedrock to fracture and cave to compound the cleaning effort. Since initial cleaning, surface hole packers have been installed in all holes to preclude debris washing into the holes. Project personnel annually remove the packers and sound the hole for obstructions. When a drain hole is blocked, it is cleaned out to full depth using an air-powered noncentrifugal type cleaning tool. All foundation drain holes appear to function as designed. The increased total leakage beginning in 1985 is apparently due to failure of monolith joint waterstops at elevations above minimum pool elevation.

SECTION 6. INSTRUMENTATION

6.01 General. Instrumentation has been placed in Wynoochee Dam and in the abutments to measure structural behavior, insure safety, determine displacements, seepage, check design assumptions, check theoretical computations, and to obtain information for the design of future projects. The instrumentation includes measurement of uplift pressure, joint and crack movement, internal drainage, abutment seepage, and structural response to earthquake activity. The instruments are read by project personnel and the data are reduced and reviewed by Seattle District.

6.02 Foundation Instrumentation.

6.02.1 Uplift pressure cells are located under three monoliths: monolith 4, monolith 7, and monolith 10 (plates 8 and 12 in appendix B). Gradually increasing uplift pressures were noted prior to the 1978 periodic inspection due to calcification of the foundation drain holes. From June 1975 to June 1976, uplift pressure cells 7-4 and 7-8 indicated steadily increasing uplift pressures in the foundation. In June 1975, cell pressures averaged 5.8 p.s.i. with pool at elevation 795.5 feet. In June 1976, the cell pressure averaged 10.6 p.s.i. with pool at 799.4 feet and in June 1977, cell 7-8 averaged 11.8 p.s.i. with pool at 799.4 feet. The uplift pressure in cell 7-8 approached the design hydraulic gradient before the drain hole cleaning. This pressure increase is a result of the decrease in drainage. After the foundation drains were cleaned in early 1978 the uplift pressures decreased. During the 1973 and 1974 periodic inspections, uplift pressure gradients downstream of the grout curtain were within design assumptions. Several of the upstream cells, however, were above design assumptions, but the total effect of actual uplift was below the maximum assumed in design. The uplift pressures assume a drain effectiveness of 33 percent at the foundation plane for the canyon monoliths (Corps of Engineers, DM 10, 1967).

6.02.2 Since construction of the dam, relative movement joint indicators have been installed across joints in the canyon monoliths. The instruments are manually read with a feeler gauge by various people. Movement patterns are erratic which may be because these types of instruments are difficult to read consistently. An automatic joint meter system is planned.

6.02.3 Drainage inflow from foundation drains, and monolith joint and face drains is measured by weirs in the drainage galleries. Locations of weirs are shown in figure 5-1.

6.02.4 In October 1985, eight rebar type survey monuments were placed atop the left and right embankments to observe settlement. Monument locations are shown on plate 13. The monuments were originally surveyed in October 1985. Table 6-1 gives the original survey elevation for each settlement monument.

TABLE 6-1

ORIGINAL SURVEY ELEVATIONS FOR EMBANKMENT SETTLEMENT MONUMENTS

Point No.	Original Elevation (ft)
SM-1	804.386
SM-2	804.286
SM-3	804.267
SM-4	804.586
SM-5	804.528
SM-6	804.422
SM-7	804.517
SM-8	804.400

6.03 Abutment Leakage. Abutment leakage and downstream spring discharges are monitored by measurements in weirs, piezometers, and staff gages shown on plate 17. Left abutment leakage is monitored by weir box 5 located on the canyon lip just downstream from the spillway chute. Discharge from springs immediately downstream of monolith 13 flows into the spillway service road ditch, through a culvert under the service road, and into weir box 5. Until 1982, staff gage No. 3 located in the service road ditch served in place of weir box 5. Right abutment leakage is monitored by weir box 4, formerly staff gage No. 4, and is located in the ditch adjacent to the monolith 5 adit access walkway. Downstream spring discharges are monitored by measurements in manhole 6, weir 3, and staff gage 2. Staff gage 1 has not been monitored since the late 1970's. Eighteen piezometers have been installed to monitor ground water around the dam abutments. In addition, 11 piezometers were installed through the core of the left and right embankments in March 1987.

6.04 Earthquake Instrumentation. Strong motion accelerographs record data for analysis in determining the seismic response of dams. In 1973 and 1974, three Kinemetrics SMA-1 strong motion accelerographs were installed at Wynoochee Lake Project as required by Corps of Engineers Engineering Regulation ER-1110-2-103. One free field motion accelerograph is founded on bedrock approximately 600 feet downstream from the dam atop the left canyon wall (plate 17). This unit is sensitive to 3/8 centimeter (cm) per g-force and is triggered by either horizontal or vertical components of the initial earthquake ground motion. Two strong motion accelerographs are located in monolith 7. One unit, located on the monolith 7 centerline in the upper service gallery at elevation 790.5 feet, is sensitive to 1.9 cm per g-force and is triggered by the horizontal component of earthquake ground motion. The other unit, located in monolith 7 drainage and grouting gallery valve room passage at elevation 640.9 feet, is sensitive to 1.9 cm per g-force and is triggered by the vertical ground motion component. The accelerographs only record during a seismic disturbance. The SMA-1 accelerograph is actuated automatically by an earthquake, records the earthquake motion in three axes (x, y, z) on 70 millimeter (mm) photographic film, and automatically stops and resets itself when the seismic trigger ceases detection of the motion.

SECTION 7. SUMMARY

No serious foundation problems relating to foundation stability were anticipated prior to, or developed during, construction. Only minor structural defects were found in the foundation which were readily corrected through standard bedrock foundation preparation and reinforcement techniques. Grout injection and drain hole seepage indicate that the foundation is generally tight. In general, the foundation of the dam is excellent. The lack of control over contractor blasting procedures resulted in extra excavation in some cases and redesign of project elements in others. As a result of the Wynoochee experience, the Seattle District has established contract specifications which require Corps approval on general and specific blast plans and where necessary, establish vibration control limits. Abutment and embankment seepage will be monitored for the life of the project under the dam safety program.

REFERENCES

1. Atwater, T., 1970. Implications of Plate Tectonics for the Cenozoic Evolution of Western North America. Bulletin of Geological Society of America, Vol. 81, pp 3513-3536.

2. Silver, E.A., 1971. Small Plate Tectonics in the Northeastern Pacific. Bulletin of Geological Society of America, Vol. 82, pp 3491-3496.

3. Steward, R.J., 1974. Zeolite Facies Metamorphism of Sandstone in the Western Olympic Peninsula, Washington. Bulletin of Geological Society of America, Vol. 85, pp 1139-1142.

4. Tabor, R.W. and W.M. Cady, 1978. The Structures of the Olympic Mountains, Washington. Analysis of a Subduction Zone. U.S. Geological Survey, Professional Paper 1033.

5. U.S. Army Corps of Engineers, 1981, Engineering and Design - Construction Foundation Reports. ER 1110-1-1801.

6. U.S. Army Corps of Engineers, Seattle District, 1965. Wynoochee Reservoir, Site Selection, Design Memorandum No. 1.

7. U.S. Army Corps of Engineers, 1966, Wynoochee River, General Design, Design Memorandum No. 3.

8. U.S. Army Corps Engineers, 1967, Wynoochee Reservoir, Dam - Basis of Design, Design Memorandum No. 10, Volume 1 of 2.

9. U.S. Army Corps of Enineers, 1983, Earthquake Analysis of Wynoochee Dam, Design Memorandum No. 17.

10. Wilson, J.R., M.J. Bartholomew, and R.J. Carson, 1979. Late Quaternary Faults and their Relationship to Tectonism in the Olympic Peninsula, Washington. Geology, Geological Society of America, Boulder, Colorado, Vol. 7., No. 5., pp 235-239.

APPENDIX A

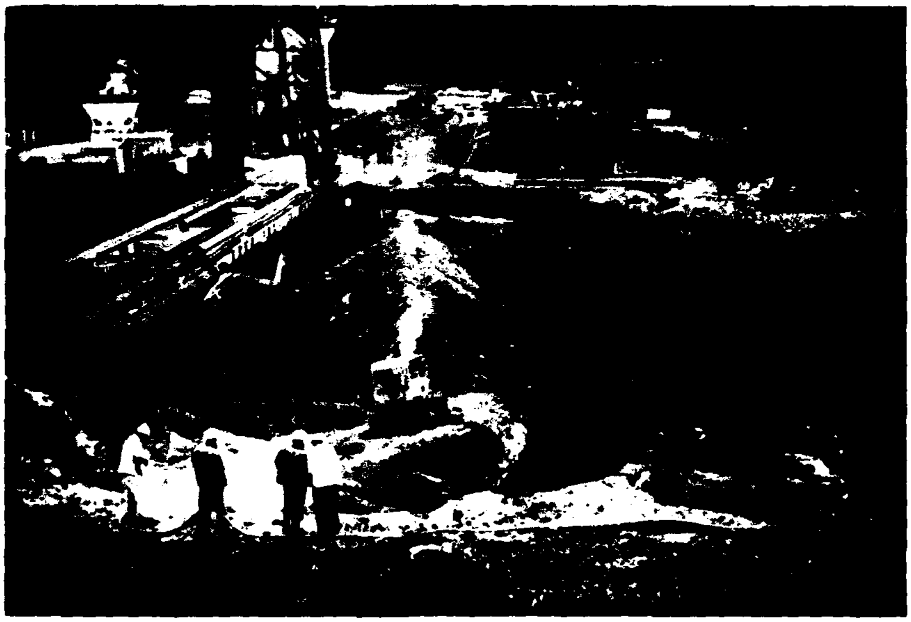
CONSTRUCTION PHOTOGRAPHS

TABLE OF CONTENTS

Right bank cut off trench, view downstream (southeast) showing excavation on A-line. Equipment between stations 7+00 and 8+00, 8 Jun. 1970. (Refer to plate 13 for stationing).

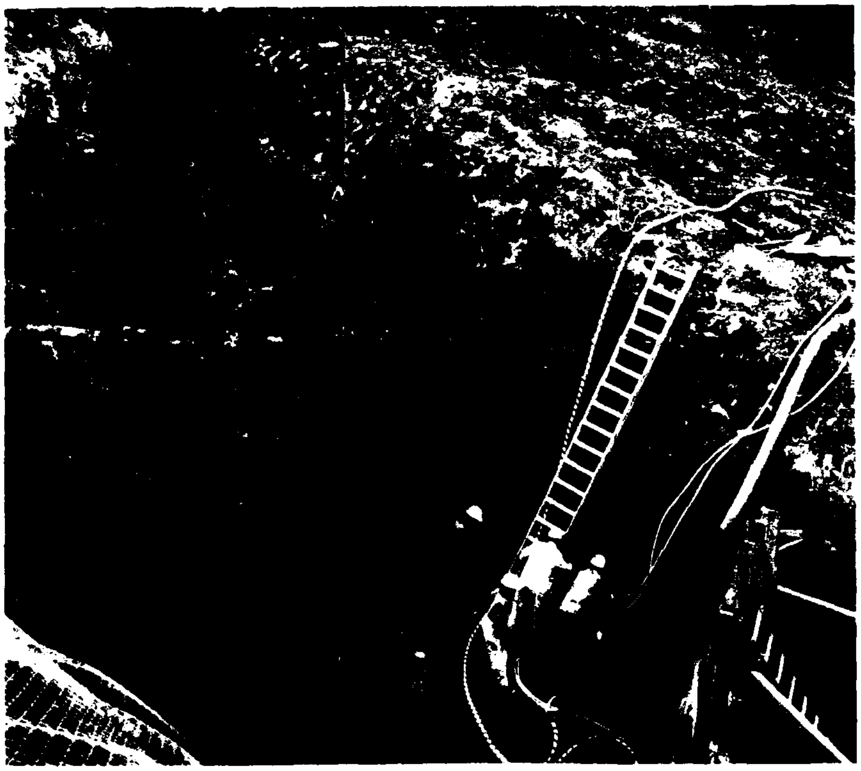
Right bank cut off trench, view downstream (south) showing hard glacial till in foundation. Cleanup is not complete. Camera located at station 2+60. 10 Jun. 1970 (Refer to plate 13 for stationing)

Right abutment initial stripping, view northwest, 28 Oct. 1969.

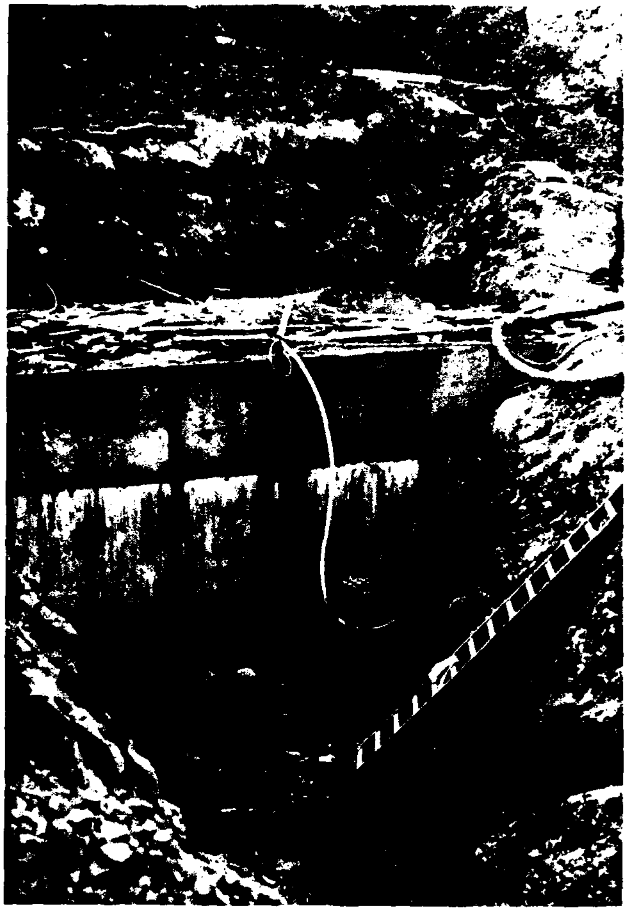


Right abutment, monoliths I-5 foundation cleanup with D-9 Cat, view east, 20 Oct. 1970.

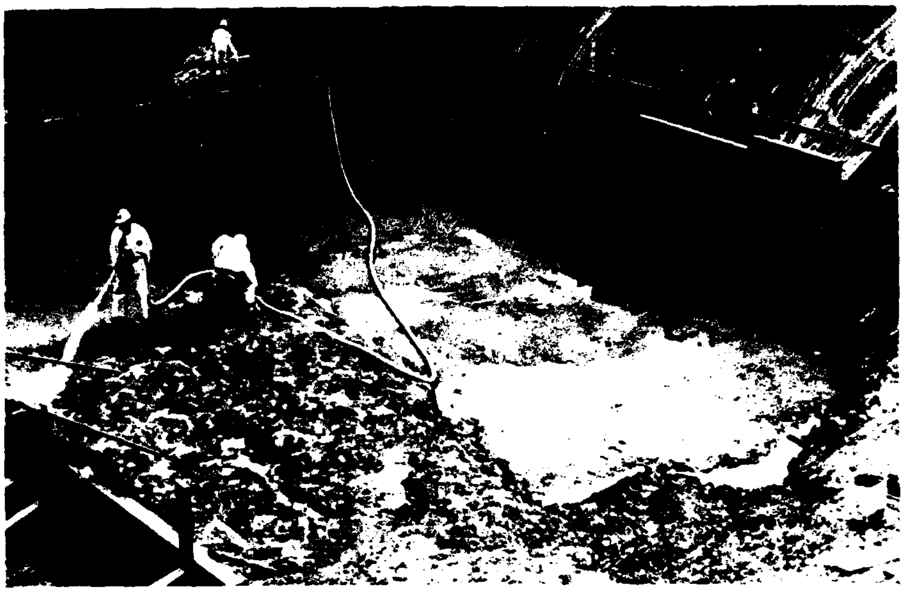
Mono. 1/2 toe area, view downstream (south) showing spilitic basalt bedrock in foundation. Form divides mono. 1 in foreground from mono. 2, 27 Oct. 1970.



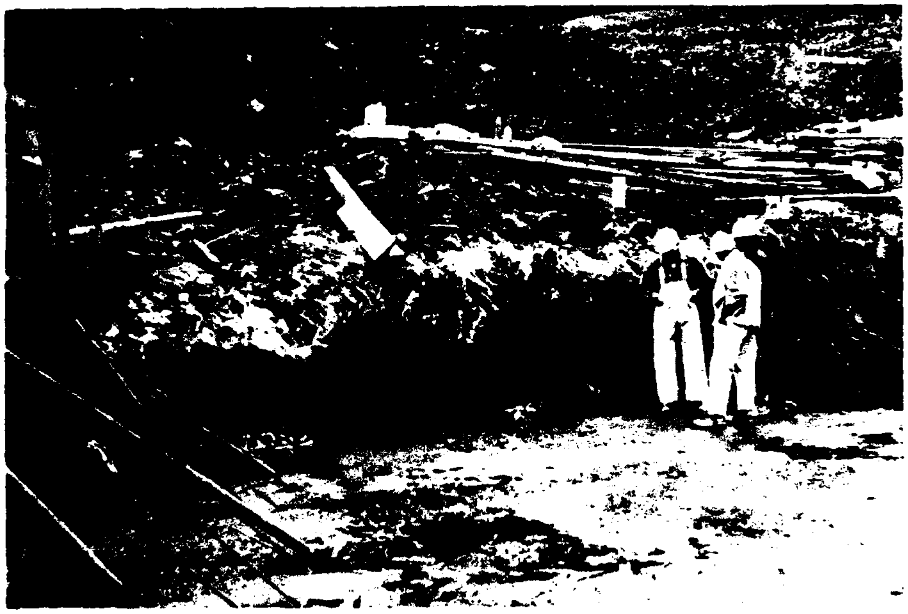
Monolith 1 toe area, view right (west) showing spilitic basalt bedrock in foundation, 27 Oct. 1970.



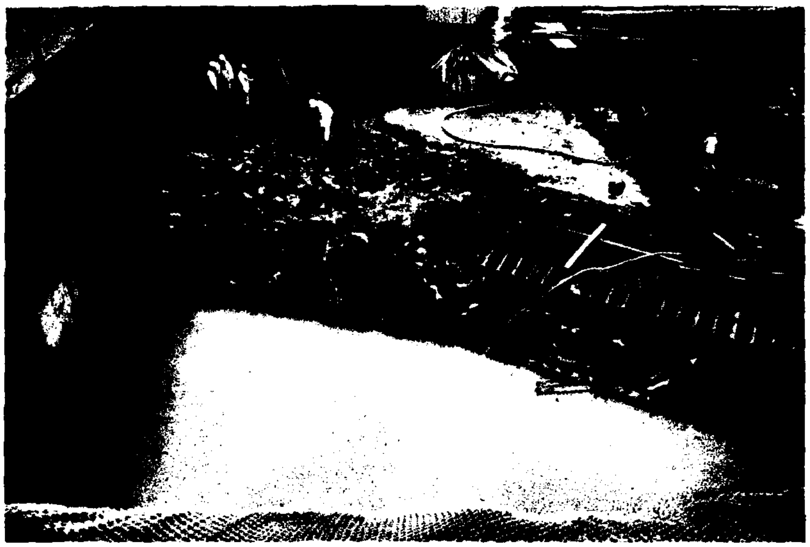
Mono. 1/2 toe area, view right (west) showing backfill concrete in mono. 1, 2 Nov. 1970.



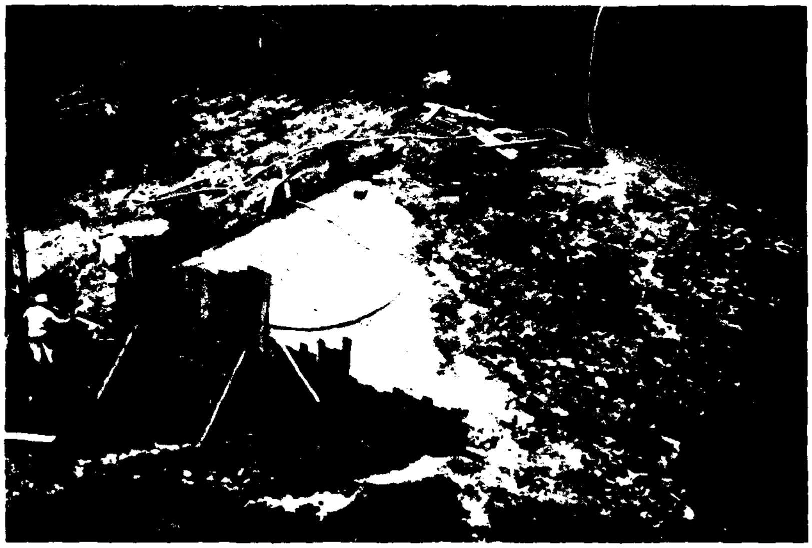
Mono. 1 foundation, view downstream (south) showing backfill concrete to elevation 750 feet, 9 Nov. 1970.



Mono. 1 foundation, view right (west) showing backfill concrete to elevation 750 feet, 9 Nov. 1970.



Mono. 2 foundation, view upstream (north) showing backfill concrete, 10 Nov. 1970.



Mono. 2 foundation, view downstream (south), 10 Nov. 1970.

Monolith 5 foundation excavation, view left (east) showing backhoe excavation in toe area, 9 Nov. 1970.

Monoliths 3-5 foundations, view upstream (north) showing mono. 3 with forms and monos. 4 and 5 without forms, 10 Nov. 1970.

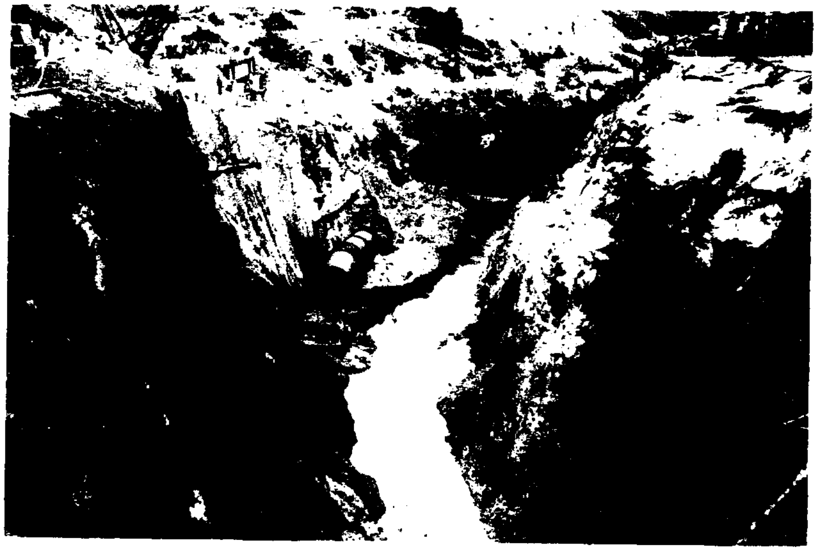
Monolith 4 foundation, view upstream (north) showing 2 uplift pressure cells in center of photo, 20 Nov. 1970.

Right canyon wall, view downstream (southwest) showing maximum excavation for the original diversion slope. Drills on layback line for the revised slope alinement, 3 June 1970.

Monolith 6, right canyon wall, view right (west) showing cushion blasted cut slope and crew working at elevation 660 feet. Trestle footing excavation in center and on right, 8 June 1970.

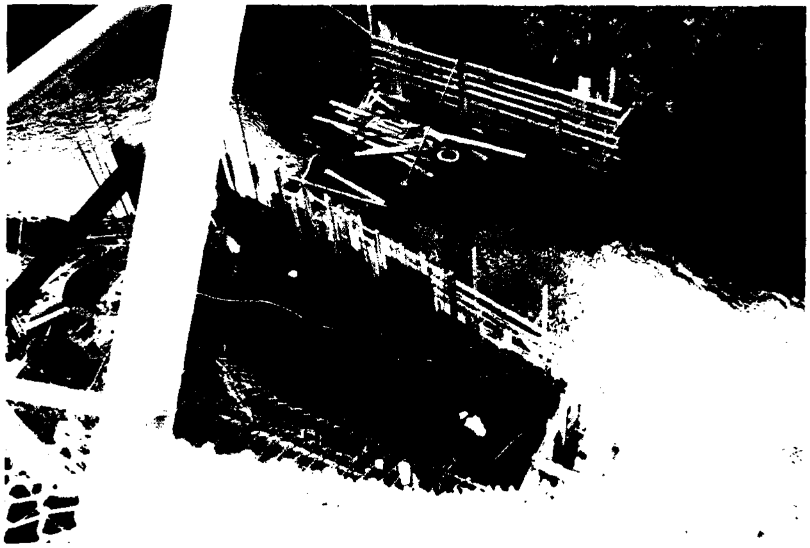
Right canyon wall diversion slope, view downstream (southwest). Monolith 8, elevation 680 berm in foreground, 15 Jun. 1970.

Mono. 6 cut slope with rock bolts and wire mesh on right canyon wall, view northwest showing workers preparing to blast lift between elevations 650 and 670 feet. Blast area is 35 to 100 feet downstream of dam axis, 10 Jul. 1970.



Diversion pipe, view upstream (north), 20 Jul. 1970.

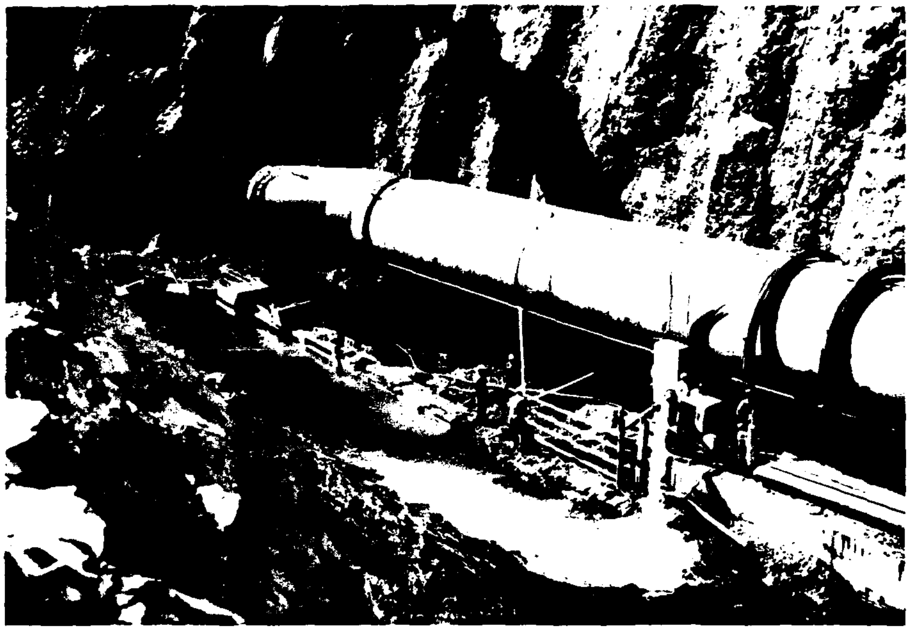
Trestle erection, view upstream (north), 22 Jul. 1970.



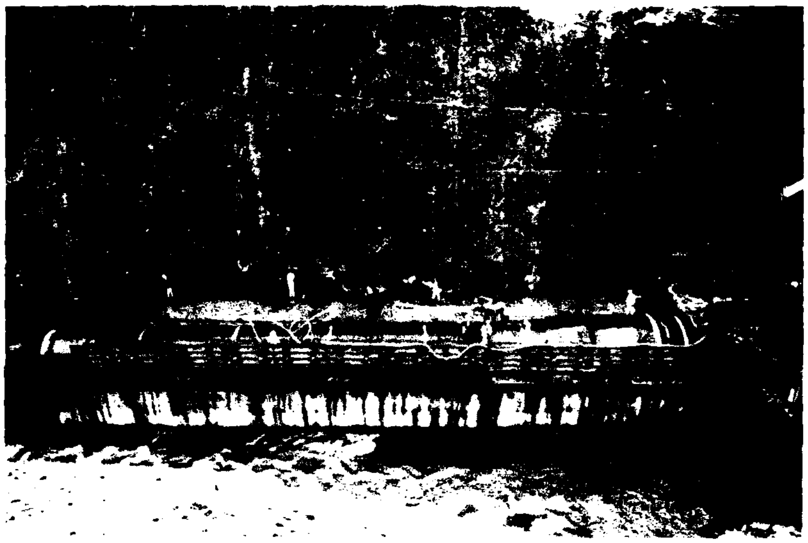
Construction of headwall for diversion pipe, view northeast, 6 Aug. 1970.

Diversion layback slope, view upstream (northwest), 12 Aug. 1970.

Trestle construction, view downstream (south), 21 Aug. 1970.



Monolith 6 diversion pipe, right canyon wall, view looking downstream showing crib and dewatering effort, 6 Oct. 1970.



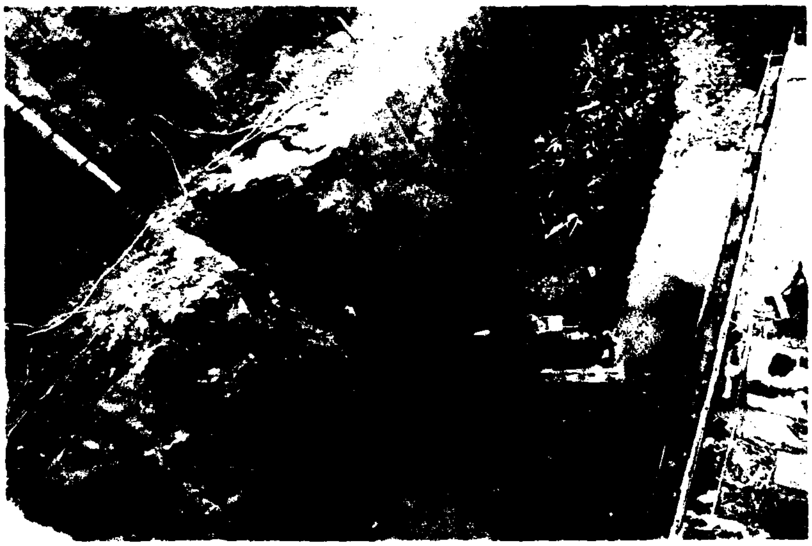
Monolith 6 diversion pipe, right canyon wall view looking west showing new 5 foot thick concrete left, surface elevation 660 feet, 10 Nov. 1970.

Inlet for diversion pipe, view looking downstream 3 Dec. 1970.

Downstream side of cofferdam, view upstream (north) showing installation of "z" piles with 9B3 - 7800 pound hammer, 3 Dec. 1970.

Completed coffer dam and diversion pipe, view upstream (north) showing flow overtopping at about 5200 c.f.s., 7 Dec. 1970.

Monolith 7 foundation, left canyon wall, view downstream, 18 Dec. 1970.



Monoliths 7/8 view downstream, showing low-flow conduit excavation from 680 berm in monolith 8 to elevation 640 in monolith 7.

Monolith 7 foundation, view downstream showing first concrete lift.

Monolith 8 - elevation 680 berm on left canyon wall, view southeast showing final 2 to 9 foot lift drilled and ready for loading, 28 May 1970.

Monolith 8, view northeast, showing slope excavation and elevation 680 berm, 21 Aug. 1970.

Monolith 8, cut slope above elev. 680 berm, view southeast, 25 Nov. 1970.

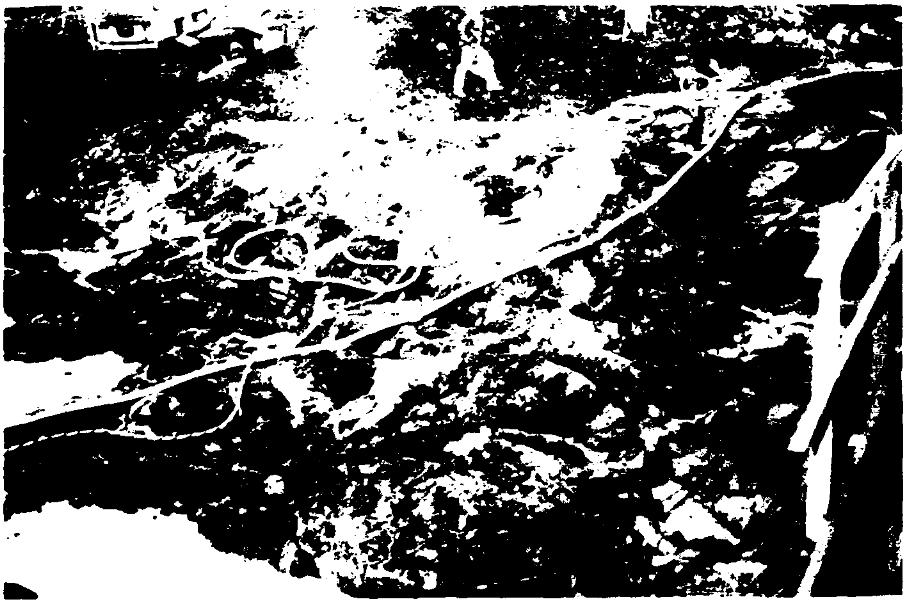
Monolith 8, left canyon wall cutslope, view upstream (northeast), 18 Dec. 1970.

Monolith 8, left canyon wall, view east showing low flow conduit excavation from elevation 680 berm to elevation 640 in monolith 7.

Spillway, view east showing final excavation for spillway left wall with "J" bars installed, 18 Dec. 1970.

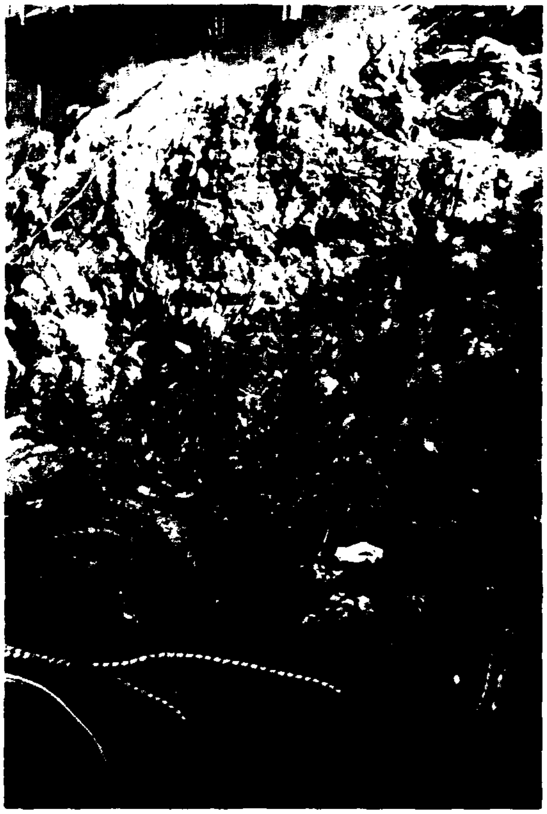
Spillway, view southeast, showing downstream continuation of left wall, 18 Dec. 1970.

Monolith 10, view upstream (northeast) showing rock foundation, 30 Oct. 1970.



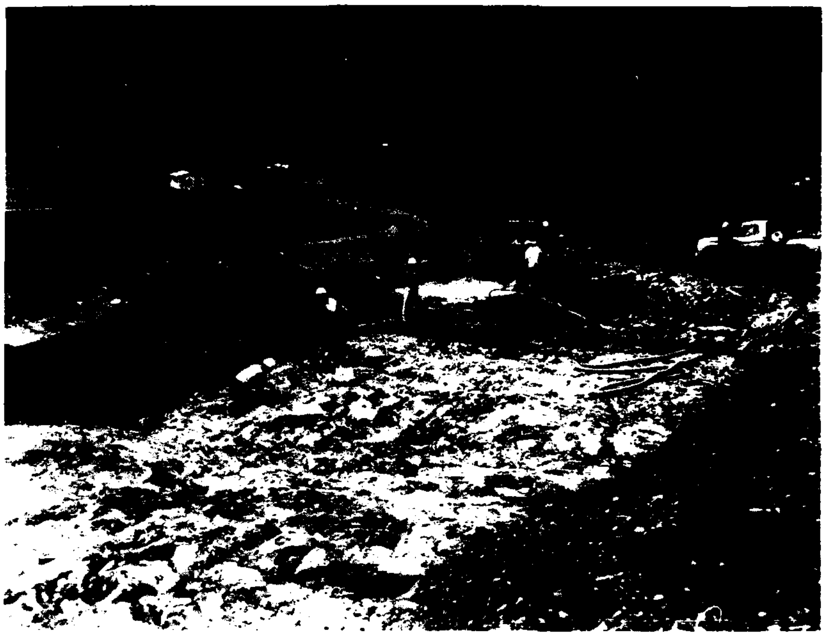
Monolith 10, view upstream (north) showing rock foundation, 30 Oct. 1970.

Monolith 11 bench cut slope foundation, view east, 14 Oct. 1970.



Monolith 11 cut slope, view east, 14 Oct. 1970.

Monolith 10, view east showing final foundation preparation with uplift pressure cells, two in center and two on right. Monolith 11 concrete in background, 6 Nov. 1970.

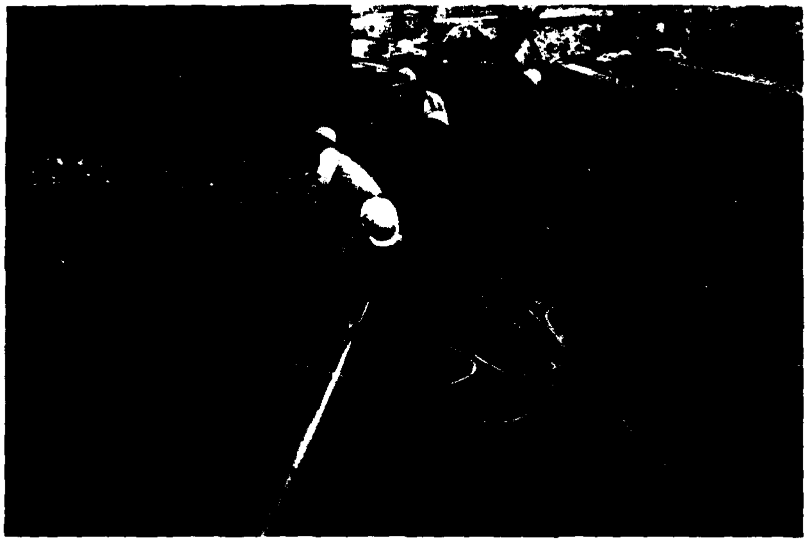


Monoliths 12, 13 and 14, view east showing preliminary foundation preparation using air-water jetting, 15 June 1970.

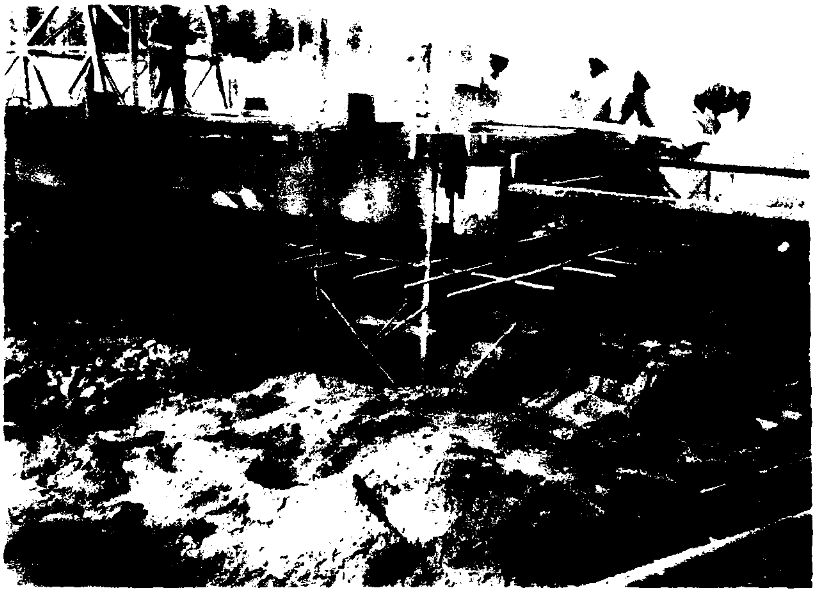
Monolith 12, view south showing "J" bars drilled 15 feet into foundation. Concrete surface at elevation 755 feet, 15 Oct. 1970.

Monolith 12, view northeast, showing foundation forming preparation, 9 Sep. 1970.

Monolith 12, view north showing Joy model 500 track drill boring "J" bar holes in foundation, 15 Sep. 1970.



Monolith 13, view north showing final foundation preparation. Note grouting gallery gutter forms at right, 12 Oct. 1970.



Monolith 14, view north showing final concrete placement on foundation bedrock. Mortar grout on surface and gutter forms for grouting gallery, 15 Sep. 1970.

Left Embankment core trench, view east, 5 Aug. 1971. (Refer to plate 13 for trench location)

Left embankment core trench, view west. Top of bedrock exposed in flat portion of trench, 5 Aug. 1971. (Refer to plate 13 fo- trench location)

APPENDIX B

PLATES

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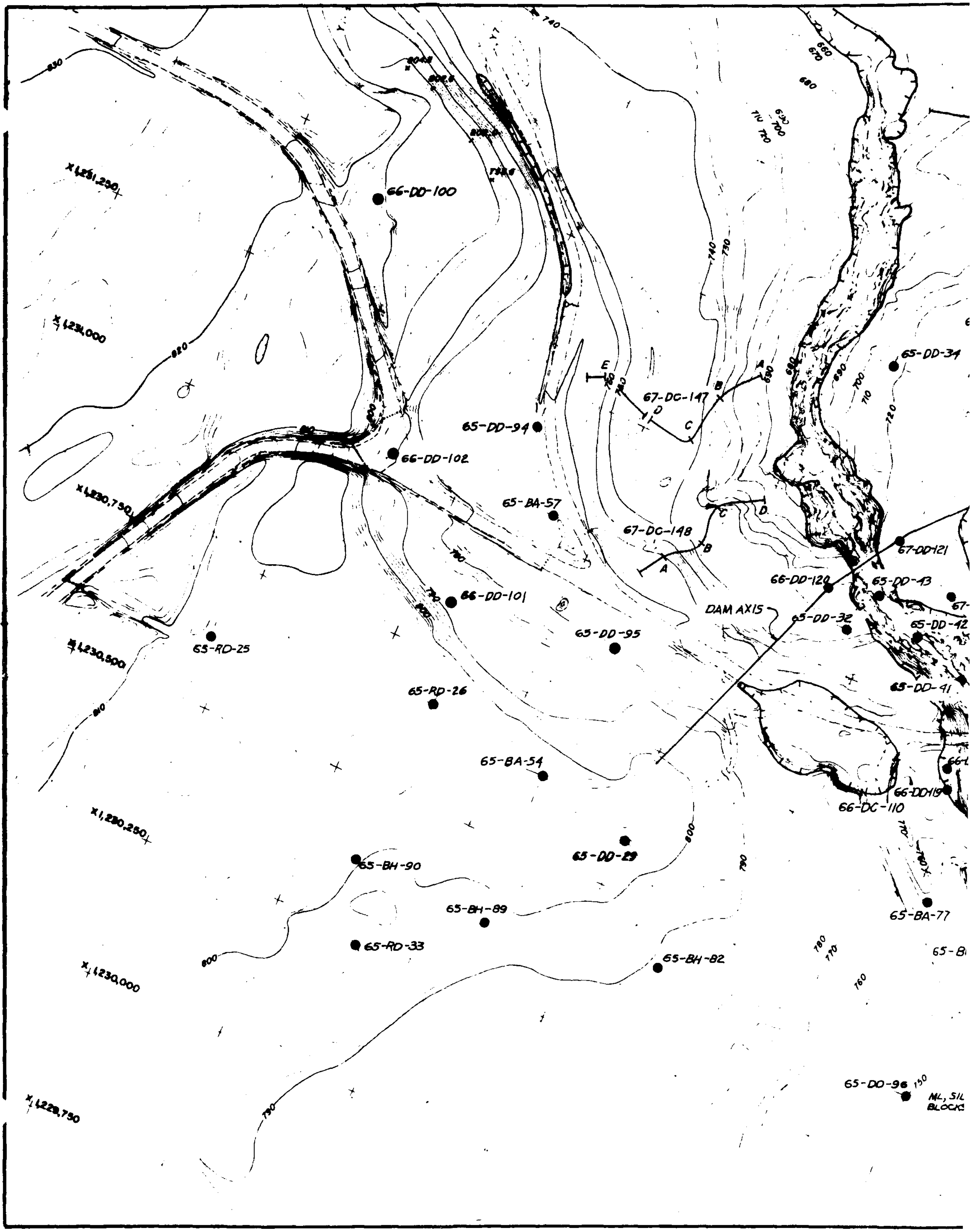
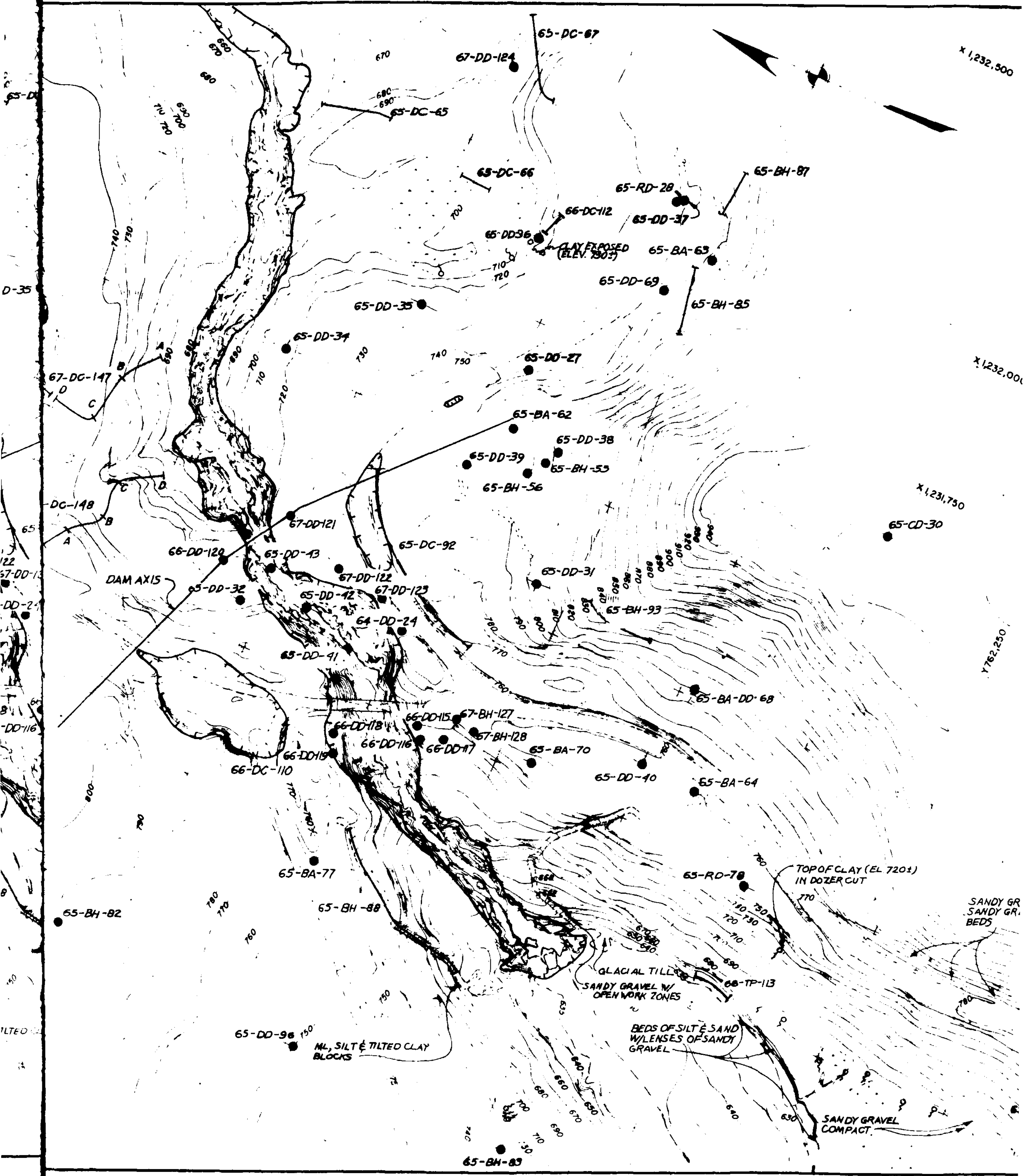

830
740
660
670
680
690
710
720
804.8
802.6
806.8
798.8
X 1,231,250
66-DD-100
X 1,231,000
820
810
E
D
C
B
A
67-DC-147
65-DD-94
66-DD-102
X 1,230,750
65-BA-57
67-DC-148
65-DD-34
67-DD-121
66-DD-120
65-DD-43
DAM AXIS
65-DD-32
65-DD-42
65-DD-41
66-DD-101
65-RD-25
X 1,230,500
65-DD-95
65-RD-26
65-BA-54
66-DC-110
66-DD-119
X 1,230,250
800
790
65-BH-90
65-DD-29
65-BH-89
65-RD-33
65-BA-77
65-BH-82
780
770
760
X 1,230,000
65-DD-96
750
ML, SIL
BLOCKS
X 1,229,750


65-DC-67
67-DD-124
x 1,232,500
65-DC-65
65-DC-66
65-RD-28
65-BH-87
66-DC-112
65-DD-37
65-DD36
CLAY EXPOSED (ELEV. 730±)
65-BA-63
65-DD-69
65-BH-85
65-DD-35
65-DD-34
65-DD-27
x 1,232,000
67-DC-147
A
B
C
D
65-BA-62
65-DD-38
65-DD-39
65-BH-53
65-BH-56
x 1,231,750
DC-148
67-DD-121
65-CD-30
66-DD-120
65-DD-43
65-DC-92
DAM AXIS
65-DD-32
67-DD-122
67-DD-123
65-DD-42
65-DD-31
65-BH-93
64-DD-24
65-DD-41
Y 762,250
65-BA-DD-68
66-DD-118
66-DD-115
67-BH-127
67-BH-128
66-DD-116
66-DD-117
66-DD-119
65-BA-70
66-DC-110
65-DD-40
65-BA-64
65-BA-77
65-RD-78
TOP OF CLAY (EL 720±) IN DOZER CUT
65-BH-82
65-BH-88
SANDY GR
SANDY GR
BEDS
GLACIAL TILL
SANDY GRAVEL W/ OPEN WORK ZONES
68-TP-113
65-DD-96
ML, SILT & TILTED CLAY BLOCKS
BEDS OF SILT & SAND W/LENSES OF SANDY GRAVEL
SANDY GRAVEL COMPACT
65-BH-83
65-D
D-35
67-DD-1
-DD-2
-DD-116
ILTED
670
680
690
700
710
720
730
740
750
760
770
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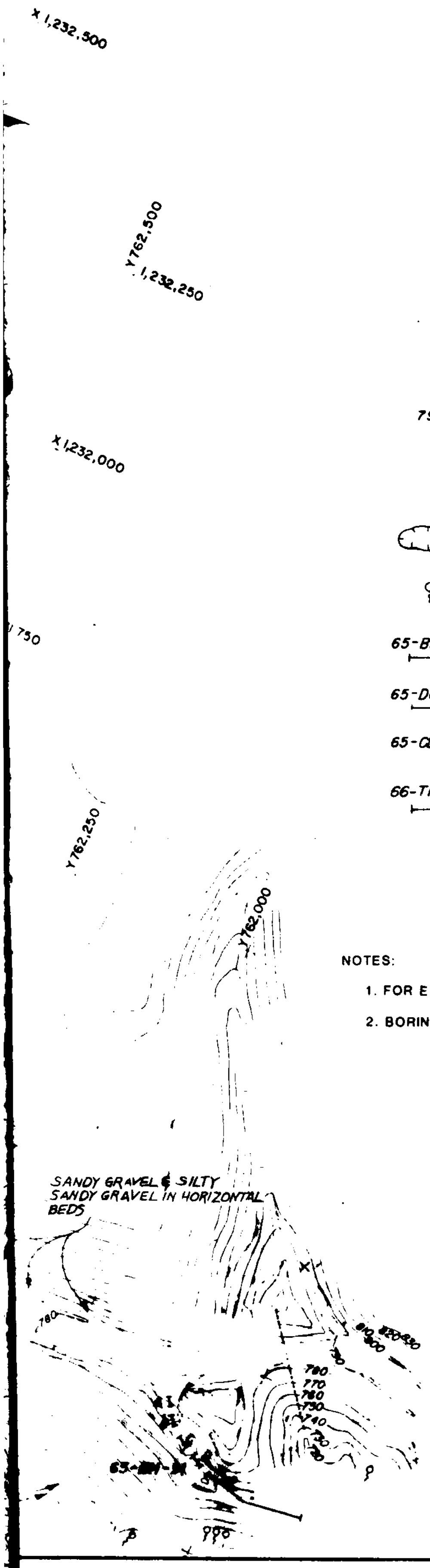
930
940
650
640
630



LEGEND

798.0 X	LOCATION & ELEVATION OF ROCK EXPOSED IN BULLDOZER CUTS
⬭	EXPOSED BEDROCK
♀	APPROXIMATE LOCATION OF SPRING OR SEEP
65-BH-87 ⊢⊣	BACKHOE TRENCH LOCATION & NO.
65-DC-92 ⊢⊣	DOZER CUT LOCATION & NO.
65-CD-30 ●	BORING LOCATION & NO.
66-TP-113 ⊢⊣	TEST PIT LOCATION & NO.

NOTES:

1. FOR EXPLORATION - SECTIONS SEE PLATES 4,5,6, AND 7
2. BORING LOGS ARE IN APPENDIX "D"

SCALE IN FEET

100' 50' 0 100' 200'

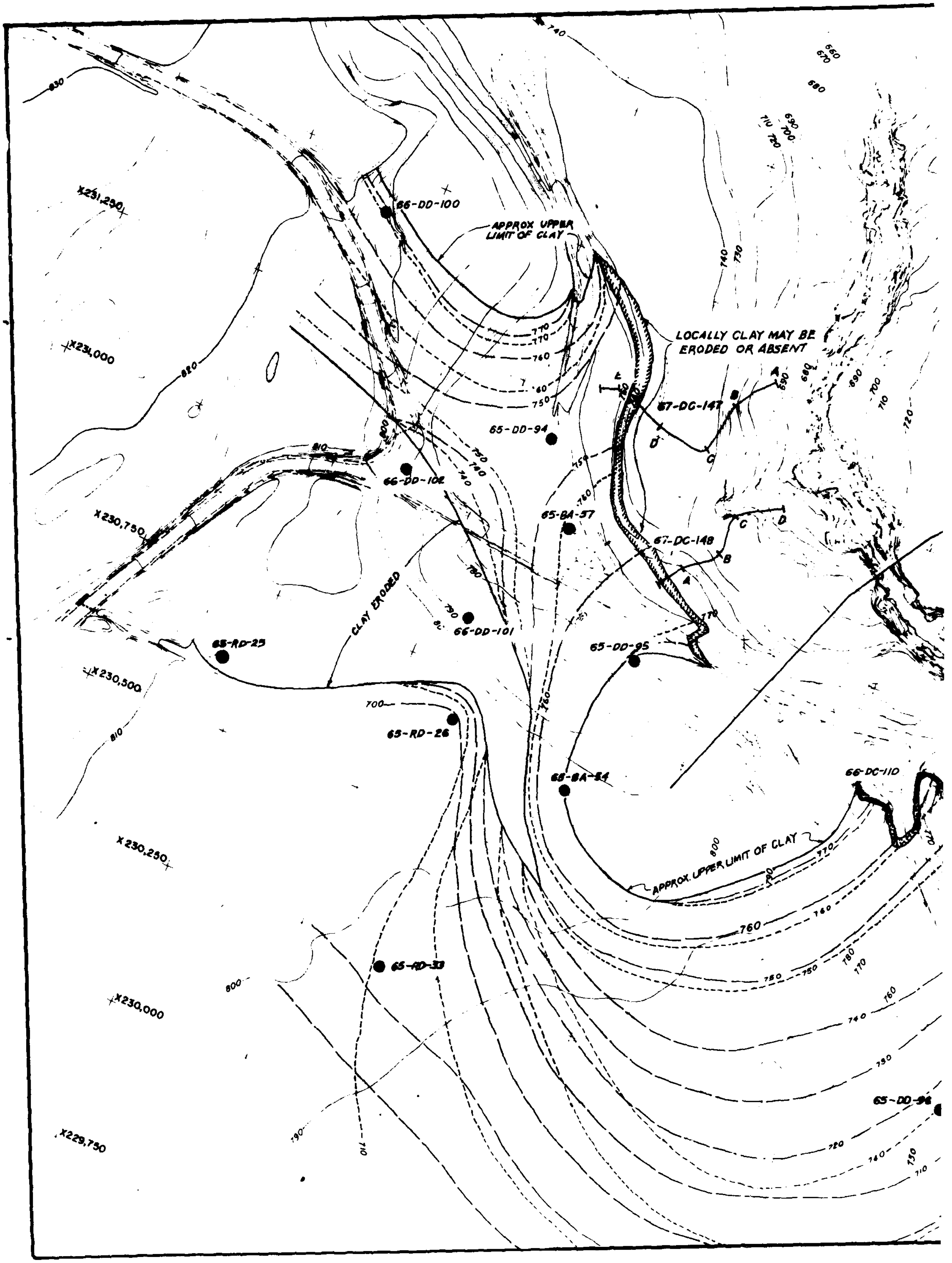
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

FOUNDATION REPORT

PRE-CONSTRUCTION EXPLORATION
WYNOOCHEE DAM

WYNOOCHEE RIVER WASHINGTON

SIZE	INVITATION NO	FILE NO	DATE	PLATE
D		E-57-6-4	DEC87	1
DSGN ECKERLIN		CHK GALSTER	SHEET	



X231,250
X231,000
X230,750
X230,500
X230,250
X230,000
X229,750
66-DD-100
APPROX UPPER LIMIT OF CLAY
LOCALLY CLAY MAY BE ERODED OR ABSENT
67-DC-147
65-DD-94
66-DD-102
65-BA-57
67-DC-148
66-DD-101
65-RD-25
65-DD-95
CLAY ERODED
65-RD-26
65-BA-54
66-DC-110
APPROX. UPPER LIMIT OF CLAY
65-RD-33
65-DD-96
A
B
C
D
E
830
820
810
800
790
780
770
760
750
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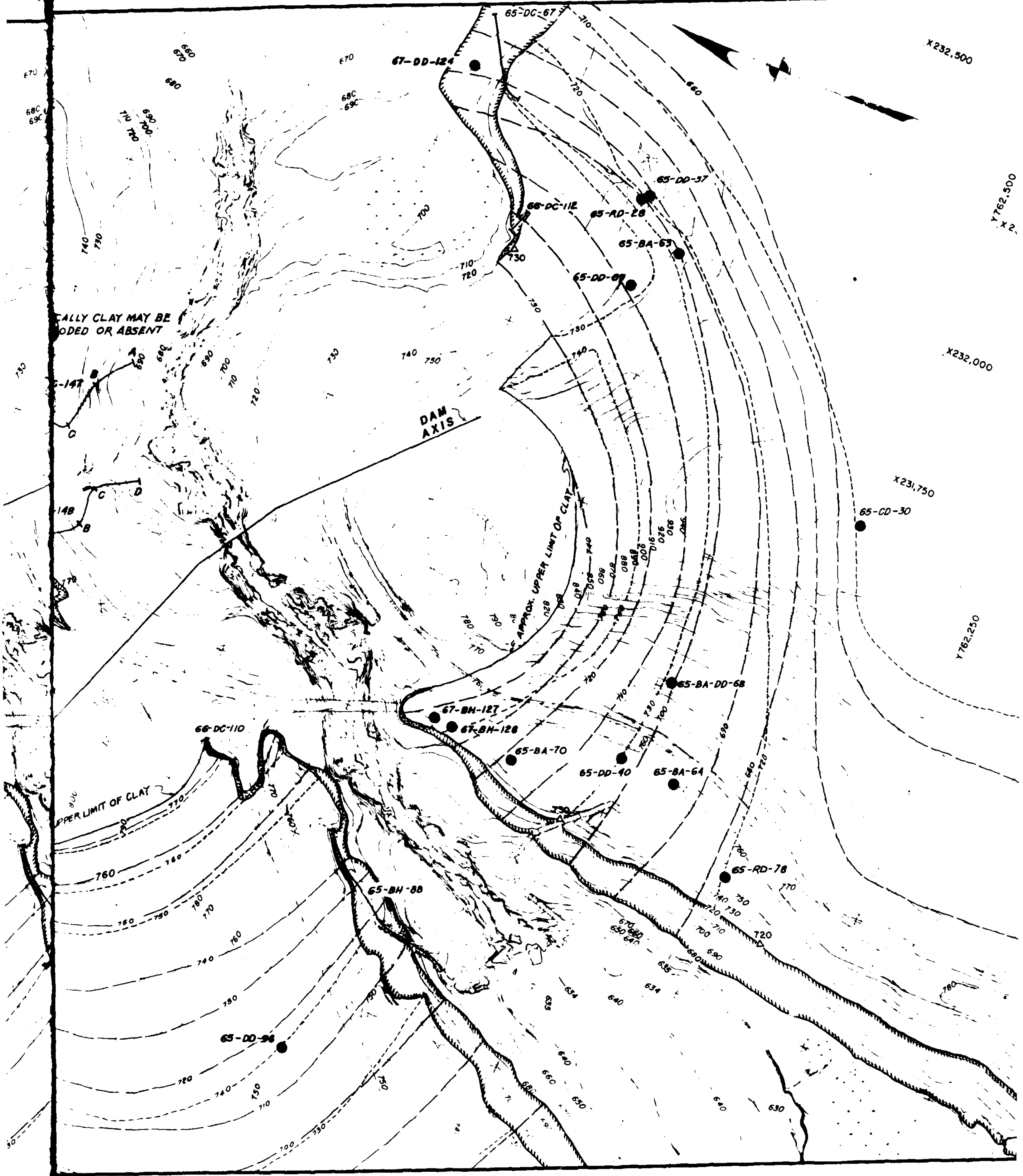
700
690
680
670
660

2.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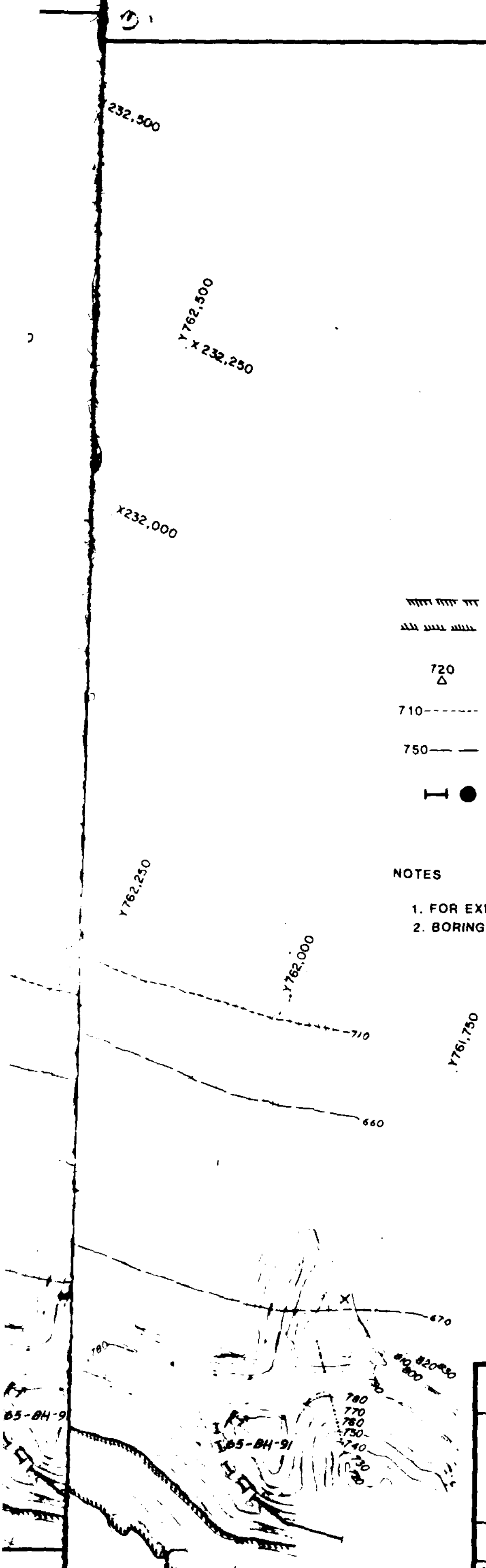
66-DC-112
65-RD-28
65-BA-63
65-DD-69
X232,500
Y762,500
X232,000
X231,750
65-CD-30
Y762,250
ALLY CLAY MAY BE
ODED OR ABSENT
-147
A
B
C
D
-148
DAM AXIS
APPROX. UPPER LIMIT OF CLAY
65-BA-DD-68
67-BH-127
67-BH-128
66-DC-110
65-BA-70
65-DD-40
65-BA-64
UPPER LIMIT OF CLAY
65-RD-78
65-BH-88
65-DD-96
760
750
740
730
720
710
700
690
680
670
660
650
640
635
634
630



LEGEND

⊤⊤⊤ ⊤⊤⊤ ⊤⊤ ⊥⊥⊥ ⊥⊥⊥ ⊥⊥⊥	INFERRED INTERSECTION OF TOP AND BOTTOM SURFACES OF LAKE CLAY LAYER WITH NATURAL GROUND SURFACE WHEN PROJECTED THROUGH COVERING SLOPE WASH.
720 △	LOCATION AND ELEVATION OF LOCALLY EXPOSED TOP OF CLAY LAYER NOT OTHERWISE SHOWN
710-------	APPROXIMATE CONTOUR ON TOP OF CLAY, 10' INTERVAL
750—— —	APPROXIMATE CONTOUR ON BASE OF CLAY 10' INTERVAL
⊢⊣ ●	LOCATION OF BORINGS, TEST HOLES, AND DOZER CUTS ENCOUNTERING CLAY OR PENETRATING THROUGH CLAY UNIT.

NOTES

1. FOR EXPLORATION SECTIONS SEE PLATES 4, 5, 6 AND 7
2. BORING LOGS ARE IN APPENDIX D.

SCALE IN FEET

100' 50' 0 100' 200'

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

FOUNDATION REPORT

CLAY CONTOURS
WYNOOCHEE DAM

WYNOOCHEE RIVER WASHINGTON

SIZE	INVITATION NO.	FILE NO	DATE	PLATE
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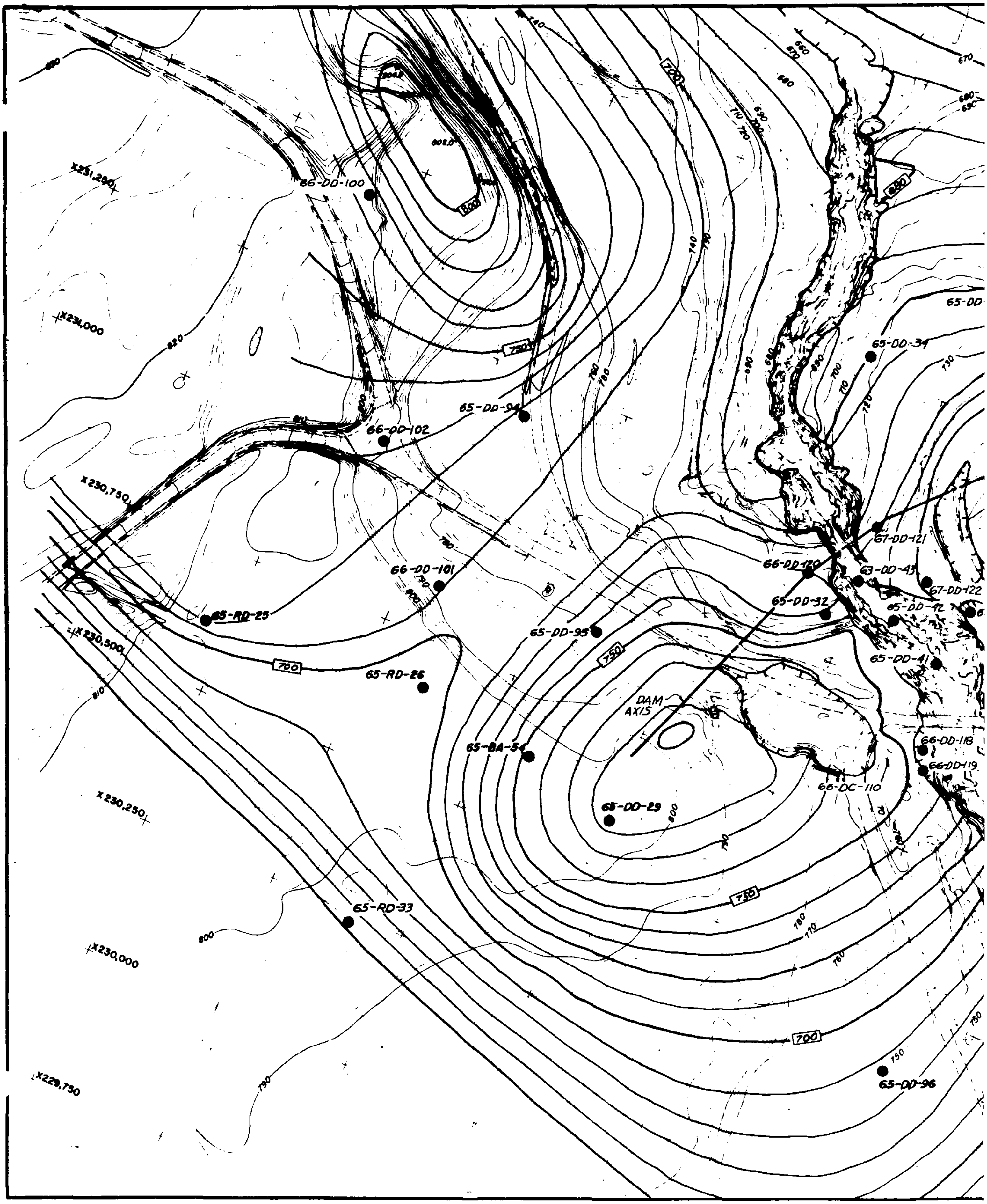
DSGN. ECKERLIN		CHK GALSTER	SHEET	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X231,000
X230,750
X230,500
X230,250
X230,000
X229,750
66-DD-100
65-DD-94
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66-DD-101
65-RD-25
65-RD-26
65-DD-95
65-BA-54
65-DD-29
DAM AXIS
66-DD-120
65-DD-32
67-DD-121
63-DD-43
67-DD-122
65-DD-42
65-DD-41
66-DD-118
66-DD-119
66-DC-110
65-DD-34
65-DD
65-RD-33
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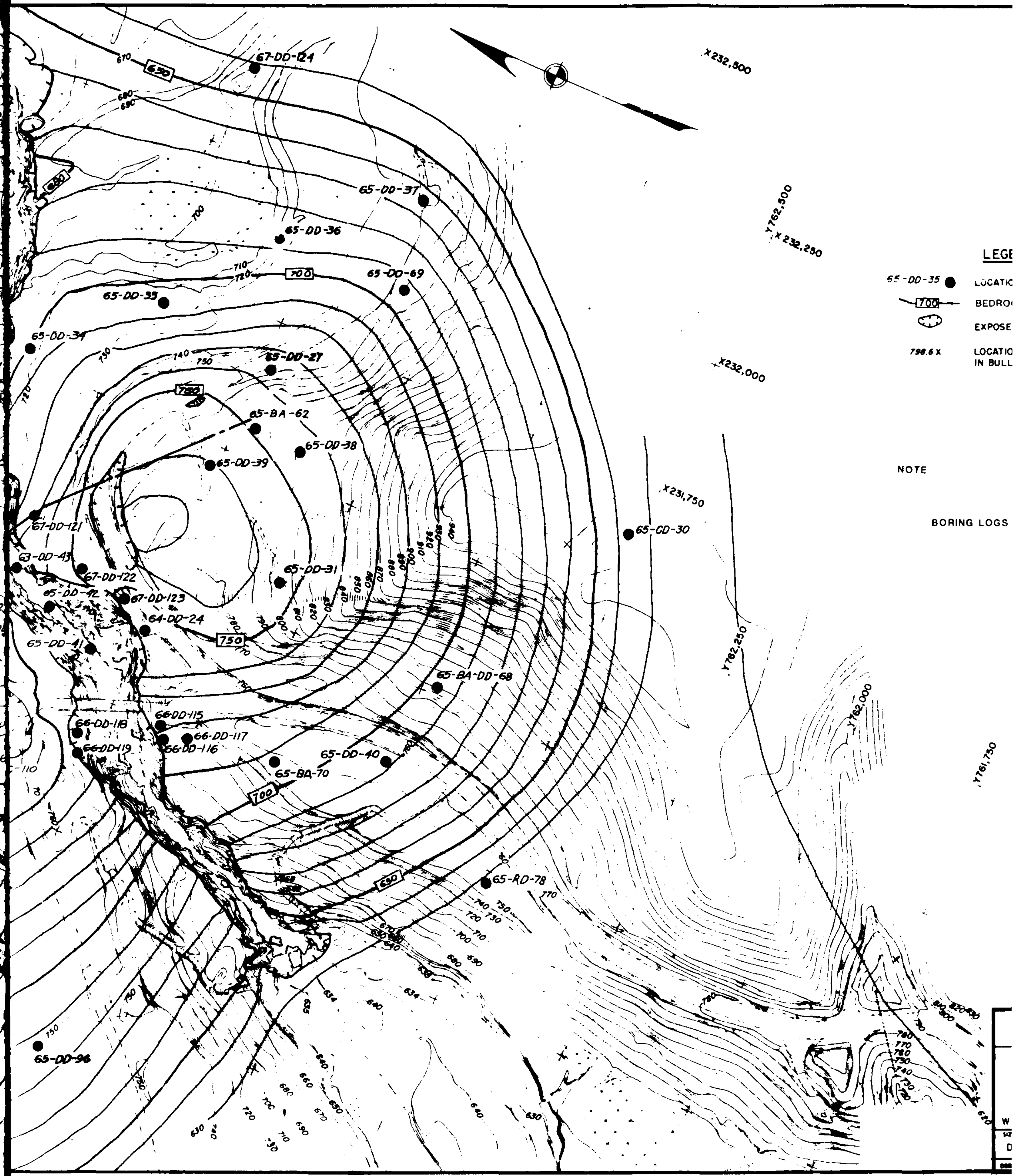
730
740
760
780
790
810
820



LEGE
65-DD-35 ● LOCATIO
700 BEDRO
EXPOSE
798.6 X LOCATIO IN BULL
NOTE
BORING LOGS
X232,500
X232,250
X232,000
X231,750
Y762,500
Y762,250
Y762,000
Y761,750
67-DD-124
65-DD-37
65-DD-36
65-DD-69
65-DD-35
65-DD-34
65-DD-27
65-BA-62
65-DD-38
65-DD-39
67-DD-121
63-DD-43
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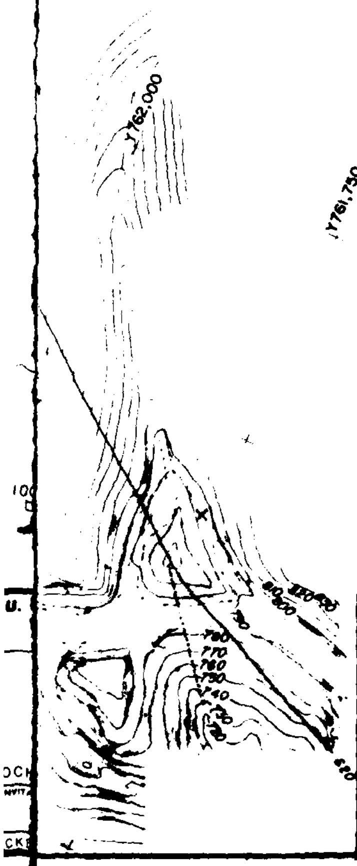
65-RD-78
65-DD-96
690
680
700
710
720
730
740
750
760
770
780
790
800
630
640
650
660
670

LEGEND

65-DD-35 ●	LOCATION & NO. OF BORING TO BEDROCK
700	BEDROCK CONTOUR
	EXPOSED BEDROCK
798.6 X	LOCATION & ELEVATION OF ROCK EXPOSED IN BULLDOZER CUTS

NOTE

BORING LOGS ARE IN APPENDIX "D"



SCALE IN FEET

100' 50' 0 100' 200'

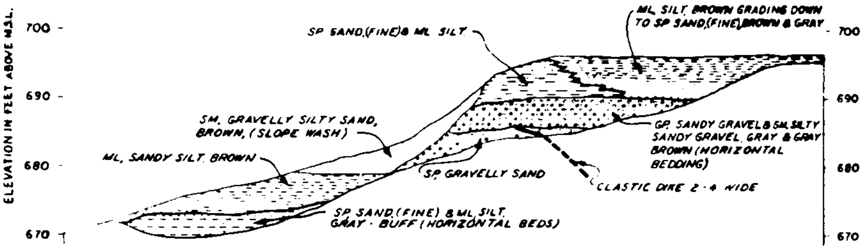
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

FOUNDATION REPORT

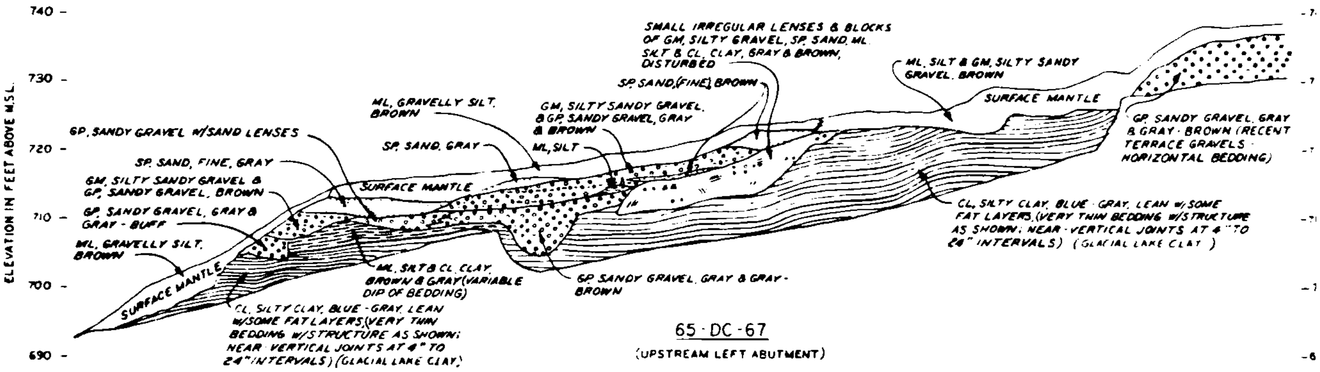
ROCK CONTOURS
WYNOOCHEE DAM

WYNOOCHEE RIVER WASHINGTON

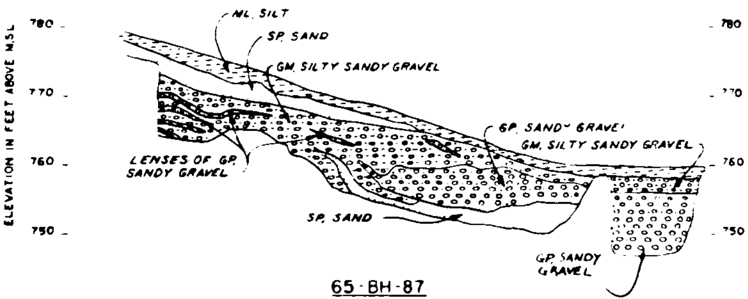
SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D		E-57-6-4	DEC67	3
DSGN. ECKERLIN		CHK GALSTER	SHEET	



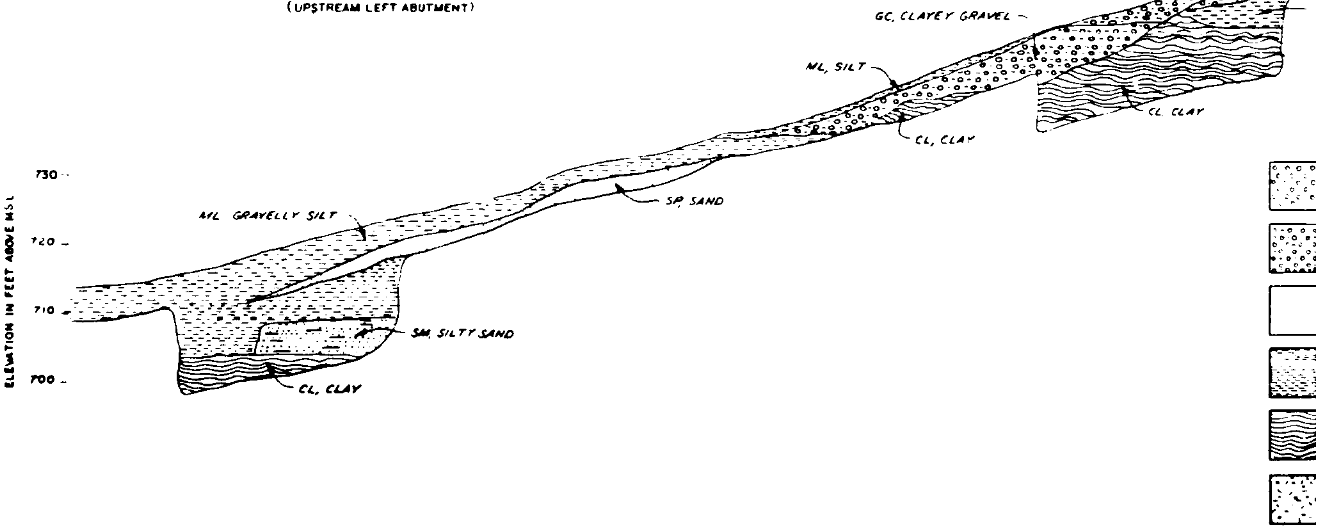
65-DC-65
(UPSTREAM LEFT ABUTMENT)

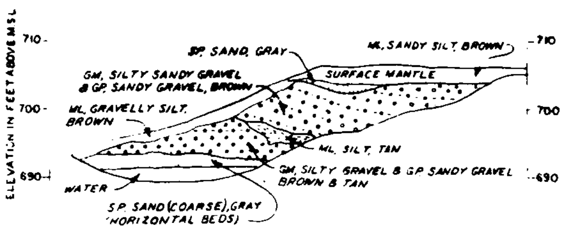


65-DC-67
(UPSTREAM LEFT ABUTMENT)

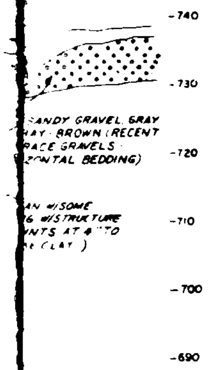


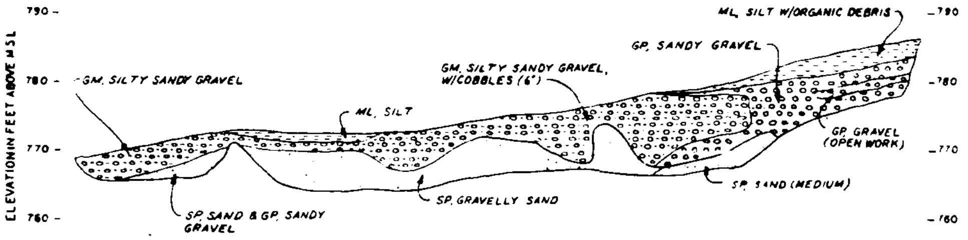
65-BH-87
(UPSTREAM LEFT ABUTMENT)



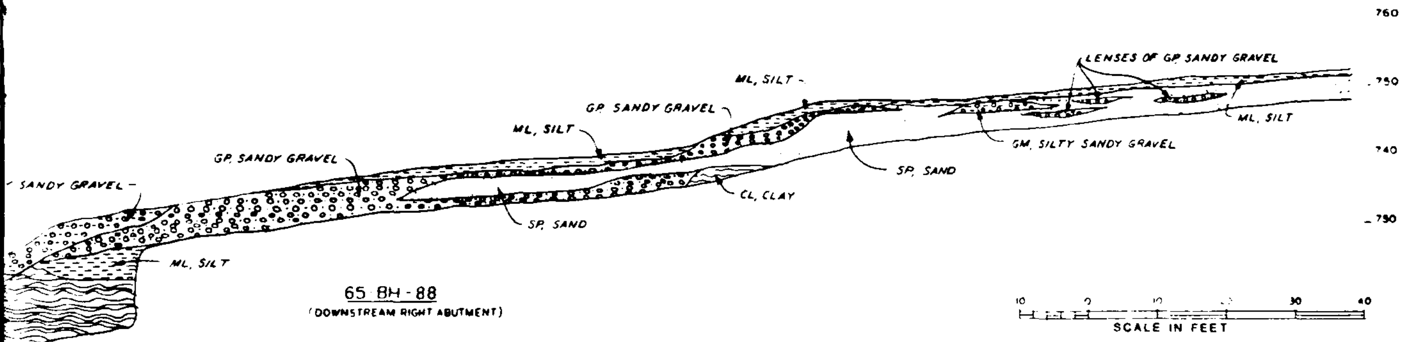


65-DC-66
(UPSTREAM LEFT ABUTMENT)





65-BH-85
(UPSTREAM LEFT ABUTMENT)



65 BH-88
(DOWNSTREAM RIGHT ABUTMENT)

10 0 10 20 30 40
SCALE IN FEET

NOTES:

1. FOR LOCATIONS OF SECTIONS SEE PLATE 1.

LEGEND

- ⁘ GP, SANDY GRAVEL
- ⁘ GM, SILTY SANDY GRAVEL
  GC, CLAYEY GRAVEL
- ☐ SP, SAND
- ▤ ML, SILT
- ≋ CL, CLAY
- ⁘ GM, GC OR SC, GLACIAL TILL
- ▤ SM, SILTY SAND

U. S. ARMY ENGINEER DISTRICT, SEATTLE
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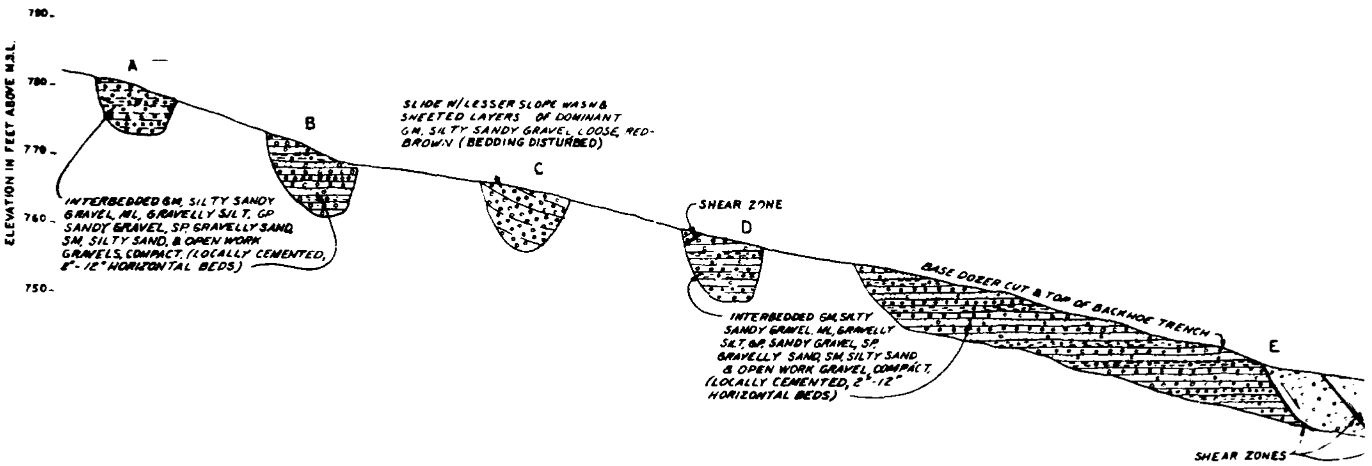
SEATTLE, WASHINGTON

FOUNDATION REPORT

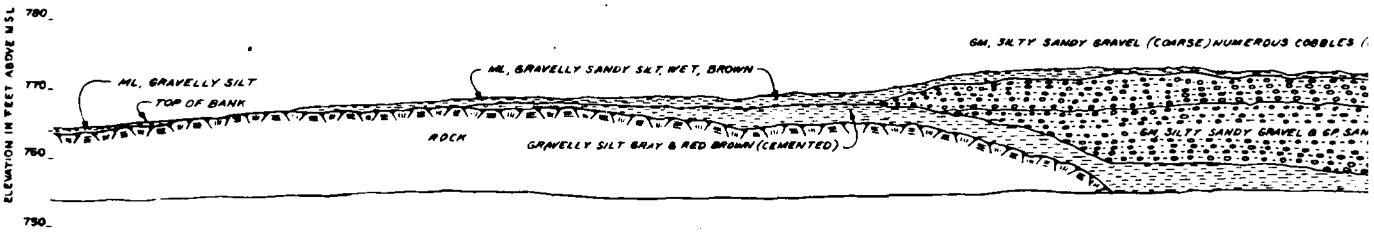
PRE-CONSTRUCTION
EXPLORATION-SECTIONS
WYNOOCHEE DAM

WYNOOCHEE RIVER WASHINGTON

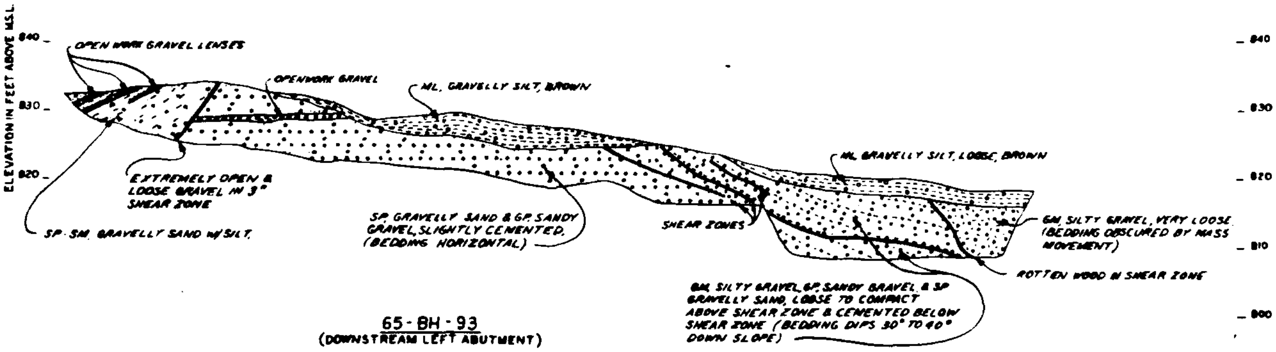
F		FILE NO E-67-8-4	DATE DEC67	PLATE 4
DESIGN ECKERLIN		CHK GALSTER	SHEET	



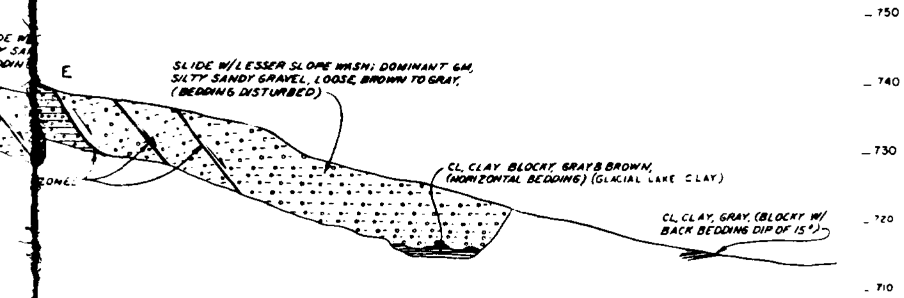
65 - BH - 91
(DOWNSTREAM LEFT ABUTMENT)

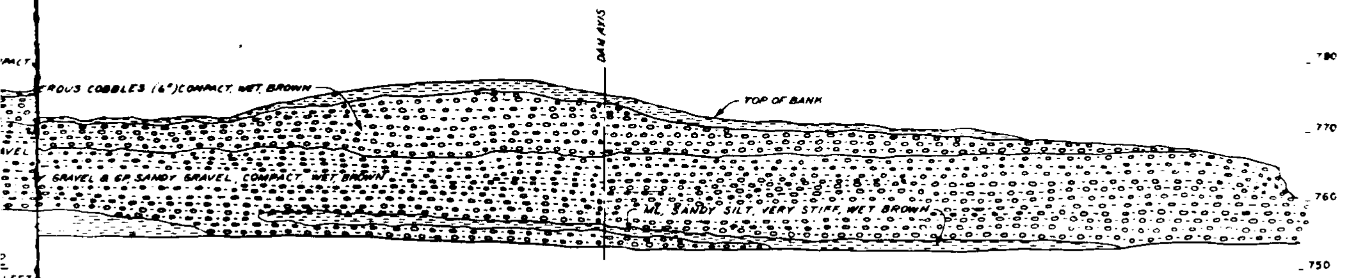


65 - D
(EXISTING ROAI
IN VICINITY

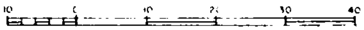


65 - BH - 93
(DOWNSTREAM LEFT ABUTMENT)





65 - DC - 92
(EXISTING ROAD CUT, LEFT ABUTMENT IN VICINITY OF DAM AXIS)



SCALE IN FEET

NOTES:

1. FOR MATERIALS LEGEND SEE PLATE 4.
2. FOR LOCATIONS OF SECTIONS SEE PLATE 1.

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

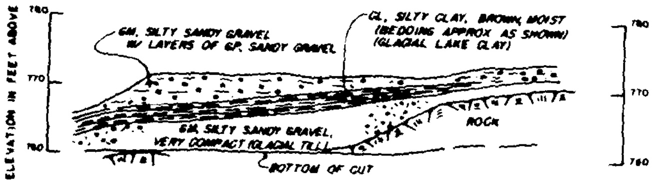
FOUNDATION REPORT

PRE-CONSTRUCTION
EXPLORATION-SECTIONS
WYNOOCHEE DAM

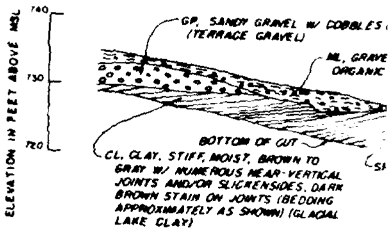
WYNOOCHEE RIVER WASHINGTON

F		E-67-6-4	DEC67	5
ECKERLIN	GALSTER			

2.

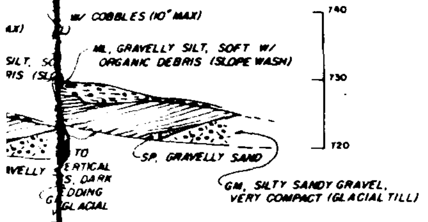


66-DC-110
(EXISTING ROAD CUT, DOWNSTREAM RIGHT ABUTMENT)



66-DC-112

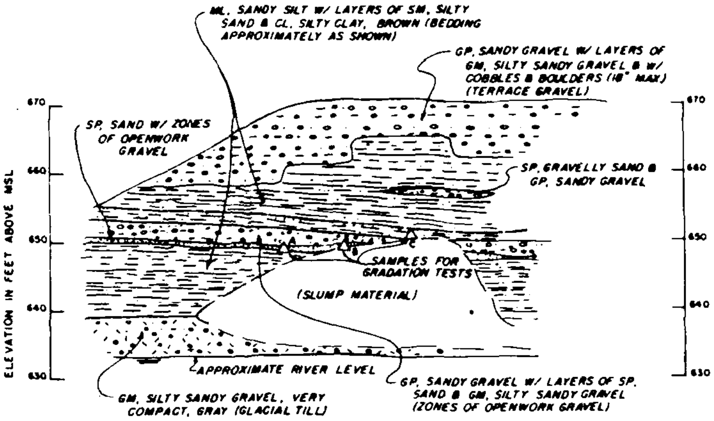
(UPSTREAM LEFT ABUT



DC-112

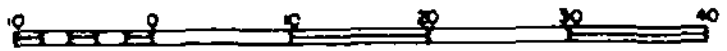
LEFT ABUTMENT)

)



66-TP-113

(NATURAL SLOPE ADJACENT TO RIVER, DOWNSTREAM LEFT ABUTMENT)



SCALE IN FEET

NOTES:

1. FOR MATERIALS LEGEND SEE PLATE 4.
2. FOR LOCATIONS OF SECTIONS SEE PLATE 1.

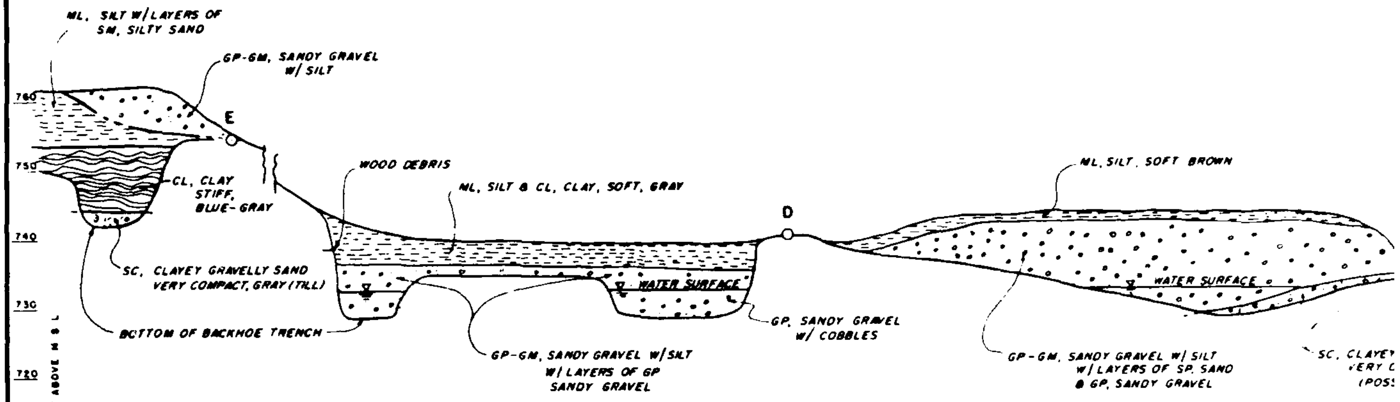
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

FOUNDATION REPORT

PRE-CONSTRUCTION
EXPLORATION-SECTIONS
WYNOOCHEE DAM

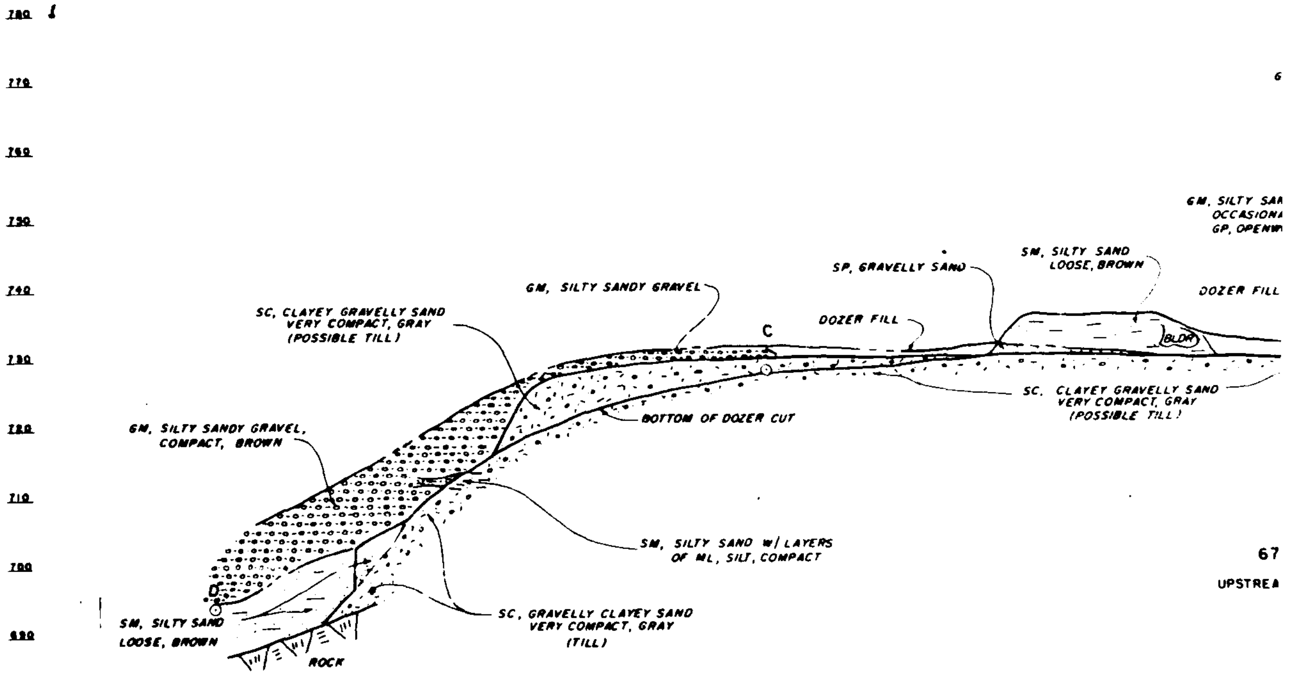
WYNOOCHEE RIVER WASHINGTON

F		E-67-6-4	DEC87	6
ECKERLIN		GALSTER		



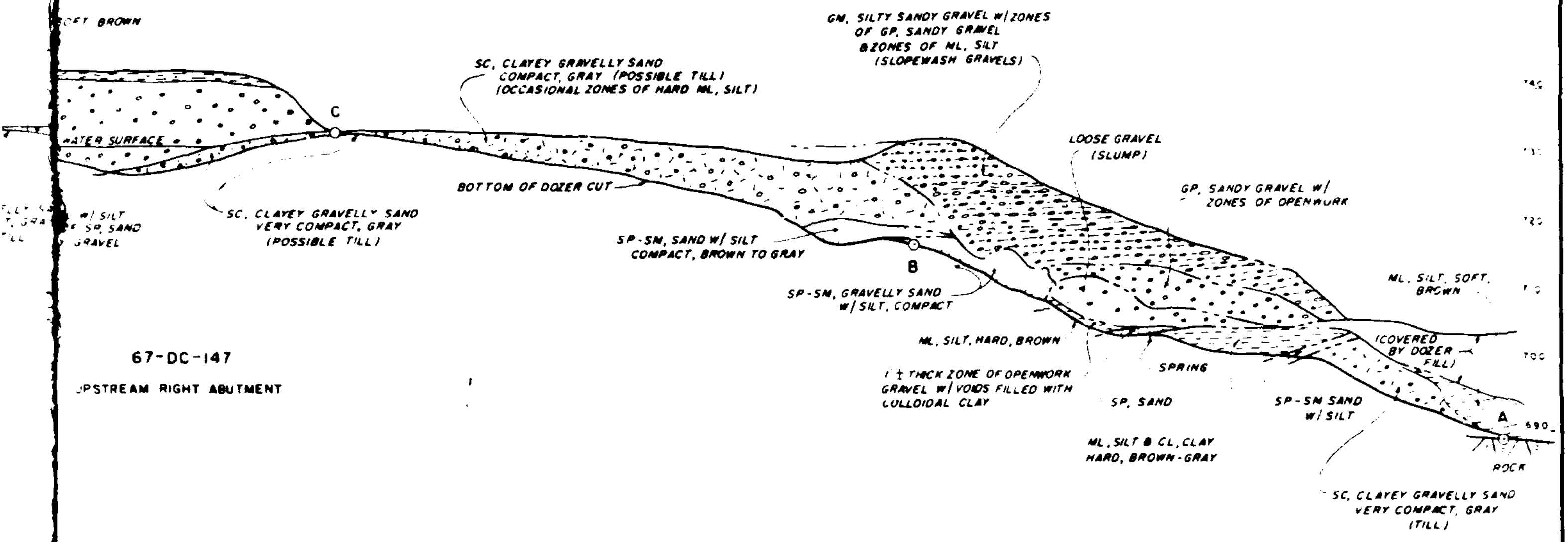
67-OC-147

UPSTREAM RIGHT ABUTMENT



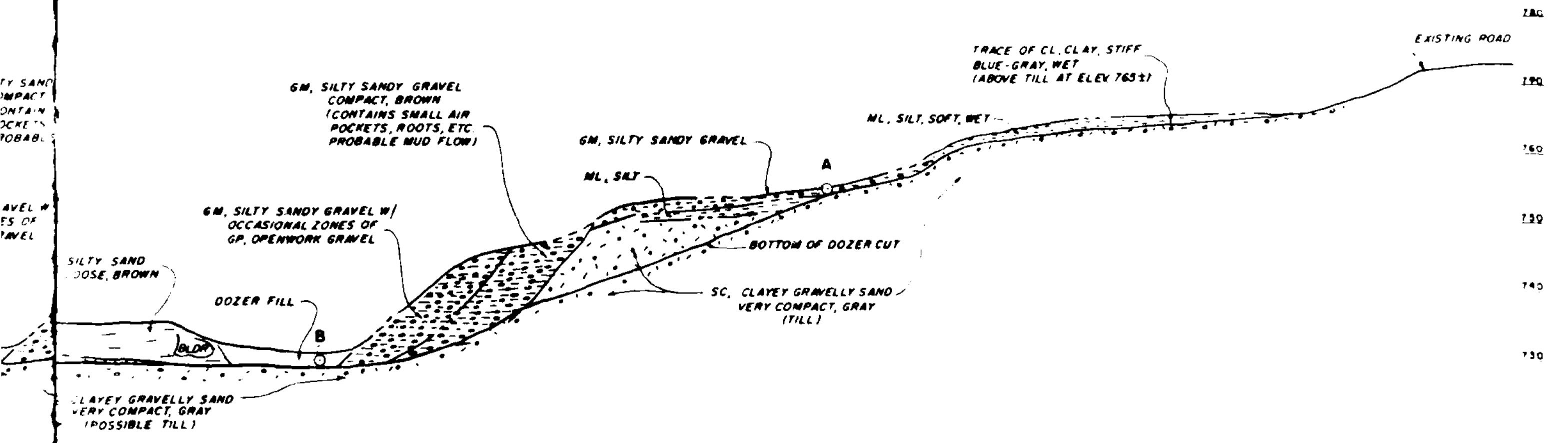
67

UPSTREA



67-DC-147

UPSTREAM RIGHT ABUTMENT



67-DC-148

UPSTREAM RIGHT ABUTMENT

NOTES:

1. FOR MATERIALS LEGEND SEE PLATE 4.
2. FOR LOCATIONS OF SECTIONS SEE PLATE 1.

10' 5' 0 10' 20'

SCALE IN FEET

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

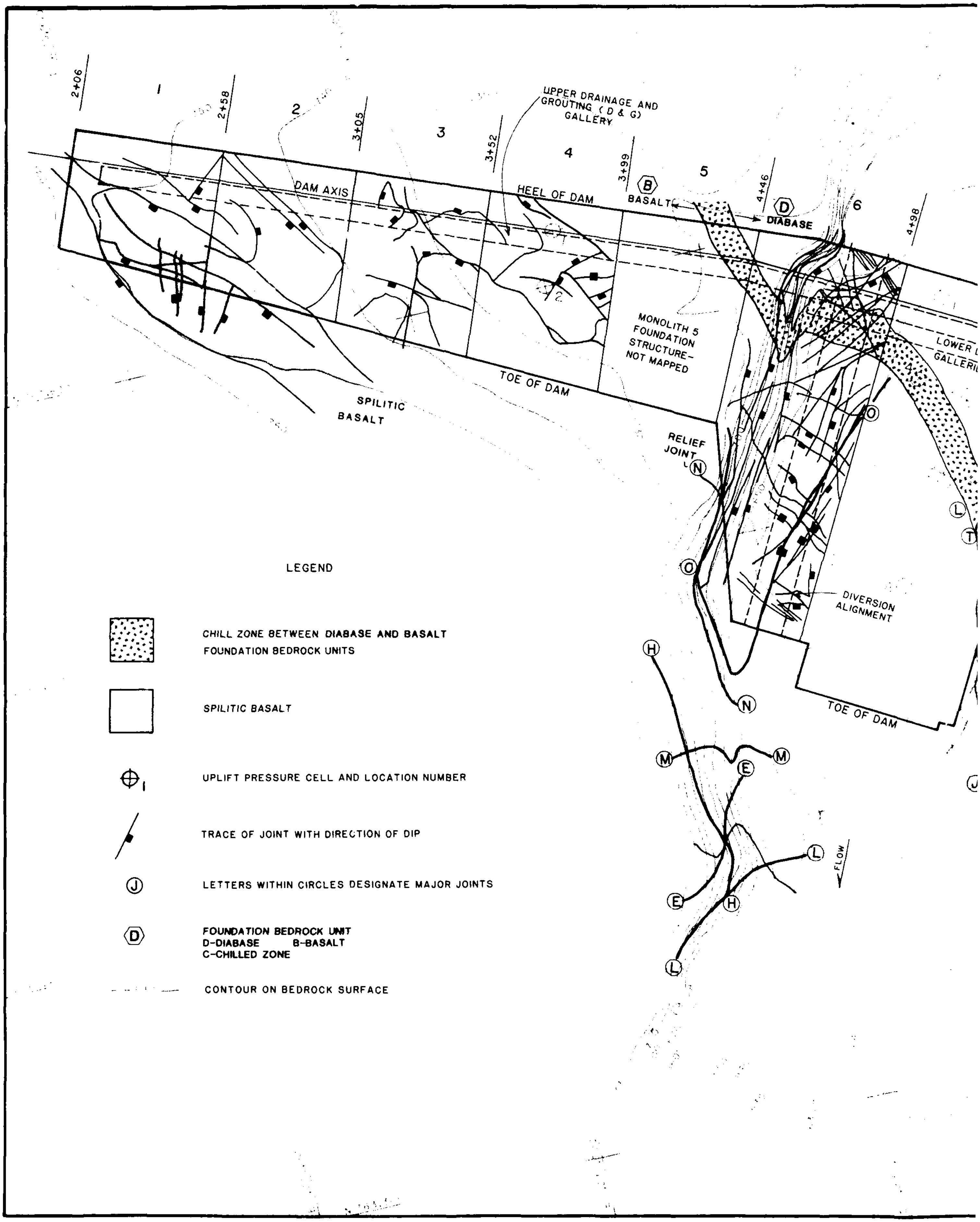
FOUNDATION REPORT

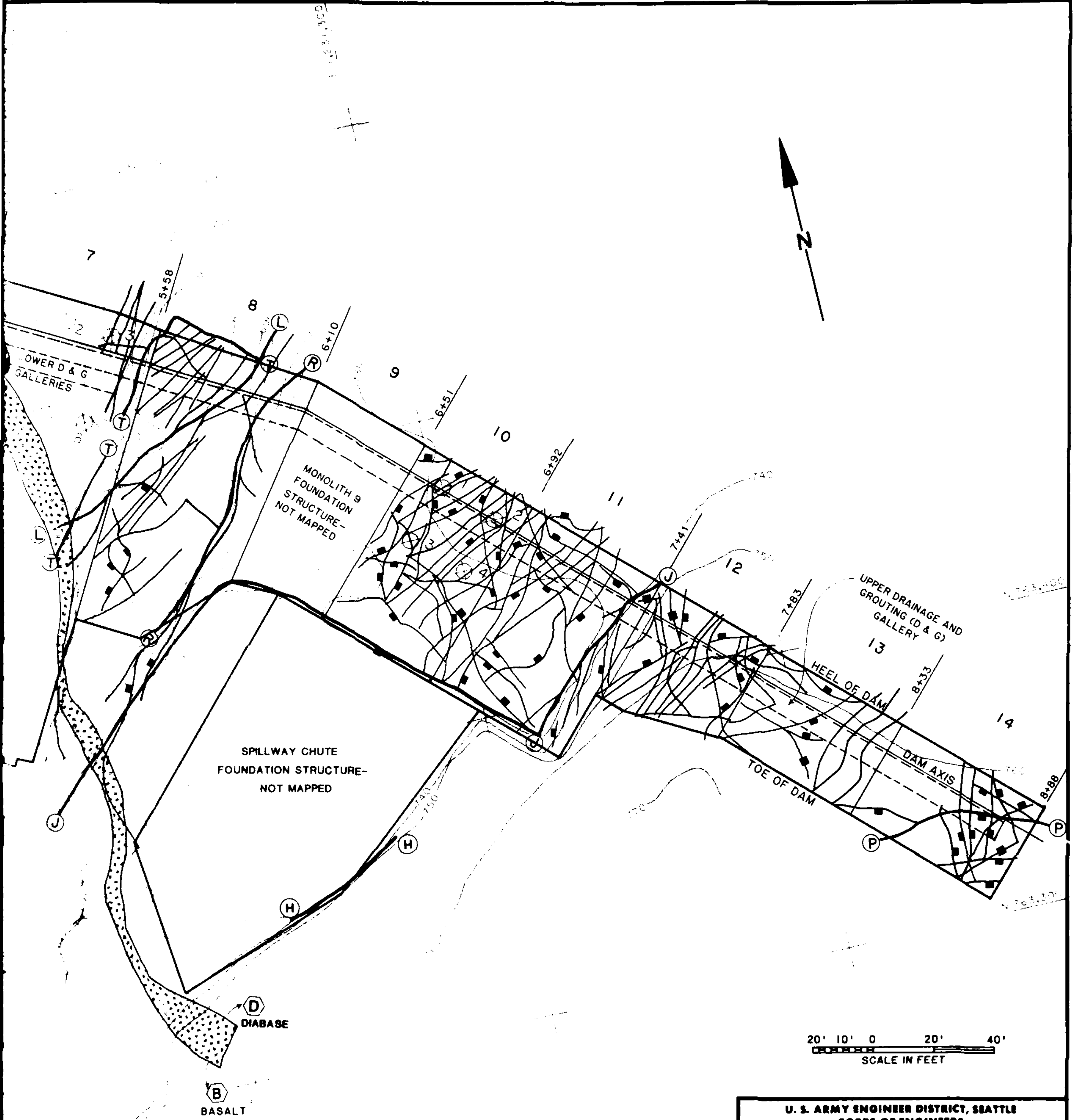
PRE-CONSTRUCTION
EXPLORATION-SECTIONS
WYNOOCHEE DAM

WYNOOCHEE RIVER WASHINGTON

F
E-67-0-4
DEC67
7

ECKERLIN
GALSTER


2+06
1
2+58
2
3+05
3
3+52
4
3+99
5
4+46
6
4+98
UPPER DRAINAGE AND GROUTING (D & G) GALLERY
DAM AXIS
HEEL OF DAM
B
BASALT
D
DIABASE
LOWER
GALLERI
MONOLITH 5 FOUNDATION STRUCTURE-NOT MAPPED
TOE OF DAM
SPILITIC BASALT
RELIEF JOINT
N
O
L
T
DIVERSION ALIGNMENT
H
N
TOE OF DAM
M
M
E
J
L
E
H
L
FLOW
1
2
LEGEND
CHILL ZONE BETWEEN DIABASE AND BASALT FOUNDATION BEDROCK UNITS
SPILITIC BASALT
UPLIFT PRESSURE CELL AND LOCATION NUMBER
TRACE OF JOINT WITH DIRECTION OF DIP
J
LETTERS WITHIN CIRCLES DESIGNATE MAJOR JOINTS
D
FOUNDATION BEDROCK UNIT
D-DIABASE B-BASALT
C-CHILLED ZONE
CONTOUR ON BEDROCK SURFACE



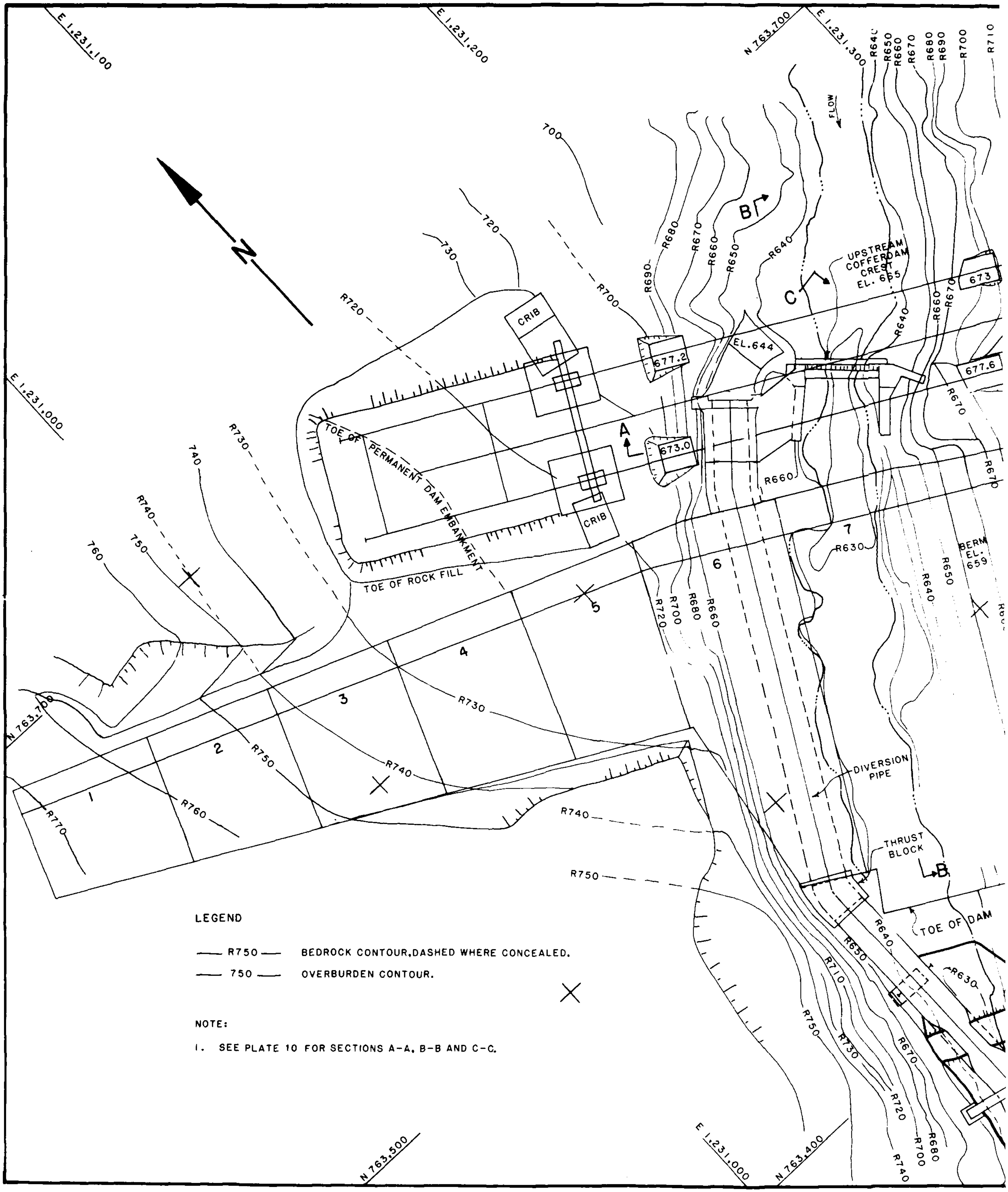
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE WASHINGTON

FOUNDATION REPORT

GEOLOGICAL PLAN

WYNOOCHEE DAM

WYNOOCHEE RIVER			WASHINGTON	
SIZE	INVITATION NO	FILE NO	DATE	PLATE
D		E-57-6-4	DEC87	8
DSGN ECKERLIN		CHK GALSTER	SHEET	



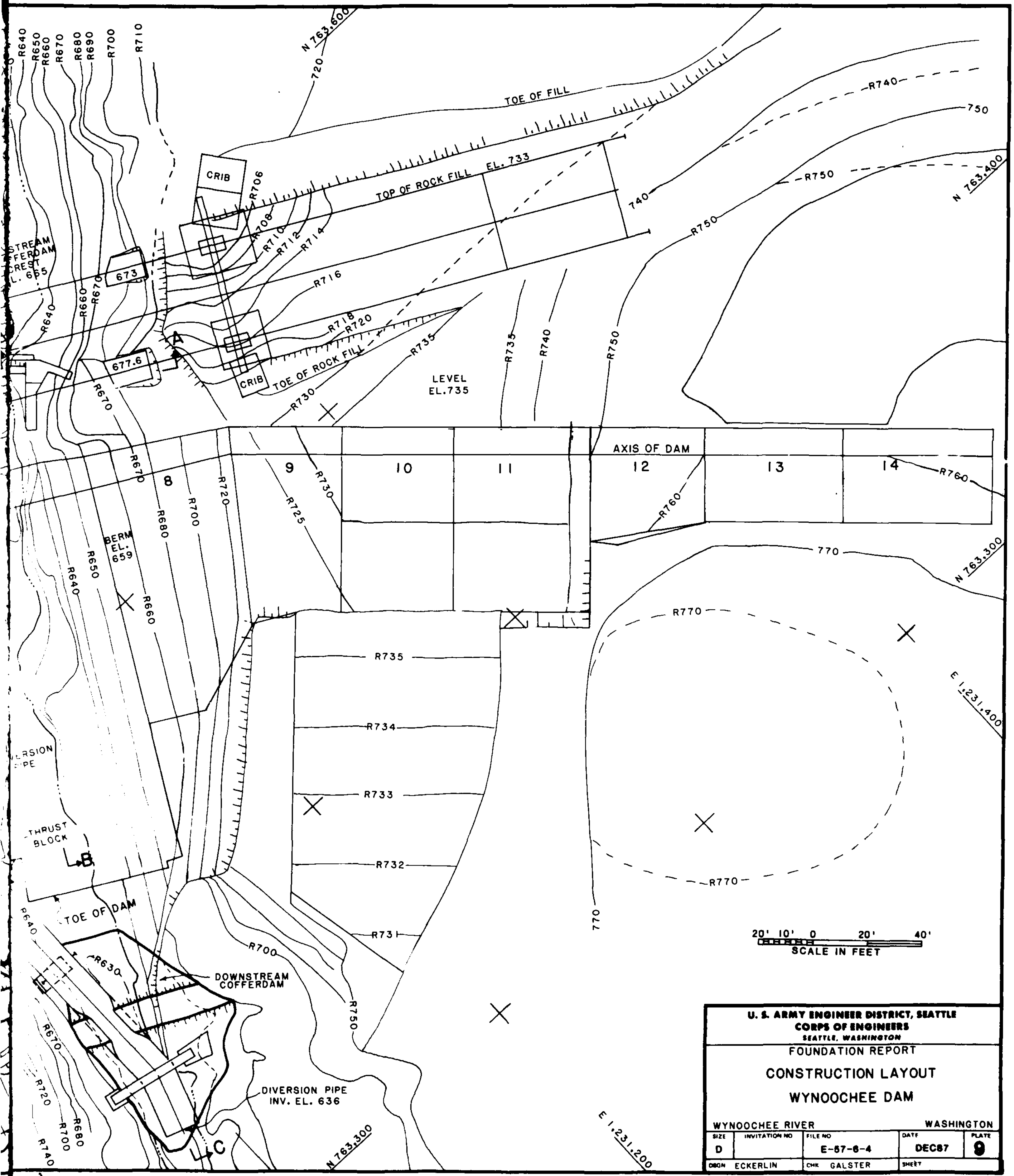
LEGEND

—— R750 —— BEDROCK CONTOUR, DASHED WHERE CONCEALED.

—— 750 —— OVERBURDEN CONTOUR.

NOTE:

1. SEE PLATE 10 FOR SECTIONS A-A, B-B AND C-C.



U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

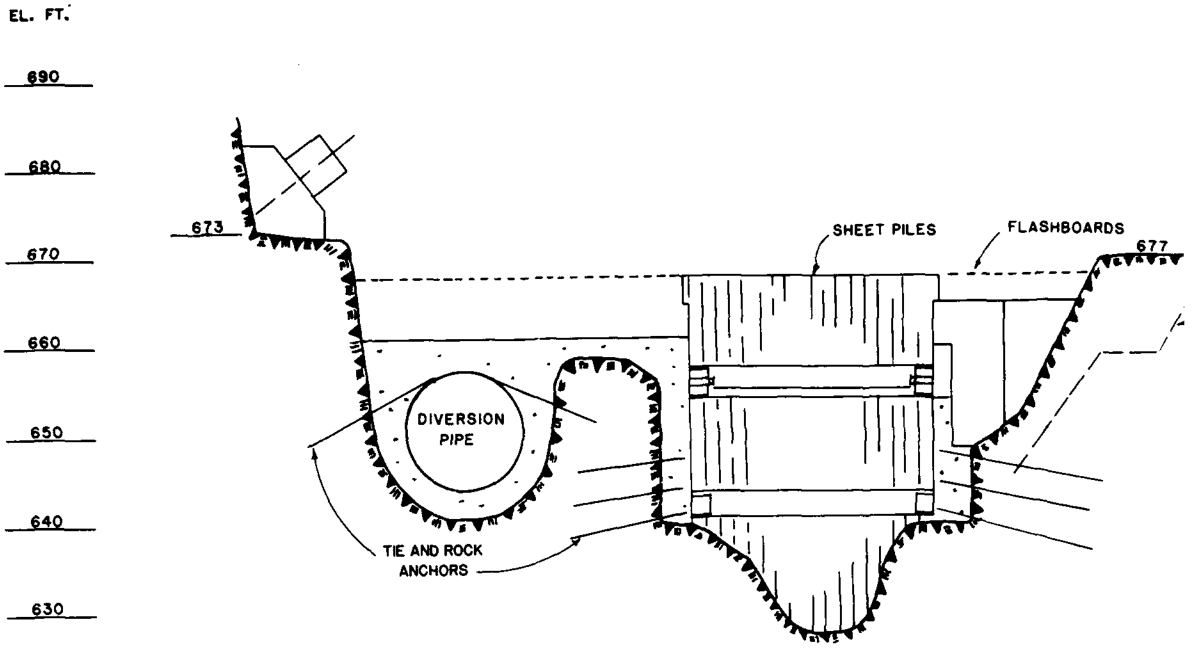
FOUNDATION REPORT

CONSTRUCTION LAYOUT

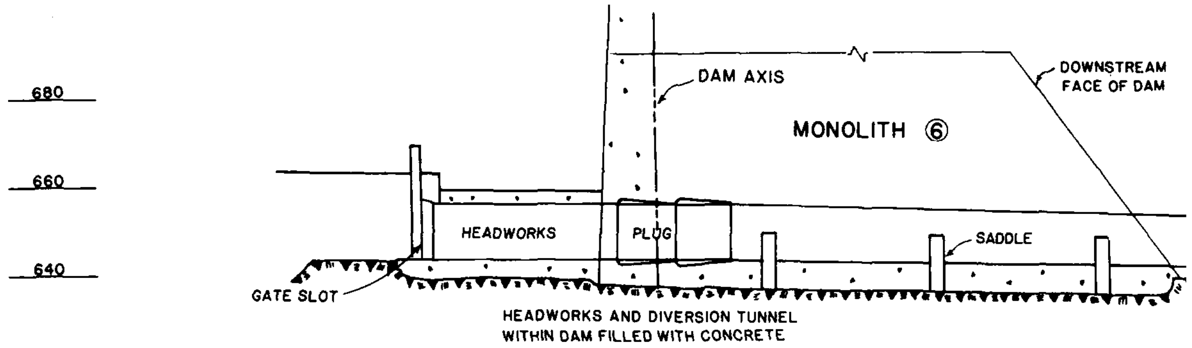
WYNOOCHEE DAM

WYNOOCHEE RIVER WASHINGTON

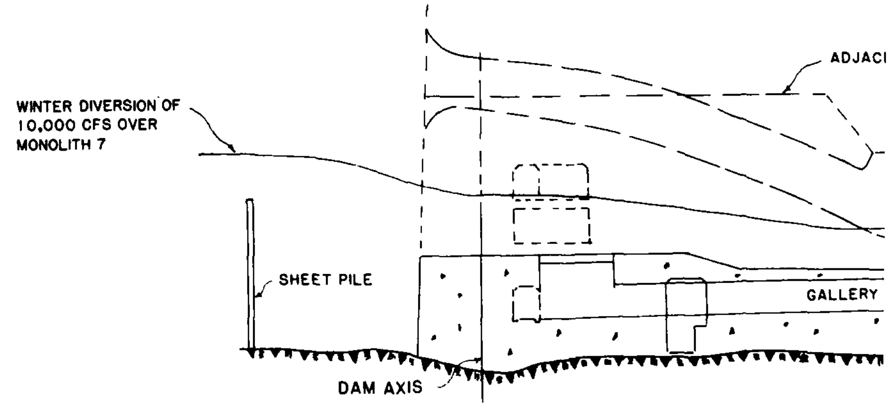
SIZE	INVITATION NO	FILE NO	DATE	PLATE
D		E-57-6-4	DEC87	9
DSGN ECKERLIN		CHK GALSTER	SHEET	



SECTION A-A

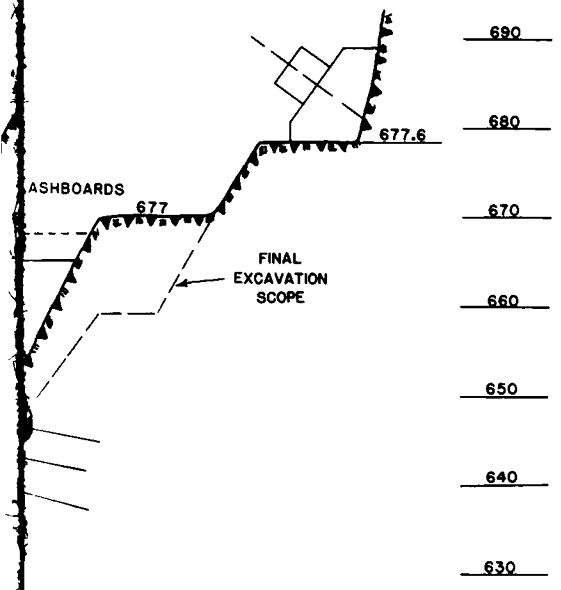


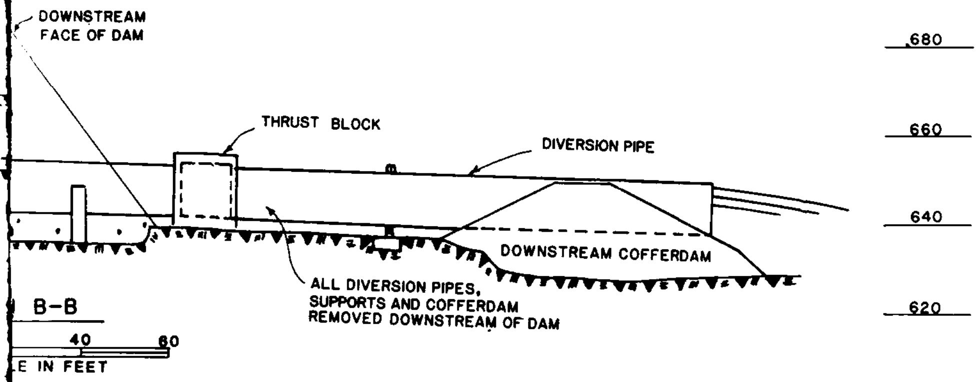
SECTION B-B

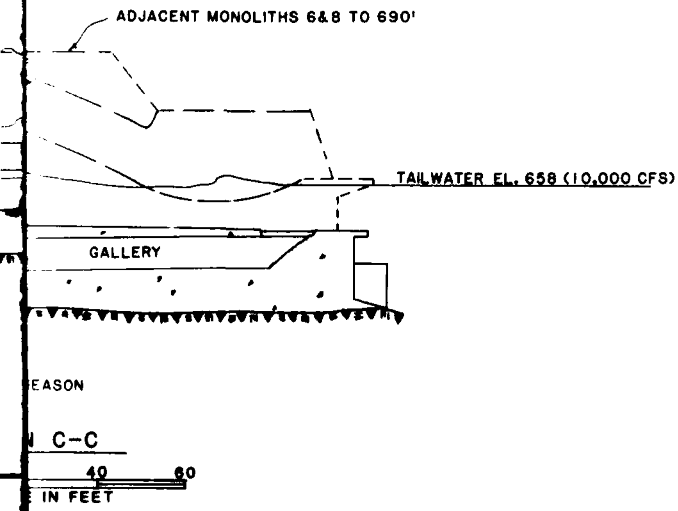


LOW MONOLITH ⑦ AT FINISH OF 1970 WORKING SEASON

SECTION C-C







NOTES:

1. REFER TO PLATE 9 FOR PLAN.
2. THIS DRAWING IS AS-BUILT MODIFIED FROM DRAVO CORP. DRAWING NO. D-16 (3 OF 12).

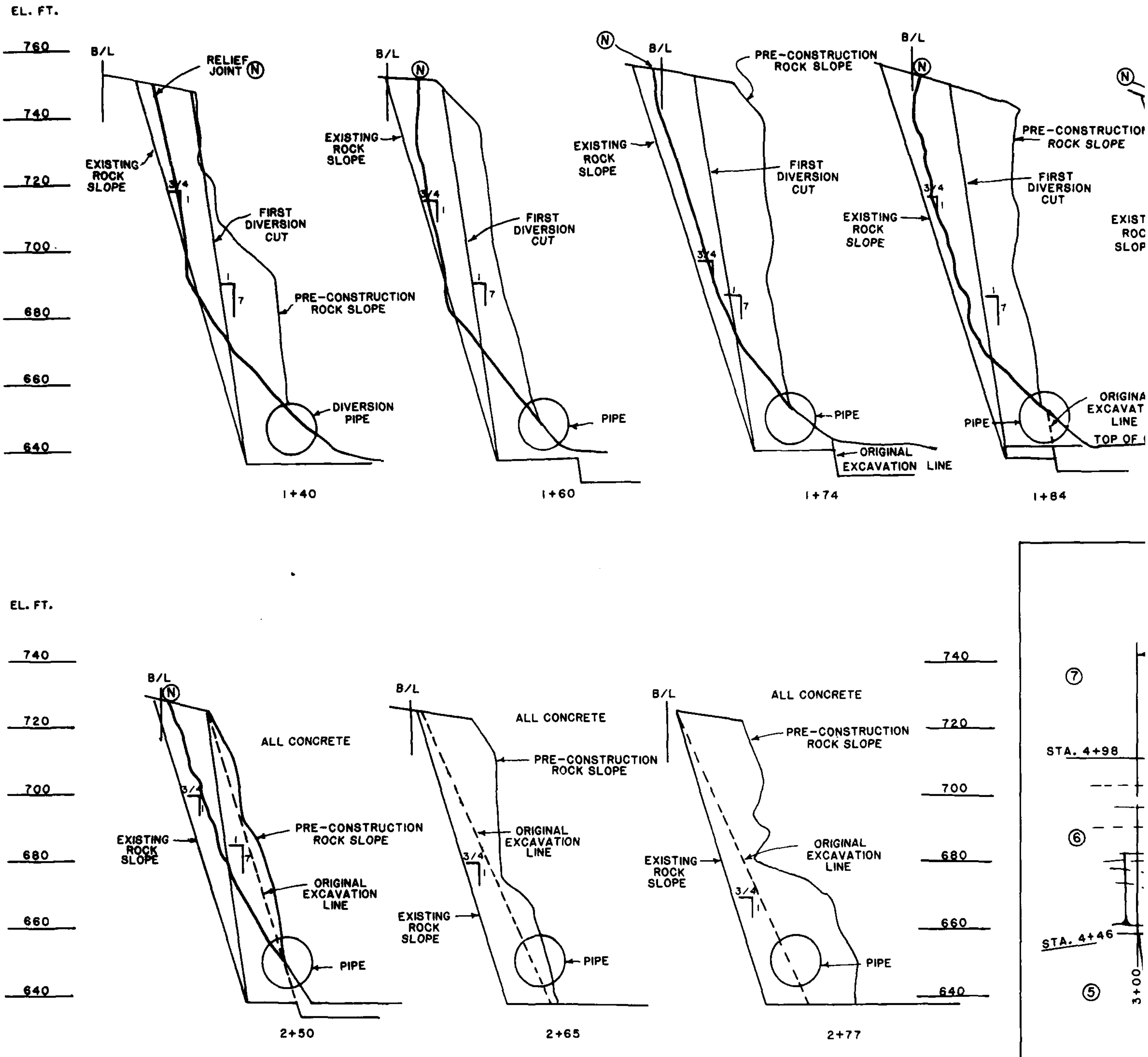
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

FOUNDATION REPORT

DIVERSION SCHEME SECTIONS
WYNOOCHEE DAM

WYNOOCHEE RIVER WASHINGTON

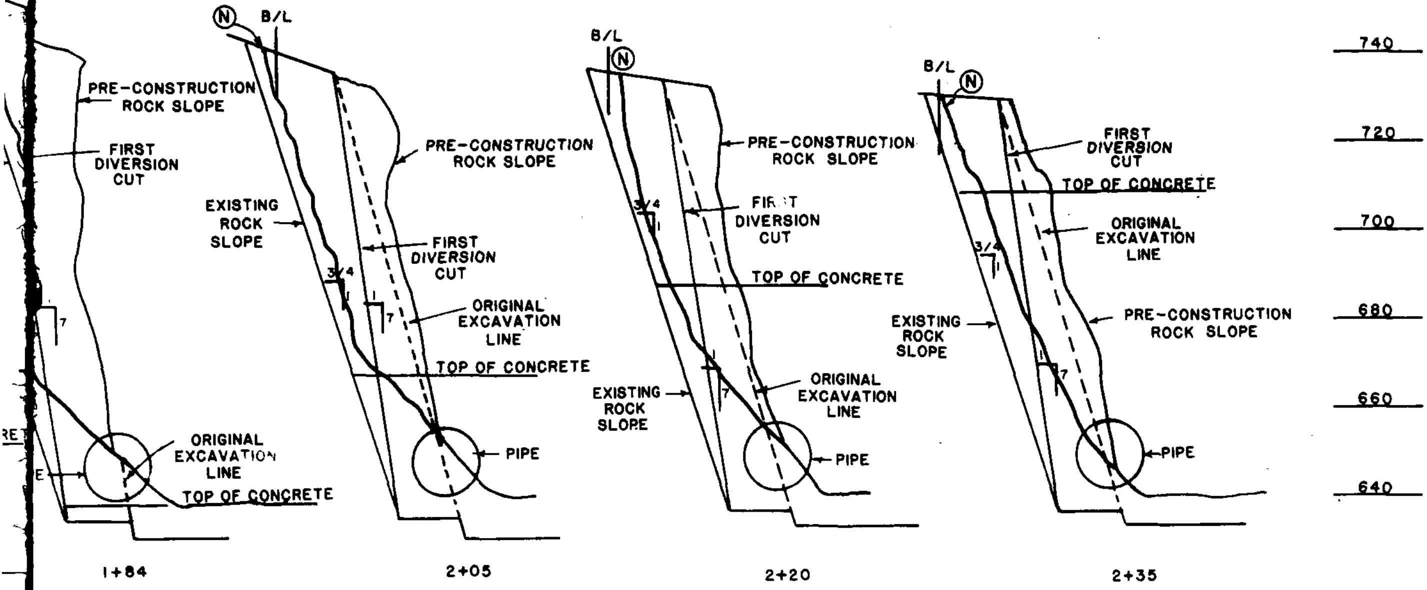
SIZE	INVITATION NO	FILE NO	DATE	PLATE
D		E-57-6-4	DEC87	10
DSGN ECKERLIN		CHK GALSTER	SHEET	

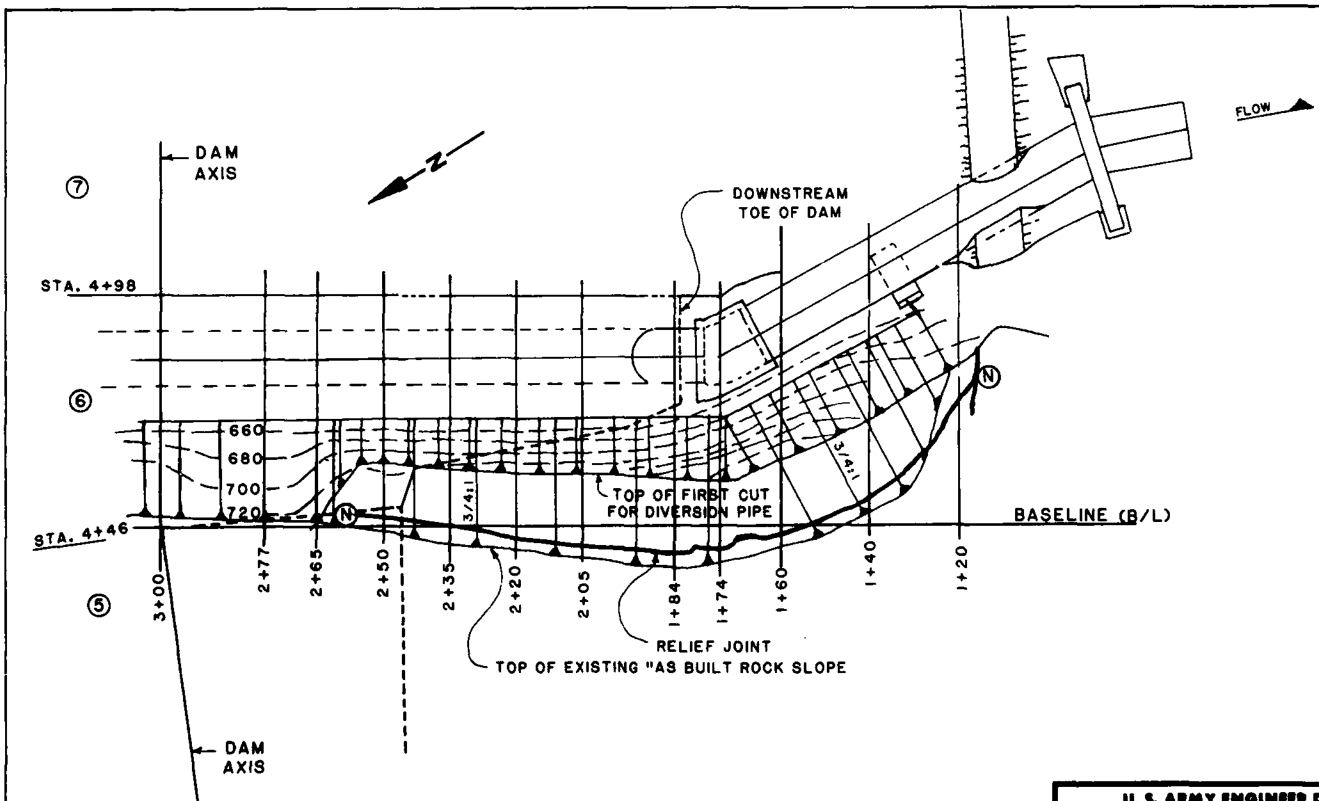

EL. FT.
760
740
720
700
680
660
640
B/L
RELIEF JOINT Ⓝ
EXISTING ROCK SLOPE
3/4
1
FIRST DIVERSION CUT
7
PRE-CONSTRUCTION ROCK SLOPE
DIVERSION PIPE
1+40
Ⓝ
EXISTING ROCK SLOPE
FIRST DIVERSION CUT
PIPE
1+60
PRE-CONSTRUCTION ROCK SLOPE
ORIGINAL EXCAVATION LINE
1+74
PRE-CONSTRUCTIOI ROCK SLOPE
ORIGINA EXCAVAT LINE
TOP OF
1+84
EXIST ROC SLOP
EL. FT.
740
720
700
680
660
640
ALL CONCRETE
ORIGINAL EXCAVATION LINE
2+50
2+65
2+77
⑦
STA. 4+98
⑥
STA. 4+46
⑤
3+00

SECTIONS


20'
10'
0
20'
40'
SCALE IN FEET

2.





PLAN

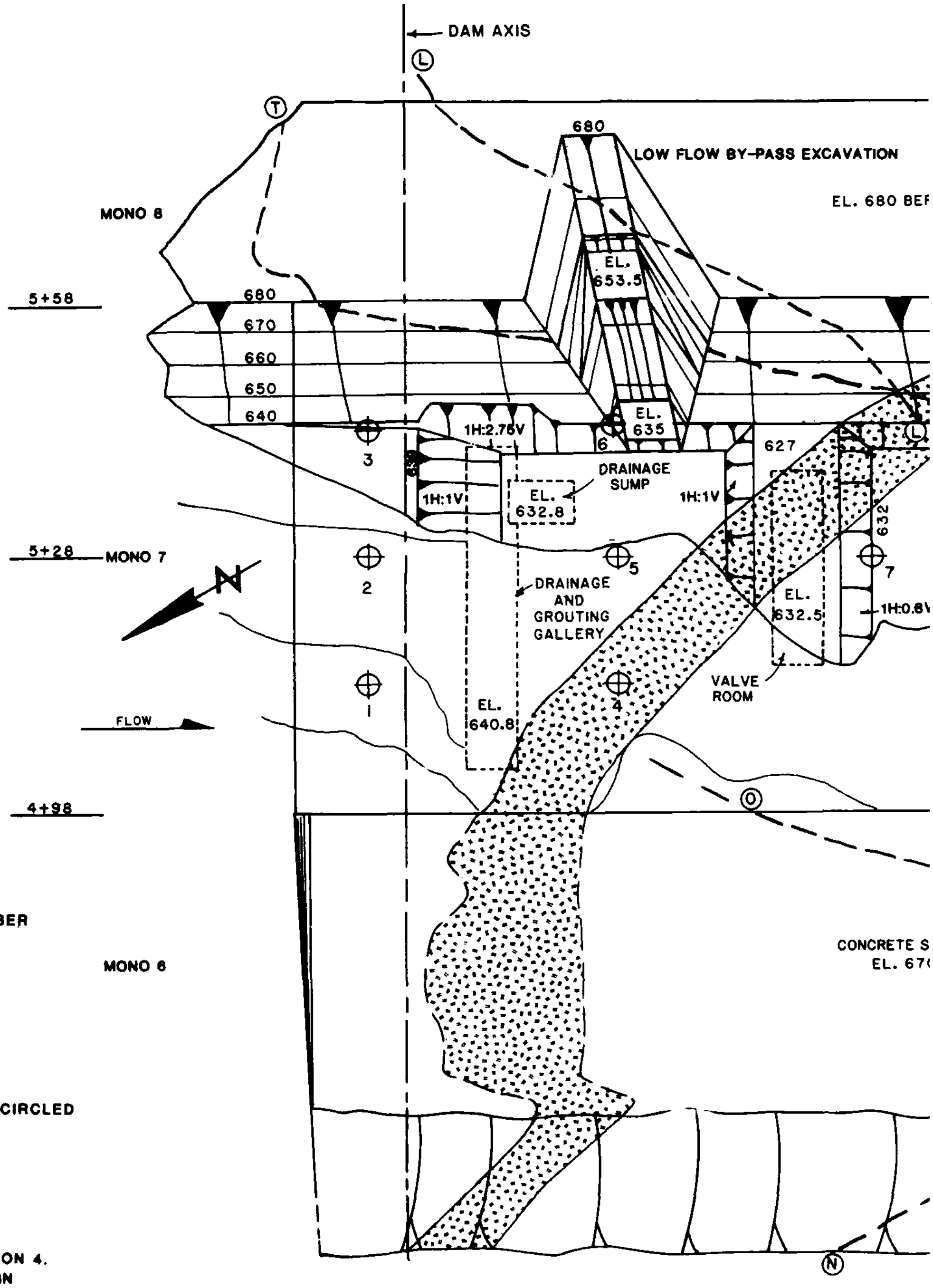
20' 10' 0 20' 40'
SCALE IN FEET

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

FOUNDATION REPORT
DIVERSION SLOPE LAYBACK-
MONOLITH 6
WYNOOCHEE DAM

WYNOOCHEE RIVER WASHINGTON

SIZE	INVITATION NO	FILE NO	DATE	PLATE
D		E-57-6-4	DEC87	11.
DSGN ECKERLIN		CHK GALSTER	SHEET	



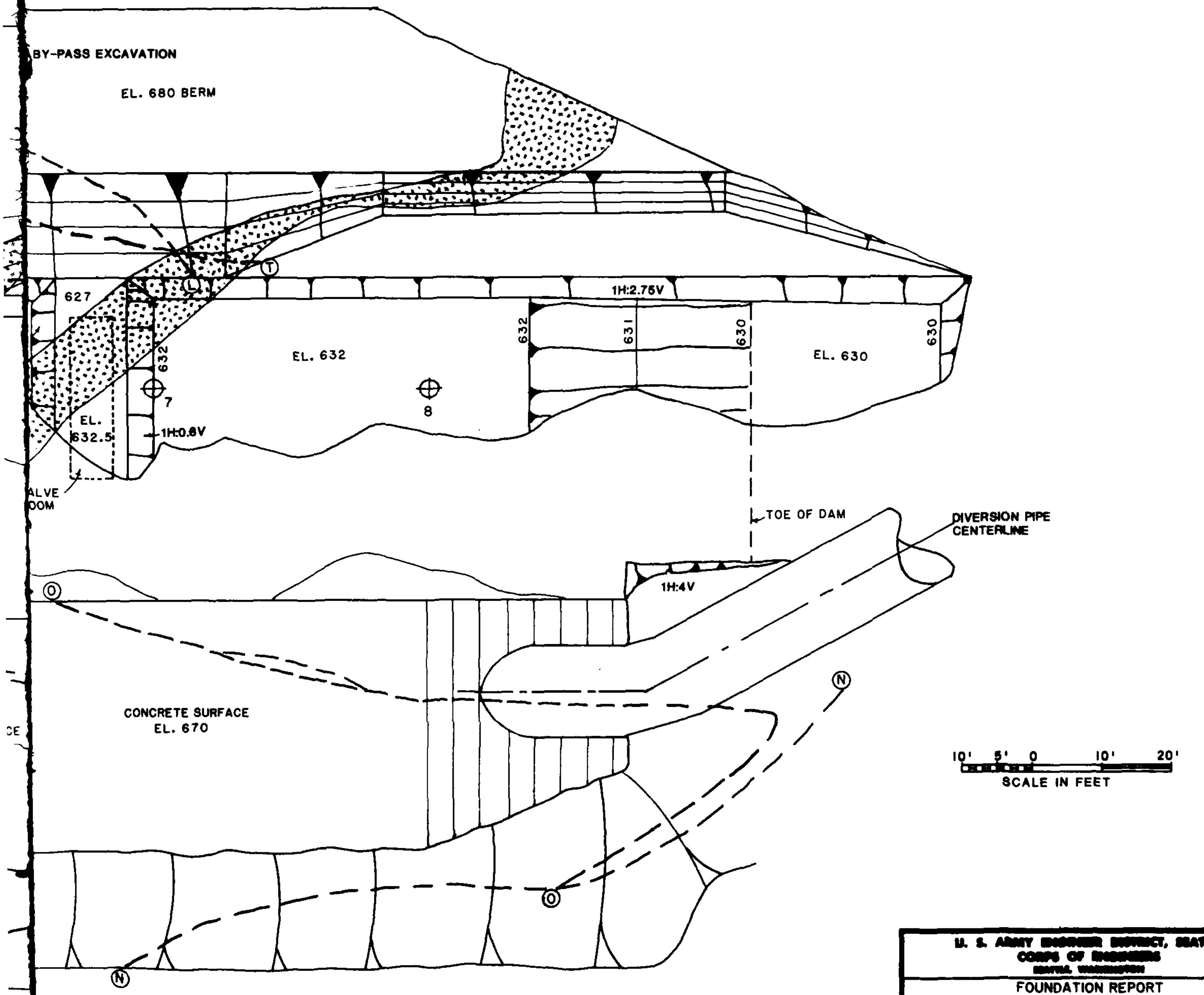
LEGEND:

⊕ 1	UPLIFT PRESSURE CELL AND LOCATION NUMBER
▨	CHILLED ZONE BETWEEN DIABASE AND BASALT FOUNDATION BEDROCK UNITS
Ⓛ	MAJOR JOINT IN BEDROCK, DESIGNATED BY CIRCLED ALPHA-CHARACTER

NOTES:

1. BEDROCK DETAILS ARE SHOWN ON FIGURES IN SECTION 4.
2. THIS DRAWING IS MODIFIED FROM DRAVO CORP. DESIGN DRAWING NO. D-45.

2



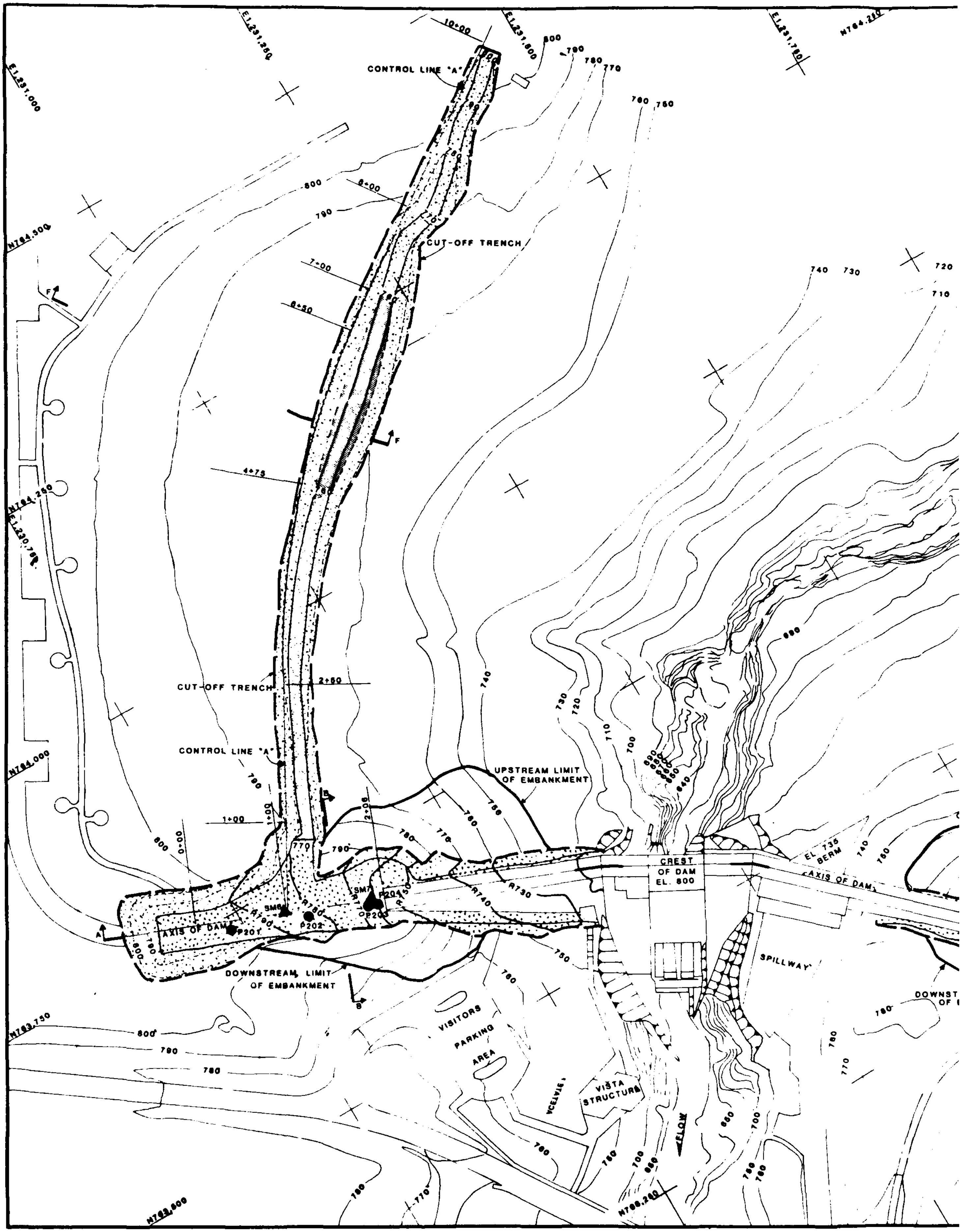
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

FOUNDATION REPORT

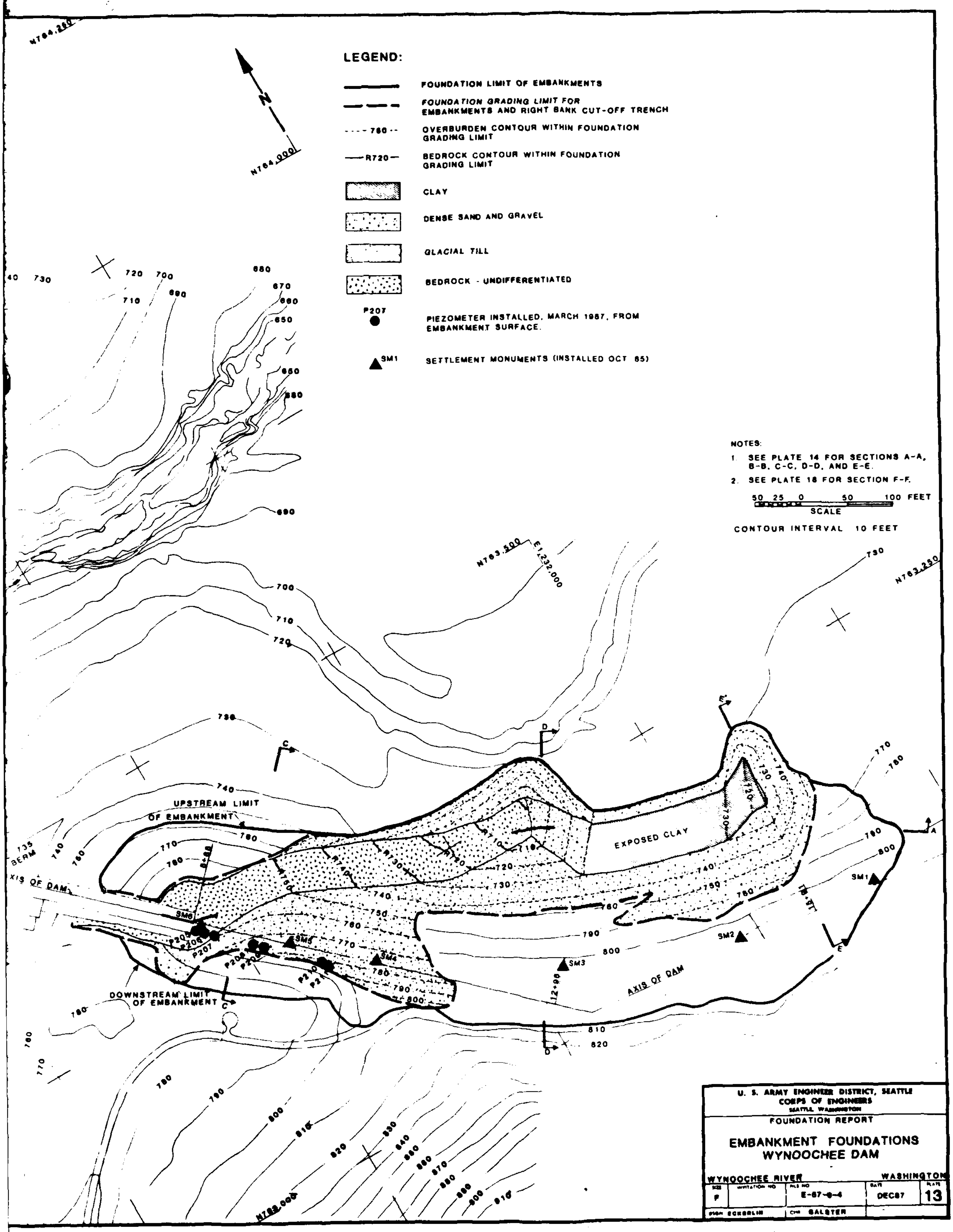
FOUNDATION EXCAVATION-MONOLITH 7
WYNOOCHEE DAM

WYNOOCHEE RIVER WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE	PLATE
D		E-67-6-4	DEC67	12
DSGN. ECKERLIN		CHK. GALSTER		



E1,231,000
E1,231,250
E1,231,500
E1,231,750
N764,250
N764,500
N764,250
E1,230,750
N764,000
N763,750
N763,500
N763,250
10+00
8+00
7+00
6+50
4+75
2+50
1+00
0+00
2+08
CONTROL LINE "A"
CUT-OFF TRENCH
CUT-OFF TRENCH
CONTROL LINE "A"
F
F
A
B
B
UPSTREAM LIMIT OF EMBANKMENT
DOWNSTREAM LIMIT OF EMBANKMENT
AXIS OF DAM
SM6
SM7
P201
P202
P203
P204
R790
R780
R770
R750
R740
R730
CREST OF DAM EL. 800
EL 735 BERM
AXIS OF DAM
SPILLWAY
DOWNST OF
VISITORS PARKING AREA
VISTA STRUCTURE
STAIRS
FLOW
800
790
780
770
760
750
740
730
720
710
700
690
680
670
660
650
640



LEGEND:

▬▬▬	FOUNDATION LIMIT OF EMBANKMENTS
▬ ▬ ▬	*FOUNDATION GRADING LIMIT FOR EMBANKMENTS AND RIGHT BANK CUT-OFF TRENCH*
- - - 750 - -	OVERBURDEN CONTOUR WITHIN FOUNDATION GRADING LIMIT
——R720——	BEDROCK CONTOUR WITHIN FOUNDATION GRADING LIMIT
▨	CLAY
⁘	DENSE SAND AND GRAVEL
☐	*GLACIAL TILL*
⁙	BEDROCK - UNDIFFERENTIATED
P207 ●	PIEZOMETER INSTALLED, MARCH 1987, FROM EMBANKMENT SURFACE.
▲SM1	SETTLEMENT MONUMENTS (INSTALLED OCT 85)

NOTES:

1. SEE PLATE 14 FOR SECTIONS A-A, B-B, C-C, D-D, AND E-E.
2. SEE PLATE 18 FOR SECTION F-F.

50 25 0 50 100 FEET
SCALE

CONTOUR INTERVAL 10 FEET

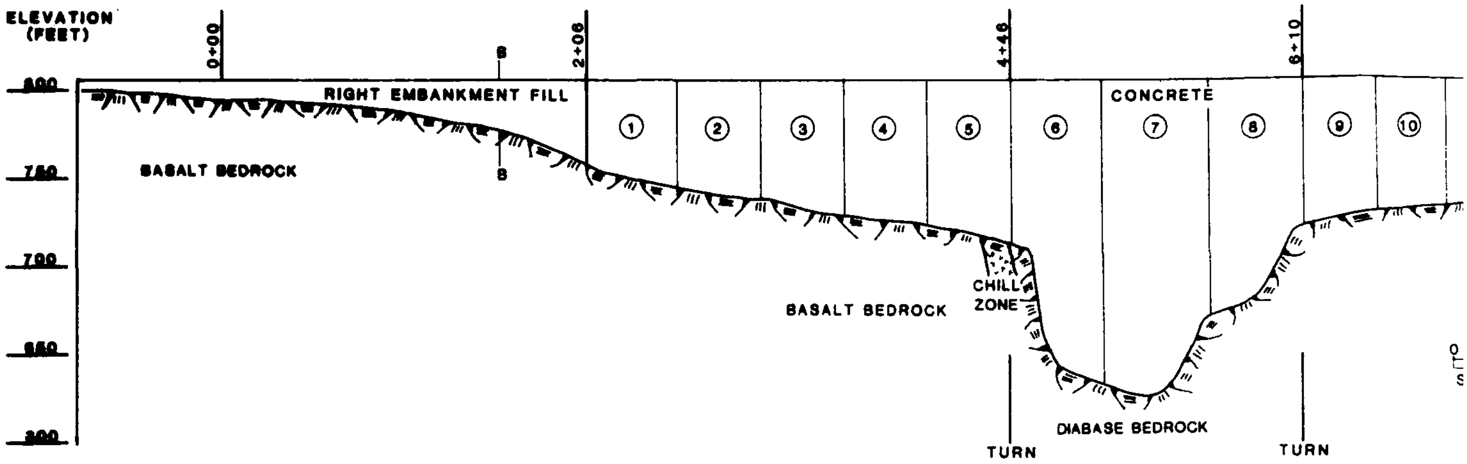
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

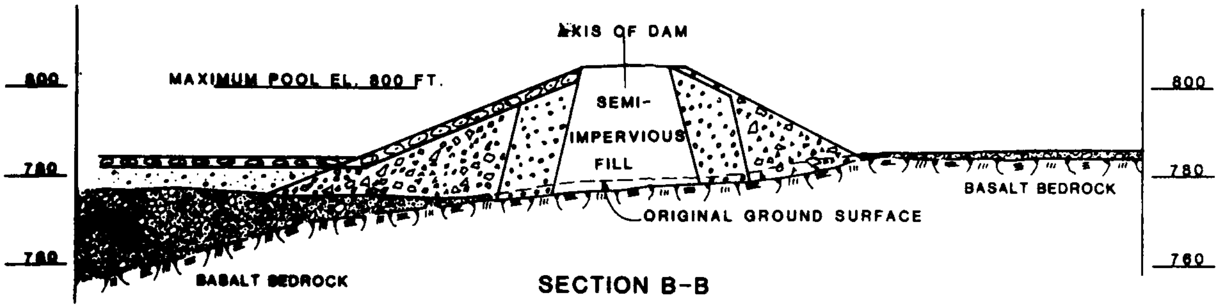
FOUNDATION REPORT

EMBANKMENT FOUNDATIONS
WYNOOCHEE DAM

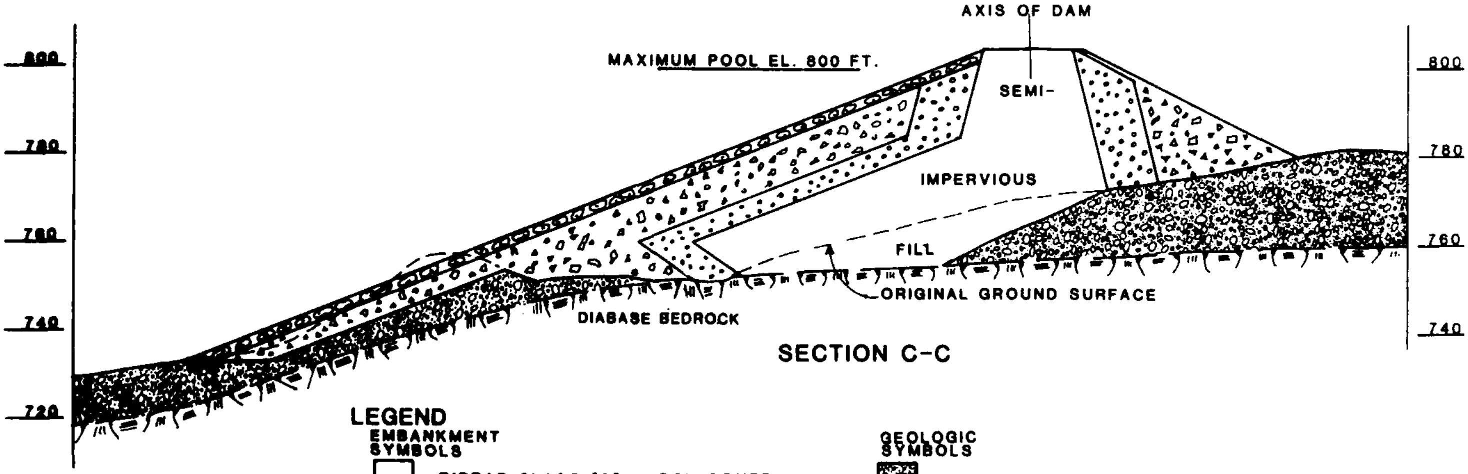
WYNOOCHEE RIVER WASHINGTON

SIZE	INVITATION NO	FILE NO	DATE	PLATE
F		E-67-6-4	DEC87	13
DSGN ECKERLIN		CHK GALSTER		





SECTION B-B



SECTION C-C

LEGEND

EMBANKMENT SYMBOLS

▨	RIPRAP CLASS "B" ROCK COVER
▨	ROCKFILL
▨	GRANULAR FILL
▨	GRAVEL FILTER
☐	SEMI-IMPERVIOUS FILL

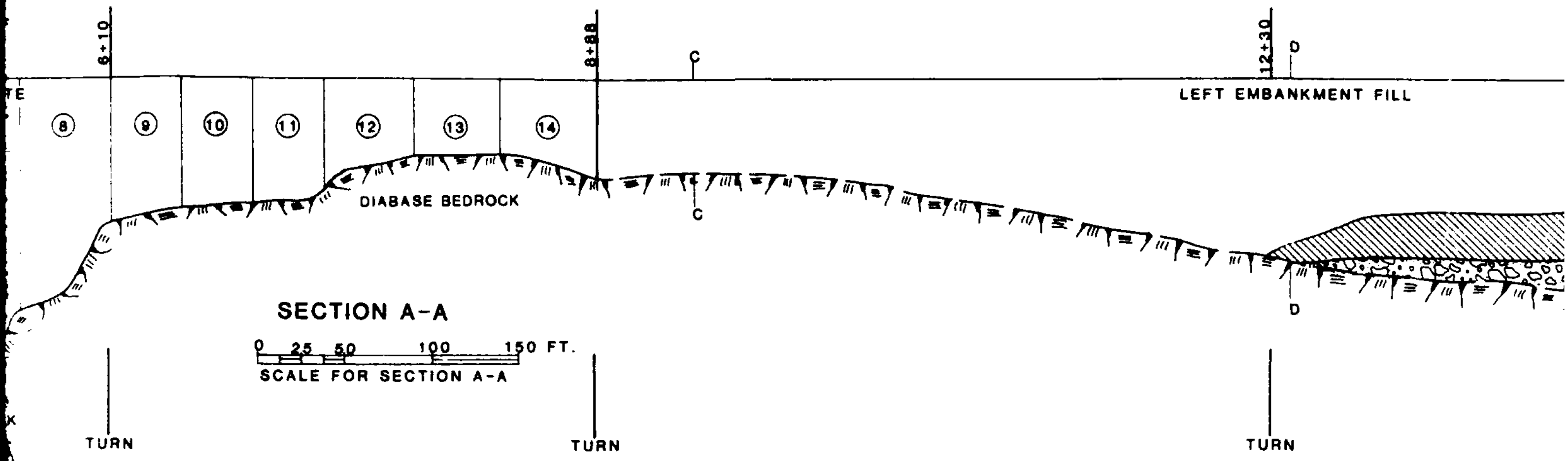
GEOLOGIC SYMBOLS

▨	UPPER GRAVEL UNIT
▨	CLAY
▨	LOWER GRAVEL UNIT
▨	BEDROCK

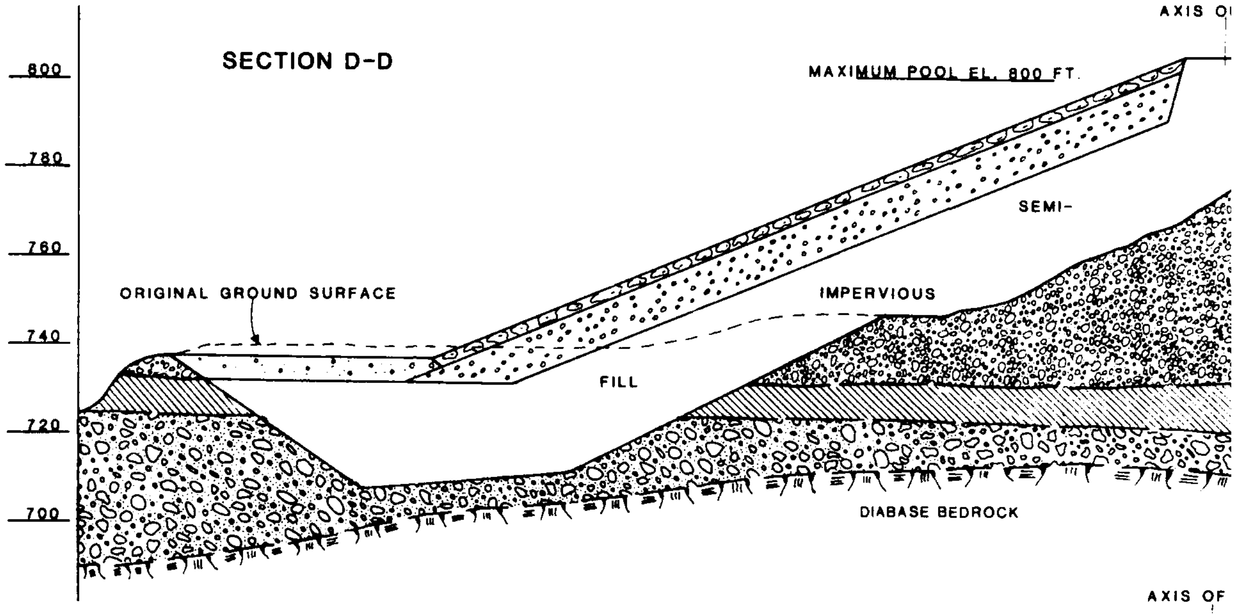
0 10 20

SCALE FOR SECTIONS

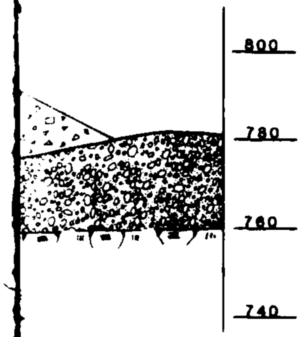
NOTE: SEE PLATE 13 FOR PLAN VIEW AND LOCATION OF SECTIONS.

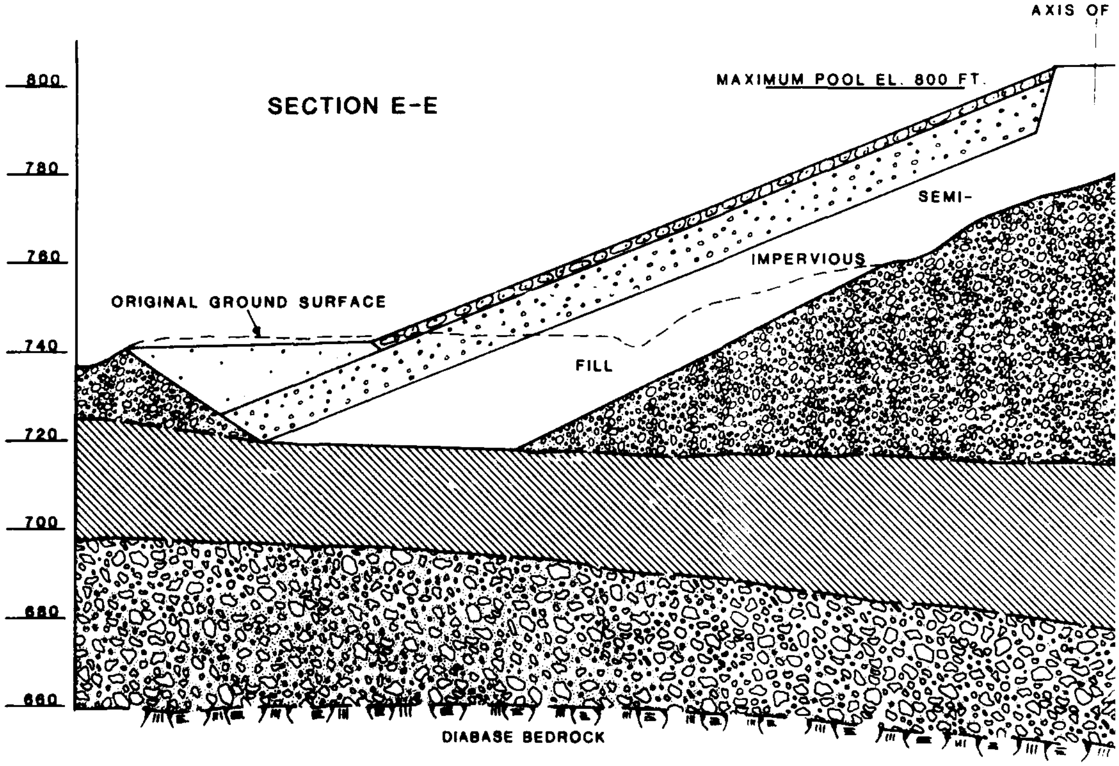


SECTION A-A



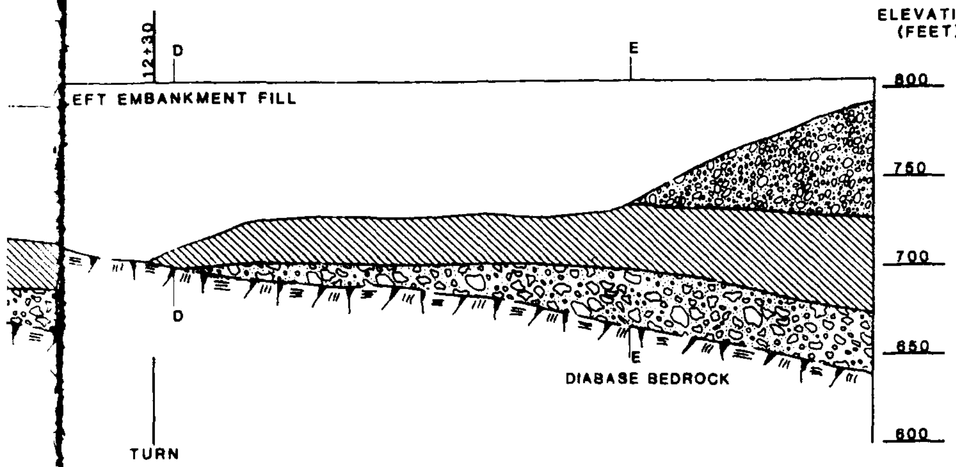
SECTION D-D

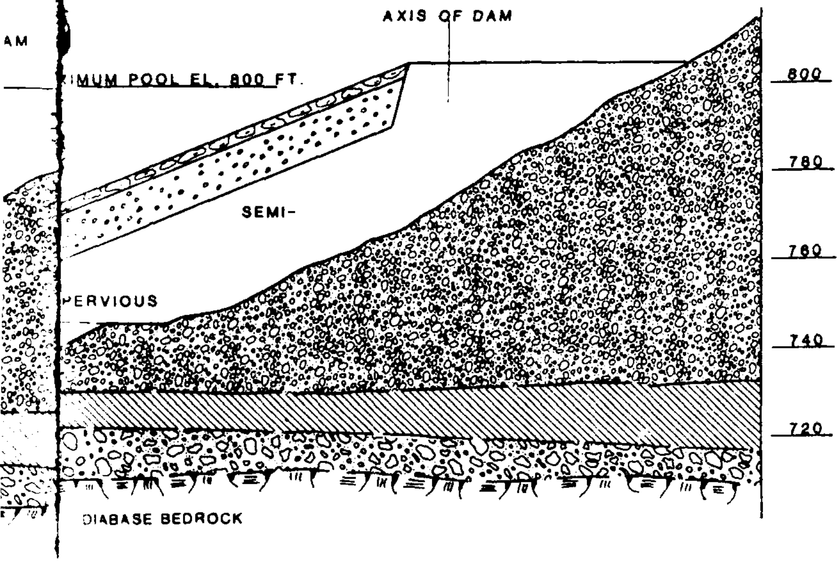


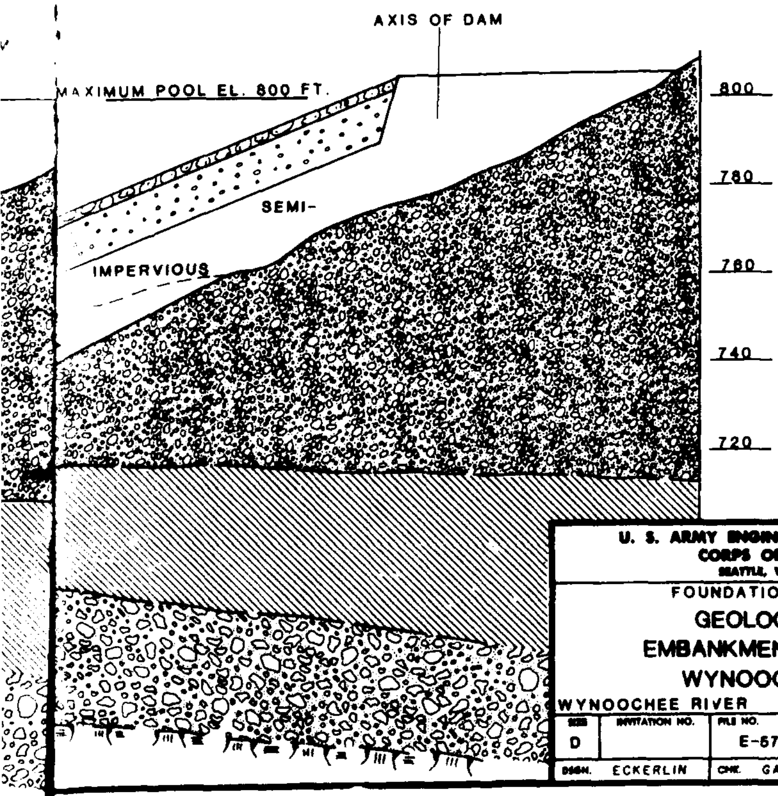


SECTION E-E

0 10 20 40 80 FT.
SCALE FOR SECTIONS B-B THROUGH E-E







U. S. ARMY ENGINEER DISTRICT, SEATTLE
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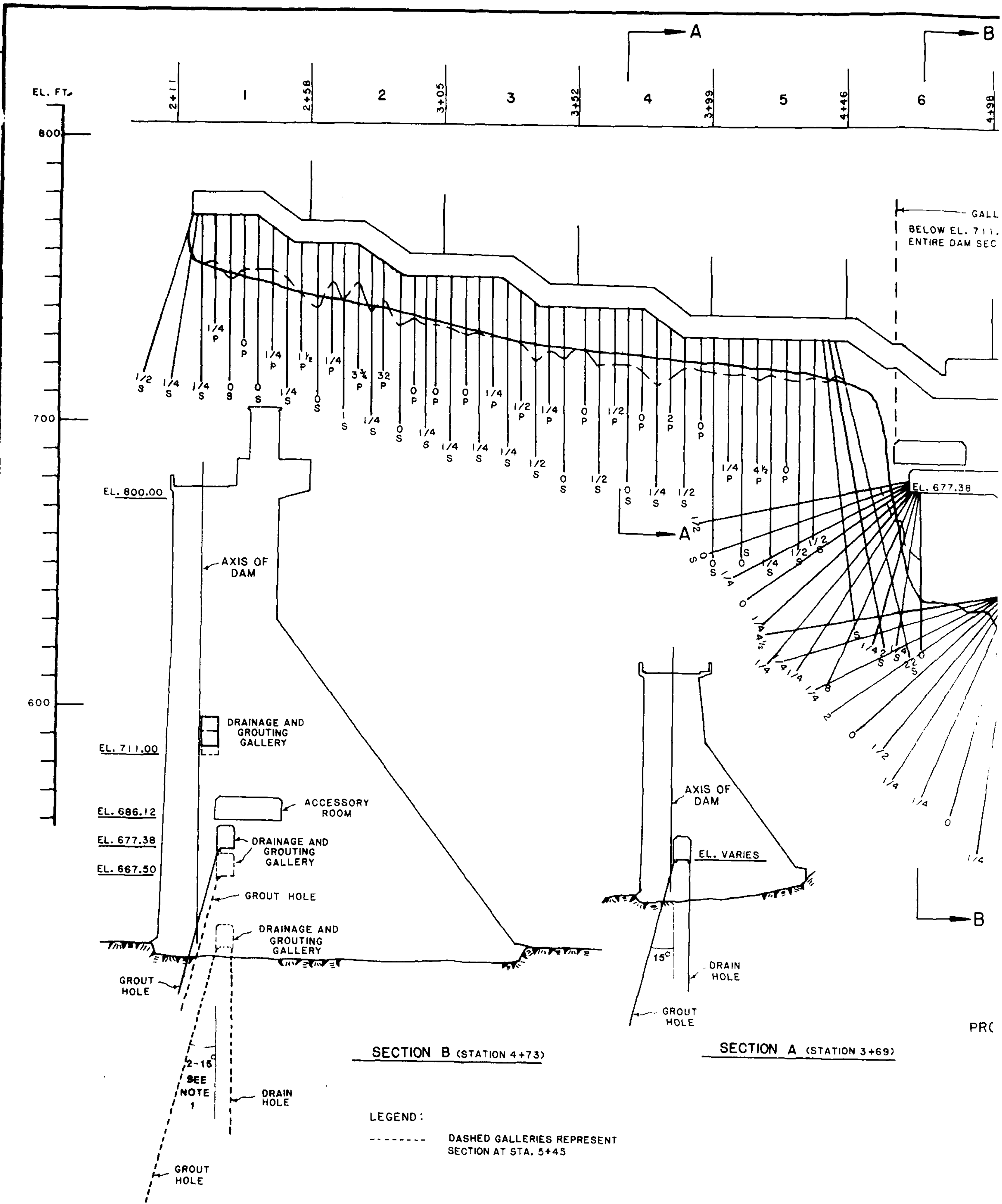
SEATTLE, WASHINGTON

FOUNDATION REPORT

GEOLOGIC AND EMBANKMENT SECTIONS WYNOOCHEE DAM

WYNOOCHEE RIVER WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D		E-57-6-4	DEC87	14
DSGN. ECKERLIN		CHK. GALSTER	SHEET	

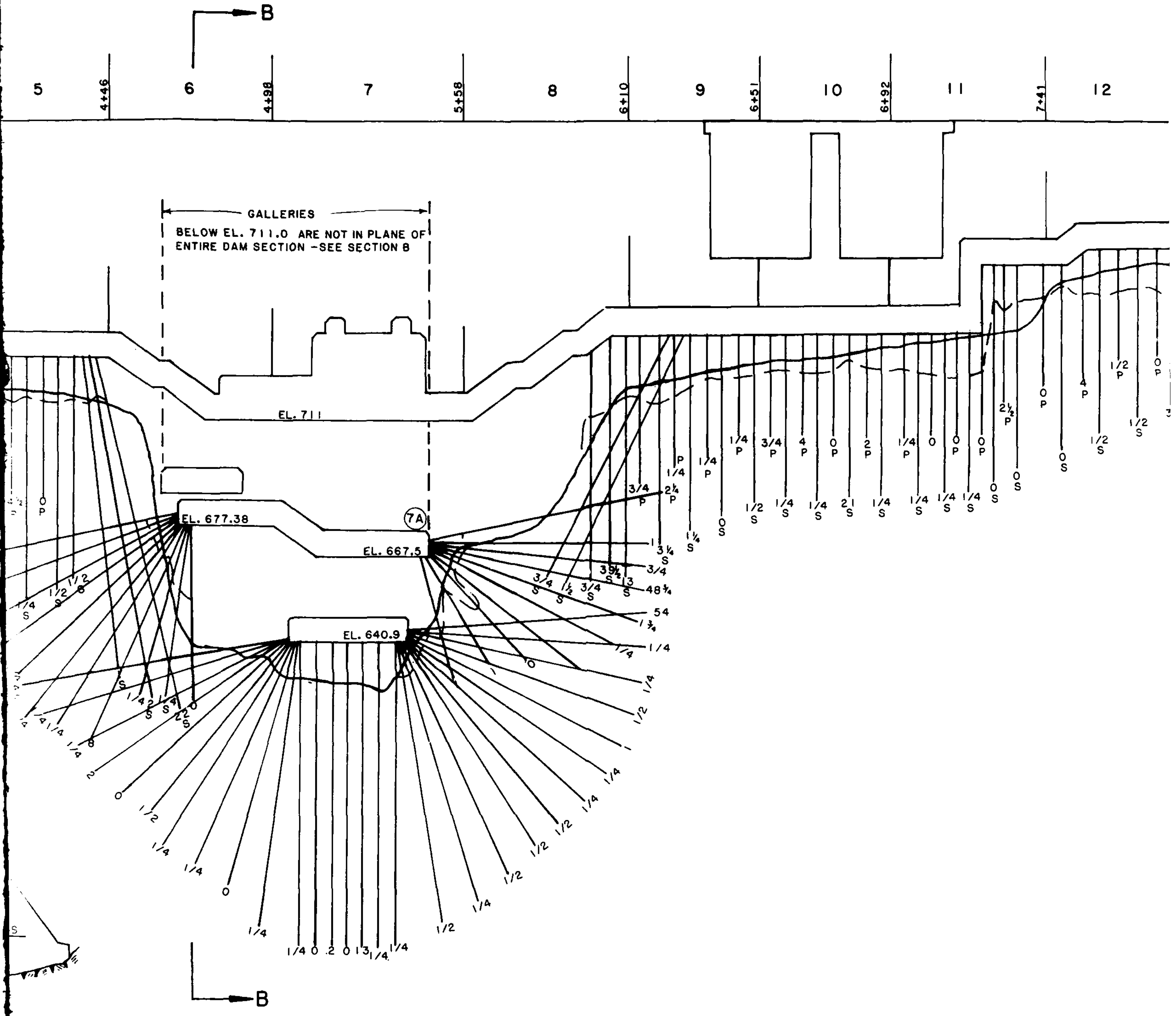


SECTION B (STATION 4+73)

SECTION A (STATION 3+69)

LEGEND:

-------- DASHED GALLERIES REPRESENT SECTION AT STA. 5+45



PROFILE VIEW UPSTREAM

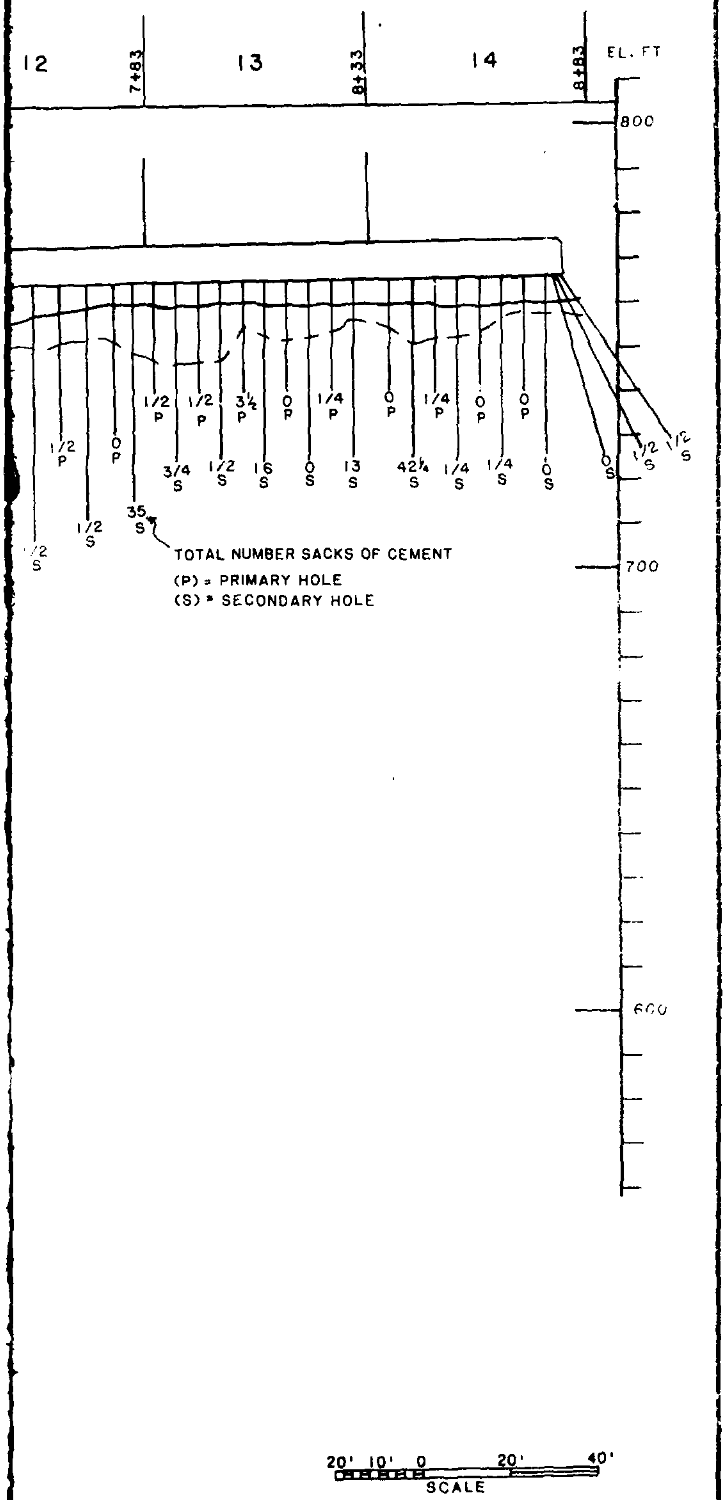
ION A (STATION 3+69)

LEGEND:

————	ROCKLINE DETERMINED BY FOUNDATION MAPPING
– – – – –	ROCKLINE DETERMINED BY GROUT HOLE DRILLING

NOTES:

1. GROUT HOLES ARE INCLINED 15 DEGREES UPSTREAM FROM EXCEPT IN MONOLITH 5 BETWEEN STATIONS 4+28 AND 4+4 HOLES ARE INCLINED 2 DEGREES. WITHIN MONOLITHS 6 AND UPSTREAM BATTER OF GROUT HOLES WAS GRADUALLY VARI BETWEEN 2 AND 15 DEGREES TO FORM A CONTINOUS WARPE GROUT CURTAIN.
2. REFER TO PLATE 8 FOR PLAN.



STREAM FROM VERTICAL
4+28 AND 4+46, THE
NOLITHS 6 AND 7 THE
RADUALLY VARIED
TINOUS WARPED

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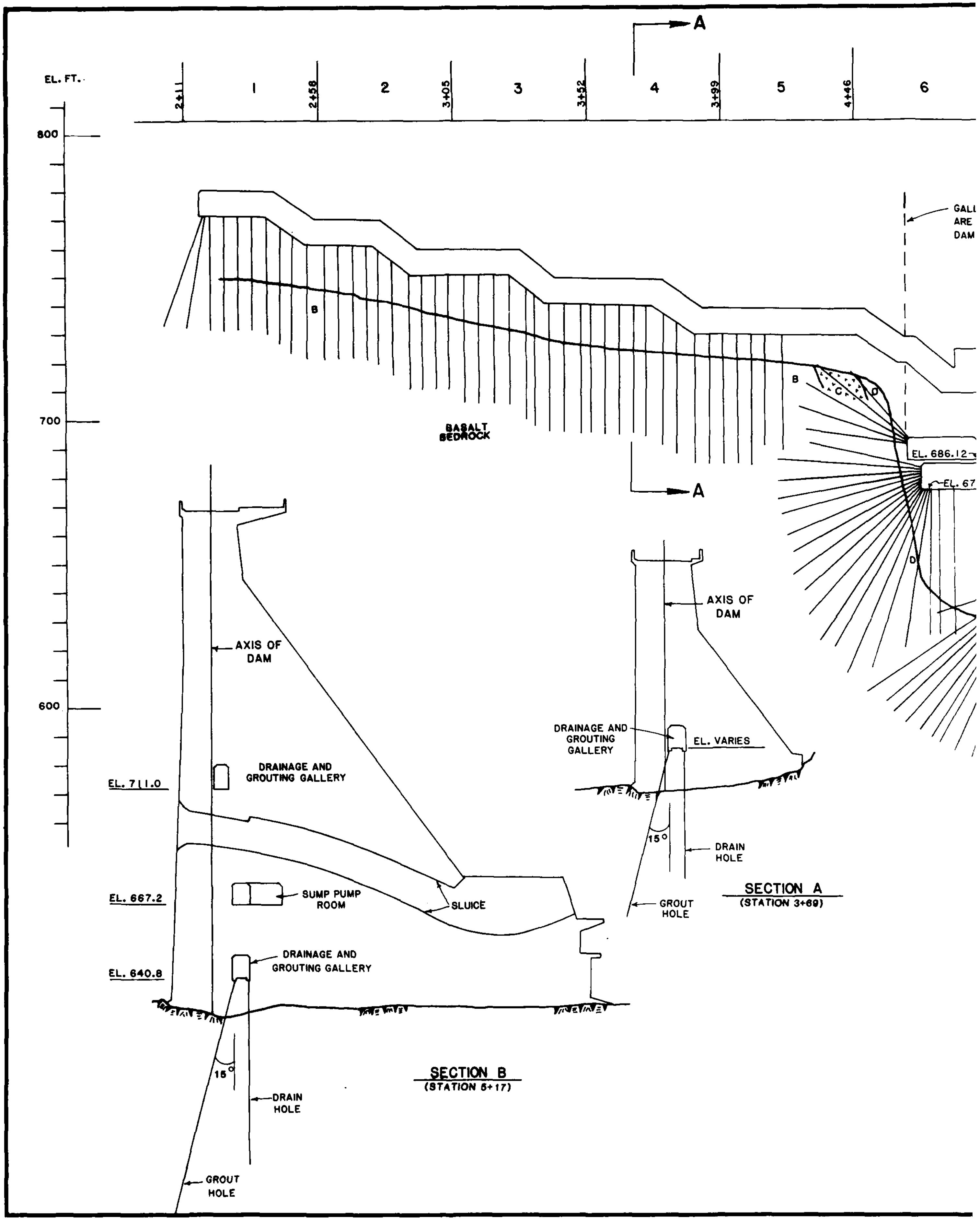
FOUNDATION REPORT

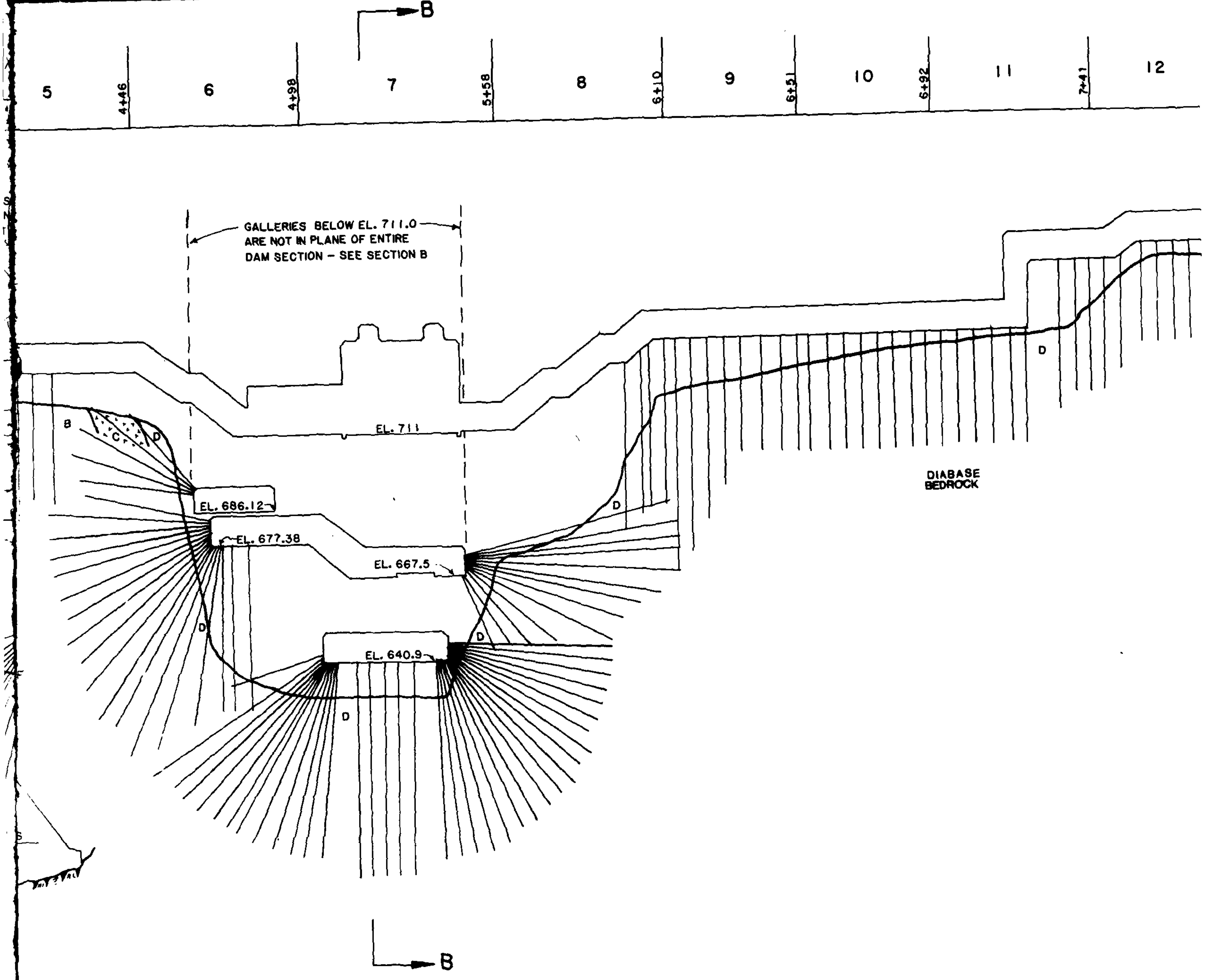
DRAINAGE AND GROUTING GALLERIES
GROUT HOLES
WYNOOCHEE DAM

WYNOOCHEE RIVER WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D		E-57-6-4	DEC87	15
DSGN. ECKERLIN		CHK. GALSTER	SHEET	


A
EL. FT.
2+11
1
2+58
2
3+05
3
3+52
4
3+99
5
4+46
6
800
700
600
GALL
ARE
DAM
B
B
C
D
D
BASALT BEDROCK
EL. 686.12
EL. 67
A
AXIS OF DAM
DRAINAGE AND GROUTING GALLERY
EL. 711.0
EL. 667.2
SUMP PUMP ROOM
SLUICE
EL. 640.8
DRAINAGE AND GROUTING GALLERY
15°
DRAIN HOLE
GROUT HOLE
SECTION B
(STATION 5+17)
AXIS OF DAM
DRAINAGE AND GROUTING GALLERY
EL. VARIES
15°
DRAIN HOLE
GROUT HOLE
SECTION A
(STATION 3+69)

2.


GALLERIES BELOW EL. 711.0 ARE NOT IN PLANE OF ENTIRE DAM SECTION – SEE SECTION B

SECTION A
STATION 3+69)

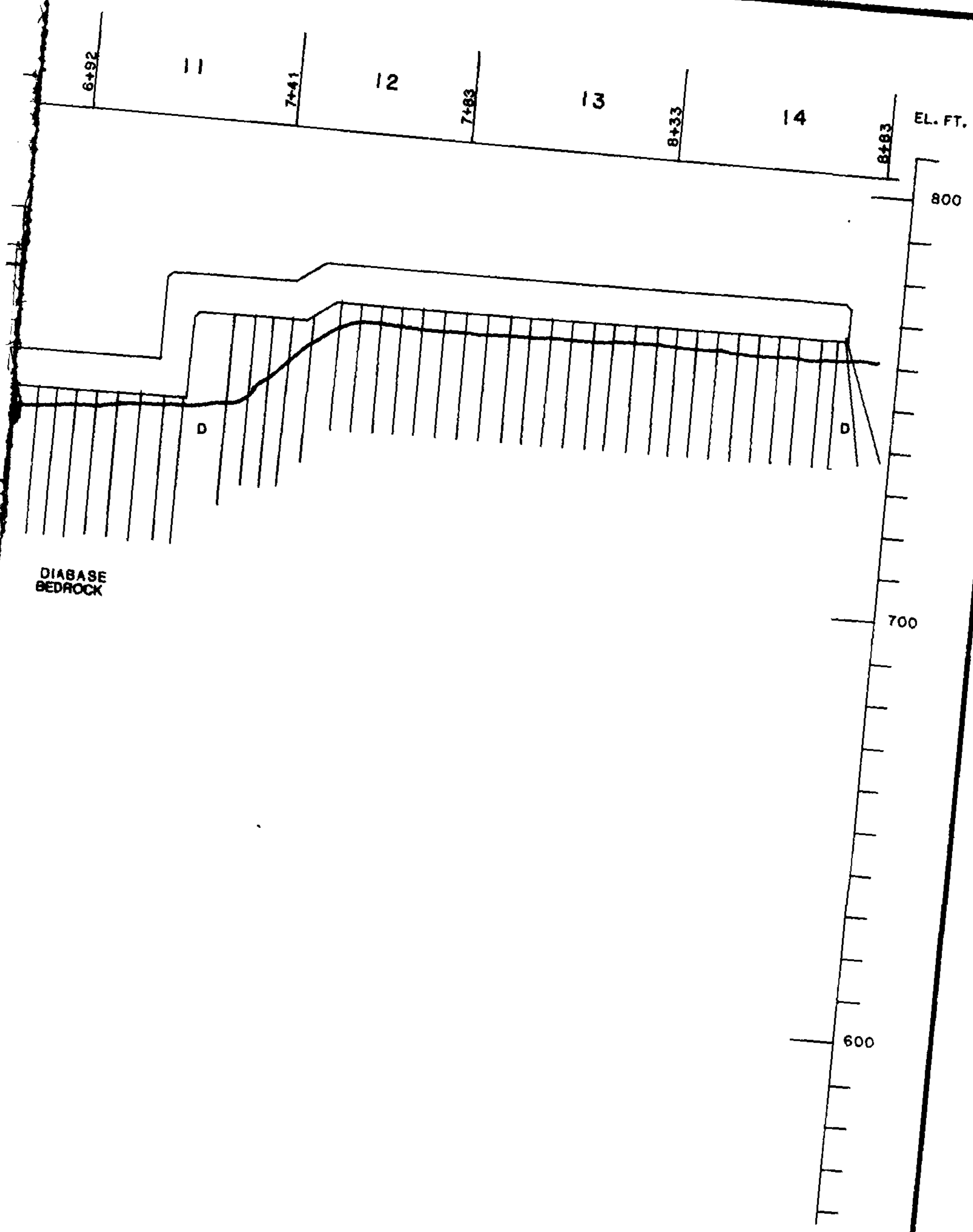
PROFILE VIEW UPSTREAM

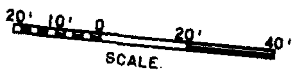
LEGEND:

————	ROCKLINE DETERMINED BY FOUNDATION MAPPING
BEDROCK B	BASALT
C	CHILL ZONE
D	DIABASE

NOTES:
1. NO ROCKLINE WAS DETERMINED BY DRAIN HOLE DRILLING.
2. REFER TO PLATE 8 FOR PLAN.

3





LEGEND:

——— ROCKLINE DETERMINED BY FOUNDATION MAPPING

BEDROCK
B BASALT
C CHILL ZONE
D DIABASE

NOTES:

1. NO ROCKLINE WAS DETERMINED BY DRAIN HOLE DRILLING.
2. REFER TO PLATE 8 FOR PLAN.

U. S. ARMY ENGINEER DISTRICT, SEATTLE
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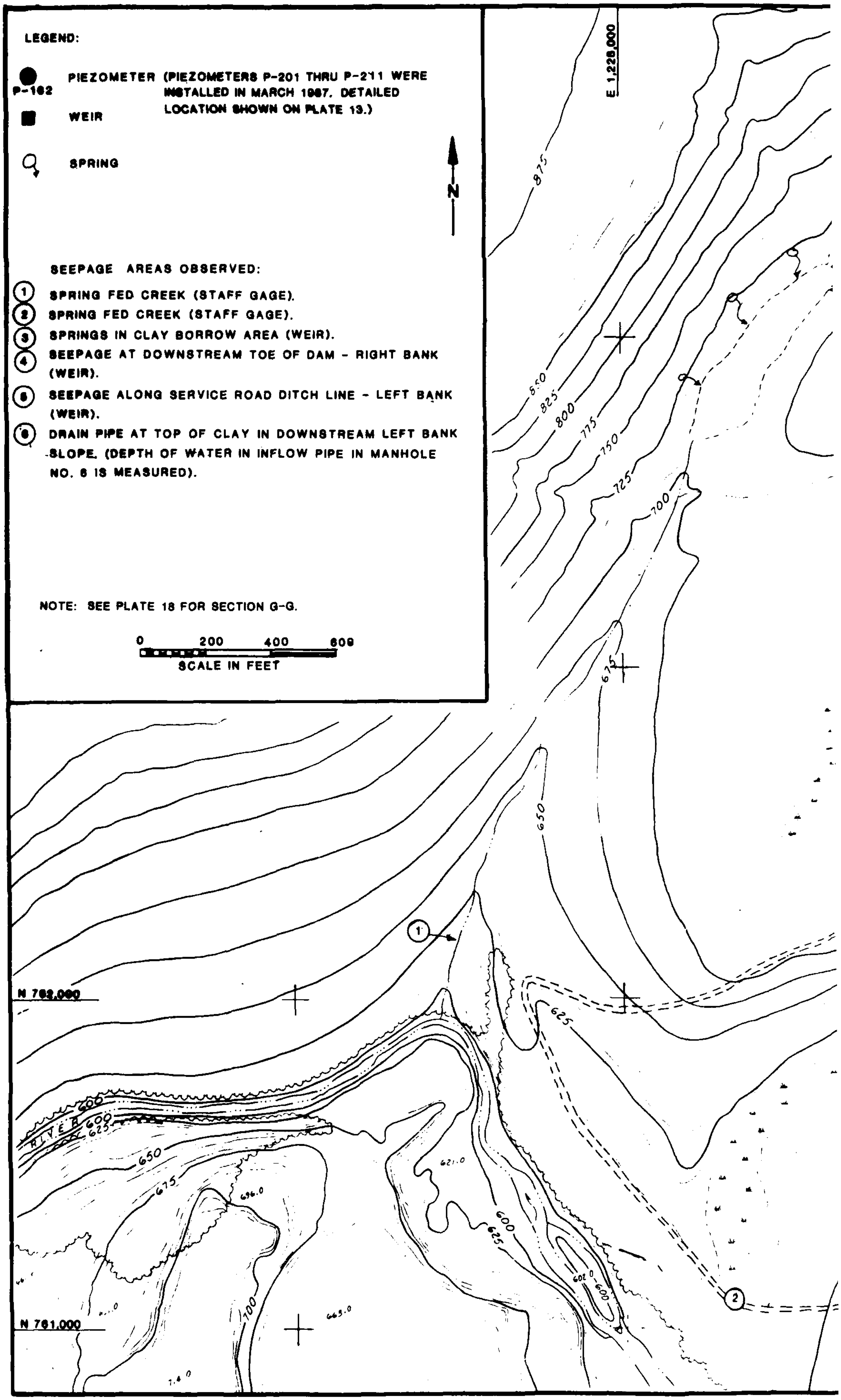
FOUNDATION REPORT
DRAINAGE AND GROUTING GALLERIES
DRAIN HOLES
WYNOOCHEE DAM

WYNOOCHEE RIVER WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE	PLATE
D		E-57-6-4	DEC87	16
DSGN. ECKERLIN		CHK. GALSTER	SHEET	


LEGEND:

● P-162 PIEZOMETER (PIEZOMETERS P-201 THRU P-211 WERE INSTALLED IN MARCH 1987. DETAILED LOCATION SHOWN ON PLATE 13.)

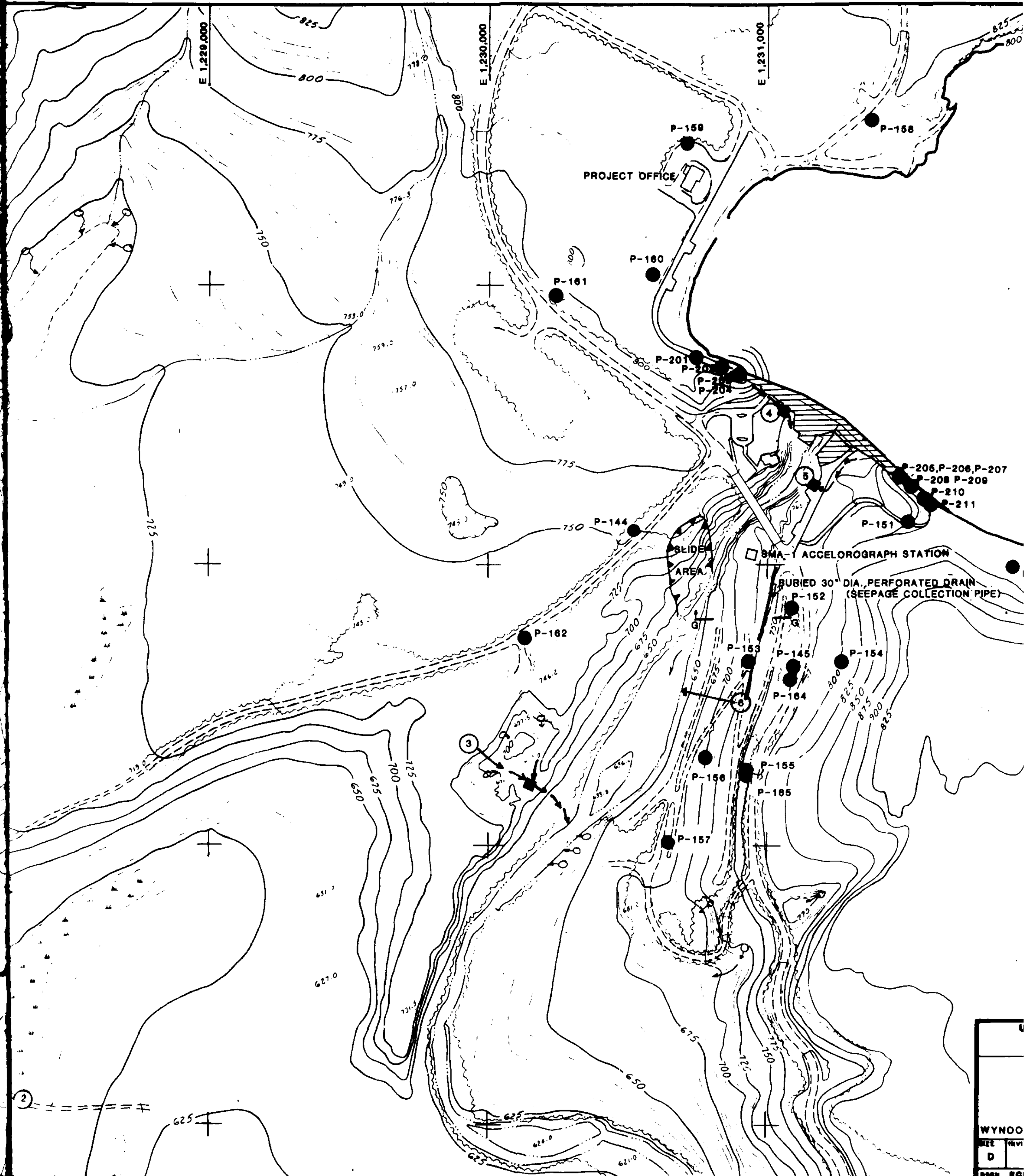
■ WEIR

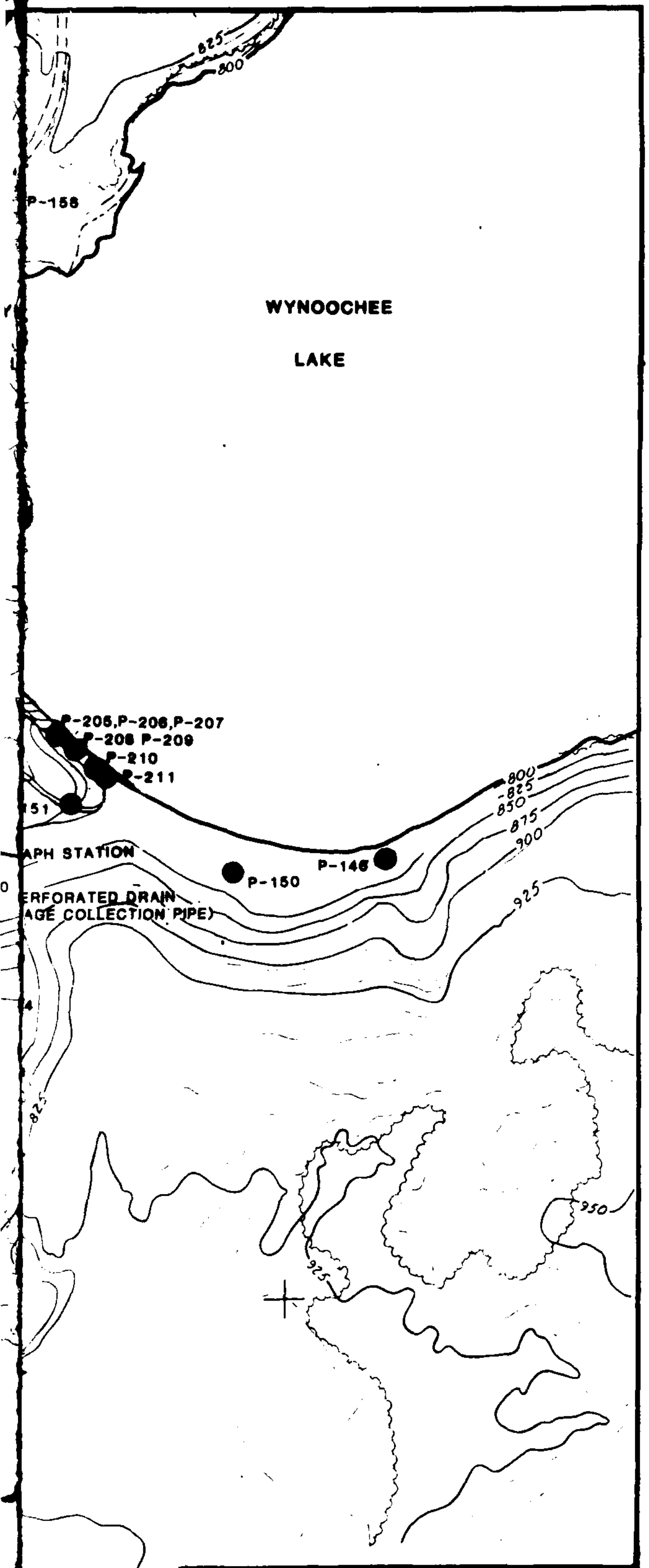
SPRING

SEEPAGE AREAS OBSERVED:

① SPRING FED CREEK (STAFF GAGE).
② SPRING FED CREEK (STAFF GAGE).
③ SPRINGS IN CLAY BORROW AREA (WEIR).
④ SEEPAGE AT DOWNSTREAM TOE OF DAM – RIGHT BANK (WEIR).
⑤ SEEPAGE ALONG SERVICE ROAD DITCH LINE – LEFT BANK (WEIR).
⑥ DRAIN PIPE AT TOP OF CLAY IN DOWNSTREAM LEFT BANK SLOPE. (DEPTH OF WATER IN INFLOW PIPE IN MANHOLE NO. 6 IS MEASURED).

NOTE: SEE PLATE 18 FOR SECTION G-G.


E 1,229,000
E 1,230,000
E 1,231,000
825
800
775
750
725
700
675
650
625
900
875
850
778.0
776.5
753.0
759.0
757.0
749.0
745.0
746.2
731.5
719.0
631.7
627.0
626.0
621.0
P-158
P-159
PROJECT OFFICE
P-160
P-161
P-201
P-202
P-203
P-204
P-205,P-206,P-207
P-208 P-209
P-210
P-211
P-151
P-144
SLIDE AREA
SMA-1 ACCELOROGRAPH STATION
BURIED 30" DIA., PERFORATED DRAIN (SEEPAGE COLLECTION PIPE)
P-152
G
G
P-162
P-153
P-145
P-154
P-164
P-156
P-155
P-165
P-157
②
③
④
⑤
⑥
WYNOO
D



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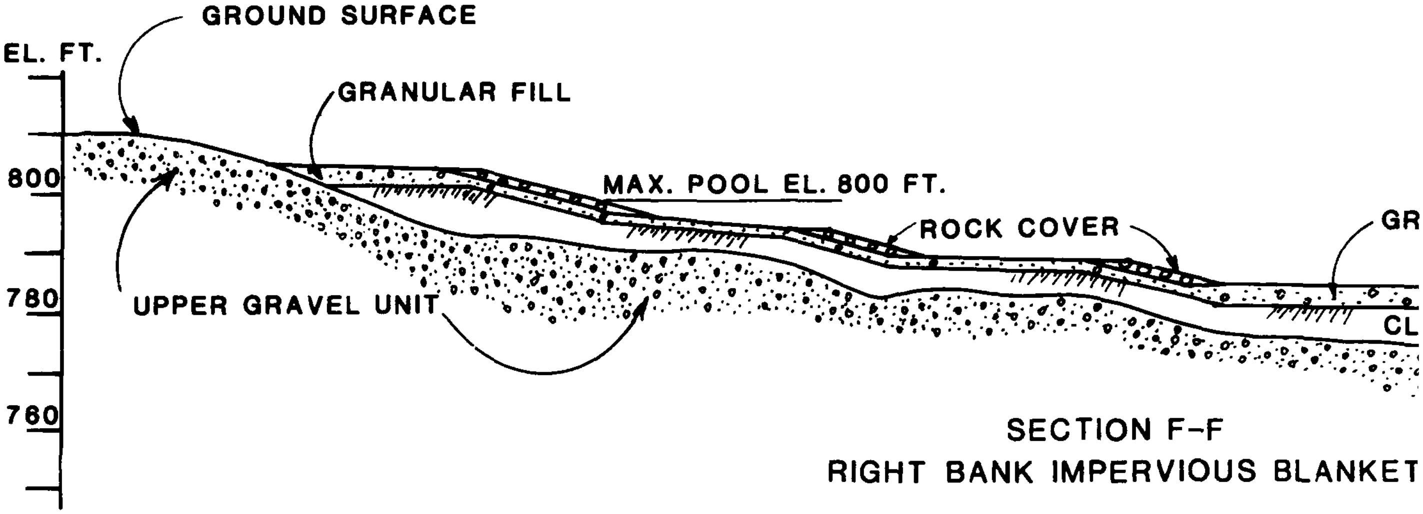
FOUNDATION REPORT

SEEPAGE OBSERVATION

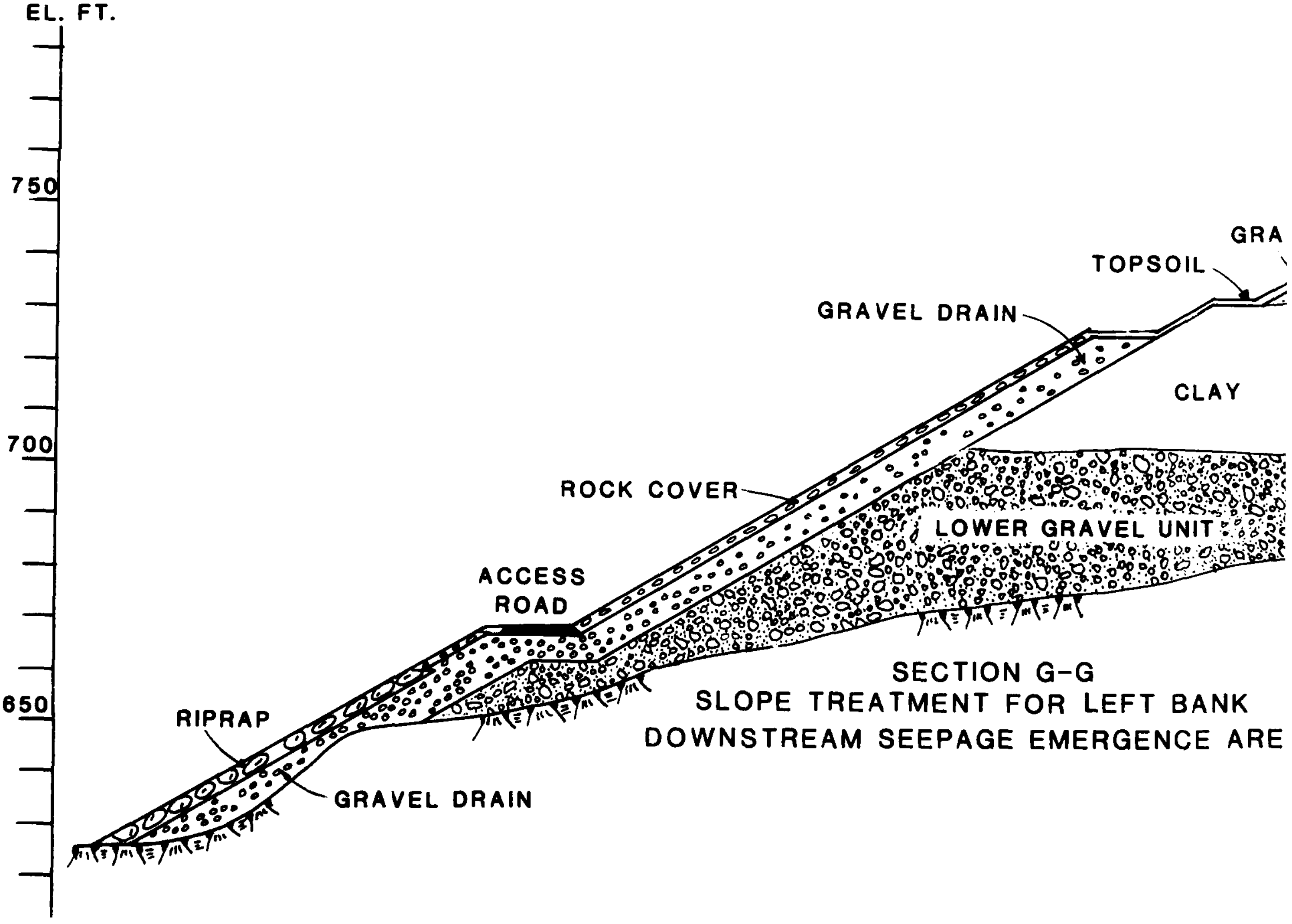
WYNOOCHEE DAM

WYNOOCHEE RIVER WASHINGTON

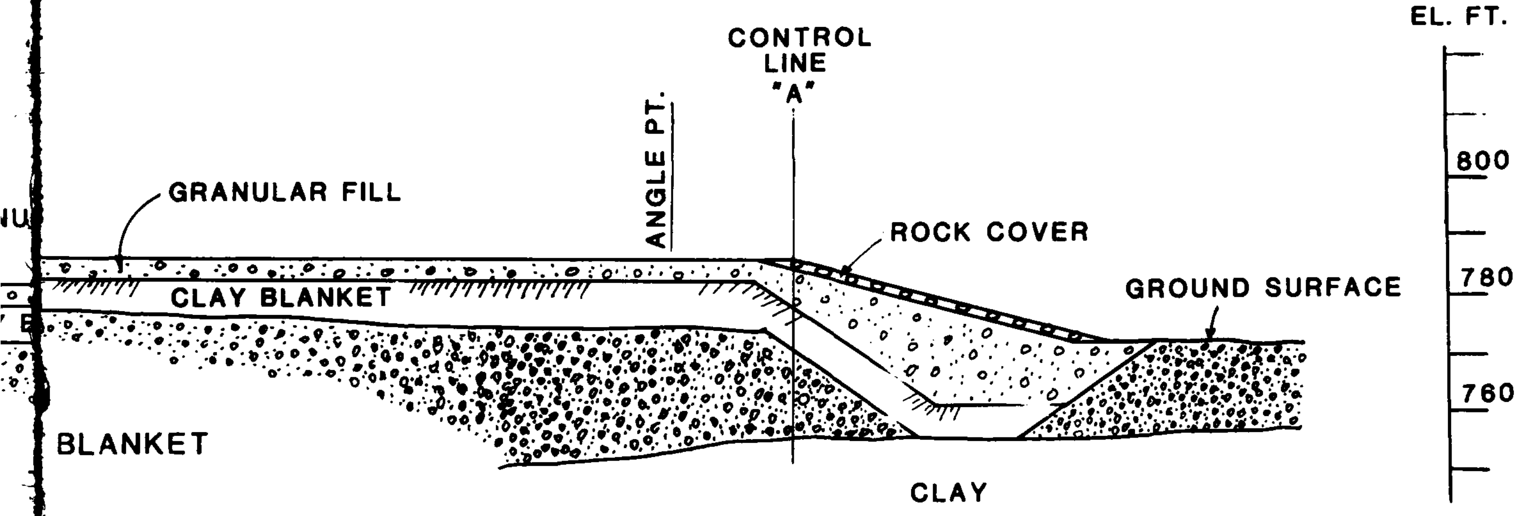
SIZE	INVITATION NO.	FILE NO.	DATE	[illegible]
D		E-67-6-4	DEC67	17
DWN EGGERLIN		CHK [illegible]	SHEET	

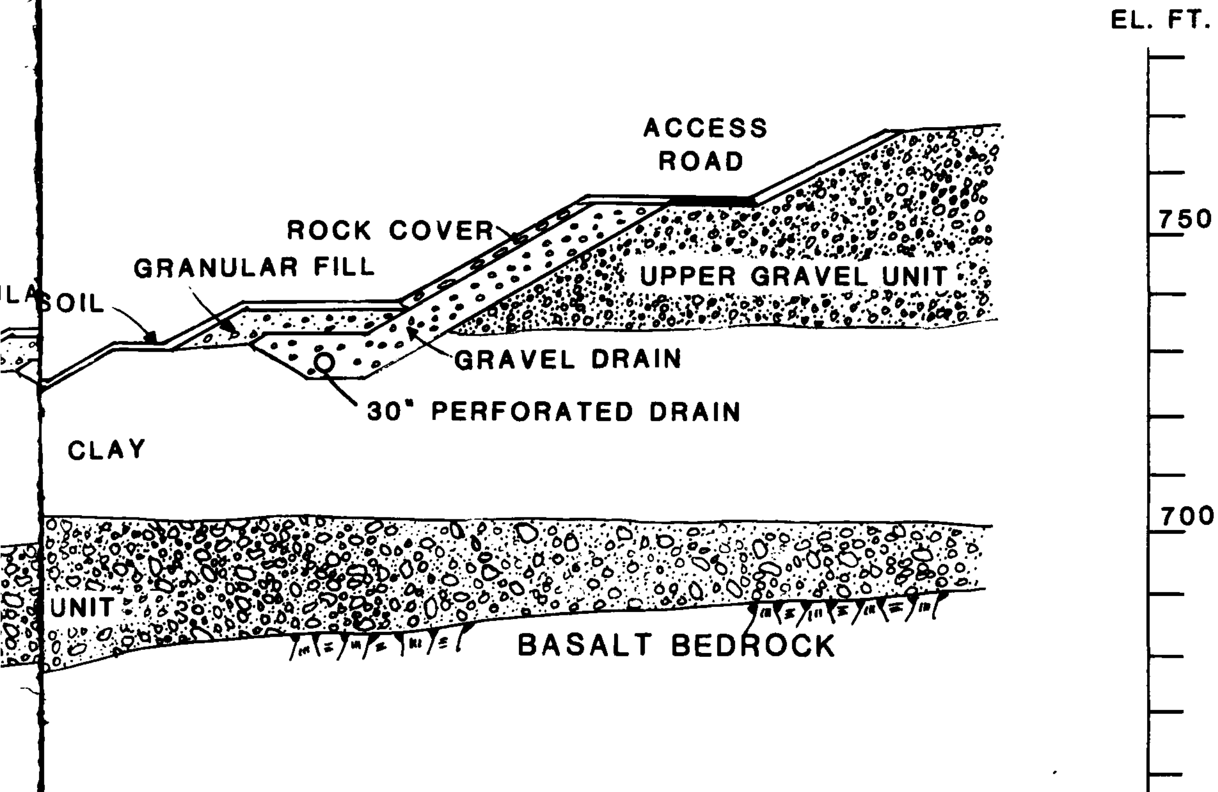


SECTION F-F
RIGHT BANK IMPERVIOUS BLANKET



SECTION G-G
SLOPE TREATMENT FOR LEFT BANK
DOWNSTREAM SEEPAGE EMERGENCE ARE





BANK
NCE AREA

NOTES:

1. FOR LOCATION OF SECTION F-F SEE PLATE 13.
2. FOR LOCATION OF SECTION G-G SEE PLATE 17.

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

FOUNDATION REPORT

GEOLOGIC AND
BLANKET SECTIONS

WYNOOCHEE DAM
WYNOOCHEE R. WASHINGTON

B E57-6-4 APR 88 18

ECKERLIN GEMBALA

APPENDIX C

LABORATORY ANALYSES

EARTHWORK LABORATORY TESTING

Selected drill boring and backhoe samples, shown on table C-1, were tested in the laboratory. Laboratory testing supplemented design analyses of the earthfill and rockfill embankments adjacent to the concrete sections of the dam, the right abutment upstream blanket, and the left abutment downstream slope treatment.

Shear Strengths. Standard unconsolidated undrained Q tests and consolidated undrained R tests were made on undisturbed samples of clay. Consolidated drained S tests on clay were not conducted; however, equivalent strength envelopes were obtained by utilizing pore-pressure measurements in the R tests. The results of consolidated undrained tests, corrected for pore-pressures, are referred to hereinafter as $\bar{R}$ strengths. Six R tests on clay (68-R2, 78AL & AP, and 94A, B, and C) showed ultimate strengths substantially lower than peak strengths. These relatively low ultimate strengths were given maximum consideration in the selection of shear strength parameters for design, and were assumed to be representative of the strength of the clay considering the presence of joints and fissures observed in the abutment clays. Six standard consolidated drained S tests and three R tests were made on samples of typical gravels from above the clay, remolded at the apparent natural density observed in field density tests. Because of the free-draining characteristics and the apparent high strength of the upper gravels exhibited by exposed slopes in the vicinity of the damsite, the R tests on the upper gravels were disregarded. A shear strength of Ø = 37.5°, C = 0 was assigned to the upper gravels for the S condition. A conservative value of Ø = 30°, C = 0 was assigned to the abutment materials below the clay layer. A shear strength of Ø = 35°, C = 0 was assigned to all granular embankment materials. Shear strength parameters for the foundation and embankment design are summarized as follows:

Material	Test Condition	Cohesion 2/ lbs/ft	Ø	Tan Ø
Undisturbed clay layer	Q	2,000	13°	0.231
	R	600	20°	0.364
	$\bar{R}$	0	27°	0.510
Undisturbed gravels and sands above the clay layer	S	0	37.5°	0.767
Undisturbed gravels, sands, and silts below the clay layer and slopewash gravels		0	30°	0.577
All granular embankment materials		0	35°	0.700

Three Q tests and four R and $\tilde{R}$ tests were also made on samples of clay completely remolded at natural water content to examine the possible effects of disturbance from existing slides in the natural abutments and to determine the sensitivity of the clay. The Q strength of the remolded clay is Ø = 9°, C = 800 p.s.f. and the sensitivity is relatively low. Shear strength summaries are shown on figures C-1 through C-6. See Wynoochee Reservoir Dam - Basis of Design, Design Memorandum 10, May 1967 for the detailed laboratory analyses.

TABLE C-1

MOISTURE CONTENT AND ATTERBERG LIMIT TEST RESULTS
PRECONSTRUCTION EXPLORATION

Sample	Depth	Unified Soils Symbol	Moisture Content Percent	Atterberg Limit, Percent Liquid	Atterberg Limit, Percent Plasticity Index	Dry Weight lb/cu.ft	Triaxial Test 1/
Boring 65-DD-40							
A	5	GM	13.9	*	*	*	
B	37	CL	41.2	44	19	*	
C	45	CL	16.4	45	20	116	
D	50	CL	33.4	45	20	*	
Boring 65-BA-54							
A	5	GW	*	32	5	*	
B	10	GW-GC	*	41	17	*	
C	20	GW-GC	*	32	12	*	
D	25	GW-GC	*	34	13	*	
E	37	GP-GM	12.2	*	*	*	
Trench 65-BH-55							
A	2-4	GM	*	*	*	*	
B	4-6	GM	*	*	*	*	
C	6-10	GM	*	*	*	*	
Trench 65-BH-56							
A	2-4	GM	*	*	*	*	
B	4-7	GM	*	*	*	*	
D	9-12	GP	*	*	*	*	
Boring 65-BA-62							
A	5-6	GP-GM	*	*	*	*	
C	14	GP	7.2	*	*	125	
D	30	GP-GC	5.5	46	20	133	Yes
Boring 65-BA-63							
B	6	GP-FM	9.4	27	6	140	Yes
D	14	GW-GM	6.3	32	8	126	Yes
E	27	GW-GM	*	*	*	*	
F,G	38	SM	26.2	*	*	79	
H	43	ML-CL	*	24	5	*	

*Test not requested.
1/Triaxial test data shown on figures C-1 through C-6.

TABLE C-1 (con.)

Sample	Depth	Unified Soils Symbol	Moisture Content Percent	Atterberg Limit, Percent		Dry Weight lb/cu.ft	Triaxial Test 1/
				Liquid	Plasticity Index		
Boring 65-BA-64							
A	8.5	GP	14.2	*	*	111	
C,D	15	GW	11.5	62	24	124	
F	28	GW-GC	8	40	15	128	
G	36	CL	24	34	10	*	
H	38	CL	26.9	38	15	*	
I	43	CL	33.2	40	16	*	
J	50	CH	39.2	54	25	*	
Boring 65-BA-DD-68							
B	9	GW-GM	6.1	32	5	135	
D	18	GP-GM	4.7	*	*	*	
F	30	GW-GM	6.3	48	15	127	
H	45	GP-GM	7.1	*	*	124	
I	61	GP	*	*	*	*	
	73	CL	23.4	30	9	107	
E	77	CL	24.7	37	14	104	Yes
	79	CL	27.7	40	20	99	
	83	CL	34	42	17	90	
K	83	CL	34	40	19	90	Yes
	86	CL	29.2	35	15	99	
R	91	CL	32.7	48	21	91	Yes
	96	CL	33.7	49	21	92	
Boring 65-DD-69							
B	35	CL	23.3	33	11	102.7	Yes
D	37	CL	27.6	35	13	94.2	Yes
F	39	CL	16.7	34	11	110.5	Yes
H	41	CL	25.8	29	8	103	Yes
J	44	CL	25.7	32	11	101.2	Yes
L	46	CL	25.8	33	10	101	Yes
O	49	CL	25.8	32	10	101.5	Yes
Boring 65-BA-70							
A	3	SP	*	*	*	*	
	25	CL	*	50	21	*	
	35	CL	*	53	25	*	
	43	CL	*	32	11	*	
G	46	SP	*	*	*	*	

*Test not requested.
1/Triaxial test data shown on figures C-1 through C-6.

TABLE C-1 (con.)

Sample	Depth	Unified Soils Symbol	Moisture Content Percent	Atterberg Limit, Percent		Dry Weight lb/cu.ft	Triaxial Test 1/
				Liquid	Plasticity Index		
Boring 65-RD-78							
A	36	CL	26.3	34	11	100.8	
C	38	CL	27	37	15	100.2	
K	46	CL	26.3	37	15	101.7	Yes
	48	CL	27.2	37	15	*	
	56	CL	26.2	37	15	*	
AC	62	CL	30.4	41	19	94.9	
AL	70	ML	35.3	37	12	88	
AP	74	CL	32.6	49	23	91.7	
Trench 65-BH-88							
	5	CL	*	66	33	*	
	11	SW-SC	*	80	39	*	
Trench 65-BH-89							
A	0-3	GW-GM	*	*	*	*	
B	5	GP	*	*	*	*	
C	10	GP	*	*	*	*	
Trench 65-BH-90							
A	6	GP	*	*	*	*	
B	9	GP	*	*	*	*	
C	12	GP	*	*	*	*	
Boring 65-DD-94							
A	16	MH	46.9	65	32	*	Yes
B	18	MH,CL	32.5	41	15	*	Yes
C	20	CL	35.3	47	20	*	Yes
D	25	CL1	19.8	38	18	*	Yes

*Test not requested.
1/Triaxial test data shown on figures C-1 through C-6.

PETROGRAPHIC ANALYSIS OF CONCRETE AGGREGATE

1. General. The coarse aggregate used in the concrete for construction of Wynoochee Dam was obtained from the Wynoochee River flood plain approximately 2 miles upstream of the dam. The tabulation below shows the average composition of the coarse aggregate:

	Percent
massive graywacke	55
impure bedded graywacke	16
coarse-grained basalt	8
fine-grained basalt	11
breccia	6
vein materials	4

Following is a summary of the petrographic reports:

2. Wynoochee River Gravels. The gravels are greenish-gray and consist predominantly of graywacke sandstone and minor basalt metamorphosed to varying degrees. The gravels are moderately weathered, but contain less than 1 percent soft particles. Particle shapes are predominantly rounded or subrounded, with moderately rough surface textures. Flat-elongate particles are not present in significant amounts in either sand or gravel. No deleterious constituents that could swell and break down the rock or concrete were observed. The graywacke sandstone is fine to medium grained and consists of ever decreasing sized angular fragments of plagioclase feldspar, quartz and minor pyroxene minerals plus basalt and minor altered sedimentary rock grains in pastry matrix containing shreds of altered biotite, chlorite, secondary quartz, traces of carbonate and pyrite, and silty dark crystalline material. The coarse-grained basalt stones are diabase or gabbro in texture. Green alteration products, which occur both as separate inserts and as alteration rims around pyroxene, consist of chlorite clays with minor amounts of secondary tremolite. The fine-grained basalt has constituents less than 0.3-millimeter in size and contains relict clusters (spherulite or variolitic) of plagioclase feldspar in dark altered and oxidized volcanic glass along with green products consisting of chlorite and celadonite. Breccias and contact rocks consist largely of variegated red fractured and fissured fine-grained basalt with minor associated sedimentary assimulates. Vein materials occur in both basalt and graywacke particles and contain one or more of the following minerals: quartz, secondary plagioclase feldspar (albite-oligoclase) sericite mica, epidote, chlorite, nephrite amphibole and cordierite. The volcanic glass in the fine-grained basalts is extensively altered and other constituents are present in negligible amounts. Alkali-reactive tests indicated the materials to be nonreactive.

3. Wynoochee River Sand. The tabulation below shows the average composition of the natural sand:

	Percent
graywacke	57
coarse-grained basalt	10
fine-grained basalt	10
vein breccia	11
other rock	12

The concrete sand was a blend of natural sands made from Wynoochee River gravels and finer sand obtained from the Wynoochee River west bank, a few hundred feet downstream from its confluence with Trout Creek. Particle shapes are predominately subrounded for material retained on the No. 30 sieve. The sand is of greenish-gray color and is made up of moderately weathered grains containing 5.6 percent soft constituents and 3 percent minus 200 silty fines. This would be classed as a sand of good quality, comparable to most of the sands used in major NPD concrete structures containing less than 6 percent soft constituents. The gradation of the processed natural sand from the pit gravels was deficient in sizes passing the No. 30 sieve. This made it necessary to selectively use sand deposits in the riverbed and blend materials at the screening plant surge pile during plant feed.

NORTH PACIFIC DIVISION, CORPS OF ENGINEERS

NORTH PACIFIC DIVISION MATERIALS LABORATORY
RT 2, BOX 12A
TROUTDALE, OREGON

PETROGRAPHIC REPORT

DATE: 23 April 1969
EXPL NO
SAMPLE NO
PETROGRAPHER: N. B. Higgs
W/O NO: 69-CPCh-802

SAMPLED BY: K. Graybeal
SUBMITTED BY (DIST OR AGENCY): Seattle District
PROJECT: Wynoochee Dam
SOURCE: Chunk samples from Wynoochee Rprap Source.

1. Samples and Tests

Chunk samples of rock from the Wynoochee riprap source were submitted for magnesium sulfate soundness, accelerated expansion and petrographic tests. This report contains the results of the petrographic studies and, since quarry conditions are unknown, the findings are restricted to the sample submitted. Three thin sections were prepared from representative rock and were examined under the petrographic microscope. X-ray diffraction analyses to determine the type of alteration products present were also made.

2. Hand Specimen Features

The three 6"-10" diameter rock chunks submitted consist of hard and tough, dark gray basaltic rock. Clayey seams, soft rock, gougy material, or significantly weathered rock are not present. The rock chunks contained only minor amounts of microjoints. The texture is rather coarse with lacy networks of plagioclase feldspar being seen on a sawed surface. The rock has a pseudo-porphyritic texture because of larger crystals of dark colored pyroxene. Microscopic examination reveals, however, that the rock is not porphyritic and that what appears to be pyroxene phenocrysts is actually pyroxene in an ophitic texture with plagioclase feldspar laths set in larger pyroxene crystals. The pyroxene formed after the plagioclase in sample submitted, whereas, in porphyritic rocks the pyroxene crystallizes prior to plagioclase. Examination under the binocular microscope revealed that green clay alteration is present and as a result both microscopic thin section and X-ray diffraction studies were made to determine the type and distribution of clay minerals present. A few small crystals of pyrite were observed here and there in the rock.

3. Microscopic Examination

a. Texture: Textural inferences indicate that the rock is a coarse grained basalt or diabase. As far as engineering properties are concerned, it makes little difference whether the rock is called coarse grained basalt or diabase. However, in the strict sense and from a petrographic viewpoint, the rock is a diabase because it has a distinct ophitic texture. The ophitic texture is characterized by smaller plagioclase feldspar laths haphazardly set in a larger crystal of augite pyroxene. The pyroxene crystals are comparatively large and measure up to 8 mm (3/8-inch) in maximum dimension. Plagioclase laths embedded in the pyroxene average about 0.5 mm in length. Diabases occur in dikes, sills and kindred small shallow intrusives. At Lookout Point Dam, Oregon and Twin Springs Damsite, Idaho small plugs or dikes have diabase at the central portions of the intrusive mass but grade towards basalt at intrusive margins. Hence, it depends upon where the intrusive is sampled as to whether basalt or diabase is diagnosed. The rock submitted is reportedly from a dike.

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PETROGRAPHIC REPORT
(CONTINUED)

DATE 23 April 1969	FXPL NO	SAMPLE NO
PETROGRAPHER N. B. Higgs		W/O NO 69-CPCh-802

b. Composition: The diabase contains about 35%-40% plagioclase feldspar, 30%-35% pyroxene, 5%-10% magnetite and 20%-25% green clay alteration products.

c. Alteration: The rock is appreciably altered and contains 20%-25% of green clays that are identified as chlorite by X-ray diffraction methods. The chlorite clays occur chiefly as insets between a mesh of plagioclase feldspar laths. Some of the chlorite is arranged in oriented fibrous form, however, the majority of the chlorite appears to have random orientation. The plagioclase feldspars do not have a fresh appearance. The majority of the plagioclase crystals are abundantly microfractured, have a clouded appearance and frequently have chlorite penetrating along the microfractures. The chlorite appears to be formed from the alteration of pyroxene as it mimics the habit of the pyroxene. The type of alteration observed is due to late magmatic action and is not caused by weathering of the rock. The few grains of pyrite seen in hand specimen attest to the late magmatic or hydrothermal alteration.

4. X-ray Diffraction Analyses

Representative portions of the rock were ground to a fine powder, water slurried onto glass slides and X-rayed as oriented aggregates. X-ray analysis indicate that the green clays seen under the microscope are some variety of chlorite. The chlorite is present in moderate amounts. No montmorillonite clays that could swell and breakdown the rock are present. An explanation of the strucutural and hence behavioral differences between montmorillonite and chlorite should be given. Both chlorite and montmorillonte are layered silicates similar to mica, however, the chlorite has magnesium atoms bonding the layers together whereas montmorillonite has water along with cations between the layers and thus the layers are free to move apart and expand. Imagine the leaves of a book. In the case of chlorite the book leaves are bonded together by magnesium whereas in montmorillonite the leaves have water and cations between them and thus are free to expand and move apart with the degree of movement being dependent upon the type of cation and the amount of interlayer water. When sodium is the interlayer cation the montmorillonite shows pronounced expansion when wetted. The montmorillonite in bentonite is usually of the sodium type and therefore the pronounced expansion that results with bentonitic clays. Montmorillonite clays having a divalent cation such as calcium show less expansion. The ethylene glycol used in the accelerated expansion test expands the distance between the layers and therefore, if the rock contains montmorillonite in proper orientation or habit, the rock breaks down by the pressure exerted by ethylene glycol penetrating along the layers. Since chlorite has layers that are bonded together, the ethylene glycol does not cause expansion. The sample submitted contains chlorite rather than montmorillonite and thus no breakdown should be evidenced during the accelerated expansion test.

5. Rock Quality

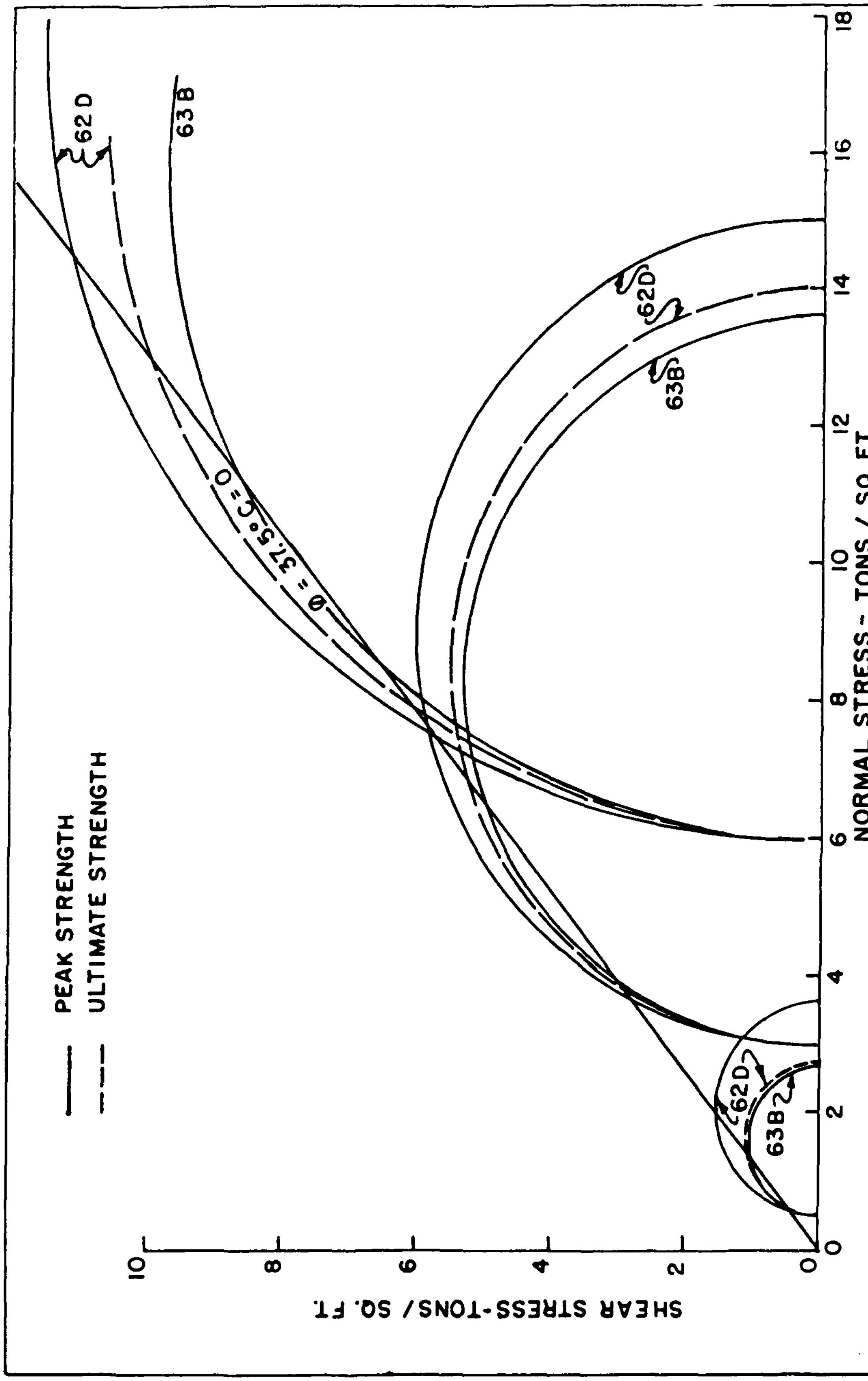
The basaltic diabase sample submitted consists of strong and hard rock that does not contain clayey seams, soft material, weathered material or significant amounts of microjoints. No montmorillonite clays that could swell and cause rock breakdown are present. However, although there is no montmorillonite, the

PETROGRAPHIC REPORT (CONTINUED)	DATE 23 April 1969	EXPL NO	SAMPLE NO
	PETROGRAPHER N. B. Higgs		W/O NO 69-CPCh-802

rock is appreciably altered and contains 20%-25% of chlorite clays. The effect of these clays on rock durability are difficult to evaluate. We recently tested a basaltic rock with chlorite clays that had 33% loss after the freeze-thaw test. The chlorite clays in this rock were present in amounts of 15%-20% and occured in inclusions, as insets in feldspar and along numerous microjoints. Significantly, the tested rock had the structural imperfections of numerous microjoints with chlorite being oriented along the joints. Most of the chlorite clays in the rock submitted have random orientation, however, there are some areas where the chlorite has a subparallel orientation. Chlorite occurs in many kinds of rocks, e.g., in graywacke sandstone sediments, in chlorite metamorphic schists and in propylitized andesite volcanic rocks. Tests on chlorite-bearing graywackes (Lummi Island and Robe Quarry, Seattle District) and propylitized chlorite-bearing andesites (Blue River and Lookout Point Dams, Portland District) have shown these rocks to be durable materials with only minor freeze-thaw losses. Over-all evaluation would indicate that the chlorite clays are probably not detrimental to rock durability. However, since there are basaltic rocks that have undergone appreciable freeze-thaw losses, absolute insurance of rock durability would indicate performance of freeze-thaw testing on rock from the Wynoochee source. The sample submitted was not noticeably microjointed but the gross scale of jointing in the field is not known. Numerous joints with green clay infillings might affect rock durability.

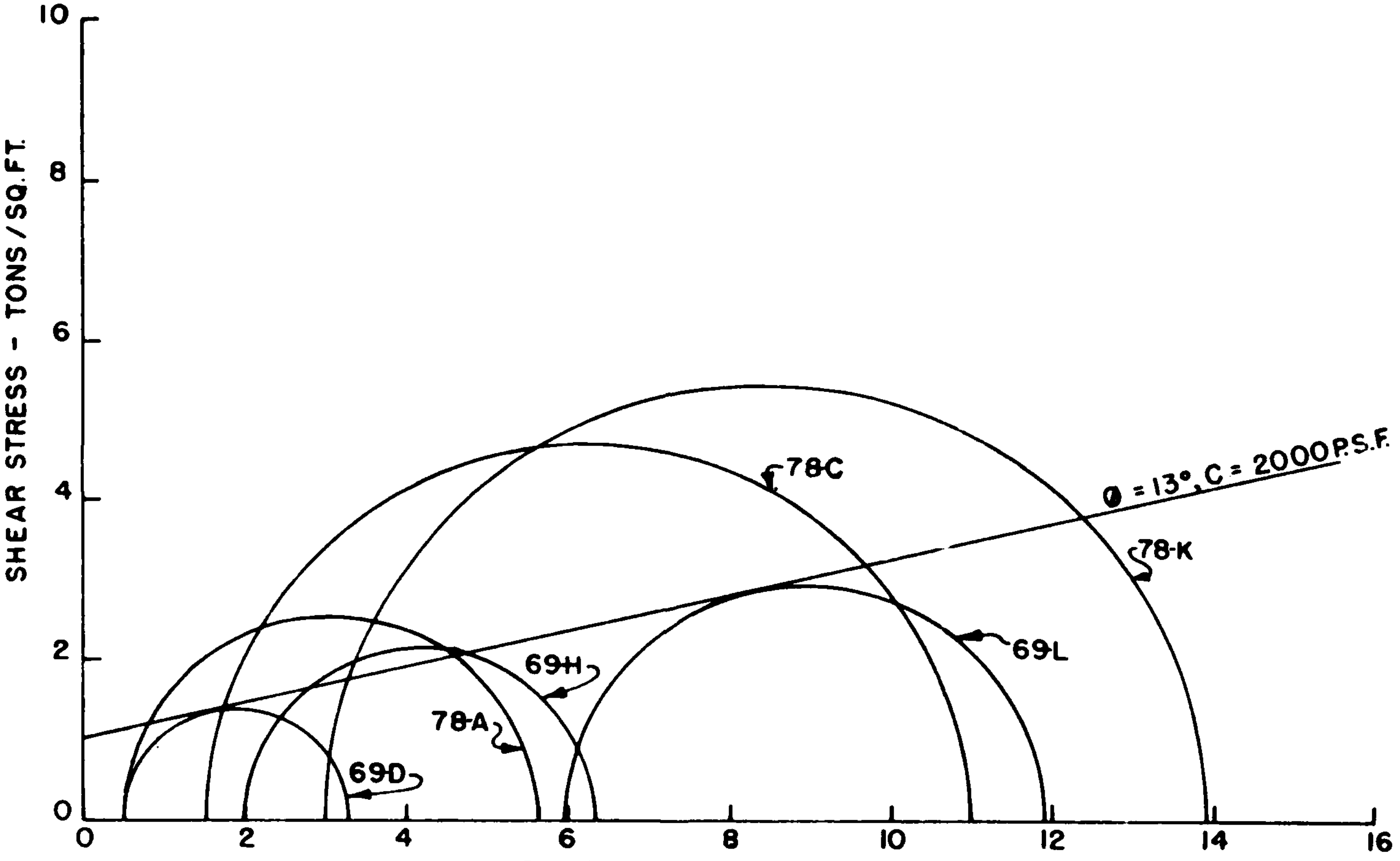
Nelson B. Higgs
NELSON B. HIGGS
Chief, Petrography Branch

NPD FORM 22 MAR 49 306 **Continuation** SHEET 3 OF 3



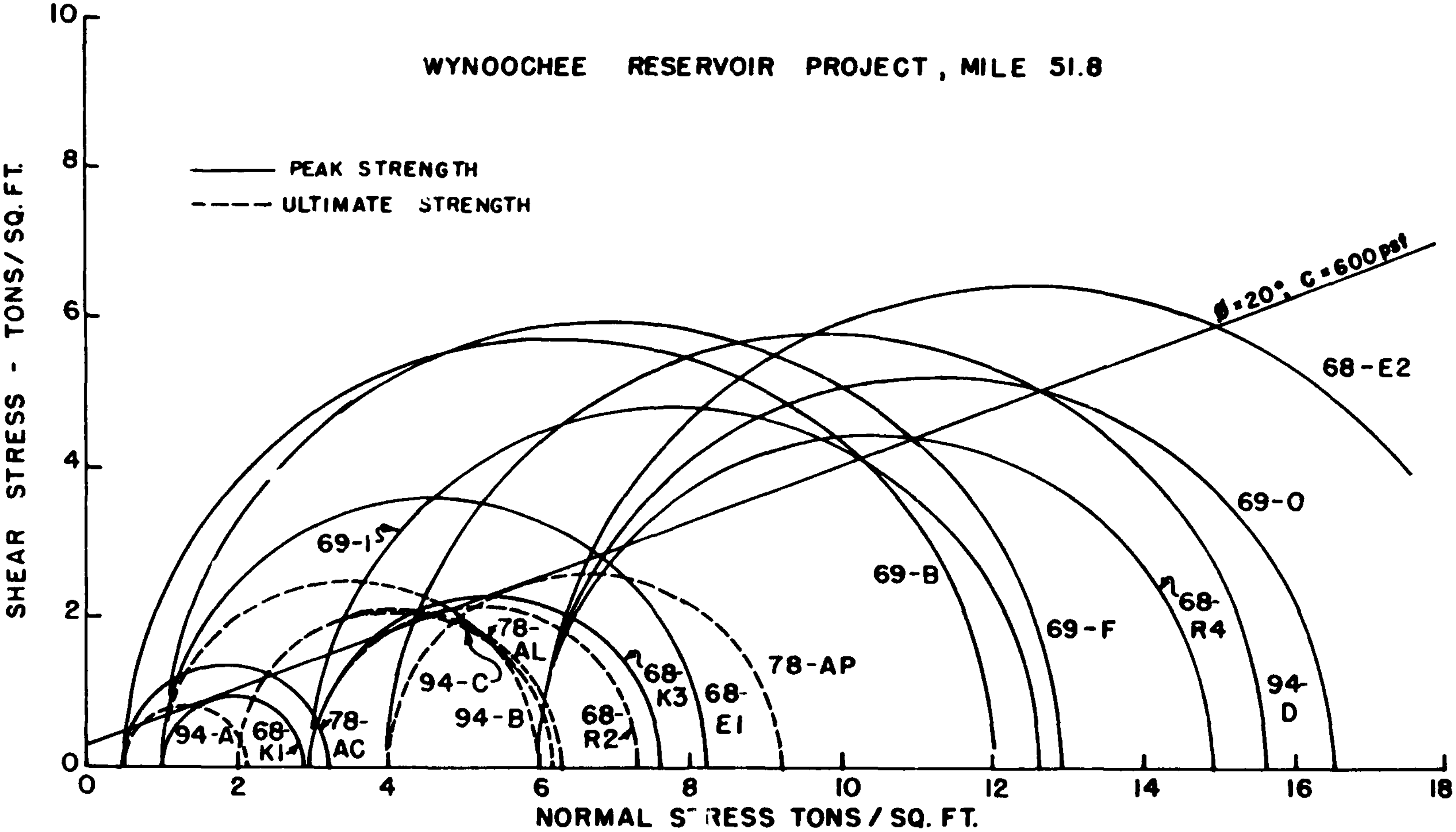
SUMMARY OF TRIAXIAL COMPRESSION TESTS ON SAMPLES OF GRAVEL REMOLDED AT NAT. DENSITY
"S" CONSOLIDATED DRAINED

FIGURE C-1



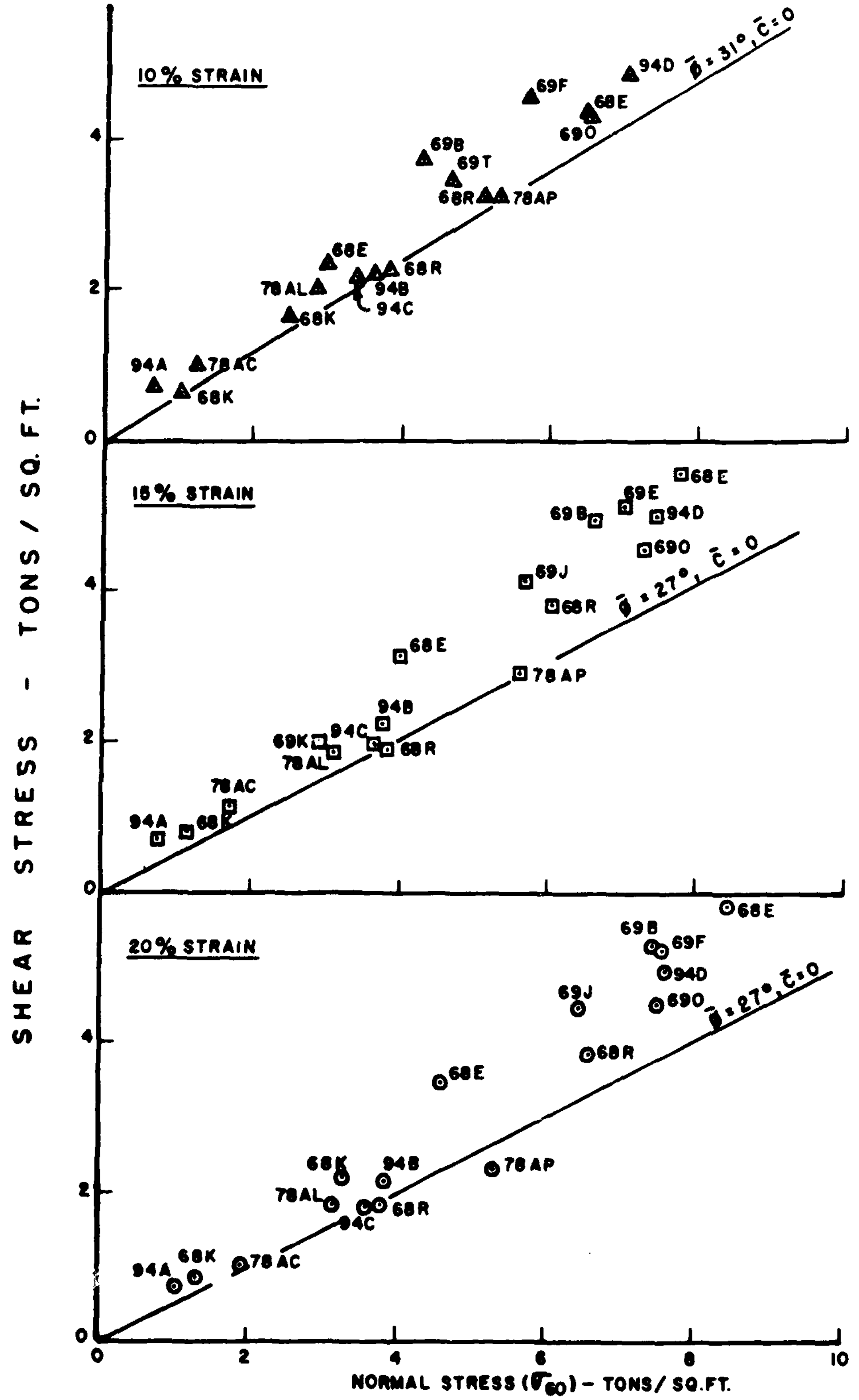
SUMMARY OF TRIAXIAL COMPRESSION TESTS ON UNDISTURED SAMPLES OF CLAY
"Q" UNCONSOLIDATED UNDRAINED

FIGURE C-2



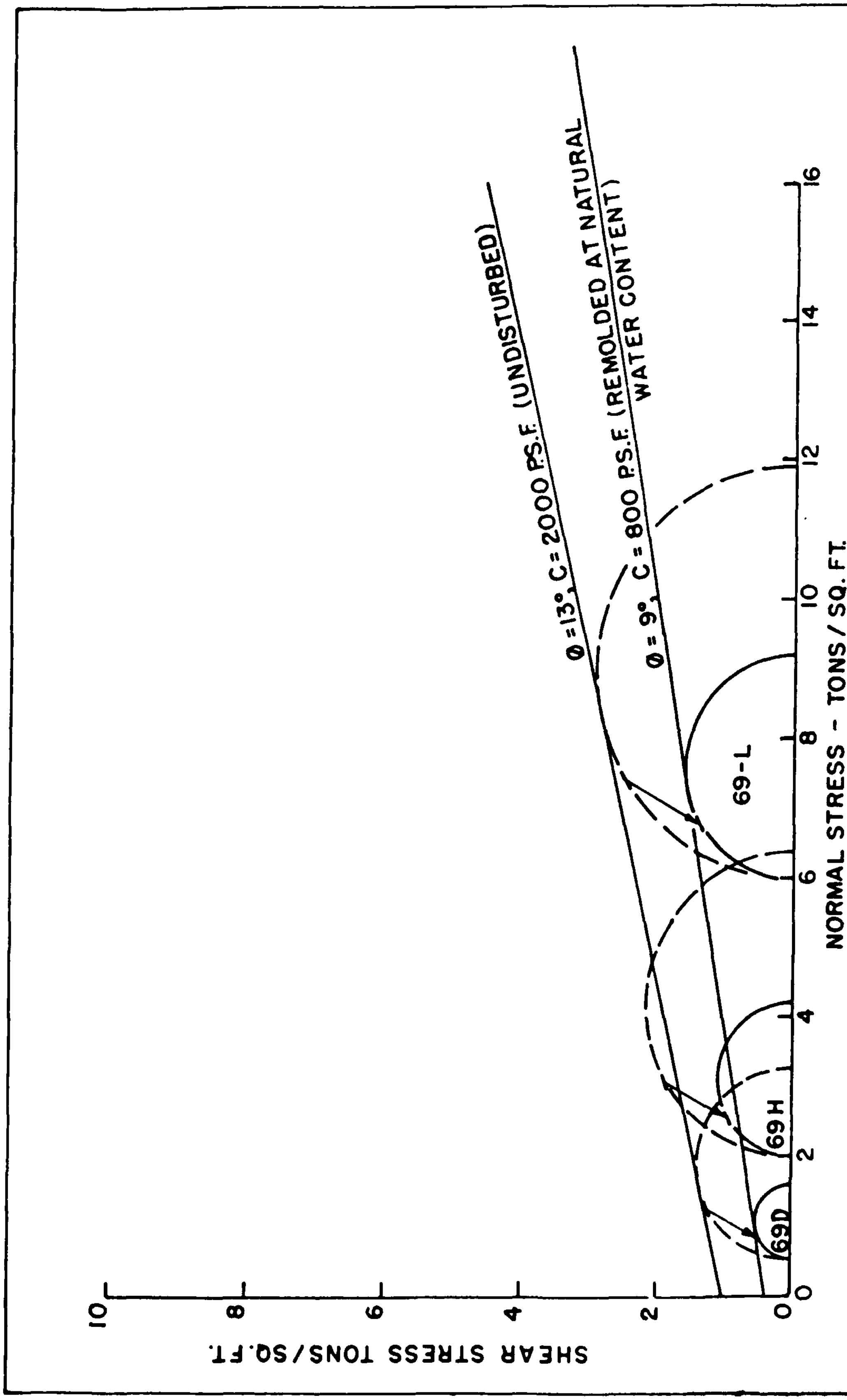
SUMMARY OF TRIAXIAL COMPRESSION TESTS ON UNDISTURBED SAMPLES OF CLAY
"R" CONSOLIDATED UNDRAINED

FIGURE C-3



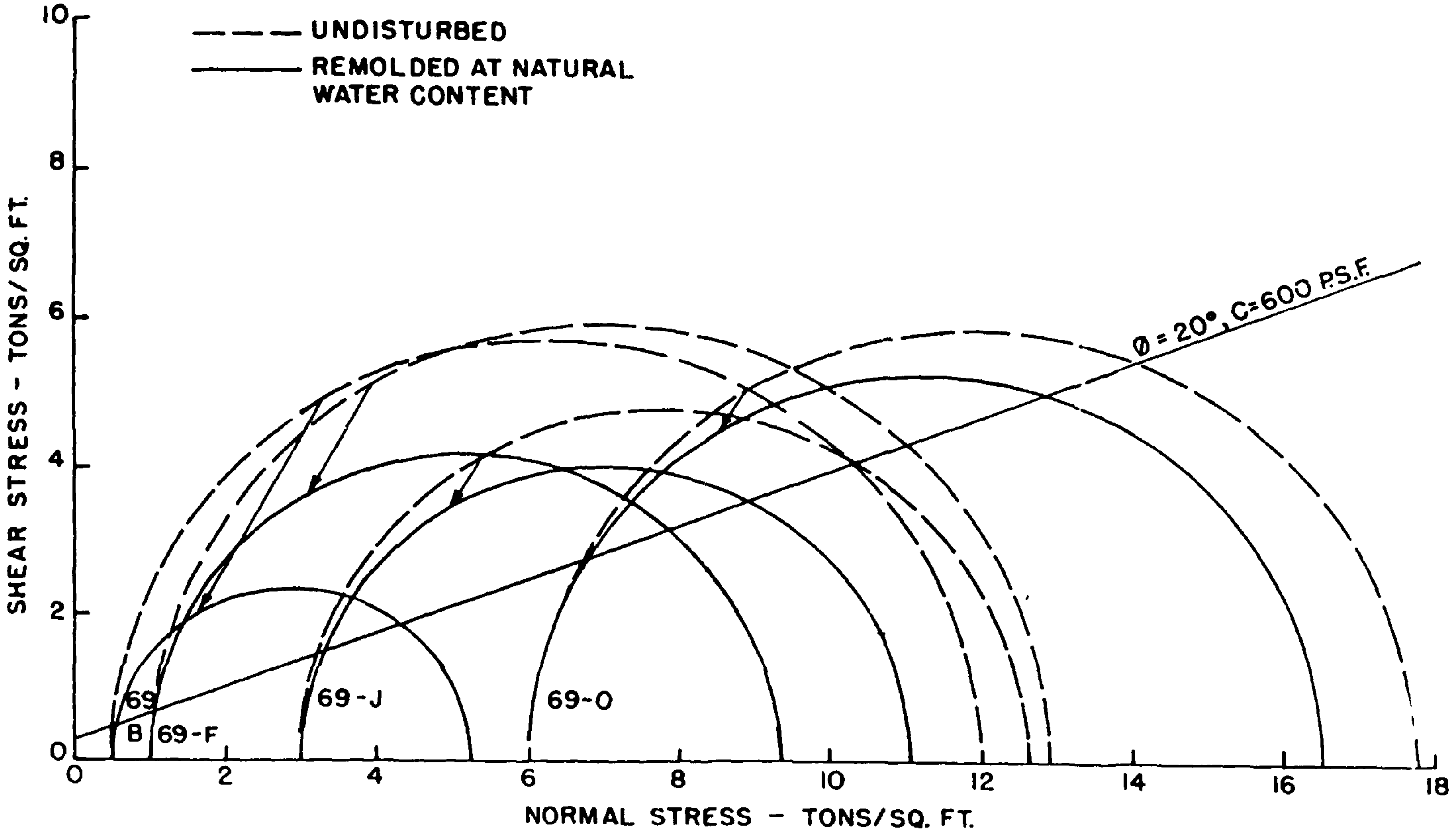
SUMMARY OF TRIAXIAL COMPRESSION TESTS ON UNDISTURBED SAMPLES OF CLAY, "$\bar{R}$" CONSOLIDATED UNDRAINED W/MEASURED PORE PRESSURE

FIGURE C-4



SUMMARY OF TRIAXIAL COMPRESSION TESTS SHOWING EFFECT OF REMOLDING ON "Q" STRENGTH OF CLAY

FIGURE C-5



SUMMARY OF TRIAXIAL COMPRESSION TESTS SHOWING EFFECT OF REMOLDING ON "R" STRENGTH OF CLAY

FIGURE C-6

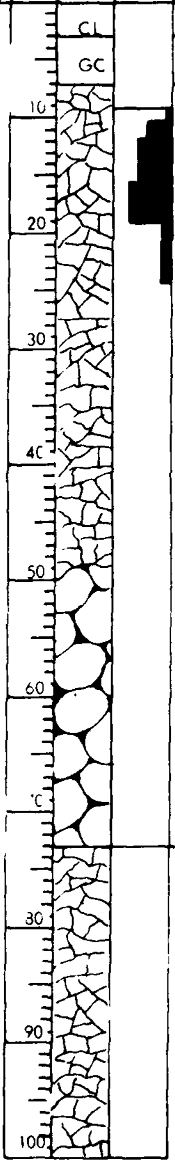
APPENDIX D

BORINGS LOGS

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

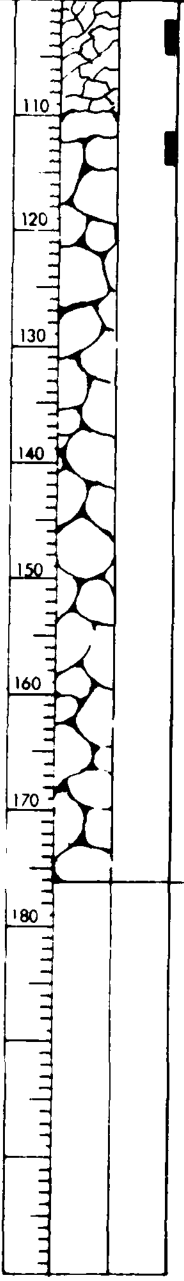
DEPTH OF HOLE 176.1 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 7.0 **DATE STARTED** 1 Dec. 1964
ROCK DRILLED 169.1 **DATE COMPLETED** 15 Dec. 1964
% CORE RECOVERED 95 **CONTRACTOR** U.S.A.E.D. Seattle

SURFACE EL 756.0 **HOLE NO** 64-DD-24 **N** 763 251 **E** 1 221 145



ELEVATIONS 756.0	DESCRIPTION OF MATERIALS	REMARKS
753.0	Gravelly CLAY, Brown	Began drilling w tricone rock bit. Soils logged by visual classification of wash samples. NX casing seated at 8 6' depth. Began coring w NX dia. bit at 9.2'.
749.0	Clayey GRAVEL, (Angular Rock Fragments)	
	Top Rock 7.0' BASALT, finely crystalline to aphanitic, 1 4" feldspar phenocrysts in local zones. Few zones of palagonite with carbonate veinlets. Unweathered joints show mirror polish on black chloritic coatings. Few joints show striae. Weathering along joints extends to depth 23'. Small 1 8", amygdules appearing at 20' depth and increasing in number, up to 2% ± of rock mass, at 70' depth. Abundant carbonate and palagonite in 1" thick curved planes from 50' to 60' decreasing in frequency and ending at 73'depth. Base of Flow	Rock is generally closely jointed and fractured. Core lengths range from fragments to 0.6', with rare longer pieces to 1.2'. Average length of run approximately 3'. Pillow zone at base of flow.
683.0	Top of Flow BASALT, as first described above. phenocrysts are to 1 4 [illegible] 2" amygdules [illegible] unweathered	

SURFACE EL 756.0 HOLE NO 64-DD-24 N 763,251
E 1,231,145

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
				Below 110' depth, curved planes appear and become more evident with depth.	
					Interpreted as representing a pillow zone near base of a flow.
				Hydrous glass and carbonate zones to 1/4" wide at periphery of pillows from 126.5 to 160.0.	
				<u>160.0' - 176.1'</u> Hydrous glass and carbonate zones to 1" thick peripheral to pillows, phenocrysts decreasing in size with depth. Soft material in interpillow zones.	Inter pillow zones of softer material are moderately etched by drill water. Water return approximately 95% for entire boring.
579.9				Bottom @ 176.1'	<u>Inflow Test</u>, 8.6 - 176.1'. Filled hole w/ water, lost 5 gpm to 18', then W.L. remain static at 18' depth.

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 98.7 **DIAMETER OF HOLE** 4-1/4"
DEPTH OF O.B. 88.7 **DATE STARTED** 15 July 65
ROCK DRILLED 10' **DATE COMPLETED** 27 July 65
% CORE RECOVERED -- **CONTRACTOR** KOR-IT CO., INC.

SURFACE EL 809.7 **HOLE NO** 65-RD-25 N 764,541 E 1,230,619

ELEVATIONS 809.7	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
789.7	10 20	GM & GP		Interbedded Silty Sandy GRAVEL and Sandy GRAVEL, brown above 4' and gray below. Loose in upper 10 feet and increasing compaction below	Drilling w 4-1/4" tricone bit, bentonite mud & no casing. Action rough Minor mud loss Overburden classification by drill action, mud loss, & examination of mud return
764.2	30 40	GP		Sandy GRAVEL, gray	Action rough Caves Losing mud & only 70% return at 35'
735.7	50 60 70	GM & GP		Interbedded Silty Sandy GRAVEL and Sandy GRAVEL w/few 3" Silt and/or Sand lenses, gray	Open hole stands w heavy mud. Action rough & penetration slow except for common smooth fast advance of 3"
721.0	80	GP & GM		Interbedded Sandy GRAVEL and Silty Sandy GRAVEL, few Cobbles, gray Top of Rock @ 88.7'	Action rough Lost 50 gal. mud in 5' advance
711.0	90 100			BASALT cuttings	Penetration 22 minutes/ft No cave or rough spots Tricone rolls evenly w 12" wrench
				Bottom @ 98.7	No pressure test or NX core

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 113.7 **DIAMETER OF HOLE** 4-1,4"
DEPTH OF O.B. 109.2 **DATE STARTED** 6 July 65
ROCK DRILLED 4.5 **DATE COMPLETED** 14 July 65
% CORE RECOVERED -- **CONTRACTOR** KOR-IT CO., INC.

SURFACE EL 806.4 **HOLE NO** 65-RD-26 **N** 764.141 **E** 1.230.668

ELEVATIONS 806.4	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
802.4		ML		Gravelly SILT, soft, tan	Entire hole drilled w 4-1/4" tricone bit, bentonite mud, uncased. Overburden classification by drill action, mud loss & examination of mud return.
794.4	10	GM		Silty Sandy GRAVEL w few Cobbles, loose, gray	
793.4		GP		Sandy GRAVEL, loose, gray	50 gal mud loss
762.4	20 30 40	GM		Silty Sandy GRAVEL w Cobbles, compact gray	No mud loss
754.4	50	GM & GP		Interbedded Silty Sandy GRAVEL & Sandy GRAVEL, gray	No mud loss
752.4		GM		Silty Sandy GRAVEL, very compact (or cemented)	Penetration very slow
732.4	60 70	GP		Sandy GRAVEL w Cobbles, gray	Lost 100 gal mud
724.4	80	GM		Silty Sandy GRAVEL w Cobbles (5"), gray	Very little mud loss
720.0		SM		Silty SAND, (fine) compact, gray w 2" to 4" lenses of GP, Sandy Gravel at 12" to 18" intervals	
	90 100				Action smooth Penetration fast Little or no mud loss

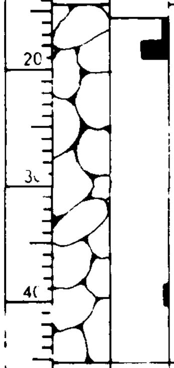
SURFACE EL 806.4	HOLE NO 65-RD -26	N 764,141 E 1,230,668

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
		SM			
703.4		CL		Sandy Silty CLAY, stiff, blue-gray Top of Rock @ 109.2	
697.4	110			BASALT cuttings	4-1/4" tricone in rock No core
692.7				Bottom @ 113.7	No pressure test

WYNOOCHEE DAM PROJECT MILE 51.3, WYNOOCHEE RIVER

DEPTH OF HOLE 45.4 DIAMETER OF HOLE NX
DEPTH OF O.B. 14.5 DATE STARTED 11 Feb. 1965
ROCK DRILLED 30.9 DATE COMPLETED 15 Feb. 1965
% CORE RECOVERED 96 CONTRACTOR U.S.A.E.D. Seattle

SURFACE EL 48.0 HOLE NO 65-DD-27 N 743,234 E 1,231,667

ELEVATIONS 748.0	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
744.5		GC		Clayey GRAVEL, wet, (Roadfill)	Overburden penetrated w tricone rock bit and NX chopping bit. Soils logged by visual classification of wash samples. NX casing seated at 10 4' depth Began coring w NX dia. bit at 15.7'.
733.5	10	GM		Silty Sandy GRAVEL.	
702.6	20 30 40			Top of Rock at 14.5' BASALT, hard, gray to gray-black, unweathered, finely crystalline to aphanitic texture, phenocrysts to 1 8', carbonate and palagonite zones to 1 2' peripheral to pillows. Almost all joints show mirror polish on dark chloritic surfaces. Some joints show striae.	Rock is closely jointed and fractured Core lengths range from fragments to 0.9'. Length of core usually less than 0.3'. Water Level 9.0
	50			Bottom at 45.4'	Inflow Test: Filled NX casing w water, lost 1 2 gpm till W.L. dropped to 8.7'. Water loss into over-burden, rock considered tight since static W.L. at 8.7' and all rock was unweathered.

WYNOOCHEE DAM PROJECT MILE 51.8, WYNOOCHEE RIVER

DEPTH OF HOLE 72.7 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 72.7 **DATE STARTED** 16 Feb. 1965
ROCK DRILLED 0.0 **DATE COMPLETED** 19 Feb. 1965
% CORE RECOVERED - **CONTRACTOR** U.S.A.E.D. Seattle

SURFACE EL 744.8 HOLE NO 65-RD-28 N 763,115 E 1,232,051

ELEVATIONS 744.8	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
743.3		GP		Sandy GRAVEL	Began drilling w tricone rock bit Advanced hole by triconing then driving casing and cleaning out w NX chopping bit.
	10	GP & GM		Alternate layers of Sandy GRAVEL & Silty Sandy GRAVEL w Cobbles (6") & a few Boulders	
726.3		SM		Silty SAND, brown	Soils logged by visual classification of 3" Shelby tube and wash samples.
726.3	20	CL		CLAY, gray	
724.8		GP		Sandy GRAVEL w Boulders	
722.3		CL		Sandy CLAY, blue - gray	
714.9	30	CL		Sandy CLAY	
712.8	40	CL	I I	CLAY, blue	
700.9		GC		Clayey Sand, GRAVEL w Cobbles	
697.9	50	SC		Clayey SAND, coarse, w occasional Gravel	
693.9		GC		Clayey GRAVEL, compact	
691.8		GM		Silty Sandy GRAVEL, brown	
686.5	60	GP		GRAVEL w Boulders	Drove NX casing to 72.7'. Bottom 10' section of casing became unscrewed and was lost in the hole. Hole abandoned.
685.3	70	SP		SAND (fine), blue-gray	
672.1	80 90 100			Bottom 72.7'	No water levels recorded.

WYNOOCHEE DAM PROJECT MILE 51.8,WYNOOCHEE RIVER

DEPTH OF HOLE 48.6 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 18.6 **DATE STARTED** 18 Dec. 1964
ROCK DRILLED 30.0 **DATE COMPLETED** 29 Jan. 1965
% CORE RECOVERED 100 **CONTRACTOR** U.S.A.E.D. Seattle

SURFACE EL 802.0 **HOLE NO** 65-DD-29 **N** 763 744 **E** 1,230.585

ELEVATIONS 802.0	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
783.4	10	GP & GM		Alternate layers of Sandy GRAVEL & Silty Sandy GRAVEL w a few Cobbles (9")	Overburden penetrated w NX chopping bit and tricone rock bit. Soils logged by visual classification of wash samples. NX casing seated at 18.6' depth
753.4	20 30 40			Top of Rock at 18.6' BASALT, dark gray, aphanitic with phenocrysts to 1/4". Traces of carbonate veinlets. Joints are weathered brown to depth 47'. Joints show mirror polish with some showing striae. Curved carbonate and hydrous glass zones, 44.2 to 44.5, suggest nearness of flow base.	Rock is closely jointed and fractured, core lengths range from fragments to 0.5'.
	50			Bottom at 48.6'	Inflow Test: Filled hole with water, water dropped to 14' at 9 gpm rate, then rate of outflow decreased and W.L. stabilized at 19' depth.

WYNOOCHEE DAM PROJECT MILE 51.8, WYNOOCHEE RIVER

DEPTH OF HOLE 331.0
DIAMETER OF HOLE 3
DEPTH OF O.B. 304.0
DATE STARTED 4 March 1965
ROCK DRILLED 27.0
DATE COMPLETED 8 April 1965
% CORE RECOVERED Churn
CONTRACTOR U.S.A.E.D. Seattle

SURFACE EL 937.8
HOLE NO 65-CD-30
N 762,523
E 1,231,659

ELEVATIONS 937.8	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
935.8		ML		SILT, w organic debris, brown	Churn drill hole, cased to rock w 8" pipe.
	10 20 30	GP & GM		Sandy GRAVEL w layers of Silty Sandy GRAVEL, many Cobbles & Boulders (24"), compact and or cemented, brown	Drilling water added from depth 0 to 105', no water inflow Soils logged by visual classification of bailer and drive samples.
906.3		GM		Silty Sandy GRAVEL w many Cobbles & Boulders, compact, brown	
901.6	40 50 60 70	GP & GM		Sandy GRAVEL w layers of Silty Sandy GRAVEL, many Cobbles & Boulders 24") compact and or cemented, brown	
859.8	80 90 100	SM GP GM	I	Silty Gravelly SAND w lenses of Sand. GRAVEL & Silty Sandy GRAVE compact, brown	

SURFACE EL 937.8		HOLE NO 65-CD-30			N 62,523 E 1,231,659
ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
787.8	110 120 130 140 150	SM GP & GM	I	Silty Gravelly Sand w/lenses of Sandy GRAVEL, & Silty Sandy GRAVEL, compact brown	Depth 108.6', 6' of water in hole after shift change. Depth 118.6', trace water in hole Depth 128', dry Depth 135', trace water in hole Depth 142', dry Depth 144', trace of water.
769.8	160	GM	I I	Silty Sandy GRAVEL, compacted, dry, non-plastic, some clay, gray	
762.8	170	SM	I	Silty Gravelly SAND, less compacted, gray, damp	Losing drill water from 177 to 179'
758.8		GP		Sandy GRAVEL w/ Cobbles, gray	
746.8	180 190	SM	I	Silty Gravelly SAND, mostly medium, gray	Depth 184', trace water in hole
735.8	200	GM	I	Silty Sandy GRAVEL w/Cobbles w/minor dry sand, blue-gray	Depth 192', dry after weekend.
732.8		SP		Gravelly SAND, brown	Depth 202' to 205', water level 196', bailed 11 gpm w 1 ft drawdown recovery in 15 minutes. Inflow decreases below 205' w increase of silt in soil.
	210	SM		Silty Gravelly SAND, brown	Depth 209', water enough for drilling.

SURFACE EL 937.8

HOLE NO 65-CD-30

N 762,523
E 1,231,659

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
		SM		Silty Gravelly SAND, brown	
717.8	220	SC	I	Clayey Silty SAND, w minor fine Sand beds, gray	
709.8	230	ML	I	Clayey SILT w/fine Sand, gray	
705.8		CL	I	Silty CLAY w/Sand, blue-gray	Depth 239', trace water
698.8	240 250 260	CL	I	Silty CLAY, blue-gray	Depth 260', no water
672.8	270 280	CL & ML		CLAY & SILT, gray	Depth 289', overnite water level, 274' w 1' sand inflow; water inflow 2 gpm.
648.8	290	GM	I	Silty Sandy GRAVEL, gray	
646.8		SP CL GM		SAND (fine), Silty CLAY & GRAVEL, *interbedded lenses*	Depth 297', overnite water level 282'
641.8	300	GC		Clayey, Silty, Sandy GRAVEL w Boulders, gray	
634.8		ML		SILT, buff to gray - buff	Depth 307', overnite water level 275'
633.8	310 320			Top of Bedrock at 304' Cuttings of basalt w white carbonate	

SURFACE EL 937.8 HOLE NO 65-CD-30 **N** 762,523 **E** 1,231,659

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
606.8	330			Cuttings of basalt w white carbonate	Depth 331' Water inflow Approx 2 gpm
				Bottom at 331.0'	

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHE **RIVER**

DEPTH OF HOLE 76.1 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 46.0 **DATE STARTED** 1 Feb. 1965
ROCK DRILLED 30.1 **DATE COMPLETED** 11 Feb. 1965
% CORE RECOVERED 93 **CONTRACTOR** U.S.A.E.D. Seattle

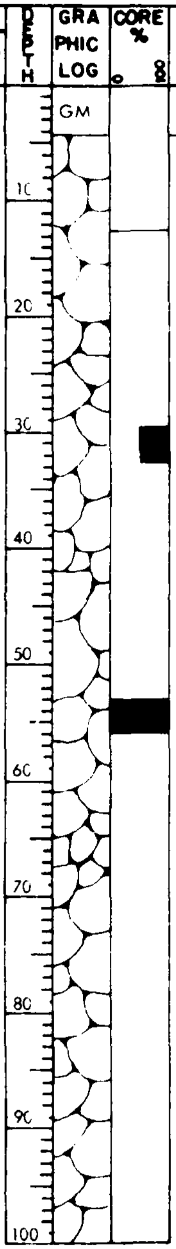
SURFACE EL 801.4 **HOLE NO** 65-DD-31 **N** 763,063 **E** 1,231,321

ELEVATIONS 801.4	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
[illegible].4	10	GM & GP		Silty Sandy GRAVEL w layers of Sandy GRAVEL, w Cobbles	Overburden drilled w NX chopping bit and tricone rock bit. NX diamond bit used on basalt blocks.
79[illegible].4		SM		Gravelly Silty SAND	
773.4	20	GM		Silty Sandy GRAVEL, w Cobbles, brown 23.0 - 28.1, w numerous Basalt Blocks.	Soils logged by visual classification of wash samples.
771.4	30	SP		Gravelly SAND, (coarse to fine)	Lost drill water, temporarily at 30.9'
757.9	40	GM		Silty Sandy GRAVEL w numerous Basalt Blocks. Well cemented.	
754.9		GM		Silty Sandy GRAVEL, cemented	NX casing seated at 45' depth.
725.3	50 60 70			Top of Rock at 46.5' BASALT, pillowflow, hard, gray to gray black, finely crystalline with phenocrysts to 1 8".Carbonate and palagonite zones peripheral to curved pillow surfaces. Joints weathered tan to 56.3' depth. Almost all joints show mirror polish on dark chloritic surface with some showing striae.	Rock is generally closely jointed and fractured. Core lengths range from fragments to 1'. Water return 80%for entire boring
	80			Bottom at 76.1'	Inflow Test Filled hole with water, initial 4 gpm loss, gradually decreasing to depth 31.3', where W.L. remained static.

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 136.5 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 4.3 **DATE STARTED** 2 Sept 1965
ROCK DRILLED 132.2 **DATE COMPLETED** 1[illegible] Sept 1965
% CORE RECOVERED 96.3 **CONTRACTOR** KOR-IT CO., INC.

SURFACE EL 736.7 HOLE NO 65-DD-[illegible]2 **N** [illegible]63,543 **E** 1,231,075



ELEVATIONS 736.7	DESCRIPTION OF MATERIALS	REMARKS
732.4	Sandy Silty GRAVEL, brown Top Rock 4.3'	Tricone 3-7/8" w/ water & no mud to depth 12.5
	BASALT, pillow structure, amygdaloidal, gray to near black, [illegible], hard to hard	NX casing to 12.3 partial brown water return
	Jointed at 1/2" to 8" intervals from 12.5 to 25.7, brown stains on some joints to depth 16.6'	NX core bbl. 100% water return
	Jointed at 1/2" to 9" intervals from 25.7' to 63.5'	
		Core loss of 1.7' w high R.P.M. in closely jointed zone.
		Core lifter slipped & no recovery.
	Jointed at 1" to 12" intervals from 63.5' to 85.0'	
	Jointed at 1" to 6" intervals from 85.0' to 103.0'	

SURFACE EL 736.

HOLE NO 65-DD-32

N 763,543
E 1,231 075

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
	110 120 130			Jointed at 1" to 24" intervals from 103.0' to 136.5'	
600.2	140			Bottom 136.5	1 G.P.M. water inflow w casing full. W.L. stabilized at 30.0'.

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 152.0 **DIAMETER OF HOLE** 4-1 4 & 3-7 8"
DEPTH OF O.B. 142.0 **DATE STARTED** 19 August 1965
ROCK DRILLED 10.0 **DATE COMPLETED** 31 August 1965
% CORE RECOVERED -- **CONTRACTOR** KOR-IT CO., INC.

SURFACE EL 796.4 **HOLE NO** 65-RD-33 **N** 764,097 **E** 1,230,235

ELEVATIONS 796.4	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
794.6		ML		Gravelly SILT, soft, brown	Tricone, 4-1 4", w mud & no casing to rock Tricone 3-7 8" in rock
	10				Mud loss of 1 gpm from 2.0' to 16.0' & 1 2' to 1' of cave in hole after pulling tricone back 5'.
	20	GP & GM		Interbedded Sandy GRAVEL and Silty Sandy GRAVEL w Cobbles and Boulders (18"), loose, tan to gray	Estimated 10% mud loss from 16.0' to 61.0' Overburden classification by drill action, mud loss, & examination of mud return
	30				
	40				
	50				
	60				
735.4		GM		Sandy Silty GRAVEL w many Boulders, gray	1 2' to 1.0' of cave in hole after pulling tricone back 5.0'
	70				
716.4	80	CL		Sandy CLAY w Cobbles, blue-gray	
711.4		CL		Silty CLAY, blue-gray	No mud loss in clays
	90				
	100				

SURFACE EL 796.4 **HOLE NO** 65-RD-33 **N** 764,097 **E** 1,230,235

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
695.4	110	GC		Clayey GRAVEL w many Boulders, gray	
682.4		GC		Clayey Sandy GRAVEL w. many Cobbles, compact, gray	
676.4	120 130	GP		Sandy GRAVEL w Cobbles & Boulders, gray	
660.4	140	GC		Clayey GRAVEL w Cobbles, blue-gray (till)	
654.4	150			Top of Rock @ 142.0 BASALT cuttings	
644.4	160			Bottom @ 152.0	No pressure test

WYNOOCHEE DAM PROJECT MILE 51 & WYNOOCHEE RIVER

DEPTH OF HOLE 66.0 **DIAMETER OF HOLE** 4-1/4
DEPTH OF O.B 16.2 **DATE STARTED** 18 June 1965
ROCK DRILLED 19.8% **DATE COMPLETED** 22 June 1965
% CORE RECOVERED 100% **CONTRACTOR** KCR-IT CO. INC.

SURFACE EL 716.4 **HOLE NO** 65-DD-34 **N** 763.651 **E** 1,231,521

ELEVATIONS 716.4	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
		SP	I	SAND (fine), loose, Top 1.0' brown, gray below	Overburden drilled w/ 4-1/4" tricone bit & bentonite mud in open hole
706.4	10	GP	I	GRAVEL, 1/4" to 1", (little or no Sand)	
705.4 700.2		GM		Silty GRAVEL w/Boulders, compact, gray Top of Rock @ 16.2	NX casing, seated at 16.2'
	20			Recrystallized SANDSTONE, gray, very hard. Joints at 0.1' to 1.1' intervals and two sets dip 45° - 50° w/intersection plunging 10° to 15°. Joints planar & not curved and not chlorite coated.*	NX core w/ drilling water
	30			Reaction zone, sheared chloritic BASALT w/30% multiple carbonate veinlets, joints at 0.1' to 1.8' intervals & chloritic coated, soft to mod. hard	
	40			Intrusion of BASALTIC composition, mod. hard to hard. Joints at 0.1' to 4.0' intervals.	
650.4	50 60			Recrystallized SANDSTONE as at 20' Joints at 0.1' to 1.6' intervals	
				Bottom @ 66.0' * Interpreted as up-faulted block of Eocene meta-sediments	Pressure Test Bottom of packer at 19.4 Pressure 30# Inflow 0.075 cfm Pressure 15# Inflow 0.025 cfm Pressure drop slow

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 51.6 **DIAMETER OF HOLE** 4-1/4" in O.B. NX in Rock
DEPTH OF O.B. 22.0 **DATE STARTED** 9 June 1965
ROCK DRILLED 29.6 **DATE COMPLETED** 11 June 1965
% CORE RECOVERED 100% **CONTRACTOR** KOR-IT CO., INC.

SURFACE EL 727.3 **HOLE NO** 65-DD-35 **N** 763,459 **E** 1,231,694

ELEVATIONS 727.3	**DEPTH**	**GRAPHIC LOG**	**CORE %** 0 100	**DESCRIPTION OF MATERIALS**	**REMARKS**
724.3		SP		Gravelly SAND, brown to gray	Operation, 4-1 4" Tricone & mud in uncased hole
	10	GP		Sandy GRAVEL w/few Cobbles, loose, gray	Overburden classification by drill action, mud loss & examination of mud return
705.3	20			Top of Rock @ 22.0'	NX casing seated at 22.0'
	30 40 50			BASALT, dark-gray, felsitic texture, amygdaloidal, mod. hard to hard. Joints curved and coated w/glossy near-black chlorite. Core lengths 0.05' to 1.0' w/ incipient joints at closer intervals. Few minor curved carbonate veinlets.	Operation, NX core drilling w/water
675.7	60			Bottom @ 51.6	Pressure test Base of packer at 25' Pressure 30# Inflow 0.04 cfm Water level 22.0'

WYNOOCHEE DAM **PROJECT** MILE 51.7, WYNOOCHEE **RIVER**

DEPTH OF HOLE 62.0 **DIAMETER OF HOLE** 4-1/4" in O.B., NX in Rock
DEPTH OF O.B. 36.3 **DATE STARTED** 12 June 1965
ROCK DRILLED 25.7 **DATE COMPLETED** 17 June 1965
% CORE RECOVERED 97.2% **CONTRACTOR** KOR-IT CO., INC.

SURFACE EL 719.7 **HOLE NO** 65-DD-36 **N** 763.315 **E** 1,231.888

ELEVATIONS 719.7	**DEPTH**	**GRAPHIC LOG**	**CORE %** 0 100	**DESCRIPTION OF MATERIALS**	**REMARKS**
714.7		GM		Silty Sandy GRAVEL w/numerous Cobbles, loose, brown	Operation, 4-1/4" tricone w/ drilling mud & open hole
711.7		SP		SAND,(medium to coarse), gray	
704.7	10	SP		Gravelly SAND,(medium to coarse), loose, gray	Overburden classification by drill action, mud loss & examination of mud return
683.4	20 30	GP		Sandy GRAVEL w/numerous Cobbles, loose, gray Top of Rock @ 36.3'	NX casing seated at 36.3'
657.7	40 50 60			BASALT, dark-gray, felsitic texture to diabasic texture, mod. hard to hard, slightly amygdaloidal. Joints curved and coated w/ near-black chlorite Minor carbonate veinlets Core lengths 0.05' to 0.8'	Operation, NX core in rock Core loss 0.7' from 37.0' - 37.7' No water loss
	70 80 90			Bottom @ 62.0'	Pressure test Bottom of packer at 39.7' Pressure 30# Inflow 0.005 cfm

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 96.2 **DIAMETER OF HOLE** 4 1/2" O.B., NX in Rock
DEPTH OF O.B. 80.0 **DATE STARTED** 30 June 1965
ROCK DRILLED 16.2 **DATE COMPLETED** 29 July 1965
% CORE RECOVERED 100% **CONTRACTOR** KOR-IT CO., INC.

SURFACE EL 743.3 **HOLE NO** 65-DD-37 **N** 763,104 **E** 1,232,058

ELEVATIONS 743.3	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
726.8	10	GM & GP		Interbedded Silty Sandy GRAVEL & Sandy GRAVEL increasingly compact w/depth brown to 5' and gray below	Drill w/tricone & mud Action rough limited caving very little mud loss. Overburden classification by drill action, mud loss, and examination of mud return.
712.8	20 30	SP		SAND (medium to fine) gray	Sand caves & runs into hole
708.3		CL		CLAY, stiff, blue-gray	
685.3	40 50	CL		CLAY, w/few pebbles, stiff, blue-gray	4" casing to 37'
681.3	60	GC		Clayey GRAVEL w/BOULDER (12")	
680.3		SC		Clayey SAND	
663.3	70 80	GP		Sandy GRAVEL w/Cobbles Top of Rock @ 80.0	NX casing to 83.0'
647.1	90			BASALT, near-black, hard Interpreted as middle of flow Jointed at 0.1' to 1.3' intervals w joints chlorite coated & many slickensided	Triconed to 83.0' NX core Full water return
	100			Bottom @ 96.2	No pressure test

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 80.0 **DIAMETER OF HOLE** 4-1/4" O.B., NX *in Rock*
DEPTH OF O.B. 54.5 **DATE STARTED** 1 June 1965
ROCK DRILLED 25.5 **DATE COMPLETED** 8 June 1965
% CORE RECOVERED 100% **CONTRACTOR** KOR-IT CO., INC.

SURFACE EL 801.8 HOLE NO 65-DD-38 **N** 763,124 **E** 1 231,552

ELEVATIONS 801.8	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
800		ML		Gravelly SILT, loose, tan	Operation, 4-1/4" Tricone w/mud in open hole to depth 54.5' No recovery of drive samples Over-burden classification by drill action, mud loss, and examination of mud return
	10 20	GM		Silty Sandy GRAVEL w/few Cobbles, compact, gray	
780.8		SP		SAND, gray	
779.8		GM		Silty Sandy GRAVEL, compact, gray	
776.8	30 40	GM & GP		Interbedded Silty Sandy GRAVEL and Sandy GRAVEL, compact, gray	
759 8		SP & GP		Gravelly SAND interbedded w/Sandy GRAVEL, compact, gray	
755.6	50	GP GM & SP		Interbedded Sandy GRAVEL, Silty Sandy GRAVEL, and SAND, compact, gray. (SAND in 4" to 12" beds) Top Rock @ 54.5'	NX casing seated at 54.7'
747.3				BASALT as below	Operation, NX core w/ water.
744.3				Tuffaceous SHALE, dark-gray, interbed or clastic dike	
743.2	60 70 80			BASALT, dark-gray, felsitic texture, amygdaloidal, mod. hard to hard, chlorite-coated joints w/ mirror polish surfaces forming curved planes at 0.1' to 0.7' intervals, trace clay & carbonate on some joints. Interpreted as one or two pillow BASALT flows.	
721.8				Bottom @ 80.0'	No pressure test

WYNOOCHEE DAM **PROJECT** MILE [illegible] WYNOOCHEE **RIVER**

DEPTH OF HOLE 47.0 **DIAMETER OF HOLE** 4-1/4 O.B., NX in rock
DEPTH OF O.B. 14.2 **DATE STARTED** 24 May 1965
ROCK DRILLED 32.8 **DATE COMPLETED** 28 May 1965
% CORE RECOVERED 100 **CONTRACTOR** KOR-IT Co., INC.

SURFACE EL 774.8 **HOLE NO** [illegible] DD-9 **N** 763 267 **E** 1 231 4·4

ELEVATIONS 774.8	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
771.5		ML		Gravelly SILT, brown	Operation, 4-1/4" tricone, water, open hole Lost all water at 5'
769		GM & GP		Interbedded Silty Sand, GRAVEL & Sandy GRAVEL, brown & gray	Overburden classification by drill action, mud loss, & examination of mud return.
	10	GM		Silty Sandy GRAVEL w/few Cobbles, gray; increasing compaction w/ depth	4" casing seated at 14.2'
760.6				Top of Rock @ 14.2'	
	20 30 40			BASALT, gray, to gray-green, mod. hard to hard, amygdaloidal, pillow-structure w/ curved chlorite-carbonate seams 1/100" to 1/4" wide on 1/2" to 6" centers; core lengths 0.05' to 4.0'	Operation, NX core drilled w/ water No water loss in rock
727					
	50			Bottom @ 47.0'	Pressure test Packer bottom at 15.0' Pressure 30# Inflow 0.04 cfm

WYNOOCHEE DAM PROJECT MILE 51.8, WYNOOCHEE RIVER

DEPTH OF HOLE 100.0 DIAMETER OF HOLE 4-1 4" O.B. NX in Rock
DEPTH OF O.B. 74.0 DATE STARTED 23 June 1965
ROCK DRILLED 26 0 DATE COMPLETED 14 July 1965
% CORE RECOVERED 100% CONTRACTOR KOR-IT CO., INC.

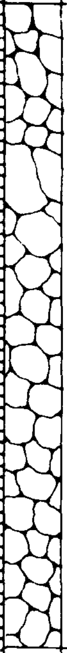
SURFACE EL 764.6 HOLE NO 65-DD-40 N 762 756 E 1,231,104

ELEVATIONS 764.6	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
752.6	10	GM	I	Silty GRAVEL, loose, brown	Drill w tricone & mud 13.9%
747.6		GP		Sandy GRAVEL w Cobbles	Lost all mud
740.1	20	GM		Silty Sandy GRAVEL w Cobbles, brown	Slight mud loss
737.6		GC		Clayey GRAVEL, compact, gray	
729.6	30	GM		Silty Sandy GRAVEL w Cobbles, compact, gray	
704.8	40 50 60	CL (lab)	I I I	Gravelly CLAY, stiff, blue-gray	41.2%, LL 44 PI 19 No mud loss 16.4% LL 45 116PCF PI 20 33.4% LL 45 PI 2
694.6	70	GP		Sandy GRAVEL w Cobbles	Lost all drill mud
690.6		GM		Silty GRAVEL, (possible till) Top of Rock 74.0	NX casing to 70' Open hole 70 to 74 Suggests glacial till
[illegible]	80 90 100			BASALT, pillow structure, amygdaloidal, near-black. Mod hard to 77.0' & hard below. Joints at 0.1' to 0.2' intervals from 74.0 to 79.0' and 0.1' to 1.8' intervals from 79.0' to 100.0', joints are chlorite-coated.	NX core below 75.0
				Bottom 100.0'	No pressure test

WYNOOCHEE PROJECT MILE 51.6, WYNOOCHEE RIVER

DEPTH OF HOLE 58.7 DIAMETER OF HOLE NX
DEPTH OF O.B. 3.2 DATE STARTED August 1965
ROCK DRILLED 55.5 DATE COMPLETED 14 August 1965
% CORE RECOVERED 100% CONTRACTOR NOR-IT CO., INC.

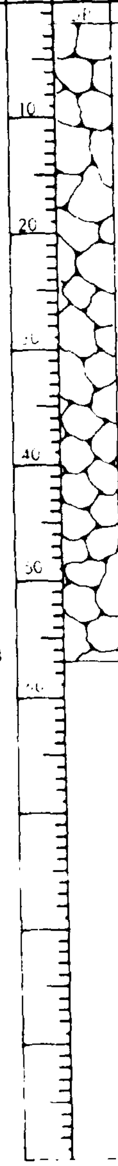
SURFACE EL 627.3 **HOLE NO** 65-DD-41 **N** 763,328 **E** 1,231,0[illegible]

ELEVATIONS 627.3	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
624.1		GP		Sandy GRAVEL, gray, w Cobbles (6")	4-1 4" tricone
568.6	10 20 30 40 50 60			Top of Rock @ 3.2 Geologic description. BASALT, black, hard, nail just scratches, pillow-structure, locally 1 8" feldspars, few carbonate amygdules, locally carbonate veins and lenses to 1" thick, up to 1 2" palagonitic rind on some pillows. Joints incipient and closed w no weathering or staining. Surfaces curved and show mirror-polish on near-black chloritoid coating; trace slickensides attributed to rock swell and not to tectonics. Closed joints break open w finger pressure but are discontinuous and mass shear strength is high if confined. Core lengths 1 4" to 6"	NX core
	70 80 90 100			Bottom 58.7	Pressure test Packer bottom at 7.3' Water pressure 30# No inflow

WYNOOCHEE DAM **PROJECT** MILE 51.?, WYNOOCHEE RIVER

DEPTH OF HOLE 57.2 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 2.0 **DATE STARTED** August 1965
ROCK DRILLED 55.2 **DATE COMPLETED** August 1965
% CORE RECOVERED 100 **CONTRACTOR** [illegible] INC.

SURFACE EL 630.5 **HOLE NO** DD 42 **N** [illegible] **E** 1,231,111

ELEVATIONS 630.5	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
628.5				Sand, GRAVEL, loose, gray	4-1/4 tricone w/ casing to 2.0
				Top Rock 2.0'	NX core Full water return
				BASALT black, hard (nail just scratches pillow structure, locally 1 3" feldspars few CaCO$_3$ amygdules, locally CaCO$_3$ veinlets to 1" thickness, palagonitic rinds to 1 2" thick on some pillows,	
				Joints incipient and closed, some weathering or staining; surfaces curved and show mirror-polish or chloritoid coating; trace slickensides attributed to rock swell and not to tectonics, closed joints break open w finger pressure but are discontinuous and mass shear strength is high if confined. Core lengths 1 4" to 6"	
573.3				Bottom 57.2	Pressure test Bottom of packer at 5.0' Water pressure 55# No inflow

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 56.8 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 1.8 **DATE STARTED** 15 August 1965
ROCK DRILLED 55.0 **DATE COMPLETED** 17 August 1965
% CORE RECOVERED 100% **CONTRACTOR** KOP-IT CO., INC.

SURFACE EL 631.2 **HOLE NO** 65-DD-43 N 763,512
E 1,231,151

ELEVATIONS 631.2	**DEPTH**	**GRAPHIC LOG**	**CORE %** 0 100	**DESCRIPTION OF MATERIALS**	**REMARKS**
629.4		GP		Sandy GRAVEL, loose, gray	Tricone to 3.9'
	10 20 30 40 50			Top of Rock 1.8' BASALT black, hard (just scratches w nail), pillow structure w palogonitic rind and few carbonate amygdules, locally 1 8" feldspars, CO_3 veins to 1" thick Joints closed & incipient w no staining or weathering; curved joint surfaces show mirror-polish on chloritoid coatings; trace slickensides attributed to rock swell and not to tectonics, closed joints break open w/ finger pressure but are discontinuous & shear strength is high if confined. Core lengths range from 1 4" to 12" w 1 2 of core pieces ranging from 4" to 12"	
574.4	60			Bottom 56.8	Pressure Test Bottom of packer at 7.8' Water pressure 30# No inflow

W[illegible]NOOCHEE DAM PROJECT MILE 51.[illegible], WYNOOCHEE RIVER

DEPTH OF HOLE 48.[illegible] DIAMETER OF HOLE 36

DEPTH OF O.B. 47.0 DATE STARTED 21 [illegible] 1965

ROCK DRILLED 1.0 DATE COMPLETED 19 August 1965

% CORE RECOVERED [illegible] CONTRACTOR [illegible] A.E.D., Seattle

SURFACE EL 604.1 HOLE NO 84-54 N [illegible] E 1,230,[illegible]31

ELEVATIONS 804.1	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
603.1		GC		Clayey GRAVEL, soft, red-brown	
		GW (Lab)		and GRAVEL, compact, [illegible] w [illegible] cobbles to 10" & trace silt, graded	LL [illegible] PI [illegible]
	10			Clayey GRAVEL, w many cobbles (8" [illegible] compact, wet, brown	LL 41 PI 1[illegible]
		GW-GC (Lab)			
	20				LL 32 PI 12
					LL 34 PI 1[illegible]
	30				
7[illegible].1				Clayey GRAVEL w [illegible] w [illegible] w Cobb[illegible] [illegible] brown	
766.6		GC			
764.6	40	GM		Silty Sandy GRAVEL, hard (cemented)	Water seeping [illegible]
		GM		Gravelly Silty SAND w Boulders, hard gray (till)	
757.1				Top of Rock 47.0	
756.1				BASALT	
	50			Bottom 48.0	

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 10.0 **DIAMETER OF HOLE** --
DEPTH OF O.B. 10.0 **DATE STARTED** 2 July 1965
ROCK DRILLED -- **DATE COMPLETED** 2 July 1965
% CORE RECOVERED -- **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 796.3 HOLE NO 65-BH-55 **N** 763,138 **E** 1,231,525

ELEVATIONS 796.3	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
		GM (Lab)	◁	Silty Sandy, GRAVEL, loose, brown	
792.3		GM (Lab)	◁	Silty Sandy GRAVEL, in interbedded lenses (4" to 12"), loose, brown & compact, gray	
790.3		GM (Lab)	◁		
786.3	10			Silty Sandy GRAVEL, compact, gray Bottom @ 10.0	

WYNOOCHEE DAM PROJECT MILE 21.8, WYNOOCHEE RIVER

DEPTH OF HOLE	12.0	**DIAMETER OF HOLE**	--
DEPTH OF O.B.	12.0	**DATE STARTED**	28 July 1965
ROCK DRILLED	--	**DATE COMPLETED**	28 July 1965
% CORE RECOVERED	--	**CONTRACTOR**	U.S.A.E.D., Seattle

SURFACE EL 787.8 **HOLE NO** 65-BH-56 **N** 763,160 **E** 1,231,494

ELEVATIONS 787.8	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
		GM [illegible]		Silty Sand, GRAVEL w Cobbles (4") cemented, brown	
780.8		SP		*Gravelly SAND (coarse, gray (openwork)	*Laboratory classification sample is GP, Sandy Gravel
778.8	10	SP & GP		Interbedded Gravelly SAND & Sandy GRAVEL, gray (openwork)	
775.8				Bottom @ 12.0	

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 15.0 **DIAMETER OF HOLE** 36"
DEPTH OF O.B. 15.0 **DATE STARTED** 12 August 1965
ROCK DRILLED -- **DATE COMPLETED** 13 August 1965
% CORE RECOVERED -- **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 771.1 HOLE NO 65-BA-57 **N** 764,083 **E** 1,231,048

ELEVATIONS 771.1	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
769.6		ML		Gravelly Sandy SILT, Soft, wet, brown	
765.1		GM		Silty Sandy GRAVEL w/numerous Cobbles (11"), loose, wet, brown	Water level 4.0'
764.1		GP		Sandy GRAVEL, loose (water bearing)	
761.1	10	SM		Silty SAND (fine) dense, gray w thin layers of SP, SAND (medium)	
757.1		CL		CLAY, stiff, multi-colored	Layer of GP, GRAVEL (water bearing) from depth 11.3 to 11.8
756.1		SC		Gravelly Clayey SAND w Boulders hard, gray (till)	
				Refusal @ 15.0 in Glacial Till	

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 35.3 **DIAMETER OF HOLE** 36"
DEPTH OF O.B. 35.0 **DATE STARTED** 16 August 1965
ROCK DRILLED -- **DATE COMPLETED** 19 August 1965
% CORE RECOVERED -- **CONTRACTOR** U. S. A. E. D., Seattle

SURFACE EL 783.0 **HOLE NO** 65-BA-62 **N** 763,217 **E** 1,231,559

ELEVATIONS 783.0	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
782.0		ML		Gravelly Clayey SILT, soft, wet, brown	
	10	GM & GP		Alternate layers of Silty Sandy GRAVEL and Sandy GRAVEL, w many Cobbles (8"), loose, moist, brown	(Composite Sample is GP-GM)
772.0	20	GP (Lab)		Sandy GRAVEL, loose, wet, brown	7.2%, 125 pcf
761.0	30	GP-GC & GW (Lab)		Sandy GRAVEL w Clay, many Cobbles (6"), w layers of Sandy GRAVEL, loose, wet	5.5%, 133 pcf LL 46 PI 20
749.0		GC		Clayey GRAVEL, loose, wet, brown	
748.0				Bedrock, highly fractured	
747.7				Bottom @ 35.3'	

WYNOOCHEE [illegible] **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 50.0 **DIAMETER OF HOLE** 36"
DEPTH OF O.B. 50.0 **DATE STARTED** 23 August 1965
ROCK DRILLED – **DATE COMPLETED** 2[illegible] August 1965
% CORE RECOVERED – **CONTRACTOR** [illegible] A.E.D., Seattle

SURFACE EL 769.6 **HOLE NO** 65-BA-63 **N** 763,012 **E** 1,231,[illegible]81

ELEVATIONS 769.6	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
76[illegible].6		GC		Clayey GRAVEL w a few Cobbles (6"), loose, wet, brown	
	10 20	GM & [illegible]		Alternate layers of silty sand, GRAVEL and Sandy GRAVEL w a few cobbles (6"), loose to compact, gray, (layers dip & slope in all directions interpreted [illegible] pe west	9.4 , 140 pcf [illegible] 2 [illegible] [illegible] , 12[illegible] pcf 32 [illegible] 8 [illegible]omposite samples are [illegible]
739.5	30	GP		Sandy GRAVEL w a few Cobbles (11"), very loose, wet, brown	
734.[illegible]		SP, ML &SM (Lab)		Alternate thin layers of SAND [illegible] and silty SAND (fine), wet, gray, N.[illegible] (water bearing)	Water Level 36.0 26.2[illegible] , [illegible]9 pcf
729.1	40	ML-C (Lab)		Clayey SILT, compact, wet, blue gray (bedding distorted) Bottom 50.0'	[illegible] 24 [illegible]
719.[illegible]	50				

WYNOOCHEE DAM PROJECT MILE 51.8, WYNOOCHEE RIVER

DEPTH OF HOLE 59.0 **DIAMETER OF HOLE** 36"
DEPTH OF O.B. 59.0 **DATE STARTED** 30 August 1965
ROCK DRILLED - **DATE COMPLETED** [illegible] September 1965
% CORE RECOVERED - **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 762.5 **HOLE NO** 65 BA-64 **N** 762,652 **E** 1,231,096

ELEVATIONS 762.5	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
758.5		ML		Silt w Organic Debris, soft, wet, brown	
754.5		GM		Silty Sandy GRAVEL w/few Cobbles(6") & trace of Organic Debris, loose, wet, brown	14.2%, 111 pcf
	10 20 30	GW GM		Sand, GRAVEL w a few Cobbles (6"), loose, wet, brown w pockets of SP, SAND & layers of Silty, Sandy GRAVEL & Clayey Sandy GRAVEL	11.5%, 124 pcf (GM) LL 62 PI 24 (Composite Samples are GP-GM & GW-GC 8.0%, 128 pcf LL 40 PI 15
731.5		[illegible]		Sandy GRAVE[illegible] loose, wet, brown (water bearing)	
727.0	40 50	C (Lab)		CLAY, stiff, moist, brown to gray (in thinly bedded horizontal layers above 48')	24.0%, LL 34, PI 16 26.9%, LL 38, PI 15 33.2%, LL 40, PI 16 39.2%, LL 54, PI 2
703.5				Bottom @ 59.0	

WYNOOCHEE DAM PROJECT MILE 51.8, WYNCOCHEE RIVER

DEPTH OF HOLE 116.7 **DIAMETER OF HOLE** 36" & NX
DEPTH OF O.B. 108.2 **DATE STARTED** 13 Sept 1965
ROCK DRILLED 8.5 **DATE COMPLETED** 6 Oct 1965
% CORE RECOVERED 93% **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 797.7 HOLE NO 65-BA DD-68 **N** 762,725 **E** 1,231,266

ELEVATIONS 797.7	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
		ML		Gravelly SILT, soft, wet, brown	
794.7	10 20	GM & GP	◁ ◁	Alternate layers of Silty Sandy GRAVEL, compact, gray, & Sandy GRAVEL, loose (openwork), brown, w/Cobbles & a few Boulders (14")	LL - 32, PI 5 6.1%, 135 pcf(GM) (Layers dip down slope) (Composite Samples are GP-GM) 4.7, 130 pcf(GP
768.7	30	GW-GM (Lab)	◁	Sandy GRAVEL w/Silt, loose, wet, brown w/lenses of openwork	LL - 48, PI 15 6.3%, 127 pcf (Fines are in small pockets & sticking to coarse fraction)
762.7		GP		Sandy GRAVEL, loose, wet, brown, (openwork)	
758.7	40 50	GM & GP	◁	Silty Sandy GRAVEL, compact, wet, w layers of Sandy GRAVEL, loose (openwork), wet w a few layers of SP, SAND	(Layers dip down-slope) 7.1%, 124 pcf (Composite Sample is GP-GM) Water seeping into hole below 56' but runs out through loose GM in bottom of hole.
738.7	60	SP (Lab)	◁	Gravelly SAND(coarse), compact, saturated, gray & brown (stratified)	Lenses dip downslope 20° to 25°
736.7		GM & SP		Silty Sandy GRAVEL, loose, saturated, brown (some openwork) w/lenses of SAND (fine)	Bucket auger Tricone
726.7	70 80 90	CL (Lab)	◁ ◁ ◁ ◁ ◁ ◁ ◁	CLAY, stiff, blue-gray	LL 30, PI 9 LL 30, PI 11 23.4%, 107 pcf LL 37 PI 14 24.7%, 104 pcf LL 40, PI 20 27.7%, 99 pcf LL 42, PI 17 LL 40, PI 19 34.0%, 90 pcf LL 35 PI 15 29.2%, 99 pcf LL 48, PI 21 32.7%, 91 pcf LL 49 PI 21 33.2%, 92 pcf
[illegible]	100	GC		Clayey GRAVEL	

SURFACE EL 797.7 **HOLE NO** 6[illegible]-BA DD-68 **N** 762,725 **E** 1,231,266

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
694.5		GC		Clayey GRAVEL Top of Rock @ 103.2	
	110		■	BASALT, dark-gray, hard; pillow structure w interstitial carbonate; joints at 1 2' to 2" intervals	Full water return 0.8' core loss by grinding in closely jointed rock. No pressure test.
686.0				Bottom @ 111.7	

NOTE: 2 plastic pipe left in hole & perforated at 33.0' to 73.0' & 94.0' to 104.0'

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 73.5 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 62.5 **DATE STARTED** 20 September 1965
ROCK DRILLED 11.0 **DATE COMPLETED** 28 September 1965
% CORE RECOVERED 100% **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 757.9 **HOLE NO** 65-DD-69 **N** 763,071 **E** 1,231,895

ELEVATIONS 757.9	DEPTH	GRAPHIC LOG	DESCRIPTION OF MATERIALS	REMARKS
753.9		ML	SILT w/Gravel, brown	Drilling w 'NX' tricone bit
	10 20	GM & SP	Sandy Silty GRAVEL w/ a few Boulders & w/ thin layers of SAND	
735.4		GM & GP	Alternate layers of Sandy Silty GRAVEL & Sandy GRAVEL w/a few Boulders	
728.9		SP	SAND (fine)	
727.9	30 40	CL (Lab)	CLAY, stiff, blue-gray	Clay bedding dips 1/4" in 3" 23.3%, LL = 33, PI = 11 27.6%, LL = 35, PI - 13 16.7%, LL = 34, PI = 11 25.8%, LL = 29, PI = 8 25.7%, LL = 32, PI = 11 25.8%, LL = 33, PI = 10 25.8%, LL = 32, PI = 10
707.9	50	GC	Clayey GRAVEL	
704.4		SP	SAND (fine), compact, black	
702.9	60	GP	Sandy GRAVEL w/ a few Boulders Top of Rock @ 62.5	
695.4	70		BASALT, dark-gray, hard; jointed at 1 2" to 8" intervals	100% water return
684.4			Bottom @ 73.5 NOTE: 2" plastic pipe left in hole & perforated @ 23.0' to 30.0' & 50.0' to 63.0'	No pressure test.

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 54.2 **DIAMETER OF HOLE** 36"
DEPTH OF O.B. 54.2 **DATE STARTED** 24 Sept 1965
ROCK DRILLED -- **DATE COMPLETED** 30 Sept 1965
% CORE RECOVERED -- **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 758.4 HOLE NO 65-8A-70 N 762,940 E 1,231,023

ELEVATIONS 758.4	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
		ML		Sandy SILT w/organic Debris, soft wet, brown	
753.4		SP (Lab)	◁	Gravelly SAND w/a few Cobbles (7") loose, wet, gray	Sand is in highly distorted lenses
747.4	10	GP		Sandy GRAVEL w/a few Cobbles (7"), compact, moist, brown (some openwork)	
741.4		GM ML		Sandy Silty GRAVEL w/Boulders & w. lenses of SILT	Lenses dip to the southwest
734.4	20	GM & SP		Sandy Silty GRAVEL w/Cobbles (8") & a few lenses of SAND (fine), brown	Seep at 24.0'
			◁		LL 50, PI 21
	30	CL (Lab)	◁	CLAY, moist to dry, brown to blue-gray	LL 53, PI 25
712.8	40		◁	Lense of SP, SAND (coarse), dry, 43.6' to 43.9'	LL 32, PI = 11
710.4		SP (Lab)	◁	SAND, medium, moist	
704.2	50	GC		Clayey Sandy GRAVEL, very compact w/Cobbles & Boulders (till)	
				Bottom @ 54.2' Top Rock	

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 6.0' **DIAMETER OF HOLE** 36"
DEPTH OF O.B. 6.0' **DATE STARTED** 8 Oct 1965
ROCK DRILLED - **DATE COMPLETED** 8 Oct 1965
% CORE RECOVERED - **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 756.0 **HOLE NO** 65-BA-77 **N** 763,227 **E** 1,230,702

ELEVATIONS 756.0	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
750.0		GP-GM (Lab)	◁	Sandy Gravel w/Silt & few Cobbles	Water Level, 2.5
	10			Bottom @ 6.0	

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 133.2 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 128.2 **DATE STARTED** 15 Oct 1965
ROCK DRILLED 5.0 **DATE COMPLETED** 5 Nov 1965
% CORE RECOVERED - - **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 755.1 **HOLE NO** 65-RD 8 **N** 762,499 **E** 1,230,978

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
	10 20	GM & GP		Alternate Layers of Sandy GRAVEL & Silty Sandy GRAVEL w Cobbles (10")	Tricone 3-7/8" w water in NX casing Variable water loss to 30'
725.1	30	GP		Sandy GRAVEL	80% water loss from 30 to 35'
720.1	40 50 60 70	CL (Lab)		CLAY, stiff, blue-gray	Water level at 720.1 26.3%, LL - 34, PI 11 27.2%, LL 37, PI=15 26.2%, LL 37, PI=15 30.4%, LL 41, PI 19 35.3%, LL 37, PI=12 32.9% 32.6%, LL - 49, PI=23
675 6	80	SP		Gravelly SAND (fine)	Variable water loss below 79.5'
672.1		GC		Sandy Clayey GRAVEL	
670.1	90	ML		Sandy SILT, stiff, brown	
663.1	100	SP & GP		Interbedded SAND & Sandy GRAVEL	Casing parted : 35' Drilling below 85' w tricone in uncased hole.

SURFACE EL 755.1		HOLE NO 65-RD-78			N 762,499 E 1,230,978
ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
	110	SP & GP		Interbedded SAND & Sandy GRAVEL	
641.1		SM & ML		Silty SAND w Lenses of SILT	
633.6	120	GP		Sandy GRAVEL	
631.1		GC		Sandy Clayey GRAVEL (till)	
626.9	130			Top of Rock @ 128.2 BASALT	Triconed to 133.2' BASALT cuttings from 128.2 to 133.2
621.9				Bottom @ 133.2	No pressure test

WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 10.5' **DIAMETER OF HOLE** -
DEPTH OF O.B. 10.5' **DATE STARTED** 19 Oct 1965
ROCK DRILLED - **DATE COMPLETED** 19 Oct 1965
% CORE RECOVERED - **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 785.1 **HOLE NO** 65-BH-82 **N** 763,603 **E** 1,230,410

ELEVATIONS 785.1	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
785.1		ML		SILT w Gravel	
		GW (Lab)		Sandy GRAVEL	[illegible]
774.6	10		◁		
				Bottom @ 10.5	

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 13.0 **DIAMETER OF HOLE** --
DEPTH OF O.B. 13.0 **DATE STARTED** 15 Oct 1965
ROCK DRILLED -- **DATE COMPLETED** 15 Oct 1965
% CORE RECOVERED -- **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 737.7 **HOLE NO** 65-BH-83 **N** 762,705 **E** 1,230,367

ELEVATIONS 737.7	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
735.7		SM (Lab)	◁	Silty Gravelly SAND, brown	
		GW (Lab)	◁	Sandy GRAVEL w/few Cobbles (8")	
	10		◁		
725.7		GP (Lab)			Water Level, 12.5'
224.7				Sandy GRAVEL Bottom @ 13.0'	

WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 13.0' **DIAMETER OF HOLE** --
DEPTH OF O.B. 13.0' **DATE STARTED** 15 Oct 1965
ROCK DRILLED -- **DATE COMPLETED** 15 Oct 1965
% CORE RECOVERED -- **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 739.7 **HOLE NO** 65-BH-88 **N** 763,127 **E** 1,230,736

ELEVATIONS 739.7	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
		GM		Sandy Silty GRAVEL	
735.7		CL (Lab)	◁	Silty CLAY, moist, brown	LL = 66, PI = 33
731.7		GP		GRAVEL, (openwork)	
730.7	10	SW-SC (Lab)	◁	Gravelly SAND w/Clay	LL 80, PI = 39
726.7				Bottom @ 13.0'	

NOOCHEE DAM PROJECT MILE 51.8, WYNOOCHEE RIVER

DEPTH OF HOLE 12.0 DIAMETER OF HOLE --

DEPTH OF O.B. 12.0 DATE STARTED 19 Oct 1965

ROCK DRILLED - DATE COMPLETED 19 Oct 1965

% CORE RECOVERED - CONTRACTOR U.S.A.E.D., Seattle

SURFACE EL 798.5 **HOLE NO** 65-BH-89 N 63,907 E 1,230,359

ELEVATIONS 798.5	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
795.5		GW-GM (Lab)	◁	Sandy GRAVEL w Silt	
			◁		
		G (Lab)		Sandy GRAVEL w Cobbles (3"	
786.5	10		◁		
				Bottom @ 12.0'	

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 12.0 **DIAMETER OF HOLE** --
DEPTH OF O.B. 12.0 **DATE STARTED** 19 Oct 1965
ROCK DRILLED -- **DATE COMPLETED** 19 Oct 1965
% CORE RECOVERED -- **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 801.6 **HOLE NO** 65-BH-90 **N** 764,152 **E** 1,230,369

ELEVATIONS 801.6	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
797.6		GM		Sandy Silty GRAVEL w/Cobbles (10")	
789.6	10	GP (Lab)	◁ ◁ ◁	Sandy GRAVEL w/many Cobbles & Boulders (14")	
				Bottom @ 12.0'	

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 65.0 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 53.5 **DATE STARTED** 16 Nov 1965
ROCK DRILLED 11.5 **DATE COMPLETED** 24 Nov 1965
% CORE RECOVERED 100% **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 770.6 **HOLE NO** 65-DD-94 **N** 764,169 **E** 1,231,175

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
769.6		GM		Sandy Silty GRAVEL w/Cobbles (6")	Water level @ 1.0'
764.1		GP		Sandy GRAVEL w/Cobbles & Boulders (14")	Tricone 3-7/8" w/ water in NX casing
759.6	10	GP SM & SP		Sandy GRAVEL w/Lenses of SAND & Silty SAND, brown to black	
754.1		SP & GP		SAND (medium) w/Lenses of Sandy GRAVEL	
744.6	20	MH & CL (Lab)	I◁ I◁ I◁ I◁	CLAY, stiff, blue-gray	46.9%, LL = 65, PI=32 32.5%, LL = 41, PI=15 35.3%, LL = 47, PI=20 19.8%, LL = 38, PI=18
731.6	30 40	GC		Sandy Clayey GRAVEL, w/Cobbles (8"), compact	
723.6		SM		Silty SAND (fine) w/CLAY Seams @ 40.0' and 43.0'	
717.1	50	GC		Sandy Clayey GRAVEL w/Cobbles (6"), compact (till)	
705.6	60			Top Rock 53.5 BASALT, near-black, mod. hard to hard. Jointed at 1/4" to 12" intervals.	Triconed to 57.0 NX core
				Bottom @ 65.0 NOTE: 2" plastic pipe left in hole & perforated at 9.0' to 16.0' & 40.0' to 47.0'	No pressure test.

WYNOOCHEE DAM PROJECT MILE 51.8, WYNOOCHEE RIVER

DEPTH OF HOLE 57.0' DIAMETER OF HOLE NX
DEPTH OF O.B. 46.0' DATE STARTED 30 Nov 1965
ROCK DRILLED 11.0' DATE COMPLETED 2 Dec 1965
% CORE RECOVERED 100% CONTRACTOR U.S.A.E.D., Seattle

SURFACE EL 778.8 HOLE NO 65-DD-95 N 763,893 E 1,230,881

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
777.8		ML		Sandy SILT	Tricone 3-7 8" w water in NX casing
774.8		GM		Sandy Silty GRAVEL w. Cobbles (6"), brown	
	10	GP & SP		Sandy GRAVEL w. Lenses of SAND (medium) & few Cobbles (8")	
766.8 736.8	20 30 40	GC		Sandy Clayey GRAVEL w/o few Cobbles (6")	Overburden classification by drill action, water loss, and examination of water return
732.8		SP		Sand (medium to coarse) Top Rock 46.0	
721.8	50			BASALT, pillow structure, dark-gray to near black, mod. hard to hard, jointed at 1/2" to 6" intervals	Triconed to 49.4 NX core to 57.0 Full water return
				Bottom @ 57.0 NOTE: 2" plastic pipe left in hole, perforated 41.0' to 47.0'	No pressure test

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 69.3 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 59.2 **DATE STARTED** 7 Dec 1965
ROCK DRILLED 10.1 **DATE COMPLETED** 9 Dec 1965
% CORE RECOVERED 100% **CONTRACTOR** U.S.A.E.D., Seattle

SURFACE EL 745.9 **HOLE NO** 65-DD-96 **N** 763,125 **E** 1,230,380

ELEVATIONS 745.9	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
741.9		GM		Sandy Silty GRAVEL w/Cobbles (6")	Tricone 3-7/8" w/water in NX casing
738.9		GP		Sandy GRAVEL	
	10 20	CL		CLAY, stiff, blue-gray	Overburden Classification by drill action water loss, & examination of water return
714.9	30 40 50	GM		Sandy Silty GRAVEL, compact, (till) Top Rock 59.2	
686.9	60			BASALT, dark-gray to near-black, mod. hard to hard, jointed at 1" to 7" intervals.	Triconed to 61.2' NX core to 69.3
676.6				Bottom @ 69.3	No pressure test

WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 64.1 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 49.8 **DATE STARTED** 22 March 1966
ROCK DRILLED 14.3 **DATE COMPLETED** 25 March 1966
% CORE RECOVERED 100 **CONTRACTOR** U.S.A.E.D. Seattle

SURFACE EL 812.6 **HOLE NO** 66-DD-100 **N** 764,578 **E** 1,231,421

ELEVATIONS 812.6	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
811.6		GM		SANDY SILTY GRAVEL, brown	Standpiped and triconed to 49.8 Overburden classification by drill action, water loss and examination of water return
	10 20 30	GP		SANDY GRAVEL w few cobbles, & layers of open work	0 to 40% water return, clear, caves Water level 22.6'
777.6	40	SM		Silty SAND, (fine to medium), brown	40% water return, brown
771.6		GC		Clayey GRAVEL	
771.1		CL		CLAY, compact, blue-gray	90% water return, gray
764.6		GC		Sandy Clayey GRAVEL, Compact (Till)	
762.8	50 60			Top rock 49.8 Basic igneous rock, gray, hard: intergrowth of 1 8" to 3 4" white plagioclase plates and pyroxenes w planer crystal orientation in almost vertical plane giving pseudo-gneissic appearance Jointed at 0.1 to 2.0' intervals	NX core
748.5	70			Bottom hole 64.1 NOTE: 2" plastic pipe left in hole, perforated 0.0' to 41.0'	

WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 84.2 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 73.0 **DATE STARTED** 9 March 1966
ROCK DRILLED 11.2 **DATE COMPLETED** 18 March 1966
% CORE RECOVERED 100% **CONTRACTOR** U.S.A.E.D. Seattle

SURFACE EL 787.7 **HOLE NO** 66-DD-101 **N** 764,185 **E** 1,230,842

ELEVATIONS 787.7	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
782.7		SP		Gravelly SAND, (coarse) w lenses of open work	50% water return, clear
767.7	10 20	GP		Sandy GRAVEL w cobbles (6") w lenses of open work	Standpiped & triconed to depth 75.2 50% water return, clear Water level 9.9'
762.7		SM		Silty SAND, medium to fine, brown	80% water return, brown
729.0	30 40 50 60	GM & GP		Silty Sandy GRAVEL w/few cobbles w layers of Sandy GRAVEL, compact, brown	Overburden classification by drill action, water loss and examination of water return 90% water return, brown w/few short clear intervals
714.7	70	GC		Clayey GRAVEL w/few cobbles, clay content increases w/depth. (Till) Top of rock at 73.0	
703.5	80	▨		BASALT, medium to dark-gray, hard, fine-grained; intrusive or middle portion of flow; jointed at 0.1' to 1.0' intervals.	Rock triconed to 75.2 NX core
	90			Bottom at 84.2 NOTE: 2" plastic pipe left in hole, perforated 1.0' to 25.0'	

WYNOOCHEE DAM PROJECT MILE 51.8 WYNOOCHEE RIVER

DEPTH OF HOLE 71.2 DIAMETER OF HOLE Nx
DEPTH OF O.B. 54.3 DATE STARTED 28 March 1966
ROCK DRILLED 16.9 DATE COMPLETED 31 March 1966
% CORE RECOVERED 100% CONTRACTOR U.S.A.E.D. Seattle

SURFACE EL 790.4 HOLE NO 66-DD-102 N 764,380 E 1,231,034

ELEVATIONS 790.4	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
	10 20	GP		Sandy GRAVEL w few cobbles (8") w lenses of open work	Standpiped and triconed to 56.3 50% water return Water level 18.4' Overburden classification from drill action, water loss, and examination of water return
762.4	30	GC		Clayey GRAVEL, brown	100% water return
761.0		GC		Clayey GRAVEL, blue-gray	100% water return
759.4	40	GM		Sandy Silty GRAVEL, compact	100% water return
748.4	50	GP		Sandy GRAVEL w few cobbles Top rock 54.3	60% water return
736.1	60 70			Basic coarse-grained intrusive rock, dark-gray, hard, variable reaction zone characterized by unoriented cumulophyric aggregate of pyroxenes to 1" diameter, jointed at 0.1' to 2.0' intervals	Nx core
719.2	80			Bottom hole 71.2 NOTE 2" plastic pipe left in hole, perforated 42.0' to 54.3'	

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 12.0 **DIAMETER OF HOLE** --
DEPTH OF O.B. 12.0 **DATE STARTED** June 1966
ROCK DRILLED - **DATE COMPLETED** June 1966
% CORE RECOVERED -- **CONTRACTOR** U.S.A.E.D., Seattle

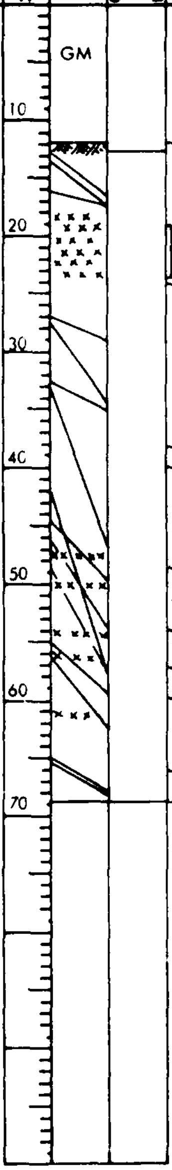
SURFACE EL 773.0 **HOLE NO** 66-DC-110 **N** 763,405 * **E** 1,230,825 *

ELEVATIONS 772.0	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
766.0		GM & GP		Silty Sandy GRAVEL w layers of Sandy GRAVEL	
764.0		CL		CLAY	
	10	GM		Silty Sandy GRAVEL, compact (Till) Top of Rock @ 12.0	
760.0				Basalt, dark-gray, hard, jointed	
				Log of existing cut slope	* Coordinates scaled from plan sheet

WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 68.6 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 11.9 **DATE STARTED** 18 October 1966
ROCK DRILLED 56.7 **DATE COMPLETED** 21 October 1966
% CORE RECOVERED 100% **CONTRACTOR** USAED Seattle

SURFACE EL 737.4 **HOLE NO** 66-DD-115 **N** 763,157 **E** 1,230,999

ELEVATIONS 737.4	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
				Silty sandy GRAVEL w cobbles (FILL)	Tricone to 12.6' Overburden classification by drill action & observation of water return
725.5				BASALT, hard, finely crystalline, fresh, dark gray, with numerous closely spaced joints stained brown, joint spacing 0.05'-0.9' Very closely spaced joints	Top of rock 11.9 Water level 7.3'
				BASALT, (as above) joint spacing mostly 0.4-0.6 most joints stained	
				Jt 80 degree dip, slickensides and gouge	
				BASALT, (as above) few joints stained, joint spacing mostly 0.4-0.6 47.0-47 5 Closely jointed Jts 65 degree-vert dip, FeO stained, trace silt 49.5-50.0, 53.7-54.4, 55.7-56.7 Closely jointed 2 Jts 45-60 degree dip FeO stained, trace silt 61.0-62.0 Closely jointed FeO stained 2 Jts FeO stain, trace silt	
668.8					Bottom @ 68.6

WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 83.3 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 18.9 **DATE STARTED** 24 October 1966
ROCK DRILLED 64.4 **DATE COMPLETED** 27 October 1966
% CORE RECOVERED 100% **CONTRACTOR** USAED Seattle

SURFACE EL 736.9 **HOLE NO** 66-DD-116 **N** 763,141 **E** 1,230,981

ELEVATIONS 736.9	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
	10	GM		Silty GRAVEL w/cobbles (FILL)	Tricone to 18.9' Overburden classification by drill action, water loss and observation of water return Btm. casing @ 18.2 Top of rock 18.9 Dry
718.0	20 30 40 50 60 70 80			Closely jointed and weathered brown 2 Jts 45 degree, open 1/8-1/4" * BASALT, hard, finely crystalline, partly weathered, with numerous closely spaced brown stained joints and numerous irregular thin calcite and gypsum veinlets 3 Jts 25-55 degrees open 1/8" - 1/4" * Jt 20° open 1/8" * BASALT, (as above) fresh with numerous joints, few stained tan, joint spacing 0.1 - 0.5' BASALT, (as above) many stained joints Jts 5 - 10 degree dip, trace clay Jt 50 degree dip trace clay BASALT, (as above) joint spacing mostly 0.5 - 1.0, no stained joints. 2 Jts 25 - 45 degree dip trace clay	
653.6				* Joints dip north to northwest (riverward)	Bottom @ 83.3 28 Oct 66 Water level 40.0 3 Nov 66 Water level 30.0

WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 40.5 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 21.4 **DATE STARTED** 1 November 1966
ROCK DRILLED 19.1 **DATE COMPLETED** 2 November 1966
% CORE RECOVERED 100% **CONTRACTOR** USAED Seattle

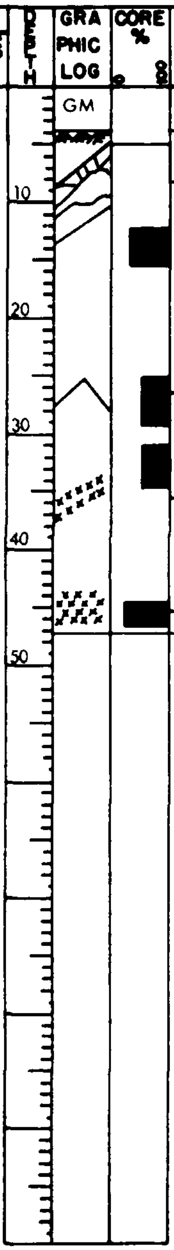
SURFACE EL 737.3 **HOLE NO** 66-DD-117 **N** 763,103 **E** 1,230,999

ELEVATIONS 737.3	**DEPTH**	**GRAPHIC LOG**	**CORE %** 0 100	**DESCRIPTION OF MATERIALS**	**REMARKS**
		GM		Silty GRAVEL (FILL)	Tricone to 22.0' Overburden classification by drill action, and observation of water return
	10				
724.8		OL		Organic SILT, black	Top original ground @ 12.5'
723.8		ML		SILT, tan	
718.3	20	GM		Silty GRAVEL, tan	Top of rock 21.4
715.9				Closely spaced stained joints, 0.1 - 0.3 apart Jt 50 degree dip open 1 16" * Most joints 0.3' apart 2 Jts 35 - 45 degree dip open 1 16" ** Jt 60 degree dip, 1/16" gray gouge	Water level 8.0
	30				
	40				
696.8				BASALT, hard, finely crystalline, fresh, dark gray, with some joints stained brown * Joint dips southeast (away from river) ** Joints dip north to northwest (riverward)	Bottom @ 40.5

WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 47.1 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 3.5 **DATE STARTED** 8 November 1966
ROCK DRILLED 43.6 **DATE COMPLETED** 16 November 1966
% CORE RECOVERED 89% **CONTRACTOR** USAED Seattle

SURFACE EL 746.4 **HOLE NO** 66-DD-118 **N** 763,289 **E** 1,230,928



ELEVATIONS 746.4	DESCRIPTION OF MATERIALS	REMARKS
	Silty Sandy GRAVEL, brown	Tricone to 4.9'
742.9	BASALT, hard, fine grained, weathered joints every 0.05 - 0.4'	Top of rock 3.5 Bottom casing @ 4 9 NX core below 4.9
738.4	Pillow BASALT, mod hard, dark gray, joints 0.05 - 1.0 Jt dip 40 degrees, open 1" @ 7' * Jts open 1/8" - 1/16" @ 7.9 & 10.7 Jt trace clay @ 12.9 Jt dip 45 degrees, open 1/8" @ 26.2 ** Jts slightly stained @ 19.9 34.6, 35.1, 35.3, 35.6, 35 9 Joints 0.05 - 0.1, stained brown	Core losses all due to grinding
699.3	*Joint dips riverward (southeast) ** Joint dips toward and away from river (southeast and northwest) Hole examined with light and mirror to 44.0' All pillow basalt core pieces flawed by minor incipient cooling cracks at 1/2" to 1" intervals	Bottom @ 47.1 Water level @ 28.0 w/water entering hole @ 4 9 17 Nov 66 Hole bailed to 46.1 & water level rose 2'/hr 19 Nov 66

WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 62.1 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 8.0 **DATE STARTED** 17 November 1966
ROCK DRILLED 54.0 **DATE COMPLETED** 18 November 1966
% CORE RECOVERED 100% **CONTRACTOR** USAED Seattle

SURFACE EL 749.5 **HOLE NO** 66-DD-119 **N** 763,271 **E** 1,230,894

ELEVATIONS 749.5	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
748.5		ML		SILT, brown	Tricone to 8.0 Overburden classification by drill action and observation of water return
		GP & GM		Sandy GRAVEL and Silty Sandy GRAVEL	
741.5	10			Pillow BASALT, mod hard, dark gray, joints, stained brown, 0.05 - 1.1 spacing.	Top of rock 8.0 NX core below 8.0
735.5				BASALT, hard, fine-grained, dark gray, joints 0.05-1.2 apart, all stained brown Jt 80 degree dip, open 1/8", weathered 1" @ 13.2 *	Bottom casing @ 12.4
	20				
				Jt open 1/8", w/clay @ 13.8	
	30				
				Jts 20-25 degree dip, open 1/8" 19.0 and 32.0 *	
	40			Jt 40 degree dip open 1/2" *	
				BASALT, (as above) joints 0.1 - 0.9 spacing with most stained brown from 24.5' to 62.1'	
	50				
	60				
687.4					Bottom @ 62.1
				* Joints dip riverward (southeast)	Water level 35.7' 19 Nov 66
				Hole examined with light and mirror to 36.2	Hole bailed to 36.2 Water pouring into hole from jt @ 36.2

WYNOOCHEE DAM PROJECT MILE 51.8 WYNOOCHEE RIVER

DEPTH OF HOLE 92.2 DIAMETER OF HOLE NX
DEPTH OF O.B. 1.5 DATE STARTED 14 November 1966
ROCK DRILLED 90.7 DATE COMPLETED 28 November 1966
% CORE RECOVERED 100% CONTRACTOR U.S.A.E.D. Seattle

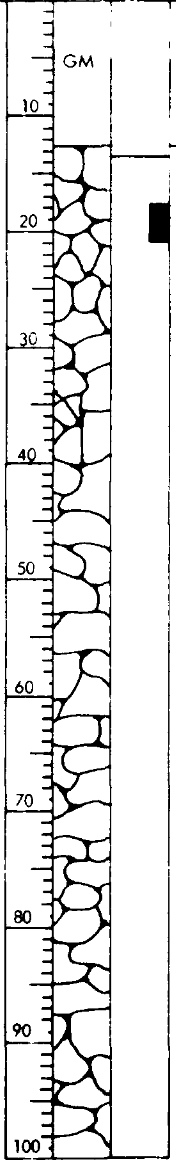
SURFACE EL 724.0 **HOLE NO** 66-DD-120 N 763,598 E 1,231,126

ELEVATIONS 724.0	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
722.5		ML		SILT, soft, brown	Triconed to 5.4' cased to 2.0' NX core below 5.4
	10			Top of Rock @ 1.5' BASALT, gray, hard w/feldspar and mafic phenocrysts, CO_3 veinlets Stained joints at 0.1' to 0.6' intervals to depth 19.0' Gradational contact 19'	
705.0	20 30			BASALT, dark-gray, hard w/mafic phenocrysts, curved CO_3 veinlets suggestive of pillow structure. Mafic phenocrysts decrease in size and abundance to depth 40'. Stained joints at 0.1' to 0.8' intervals to depth 44.0' Gradational contact @ 40'	Traces of clay on some joints to depth 36' With surface water running into the hole below casing, the lowest measured water level was 20.0'
684.0	40 50 60 70 80 90			BASALT, dark-gray, moderate hard w/curved CO_3 veinlets and altered glass rinds indicative of pillow basalt flow Unstained joints at 0.05' to 1.2' intervals joints coated with chloritoid film showing a mirror polish. Incipient cooling cracks at 0.05' to 0.1' intervals.	
631.8				Bottom @ 92.2'	
	100				

WYNOOCHEE DAM PROJECT MILE 51.8 WYNOOCHEE RIVER

DEPTH OF HOLE 112.2 DIAMETER OF HOLE NX
DEPTH OF O.B. 12.5 DATE STARTED 23 January 1967
ROCK DRILLED 99.7 DATE COMPLETED 26 January 1967
% CORE RECOVERED 99.0% CONTRACTOR U.S.A.E.D. Seattle

SURFACE EL 758.3 **HOLE NO** 67-DD-123 N 763,307 E 1,231,184



ELEVATIONS 758.3	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
		GM		Silty sandy GRAVEL w. lenses of sand	
745.8				Top of Rock 12.5	
				BASALT, amygdaloidal with pillow structure and minor palagonitic zones, dark-gray, moderately hard.	Triconed to 13.5' NX core below 13.5'
					Core loss 1.1'from 17.6' to 20.7'by drill grinding in closely jointed rock.
				Jointed at 0.02'to 0.5' intervals with all joints stained from 12.5' to 22.0'	
				Trace clay in few joints from 26.0' to 32 0'	At a hole depth of 32.0' water level was at a depth of 24.8' & remai at this depth until the hole was deepened to 48.4'
				Jointed at 0.05' to 1.5' intervals w mostly small pieces, many weathered, depth 22.0' to 48.0'	
				Trace clay in few joints from 46.0' to 47 0' and from 52.0'to 53.0'	At hole depth 48.4' water level was at depth 26 2'
				Jointed at 0.1' to 0.8' intervals with a few joints stained from 48.0'to 55.0'	
				Unstained joints coated with chloritoid film showing a mirror polish	
				Jointed at 0.1' to 1.6' intervals and no staining from 55.0'to 112.2'	
					At a hole depth of 80.0', the water level was at a depth of 27.0'

SURFACE EL 758.3 HOLE NO 67-DD-123 N 763,307 E 1,231,184

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
				Rock as above	
646.1	110				Water level 24.8'
				Bottom 112.2'	
	120				

WYNOOCHEE DAM PROJECT MILE 51.8 WYNOOCHEE RIVER

DEPTH OF HOLE 72.2 DIAMETER OF HOLE NX
DEPTH OF O.B. 67.0 DATE STARTED 16 February 1967
ROCK DRILLED 5.2 DATE COMPLETED 3 March 1967
% CORE RECOVERED 85 CONTRACTOR U.S.A.E.D Seattle

SURFACE EL 708.0 **HOLE NO** 67-DD-124 N N 763,483 E 1,232,150 *

ELEVATIONS 708.0	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
		GP		Sandy GRAVEL w cobbles to 10" compact, wet, brown	Tricone to 53.0'
702.0	10	CL		Sandy CLAY very stiff, moist, brown	Overburden classification by drill action, water loss and examination of water return
698.0	20	CL		CLAY very stiff, wet, blue-gray	
687.0		GC		Clayey GRAVEL compact, blue-gray (till)	WL remains 1.0' below top of casing. Hole stays open 20' ahead of casing.
680.0	30 40	GM & GP		Silty Sandy GRAVEL w lenses of Sandy GRAVEL, compact	Hole caves at 32' casing to 15' Water level 8.0' Bottom casing at 40.0
665.0	50 60	GM		Silty sandy GRAVEL compact, gray (till)	Water level 8.0' Hard drilling NX core below 53.0'
645.0		GM & GP		Silty Sandy GRAVEL w lenses of sandy gravel, compact, gray	100% water return to 63.0' Water level 8.0'
641.0	70		■	BASALT, Joints at 0.05' to 0.5' intervals.	Top of Rock 67.0' Water level 15.0'
635.8				Bottom : 72.2'	Core loss due to blocking & drill grinding *Scaled coordinates

WYNOOCHEE DAM PROJECT MILE 51.8 WYNOOCHEE RIVER

DEPTH OF HOLE 13.0 DIAMETER OF HOLE -
DEPTH OF O.B. 13.0 DATE STARTED 17 January 1967
ROCK DRILLED - DATE COMPLETED 17 January 1967
% CORE RECOVERED - CONTRACTOR U.S.A.E.D. Seattle

SURFACE EL 750.4 HOLE NO 67-BH-127 N 763,097 E 1,231,039

ELEVATIONS 750.4	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
		GP		Sandy GRAVEL w/occasional cobbles and boulders (18") Compact, Moist, Tan	Road fill Layers apparently dip to West
	10	CL		Silty CLAY Moist, Tan	
737.4		CL		CLAY Hard, Dry, Tan	Water seeping at top of clay Trench 6' long Bearing approximately N 20 degrees W
	20				

WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 14.0 **DIAMETER OF HOLE** -
DEPTH OF O.B. 14.0 **DATE STARTED** 17 January 1967
ROCK DRILLED - **DATE COMPLETED** 17 January 1967
% CORE RECOVERED - **CONTRACTOR** U.S.A.E.D., Seattle

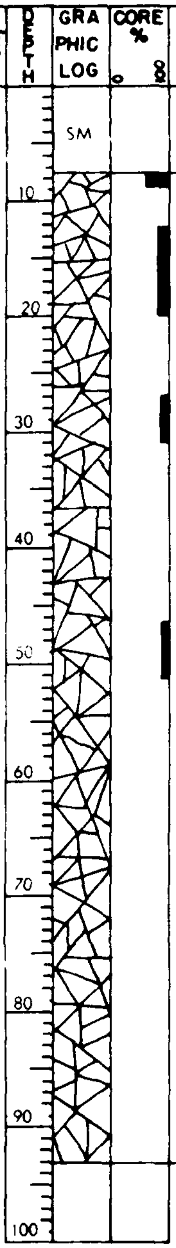
SURFACE EL 749.2 **HOLE NO** 67-BH-128 **N** 763,063 **E** 1,231,029

ELEVATIONS 749.2	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
		CL		CLAY Very soft w roots, brush and debris	Layers apprently dip to West
		GM		Silty GRAVEL Loose, Dry, Reddish Brown	
	10	ML		Gravelly Sandy SILT	
735.2		CL		CLAY Hard, Dry, Tan	Water seeping at top of clay
	20				Trench 6' long Bearing approximately N 65 degrees W

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 93.0 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 7.3 **DATE STARTED** 8 February 1967
ROCK DRILLED 85.7 **DATE COMPLETED** 14 February 1967
% CORE RECOVERED 97.5 **CONTRACTOR** U.S.A.E.D. Seattle

SURFACE EL 737.0 HOLE NO 67-DD-121 **N** 763,518 **E** 1,231,249



ELEVATIONS 737.0	DESCRIPTION OF MATERIALS	REMARKS
	Silty SAND, loose, moist, tan, basalt fragments up to 10" diameter Top of Rock 7.3'	Tricone to 7.3'
729.7	DIORITE, hard, dark-gray intergrowth of 1 8" to 1 2" feldspar and mafic minerals	NX core below 7.3' Core losses 0.5' from 7.3 to 8.8 0.2' 12.3 to 15.6 0.9' 15.6 to 19.8 0.3' 27.0 to 31.0 0.3' 46.6 to 51.5 Losses by grinding in the closely jointed rock.
	Jointed at 0.05' to 0.9' intervals w most of 0.2' intervals	
	Joints stained to depth of 56'	
	Traces of clay on some joints to depth 56.5'	Lowest water level measured between runs was 47.2'
	A few joints stained from depth of 56' to 75'	
	Joints show a chloritoid coating w minor polish below 75'	
	Trace clay at 78'	
644.0	Bottom @ 93.0'	

WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 107.5 **DIAMETER OF HOLE** NX
DEPTH OF O.B. 3.5 **DATE STARTED** 1 February 1967
ROCK DRILLED 104.0 **DATE COMPLETED** 7 February 1967
% CORE RECOVERED 100% **CONTRACTOR** U.S.A.E.D. Seattle

SURFACE EL 760.0 **HOLE NO** 67-DD-122 **N** 763,395 **E** 1,231,199

ELEVATIONS 760.0	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
756.5		GM		Silty Sandy GRAVEL w boulders	
	10			Top of Rock 3.5 DIORITE, medium-grained, gray, hard; veined w carbonate Jointed at 0.1' to 0.5' intervals w all joints stained to depth 16'	Triconed to 5.0' Casing to 5.0' NX core below 5.0'
	20				No water return below 16.0'
				Trace clay on joints from 22.0' - 28.0'	
	30			Most joints stained from depths 11.0' 40.0'	
					At depth 37' water level at 32.4'
	40			Jointed at 0.1 to 1.5' intervals from 16.0' to 57'	
				Trace clay on joints from 47.0' to 57.0'	
	50			Few joints stained from depths 40.0' to 69.0'	
				Almost all unstained joints show a soft platy chloritoid coating	
	60			Weathered joint at 63.0'	At depth 66.9', water level at 62.0'
	70			Jointed at 0.1' to 0.6' from 69.0' to 75.0' w trace clay on a few joints	
				Joints not stained below 69.0'	
	80			Jointed at 0.1' to 1.0' from 75.0' to 107.5'	
	90				
	100				

SURFACE EL 760.0 **HOLE NO** 67-DD-122 **N** 763,395 **E** 1,231,199

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100	DESCRIPTION OF MATERIALS	REMARKS
652.5				Rock as above	At depth 107.5' water level was 58.4
	110			Bottom at 107.5	
	120				

Hole No. P-144

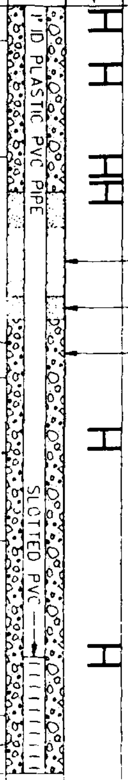
DRILLING LOG

DIVISION NPD

INSTALLATION NPS

SHEET 1 OF 1 SHEETS

1. PROJECT WYNOOCHEE DAM
2. LOCATION *(Coordinates or Station)* N 763,120 E 1,230,520
3. DRILLING AGENCY SOIL SAMPLING SERVICE INC.
4. HOLE NO. *(As shown on drawing title and file number)* 68-CD-144
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 63.5'
8. DEPTH DRILLED INTO ROCK 2.5'
9. TOTAL DEPTH OF HOLE 66.0'
10. SIZE AND TYPE OF BIT 6" CABLE TOOL BIT
11. DATUM FOR ELEVATION SHOWN *(TBM or MSL)*
12. MANUFACTURER'S DESIGNATION OF DRILL CABLE TOOL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE STARTED 4-15-68 COMPLETED 4-18-68
17. ELEVATION TOP OF HOLE 750.7'
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR



ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS *(Description)* d	PIEZ.	BOX OR SAMPLE NO. f	REMARKS *(Drilling time, water loss, depth of weathering, etc., if significant)* g
750.7		GM	SILTY SANDY GRAVEL, MOIST, BROWN			CHURN DRILL USING 6" CASING AND WATER ONLY
747.7'		GP-GM	SANDY GRAVEL WITH SILT, MOIST, GRAY			OVERBURDEN CLASSIFICATION BY DRILL ACTION AND VISUAL INSPECTION OF BAILER SAMPLES AND DRIVE SAMPLES (⌶).
	10					ENCOUNTERED SMALL AMOUNT OF WATER AT 13' (LESS THAN 1GPM)
737.7'		CL	SILTY CLAY, STIFF, MOIST, GRAY TO BLUE-GRAY			
	20					BENTONITE CLAY
						SAND
721.7'	30	ML	SANDY SILT, MOIST, BROWN			GRAVEL BACKFILL
718.7'		SC	GRAVELLY CLAYEY SAND, STIFF, MOIST, SLIGHTLY PLASTIC, GRAY			
	40					
704.7'		SP-SM & GP	GRAVELLY SAND WITH SILT AND OCCASIONAL THIN LAYERS OF SANDY GRAVEL			
	50					
689.7'	60	SC	GRAVELLY CLAYEY SAND (TILL) GRAY			BOTTOM OF CASING 63.5'
687.2'			BASALT WITH CALCITE VEINS			CASING PERFORATED 5'-10 20-25 30-60
684.7'			BOTTOM @ 66.0			
	70					
	80					
	90					
	100					

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MAR 71

PROJECT WYNOOCHEE

HOLE NO. P-144

Hole No. P-145

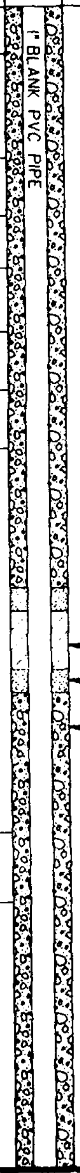
DRILLING LOG

DIVISION NPD

INSTALLATION NPS

SHEET 1 OF 2 SHEETS

1. PROJECT WYNOOCHEE DAM
2. LOCATION *(Coordinates or Station)* N 762,640 E 1,231,090
3. DRILLING AGENCY SOIL SAMPLING SERVICE, INC.
4. HOLE NO. *(As shown on drawing title and file number)* 68-CD-145
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 135.0'
8. DEPTH DRILLED INTO ROCK 2.5'
9. TOTAL DEPTH OF HOLE 137.5'
10. SIZE AND TYPE OF BIT 6" CABLE TOOL
11. DATUM FOR ELEVATION SHOWN *(TBM or MSL)*
12. MANUFACTURER'S DESIGNATION OF DRILL CHURN DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN DISTURBED UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE STARTED 4-3-68 COMPLETED 4-10-68
17. ELEVATION TOP OF HOLE 763.3' [GRND.]
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS *(Description)* d	PIEZ.	BOX OR SAMPLE NO. f	REMARKS *(Drilling time, water loss, depth of weathering, etc., if significant)* g
763.3		ML	SANDY SILT, MOIST, SLIGHTLY PLASTIC, BROWN			CHURN DRILL USING 6" CASING AND WATER ONLY
759.3	10	GP	SANDY GRAVEL, LOOSE, MOIST, BROWN			OVERBURDEN CLASSIFICATION BY DRILL ACTION AND VISUAL INSPECTION OF BAILER SAMPLES DRILLING ± 2' AHEAD OF CASING
750.3		SP-SM	GRAVELLY SAND [COARSE] WITH SILT, MOIST, BROWN			
745.3	20	SM	SILTY SAND [FINE], MOIST, BROWN			
740.8		SP-SM	GRAVELLY SAND [COARSE] WITH SILT, GRAY			
735.3	30	SM	SILTY SAND WITH GRAVEL, BROWN			ENCOUNTERED WATER AT 32'
730.3		GP	SANDY GRAVEL [COARSE], BROWN TO GRAY [WATER BEARING]			BAILING TEST. 16 GPM FOR 15 MIN. 1' DRAWDOWN IN CASING
725.3	40 50 60 70	CL	SILTY CLAY, STIFF, WET, GRAY TO BLUE-GRAY			BENTONITE CLAY SAND GRAVEL BACKFILL
692.3		SP-SM	GRAVELLY SAND WITH SILT, MEDIUM DENSITY, BLUE-GRAY			
686.3	80 90	SM ML SP	SILTY SAND WITH LAYERS OF SILT AND GRAVELLY SAND, MOIST, GRAY			DRILLING + 5' AHEAD OF CASING
663.3	100					

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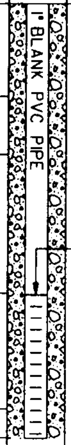
MAR 71

PROJECT WYNOOCHEE DAM

HOLE NO. P-145

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 763.3' [GRND.] | Hole No. P-145

PROJECT WYNOOCHEE DAM | INSTALLATION NPS | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	PIEZ.	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) e
	100	SM ML SP	SILTY SAND WITH LAYERS OF SILT AND GRAVELLY SAND, MOIST, GRAY	 1" BLANK PVC PIPE		
655.3	110	SM	SILTY SAND WITH GRAVEL, GRAY			MATERIAL IS MORE DENSE OR SLIGHTLY CEMENTED BOTTOM OF CASING AT 114.5'
650.3	120	SC	CLAYEY SAND [TILL], VERY COMPACT, GRAY TO BLUE-GRAY			SLOTTED PVC PIPE
638.3	130	SP SC	GRAVELLY SAND WITH CLAY, COMPACT [TILL], ANGULAR, BLUE-GRAY TOP OF ROCK AT 135'			
628.3			BASALT WITH VEINS OF CALCITE			NO WATER ENCOUNTERED BELOW 38' DEPTH
625.8	140		BOTTOM AT 137.5'			CASING PERFORATED: 3'-9' 18'-23' 31'-38' 48'-53' 71'-114'

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MAR 71

PROJECT WYNOOCHEE DAM | HOLE NO. P-145

Hole No. P-146

DRILLING LOG

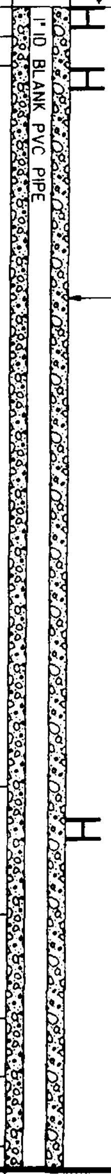
DIVISION NPD

INSTALLATION NPS

SHEET 1 OF 2 SHEETS

1. PROJECT WYNOOCHEE DAM
2. LOCATION (Coordinates or Station) N 763,020 E 1,232,240
3. DRILLING AGENCY SOIL SAMPLING SERVICE, INC.
4. HOLE NO. (As shown on drawing title and file number) 68-CD-146
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 182.5′
8. DEPTH DRILLED INTO ROCK 0
9. TOTAL DEPTH OF HOLE 182.5′
10. SIZE AND TYPE OF BIT 6" CABLE TOOL
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL CHURN DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER 738.6′
16. DATE HOLE STARTED 4-23-68 COMPLETED 5-2-68
17. ELEVATION TOP OF HOLE 805.6
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	BOX OR SAMPLE NO. e	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) f
805.6		ML	GRAVELLY SILT, MOIST, BROWN		CHURN DRILL USING 6" CASING AND WATER ONLY
803.1		GP-GM	SANDY GRAVEL WITH LAYERS OF SAND, MOIST, BROWN TO GRAY		
800.6	10 20 30 40 50 60	GP-GM	SANDY GRAVEL WITH SILT AND OCCASIONAL COBBLES, MOIST, TAN, [PEBBLES HAVE CLAY COATING]		OVERBURDEN CLASSIFICATION BY DRILL ACTION AND VISUAL INSPECTION OF BAILER SAMPLES AND DRIVE SAMPLES [⌶].
738.6	70	GP	SANDY GRAVEL [WATER BEARING] GRAY [VERY LITTLE SAND, MOSTLY GRAVEL]		WATER LEVEL 67′
827.6	80	SP	SAND [MEDIUM], BROWN TO GRAY		BAILING TEST: 24 GPM FOR 15 MIN. WITH NO DRAWDOWN. SAND HEAVED 2′.
718.6	90	SP-SM	SAND WITH SILT AND FINE GRAVEL BROWN		
713.6		SM	SILTY SAND [FINE], GRAY		
707.6	100	CL	SANDY CLAY, MOIST, DARK GRAY		



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PROJECT WYNOOCHEE DAM

HOLE NO. P-146

DRILLING LOG (Cont Sheet)

ELEVATION TOP OF HOLE 805.6' [GRND.]

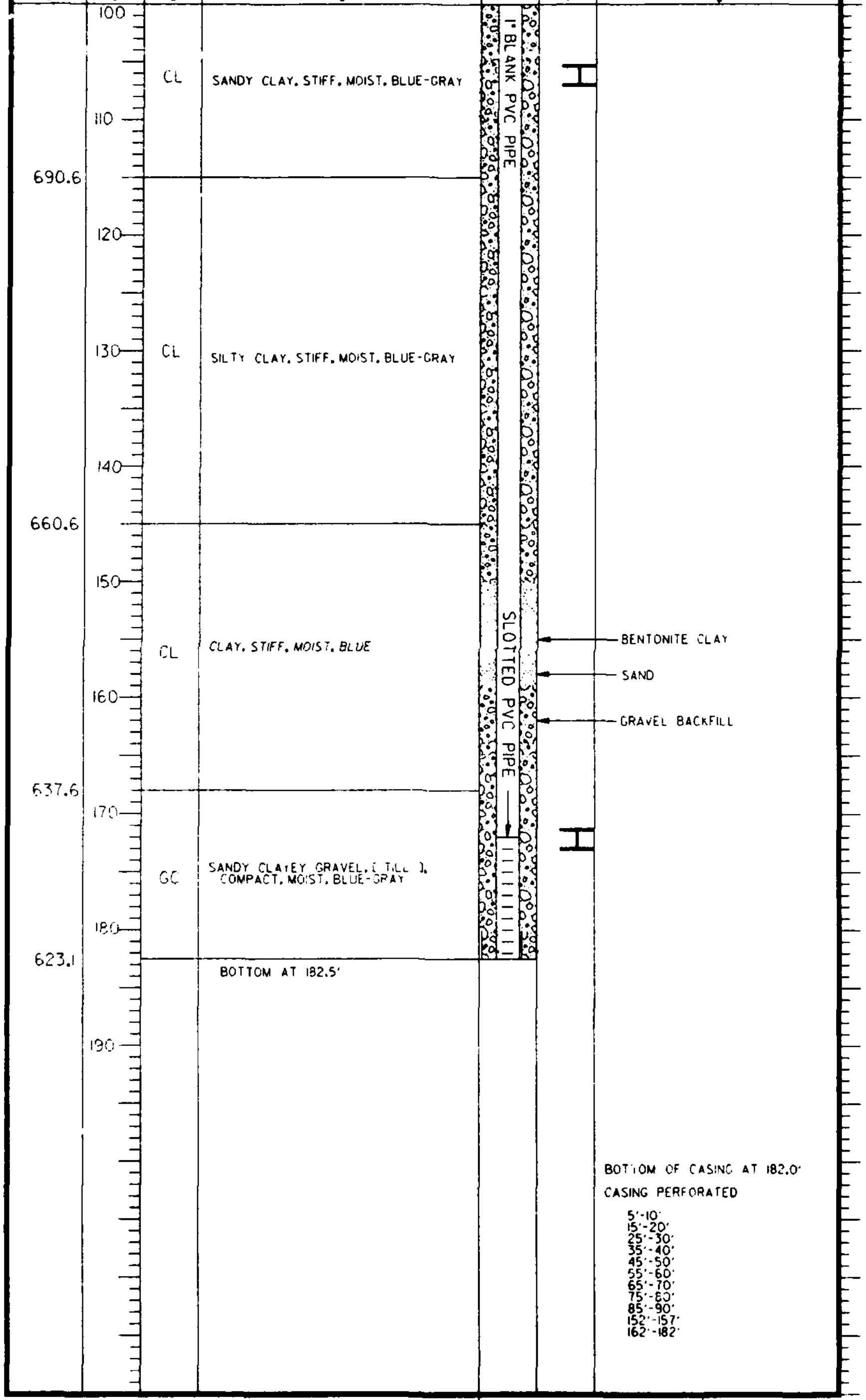
Hole No. P-146

PROJECT WYNOOCHEE DAM

INSTALLATION NPS

SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	PIEZ.	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100	CL	SANDY CLAY, STIFF, MOIST, BLUE-GRAY			
690.6		CL	SILTY CLAY, STIFF, MOIST, BLUE-GRAY			
660.6		CL	CLAY, STIFF, MOIST, BLUE			BENTONITE CLAY SAND GRAVEL BACKFILL
637.6		GC	SANDY CLAYEY GRAVEL, [TILL], COMPACT, MOIST, BLUE-GRAY			
623.1			BOTTOM AT 182.5'			



BOTTOM OF CASING AT 182.0'

CASING PERFORATED

5'-10'
15'-20'
25'-30'
35'-40'
45'-50'
55'-60'
65'-70'
75'-80'
85'-90'
152'-157'
162'-182'

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MAR 71

PROJECT WYNOOCHEE DAM

HOLE NO. P-146

Hole No. P-150

DRILLING LOG

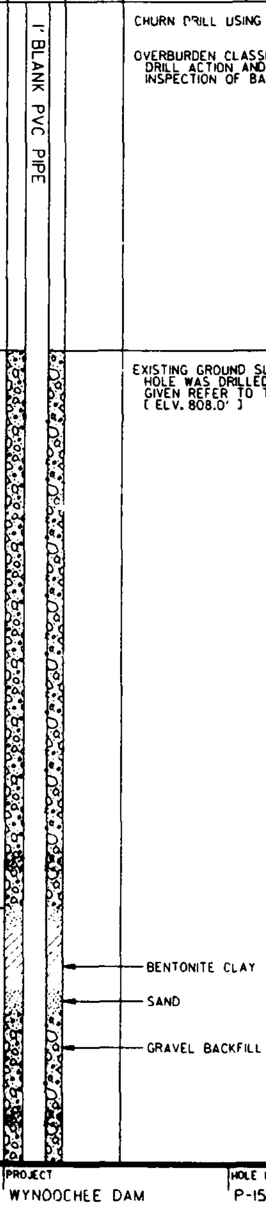
DIVISION NPD

INSTALLATION NPS

SHEET 1 OF 2 SHEETS

1. PROJECT WYNOOCHEE
2. LOCATION (Coordinates or Station) N 763,000 E 1,231,880
3. DRILLING AGENCY SOIL SAMPLING SERVICE, INC.
4. HOLE NO. (As shown on drawing title and file number) 71-CD-150
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 85.5'
8. DEPTH DRILLED INTO ROCK 0
9. TOTAL DEPTH OF HOLE 85.5'
10. SIZE AND TYPE OF BIT 6" CABLE TOOL
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL CHURN DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER ? 748 ?
16. DATE HOLE STARTED 9-7-71 COMPLETED 9-9-71
17. ELEVATION TOP OF HOLE 808 TOP OF CASING
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	PIEZ.	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10 20		COMPACTED SEMI-IMPERVIOUS FILL	1" BLANK PVC PIPE		CHURN DRILL USING 6" CASING OVERBURDEN CLASSIFICATION BY DRILL ACTION AND VISUAL INSPECTION OF BAILER SAMPLES
	30 40 50 60 70	GM	SILTY SANDY GRAVEL, HARD, BROWN			EXISTING GROUND SURFACE WHEN HOLE WAS DRILLED. DEPTHS GIVEN REFER TO TOP OF CASING [ELV. 808.0']
	80 90 100	CL	SILTY CLAY, BLUE			



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MAR 71

PROJECT WYNOOCHEE DAM

HOLE NO. P-150

DRILLING LOG (Cont Sheet)

ELEVATION TOP OF HOLE: 808.0 [TOP OF CASING]

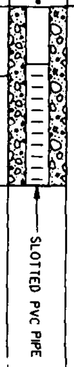
Hole No. P-150

PROJECT: WYNOOCHEE DAM

INSTALLATION: NPS

SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100	CL	SILTY CLAY, BLUE			
	110	GM	SILTY SANDY GRAVEL, HARD, GRAY			
			BOTTOM AT 115.5'			CASING PERFORATED 7'-12' 17'-22' 27'-32' 37'-42' 47'-52' 57'-62' 67'-77' 79'-84' 106'-111'
	120					



ENG FORM 1836-A PREVIOUS EDITIONS ARE OBSOLETE.
MAR 71

PROJECT: WYNOOCHEE DAM

HOLE NO.: P 150

Hole No. P-151

DRILLING LOG

DIVISION NPD

INSTALLATION NPS

SHEET 1 OF 1 SHEETS

1. PROJECT WYNOOCHEE DAM
2. LOCATION (Coordinates or Station) N 763,150 E 1,231,500
3. DRILLING AGENCY SOIL SAMPLING SERVICE, INC.
4. HOLE NO. (As shown on drawing title and file number) 70-CD-151
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 30 '
8. DEPTH DRILLED INTO ROCK 0.5'
9. TOTAL DEPTH OF HOLE 30.5'
10. SIZE AND TYPE OF BIT 6" CABLE TOOL
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL CHURN DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE STARTED 1-20-70 COMPLETED 1-22-70
17. ELEVATION TOP OF HOLE 786.2 [GRND.]
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d		BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
786.2		GM	SILTY GRAVEL, BROWN			CHURN DRILL USING 6" CASING
781.2						OVERBURDEN CLASSIFICATION BY DRILL ACTION AND VISUAL INSPECTION OF BAILER SAMPLES
	10					
		GM	SILTY SANDY GRAVEL, HARD, GRAY			
	20					
757.2						CASING TO 30.5'
756.2	30		BOULDERS WITH SILT IN LAYERS, BLK.			PERFORATED:
755.7			BASIC IGNEOUS ROCK			20.5'-30.5' 10.5'-15.5'
			BOTTOM AT 30.5'			
	40					
	50					
	60					
	70					
	80					
	90					
	100					

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MAR 71

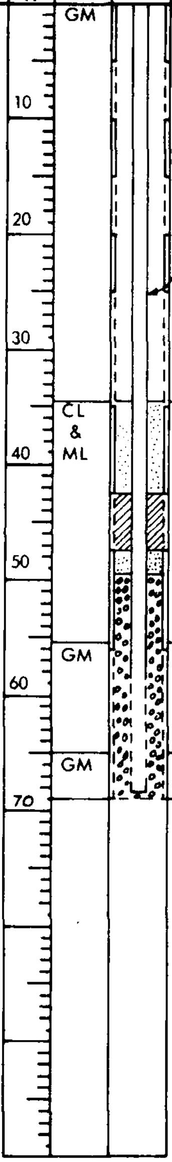
PROJECT WYNOOCHEE DAM

HOLE NO. P-151

WYNOOCHEE DAM PROJECT MILE 51.8 WYNOOCHEE RIVER

DEPTH OF HOLE 69 DIAMETER OF HOLE 6"
DEPTH OF O.B. 69 DATE STARTED 4 December 1969
ROCK DRILLED 0 DATE COMPLETED 9 December 1969
% CORE RECOVERED - CONTRACTOR Soil Sampling Service, Inc.

SURFACE EL Casing = 766.7 G.S. = 763.8 HOLE NO P-152 N 762,830 E 1,231,080



ELEVATIONS 763.8	GRAPHIC LOG	DESCRIPTION OF MATERIALS	REMARKS
	GM	Silty, Sandy GRAVEL, gray to brown	Churn drill using 6" casing Overburden classification by drill action and visual inspection of bailer end drive samples.
729.3	CL & ML	CLAY & SILT, blue	6" casing to 69' perforated: 5' - 10' 15' - 20' 25' - 35' 42.5' - 47.5' 56' - 69'
708.3	GM	Sandy, Silty GRAVEL, hard, brown to gray	
698.8	GM	Silty GRAVEL, dry, gray to brown Top of Rock	Placed 1" ID plastic pipe to 68.5', bottom 10' perforated.
694.8		Bottom 69'	Backfilled with pea gravel 49.5'-69' sand 47.5'-49.5' bentonite seal 42.5'-47.5' sand 34.5'-42.5' Tried to fill piezometer tube and casing with water, but both drained out.

WYNOOCHEE DAM PROJECT MILE 51.8 WYNOOCHEE RIVER

DEPTH OF HOLE 79.0 DIAMETER OF HOLE 6"
DEPTH OF O.B. 79.0 DATE STARTED 31 August 1971
ROCK DRILLED - DATE COMPLETED 7 September 1971
% CORE RECOVERED - CONTRACTOR Soil Sampling Service, Inc.

SURFACE EL Casing 730.78 G.S. 727.8 HOLE NO P-153 N 762,650 E 1,230,942

ELEVATIONS 727.8	DEPTH	GRAPHIC LOG		DESCRIPTION OF MATERIALS	REMARKS
				ROCK FILL	Churn Drill Using 6" Casing.
722.8	10	SM		Silty SAND & ROCK	Overburden Classification by drill action & visual inspection of bailer samples.
712.8	20	CL		CLAY, blue	
697.8	30 40 50 60 70	GM		Silty Sandy GRAVEL, hard, w/rocks, brown, gray below 75' depth.	
648.8	80			Bottom 79.0'	Bottom of casing at 78' Casing Perforated 38' - 43' 48' - 54' 58' - 63' 68' - 78'

WYNOOCHEE DAM PROJECT MILE 51.8 WYNOOCHEE RIVER

DEPTH OF HOLE 115' DIAMETER OF HOLE 6"
DEPTH OF O.B. 114' DATE STARTED 12 January 1970
ROCK DRILLED 1' DATE COMPLETED 19 January 1970
% CORE RECOVERED - CONTRACTOR Soil Sampling Service, Inc.

SURFACE EL Casing = 802.4 G.S. = 799.6 HOLE NO P-154 N 762,660 E 1,231,261

ELEVATIONS 799.6	DEPTH	GRAPHIC LOG	DESCRIPTION OF MATERIALS	REMARKS
		GM	Silty GRAVEL, soft, brown	Churn drill using 6" casing
794.6	10	GM	Silty, Sandy GRAVEL, hard, gray	Overburden classification by drill action and visual inspection of drive and bailer samples
782.6	20	GP	Sandy GRAVEL, dry, brown	
774.6	30 40 50 60	GM	Silty Sandy GRAVEL, hard (Water bearing @61')	hit enough water to drill with
729.6	70 80 90 100	CL	Sandy, Silty, CLAY, dry, gray	

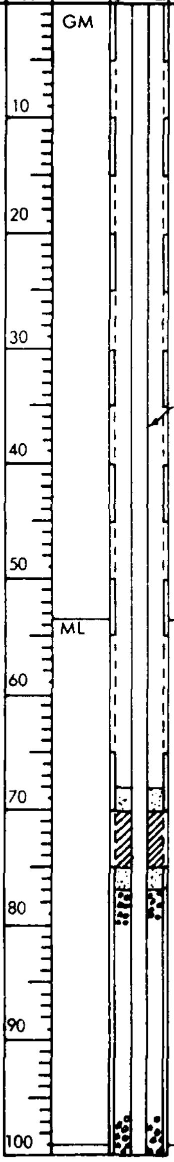
SURFACE EL	HOLE NO P-154	N E

ELEVATIONS	DEPTH	GRAPHIC LOG		DESCRIPTION OF MATERIALS	REMARKS
696.6		CL		Sandy, Silty, CLAY, dry, gray	
692.1		GM		Silty, Sandy GRAVEL, hard, dry, blue gray	
685.6	110			Basalt Cobbles & Silt Top of Rock	
684.6				Basic Igneous Rock Bottom @ 115'	Casing to 115' Perforated: 10' - 15' 20' - 25' 30' - 35' 40' - 45' 50' - 55' 60' - 70' 80' - 85' 95' - 100' 105' - 115' Placed 1" ID plastic pip to 114.5'. Bottom 10' perforated. Backfilled: pea gravel 87' - 115' Sand 85' - 87' bentonite seal 80' - 85' sand 78' - 80' pea gravel 70' - 78'

WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 186 **DIAMETER OF HOLE** 6"
DEPTH OF O.B. 186 **DATE STARTED** 9 December 1969
ROCK DRILLED - **DATE COMPLETED** 23 December 1969
% CORE RECOVERED - **CONTRACTOR** Soil Sampling Service, Inc.

SURFACE EL Casing = 777.5 G. S. - 774.6 **HOLE NO** P-155 **N** 762,248 **E** 1,230,931



ELEVATIONS 774.6	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
		GM		Silty, Sandy GRAVEL, hard, brown	Churn drill using 6" casing Overburden classification by drill action and visual inspection of bailer and drive samples.
721.1		ML		Sandy Silt w/clay, dry, blue	

SURFACE EL

HOLE NO P-155

N
E

ELEVATIONS	DEPTH	GRAPHIC LOG		DESCRIPTION OF MATERIALS	REMARKS
		GP		Sandy GRAVEL, dry	
669.6	110 120	SM		Silty SAND w/gravel, brown (water bearing at 118')	Hit enough water to drill with
648.1	130	ML & SP		SILT & SAND, interbedded, dry, brown	
642.1	140	SP		Gravelly SAND (water bearing)	
632.1		SM		Silty SAND, dry	
629.6	150	SP		SAND w/gravel (water bearing)	
614.6	160	SM		Silty SAND w/gravel, dry	6" Casing to 186' Perforated: 5'-10' 15'-20' 25'-30' 35'-40' 45'-50' 55'-65' 70'-75' 105'-110' 115'-120' 125'-130' 135'-140' 145'-150' 155'-160' 165'-170' 176'-186' Placed 1" ID plastic pipe to 185.6', bottom 10' perforated Backfilled with pea gravel 77'-186' sand 75'-77' bentonite seal 70'-75' sand 68'-70'
609.6	170	ML		SILT w/sand, dry	
600.6	180	GM		Silty, Sandy, GRAVEL, hard, gray (water bearing 74' to 75') Top of Rock	
588.6				Bottom @ 186'	

WYNOOCHEE DAM **PROJECT** MILE 51.8, WYNOOCHEE **RIVER**

DEPTH OF HOLE 60.0 **DIAMETER OF HOLE** 6"
DEPTH OF O.B. 60.0 **DATE STARTED** 9 September 1971
ROCK DRILLED - **DATE COMPLETED** 14 September 1971
% CORE RECOVERED - **CONTRACTOR** Soil Sampling Service, Inc.

SURFACE EL Casing 703.77 G.S. 698.8 **HOLE NO** P-156 **N** 762,320 **E** 1,230,780

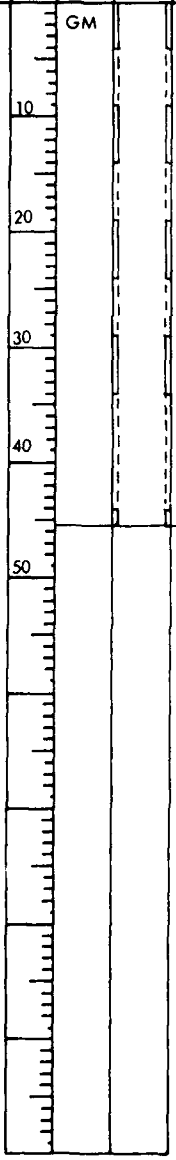
ELEVATIONS 698.8	DEPTH	GRAPHIC LOG		DESCRIPTION OF MATERIALS	REMARKS
		GM		Silty Sandy GRAVEL w/rocks, brown, hard	Churn Drill Using 6" casing
	10				Overburden classification by drill action & visual inspection of bailer samples.
	20				
	30				
659.8	40	ML		Sandy Silt w/some gravel, brown.	
	50				
638.8	60			Bottom @ 60.0'	Bottom of Casing 60' Casing Perforated -1' - 4' 9' - 14' 19' - 24' 29' - 34' 39' - 44' 49' - 59' 14 Sept. 1971 W.L. 45.8' end of shift.

WYNOOCHEE DAM PROJECT MILE 51.8 WYNOOCHEE RIVER

DEPTH OF HOLE 45.5' **DIAMETER OF HOLE** 6"
DEPTH OF O.B. 45.5' **DATE STARTED** 15 Sept. 1971
ROCK DRILLED - **DATE COMPLETED** 17 Sept. 1971
% CORE RECOVERED - **CONTRACTOR** Soil Sampling Service, Inc.

SURFACE EL Casing 670.0 G.S. 667.0 **HOLE NO** P-157 **N** 762,000 **E** 1,230,654

ELEVATIONS 667.0	DEPTH	GRAPHIC LOG		DESCRIPTION OF MATERIALS	REMARKS
		GM		Silty Sandy GRAVEL w/rocks, hard, brown, gray below 37' depth	Churn Drill Using 6" casing. Overburden classification by drill action & visual inspection of bailer samples
621.5				Top of Rock Bottom @ 45.5'	Bottom of Casing 45.3' Casing Perforated 4' - 9' 14' - 19' 24' - 29' 34' - 44' 17 Sept. 1971 W.L. 16.0' at end of shift.



WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 55 **DIAMETER OF HOLE** 6"
DEPTH OF O.B. 55 **DATE STARTED** 3 November 1969
ROCK DRILLED - **DATE COMPLETED** 7 November 1969
% CORE RECOVERED - **CONTRACTOR** Soil Sampling Service, Inc.

SURFACE EL Casing 813.6 G. S. 810.9 HOLE NO P-158 N 764,580 E 1,231,380

ELEVATIONS 810.9	DEPTH	GRAPHIC LOG		DESCRIPTION OF MATERIALS	REMARKS
		GC		Clayey GRAVEL (angular and round), brown	Churn Drill using 6" casing Overburden classification by drill action and visual inspection of bailer and drive sample.
	10				
	20				
784.9		GC		Clayey Sandy GRAVEL, brown	
	30				
	40				
768.9 767.9		GP		Sandy GRAVEL (water bearing)	Bailing test at 42'-9' of water in hole, bailed ± 1/2 hr. at 5g.p.m, drew down 6', recovered 4' in 1/2 hr.
762.9		GC		Clayey Sandy GRAVEL, brown	
	50	CL		CLAY, gray to brown	
755.9				Top of Rock Bottom @ 55'	Casing perforated: 1 row at 16' 20' - 25' 30' - 35' 40' - 50'

WYNOOCHEE DAM PROJECT MILE 51.8 WYNOOCHEE RIVER

DEPTH OF HOLE 100 DIAMETER OF HOLE

DEPTH OF O.B. 75 DATE STARTED 10 September 1969

ROCK DRILLED 25 DATE COMPLETED 19 September 1969

% CORE RECOVERED - CONTRACTOR Soil Sampling Service, Inc.

SURFACE EL Casing 812.2 G.S. 809.4 **HOLE NO** P-159 N 764,510 E 1,230,710

ELEVATIONS 809.4	DEPTH	GRAPHIC LOG	DESCRIPTION OF MATERIALS	REMARKS
806.4		SM	Silty SAND w/gravel	Churn Drill Using 8" casing
		GP	GRAVEL (basaltic), weathered, hard	Overburden classification made by drill action and visual inspection of bailer samples.
	10			
791.9	20	GM	Sandy Silty GRAVEL (basaltic)	
	30			
	40			
	50		Piezometer tube	Placed 1" ID Plastic pipe to 100', bottom 10' perforated. Back filled with pea gravel 67'-100' sand 65'-67' bentonite seal 60'-65' sand 58'-60'
749.4	60	ML-CL	Silty CLAY, blue gray	
748.4		ML-CL	Silty CLAY w/gravel, plastic, gray	
741.9	70	GC & GM	Clayey GRAVEL & Silty GRAVEL, hard, gray	
734.4			Top of Rock	Encountered water @75' Level rose to 55' in 1/2 hr. 6" casing to 77' stopped water in flow
	80		Basic Igneous Rock w/clay fault gouge at 80', gray	Casing perforated: 36' - 41' 46'-51' 56' - 61' 66' - 76'
	90			
709.4	100		Bottom @ 100'	

WYNOOCHEE DAM **PROJECT** Mile 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 98.2 **DIAMETER OF HOLE** 6"
DEPTH OF O.B. 98.2 **DATE STARTED** 23 September 1969
ROCK DRILLED - **DATE COMPLETED** 6 October 1969
% CORE RECOVERED - **CONTRACTOR** Soil Sampling Service, Inc.

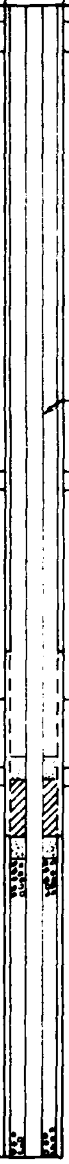
SURFACE EL Casing 805.5 G.S. 803.3 **HOLE NO** P-160 **N** 764,035 **E** 1,230,585

ELEVATIONS 803.3	DEPTH	GRAPHIC LOG	DESCRIPTION OF MATERIALS	REMARKS
		GP-GM	GRAVEL (basaltic) w/silt, hard, brown	Churn Drill using 6" Casing Overburden classification by drill action and visual inspection of bailer samples.
788.3		GP-GM	GRAVEL (fine) w/silt, light brown	
758.3		GP	GRAVEL (angular) hard (water bearing at 46')	
753.3	50	GP	Sandy GRAVEL	
745.3		ML	SILT w/gravel, soft, brown	Hole at 98.2, casing at 94.4, bailed sand from bottom 18' of casing and placed 1" plastic pipe to 98', perforated 88'-98'. Backfilled with pea gravel 66'-98' sand 64'-66' bentonite seal 59'-64' sand 57'-59'
743.3	60	ML-CL	Silty Clay, blue	
741.8		GP-GC	GRAVEL (angular) w/silty clay, hard	
723.3	80	SP	SAND (fine) w/gravel (fine) (water bearing)	
713.3	90	ML-CL	Silty CLAY w/fine gravel, hard, gray	6" casing to 94.4' Perforated 49' - 94.4' (sand filled bottom 18' after perforated)
705.1	100		Top of Rock Bottom @98.2'	

WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 128' **DIAMETER OF HOLE** 6"
DEPTH OF O.B. 128' **DATE STARTED** 7 October 1969
ROCK DRILLED - **DATE COMPLETED** 19 October 1969
% CORE RECOVERED - **CONTRACTOR** Soil Sampling Service, Inc.

SURFACE EL Casing 800.9 G.S. 798.3 **HOLE NO** P-161 **N** 763,950 **E** 1,230,239



ELEVATIONS 798.3	DEPTH	GRAPHIC LOG	DESCRIPTION OF MATERIALS	REMARKS
796.8			Wood chips	Churn Drill using 6" casing
794.3		GM	Silty Sandy GRAVEL, brown	
	10	GM	Silty GRAVEL, hard, gray	Overburden classification by drill action and visual inspection of bailer and drive samples.
	20			
	30			
757.8	40	GP	GRAVEL, angular, hard	Some water encountered
756.3		GM	Silty GRAVEL, hard, gray	
	50			
738.3	60	GM	Silty, Sandy, GRAVEL, hard, gray	Water bearing
732.3		ML	SILT, brown	
730.8	70	ML-CL	Silty CLAY, blue	
	80			
	90			
	100			

SURFACE EL	HOLE NO P-161	N E

ELEVATIONS	DEPTH	GRAPHIC LOG		DESCRIPTION OF MATERIALS	REMARKS
		ML-CL		Silty CLAY, blue	
693.3	110	CL & ML		CLAY & SILT layers w/scattered gravels, gray	
684.3		GP		GRAVEL (fine to coarse)	Some water encountered
678.3	120	GM		Silty GRAVEL, hard, gray	
660.3				Top of Rock Bottom @ 128'	Casing perforated: 56' - 72' 100' - 128' 1" ID plastic piezometer tube installed to 128'. Tube perforated 118' - 128'. Casing backfilled: Pea gravel 74' - 128' sand 72' - 74' Bentonite seal 67' - 72' sand 65'-67'

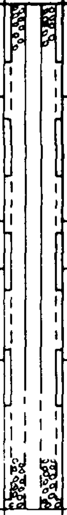
WYNOOCHEE DAM **PROJECT** MILE 51.8 WYNOOCHEE **RIVER**

DEPTH OF HOLE 144 **DIAMETER OF HOLE** 6"
DEPTH OF O.B. 144 **DATE STARTED** 10 November 1969
ROCK DRILLED - **DATE COMPLETED** 21 November 1969
% CORE RECOVERED - **CONTRACTOR** Soil Sampling Service, Inc.

SURFACE EL Casing 753.2 G.S. 750.3 **HOLE NO** P-162 **N** 762,730 **E** 1,230,130

ELEVATIONS 750.3	DEPTH	GRAPHIC LOG	DESCRIPTION OF MATERIALS	REMARKS
		GC	Clayey GRAVEL	Churn drill using 6" casing
743.3	10	GC	Clayey Sandy GRAVEL gray to brown	Overburden classification by drill action and visual inspection of bailer and drive samples
732.3	20	CL	CLAY, brown	
729.3	30	ML-CL	Silty CLAY w occasional gravels, gray	
	40 50		Piezometer Tube	
699.3		SC	Clayey SAND w gravel	Water Bearing at 52'
697.3	60 70	CL	CLAY w occasional silt and gravel, brown	
671.8	80	GC	Clayey GRAVEL (angular), brown	
666.3 665.8		GP	Sandy, GRAVEL, brown	Water Bearing at 84'
660.3	90	GC	Clayey GRAVEL, brown	
657.3		SP	Gravelly SAND (water bearing)	Bailed 5g. p.m. at 92', no drawdown
654.3		GC	Clayey GRAVEL gray to brown	
652.3		SP	Gravelly SAND (water bearing)	
	100	GC	Clayey GRAVEL, hard	

SURFACE EL HOLE NO P-162 **N** **E**

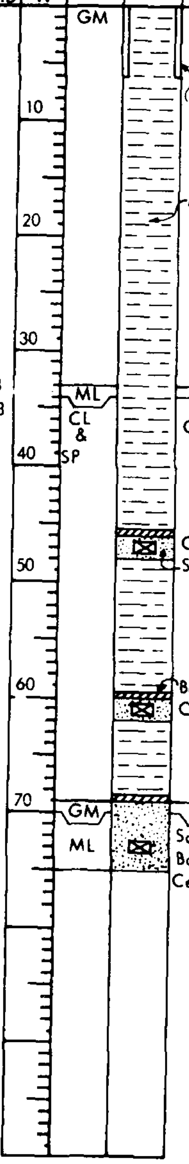


ELEVATIONS	**DEPTH**	**GRAPHIC LOG**	**DESCRIPTION OF MATERIALS**	**REMARKS**
		GC	Clayey GRAVEL, hard	
642.3	110	GP	Sandy GRAVEL	Water bearing at 112'
631.3	120	SC	Gravelly Clayey SAND	Heaving when casing is driven-
627.3		GC	Clayey GRAVEL (angular and round)	Bailed 5g. p. m, hole bailed dry
	130			
619.3		GC	Sandy Clayey GRAVEL, gray	
	140			
606.3			Top of Rock Bottom @ 144'	Casing to 143' Perforated bottom 10' and every other 5' to within 5' of ground surface. Placed 1" ID plastic pipe to 144'. Perforated bottom 10'. Backfilled w/pea gravel 30'-144' sand 28' - 30' bentonite seal 23' - 28' sand 21' - 23'

WYNOOCHEE DAM PROJECT MILE 51.8 WYNOOCHEE RIVER

DEPTH OF HOLE 75 DIAMETER OF HOLE 6"
DEPTH OF O.B. 75 DATE STARTED 1 December 1969
ROCK DRILLED - DATE COMPLETED 3 December 1969
% CORE RECOVERED - CONTRACTOR Soil Sampling Service, Inc.

SURFACE EL Casing 765.2 G.S. 762.3 HOLE NO PN-164 N 762,590 E 1,231,081

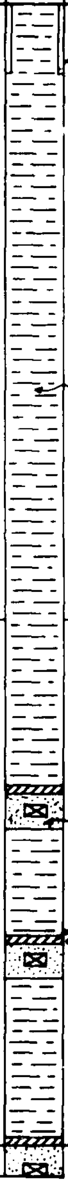


ELEVATIONS 762.3	DEPTH	GRAPHIC LOG	DESCRIPTION OF MATERIALS	REMARKS
		GM	Silty Sandy GRAVEL, brown	Churn drill using 6" casing
	10		Casing	Overburden classification by drill action and visual inspection of drive and bailer samples.
	20		AM-9 Chemical Grout	
	30			Water bearing at 30'
729.3		ML	Silt, brown	
728.3	40	CL & SP	CLAY w/sand leanses, blue	No water below 34'
	50		Cell No. 854 @ 47' Sand	
	60		Bentonite seal Cell No. 845 @ 61'	
693.3	70	GM	Silty GRAVEL	
692.3		ML	Sandy SILT, brown Bottom @ 75' Cell No. 679 @ 73'	
687.3				

WYNOOCHEE DAM PROJECT MILE 51.8 WYNOOCHEE RIVER

DEPTH OF HOLE 102 DIAMETER OF HOLE 6"
DEPTH OF O.B. 102 DATE STARTED 6 January 1970
ROCK DRILLED - DATE COMPLETED 9 January 1970
% CORE RECOVERED - CONTRACTOR Soil Sampling Service, Inc.

SURFACE EL Casing = 777.4 G. S. = 774.6 HOLE NO PN-165 N 762,236 E 1,230,930



ELEVATIONS 774.6	DEPTH	GRAPHIC LOG	DESCRIPTION OF MATERIALS	REMARKS
		GP-GM	Sandy GRAVEL w silt, hard casing	Churn drill using 6" casing Overburden classification by drill action and visual inspection of bailer samples.
	10			
	20			
	30		AM-9 Chemical Grout	
	40			
	50			
721.1		ML-CL	Silty CLAY, blue	
	60			
	70		Cell No. 869 @ 70' Sand	
	80		Bentonite seal Cell No. 872 @ 83'	
	90			
675.6	100		Cell No. 857 @ 102'	
672.6		GM	Silty GRAVEL BOTTOM @ 102'	

Hole No. 87-PA-201

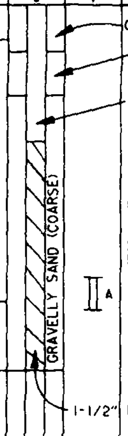
DRILLING LOG DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT WYNOOCHEE LAKE PROJECT
2. LOCATION (Coordinates or Station) RT. EMBANKMENT DAM CREST
3. DRILLING AGENCY GOVERNMENT
4. HOLE NO. (As shown on drawing title and file number) 87-PA-201
5. NAME OF DRILLER STAN BALES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ________ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 13'
8. DEPTH DRILLED INTO ROCK 3'
9. TOTAL DEPTH OF HOLE 16'
10. SIZE AND TYPE OF BIT 8" HOLLOW STEM
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE B-80 AUGER
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED 1 UNDISTURBED
14. TOTAL NUMBER CORE BOXES 0
15. ELEVATION GROUND WATER N/A
16. DATE HOLE STARTED 3/6/87 COMPLETED 3/6/87
17. ELEVATION TOP OF HOLE 805'
18. TOTAL CORE RECOVERY FOR BORING 0 %
19. SIGNATURE OF INSPECTOR KAISER

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	PIEZ. INST. e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
805			ASPHALT CONCRETE (2-1/4") ON CRUSHED BASE COURSE			CORE MATERIAL
		GM	SILTY SANDY GRAVE_ W/COBBLES (8"), DENSE, MOIST, BROWN			1/4" BENTONITE PELLETS
						1-1/2" SOLID PVC PIPE
	5					
						N= NUMBER OF BLOWS TO DRIVE SAMPLER 12"
	10					2-1/2" SPLIT SPOON SAMPLER DRIVEN BY 400# HAMMER
892			BASALT BEDROCK - SOFT		A	N=65
	15					
889			BOTTOM @ 16' IN BEDROCK			1-1/2" PERFORATED PVC PIPE
	20					
	25					
	30					
	35					
	40					
	45					
	50					



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MAR 71

PROJECT WYNOOCHEE LAKE PROJ

HOLE NO. 87-PA-201

Hole No. 87-PA-202

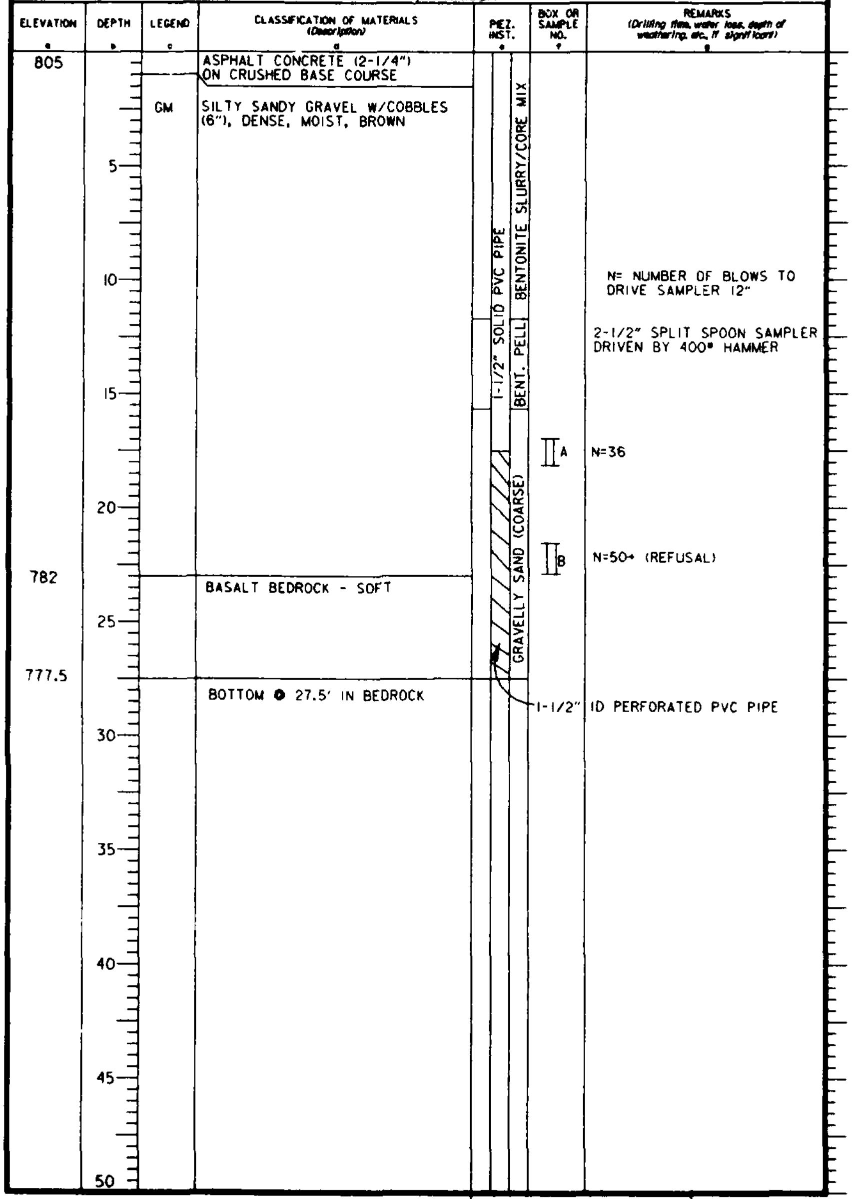
DRILLING LOG

DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT WYNOOCHEE LAKE PROJECT
2. LOCATION *(Coordinates or Station)* RT. EMBANKMENT DAM CREST
3. DRILLING AGENCY GOVERNMENT
4. HOLE NO. *(As shown on drawing title and file number)* 87-PA-202
5. NAME OF DRILLER STAN BALES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 23′
8. DEPTH DRILLED INTO ROCK 4.5′
9. TOTAL DEPTH OF HOLE 27.5′
10. SIZE AND TYPE OF BIT 8" HOLLOW STEM
11. DATUM FOR ELEVATION SHOWN *(TBM or MSL)*
12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE B-80 AUGER
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 2 ; UNDISTURBED
14. TOTAL NUMBER CORE BOXES 0
15. ELEVATION GROUND WATER N/A
16. DATE HOLE: STARTED 3/5/87 ; COMPLETED 3/5/87
17. ELEVATION TOP OF HOLE 805′
18. TOTAL CORE RECOVERY FOR BORING 0 %
19. SIGNATURE OF INSPECTOR KAISER



ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS *(Description)* d	PIEZ. INST. e	BOX OR SAMPLE NO. f	REMARKS *(Drilling time, water loss, depth of weathering, etc., if significant)* g
805			ASPHALT CONCRETE (2-1/4") ON CRUSHED BASE COURSE			
		GM	SILTY SANDY GRAVEL W/COBBLES (6"), DENSE, MOIST, BROWN			
	10					N= NUMBER OF BLOWS TO DRIVE SAMPLER 12"
						2-1/2" SPLIT SPOON SAMPLER DRIVEN BY 400# HAMMER
					A	N=36
					B	N=50+ (REFUSAL)
782			BASALT BEDROCK - SOFT			
777.5			BOTTOM @ 27.5′ IN BEDROCK			

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PROJECT WYNOOCHEE LAKE PROJ

HOLE NO. 87-PA-202

Hole No. 87-PA-203

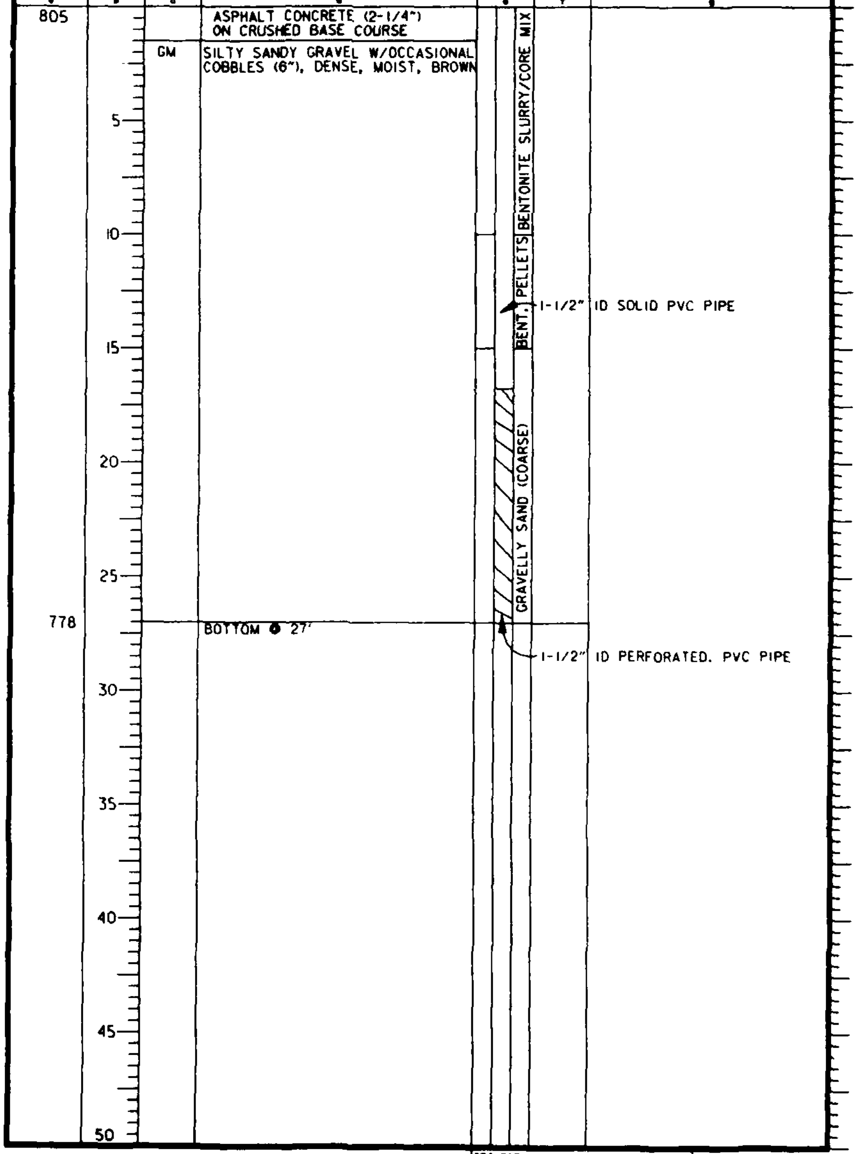
DRILLING LOG

DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT WYNOOCHEE LAKE PROJECT
2. LOCATION *(Coordinates or Station)* RT. EMBANKMENT DAM CREST
3. DRILLING AGENCY GOVERNMENT
4. HOLE NO. *(As shown on drawing title and file number)* 87-PA-203
5. NAME OF DRILLER STAN BALES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 27'
8. DEPTH DRILLED INTO ROCK 0
9. TOTAL DEPTH OF HOLE 27'
10. SIZE AND TYPE OF BIT 8" HOLLOW STEM
11. DATUM FOR ELEVATION SHOWN *(TBM or MSL)*
12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE B-80 AUGER
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED 0 UNDISTURBED
14. TOTAL NUMBER CORE BOXES 0
15. ELEVATION GROUND WATER N/A
16. DATE HOLE STARTED 3/4/87 COMPLETED 3/5/87
17. ELEVATION TOP OF HOLE 805'
18. TOTAL CORE RECOVERY FOR BORING 0 %
19. SIGNATURE OF INSPECTOR KAISER



ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS *(Description)* d	PIEZ. INST. e	BOX OR SAMPLE NO. f	REMARKS *(Drilling time, water loss, depth of weathering, etc., if significant)* g
805			ASPHALT CONCRETE (2-1/4") ON CRUSHED BASE COURSE			
		GM	SILTY SANDY GRAVEL W/OCCASIONAL COBBLES (6"), DENSE, MOIST, BROWN			
						1-1/2" ID SOLID PVC PIPE
778			BOTTOM @ 27'			
						1-1/2" ID PERFORATED. PVC PIPE

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MAR 71

PROJECT WYNOOCHEE LAKE PROJ

HOLE NO. 87-PA-203

Hole No. 87-PA-204

DRILLING LOG | DIVISION | INSTALLATION | SHEET 1 OF 1 SHEETS

1. PROJECT WYNOOCHEE LAKE PROJECT
2. LOCATION (Coordinates or Station) RT. EMBANKMENT DAM CREST
3. DRILLING AGENCY GOVERNMENT
4. HOLE NO. (As shown on drawing title and file number) 87-PA-204
5. NAME OF DRILLER STAN BALES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ________ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 47'
8. DEPTH DRILLED INTO ROCK 0
9. TOTAL DEPTH OF HOLE 47'
10. SIZE AND TYPE OF BIT 8" HOLLOW STEM
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE B-80 AUGER
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED 5 UNDISTURBED
14. TOTAL NUMBER CORE BOXES 0
15. ELEVATION GROUND WATER 765'
16. DATE HOLE STARTED 3/4/87 COMPLETED 3/4/87
17. ELEVATION TOP OF HOLE 805'
18. TOTAL CORE RECOVERY FOR BORING 0 %
19. SIGNATURE OF INSPECTOR KAISER

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	PIEZ. INST. e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
805			ASPHALT CONCRETE (2-1/4") ON CRUSHED BASE COURSE	1-1/2" SOLID PVC PIPE BENTONITE SLURRY/CORE MATERIAL MIXTURE		
803		GM	SILTY SANDY GRAVEL W/OCCASIONAL COBBLES (6"), DENSE, MOIST, BROWN			
	5					
	10					
	15					N= NUMBER OF BLOWS TO DRIVE SAMPLER 12" 2-1/2" SPLIT SPOON SAMPLER DRIVEN BY 400# HAMMER
	20					
	25			1/4" BENTONITES PELLETS		
					A	N=53
	30					
					B	N=39
	35					
					C	N=42
765	40		WATER @ 40', 3/4/87, WHILE DRILLING	1-1/2" PERF. PVC PIPE GRAVELLY SAND (COARSE)		
					D	N=38
	45					
757.8			BOTTOM @ 47.2' ON BASALT BEDROCK		E	N=50+ (REFUSAL)
	50					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT WYNOOCHEE LAKE PROJ

HOLE NO. 87-PA-204

Hole No. 87-PA-205

DRILLING LOG	DIVISION
INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT WYNOOCHEE LAKE PROJECT	10. SIZE AND TYPE OF BIT 8" HOLLOW STEM
2. LOCATION *(Coordinates or Station)* LT. EMBANKMENT DAM CREST	11. DATUM FOR ELEVATION SHOWN *(TBM or MSL)*
3. DRILLING AGENCY GOVERNMENT	12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE B-80 AUGER
4. HOLE NO. *(As shown on drawing title and file number)* 87-PA-205	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 4; UNDISTURBED
5. NAME OF DRILLER STAN BALES	14. TOTAL NUMBER CORE BOXES 0
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ________ DEG. FROM VERT.	15. ELEVATION GROUND WATER 768'
7. THICKNESS OF OVERBURDEN 45'	16. DATE HOLE: STARTED 3/6/87; COMPLETED 3/6/87
8. DEPTH DRILLED INTO ROCK 0	17. ELEVATION TOP OF HOLE 805'
9. TOTAL DEPTH OF HOLE 45'	18. TOTAL CORE RECOVERY FOR BORING 0 %
	19. SIGNATURE OF INSPECTOR KAISER

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS *(Description)* d	PIEZ. INST. e	BOX OR SAMPLE NO. f	REMARKS *(Drilling time, water loss, depth of weathering, etc., if significant)* g
804.5			ASPHALT CONCRETE (2") ON CRUSHED BASE COURSE			
		GM	SILTY SANDY GRAVEL W/ COBBLES (8"), DENSE, MOIST, BROWN			
	5					
	10					
	15			1-1/2" ID SOLID PVC PIPE BENTONITE SLURRY/CORE MATERIAL MIX		N= NUMBER OF BLOWS TO DRIVE SAMPLER 12" 2-1/2" SPLIT SPOON SAMPLER DRIVEN BY 400# HAMMER
	20				A	N=30
	25					
	30					
		SP-SM	GRAVELLY SAND (FINE TO COARSE) W/SILT, DENSE, WET, BROWN		B	N=57
	35					
768		GM	WATER @ 37', 3/6/87 WHILE DRILLING SILTY SANDY GRAVEL (3"), DENSE, SATURATED, BROWN		C	N=60
	40		SOFT FROM 40' TO 42'	1-1/2" PERF. PVC PIPE CAVE IN MATERI'L	D	N=30
760	45		BOTTOM @ 45' ON BEDROCK			
	50					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.
MAR 71

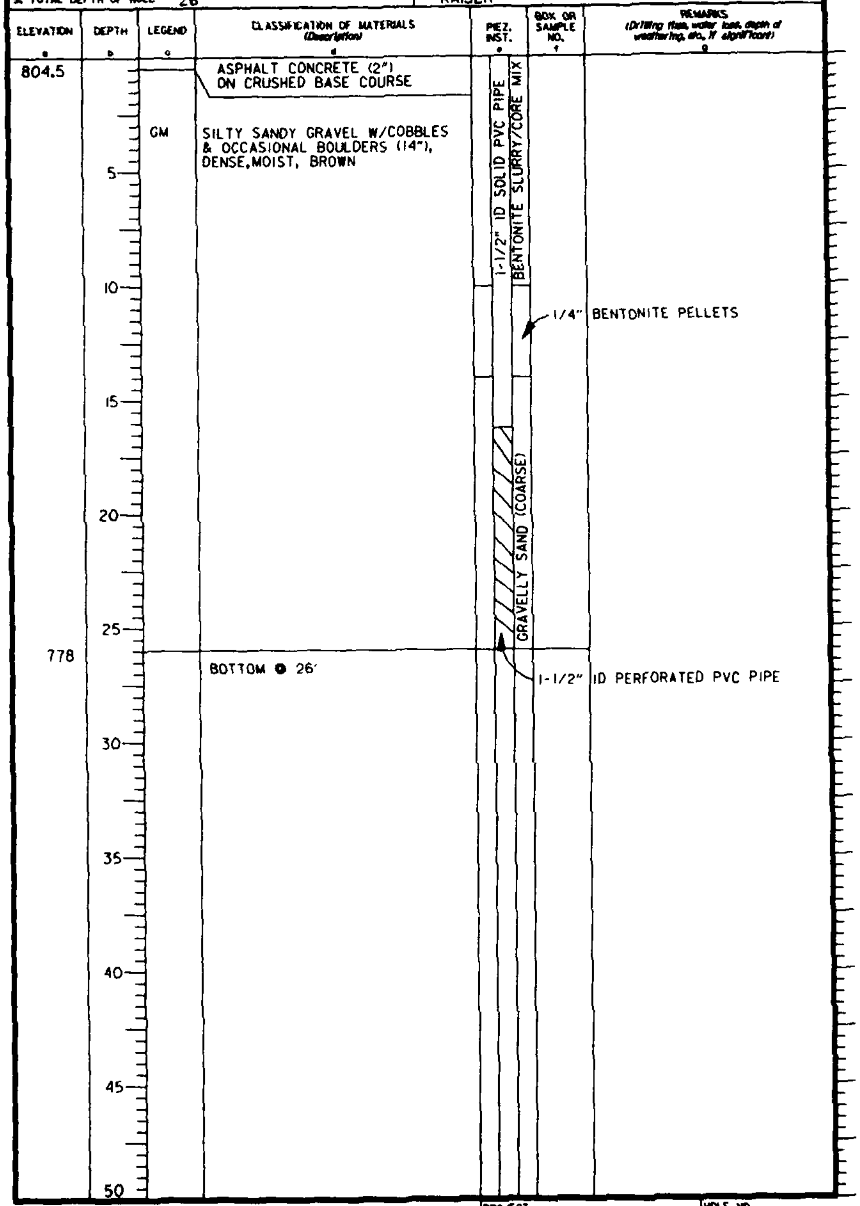
PROJECT
WYNOOCHEE LAKE PROJ

HOLE NO.
87-PA-205

Hole No. 87-PA-206

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT WYNOOCHEE LAKE PROJECT
2. LOCATION (Coordinates or Station) LT. EMBANKMENT DAM CREST
3. DRILLING AGENCY GOVERNMENT
4. HOLE NO. (As shown on drawing title and file number) 87-PA-206
5. NAME OF DRILLER STAN BALES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 26'
8. DEPTH DRILLED INTO ROCK 0
9. TOTAL DEPTH OF HOLE 26'
10. SIZE AND TYPE OF BIT 8" HOLLOW STEM
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE B-80 AUGER
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED 0 UNDISTURBED
14. TOTAL NUMBER CORE BOXES 0
15. ELEVATION GROUND WATER N/A
16. DATE HOLE STARTED 3/7/87 COMPLETED 3/7/87
17. ELEVATION TOP OF HOLE 805'
18. TOTAL CORE RECOVERY FOR BORING 0 %
19. SIGNATURE OF INSPECTOR KAISER



ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	PIEZ. INST. e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
804.5			ASPHALT CONCRETE (2") ON CRUSHED BASE COURSE			
		GM	SILTY SANDY GRAVEL W/COBBLES & OCCASIONAL BOULDERS (14"), DENSE, MOIST, BROWN			
						1/4" BENTONITE PELLETS
778			BOTTOM @ 26'			1-1/2" ID PERFORATED PVC PIPE

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

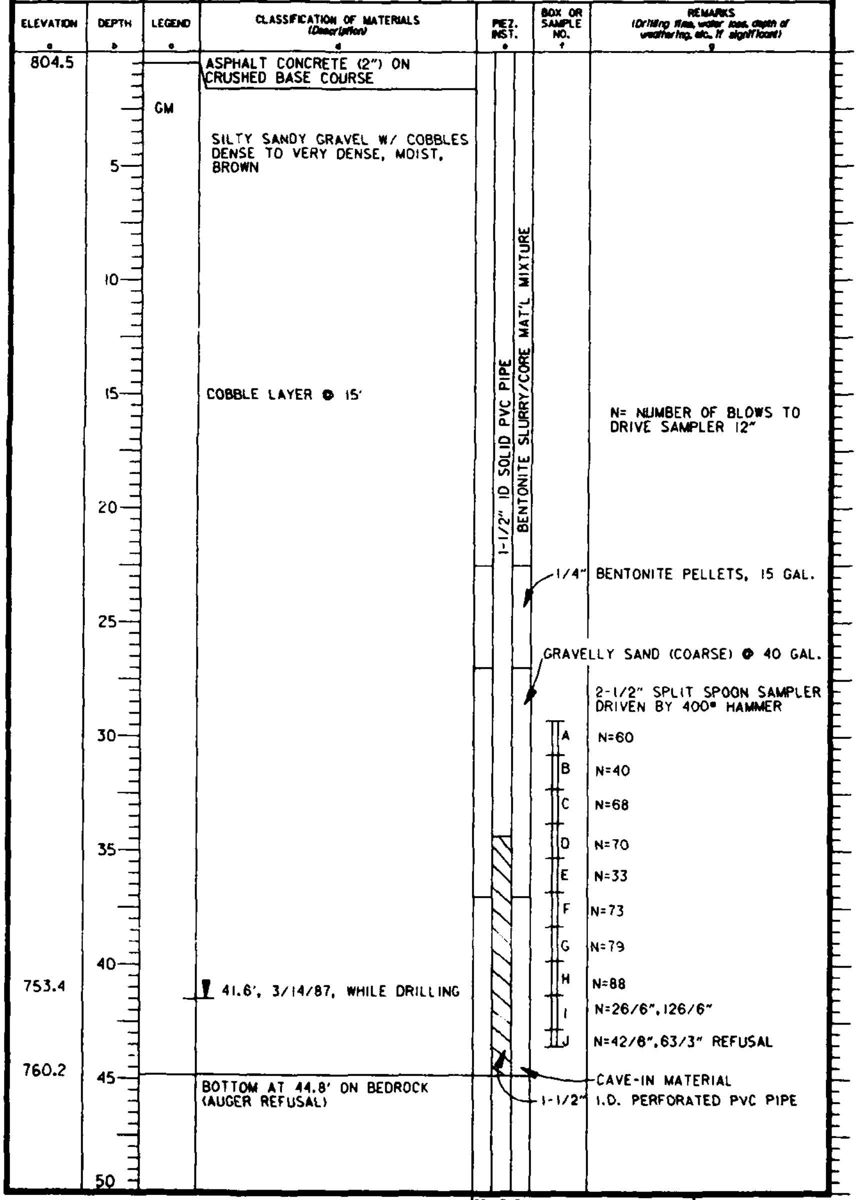
PROJECT WYNOOCHEE LAKE PROJ

HOLE NO. 87-PA-206

Hole No. 87-PA-207

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT WYNOOCHEE LAKE PROJECT
2. LOCATION (Coordinates or Station) LT. EMBANKMENT DAM CREST
3. DRILLING AGENCY GOVERNMENT
4. HOLE NO. (As shown on drawing title and file number) 87-PA-207
5. NAME OF DRILLER STAN BALES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 44.8'
8. DEPTH DRILLED INTO ROCK 0
9. TOTAL DEPTH OF HOLE 44.8'
10. SIZE AND TYPE OF BIT 8" HOLLOW STEM
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE B-80 AUGER
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED 10 UNDISTURBED
14. TOTAL NUMBER CORE BOXES 0
15. ELEVATION GROUND WATER
16. DATE HOLE STARTED 3/13/87 COMPLETED 3/14/87
17. ELEVATION TOP OF HOLE 805'
18. TOTAL CORE RECOVERY FOR BORING 0 %
19. SIGNATURE OF INSPECTOR KATO



ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	PIEZ. INST. e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
804.5			ASPHALT CONCRETE (2") ON CRUSHED BASE COURSE			
		GM	SILTY SANDY GRAVEL W/ COBBLES DENSE TO VERY DENSE, MOIST, BROWN			
	5					
	10			1-1/2" ID SOLID PVC PIPE BENTONITE SLURRY/CORE MAT'L MIXTURE		
	15		COBBLE LAYER @ 15'			N= NUMBER OF BLOWS TO DRIVE SAMPLER 12"
	20					
				1/4"		BENTONITE PELLETS, 15 GAL.
	25					GRAVELLY SAND (COARSE) @ 40 GAL.
						2-1/2" SPLIT SPOON SAMPLER DRIVEN BY 400# HAMMER
	30				A	N=60
					B	N=40
					C	N=68
	35				D	N=70
					E	N=33
					F	N=73
					G	N=79
	40				H	N=88
753.4			41.6', 3/14/87, WHILE DRILLING		I	N=26/6",126/6"
					J	N=42/6",63/3" REFUSAL
760.2	45		BOTTOM AT 44.8' ON BEDROCK (AUGER REFUSAL)			CAVE-IN MATERIAL
				1-1/2"		I.D. PERFORATED PVC PIPE
	50					

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MAR 71

PROJECT WYNOOCHEE LAKE PROJECT
HOLE NO. 87-PA-207

Hole No. 87-PA-208

DRILLING LOG

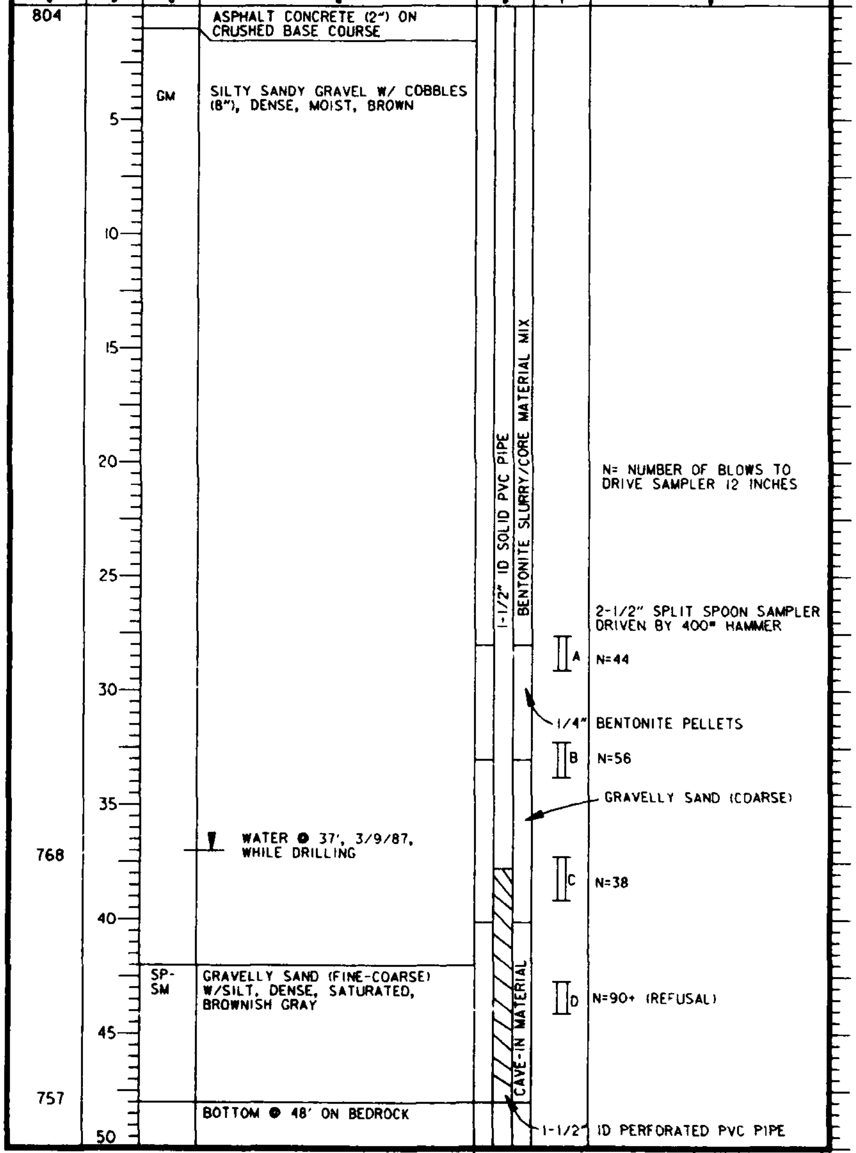
DIVISION

INSTALLATION

SHEET 1 OF 1 SHEETS

1. PROJECT WYNOOCHEE LAKE PROJECT
2. LOCATION (Coordinates or Station) LT. EMBANKMENT DAM CREST
3. DRILLING AGENCY GOVERNMENT
4. HOLE NO. (As shown on drawing title and file number) 87-PA-208
5. NAME OF DRILLER STAN BALES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 48'
8. DEPTH DRILLED INTO ROCK 0
9. TOTAL DEPTH OF HOLE 48'
10. SIZE AND TYPE OF BIT 8" HOLLOW STEM
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE B-80 AUGER
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED 5 UNDISTURBED
14. TOTAL NUMBER CORE BOXES 0
15. ELEVATION GROUND WATER 768'
16. DATE HOLE STARTED 3/7/87 COMPLETED 3/9/87
17. ELEVATION TOP OF HOLE 805'
18. TOTAL CORE RECOVERY FOR BORING 0 %
19. SIGNATURE OF INSPECTOR KAISER

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	PIEZ. INST. e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g



ASPHALT CONCRETE (2") ON CRUSHED BASE COURSE

GM SILTY SANDY GRAVEL W/ COBBLES (8"), DENSE, MOIST, BROWN

N= NUMBER OF BLOWS TO DRIVE SAMPLER 12 INCHES

2-1/2" SPLIT SPOON SAMPLER DRIVEN BY 400# HAMMER

A N=44

1/4" BENTONITE PELLETS

B N=56

GRAVELLY SAND (COARSE)

WATER @ 37', 3/9/87, WHILE DRILLING

C N=38

SP-SM GRAVELLY SAND (FINE-COARSE) W/SILT, DENSE, SATURATED, BROWNISH GRAY

D N=90+ (REFUSAL)

BOTTOM @ 48' ON BEDROCK

1-1/2" ID PERFORATED PVC PIPE

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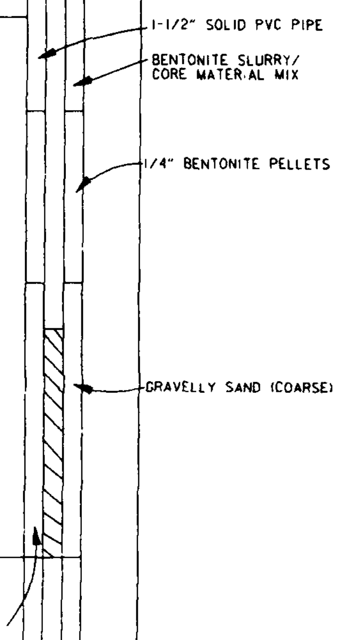
PROJECT WYNOOCHEE LAKE PROJ

HOLE NO. 87-PA-208

Hole No. 87-PA-209

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT WYNOOCHEE LAKE PROJECT
2. LOCATION (Coordinates or Station) LT. EMBANKMENT DAM CREST
3. DRILLING AGENCY GOVERNMENT
4. HOLE NO. (As shown on drawing title and file number) 87-PA-209
5. NAME OF DRILLER STAN BALES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 25'
8. DEPTH DRILLED INTO ROCK 0
9. TOTAL DEPTH OF HOLE 25
10. SIZE AND TYPE OF BIT 8" HOLLOW STEM
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE B-80 POWER AUGER
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED 0 UNDISTURBED
14. TOTAL NUMBER CORE BOXES 0
15. ELEVATION GROUND WATER N/A
16. DATE HOLE STARTED 3/10/87 COMPLETED 3/10/87
17. ELEVATION TOP OF HOLE 805'
18. TOTAL CORE RECOVERY FOR BORING 0 %
19. SIGNATURE OF INSPECTOR KAISER



ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	PIEZ. INST. e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
804.5			ASPHALT CONCRETE (2") ON CRUSHED BASED COURSE			
		GM	SILTY SANDY GRAVEL W/ COBBLES (6"), DENSE, MOIST, BROWN			
	5					
	10					
	15					
	20					
780	25		BOTTOM @25.0'			

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MAR 71

PROJECT WYNOOCHEE LAKE PROJ
HOLE NO. 87-PA-209

Hole No. 87-PA-210

DRILLING LOG

DIVISION

INSTALLATION

SHEET 1 OF 2 SHEETS

1. PROJECT WYNOOCHEE LAKE PROJECT
2. LOCATION (Coordinates or Station) LT. EMBANKMENT DAM CREST
3. DRILLING AGENCY GOVERNMENT
4. HOLE NO. (As shown on drawing title and file number) 87-PA-210
5. NAME OF DRILLER STAN BALES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____________ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 57.6'
8. DEPTH DRILLED INTO ROCK 0.0'
9. TOTAL DEPTH OF HOLE 57.6'
10. SIZE AND TYPE OF BIT 8" HOLLOW STEM
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE B-80 POWER AUGER
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED 6 UNDISTURBED
14. TOTAL NUMBER CORE BOXES 0
15. ELEVATION GROUND WATER
16. DATE HOLE STARTED 3/10/87 COMPLETED 3/13/87
17. ELEVATION TOP OF HOLE 805'
18. TOTAL CORE RECOVERY FOR BORING 0 %
19. SIGNATURE OF INSPECTOR KATO

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	PIEZ. INST. e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
805			ASPHALT CONCRETE (2") ON CRUSHED BASE COURSE			
	5	GM	SILTY SANDY GRAVEL W/COBBLES (6"), MEDIUM TURNING VERY DENSE @3', MOIST, BROWN			
	10		NUMEROUS COBBLES BETWEEN 10' AND 15'			
	15			BENTONITE SLURRY/ CORE MAT'L MIXTURE		
			OCCASIONAL COBBLES			
	20					N=NUMBER OF BLOWS TO DRIVE SAMPLER 12"
	25		OCCASIONAL COBBLES			2-1/2" SPLIT SPOON SAMPLER DRIVEN BY 400# HAMMER
				1-1/2" ID SOLID PVC PIPE	IA	N=67
	30				IB	N=156
	35				IC	N=120
			WATER @ 39.5', 3-11-87, 1200 WHILE DRILLING	CAVE-IN MAT'L		
765.5	40		OCC. COBBLES @ 40'			
					ID	N=100
	45				IE	N=115 + REFUSAL
755	50					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT WYNOOCHEE LAKE PROJ

HOLE NO. 87-PA-210

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE 805'	Hole No. 87-PA-210
PROJECT WYNOOCHEE LAKE PROJECT	INSTALLATION	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	ERY ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
755		GM	SILTY SANDY GRAVEL W/COBBLES		F	N= 70/6" 15/1" (REFUSAL)
	55					
747.4			BOTTOM @ 57.6' ON BEDROCK	1-1/2" ID PERF. PVC PIPE	G	N= 50/1" (REFUSAL)
	60					

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MAR 71

PROJECT
WYNOOCHEE LAKE PROJ

HOLE NO.
87-PA-210

Hole No. 87-PA-211

DRILLING LOG

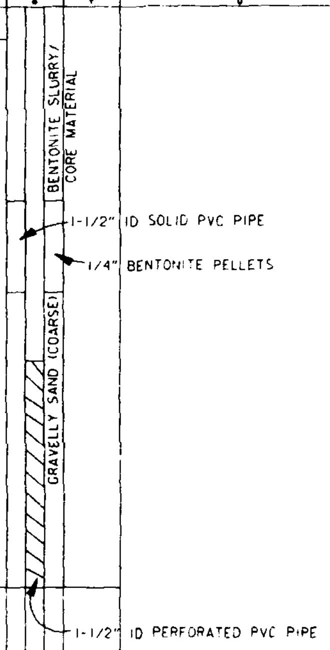
DIVISION

INSTALLATION

SHEET OF SHEETS

1. PROJECT WYNOOCHEE LAKE PROJECT
2. LOCATION (Coordinates or Station) LT. EMBANKMENT DAM CREST
3. DRILLING AGENCY GOVERNMENT
4. HOLE NO. (As shown on drawing title and file number) 87-PA-211
5. NAME OF DRILLER STAN BALES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 25.5'
8. DEPTH DRILLED INTO ROCK 0
9. TOTAL DEPTH OF HOLE 25.5'
10. SIZE AND TYPE OF BIT 8" HOLLOW STEM
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL MOBILE B-80 AUGER
13. TOTAL NO. OF OVER BURDEN SAMPLES TAKEN DISTURBED 0 UNDISTURBED
14. TOTAL NUMBER CORE BOXES 0
15. ELEVATION GROUND WATER
16. DATE HOLE STARTED 3/12/87 COMPLETED 3/12/87
17. ELEVATION TOP OF HOLE 805'
18. TOTAL CORE RECOVERY FOR BORING 0 %
19. SIGNATURE OF INSPECTOR KATO

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	PIEZ. INST. e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
804.5			ASPHALT CONCRETE (2") ON CRUSHED BASE COURSE			
800	5	GM	SILTY SANDY GRAVEL W/COBBLES (6"), DENSE TO VERY DENSE, MOIST, BROWN			
	10		VERY DENSE 10'-15' NUMEROUS COBBLES			
	15		DENSE BELOW 15, LESS COBBLES			
	20					
780	25		BOTTOM @ 25.5'			
	30					



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PROJECT WYNOOCHEE LAKE PROJ

FILENAME: WYN OG.DGN

HOLE NO. 87-PA-211