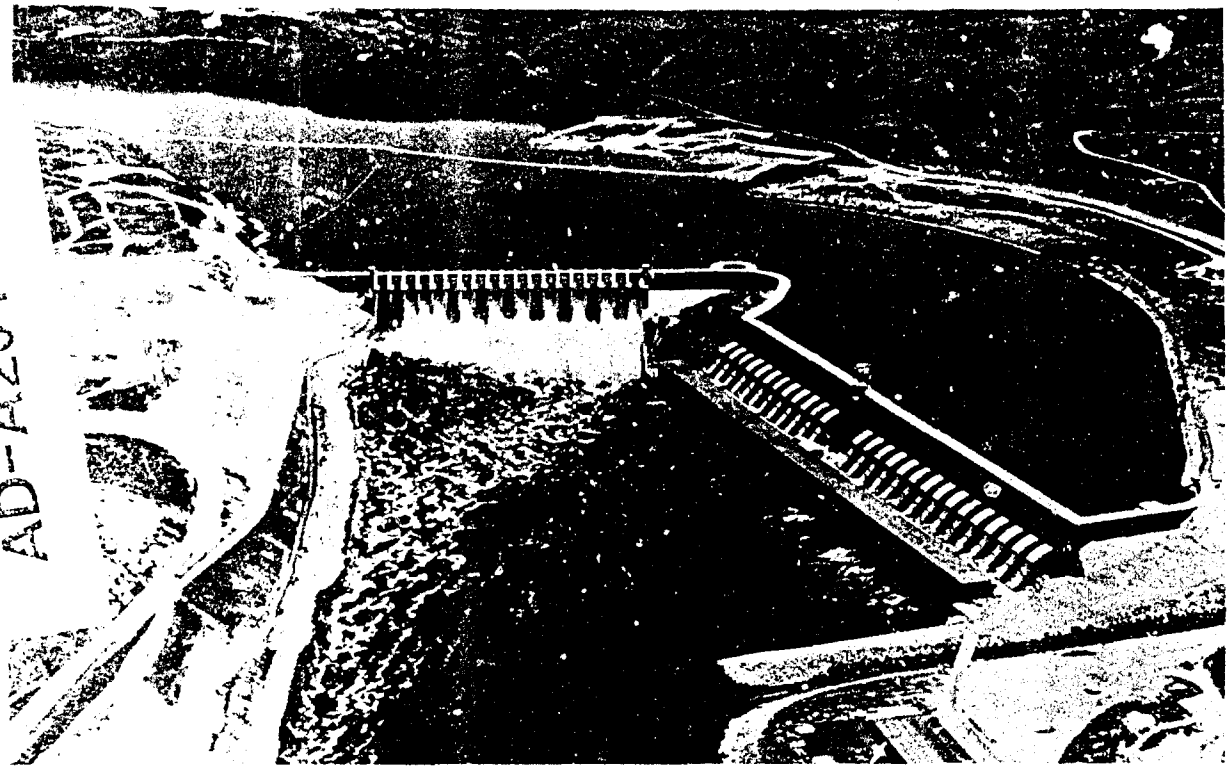
(2)

CHIEF JOSEPH DAM
Columbia River, Washington



ADDITIONAL UNITS AND STRUCTURAL MODIFICATION FOUNDATION REPORT

US Army Corps
of Engineers
Seattle District

REPORT DOCUMENTATION PAGE

Form Approved
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Additional Units and Structural Modification Foundation Report
Chief Joseph Dam, Columbia River, Washington

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Richard D. Eckerlin (Geologist) and Edward T. Bailey (Project Geologist)

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FIELD	GROUP	SUB-GROUP	Chief Joseph Dam Foundation Report, Geology, Additional Powerhouse Units, Reservoir, Columbia River, Instrumentation, Foundation Geology for Dam Structures.

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. Purpose of this report is to ensure the preservation for future use of complete records of foundation conditions and treatment for the powerhouse additional units 21-27; post construction instrumentation, drain hole drilling, and rock contour maps for the spillway, nonoverflow, intake and closure monoliths; and for the left and right abutment exploration and instrumentation programs. In general, the foundations of the dam and powerhouse are of excellent quality.

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DD Form 1473, JUN 86 *Previous editions are obsolete.* SECURITY CLASSIFICATION OF THIS PAGE

CHIEF JOSEPH DAM
Columbia River, Washington

ADDITIONAL UNITS AND STRUCTURAL MODIFICATION FOUNDATION REPORT

U.S. Army Corps of Engineers
Seattle District

CENPD-EN-G (CENPS-EG-G/26Apr88)(1130-2-320b) 3rd End Mr. Sager/503-221-3867
SUBJECT: Chief Joseph Dam, Additional Units and Structural Modification Foundation Report, April 1988

DA, North Pacific Division, US Army Corps of Engineers, P.O. Box 2870, Portland, OR 97208-2870 22 September 1988

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

The subject report is approved based on the response contained in your 2nd End.

FOR THE COMMANDER:

for Gary K. Leighton
ROBERT P. FLANAGAN, P.E.
Chief, Engineering Division

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

CENPS-EG-G

26 Apr 88

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

SUBJECT: Chief Joseph Dam, Additional Units and Structural Modification Foundation Report, April 1988

Enclosed you will find 3 copies of the above report for your review and approval as required by ER 1110-1-1801.

Encl (3 copies)
as

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

CENPDEN-G (CENPSEG-G/26Apr88)(1130-2-320b) 1st End Mr. Sager 503-221-3867
SUBJECT: Chief Joseph Dam, Additional Units and Structural Modification Foundation Report, April 1988.

DA, North Pacific Division, Corps of Engineers, P.O. Box 2870;
Portland, OR 97208-2870 6 June 1988

TO: Commander, Seattle District (CENPSEG-G)

1. The subject report has been reviewed and is returned for revision as indicated in the enclosed comments.

2. We anticipate that incorporating the enclosed comments will require a republication of the report, or at a minimum, an additional chapter dealing with the major foundation modification work identified in the Construction Branch comments.

FOR THE COMMANDER:

Craig R. Nightingale

1 Encl

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

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is TAGO.

REFERENCE OR OFFICE SYMBOL	SUBJECT
CENPD-CO-C	Chief Joseph Dam, Additional Units and Structural Modification Foundation Report, Apr 88

TO: CENPD-EN-G
FROM: CENPD-CO-C
DATE: 24 May 88
CMT 1
Zakovics/7386/ms

1. Reference your 23 May request for review comments on 26 April subject report.

2. We believe the report should document some of the difficulties experienced and lessons learned on the project which also had major cost growths in its contracts. From its 1971 baseline to substantial completion in 1980, design changes added almost 40% to the project cost (Encl 1), including impacts (e.g., Case 61) disruptions, accelerations, overtime, weather, etc.

3. Cursory review of some old (1975-79) field trip reports (Encls 2-9) would indicate the need to elaborate in more detail, at least on the following areas, to avoid recurrence and to enhance quality of similar work in the future.

a. Cofferdam dewatering delays and difficulties in 1975 started our buying-back-time problems and cost increases to maintain promised power-on-line dates. Obviously, it is not in the best interests of the Corps to have a cofferdam built under a separate contract (which also had modifications due to claims), thus ending up with government-furnished dewatering problems passed on to the follow-up work contractor.

b. Rock excavation involving the $1.5-2.0M "dragon-teeth" VE savings ended up adding about $3.5M to the cost of the service bridge, etc. All foundation reinforcing steel and concrete formwork had to be custom-made to fit the overbreaks (25%+) etc.

c. Quarry waste overruns (increased from the estimated 25% to about 50%) added to the right bank stabilization riprap work cost.

d. Grouting (combined with inadequate waterstops?) may have contributed to the drain seepage/blockage problems. The possible causes have not been fully addressed, although a proposed fix is in the mill.

4. There probably were other "foundation" related items involving big ticket claims, change orders, and modifications. Perhaps CENPS-CO and CENPS contract files could provide additional information to enhance the final report.

GLENN W. LATTA, Acting Chief
Construction Branch

9 Encls
(Listed on page 2)

CF:
CENPS-CO
CENPD-CO
CENPD-EN
CENPS-FO-CJ
CENPD-CO-O

CENPS-EG-G (CENPS-EG-G/26Apr88) (1130-2-320b) 2nd End Gembala/206-764-3712
SUBJECT: Chief Joseph Dam, Additional Units and Structural Modification Foundation Report, April 1988

DE, Seattle District, Corps of Engineers, Post Office Box C-3755, Seattle, WA 98124-2255

SEP 16

FOR: DA, North Pacific Division, Corps of Engineers, Post Office Box 2870, Portland, OR 97208-2870

1. Comments provided by J. Sager, CENPDEN-G, are incorporated in the Foundation Report.

2. Although the comments identified by Construction Branch are valid and should be documented, we feel that the Foundation Report is not the proper vehicle. A Construction History Report is scheduled in the future, after the completion of the general construction at the site. The issues raised by CENPD-CO-C will be covered in this report.

3. Please contact Mr. David D. Gembala, (206) 764-3711, CENPS-EG-G, for any information or comments concerning the Foundation Report. Any additional comments should be received by 30 September 1988. At that time the Geology Section will prepare the report for final printing.

FOR THE COMMANDER:

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

CF:
CENPS-EG-G (Gembala)
CENPS-PE-CP (Ohlstrom)

CHIEF JOSEPH DAM
ADDITIONAL UNITS AND STRUCTURAL MODIFICATION

FOUNDATION REPORT

U.S. Army Corps of Engineers
Seattle District

1988

CHIEF JOSEPH DAM - FOUNDATION REPORT

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TABLE OF CONTENTS (cont.)

FIGURES

TABLE OF CONTENTS (cont.)

TABLE 1-1

PERTINENT DATA

General	
Federal ID number	WA 00299
Owner and operator	U.S. Army Corps of Engineers, Seattle District
County, State	Douglas, Washington
Hazard potential	Category 1 (High)
Location	
Upstream from mouth of Columbia River	545 miles
Upstream from Bridgeport, Washington	1.5 miles
Downstream from Grand Coulee Dam	51.0 miles
Hydrology	
Drainage area above dam	75,400 square miles
Flood peak, historical (1894)	740,000 c.f.s.
Flood peak, maximum recorded (1948) at Grand Coulee Dam	638,000 c.f.s.
Mean annual streamflow at Bridgeport (1952-1981)	113,200 c.f.s.
Mean annual regulated peak flow with treaty storage (based upon 1929-1958 routings)	190,000 c.f.s.
Spillway design flood (SDF)	1,200,000 c.f.s.
Reservoir	
Maximum pool elevation	958.8 feet*
*All elevations are based on National Geodetic Vertical Datum (NGVD)	
Maximum regulated pool elevation	956 feet
Normal full pool (NFP) elevation	956 feet
Normal low pool elevation	950 feet
Minimum pool elevation	930 feet
Tailwater elevation at mean flow and Wells pool at elevation 779	782.3 feet
Area, full pool	8,400 acres
Reservoir gross capacity (full pool)	593,000 acre-feet
Power pondage (for 5-foot drawdown)	38,000 acre-feet
Length of reservoir	51 miles
Shoreline of reservoir	106 miles

TABLE 1-1 (cont.)

PERTINENT DATA

Dam

Length right embankment	250± feet
Length right nonoverflow monoliths	196 feet
Length spillway monoliths	980 feet
Length center nonoverflow monoliths	1,088.37 feet
Length intake monoliths	2,036 feet
Length closures monoliths	524.75 feet
Length left embankment	476± feet
Length left buried core	416± feet
Length of entire dam along axis*	5,962± feet

*The total length of the dam is not equal to the sum of its individual sections because of the angle of intersection of the intake and closure monoliths.

Maximum height of structure from bedrock to top of dam	230± feet
Elevation top of dam	970 feet
Volume of concrete used in dam	1,731,240 c.y.

Spillway

Design discharge	1,200,000 c.f.s.
Crest length	19 bays at 36 feet
Gate number	19
Gate type	Tainter
Gate width	36 feet
Gate height	58.2 feet
Gate radius	55 feet
Crest elevation	901.5 feet
Gate top elevation	958 feet
Top of dam elevation	970 feet
Spillway bridge elevation	970 feet
Gate hoist	Individual drums with remote control in the powerhouse for all gates
Gate seals	Musical note rubber side seal
Frostproofing	Odd-numbered gates, seals, and seal, by oil heat system

Stilling Basin

Length	211 feet
Width	915 feet
Apron elevation	743 feet
End sill	11 feet high, 2 steps
Top of training wall elevation	810 feet
1948 flood tailwater elevation	805.5 feet

TABLE 1-1 (cont.)

PERTINENT DATA

Dam Intake Section	
Type of structure	Concrete gravity
Intake invert elevation	879 feet
Top elevation of structure	970 feet
Length	2,036 feet
Main Units:	
Number of penstocks	27
Penstock diameter	25 feet
Penstock length	258 feet
Penstock shell thickness	5/8 inch to 1-1/4 inches
Number of gates	27 (plus 1 spare gate and 2 maintenance bulkheads)
Gate size	22 feet by 34 feet
Full gate velocity	14.5 f.p.s.
Station Service Units:	
Number of penstocks	2
Penstock diameter	6 feet
Number of gates	2 (plus 1 maintenance bulkhead)
Gate size	8 feet by 8 feet
Powerhouse	
Length	2,039 feet
Number of units	27
Height from bedrock	136 feet
Thickness of walls	5 feet
Inside width of generator room	68 feet
Main Units	
Type	Francis
Turbine Rating	117,700 hp @ 165 feet rated head (units 1-4, 15, and 16) 115,100 hp @ 165 feet rated head (units 5-14) 136,000 hp @ 163 feet rated head (units 17-27)
Manufacturer, turbines	Newport News Ship Building and Drydock Company (units 5-14), S. Morgan Smith Company (units 1-4, 15, and 16), and Hitachi American, Ltd. (units 17-27)
Generator rated capacity per unit	64,000kW (units 1-16) and 95,000kW (units 17-27)
Manufacturer, generators	Westinghouse (units 1-16) and General Electric (units 17-27)
Transformer number	21 plus 2 spare

TABLE 1-1 (cont.)

PERTINENT DATA

Station Service Units

Number and type	2 Francis vertical shaft
Turbine rating	3,500 hp @ 165 feet net head
Generator rating	3,000kVA @ 0.8 p.f., 60-cycle, 3-phase 4,160 volts
Manufacturer, turbines	Pelton Waterwheel Company
Manufacturer, generators	Elliott Company

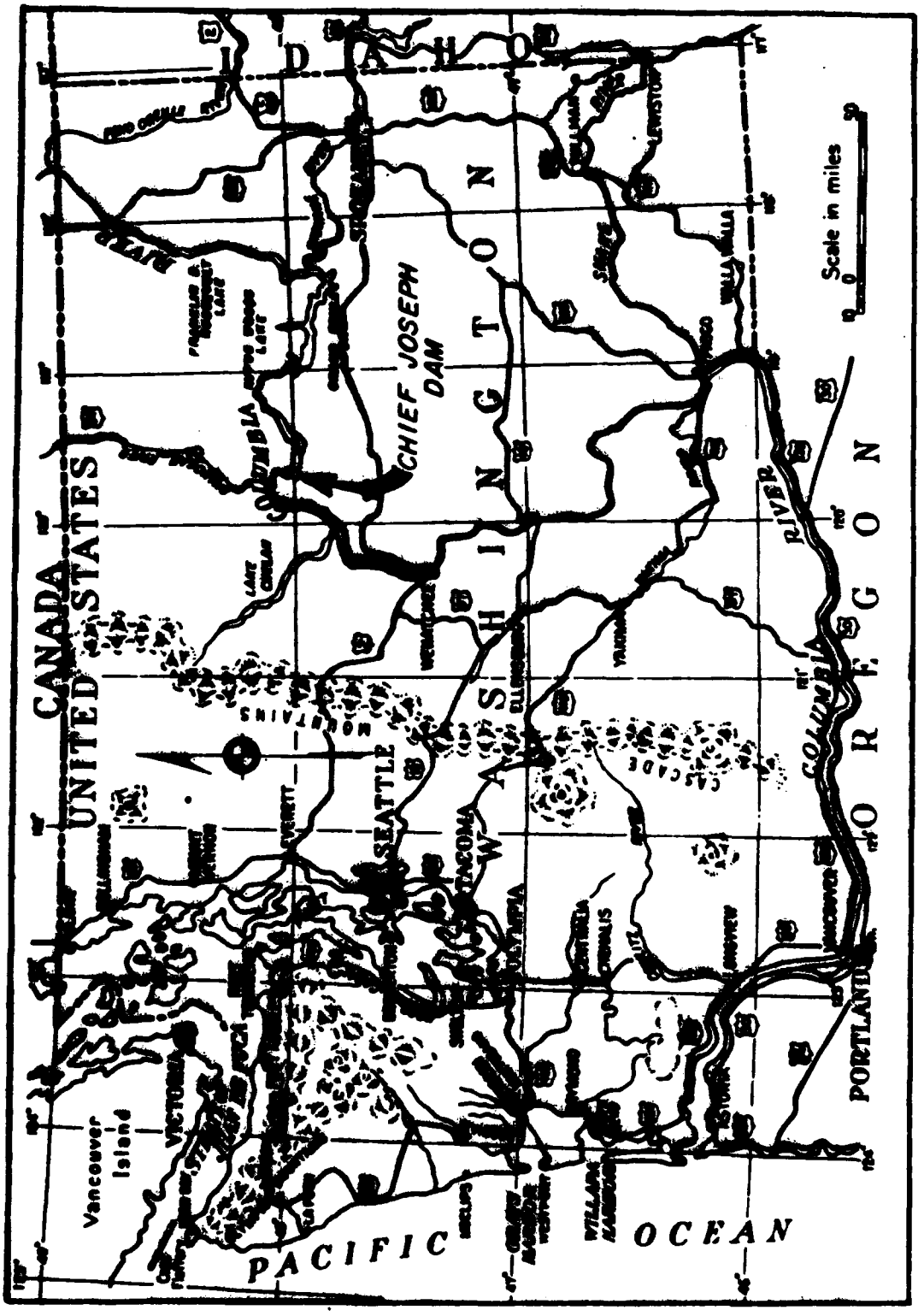
SECTION 1. INTRODUCTION

1.01 Location and Description of Project. Chief Joseph Dam is located on the Columbia River in north central Washington, 545 river miles (R.M.) above its mouth and 51 R.M. below Grand Coulee Dam (figure 1-1). The river, originally 800 feet wide at the damsite, was confined between steep walls. The dam consists of, from right to left (looking downstream), a 250-foot long right embankment, 4,820.5 feet of concrete gravity sections, a 476-foot long left embankment, and 416 feet of impervious cutoff core (figure 1-2). The concrete gravity section consists of a nonoverflow section (monoliths 1-4), a spillway section (monoliths 5-24), a nonoverflow section (monoliths 25 through 44, plus A and B), an intake section (monoliths 1 through 27, plus S-1 and S-2), and a closure section (monoliths C-1 through C-11). The right abutment of the dam is a terrace rising more than 250 feet above the riverbed. The lower 100 feet of this terrace is openwork gravel with sand, while the upper 150 feet is hard, glacial till. The left abutment is granitic bedrock which rises sharply about 100 feet above the bed of the river and then continues upward in a moderate and broken slope. The foundation is an irregular bedrock surface composed of a suite of rock types collectively termed "granite".

The powerhouse additional units and structural modification work was proposed in House Document 693, 79th Congress, Second Session, and authorized under the 1946 River and Harbor Act, as amended by the 1948 River and Harbor Act.

1.02 Purpose of Report. 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 ensure the preservation for future use of complete records of foundation conditions encountered during construction and methods used to adapt structures to these conditions. This report documents the final foundation conditions and treatment for the powerhouse additional units 21-27; post construction instrumentation, drain hole drilling and rock contour maps for the spillway, nonoverflow, intake and closure monoliths; and for the left and right abutment exploration and instrumentation programs.

1.03 Construction History. Initial construction started in 1949, and the reservoir was first raised to normal operating pool, elevation 946 feet, in July 1955. The first generating unit was placed on line in 1955 and the last of the initial 16 units in 1958. In order to produce additional power, construction of structural modifications to raise the pool elevation 10 feet and install 11 additional units was started in 1974 and was completed in 1980. The pool raise to elevation 956 feet occurred in February 1981. The structural modification consisted of raising the dam 10 feet (including the spillway monoliths, nonoverflow sections, and intake structure); removal and rebuilding of the spillway piers; new gate installation; and adding additional concrete mass to insure stability of the gravity structures with the higher reservoir. To accommodate the 11 additional units, the powerhouse was extended to a length of 2,039 feet and penstocks were added to the 11 spaces provided during the initial construction in the 1950's. Powerhouse skeleton bays 17 through 20 were provided during the initial construction.



VICINITY MAP

FIGURE 1-1

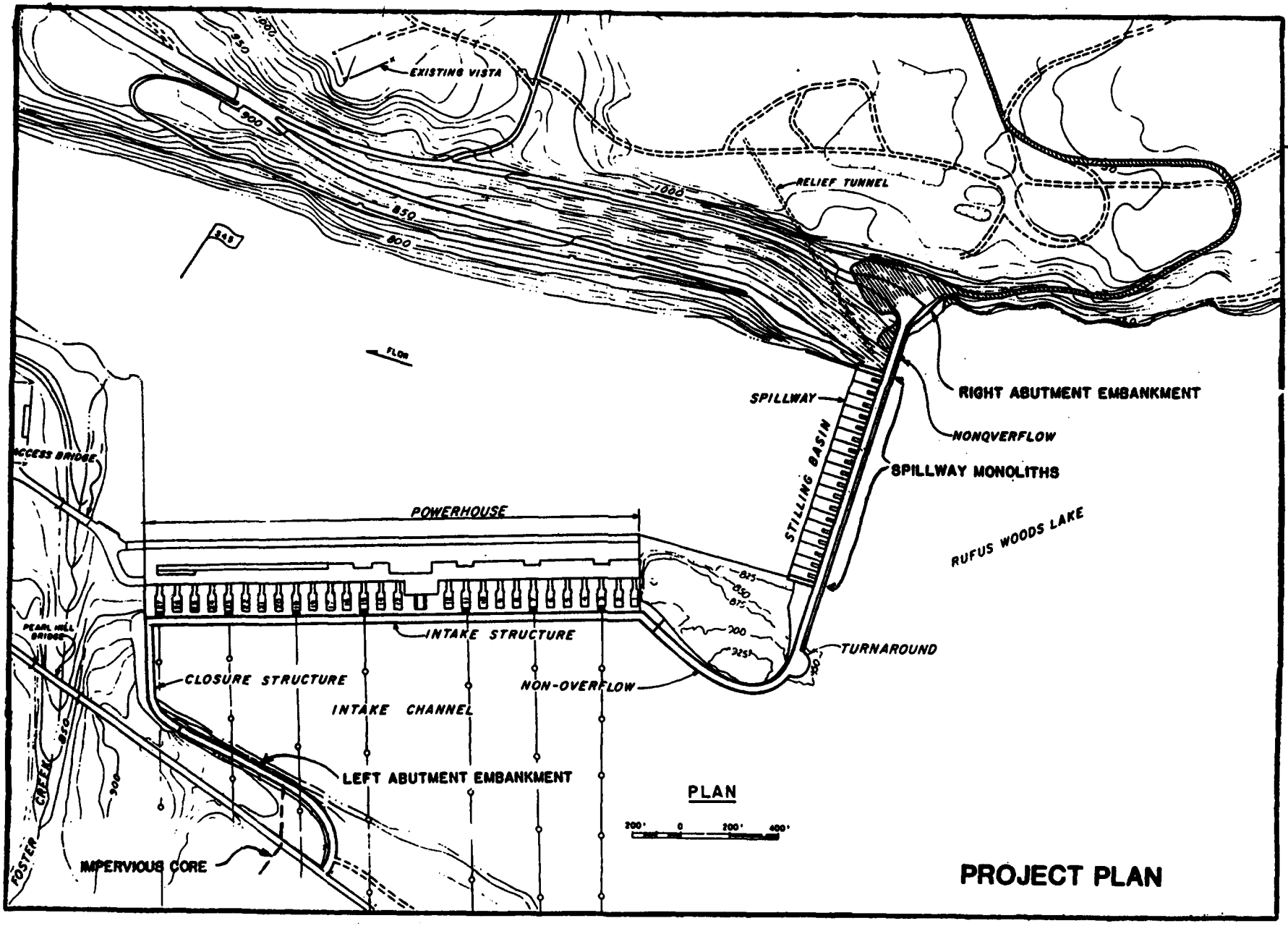

EXISTING VISTA
RELIEF TUNNEL
SPILLWAY
RIGHT ABUTMENT EMBANKMENT
NONQVERFLOW
SPILLWAY MONOLITHS
STILLING BASIN
RUFUS WOODS LAKE
ACCESS BRIDGE
POWERHOUSE
PEARL HILL BRIDGE
INTAKE STRUCTURE
TURNAROUND
CLOSURE STRUCTURE
NON-OVERFLOW
INTAKE CHANNEL
LEFT ABUTMENT EMBANKMENT
FOSTER CREEK
IMPERVIOUS CORE
PLAN
200' 0 200' 400'
PROJECT PLAN

FIGURE 1-2

The powerhouse additional units and structural modifications were constructed by four major contracts. The initial contract, DACW67-75-C-0009, was awarded to the William Gregory Company in August 1974. Items of work included installation of 2-inch diameter rock bolts and 3-inch diameter companion drain holes in the area below the intake structure. The second contract, DACW67-75-C-0042, was awarded to Goodfellow Brothers, Inc. in November 1974. This contract pro-vided the initial excavation and construction of the powerhouse cofferdam. The third contract, DACW67-75-C-0077, was awarded to a joint venture, S.J. Groves and Sons Co. and Granite Construction in March 1975 and included completion of the foundation excavation, dewatering systems, rock bolts and drain holes and the structural portion of the powerhouse. The fourth contract, DACW67-76-C-0043, was awarded to Peter Kiewit and Sons and Standard Construction in March 1976 for structural modification to increase height of the dam.

1.04 Acknowledgements. This report was originally drafted by Edward T. Bailey, Project Geologist, Chief Joseph Dam and substantially modified by Richard D. Eckerlin, Staff Geologist, Seattle District under the supervision of David Gembala, District Geologist, and general supervision of Charles Perry, Chief, Geotechnical Branch, Seattle District. During project construction, Robert Rudman was Resident Engineer and Richard Means was Project Engineer.

The authors wish to acknowledge Kenneth D. Graybeal, Chief, Soils Section, and Richard W. Galster, former Chief, Geology Section, for their careful review of this document and their numerous valuable suggestions.

1.05 Construction Photographs. Refer to Appendix B for selected construction photographs.

SECTION 2. INVESTIGATIONS

2.01 Investigations Prior to Construction. Between 1967 and 1974 several subsurface exploration programs were completed for investigation of the powerhouse foundation, the aggregate borrow source, and the right bank blanket addition. Subsurface powerhouse investigations began in 1967 with 24 borings drilled into the foundation. Overburden was drilled and drive samples were taken employing cable tool methods, while the granitic bedrock was core drilled using a Sprague and Henwood drill. The additional powerhouse units 21 to 27 required excavation in the dry for the substructure, training wall and rock excavation in the tailrace. In 1973 and 1974, 13 additional borings and 2 test wells were drilled to provide data for design of the cofferdam, dewatering system, and excavation slope stability. The 13 borings were drilled and sampled in overburden using a rotary drill and the foundation rock was cored by diamond drill. The two test wells were drilled and sampled with a cable tool drill. Borings logs are in appendix C.

In 1972, five piezometer borings were drilled on the right bank for extension of the right bank impervious blanket. The borings were drilled into granitic bedrock using a combination of air rotary and cable tool methods.

In 1973, three borings were drilled in the Government borrow area located 2 miles downstream from the dam (plate 3). Borings were drilled using a Williams bucket auger. Samples were mechanically separated by shaker and weighed at the site. In addition to the auger borings, five backhoe trenches were excavated to confirm the extent of the gravelly material.

Stability analyses and monolith stress studies completed in the design phase provided for prestressing in the spillway and intake monoliths. Need for prestressing was later reevaluated and eliminated. In 1975, six prototype core drill borings for tendon installation were completed in spillway monoliths 7 and 8, intake monolith 21 and closure monolith 2. Experimental drilling of the prototype holes was varied to provide comparative information to bidders. Boring logs and boring summaries for the structural modifications contract are provided in appendix C.

2.02 Investigations During Construction. Powerhouse contract DACW67-75-C-0077 provided for additional piezometer installations in the powerhouse excavation. In 1975, 15 observation holes consisting of seven 6-inch diameter observation wells and eight well points were installed for the dewatering system. Also in 1975, five wells were added to the cofferdam interceptor seepage control drain system. In late 1975, 18 vertical holes were drilled with a rotary drill from the cofferdam roadbed, through the cofferdam and into bedrock to identify leakage zones. Six of the 18 borings were used for grout injection to seal the leaky zones. In 1977, three additional borings were drilled through cell 5 to check material condition.

Approximately 130 borings were drilled from temporary sluiceways within the dam into the bedrock foundation to determine bedrock elevation for the structural stability analysis (see table 2-1). Rock surface exploration was translated into the bedrock contours shown on plates 14 and 16.

Uplift pressure cells were installed in selected sluiceway borings. These were installed to determine uplift pressures for the initial structural stability analysis.

The turnaround bridge near the left end of the spillway section was modified requiring additional exploration. In October 1975, four borings were completed using a rotary drill. Standard penetration tests were taken in overburden to provide data for design of the allowable bearing capacity for the bridge footings.

2.03 Post Construction Investigations. Erratic water levels were observed in numerous uplift pressure holes in the intake structure. These holes were backfilled with grout, and new uplift holes were drilled adjacent to the old ones. Uplift pressure borings and foundation drains were also drilled in all spillway monoliths, intake monoliths, closure monoliths, and all the nonoverflow monoliths.

In February 1982, ground subsidence was observed near the left abutment earthfill embankment section just downstream from the buried impervious cutoff wall. Several backhoe trenches were excavated in the fill and adjacent ground next to the Pearl Hill Road to determine location and configuration of the impervious core wall. Sixteen borings were drilled and sampled using both rotary and diamond drill methods, and two test wells were drilled using a cable drill. Boring logs are in appendix C. The report on the left abutment settlement is included in the Chief Joseph Dam, Periodic Report No. 7, October 1984. In April 1987, four borings were drilled in the left embankment, and in June 1987, two borings were drilled adjacent to closure monolith 1 (refer to plate 18 in appendix A). Piezometers were installed in the six borings for monitoring possible reservoir leakage.

TABLE 2-1

SLUICEWAY DRILLING DATA
(Confirmation Top of Rock)

Monolith Number	Hole Number	Elevation in Feet	Total Depth in Feet	Depth to Rock in Feet	Elevation at Top of Rock	Angle From Vertical
7	7N-A	769.0	28.0	25.8	741.0	0
	7N-B	769.1	26.7	24.0	745.1	0
	7N-C	769.1	30.1	28.0	741.1	0
	7N-D	769.1	41.0	39.2	736.3	37°
	7N-E	769.1	42.7	40.2	738.1	44°
	7N-F	769.1	59.2	55.0	733.4	55°
7	7S-B	769.0	30.5	25.9	743.1	0
	7S-D	769.1	29.6	25.5	743.6	0
	7S-E	769.1	43.9	43.6	732.7	37°
	7S-F	769.1	58.7	56.3	730.6	52°
	7S-G	769.1	67.3	65.5	729.8	59°
	7S-H	769.1	78.0	75.9	729.4	65°
	7S-I	769.1	102.8	93.0	708.7	55°
	7S-J	769.0	92.0	87.9	697.9	40°
	7S-K	769.1	52.8	47.2	735.7	50°
	7S-L	769.1	90.4	85.6	724.4	65°
	7S-M	769.1	43.9	37.7	736.1	32°
	7S-N	769.0	35.3	29.0	740.0	0
	7S-O	769.1	42.1	36.1	737.5	32°
9	9N-B	769.0	36.0	34.7	734.3	0
	9N-D	768.9	35.6	34.9	734.0	0
	9N-E	769.0	30.2	28.8	740.2	0
	9N-F	768.9	44.9	43.1	732.9	37°
	9S-A	769.0	43.0	42.3	726.7	0
	9S-B	769.0	39.5	38.3	730.7	0
	9S-C	769.0	36.7	34.3	734.7	0
	9S-D	769.2	41.6	41.4	727.8	0
	9S-E	769.0	52.0	49.5	728.1	38°
	9S-F	769.0	46.7	43.9	731.9	36°
	9S-G	769.0	52.6	49.7	727.5	37°
	9S-H	769.0	51.0	50.0	727.6	38°
	9S-I	768.9	39.0	36.3	742.1	47°
	9S-J	769.0	32.8	30.8	745.6	45°
11	11N-A	769.0	23.9	21.6	747.4	0
	11N-B	769.0	27.0	24.0	745.0	0
	11N-C	769.0	29.0	25.7	742.3	0
	11N-D	769.0	30.2	27.0	746.4	37°
	11N-E	769.0	35.3	32.0	743.4	41°
	11N-F	769.0	38.0	34.2	744.1	48°
	11N-G	769.0	53.9	49.4	741.2	62°

TABLE 2-1 (cont.)

SLUICEWAY DRILLING DATA
(Confirmation Top of Rock)

Monolith Number	Hole Number	Elevation in Feet	Total Depth in Feet	Depth to Rock in Feet	Elevation at Top of Rock	Angle From Vertical
	11N-H	769.0	51.8	47.8	735.7	51°
	11N-I	769.0	30.0	24.2	744.8	0
	11N-J	769.0	32.8	27.5	745.1	33°
	11N-K	769.5	40.9	35.5	742.5	45°
	11N-L	769.5	43.2	35.6	743.2	47°
	11S-G	769.0	30.6	28.0	745.6	37°
	11S-H	769.0	25.3	23.5	745.5	0
	11S-I	769.0	23.2	20.7	748.3	0
	11S-J	769.0	41.5	35.9	741.7	45°
	11S-K	769.0	41.4	38.6	739.6	45°
	11S-L	769.0	40.7	37.7	744.5	55°
13	13N-A	769.0	31.1	23.6	745.4	0
	13N-B	769.0	25.5	22.5	746.5	0
	13N-C	769.0	25.1	22.4	746.6	0
	13N-D	769.0	35.7	33.7	740.6	36°
	13N-E	769.0	62.6	33.4	745.4	50°
	13N-F	769.0	58.3	31.2	748.7	55°
	13N-G	769.0	66.9	39.0	751.3	70°
	13N-H	769.0	42.0	36.1	741.9	46°
	13N-I	769.0	35.9	32.8	745.8	50°
	13N-J	769.0	77.3	72.0	718.1	50°
	13N-K	769.0	73.8	38.0	744.3	55°
	13N-L	769.0	21.0	19.2	749.8	0
	13S-B	769.0	25.6	20.5	748.5	0
	13S-D	769.0	29.8	24.8	744.2	0
	13S-E	769.0	37.0	30.9	743.4	38°
	13S-F	769.0	39.6	34.5	745.0	51°
	13S-G	769.0	62.7	56.4	734.4	58°
	13S-H	769.0	30.7	22.8	746.2	0
	13S-I	769.0	34.9	29.6	745.3	41°
	13S-J	769.0	71.0	64.8	731.7	61°
16	16N-B	768.9	27.0	25.5	743.4	0
	16N-D	769.0	25.9	22.0	747.0	0
	16N-E	768.9	26.5	24.6	744.3	0
	16N-F	769.0	36.4	32.0	742.5	38°
	16N-G	769.0	31.6	28.2	745.7	38°
	16N-H	769.3	49.5	43.8	736.0	45°
	16N-I	769.0	72.6	67.3	729.4	60°
	16N-J	769.0	75.5	47.0	731.0	40°
	16N-K	769.6	53.1	48.7	741.0	60°
	16N-L	769.0	65.9	60.0	730.0	55°
	16S-A	769.0	29.8	27.3	741.7	0
	16S-B	769.0	17.6	15.5	753.5	0

TABLE 2-1 (cont.)

SLUICEWAY DRILLING DATA
(Confirmation Top of Rock)

Monolith Number	Hole Number	Elevation in Feet	Total Depth in Feet	Depth to Rock in Feet	Elevation at Top of Rock	Angle From Vertical
	16S-C	769.0	16.9	14.6	754.4	0
	16S-D	769.0	24.6	23.2	745.8	0
	16S-E	768.9	28.3	26.2	746.8	36°
17	17N-B	769.0	20.3	15.1	753.9	0
	17N-D	769.0	23.9	18.4	750.6	0
	17N-E	769.0	42.5	36.4	738.9	38°
	17N-F	769.0	26.6	20.8	748.2	0
	17S-A	769.0	21.1	16.1	752.9	0
	17S-B	769.0	20.6	15.2	753.8	0
	17S-C	769.0	25.7	19.5	749.5	0
	17S-D	769.0	44.5	40.6	735.4	38°
	17S-E	769.0	26.8	21.7	747.3	0
18	18N-B	769.0	22.1	17.6	751.4	0
	18N-D	769.0	28.7	23.6	745.4	0
	18N-E	769.0	44.8	37.7	737.8	38°
	18N-F	769.0	33.2	28.1	740.9	0
	18S-A	769.0	27.5	22.5	746.5	0
	18S-B	769.0	25.5	18.5	750.5	0
	18S-C	769.0	26.7	21.5	747.5	0
	18S-D	769.0	52.8	45.6	731.3	38°
	18S-E	769.0	36.9	31.9	737.1	0
	18S-F	769.0	56.0	50.0	731.0	45°
	18S-G	769.0	57.4	48.4	732.2	45°
19	19N-D	769.0	32.3	29.5	739.5	0
	19N-E	769.0	37.0	34.6	734.4	0
	19N-A	769.0	34.5	32.0	743.1	40°
	19N-F	769.0	24.7	19.6	749.4	0
	19N-C	769.0	26.5	23.9	756.2	64°
	19N-B	769.0	36.5	34.6	734.4	0
	19S-F	768.9	46.3	41.8	728.1	14°
	19S-G	768.9	30.3	29.4	740.1	13°
	19S-H	768.9	25.2	22.6	750.6	40°
	19S-I	768.9	47.0	41.6	735.2	40°
	19S-J	768.9	29.0	28.0	746.0	39°
20	20N-A	769.0	23.9	18.9	750.1	0
	20N-B	769.0	31.6	26.6	742.4	0
	20N-C	769.0	40.2	32.5	736.5	0
	20N-D	769.0	26.4	21.6	749.3	27°
	20N-E	769.0	24.0	19.0	750.0	0
	20S-A	769.0	28.2	23.2	745.8	0
	20S-C	769.0	40.0	32.5	736.5	0
	20S-D	769.0	31.0	26.0	746.8	35°

TABLE 2-1 (cont.)

SLUICEWAY DRILLING DATA
(Confirmation Top of Rock)

Monolith Number	Hole Number	Elevation in Feet	Total Depth in Feet	Depth to Rock in Feet	Elevation at Top of Rock	Angle From Vertical
	20S-E	769.0	27.5	22.5	746.5	0
21	21N-A	769.0	32.0	27.2	741.8	0
	21N-B	769.0	34.7	31.3	737.7	0
	21N-C	769.0	25.2	20.2	748.8	0
	21N-D	769.0	34.4	28.1	747.4	44°
	21N-E	769.0	24.8	20.2	748.8	0
	21S-C	769.0	20.5	18.5	750.5	0
	21S-D	769.0	29.1	27.1	746.8	39°
	21S-E	769.0	23.0	18.0	751.0	0
22	22N-A	769.0	34.7	32.6	736.4	0
	22N-C	769.0	18.2	15.0	754.0	0
	22N-D	769.0	32.8	31.6	742.1	35°
	22N-E	769.0	31.7	25.4	748.2	39°
	22N-F	769.0	32.6	30.2	744.0	38°
	22N-G	769.0	22.7	19.6	749.4	0
	22N-H	769.0	24.9	23.0	751.5	45°
	22N-I	769.0	36.8	35.6	743.4	49°
22	22S-A	769.0	24.3	21.3	747.7	0
	22S-B	769.0	20.4	16.3	752.7	0
	22S-C	769.0	15.3	14.2	754.8	0
	22S-D	769.0	24.1	20.3	750.6	28°
23	23N-A	769.0	23.4	21.1	747.9	0
	23N-B	769.0	21.2	18.8	750.2	0
	23N-C	769.0	21.8	18.0	751.0	0
	23N-D	769.0	27.4	24.3	747.4	30°
	23S-A	769.0	23.0	19.0	750.0	0
	23S-C	769.0	20.0	18.0	751.0	0
	23S-D	769.0	31.0	27.8	746.0	38°
	23S-E	769.0	29.9	24.9	750.1	45°
	23S-F	769.0	42.7	37.5	747.4	61°
	23S-G	769.0	54.9	49.9	742.9	65°
	23S-H	769.1	56.8	51.8	742.0	65°
	23S-I	769.0	24.5	17.1	751.9	0

NOTE: Hole number indicates monolith and north (N) or south (S) sluiceway, followed by hyphen and letter which represents hole designation within sluiceway.

SECTION 3. GEOLOGY

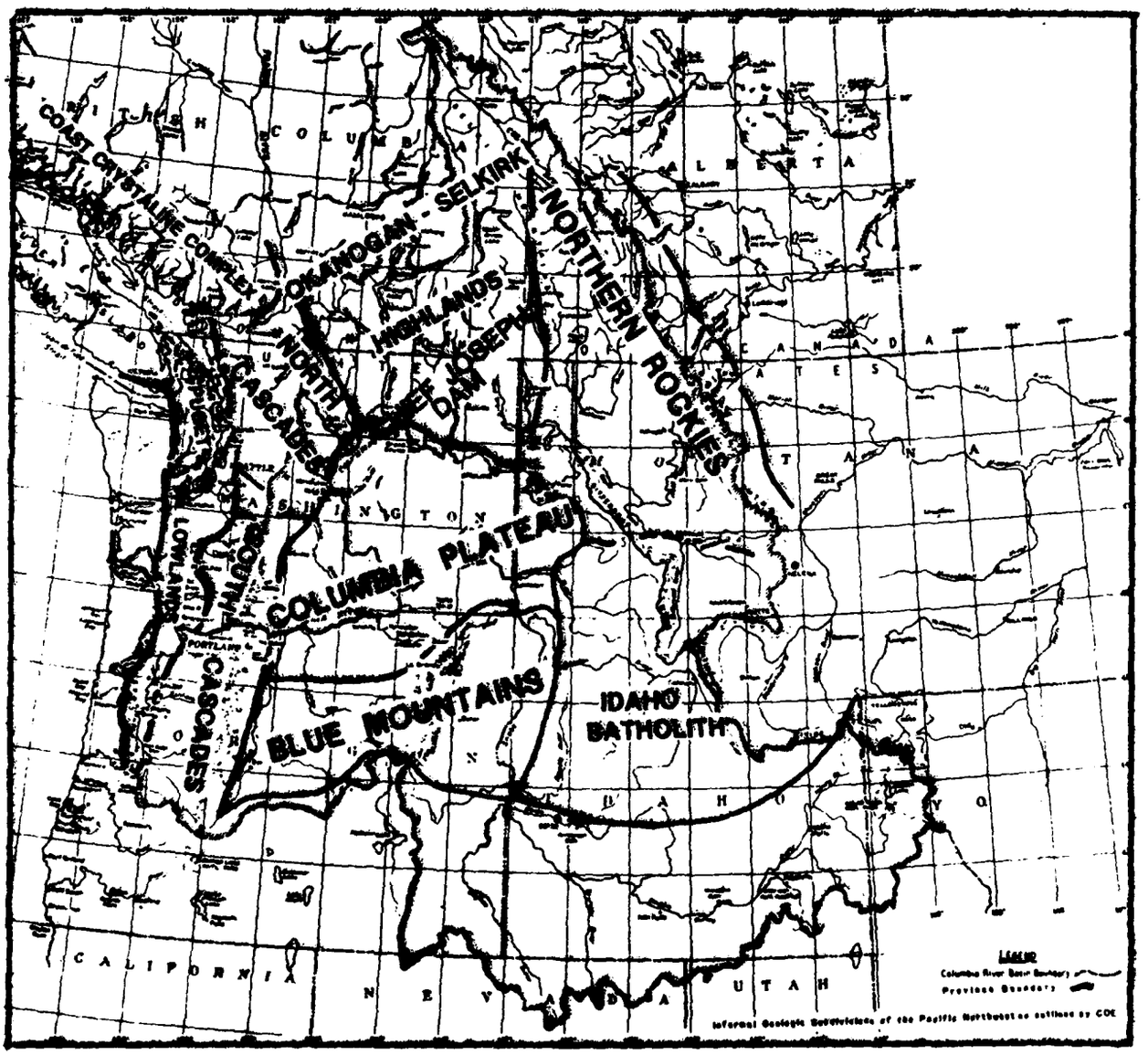
3.01 Geologic Setting. The project lies at the division between two major geologic provinces: The Okanogan-Selkirk Highlands to the north and the Columbia Plateau on the south. Figure 3-1 locates the dam with respect to the provincial divisions. The Columbia River has cut a valley about 1,000 feet deep below the plateau surface into hard crystalline rocks. The rocks in the lower part of the valley and in the Okanogan Highlands are a complex of old metamorphic rocks intruded by granitic rocks of Mesozoic age. Miocene Columbia Plateau basalts are exposed high on the southern side of the valley and locally on the northern side. The valley has been modified by continental glaciation. Variable thicknesses of glacial outwash sand and gravel, lacustrine silts, and till overlie the irregular bedrock surface. The present river has cut down through the glacial sediments into the granitic bedrock leaving a terraced, inner valley within the larger old valley.

3.02 Site Geology. The Columbia River at Chief Joseph Dam flows westerly through a steep-walled, terraced valley 12,000 feet wide and almost 1,000 feet deep. At the dam, the river is 800 feet wide and flows along the base of the southern valley wall.

On the south (left) bank of the river, the bedrock surface generally rises well above the river channel. Glacial deposits fill old abandoned channels of the Columbia River and many of the abandoned tributary canyons. Glacial deposits form a series of extensive terraces south of the river. These deposits include one or more glacial till sheets, a variety of morainal materials, and large quantities of glacio-fluvial and glacio-lacustrine sediments. Slope wash derived from all of the above units mantles most of the ground surface. The glacial till is compacted, unstratified, silty, sandy gravel. Morainal deposits are poorly-to-moderately compacted gravels with or without admixed sand and silt. Glacio-fluvial deposits are stratified, dominantly silty, sandy gravel, but also include sandy gravel, openwork gravel, boulder beds and flood plain silts. Glacio-lacustrine deposits are stratified silt and clay. The bedrock surface north of the river gradually rises above the river channel. A glacial fill terrace extends from the river to the north valley wall. The terrace varies in elevation from 1,030 feet adjacent to the river to over 1,100 feet to the north. The terrace sequence consists of an extensive deposit of torrentially bedded, largely openwork gravel and cobbles, 10 to 100 feet thick overlying the bedrock surface. This highly pervious unit is overlain by varying thickness of "dump moraine" and more than 100 feet of glacial till.

Bedrock is an assemblage of hard, competent crystalline rocks that include granodiorite, granodiorite gneiss, dark schistose granodiorite, hornblende granodiorite, and lamprophyre. These various rock types exhibit different characteristics of soundness as described in the paragraphs below:

a. Granodiorite is the predominant rock type. It is hard, medium to coarse grained and light colored. Generally this rock type is very sound with a high resistance to chemical weathering.



PHYSIOGRAPHIC DIVISIONS

FIGURE 3-1

b. Granodiorite gneiss is a hard, medium to coarse grained, light gray to gray colored rock which exhibits a banded structure with mineral orientation along parallel planes. This rock type is generally very sound with good resistance to chemical weathering. However, with increasing biotite percentage this rock tends to exfoliate along planes.

c. Dark schistose granodiorite may be soft or hard depending on mafic content and degree of weathering. This rock type is usually fine to medium grained, dark colored and may be schistose or gneissic in structure. The contents of biotite or hornblende are present in quantities up to 50 percent. The rock is sound when fresh, but where high biotite content and schistose structure prevail, this rock type has the least resistance to chemical weathering and is, therefore, generally less sound than all the other rock types.

d. Hornblende granodiorite is a granitic type rock containing randomly oriented, medium to coarse grained crystals of hornblende. This rock is medium to dark colored, hard and highly resistant to chemical weathering.

e. Lamprophyre is a very hard, fine grained, dark greenish colored rock found in dikes. Having post dated most major periods of faulting, it is generally less fractured and less altered than surrounding rocks.

f. Lesser rock types such as pegmatite and aplite dikes are commonly found throughout the area, but are relatively small discontinuous bodies. Faults and joints are important rock structures which influence rock mass behavior in excavations and slopes. Faults and fault zones are common throughout the dam foundation and appurtenant structures (plate 7). They are attributable to late stages of the grandiorite intrusions and concurrent orogeny. These faults are inactive and, as so, oriented as to produce no planes of weakness which might be overstressed by addition of large concrete monoliths (U.S. Army Corps of Engineers, 1957). During excavation for the additional powerhouse units, three faults were mapped in the foundations for units 22, 25, and 27 as shown on plate 10. These faults are free of gouge, but rock faces are coated with chlorite. No attempt was made to measure magnitude of offset. Unit 22 fault strikes N60°-70°W, dips 65°-75°E, and consists of a shattered rock zone 1 inch to 2 inches in width. Unit 25 fault strikes N10°W, dips 35°W, and consists of a 4-inch wide shattered rock zone. Unit 27 fault strikes N3°W to N8°E, dips 35°W, and consists of a shattered zone 4 feet wide on each side of a brecciated zone 2 inches to 6 inches in width. Zones of closely jointed rock associated with the faults may be as much as 20 feet wide. Joint faces within the powerhouse excavation and the adjacent rock slope below the intake structure were often slickensided, healed with chlorite, and showed no strain or evidence of being open after the period of chloritization. Joints are attributed to compression and shear coincident and immediately following the period of granodiorite emplacement.

Bedrock weathering is not severe. The most common weathering action was the presence of iron stain. All joint planes near the surface of rock exhibit this characteristic to varying degrees, usually diminishing with depth and disappearing within 20 feet below the surface.

3.03 Powerhouse Foundation (Additional Units 21-27). Additional units 21-27 are founded on various crystalline rock types including schistose and gneissic granodiorite, massive granodiorite and lamprophyre intrusions (plate 11). Two minor faults, striking northerly with 35 degree westerly dips were encountered in the excavation (plate 12). Conjugate joints occur in zones to 8 feet in width. Two prominent joint sets were mapped in the foundation; one set strikes N40-45°W and dips 60-65°NE and the second set strikes N75-80°W with a dip of 75-80°N. Joints within the lamprophyre intrusives extend into the adjacent granodiorite. Joint spacing ranges from 0.1 to 5 feet within the granodiorite rocks and the transecting intrusives. Many joints are coated with unweathered dark chlorite, some resembling a polished appearance. Where the chlorite bond to joints was broken by blasting, the chlorite lubricated surfaces offered little resistance to slippage. Precision rock blasting techniques were employed in the jointed granitic rocks so that maximum utilization of the bedrock could be obtained in the foundation. Precision blasting techniques made possible the use of natural rock piers ("dragon teeth") for the powerhouse. No increase in joint frequency or mechanical breakage was observed in the foliated rock types; however, the foliated rocks broke more platy than the massive granodiorite rocks.

3.04 Construction Materials. Concrete aggregate and common and granular materials were excavated from a government source on the right bank, 2 miles downstream from the project (see plates 1 and 3). This pit was used during the original dam construction. The borrow area is a large gravel terrace adjacent to the Columbia River and composed of clean sandy gravel. A cap of eolian sandy silt, 2 to 4 feet thick, locally overlies the source area. All aggregate processing was conducted on site, stockpiled and hauled to the project. Material quantity surveys were not performed.

Rock for the project was mined in the rock quarry located 2 miles northeast of the project, next to Bridgeport State Park. This source was used for the original dam construction. The quarry was reopened, approximately 94,000 tons of granodiorite rock were removed, then the quarry was closed and reclaimed to natural conditions. About 47,000 tons of rock were used for the downstream right bank tailrace protection. Remaining rock has been stockpiled adjacent to the quarry for future work. Granitic rock that was blasted and removed from the powerhouse additional units excavation was placed in the Foster Creek channel along the right bank several hundred feet upstream of the dam.

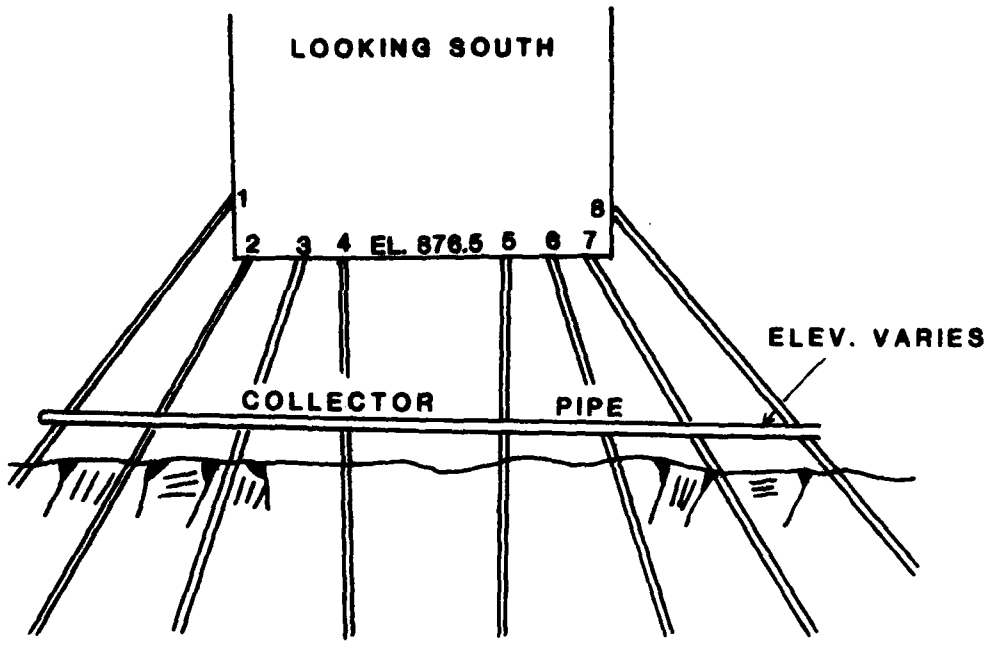
Impervious fill, blanket, and core material were borrowed from a glacial till source located on the right bank 1,000 feet upstream from the dam. The till material was placed in the upstream right bank impervious blanket extension and in the left abutment impervious fill and core.

SECTION 4. FOUNDATION EXCAVATION AND TREATMENT (ADDITIONAL UNITS 21-27)

4.01 General Two major construction contracts were administered for foundation excavation and treatment. A third contract provided for rock bolts and drain holes on the rock slope below intake structure units 1-27.

4.02 Initial Rock Bolting and Drain Hole Drilling. Design analyses indicated that stresses would increase within the unconfined rock mass below the intake structure. The increased stresses would be created by added weight of raising the intake structure, the higher pool, and powerhouse excavation blasting. In addition, foundation uplift pressures would increase. The majority of the drainage system within the intake structure is inaccessible and cannot be monitored nor cleaned as shown on figures 4-1 and 4-2. To supplement the drainage system, a series of subhorizontal drains were drilled in the exposed rock surface below intake monoliths 1-27 (plate 4). In 1986, polyvinylchloride (PVC) pipes were installed. The PVC pipes extend beyond the rock surface to prevent vegetation from plugging the outlets. A system of rock bolt reinforcement was installed in addition to the drainage system below intake monoliths 1-27 (plate 4). Rock bolts were designed to offset the change in load resulting from pool raise and additional height of the dam. The reinforcement system consists of Williams hollow core rock bolts (model number US-16-HC-SCS-300, 2-inch nominal diameter, with standard Type A short cone and shell and Type B long cone and shell). Three-inch diameter rock bolt holes were drilled using an Ingersol-Rand ECM 450 air track drill. In areas where air track access was impossible, holes were drilled using a quarry bar ECM hammer and shortened mast. At drilling completion, all holes were gaged with a "go-no-go" template to assure proper tolerances for bolt anchors. Subhorizontal companion drain holes were drilled adjacent to the rock bolt holes. Negligible ground water was encountered during drain hole drilling. Drain holes were gaged similar to the bolt holes. Both types of holes were flushed with compressed air and water upon completion.

Rock bolts were installed and anchors torqued to manufacturer's specification. Bolts varied from 40 to 75 feet in length with no more that 4 couplings per installation. The bolts were tensioned with a hydraulic ram until a load of 110,000 pounds was reached. The load was maintained for 10 minutes and relaxed. This tensioning procedure was repeated. Bolts that did not withstand the tensioning tests were removed and replaced. For the first 35 bolts installed, five anchors failed loading tests. Contractor research at other projects with similar type bedrock showed that holes drilled in granitic rock tend to have a smooth bore. The Type A short malleable cone tends to produce an insufficient bearing area. The Type B long cone and shell were used for the remaining bolts and no further failures occurred. Rock bolts passing the tests were locked off. Per contract specification, several bolt installations were selected at random and tested to yield. These bolts were loaded to ultimate strength of 200,000 pounds and then restressed.



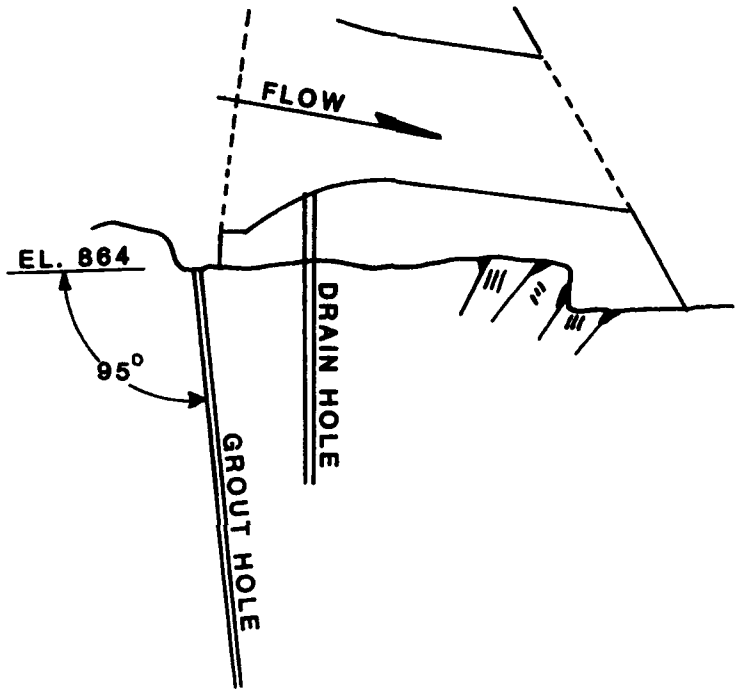
INTAKE STRUCTURE DRAIN HOLES

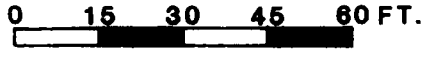
TYPICAL SETUP FOR MONO 1 THROUGH MONO 11 AND MONO 15 THROUGH 27

0 5 10 15 20 FT.

SCALE IN FEET

FIGURE 4-1





INTAKE STRUCTURE SECTIONAL VIEW

TYPICAL GROUT AND DRAIN HOLE RELATIONSHIP
(EXCEPT GALLERIES)

FIGURE 4-2

Prior to grouting, all rock bolts were flushed with water and the water evacuated with compressed air. Neat cement was pumped into rock bolts for bonding and sealing against corrosion.

4.03 Powerhouse Cofferdam and Initial Excavation. The second construction contract provided for the powerhouse cofferdam and initial excavation. Contract features included:

a. common and rock excavation

b. cofferdam cutoff wall and cellular cofferdam construction

c. dewatering wells and piezometers.

The initial excavation contract required all common and rock to be excavated to elevation 785 feet. The following contract for the powerhouse additional units provided for rock removal between elevation 785 feet and finish grade. Shortly after the initial excavation work began, a stop order was issued to halt rock excavation. Members of the North Pacific Division Geotechnical Branch and Technical Engineering Branch proposed a new design for supporting the service deck bridge. It appeared that substantial savings could be realized by leaving rock piers to support the service deck bridge in lieu of concrete piers. The initial excavation contract was then modified so that rock excavation would not go below elevation 799 feet. The contractor installed rock bolts and companion drain holes in the excavated rock down to elevation 799 feet. Materials excavation began at the toe of the rock slope below the intake structure and progressed riverward. Excavated common material was processed and used in construction of the cutoff wall and cofferdam cells.

The additional powerhouse units 21 to 27 required excavation in the dry below tailwater for the substructure, training wall, and rock excavation. This was achieved behind a combination cellular and embankment cofferdam between the original powerhouse and the right bank of Foster Creek. Cofferdam construction began in spring 1975 with the cellular units and progressed from the land section to the powerhouse. Foundation excavation was by dragline. Divers were employed to inspect the foundation prior to seating the cell template. Irregularities too large to be removed by dragline were blasted and then the templates seated. Sheet piles were threaded and seated and the cells backfilled. Driving resistance was encountered during placement of the deep arched sheet pile cutoff wall sections. Designed pile depth was not reached in the dense sand and gravel underlying the cutoff wall while using either a vibrating hammer or the Vulcan 65, steam, single acting hammer. A Delmag 12, diesel, single acting hammer was more successful, however, even with this hammer, full design depth was not reached. Stability analysis indicated that the structure would be stable even at the shallower depths achieved. Cofferdam cells were approximately 60 feet in diameter with top of fill between elevation 800 to 810 feet.

The powerhouse cofferdam and initial excavation contract provided for a dewatering system (plate 5). A preconstruction pumping test in well 364 on the west side of the excavation indicated that effective water control could be

accomplished by pumping from a single row of wells. The pumping test in well 358 on the north side indicated that materials in this area had relatively low permeability so dewatering could be accomplished by one to two rows of vacuum well points. Since the pile cutoff wall in the embankment cofferdam section did not extend to the rock surface as planned, an extensive dewatering system, together with monitoring of phreatic levels within the cofferdam, was required throughout the construction period. Powerhouse dewatering wells and observation piezometers data is summarized in table 4-1. Since the dewatering system was temporary and all materials were to be removed, no well logs nor as-built details of wells were maintained.

Powerhouse cofferdam construction was started in spring 1975 and completed in fall 1975. In December 1975 during a high spillway discharge, which resulted in a tailwater elevation of 786, a leak occurred through the northwest corner of the cofferdam at elevation 785. As soon as the tailwater elevation dropped below elevation 785, the water flow reversed. Pre-1950 topography indicated an old channel of Foster Creek about 50 feet east of the leak area. The old channel was apparently filled during the original powerhouse construction, and the cofferdam excavation appeared to intersect the old channel near elevation 770 in the vicinity of the leak. In April 1976, a seepage interceptor system to accommodate flows of 5,000 gallons per minute was constructed together with rock blanketing and installation of piezometers. The dewatering system is shown on plate 5. High river levels did nor occur again until August 1976, at which time the river reached elevation 787. Construction personnel expressed concern about large flows from the drain system. A seepage test was performed on 24 August 1976. General conclusions from the test were as follows.

a. For river levels up to, and including, elevation 788, the existing cofferdam seepage control system was adequate. The 788-foot river elevation represented a flood of about 1 year frequency.

b. For river levels at or above elevation 790, the seepage control system was inadequate. During the test, the collector drain system was approaching its maximum hydraulic capacity, and piping erosion was occurring upstream from the rockfill treated area. This caused early termination of the test. Total sump inflow at river elevation 790 was about 11,500 gpm, of which about 6,500 gpm were coming from the collector drain system. The 790-foot river elevation represented a flood of 3- to 5-year frequency. Drilling exploration was conducted in September and October 1976 to evaluate the cofferdam, and one boring was grouted to determine effectiveness of using a grout curtain to reduce seepage. After several thousand sacks of cement were pumped into 6 additional borings, the grout curtain scheme was abandoned and the interceptor drainage system was extended. The leakage problem was resolved.

TABLE 4-1

POWERHOUSE DEWATERING WELLS AND OBSERVATION PIEZOMETERS

Boring	Diameter (inches)	Type	Surface Elevation	Top of Rock Elevation
355	4	Piezometer	810	739
358	12	Well	811	726
366	4	Piezometer	817	732
367	4	Piezometer	823	756
371	12	Well	785	754
372	12	Well	785	730
373	12	Well	785	698
374	12	Well	785	693
375	12	Well	785	696
376	12	Well	785	696
377	6	Piezometer	785	693
378	6	Piezometer	785	695
379	6	Piezometer	785	700
380	6	Piezometer	785	706
381	6	Piezometer	785	748
382	6	Piezometer	785	*
383	6	Piezometer	785	*
384	12	Well	785	708
385	12	Well	785	714
386	24	Well	786	<709
387	24	Well	784	736
388	24	Well	786	<705
389	24	Well	*	*
400	*	Well Point	785	*
401	*	Well Point	785	*
402	*	Well Point	768	*
403	*	Well Point	768	*
404	*	Well Point	768	*
405	*	Well Point	768	*
406	*	Well Point	768	*
407	*	Well Point	768	*
500	4	Piezometer	805	<754
501	4	Piezometer	805	<753
502	4	Piezometer	805	<754

*Data unavailable.
Refer to plate 5 for boring locations.

4.04 Powerhouse Additional Units Excavation. The powerhouse additional units contract included rock removal below elevation 799 to finish grade with installation of rock bolts, final excavation limits for overburden, dewatering system, rock reinforcement of rock piers (dragon teeth), removal of the cofferdam and cutoff wall, and final grading. Most overburden was removed during the previous contract. The remaining overburden was removed by front end loader either to top of rock or to elevation 735 feet. Approximately 340,000 cubic yards of common material and 97,000 cubic yards of rock were removed from the excavation area under both contracts (appendix D).

Rock excavation design for penstock units 21 through 27 was intended to result in savings by a "dragon teeth" pattern of vertical walls and horizontal surfaces. However, increased rock bolt and wire mesh costs for rock pier reinforcement apparently offset the reduction in excavation costs.

Powerhouse rock excavation was stringently controlled through contract specifications and constant blast monitoring. See appendix D for the report describing preshear testing for excavation of the penstock slots and powerhouse addition. Precision rock blasting techniques were employed to preserve rock formations for founding the powerhouse service deck. Before excavation, tops and upper sides of the "dragon teeth" between the penstock slots were somewhat jagged and irregular due to the strike of both primary joint sets being 45 degrees to the trend of the teeth. The sides of the teeth responded well to excavation. Rock bolts were systematically installed as rock excavation progressed downward (figures 4-4 through 4-9). The intent of the stringent contract specification was to prevent damage to existing concrete structures on the final design rock face by limiting peak particle velocity. To meet contract vibration restrictions for final bedrock faces, presplit shots were detonated in a series of delays with only three line holes in each shot. Con-tract blasting specifications are in appendix D. The maximum peak particle velocity (vectoral sum) allowed was 2 inches per second in rock at a minimum of 20 feet distance from the design rock face, and 4 inches per second in concrete.

FIGURE 4-3

LEGEND FOR FIGURES 4-4 THROUGH 4-9

Trace of dipping joint plane with angle and direction of dip.

Trace of vertical joint plane.

Lamprophyre Dike

Rock Bolt

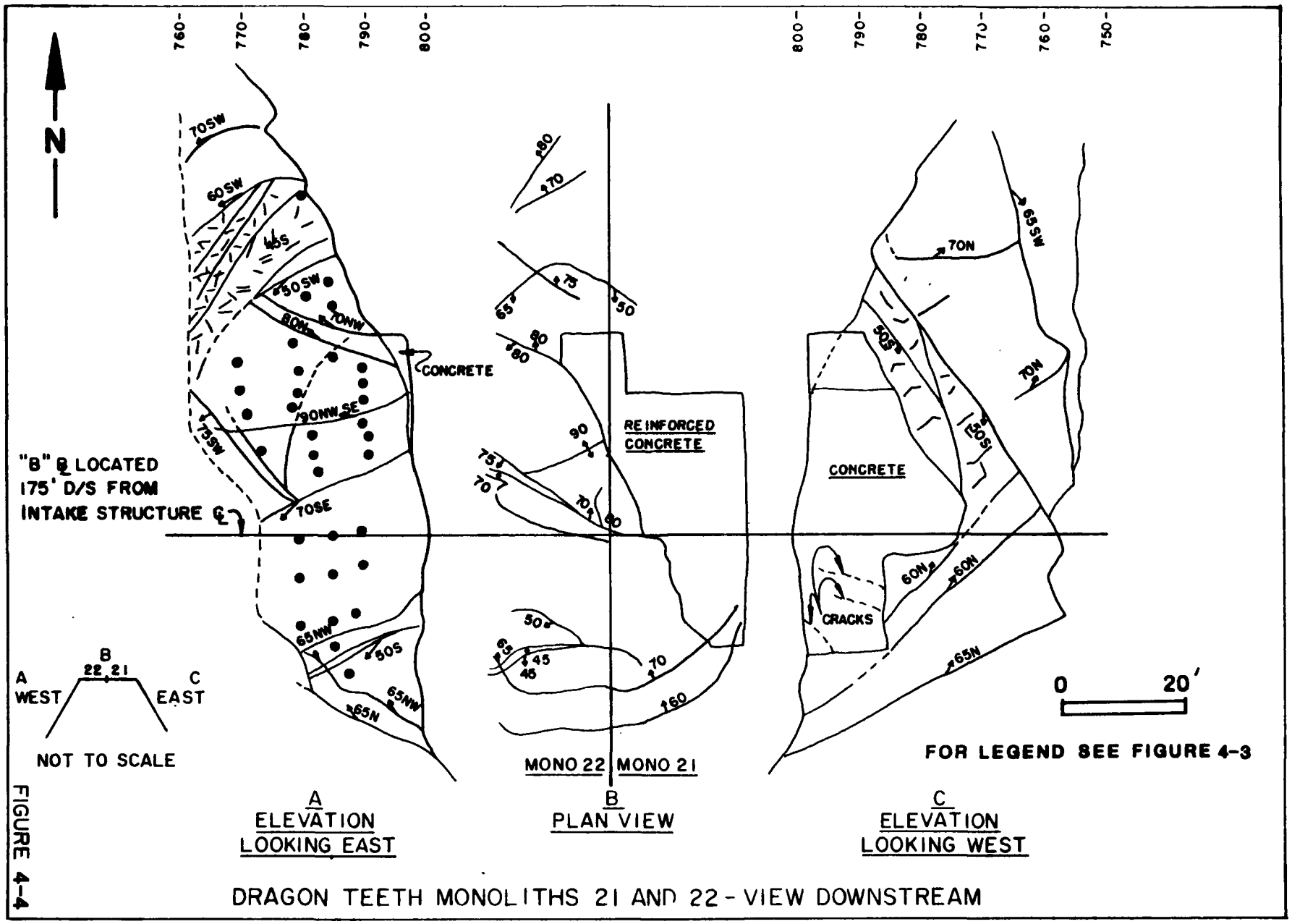


FIGURE 4-4

DRAGON TEETH MONOLITHS 21 AND 22 - VIEW DOWNSTREAM

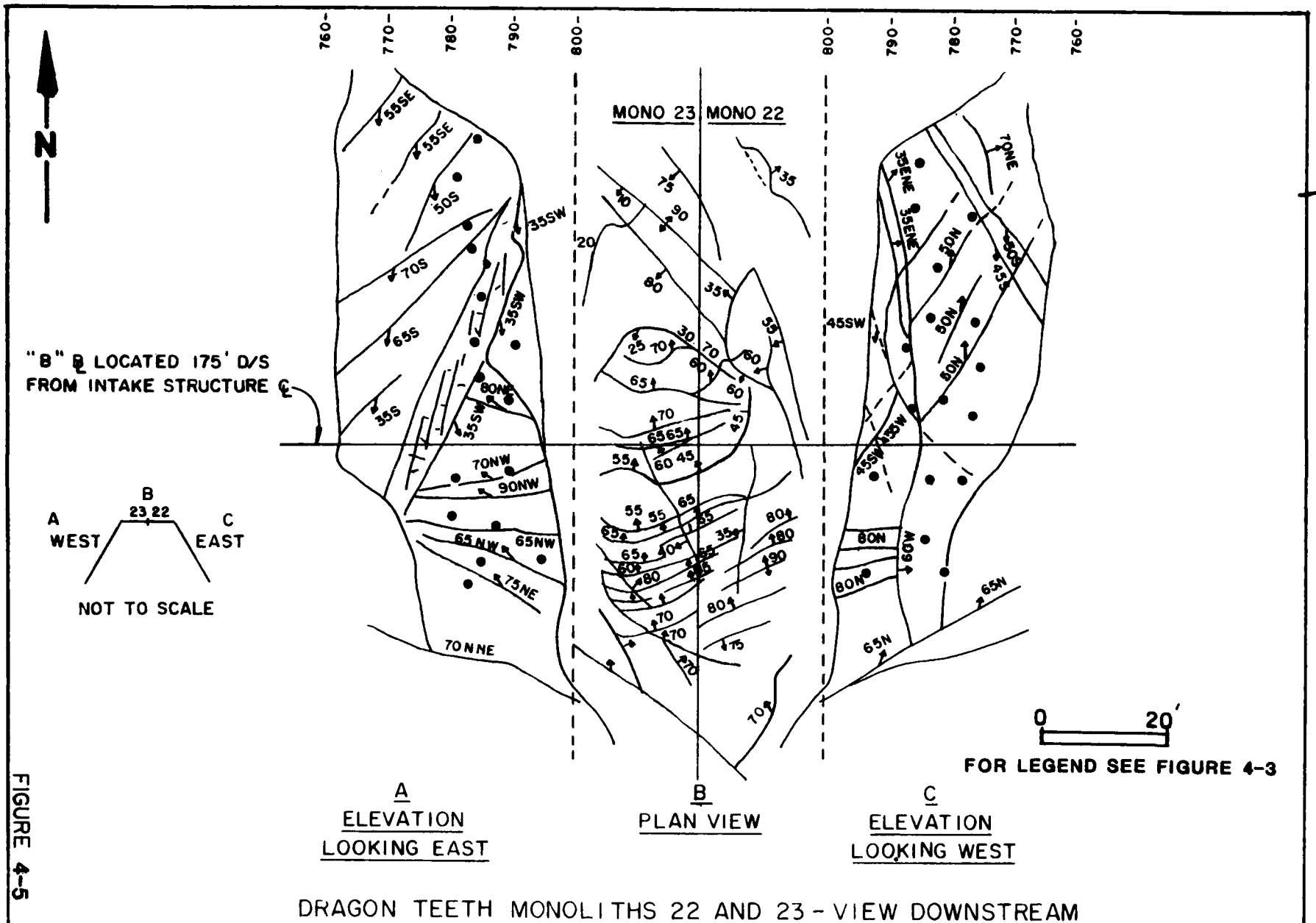
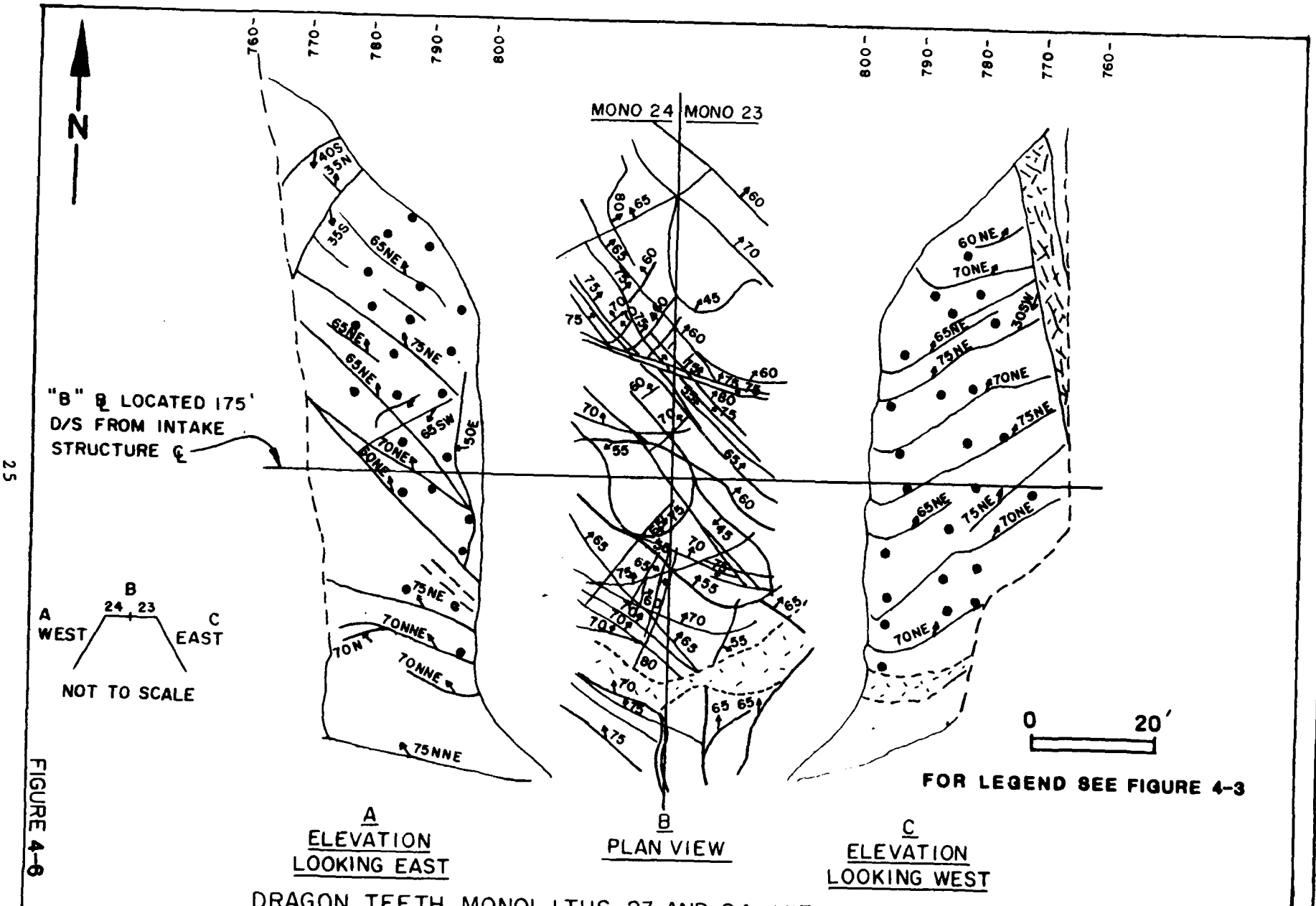


FIGURE 4-5

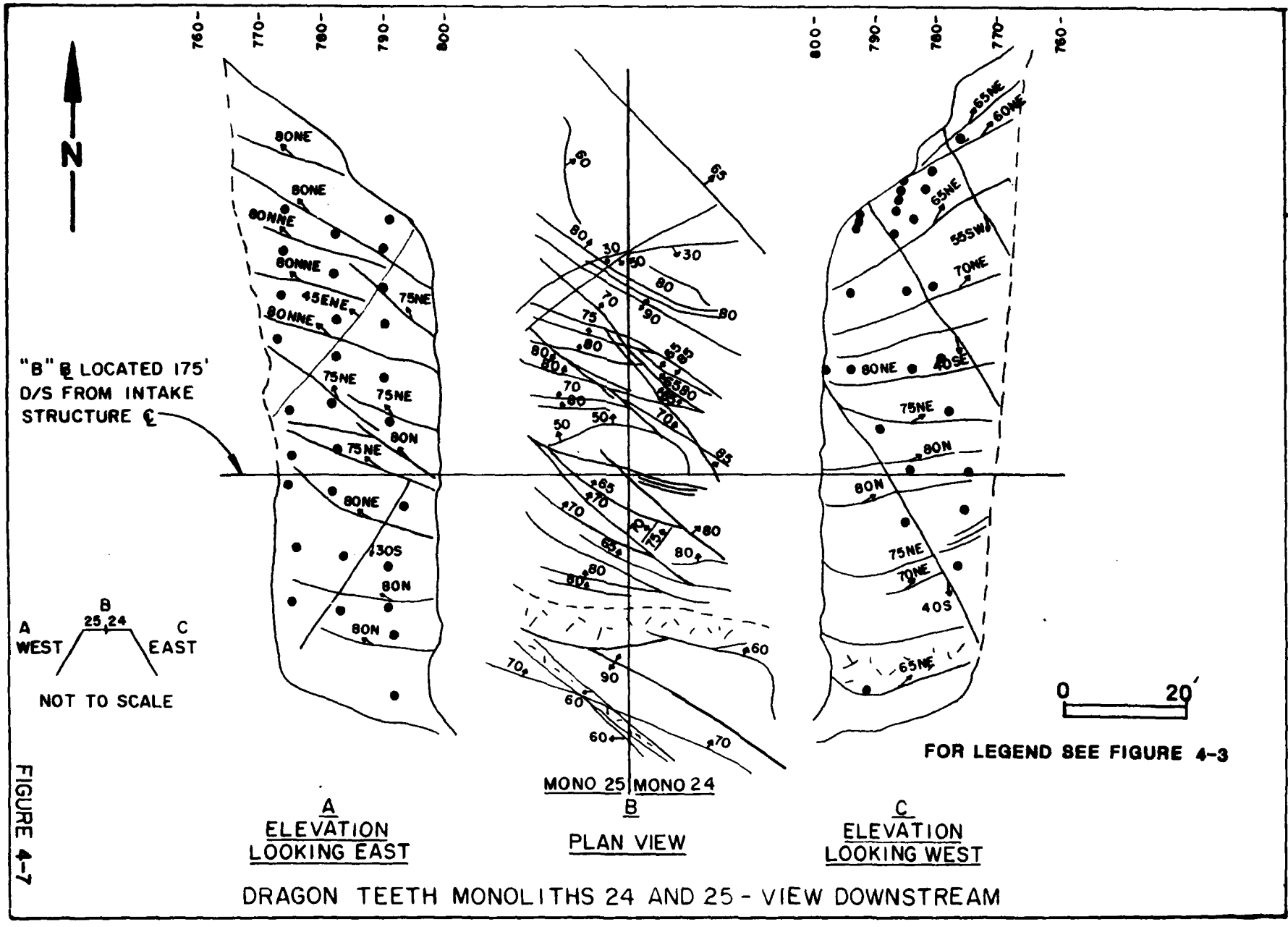
DRAGON TEETH MONOLITHS 22 AND 23 - VIEW DOWNSTREAM



FOR LEGEND SEE FIGURE 4-3

FIGURE 4-6

DRAGON TEETH MONOLITHS 23 AND 24 - VIEW DOWNSTREAM



FOR LEGEND SEE FIGURE 4-3

FIGURE 4-7

DRAGON TEETH MONOLITHS 24 AND 25 - VIEW DOWNSTREAM

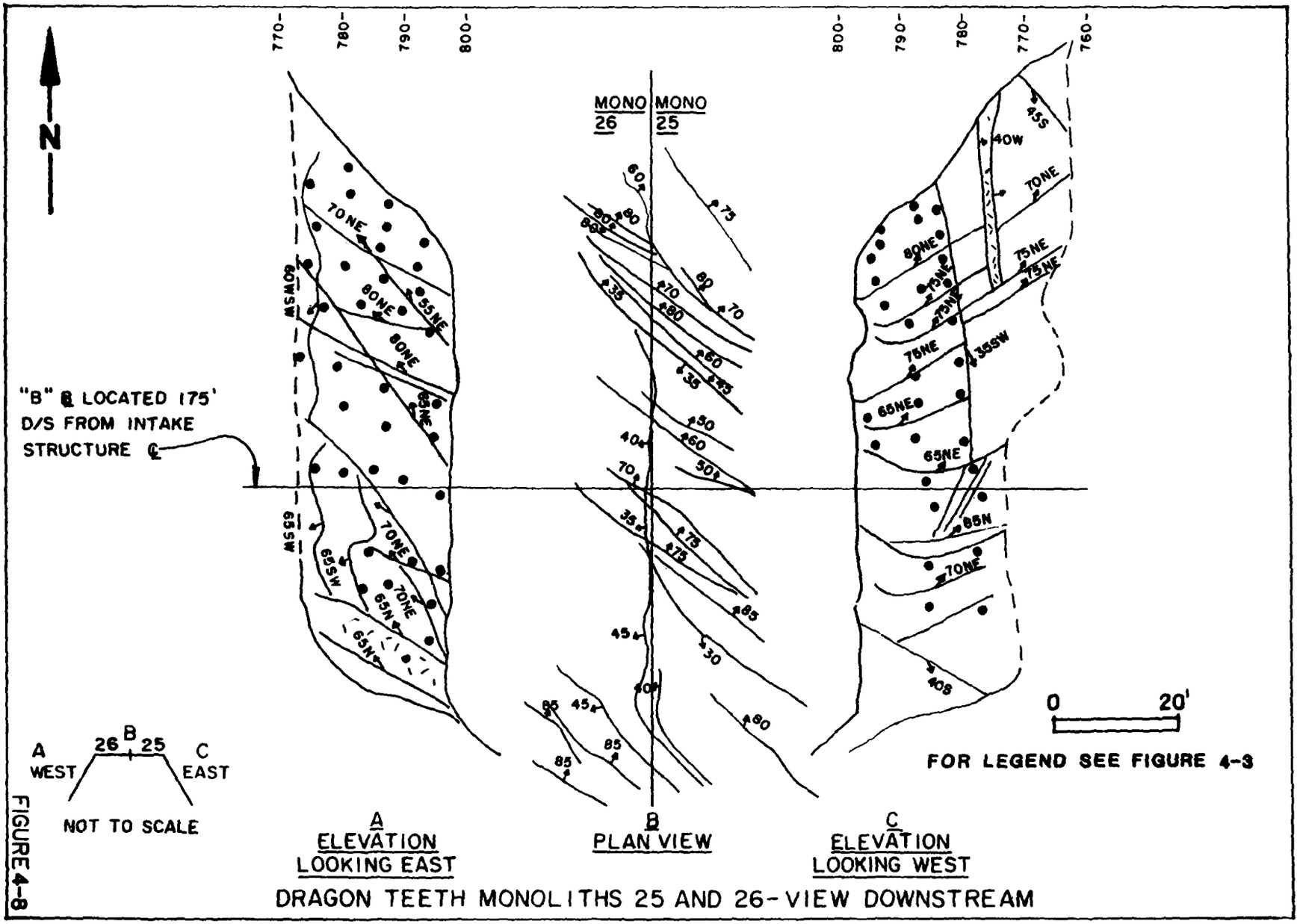


FIGURE 4-8

DRAGON TEETH MONOLITHS 25 AND 26 - VIEW DOWNSTREAM

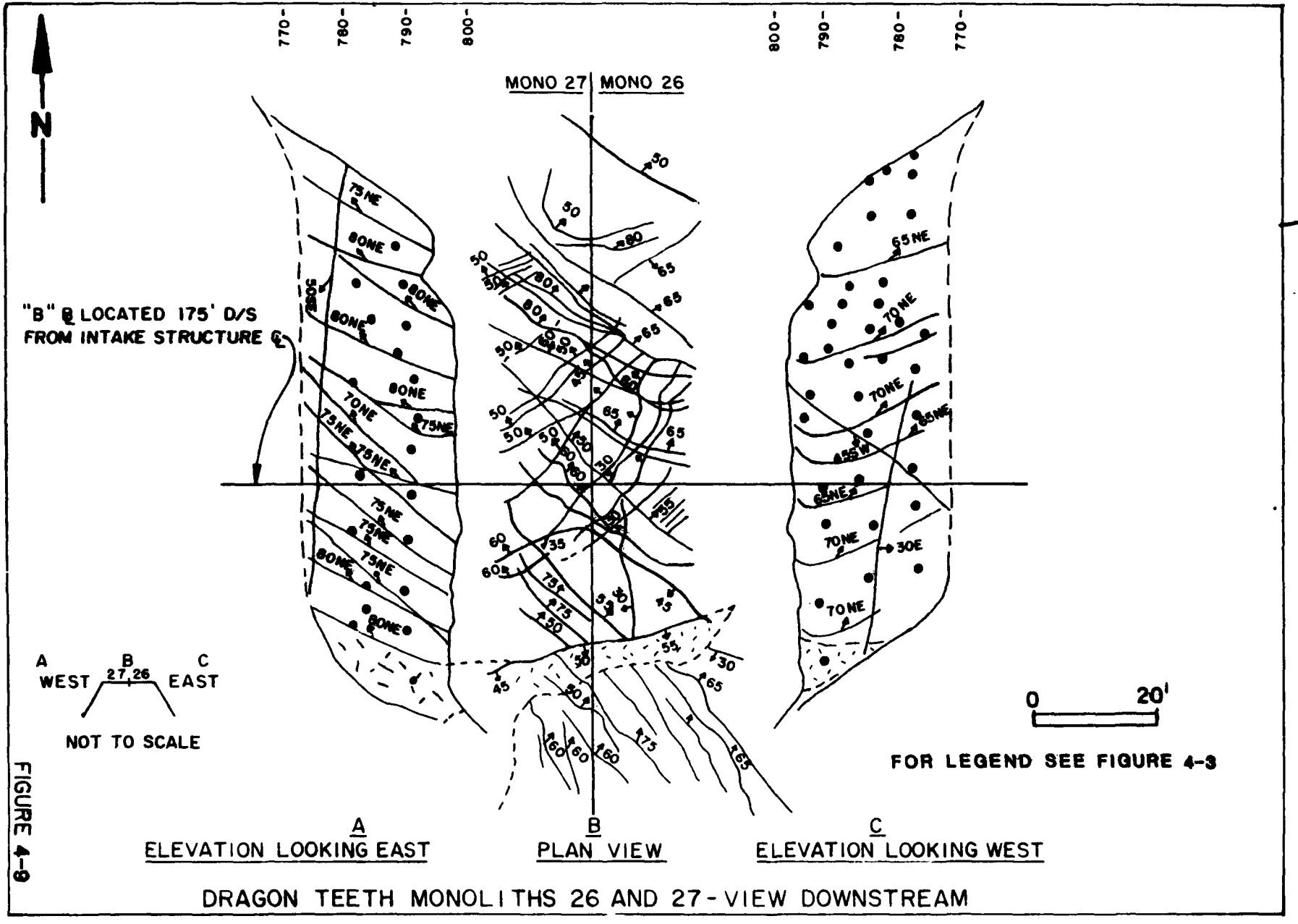


FIGURE 4-9

DRAGON TEETH MONOLITHS 26 AND 27 - VIEW DOWNSTREAM

SECTION 5. STRUCTURAL MODIFICATION INSTRUMENTATION

5.01 General. The structural modification consisted of raising the dam 10 feet including the spillway monoliths, nonoverflow sections, intake structure, closure monoliths and abutments. The dam consists of a 250-foot long right embankment, 4,820.5 feet of concrete gravity sections, a 476-foot long left embankment and 416 feet of buried impervious core. The concrete gravity sections consist, from right to left, of a nonoverflow section (monoliths 1 through 4), a spillway section (monoliths 5 through 24), a nonoverflow section (monoliths 25 through 44, plus A and B), an intake section (monoliths 1 through 27, plus S-1 and S-2), and a closure section (monoliths C-1 through C-11). Refer to plate 7.

5.02 Instrumentation for Spillway and Intake Monoliths. Instrumentation has been placed throughout the dam to monitor structural behavior, determine bending, tilting and displacement and to insure safety. Instrumentation includes measurement of the interior concrete temperatures, joint movements, crack movements, uplift pressures, leakage and structural deflections. The following paragraphs describe the various types of instrumentation, their location and function. Table 5-1 shows instrument locations and reading schedule.

5.02.1 Strong Motion. Instruments for measuring seismic response of the dam are installed in spillway monolith 24 at elevations 950 and 764 feet. Another instrument to measure ground motion is installed downstream of the dam on the left bank. These instruments are electrically powered with an emergency battery power and automatically record when triggered by seismic activity. The only earthquake recorded to date was by the downstream strong motion instrument occurring on 19 January 1979. An earthquake of local magnitude 4.3 occurred approximately 5 to 7 miles southeast of Chief Joseph Dam.

5.02.2 Concrete Temperatures. Resistance thermometers were embedded in the concrete of spillway monoliths 13, 14, 15, and 17 in vertical and horizontal arrays during the original construction of the dam. These thermometers measure the temperature profile throughout the monoliths as affected by water and ambient air temperatures. The pool raise had no noticeable effect on concrete temperatures, and the thermometers show only small annual variations; therefore, the readings of the thermometers in monoliths 13, 14, and 17 have been discontinued. Reading of monolith 15 thermometer will continue on a monthly basis to provide data for structural evaluation.

5.02.3 Crack and Joint Meters. Since construction of the dam, Whittemore gage points have been installed across several monolith joints and exterior cracks throughout the spillway and nonoverflow monoliths and across all the monolith joints in the intake and closure sections. Manual mechanical measurements of these points were made periodically to monitor deviation of movement from annual cycles of movement established from prior measurements. In 1979-80, electronic joint meters were installed in galleries across all dam monolith joints and one crack in monolith C-2. These meters automatically read both axes of movement in the horizontal plane by means of variable resistance potentiometers. Data are transmitted by wire to a microprocessor located in the control room of the powerhouse and transmitted from there via

TABLE 5-1

INSTRUMENT LOCATIONS AND READING SCHEDULE

Instrument Type and Number of Total	Normal Reading Frequency and Remarks	Instrument Location(s)
1. Joint Meters, Potentiometer Type, 85	Monthly monitoring controlled remotely from District office.	Spillway: All mono joints in access gallery. El. 832 Nonoverflow: All mono joints in nonoverflow gallery. Elevation varies. Intake/closure: All mono joints in 948 gallery.
2. Deformation Meters, 8	Discontinued 26 July 1982	Spillway: Drainage gallery, monoliths 7, 9, 16, and 19, 2 each.
3. Deflection Plumblines, 2.	Twice monthly.	Spillway: Access gallery and drainage gallery, monoliths 5 and 24.
4. Precise Alignment: Laser Survey	Twice annually. Laser survey taken at maximum upstream and downstream deflections.	Intake: 960.75 gallery, monoliths 1-27.
5. Uplift Pressure Cells	Monthly.	
a. Gage Type, 53		a. Closure: Drainage gallery, monoliths C2-C11 (2 each); C1 (1); Intake: drainage gallery, monoliths 12-14, S1, S21; Spillway: drainage gallery, monoliths 1-6, 8, 10-12, 14, 15, 19, 21, 24 (1 each); Nonoverflow: 25, 27, 30, 31, A (1 each), B (2).
b. Air Pressure Type, 106		b. Cells located in all sluices of monoliths 7, 9, 11, 13, and 16-23.

TABLE 5-1 (cont.)

INSTRUMENT LOCATIONS AND READING SCHEDULE

Instrument Type and Number of Total	Normal Reading Frequency and Remarks	Instrument Location(s)
c. Sounding Type, 77		c. Intake monoliths 1-11, 15-27 (2 each) from the 948 gallery; monoliths 3, 11, 16, 17, 20, 22, 24 (2 each) from the 960.75 gallery; nonoverflow monoliths 28, 29, 32-44 (1 each).
6. Leakages	Minimum twice annually (February and August), additional readings required under certain conditions (except weirs).	Drainage Gallery: Joint and face drains-spillway, 198. Foundation Drains: Spillway, 248; Intake, 34; Closure, 51.
a. Joint Drains, 25		
b. Face Drains, 173		
c. Foundation Drains, 333		
d. Weirs	Monthly.	Nonoverflow 26,44; Closures C1, C4.
7. Sump Discharge	Measure weekly.	Spillway: Monolith 15.
8. Whittemore Crack Gages, 41	Discontinued 22 July 1982.	Spillway and Nonoverflow: Downstream, exterior, monoliths 3-5 and 24-43.
9. Resistance Thermometers, 141	Monthly for monolith 15 only, other thermometers no longer read.	Spillway: Monoliths 13, 14, 15, and 17.
10. Piezometers, 90	Monthly.	Right abutment; 70 (3 taken out of service).
		Left abutment; 20 in service.
11. Relief Tunnel Wells, 22	Twice annually (September and March).	Relief tunnel in right abutment.

TABLE 5-1 (cont.)

INSTRUMENT LOCATIONS AND READING SCHEDULE

Instrument Type and Number of Total	Normal Reading Frequency and Remarks	Instrument Location(s)
12. Relief Tunnel Leakage	Weekly.	Relief tunnel in right abutment.
13. Slope Indicator, Bridgeport Slide, 14	Quarterly.	Reservoir, left bank. (See Figure 8-1)
14. Foster Creek Culvert Flow	Weekly.	Foster Creek
15. Settlement Monuments, 25	As directed by GT Branch; survey conducted by District Survey Branch.	21 on top and downstream of left abutment; 4 on top of right abutment.

telephone to a computer terminal in the District office. Frequency of readings can be varied and transmission of data controlled directly from the District office. The automatic system became fully operational in May 1980. Movements indicated to date are within expected ranges. Readings from the new instruments do not correlate with past Whittemore gage readings. This is attributed to inherent inaccuracies of the Whittemore system and human error involved in manual readings. Readings of Whittemore gages have been discontinued at joints and on exterior cracks.

5.02.4 Plumblines. Suspended wire plumblines were installed in the access shafts at each end of the spillway in monoliths 5 and 24 during the contract for pool raising structural modifications. The plumblines measure monolith deflection trends. The wires extend from elevation 957 feet near the top of the dam to the approximate elevation of 767 feet. Reading stations for both plumblines are located at approximately elevations 836 and 770 feet at intersections of the access shafts with galleries.

5.02.5 Uplift Pressures. With increased height of the dam, determination of uplift pressures at the foundation was critical so uplift pressure wells were installed in all spillway monoliths, intake monoliths, closure monoliths, and all of the nonoverflow monoliths, except monolith 26. Locations are shown on plates in appendix A. Three types of readouts are used for the uplift pressures: direct reading type using a gage for measurement of the uplift pressure, the air pressure type using air pressure to displace a column of water, and sounding wells where the depth to water is measured. Uplift pressures in the spillway section are generally below the design limits, but several air pressure-type cells near the downstream toe of the dam indicate pressures above design assumptions. The intake structure uplift monitoring system consisted of 48 vertical, size EX (1-1/2 inch diameter) holes drilled during the structural modification contract. These holes were drilled from the elevation 948-foot gallery through concrete into foundation bedrock. Two uplift wells were drilled each in monoliths 1 through 11 and 15 through 27. Numerous uplift wells showed erratic water level readings which were attributed to water leaking through the horizontal concrete lift joints. Between 1981 and 1983, EX holes in 18 intake monoliths were filled with grout and a new pair of NHR wireline holes (3-inch diameter) were drilled to replace them (table 5-2). As-built rock elevations beneath the dam were never developed for the initial foundation report published in 1957. Table 5-2 gives uplift boring drilling data (1981-1983) completed in the intake structure and is presented here to supplement top of the rock elevation data. Location of the intake structure uplift pressure wells are shown in the plan view on plate 12 and section view on plates 21, 22, and 23. The wells are read monthly using a model DR-760A Soiltest water level indicator. Remote readout electrical devices have been purchased and will be installed in each uplift well. PVC pipes were grouted in the holes to near top of rock to prevent water flowing in through leaking concrete lift joints. An additional pair of NHR wireline holes were drilled from the elevation 960.75-foot gallery in monoliths 3, 11, 16, 17, 20, 22 and 24 since these monoliths were considered the most unstable. In May 1983, the new uplift monitoring system was complete. Uplift pressures in monolith 11 of the intake structure continued to be high. In 1984, additional drain holes

TABLE 5-2

INTAKE STRUCTURE - UPLIFT PRESSURE BORINGS

Monolith Number	Hole Number	Elevation in Feet	Total Depth in Feet	Depth to Rock in Feet	Elevation at Top of Rock
1	1SE	948	88.7	84.9	863.1
1	1SW	948	92.5	89.2	858.8
2	2SE	948	92.5	88.8	859.2
2	2SW	948	88.5	84.8	863.2
3	3NE	960.75	114.2	110.5	850.3
3	3NW	960.75	113.3	108.6	852.2
4	4SE	948	90.1	86.6	861.4
4	4SW	948	92.5	86.8	861.2
5	5SE	948	89.0	85.6	862.4
5	5SW	948	89.5	85.2	862.8
6	6SE	948	90.7	86.5	861.5
6	6SW	948	90.5	86.3	861.7
7	7SE	948	89.5	86.2	861.8
7	7SW	948	92.5	88.5	859.5
8	8SE	948	90.9	86.1	861.9
8	8SW	948	91.0	84.9	863.1
9	9SE	948	90.5	86.4	861.6
9	9SW	948	90.5	87.0	861.0
10	10SE	948	91.0	88.2	859.8
10	10SW	948	90.0	85.9	862.1
11	11NE	960.75	104.1	100.4	860.4
11	11NW	960.75	115.5	110.1	850.7
15	15SE	948	91.5	88.3	859.7
15	15SW	948	90.5	85.7	862.3
16	16NE	960.75	102.5	97.6	863.2
16	16SE	948	90.5	86.8	861.2
16	16NW	960.75	103.5	98.8	862.0
16	16SW	948	90.5	86.9	861.1
17	17SE	948	90.5	86.8	861.2
17	17NE	960.75	100.5	97.6	862.4
17	17SW	948	90.5	86.1	861.9
17	17NW	960.75	100.5	96.5	863.5
18	18SE	948	89.7	86.0	862.0
18	18SW	948	89.5	86.3	861.7
19	19SE	948	90.5	86.1	861.9
19	19SW	948	94.8	91.9	856.1
20	20NE	960.75	120.9	116.9	843.9
20	20NW	960.75	124.5	120.4	840.4
21	21SE	948	107.5	104.6	843.4
21	21SW	948	110.5	106.0	842.0
22	22NE	960.75	125.5	121.6	839.2
22	22NW	960.75	122.5	117.7	843.1

TABLE 5-2 (cont.)

INTAKE STRUCTURE - UPLIFT PRESSURE BORINGS

Monolith Number	Hole Number	Elevation in Feet	Total Depth in Feet	Depth to Rock in Feet	Elevation at Top of Rock
23	23SE	948	90.5	85.7	862.3
23	23SW	948	90.5	86.3	861.7
24	24SE	948	90.6	85.6	862.4
24	24NE	960.75	103.0	97.5	862.5
24	24SW	948	87.5	84.6	863.4
24	24NW	960.75	102.9	99.3	860.7
25	25SE	948	87.5	84.6	863.4
25	25SW	948	89.5	85.9	862.1
26	26SE	948	89.7	85.9	862.1
26	26SW	948	90.8	86.9	861.1
27	27SE	948	102.5	99.5	848.5
27	27SW	948	112.5	108.2	839.8

were drilled in the eastern end of the lower drainage and grouting gallery in monolith 12 to intersect faults and joints in monolith 11. Uplift pressures were slightly reduced. High uplift pressures occurred in monoliths 13 and 19 during the winter of 1985-1986. The high readings were attributed to surface water leaking past hole collars. Waterproof caps were installed and readings decreased. Leakage is also occurring at some of the pipe fittings of the uplift pressure system in the closure monoliths. All other monolith uplift pressures show no excessively high uplift pressures.

5.02.6 Laser Alignment. Movement of intake monoliths 1 through 27 in the transverse (upstream-downstream) direction is measured by means of a projected laser beam through the gallery at elevation 960.75 feet. Monolith movements can only be related to adjacent monoliths as the ends of the survey line are not fixed points and cannot feasibly be referenced to any fixed points. Two surveys of alignment prior to pool raise were made, and 12 post-pool raise alignment surveys have been made. Results of these surveys indicate most monoliths move +0.10 inch annually in a direction perpendicular to the structure's longitudinal axis as relative to their position in June 1980.

5.02.7 Leakage. Leakage from all sources in the nonoverflow and spillway monoliths 1 through 25 is collected and measured in the sump in monolith 15. Leakage into the nonoverflow monoliths 26 through 35 is collected in the gallery gutter, measured at a weir in the gallery gutter in monolith 26, and discharged downstream of the dam through a pipe in monolith 26. Leakage into nonoverflow monoliths 36 through 44 and A and B is discharged downstream through a pipe in monolith B. Foundation drainage in the closure section and monoliths 12, S-1, S-2, 13 and 14 of the intake section is provided by drain holes drilled from a gallery near the foundation surface as shown on plate 12. The remaining intake monoliths do not have such gallery and foundation drainage systems. Eight drain holes per monolith were fanned from the penstock apertures in the upstream third of each monolith with each group connected to a collector pipe embedded in the concrete and draining to the downstream side. All drain holes were angled in the plane of the dam axis to intercept an optimum number of joints. There is no means to monitor leakage from these drains and they should be considered ineffective. Past experience has shown that drains in the foundation rock tend to become clogged with mineral crystal development after a few years. There is no means of access to these holes for cleaning, as is done periodically for all other foundation drains (see figures 4-1 and 4-2). Additional drains were drilled under the intake structure from the sloping rock face downstream, angling slightly upward beneath the structure. These drains were installed along with rock bolting in 1974 as a separate contract to the additional units. All of these holes have shown minor seepage since completion. Drain holes were cleaned in the summer of 1984 and 1985. In 1986, short sections of PVC pipe were installed in the holes to prevent plant growth and blockage of drains. Flow from gallery drain holes in the intake section is so low that measurement is impractical. Flow from closure section drains appears fairly constant throughout the year (20 to 30 gpm total). Originally, leakage into the drainage gallery of the closure monoliths was removed by gravity drains located in monoliths C-1 and C-4. During structural modifications, the gravity drain located in monolith C-4 was

blocked, and efforts by the project staff to clear the drain were unsuccessful. The total drainage into the drainage gallery is now discharged through the gravity drain in monolith C-1. Monitoring of leakage is by means of a weir in the drainage gutter of C-4 and a weir in the drainage gutter immediately upstream of the gravity drain in monolith C-1.

SECTION 6. RIGHT EARTH AND ROCKFILL EMBANKMENT AND ABUTMENT

6.01 General. A zoned wraparound embankment consisting of an impervious core, filter, random fill, rockfill, and riprap section serves to limit seepage and to tie the concrete dam to the right abutment. The right abutment is composed of highly pervious gravel, 30 to 100 feet thick, sandwiched between bedrock and overlying glacial till. Right abutment seepage control features consist of impervious blankets, wells and a relief tunnel which are discussed in the following paragraphs.

6.02 Relief Tunnel. The relief tunnel was constructed in the right abutment during original dam construction to control seepage. The tunnel contains 22 relief wells and has a discharge capacity of 100 cubic feet per second (cfs). The tunnel discharges into the spillway apron. Since initial raising of the reservoir in 1955, flow from the tunnel has gradually diminished from a maximum of 93 cfs in June 1955 to the present average discharge of about 25 cfs. Seepage discharge has responded in a predictable manner to the reservoir raise to elevation 956 in February 1981. In 1982, a permanently mounted velocity-discharge meter was installed in the tunnel to permit remote reading of relief tunnel flows.

6.03 Piezometers. Forty-seven piezometer wells, 12 of which are multistage piezometers have been drilled into the right abutment at locations shown on plate 19. All piezometers were installed from 1944 through 1972 to aid in evaluating right abutment seepage and the effectiveness of seepage control measures. Piezometric water levels are measured monthly.

6.04 Upstream Seepage Control Blankets. During construction of the dam, an impervious blanket was placed extending from the wraparound section at the end of the dam upstream for 2,000 feet. Construction materials for the blanket were excavated from a glacial till source located on the right bank at the upstream end of the blanket. In 1957, the impervious blanket was extended 2,000 additional feet to further reduce seepage, however, the blanket extension had no apparent significant effect on abutment seepage. Study of seasonal ground water temperatures in relation to reservoir temperatures indicated an apparent high permeability zone near the top of the original impervious blanket about 1,000 feet upstream from the dam. In 1973, five piezometers were drilled behind the impervious blanket to verify that a leaky zone existed. Study of piezometer data between 1955 and 1972 revealed a rising piezometric surface in the abutment upstream of the dam behind the impervious blanket. A study of ground water temperatures in relation to cyclic reservoir temperatures indicated that the raised level was caused by a zone of high permeability near the top of the original impervious blanket about 1,000 feet upstream of the dam. Construction records show that the blanket was left low in the area because of the apparent nature of the soil. In 1976, the impervious blanket, extending from the dam to 1,300 feet upstream, was raised from elevation 870 feet to 940 feet. The impervious blanket was extended underwater by lowering buckets of graded silty gravel below the water to the working surface. Since raising and extending the blanket, piezometer data (through 1987) indicates that the piezometric surface has stabilized. Monthly observation of existing piezometers in the abutment area serve for tracking the piezometric head within the aquifer.

SECTION 7. LEFT ABUTMENT

7.01 General. The embankment for the intake closure section on the left abutment is founded on bedrock and constructed to crest elevation 970 feet. The zoned embankment consists of an impervious core, upstream and downstream filters, random fill, rockfill, and riprap section. A buried cutoff wall approximately 416 feet long connects the zoned embankment to the rock abutment. The buried cutoff wall is founded on bedrock and consists of an impervious core with upstream and downstream filters. Near the middle. where a depression in the rock surface is crossed, the bottom 20 to 30 feet of the core consists of concrete. During 1982, 18 piezometer wells and 14 settlement monuments were placed in this vicinity to monitor seepage and observe settlement adjacent to the buried cutoff wall. Studies indicated that the observed subsidence was probably the result of settling of poorly compacted backfill both upstream and downstream of the buried cutoff wall. Continued analysis of adjacent piezometers indicate that the seepage cutoff wall is functioning as designed (U.S. Army Corps of Engineers, 1986). A complete discussion of the investigation is found in Chief Joseph Dam Periodic Inspection Report No. 7, October 1984.

7.02 Construction History. The impervious cutoff (core wall) was constructed in 1953. Between 1976 and 1980, the core wall was raised to elevation 965 feet for added freeboard. In February 1981, the reservoir was raised to new normal maximum operating level of 956 feet.

7.03 Geology. The left abutment is characterized by an irregular granitic bedrock surface overlain by glacial outwash consisting of sand and sandy gravels and construction fill. Joints within the bedrock are locally open, some times 1 to 2 inches. The near surface material is an uncompacted variable mixture of blasted rock rubble, sand, and gravel. Voids are found in various areas throughout the rock rubble fill. During periods of cold winter weather, numerous citings have been made of vapor rising from fill areas on the left bank. This phenomenon was first reported to Seattle District geologists in the 1960's and the occurrences continue to date. The vapor may be explained by atmospheric pressure changes acting in combination with certain subsurface ground conditions. A portion of the rockfill may form a constriction over a porous media. This is analogous to a bottle with a narrow opening. When the region is subjected to high atmospheric pressure, the air pressure in the subsurface tends to achieve equilibrium. As a low pressure storm moves into the area, a pressure differential is created between the surface and subsurface. The high pressure air within the porous media escapes upward much like a balloon releasing air. Since the year-around ground temperature is 50 to 60 degrees Fahrenheit, the subsurface air tends to be the same. As the warmer air rises into the colder air, a vapor resembling steam is created. Where this vapor is found, the adjacent ground surface can be expected to be free of snow. To date no hydrothermal activity has been recognized in the vicinity of the dam.

7.04 Investigations. Several backhoe trenches were excavated both north and south of Pearl Hill Road to confirm the configuration of the core wall. The core wall alignment is as shown on plate 18. Sixteen borings were drilled and converted into piezometers. Borings were drilled to determine material properties, bedrock configuration and ground water conditions. In addition, several backhoe trenches were excavated in and adjacent to the downstream settlement area. Pockets of coarse rockfill were observed in the sides of these trenches. Bedrock surface contours were developed from photographs, foundation excavation, and exploratory data and are shown on plate 18. Bedrock contours indicate a low area in rock that extends downstream from the core wall and then closes. The contours delineate a local closed bathtub-like depression in rock between the core wall and higher rock downstream. This closed area acts as a water trap and collects seepage and surface runoff when water inflow exceeds drainage capability.

7.05 Conclusion. The impervious corewall appears to be intact and functioning as designed. There is no evidence of seepage through the corewall, however, there is evidence of seepage through joints in the bedrock underlying the wall. The settlement area downstream from the corewall is probably the result of consolidation of poorly compacted backfill.

SECTION 8. RESERVOIR SLOPES

8.01 General. Since the reservoir was increased to elevation 956 feet in February 1981, minor progressive erosion and beach development have occurred. Reservoir related slumping in glacial till has developed along the right bank for several miles upstream. Slumping in the glacio-lakebed silts and clay and raveling in certain sand and gravel terraces are common in steep bank slopes around the reservoir.

8.02 Bridgeport Slide. Bridgeport Slide (figure 8-1) is located on the left (south) bank just upstream from Chief Joseph Dam. The status report of the slide is found in Chief Joseph Dam, Periodic Inspection Report No. 8, April 1986. The slide encompasses an area 2.5 miles long by 0.5 mile wide. Initial sliding is prehistoric, but portions of the slide mass are currently being affected by the reservoir. Slide movement near the upstream end of the Bridgeport Slide required abandonment and relocation of a portion of Douglas County Road 321 during the 1970's. Easements, which restrict land use around the reservoir periphery, have been obtained. Such easements include existing landslides adjacent to the reservoir and areas subject to erosion by the reservoir. Recent fresh cracking of the ground surface is visible several hundred feet upslope from the abandoned road. The slide is monitored using photogrammetric methods at least twice annually and inclinometers are measured approximately four times per year. The Bridgeport Slide poses no apparent direct threat to the dam.

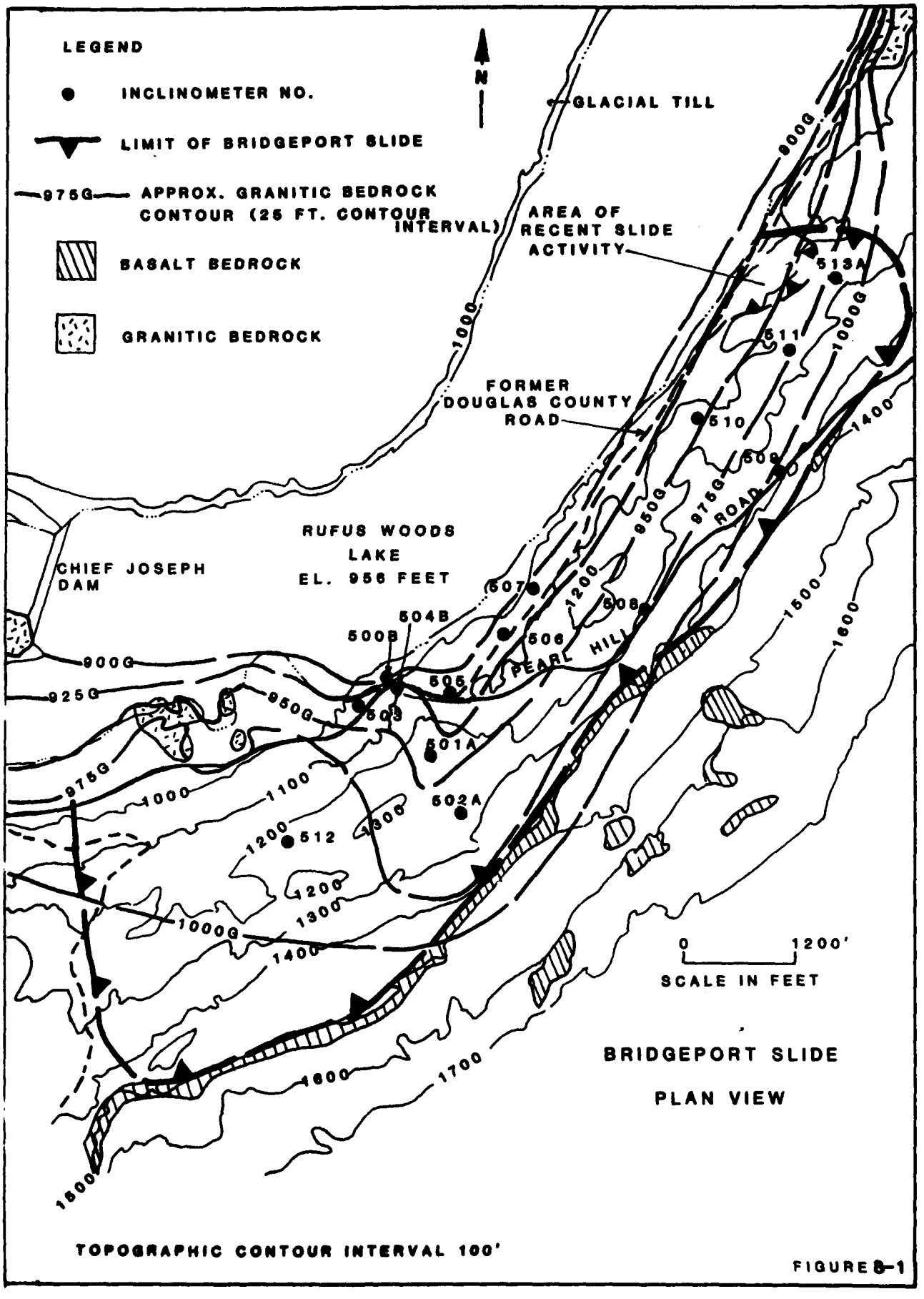

LEGEND
INCLINOMETER NO.
LIMIT OF BRIDGEPORT SLIDE
975G APPROX. GRANITIC BEDROCK CONTOUR (25 FT. CONTOUR INTERVAL)
BASALT BEDROCK
GRANITIC BEDROCK
N
GLACIAL TILL
AREA OF RECENT SLIDE ACTIVITY
FORMER DOUGLAS COUNTY ROAD
RUFUS WOODS LAKE EL. 956 FEET
CHIEF JOSEPH DAM
PEARL HILL
513A
511
510
509
508
507
506
505
504B
503
502A
501A
512
900G
925G
950G
975G
1000G
1000
1100
1200
1300
1400
1500
1600
1700
1800
0 1200'
SCALE IN FEET
BRIDGEPORT SLIDE
PLAN VIEW
TOPOGRAPHIC CONTOUR INTERVAL 100'

FIGURE 8-1

SECTION 9. SUMMARY

No serious foundation problems relating to foundation stability were anticipated prior to, or developed during, construction. In general, the foundations of the dam and powerhouse are of excellent quality. Only minor structural defects were found in the foundation and were readily corrected through standard bedrock foundation preparation techniques.

REFERENCES

U.S. Army Corps of Engineers, Seattle District (COE), 1945. Review of Report on Columbia River in Vicinity of Foster Creek, Appendix 1, Geology and Soil Mechanics.

U.S. Army Engineer District, Seattle (COE), 1957. Foundation Report, Chief Joseph Project, Columbia River, Washington.

U.S. Army Corps of Engineers, Seattle District (COE), 1974. Design Memorandum 42, Chief Joseph Dam, Pool Raising Structural Modifications.

U.S. Army Corps of Engineers, Seattle District (COE), 1975. Supplement to Design Memorandum 42, Chief Joseph Dam, Pool Raising, Structural Modification.

U.S. Army Corps of Engineers, Seattle District (COE), 1981. Supplement 4 to Design Memorandum 42, Earthquake Analysis of Chief Joseph Dam, Columbia River, Washington.

U.S. Army Corps of Engineers, Seattle District (COE), 1982. Periodic Inspection Report No. 6, Chief Joseph Dam, Columbia River, Washington.

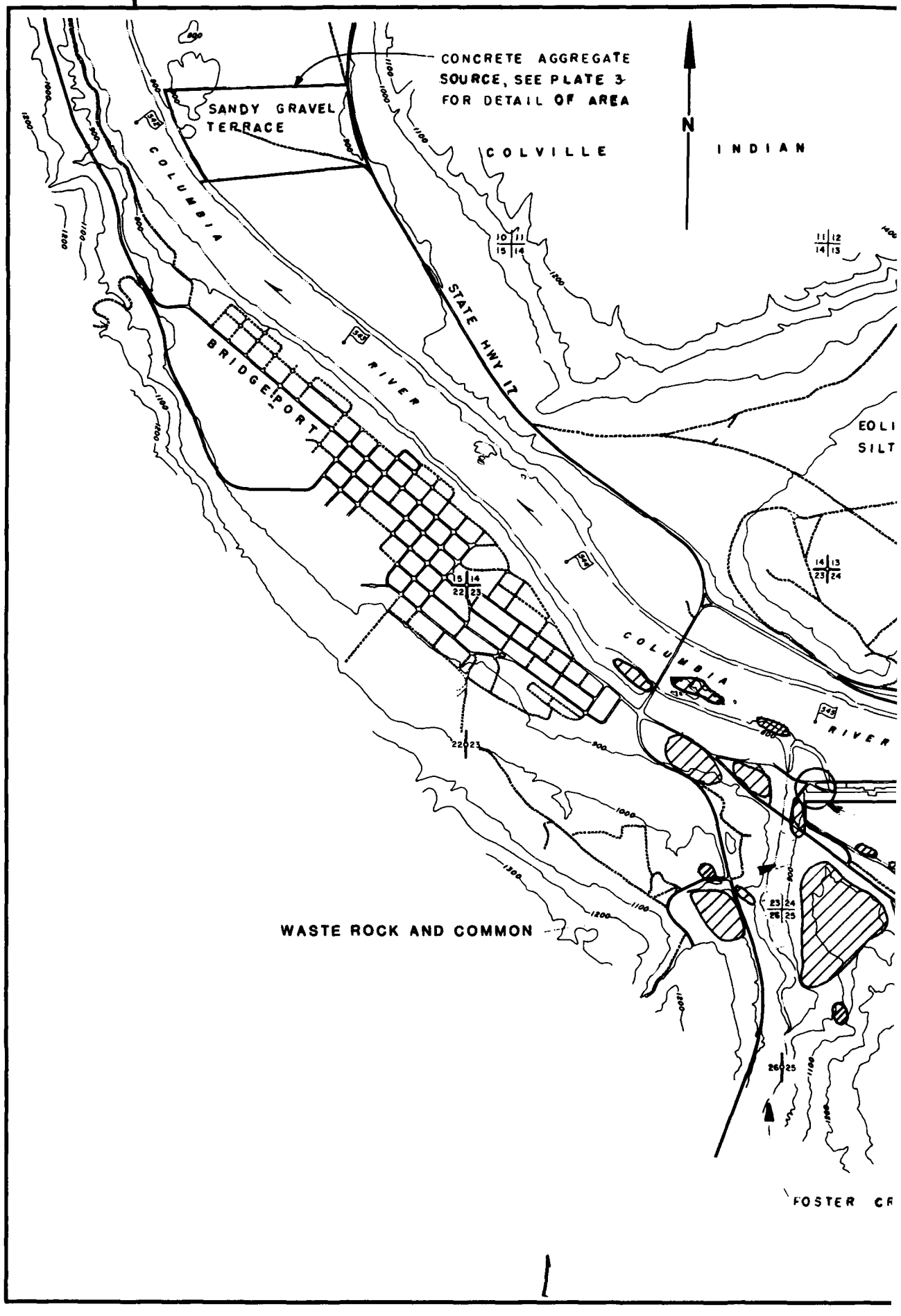
U.S. Army Corps of Engineers, Seattle District (COE), 1984. Periodic Inspection Report No. 7, Chief Joseph Dam, Columbia River, Washington.

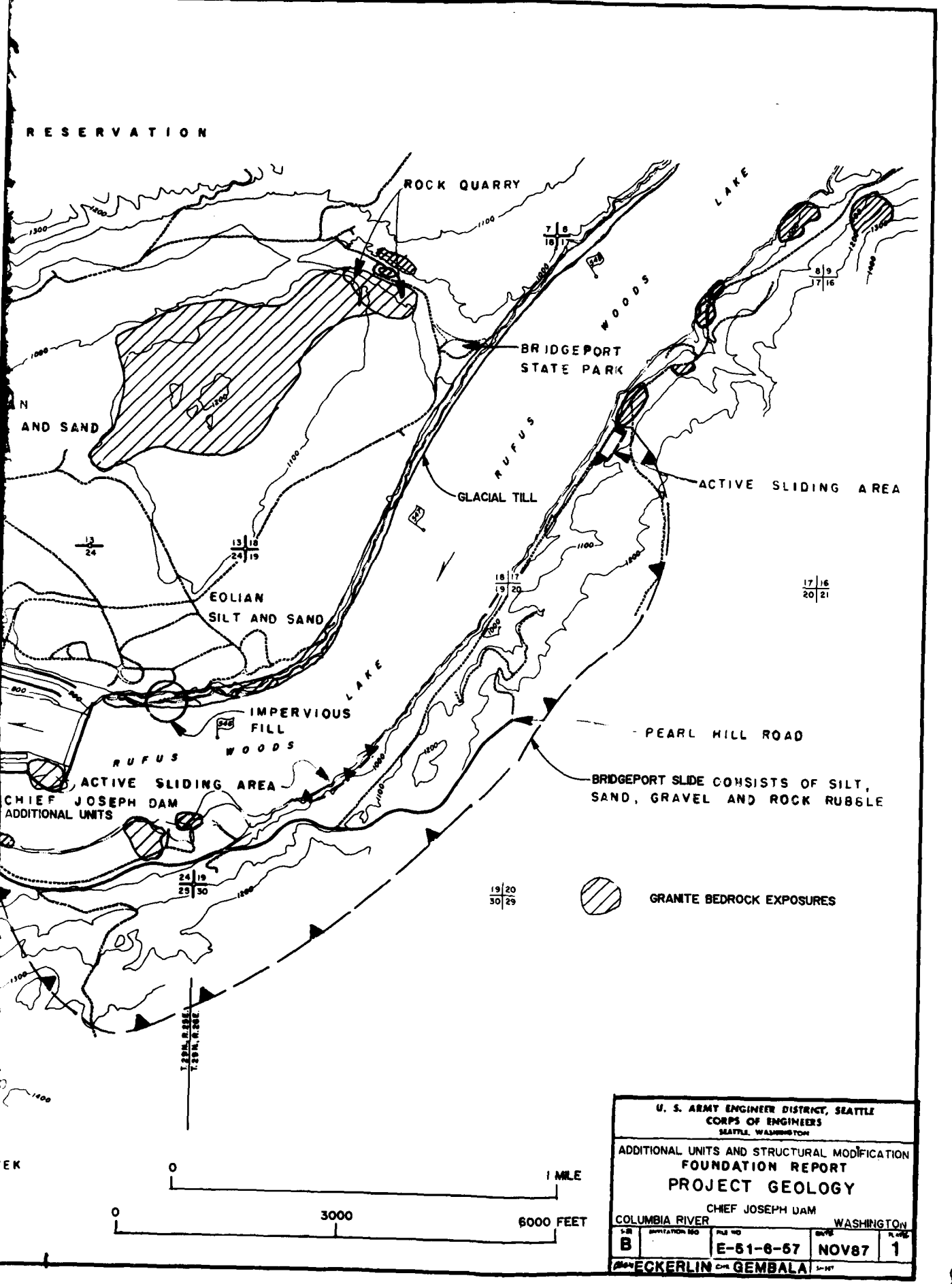
U.S. Army Corps of Engineers, Seattle District (COE), 1986. Periodic Inspection Report No. 8, Chief Joseph Dam, Columbia River, Washington.

APPENDIX A

PLATES

TABLE OF CONTENTS


CONCRETE AGGREGATE SOURCE, SEE PLATE 3 FOR DETAIL OF AREA
SANDY GRAVEL TERRACE
COLVILLE
INDIAN
N
COLUMBIA
STATE HWY 17
BRIDGEPORT
RIVER
EOLI
SILT
COLUMBIA
RIVER
WASTE ROCK AND COMMON
FOSTER CR

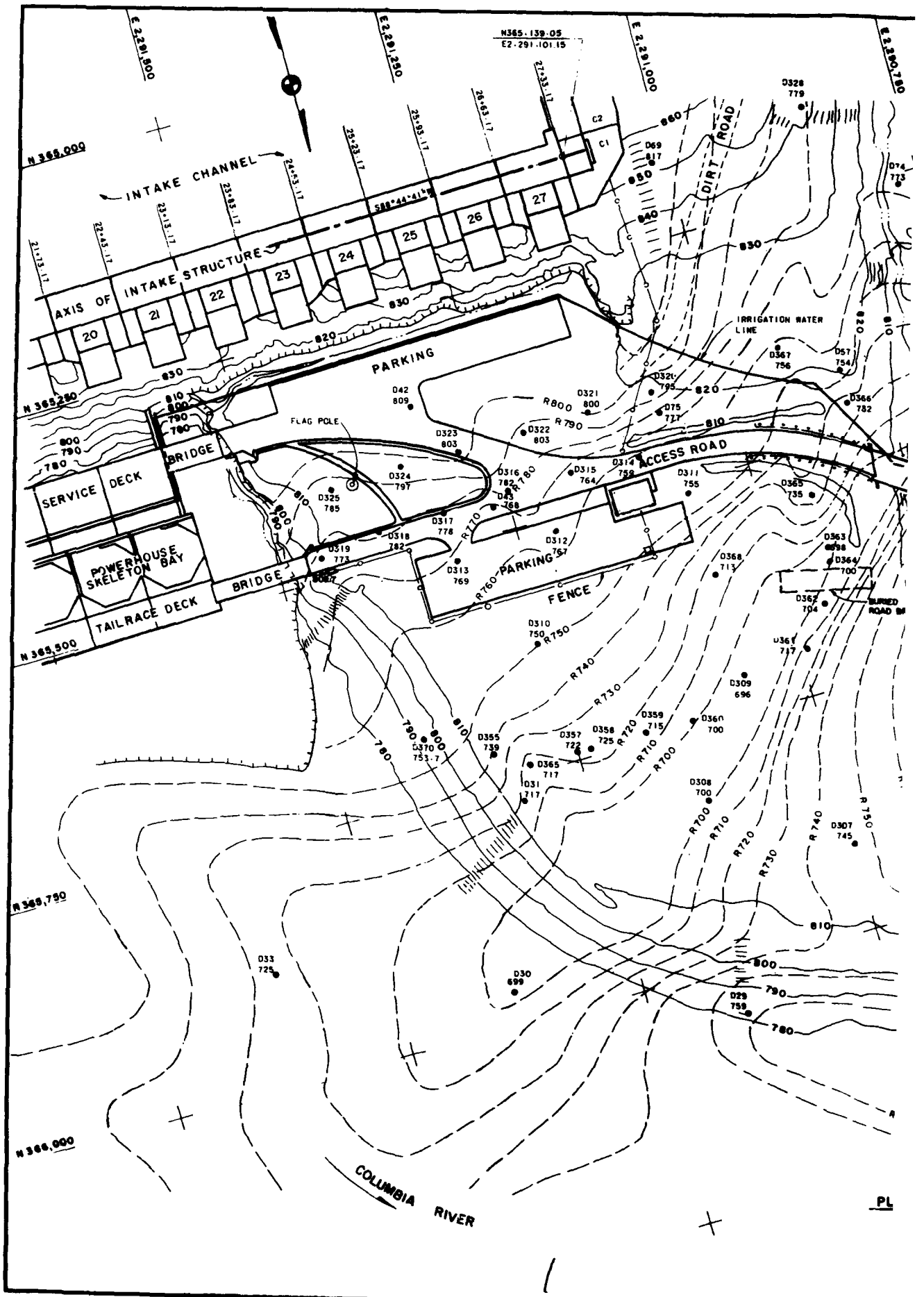


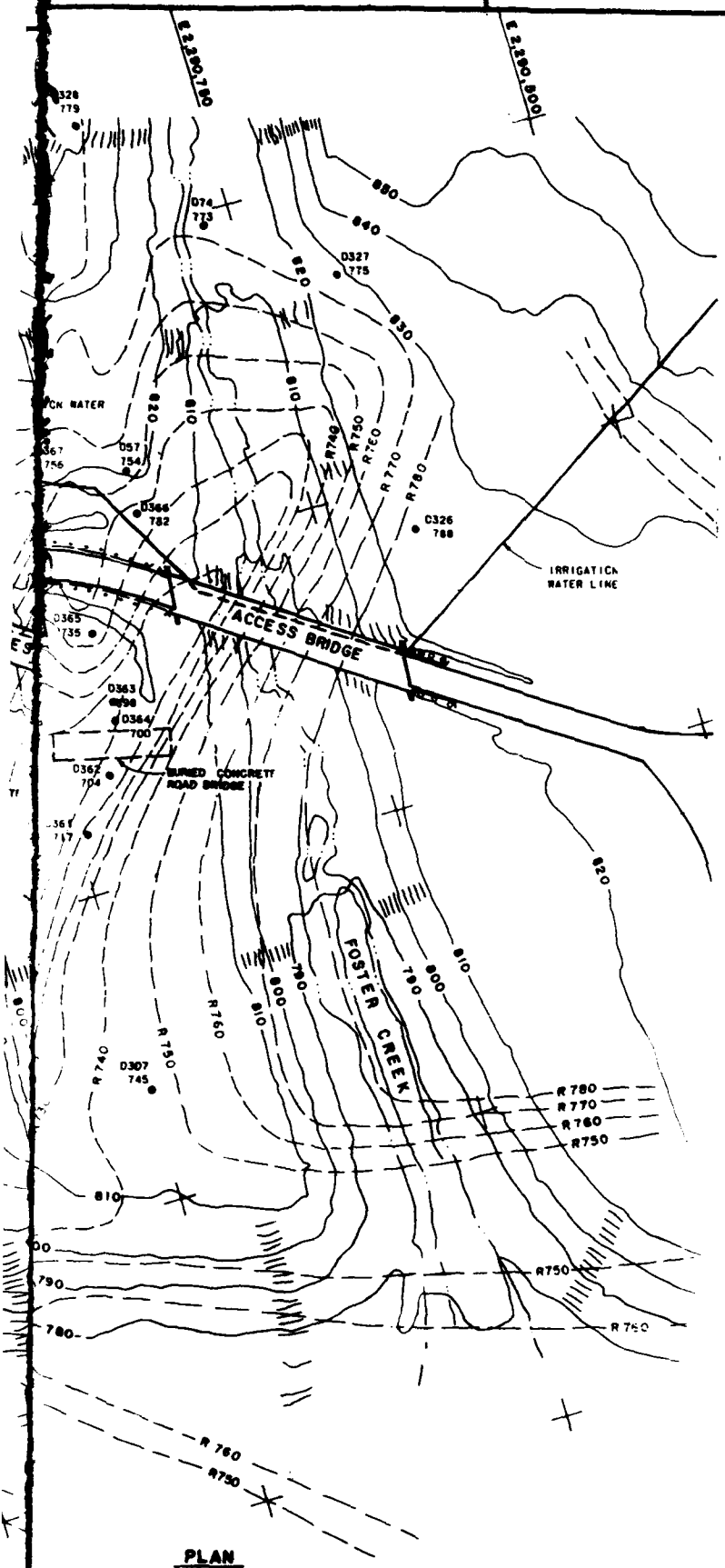
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

ADDITIONAL UNITS AND STRUCTURAL MODIFICATION
FOUNDATION REPORT
PROJECT GEOLOGY
CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

SIZE	DESIGNATION NO.	FILE NO.	DATE	PLATE
B		E-51-6-57	NOV87	1

DESIGNED ECKERLIN DRAWN GEMBALA


N365,139.05
E2,291,101.15
E 2,291,800
E 2,291,250
E 2,291,000
E 2,290,750
N 365,000
N 365,250
N 365,500
N 365,750
N 366,000
INTAKE CHANNEL
AXIS OF INTAKE STRUCTURE
20
21
22
23
24
25
26
27
C1
C2
PARKING
IRRIGATION WATER LINE
DIRT ROAD
FLAG POLE
BRIDGE
SERVICE DECK
POWERHOUSE SKELETON BAY
TAILRACE DECK
ACCESS ROAD
FENCE
COLUMBIA RIVER
D328 779
D069 817
D074 773
D367 756
D057 754
D321 795
D366 782
D042 809
D321 800
D075 727
D323 803
D322 803
D324 797
D325 785
D316 782
D315 764
D314 758
D311 755
D365 735
D043 768
D317 778
D318 782
D319 773
D313 769
D312 767
D363 698
D368 713
D364 700
D362 704
BURRIED ROAD BA
D310 750
D361 717
D309 696
D359 715
D358 725
D357 722
D355 739
D370 753.7
D360 700
D365 717
D031 717
D308 700
D307 745
D033 725
D030 699
D029 759
R800
R790
R780
R770
R760
R750
R740
R730
R720
R710
R700
PL



PLAN

LEGEND

D321 800 ● EXPLORATION BORING WITH BORING NUMBER AND ELEVATION OF TOP OF BEDROCK

—R800— BEDROCK CONTOUR

EXPOSED BEDROCK

1" = 100'

0 75 150 FEET

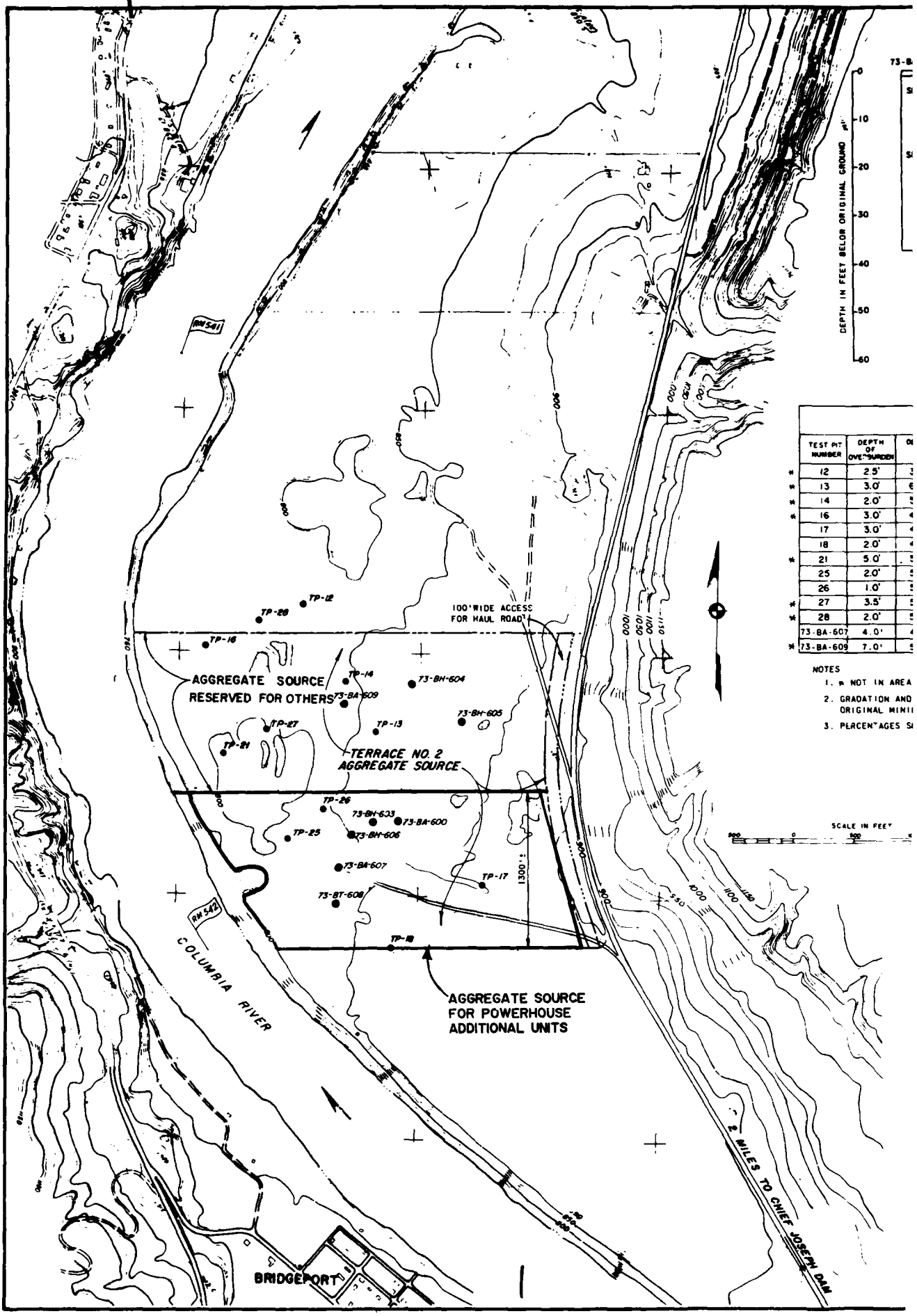
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

ADDITIONAL UNITS AND STRUCTURAL MODIFICATION
FOUNDATION REPORT
PROJECT EXPLORATION

CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

SIZE	INVITATION NO	FILE NO	DRWG.	PLATE
B		E-51-6-87	NOV87	2

DRAWN ECKERLIN CHK GEMBALA UNIT


DEPTH IN FEET BELOW ORIGINAL GROUND
0
10
20
30
40
50
60
TEST PIT NUMBER
DEPTH OF OVERBURDEN
12 2.5'
13 3.0'
14 2.0'
16 3.0'
17 3.0'
18 2.0'
21 5.0'
25 2.0'
26 1.0'
27 3.5'
28 2.0'
73-BA-607 4.0'
73-BA-609 7.0'
NOTES
1. * NOT IN AREA
2. GRADATION AND ORIGINAL MINI
3. PLACEMENT AGES S
SCALE IN FEET
100' WIDE ACCESS FOR HAUL ROAD
AGGREGATE SOURCE RESERVED FOR OTHERS
TERRACE NO. 2 AGGREGATE SOURCE
1300'±
AGGREGATE SOURCE FOR POWERHOUSE ADDITIONAL UNITS
TP-12
TP-28
TP-16
TP-14
73-BH-604
73-BA-609
73-BH-605
TP-27
TP-21
TP-13
TP-26
73-BH-603
73-BA-600
TP-25
73-BH-606
73-BA-607
TP-17
73-BT-608
TP-18
RM 542
RM 541
COLUMBIA RIVER
2 MILES TO CHIEF JOSEPH DAM
BRIDGEPORT

-600
SILTY SAND

FINE TO MEDIUM SAND WITH A FEW GRAVELS

73-BH-603
SM & SP — SILTY SAND & SAND

73-BH-604
SM & SP — SILTY SAND & SAND

73-BH-605
SM & SP — SILTY SAND & SAND

73-BH-606
SM & SP — SILTY SAND & SAND

73-BA-607
OVERBURDEN
8%, 6%, 10%, 15%, 61%
4%, 7%, 14%, 25%, 50%
20%, 13%, 18%, 33%, 16%
13%, 13%, 16%, 49%, 9%
19%, 14%, 17%, 21%, 29%
25%, 16%, 15%, 23%, 21%
41%, 13%, 10%, 14%, 22%
SEE NOTE 3

73-BT-608
SM — SILTY SAND
GP — SANDY GRAVEL

73-BA-609
OVERBURDEN
10%, 7%, 9%, 16%, 58%
18%, 15%, 18%, 39%, 10%
11%, 12%, 17%, 22%, 38%
21%, 19%, 16%, 17%, 27%
28%, 18%, 14%, 16%, 24%
26%, 14%, 14%, 18%, 28%
21%, 16%, 17%, 18%, 28%
6%, 12%, 17%, 21%, 44%
SEE NOTE 3

		TOTAL AGGREGATE		COARSE AGGREGATE		FINE AGGREGATE	
TH	PERCENT PLUS "6" MATERIAL	CUMULATIVE PERCENT MATERIAL BY WEIGHT RETAINED	PERCENT GRAVEL	CUMULATIVE PERCENT GRAVEL BY WEIGHT RETAINED	PERCENT SAND	FINENESS MODULUS	CUMULATIVE PERCENT SAND BY WEIGHT RETAINED
5'	24		50		26	3.22	
0'	7		46		47	3.35	
0'	4		57		39	3.21	
0'	13		69		18	2.79	
0'	7		46		47	2.98	
0'	3		19		78	2.44	
0'	7		62		31	2.80	
0'	7		60		33	2.76	
0'	3		58		39	3.40	
0'	9		70		21	2.98	
0'	8		61		31	2.71	
0'	19		51		30	3.49	
5'	19		50		32	3.25	

AVAILABLE FOR USE - GRADATION SHOWN FOR INFORMATION ONLY.

LOGS OF TEST PIT NUMBERS 12 THROUGH 28 MADE PRIOR TO OPERATIONS IN AREA. GRADATION SHOWN FOR INFORMATION ONLY.

OPN INDICATE 3", 1 1/2", 3/4", NO.4, AND SAND RESPECTIVELY.

DEPTH IN FEET BELOW ORIGINAL GROUND
0, 10, 20, 30, 40, 50, 60

TP-12
OVERBURDEN
74.2% G
25.8% S
82.4% G
17.6% S
75.6% G
24.4% S
82.0% G
18.0% S
80.8% G
19.2% S
62.0% G
38.0% S
61.0% G
39.0% S
68.6% G
31.4% S

TP-13
OVERBURDEN
21.0% G
79.0% S
43.0% G
57.0% S
30.2% G
69.8% S
31.0% G
69.0% S
53.1% G
46.9% S
50.1% G
49.9% S
70.9% G
29.1% S
69.8% G
30.2% S
75.5% G
24.5% S
79.8% G
20.2% S
64.8% G
35.2% S
75.2% G
23.8% S

TP-14
OVERBURDEN
34.2% G
65.8% S
48.8% G
51.2% S
53.4% G
46.6% S
20.4% G
79.6% S
61.9% G
38.1% S
74.3% G
25.7% S
82.7% G
17.3% S
79.2% G
20.8% S
77.6% G
22.4% S
76.5% G
23.5% S

TP-16
OVERBURDEN
75.0% G
25.0% S
80.0% G
20.0% S
87.5% G
12.5% S
86.2% G
13.8% S
93.2% G
6.8% S
89.3% G
10.7% S
77.5% G
22.5% S
73.3% G
26.7% S
78.7% G
21.3% S

TP-17
OVERBURDEN
35.4% G
64.6% S
17.7% G
82.3% S
0.0% G
100.0% S
64.7% G
35.3% S
64.7% G
35.7% S
77.7% G
23.3% S
78.0% G
22.0% S
84.0% G
16.0% S

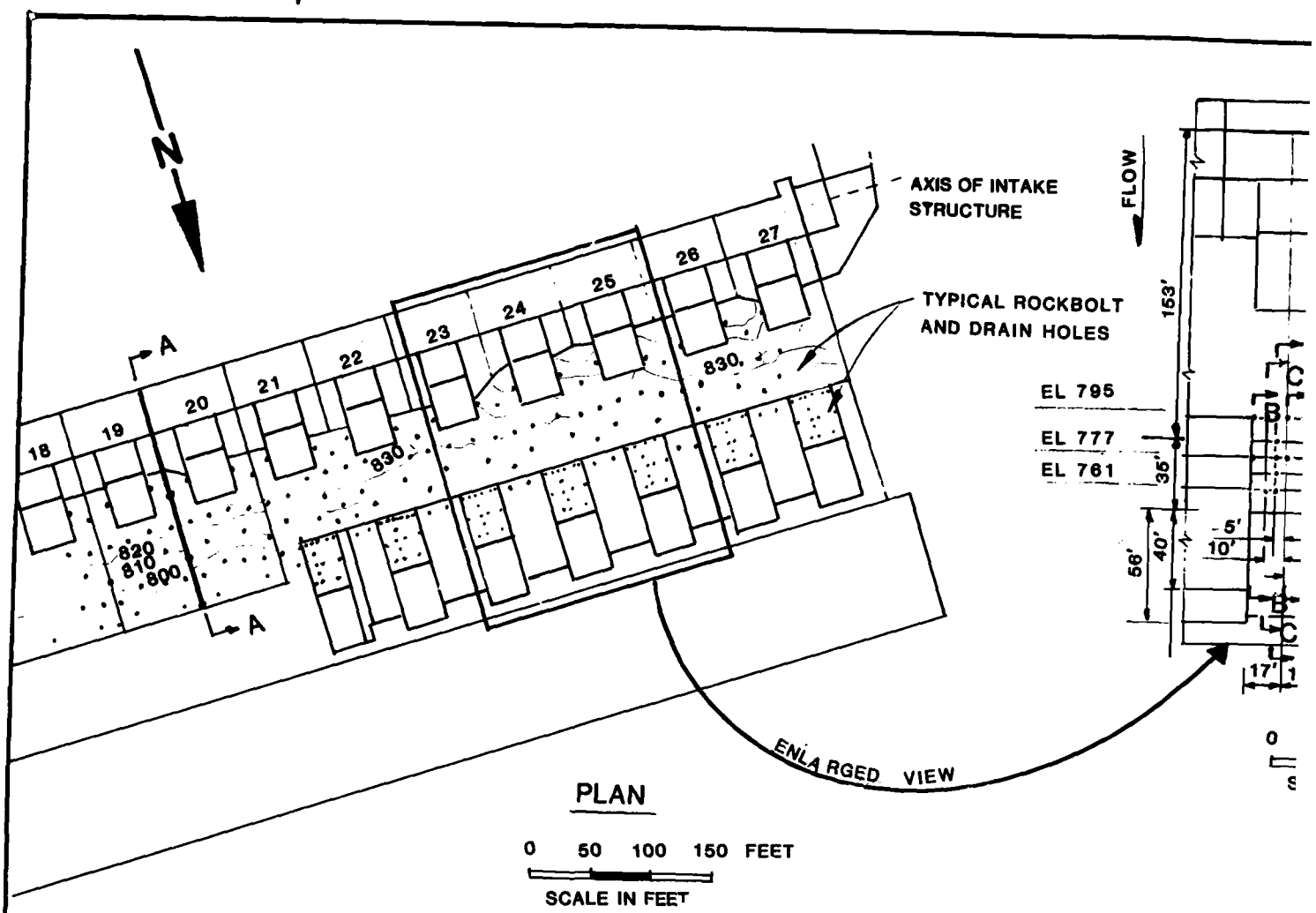
TP-18
OVERBURDEN
3.3% G
96.7% S
5.4% G
96.6% S
5.0% G
95.0% S
77.9% G
92.1% S
13.2% G
86.8% S
4.0% G
96.0% S
65.5% G
34.5% S
70.1% G
29.9% S

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

ADDITIONAL UNITS AND STRUCTURAL MODIFICATION
FOUNDATION REPORT
CONCRETE AGGREGATE SOURCE
CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

SIZE		PLATE	DATE	SHEET
B		E-51-6-57	NOV87	3

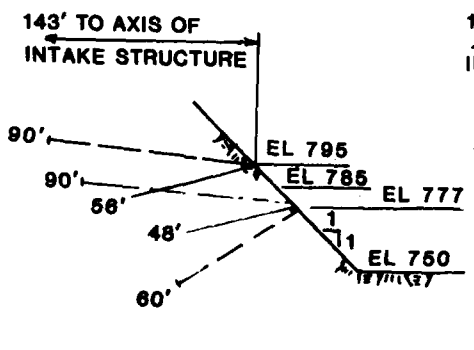
DES. ECKERLIN CHK. GEMBALA



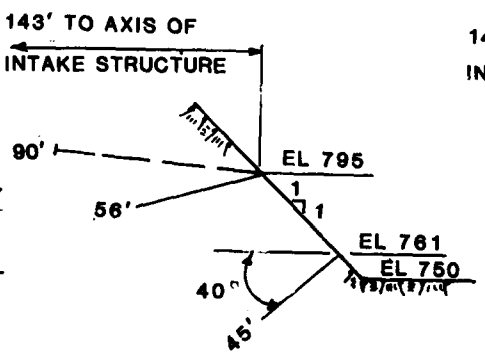
PLAN

0 50 100 150 FEET

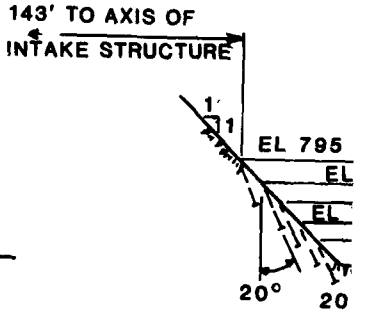
SCALE IN FEET



SECTION B-B



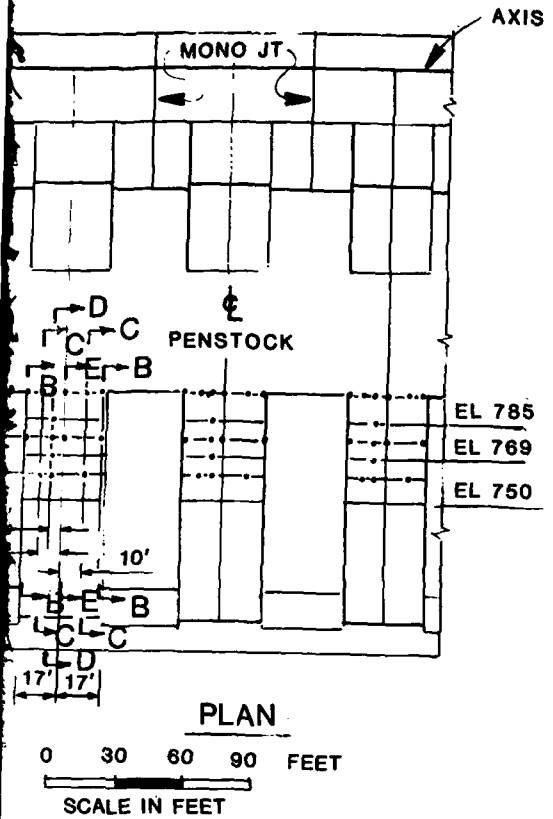
SECTION C-C



SECTI

0 30 60 90 FEET

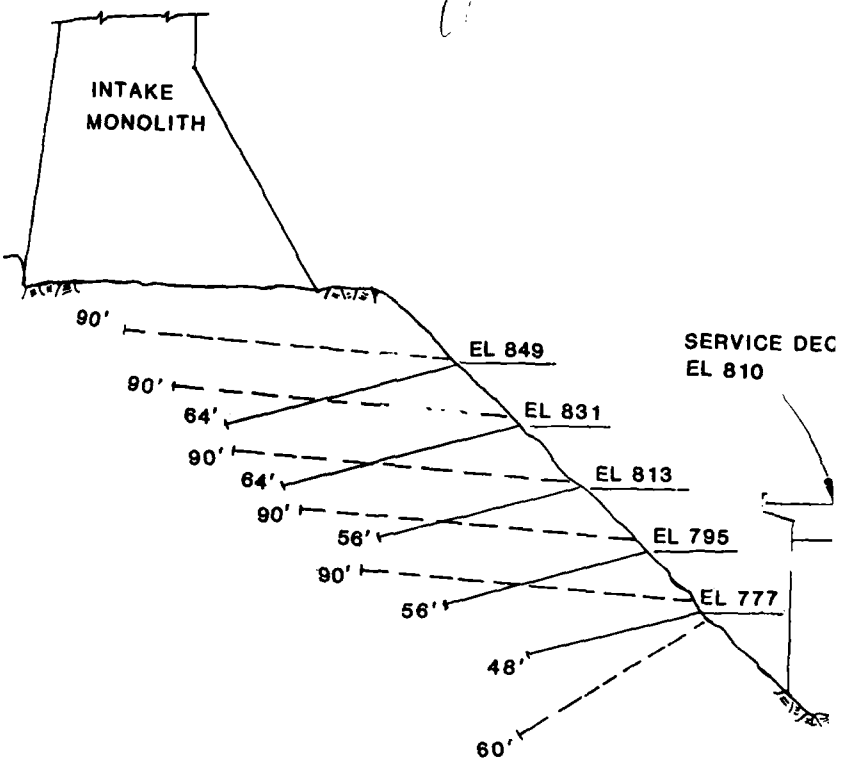
SCALE IN FEET



PLAN

0 30 60 90 FEET

SCALE IN FEET



TYPICAL SECTION A-A

0 20 40 60 FEET

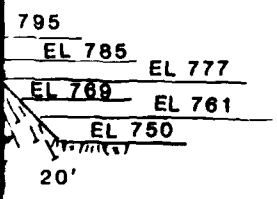
SCALE IN FEET

LEGEND

DRAIN HOLE

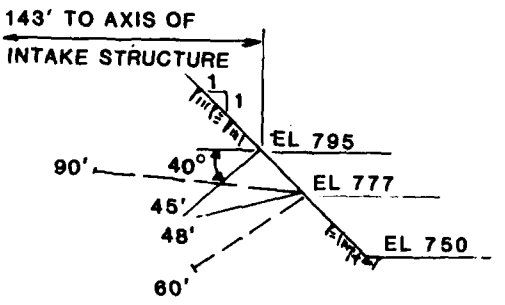
ROCKBOLT

BEDROCK



ECTION D-D

EET



SECTION E-E

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

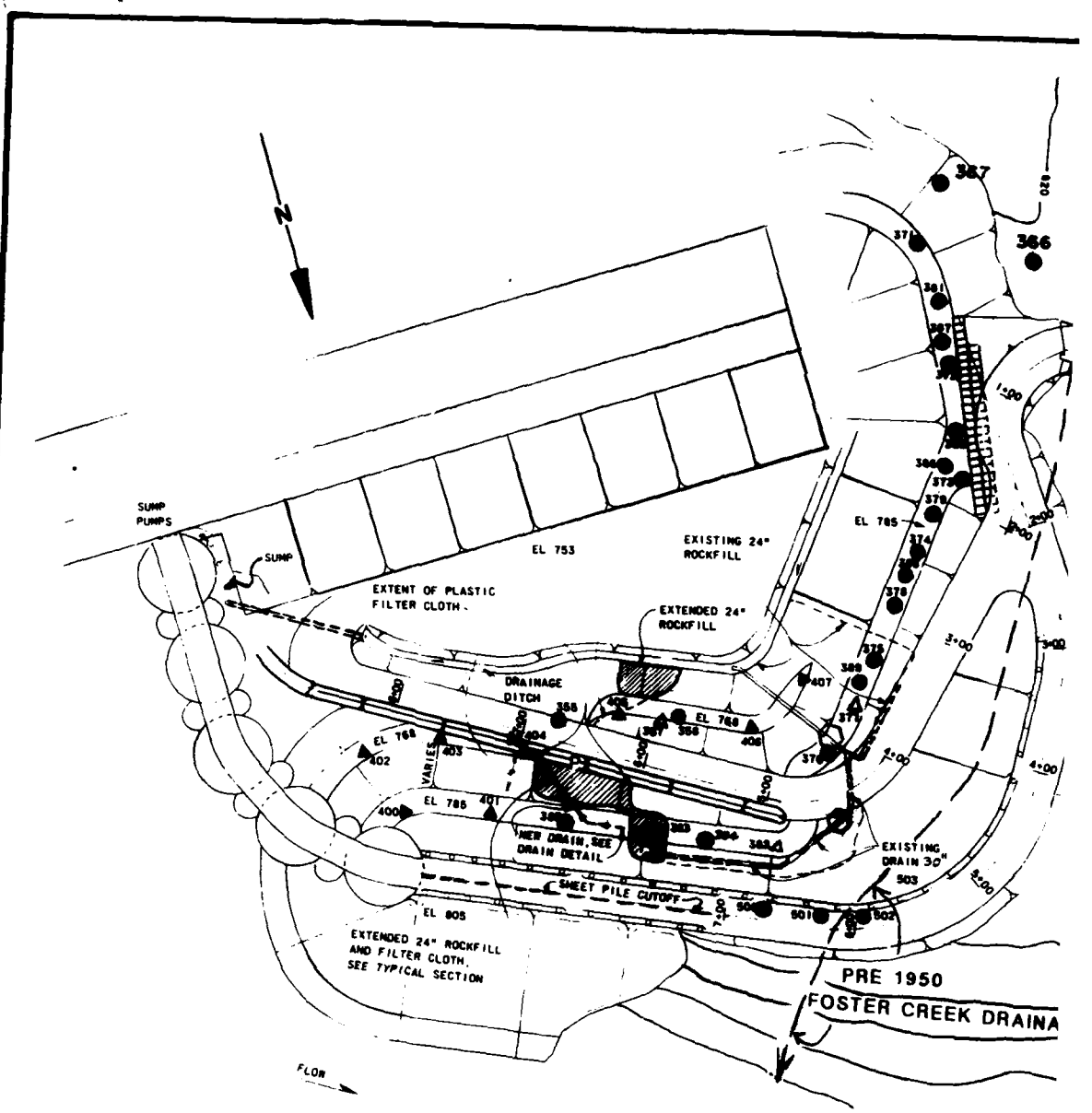
ADDIT. UNITS AND STRUCT.
FOUNDATION REPORT

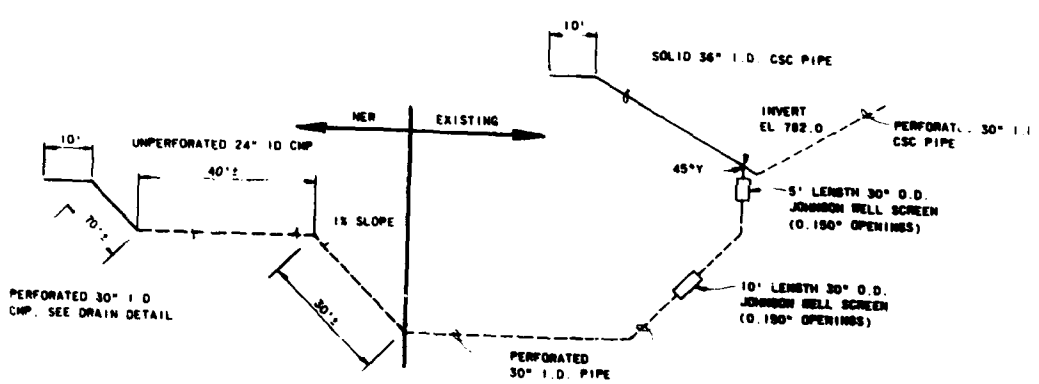
ROCK BOLTS & DRAIN HO

CHIEF JOSEPH DAM
COLUMBIA RIVER WASHIN

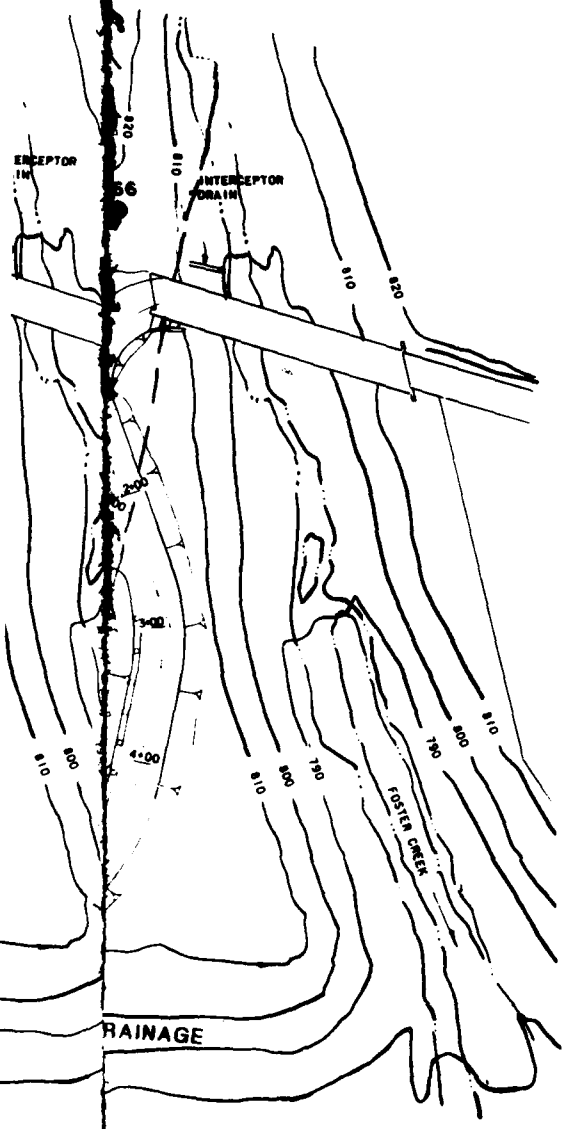
B		E-51-6-57	NOV87

DSN ECKER L.N CHK GEMBALA





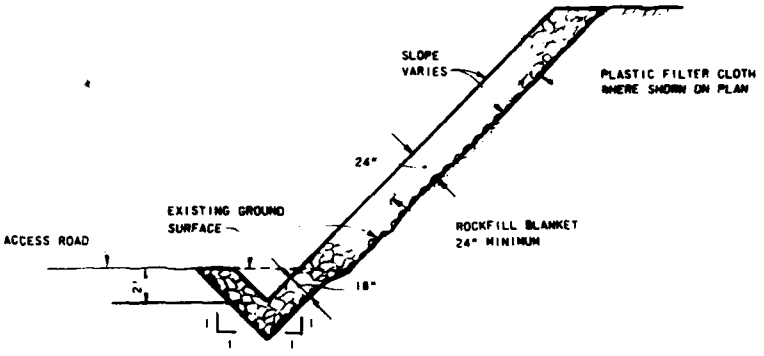
DRAIN PLAN-SCHEMATIC
NOT TO SCALE



LEGEND:

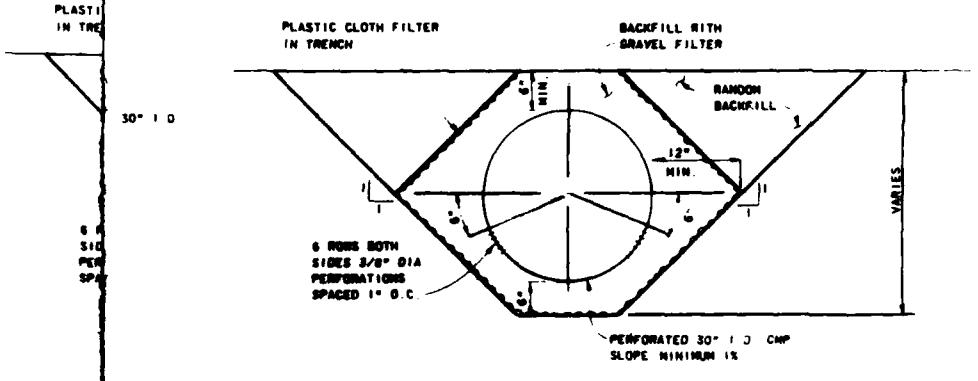
REFER TO TABLE 4-1 FOR WELL DATA)

- ● DEWATERING WELL OR PIEZOMETER
- ▲ OPEN WELL POINT
- △ OPEN TUBE
- ○ STANDPIPE IN INTERCEPTOR DRAIN SYSTEM (30"JOHNSON WELL SCREEN SLOT # 150)
- ▨ 24-INCH ROCKFILL BLANKET EXTENSION
- P WELL POINT PUMP



TYPICAL SECTION

0 5 10 FEET



DRAIN DETAIL

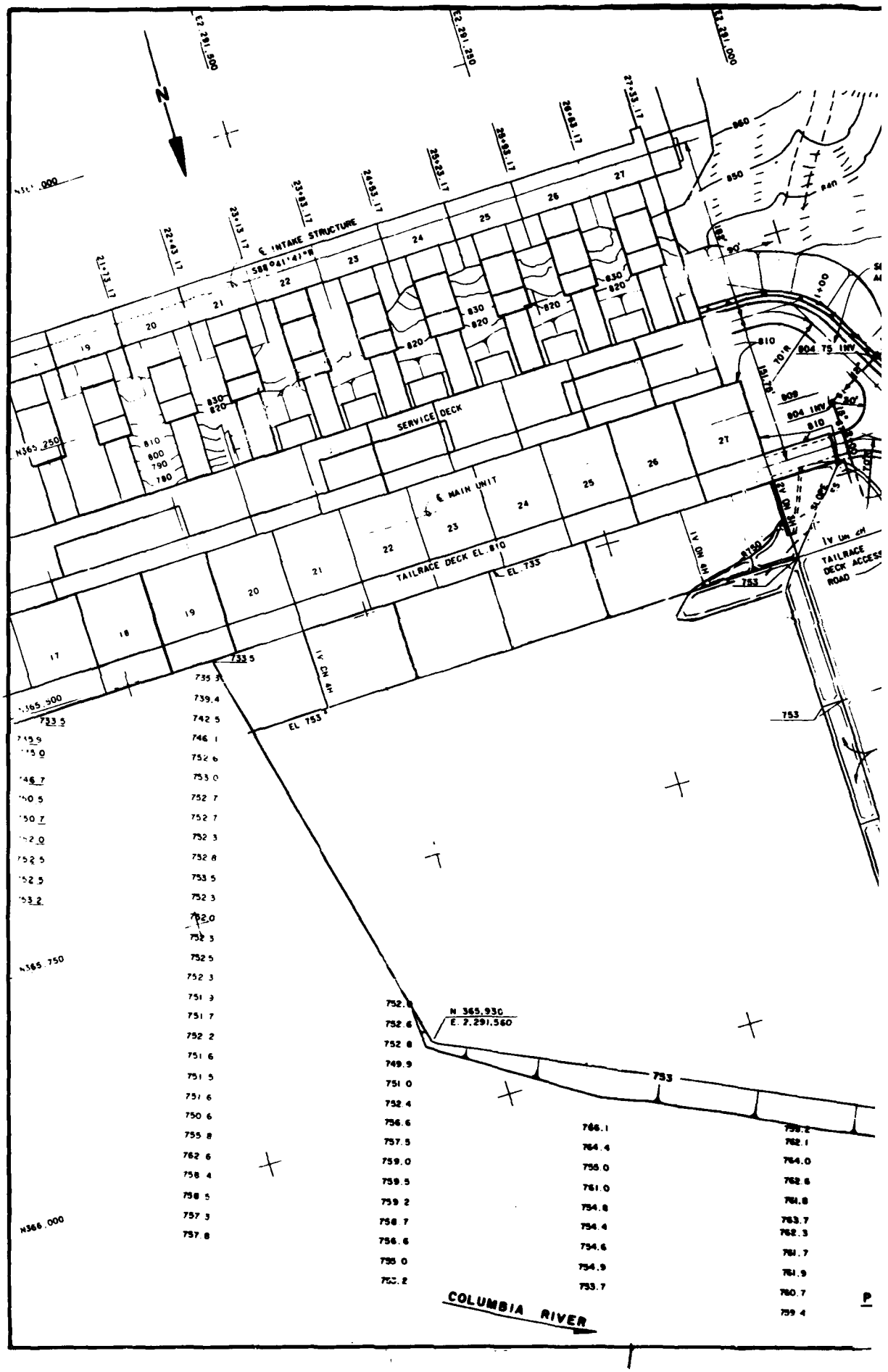
0 1 2 FEET

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

ADDIT. UNITS AND STRUCT MOD
FOUNDATION REPORT
POWERHOUSE DEWATERING SCHEME
CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

SIZE	FILE NO	DATE	PLATE
B	E-51-6-57	NOV87	5

DESIGN ECKERLIN CHK GEMBALA SHEET

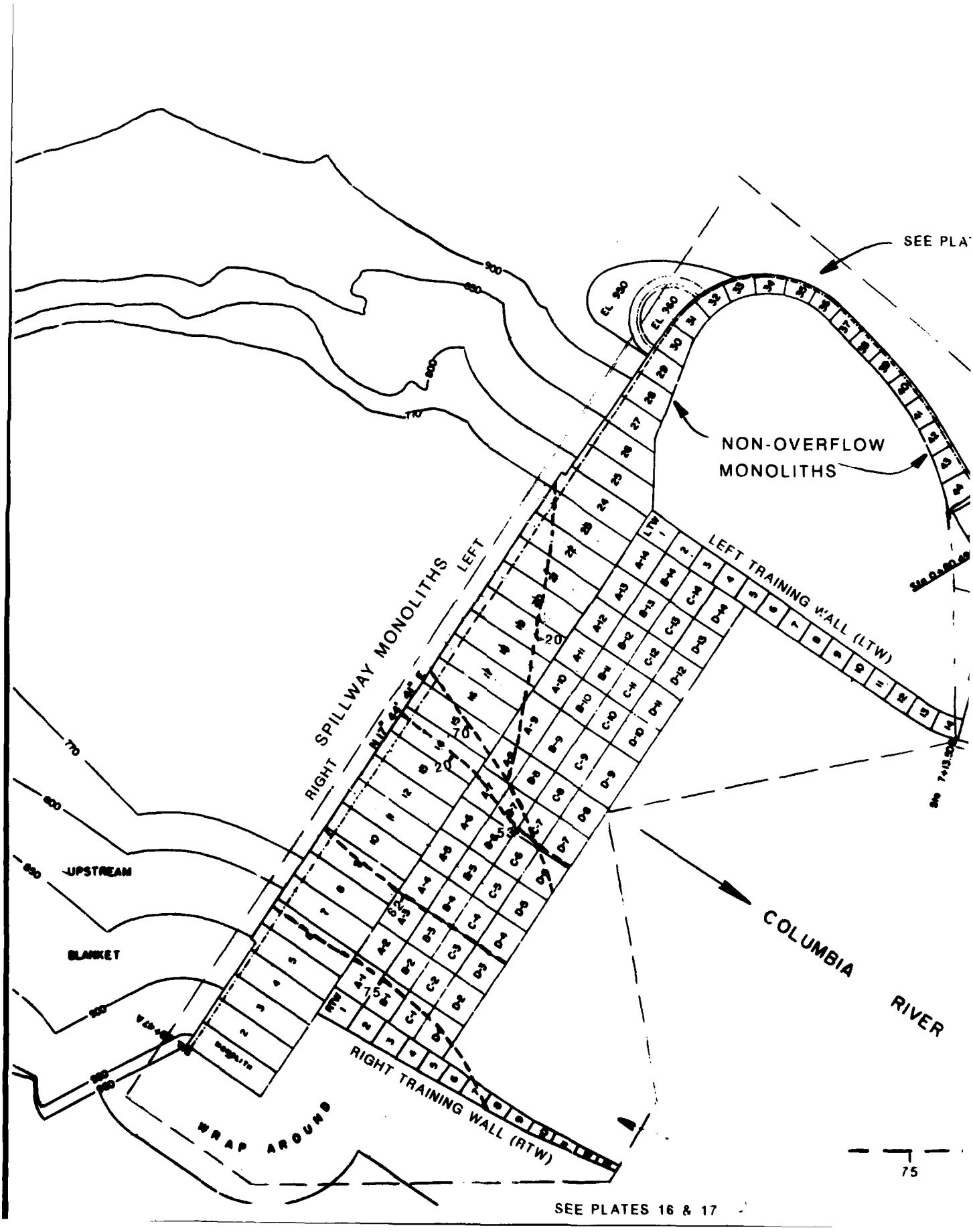

N
E2,291,500
E2,291,250
E2,291,000
N365,000
N365,250
N365,500
N365,750
N366,000
E INTAKE STRUCTURE
S88°41'47"W
SERVICE DECK
E MAIN UNIT
TAILRACE DECK EL 810
EL 733
EL 753
TAILRACE DECK ACCESS ROAD
N 365,930
E 2,291,560
733
COLUMBIA RIVER

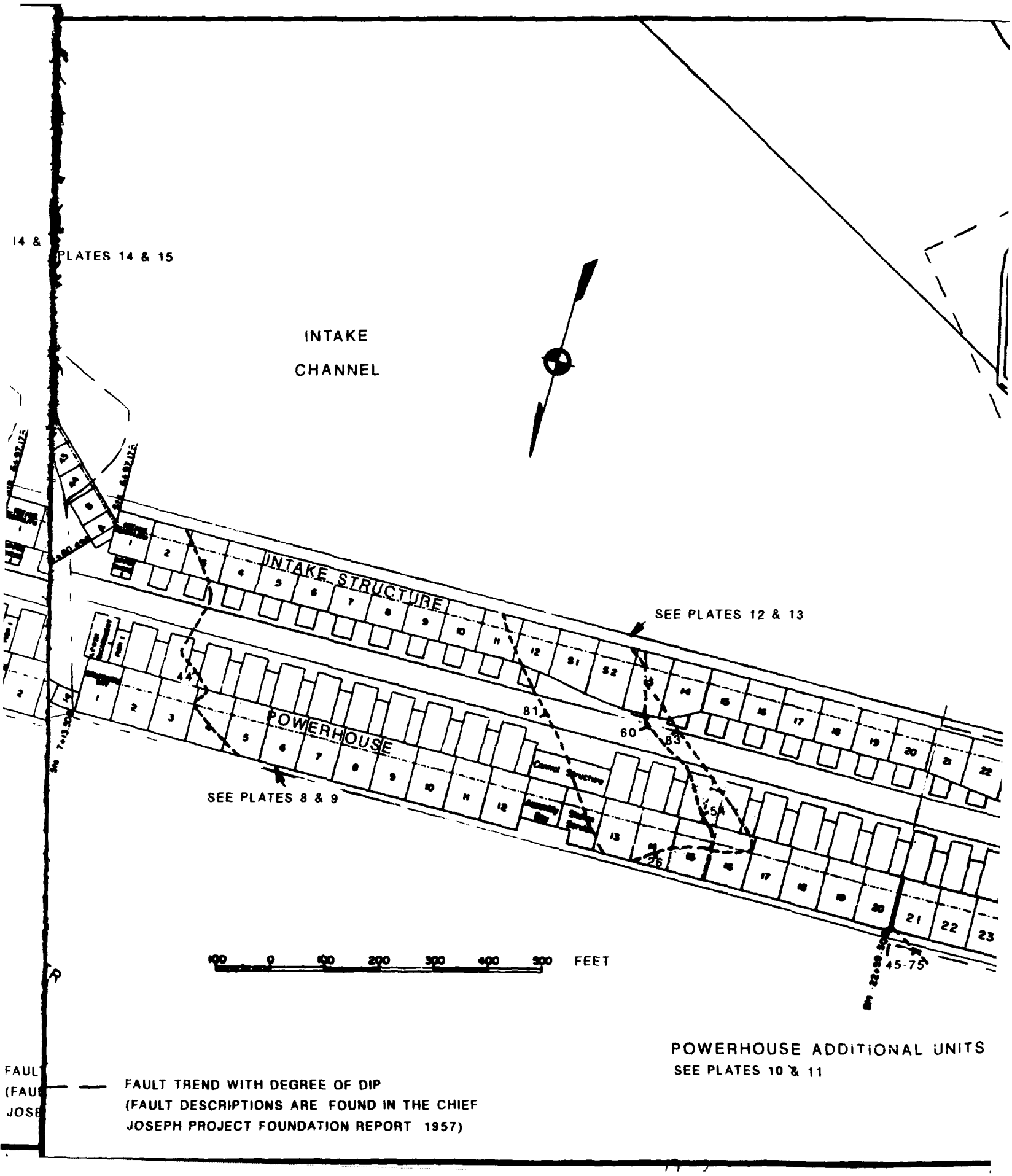
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

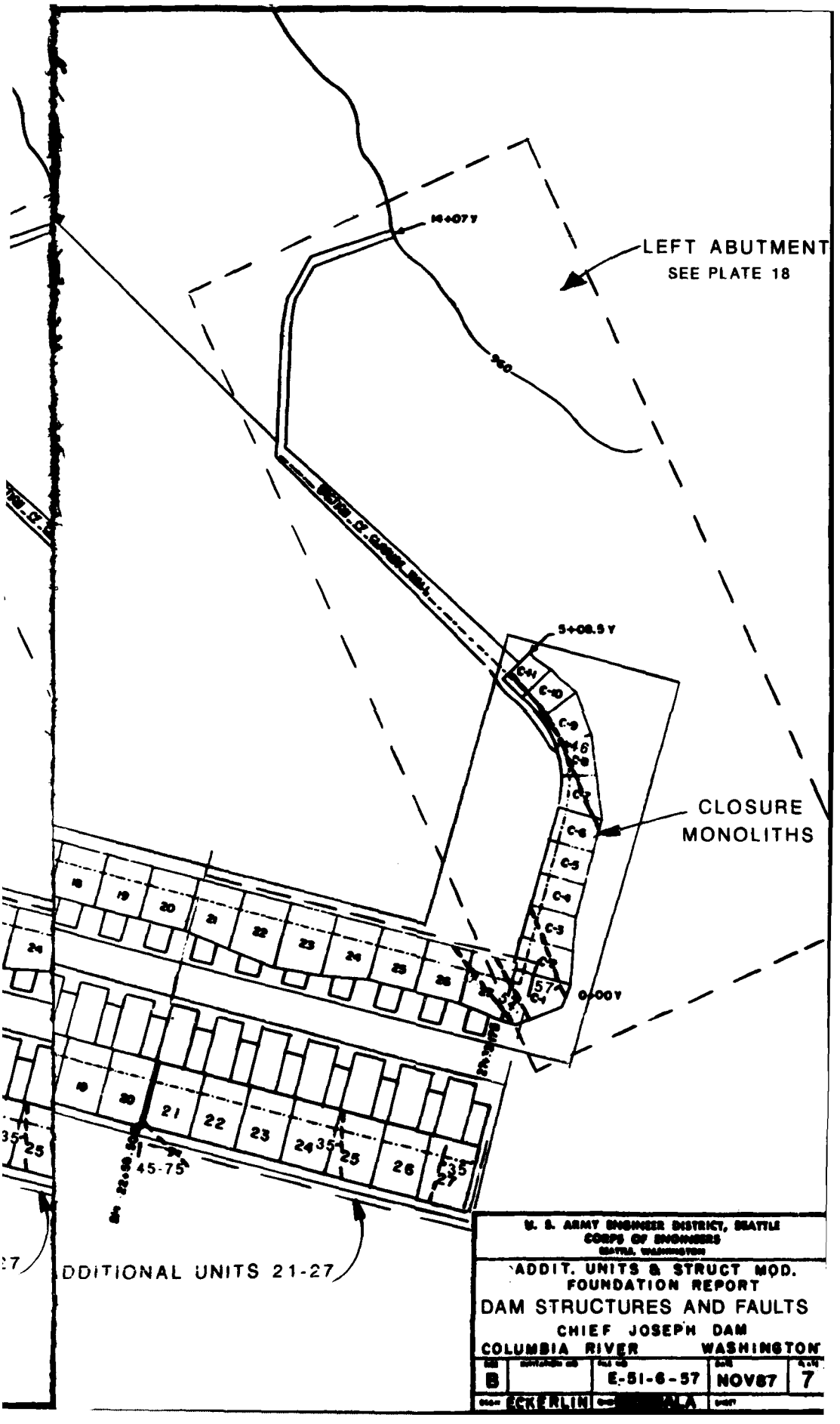
ADDIT. UNITS & STRUCT MOD.
FOUNDATION REPORT
FINISHED POWERHOUSE EXCAVATION
CHIEF JOSEPH DAM
COLUMBIA RIVER, WASHINGTON

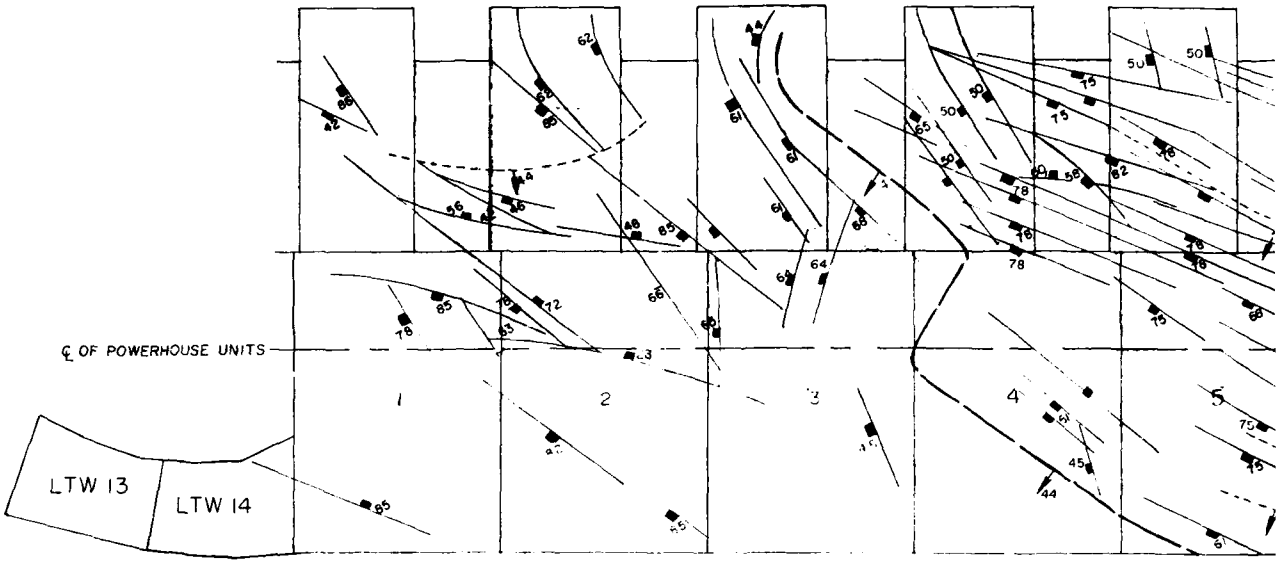
SIZE	INVITATION NO	FILE NO	DATE	PLATE
B		E-51-6-57	NOV 87	6

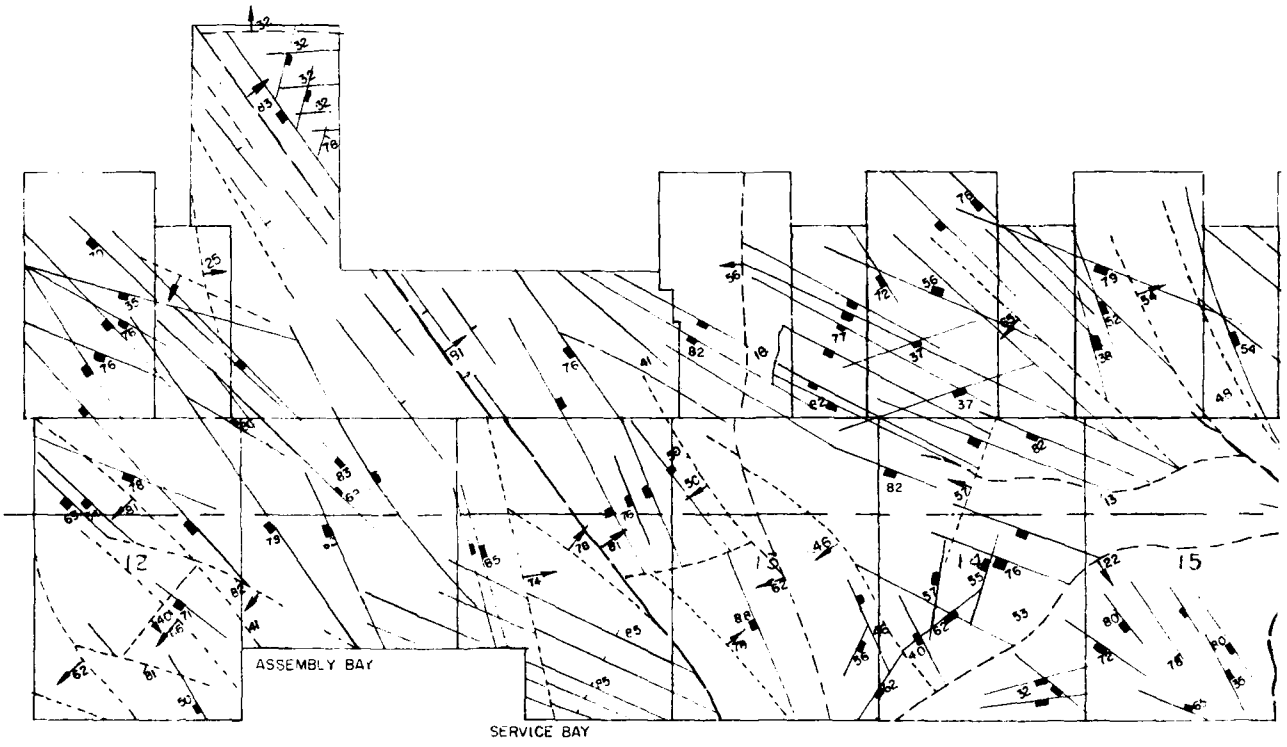
DSN ECKERLIN | DWN GEMBALA | SHEET


SEE PLA
NON-OVERFLOW
MONOLITHS
LEFT TRAINING WALL (LTW)
LEFT SPILLWAY MONOLITHS
RIGHT
UPSTREAM
BLANKET
COLUMBIA
RIVER
RIGHT TRAINING WALL (RTW)
WRAP AROUND
SEE PLATES 16 & 17
75


14 &
PLATES 14 & 15
INTAKE
CHANNEL
INTAKE STRUCTURE
SEE PLATES 12 & 13
POWERHOUSE
SEE PLATES 8 & 9
44
81
60
83
54
28
45-75
100 0 100 200 300 400 500 FEET
POWERHOUSE ADDITIONAL UNITS
SEE PLATES 10 & 11
FAULT TREND WITH DEGREE OF DIP
(FAULT DESCRIPTIONS ARE FOUND IN THE CHIEF
JOSEPH PROJECT FOUNDATION REPORT 1957)


LEFT ABUTMENT
SEE PLATE 18
CLOSURE
MONOLITHS
ADDITIONAL UNITS 21-27
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
ADDIT. UNITS & STRUCT MOD.
FOUNDATION REPORT
DAM STRUCTURES AND FAULTS
CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON
B
E-51-6-57
NOV 87
7



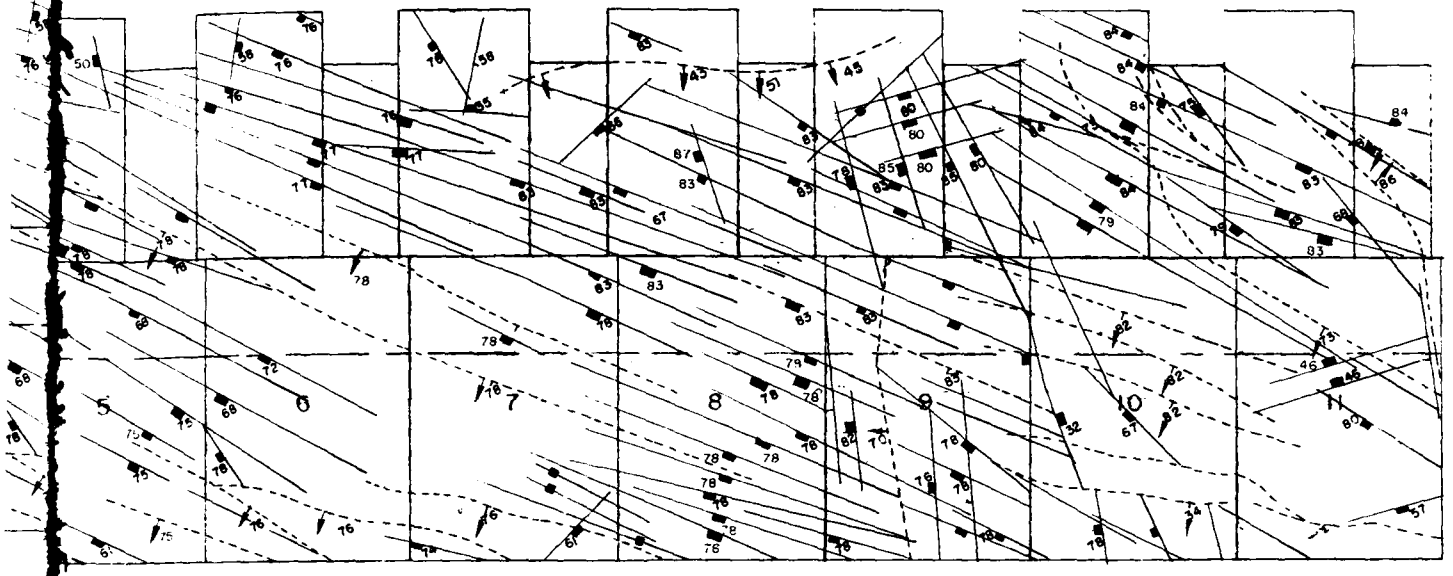


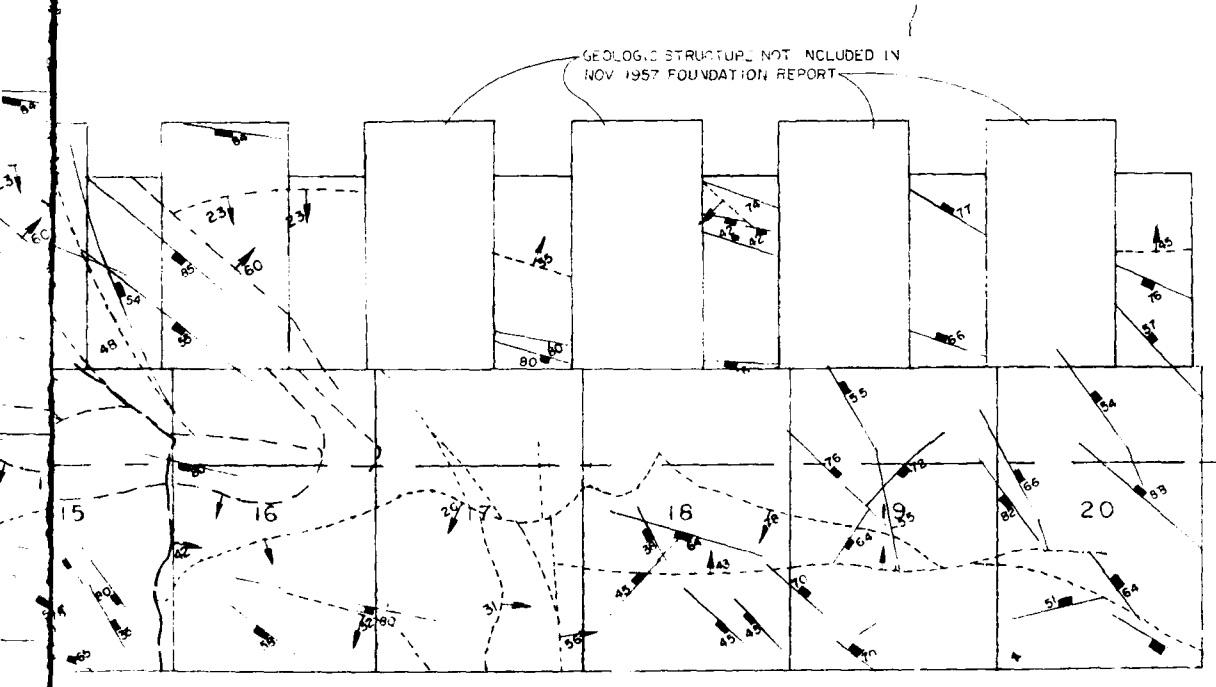
750

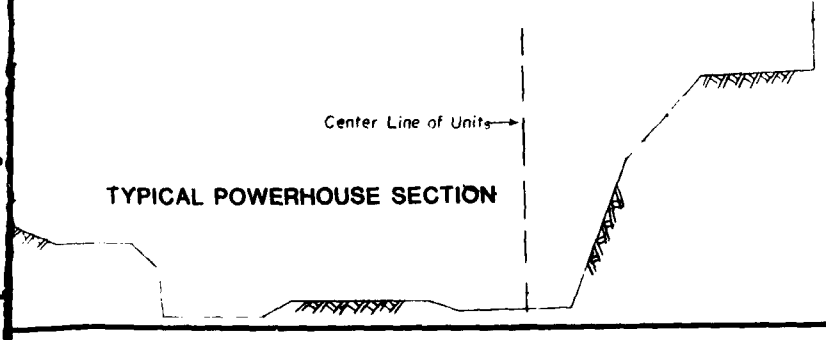
740

730

720







TYPICAL POWERHOUSE SECTION

30' 20' 10' 0 30' 60'
SCALE IN FEET

LEGEND

70
90 INDICATES TREND AND DIP OF MAJOR JOINT SYSTEMS

85 MINOR FAULT TREND WITH DEGREE OF DIP

75 MAJOR FAULT TREND WITH DEGREE OF DIP

NOTES

1. THIS DRAWING HAS BEEN MODIFIED FROM THE NOV. 1957 FOUNDATION REPORT.
2. JOINT PATTERNS ARE PLOTTED ONLY IN SUFFICIENT DETAIL TO SHOW MAJOR SYSTEMS. ANY MINOR OR INCIPENT JOINTS ARE NOT SHOWN.
3. JOINT AND FAULT STRIKES ARE DISTORTED, BUT ALL DIP ANGLES ARE TRUE. ON SLOPING SURFACES, JOINT AND FAULT PLANES ARE PLOTTED AT THEIR INTERSECTION WITH AN IMAGINARY PLANE SURFACE WHICH PARALLELS THE AVERAGE SLOPING TOPOGRAPHIC SURFACE OF THE ROCK FOUNDATION.

30' 60'
E IN FEET

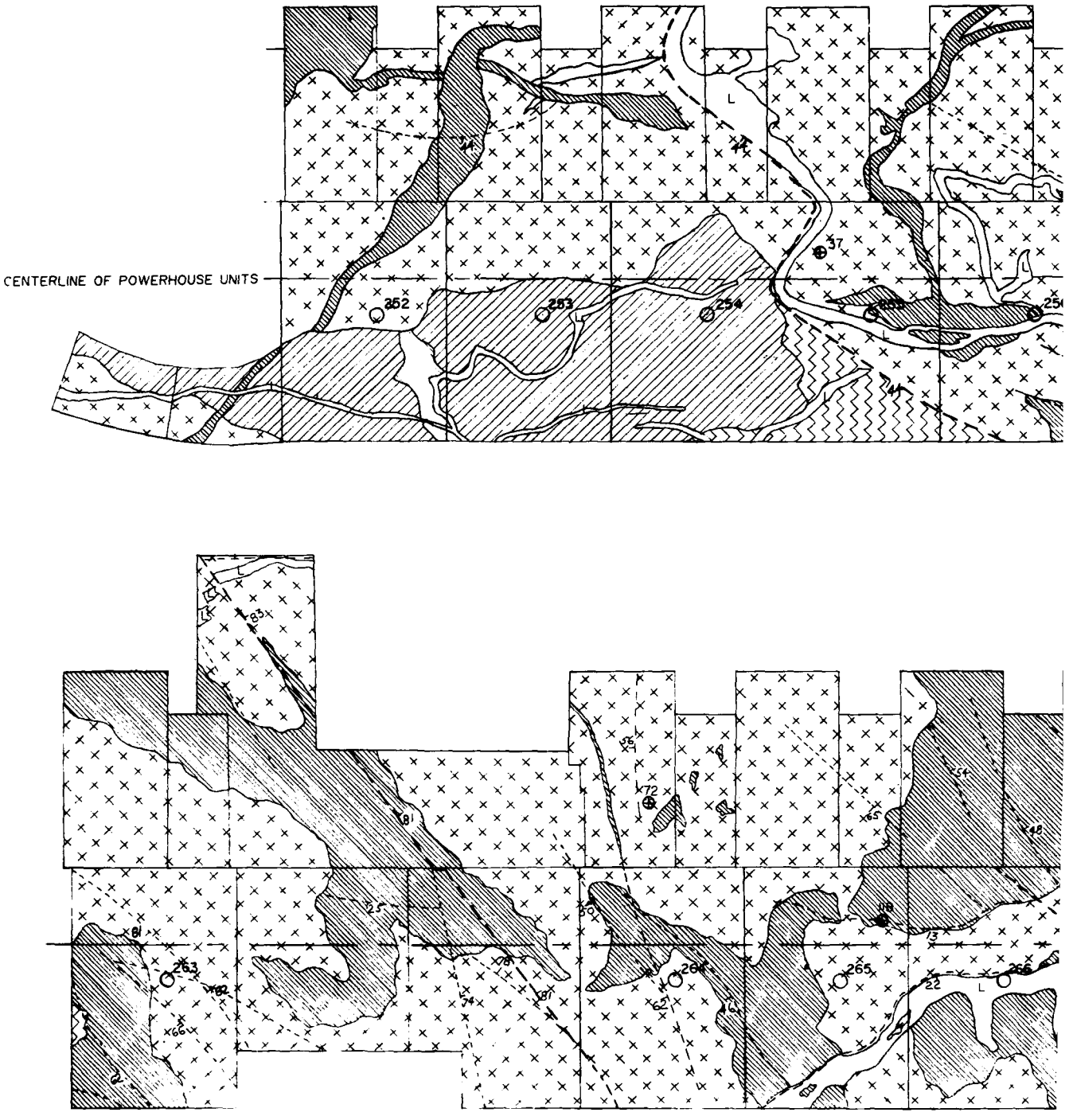
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

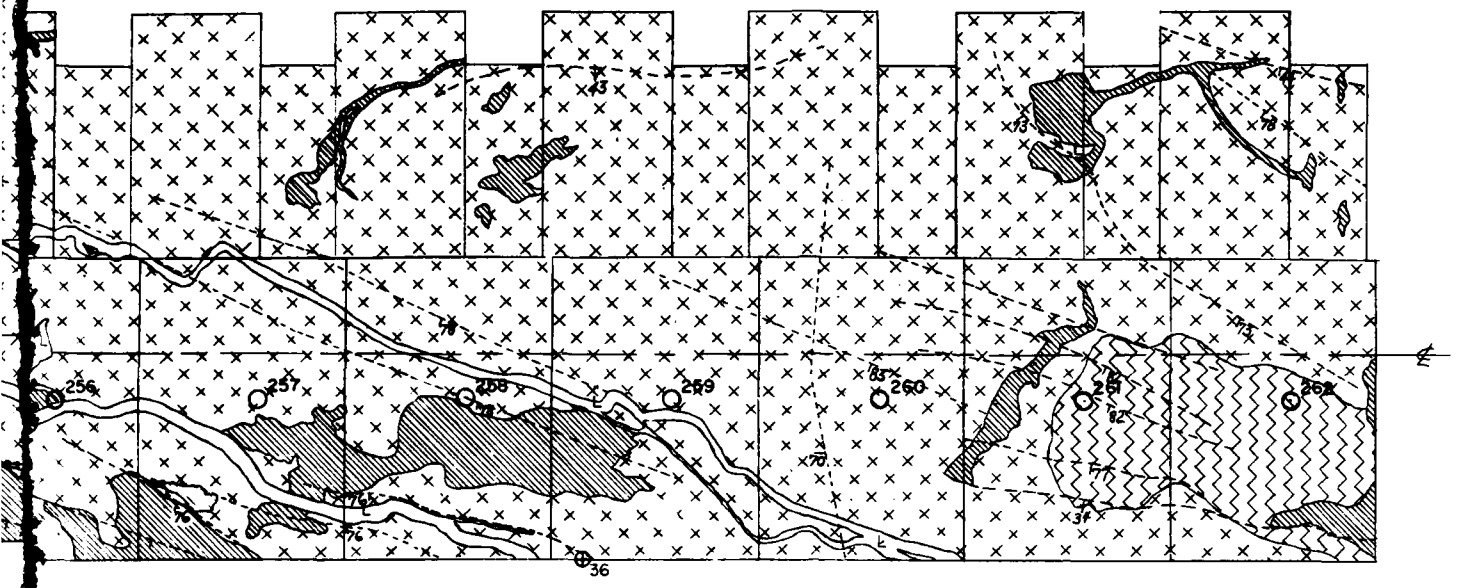
ADDITIONAL UNITS & STRUCTURAL MODIFICATIONS
FOUNDATION REPORT

POWERHOUSE (UNITS 1-20)
GEOLOGIC STRUCTURE

CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

SIZE	INVITATION NO	FILE NO	DATE	PLATE
D		E-51-6-57	NOV. 1987	8
DSGN ECKERLIN		CHK GEMBALA	SHEET	


CENTERLINE OF POWERHOUSE UNITS
252
253
254
37
263
264
265
266
LOOKING UPSTREAM

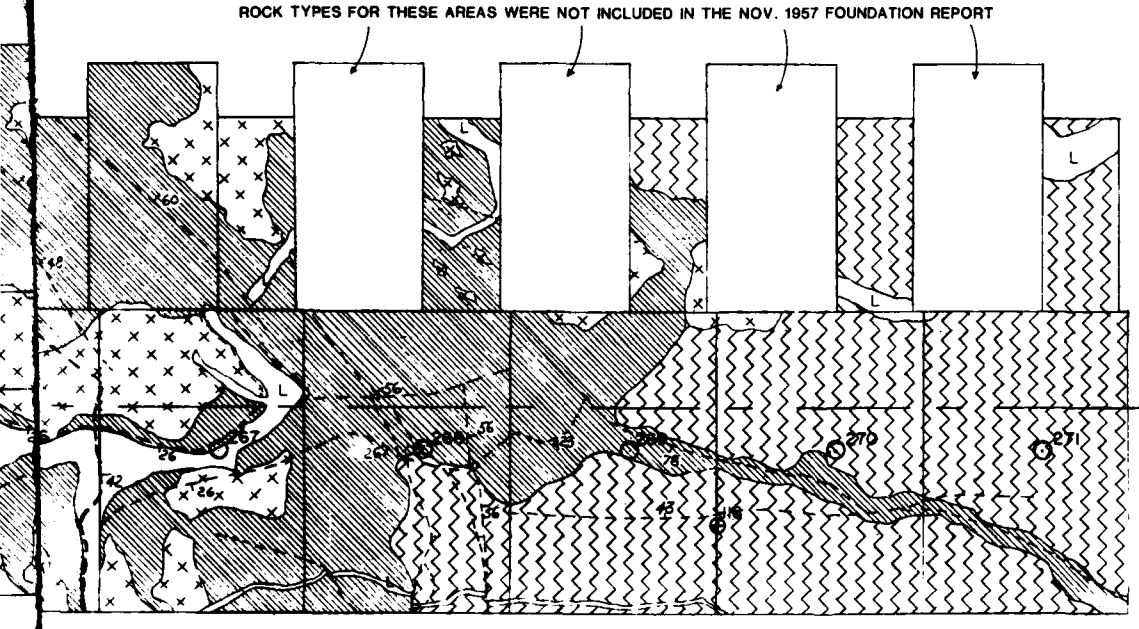


NOTES:

1. THIS DRAW
FOUNDATI

2. FAULT ST
ANGLES A
PLANES A

AN IMAGIN
AVERAGE
ROCK FOU



2

30' 20' 10' 0 30' 60'
SCALE IN FEET

LEGEND


GRANODIORITE GNEISS


GRANODIORITE

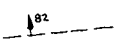

DARK SCHISTOSE GRANODIORITE


LAMPROPHYRE

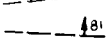

HORNBLENDE GRANODIORITE

DRILL HOLES, CONSTRUCTION

DRILL HOLES, PRE-CONSTRUCTION



MINOR FAULT TREND WITH DEGREE OF DIP



MAJOR FAULT TREND WITH DEGREEEOF DIP

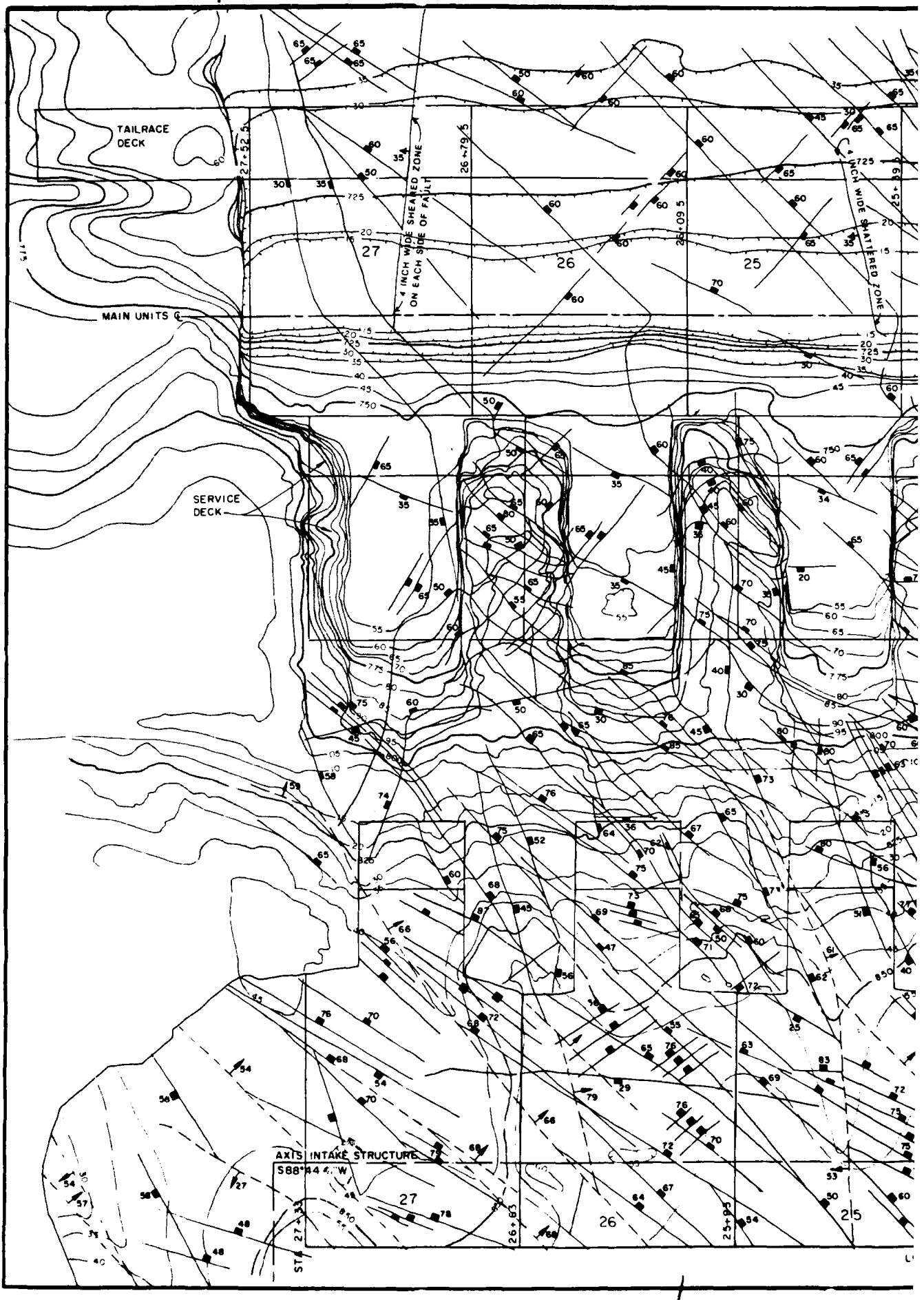
NOTES:

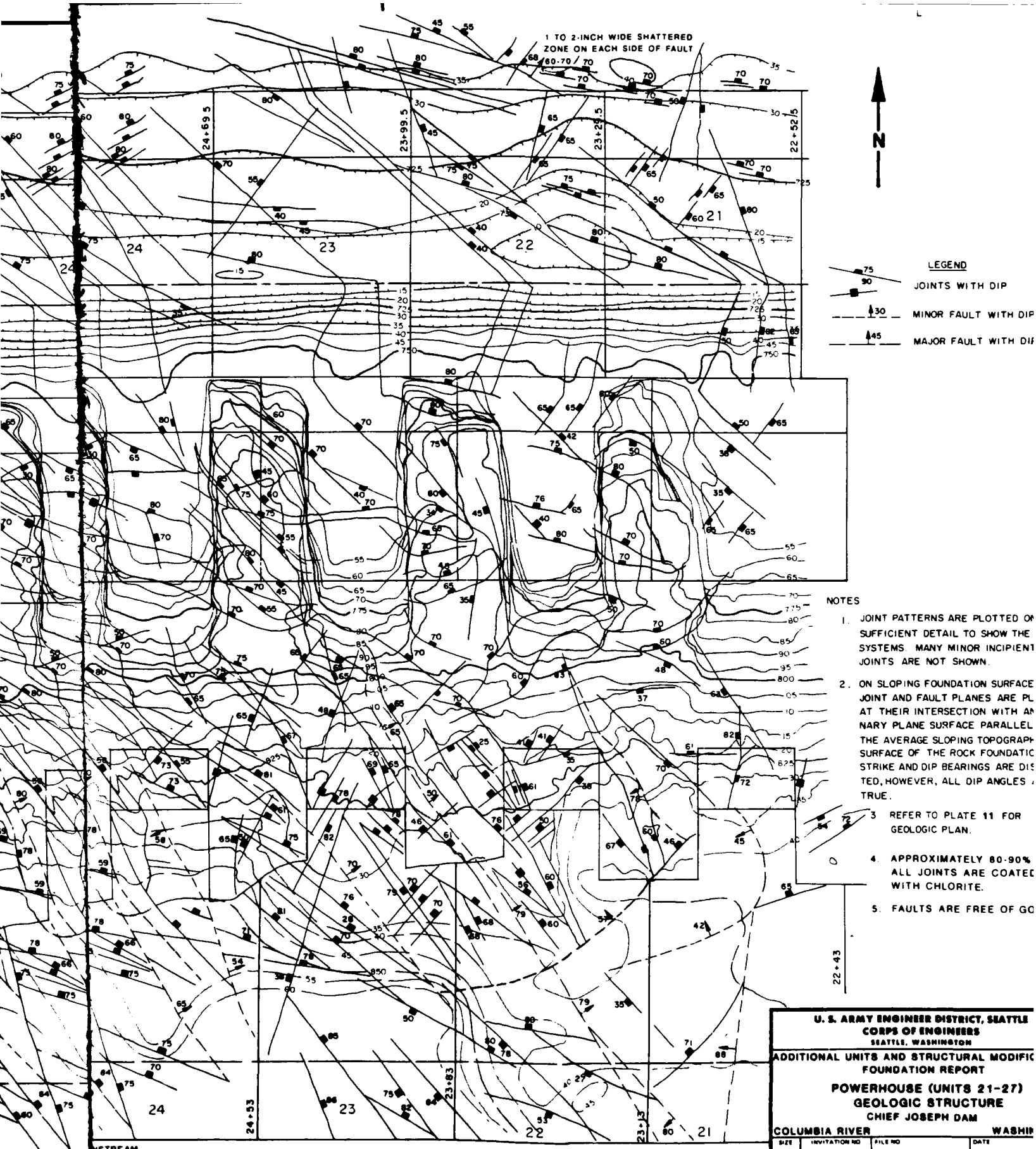
1. THIS DRAWING HAS BEEN MODIFIED FROM THE NOV. 1957 FOUNDATION REPORT
2. FAULT STRIKES ARE DISTORTED, HOWEVER ALL DIP ANGLES ARE TRUE.. ON SLOPING SURFACES, FAULT PLANES ARE PLOTTED AT THEIR INTERSECTION WITH AN IMAGINARY PLANE SURFACE PARALLELING THE AVERAGE SLOPING TOPOGRAPHIC SURFACE OF THE ROCK FOUNDATION.

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

ADDITIONAL UNITS & STRUCTURAL MODIFICATION
FOUNDATION REPORT
POWERHOUSE (UNITS 1-20)
GEOLOGIC PLAN
CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

SIZE	IDENT. NO.	FILE NO.	DATE:	PLATE
D		E-51-6-57	NOV. 1957	9
DSGN ECKERLIN		CHK. GEMBALA	SHEET	


TAILRACE DECK
SERVICE DECK
MAIN UNITS ℄
4 INCH WIDE SHEARED ZONE ON EACH SIDE OF FAULT
4 INCH WIDE SHATTERED ZONE
AXIS INTAKE STRUCTURE
S88°44 4"W
27
26
25
27+52.5
26+79.5
26+09.5
25+39.5
27+33
26+63
25+93



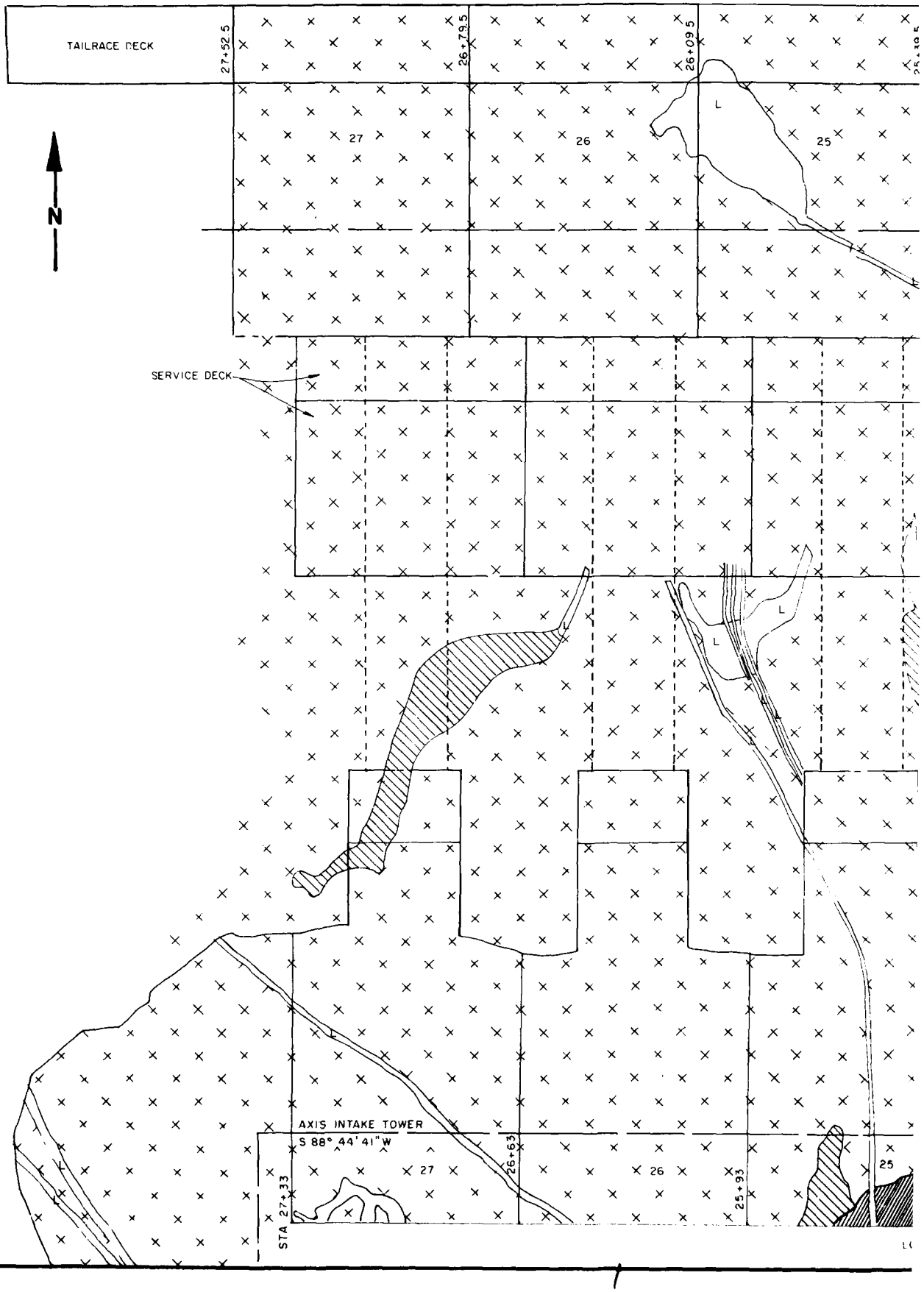
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

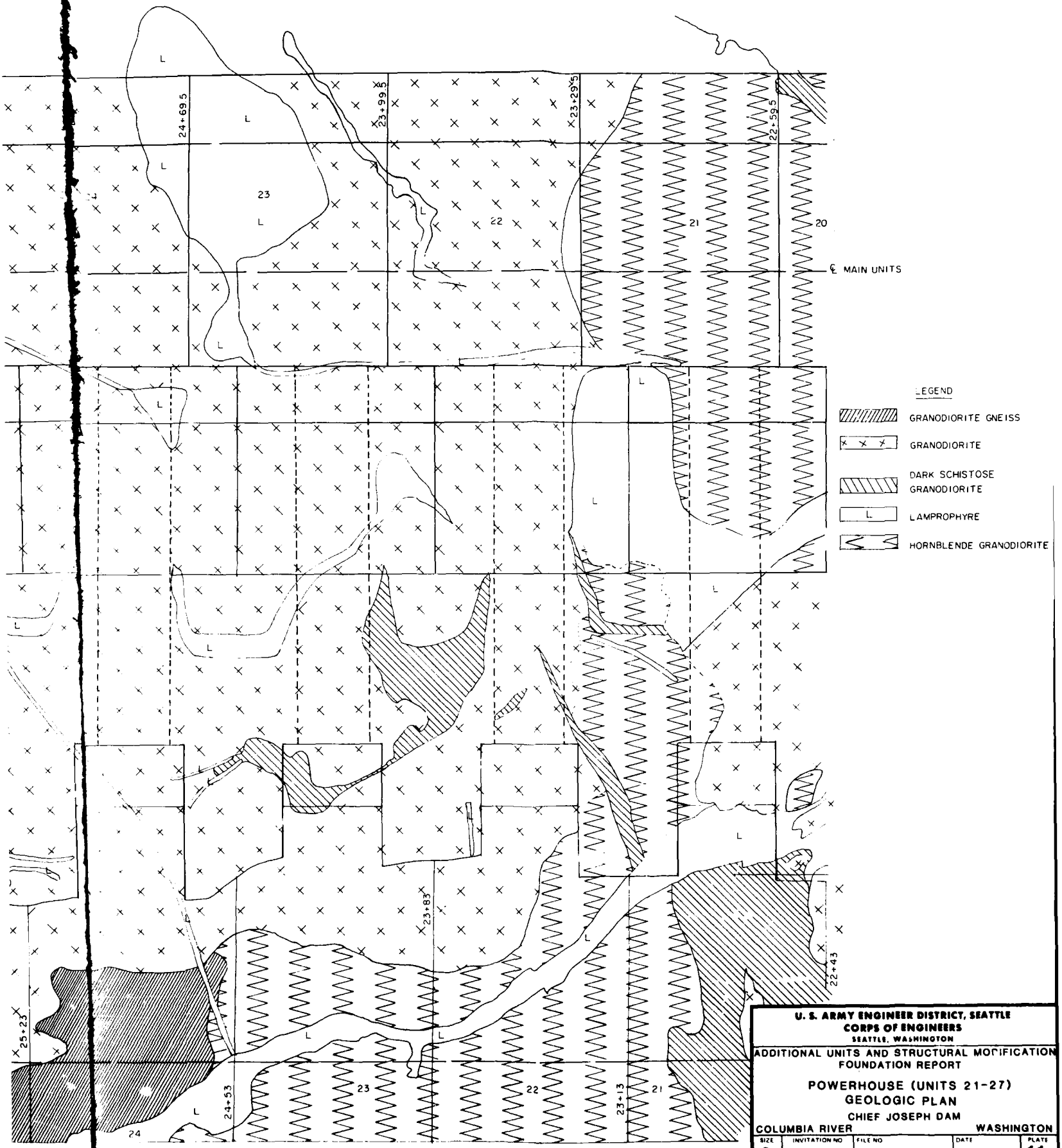
ADDITIONAL UNITS AND STRUCTURAL MODIFIC
FOUNDATION REPORT

POWERHOUSE (UNITS 21-27)
GEOLOGIC STRUCTURE
CHIEF JOSEPH DAM

COLUMBIA RIVER WASHIN

SIZE	INVITATION NO	FILE NO	DATE
D		E-81-6-87	NOV. 1987
DSGN ECKERLIN		CHK GEMBALA	SHEET


TAILRACE DECK
27+52.5
26+79.5
26+09.5
N
27
26
25
SERVICE DECK
L
AXIS INTAKE TOWER
S 88° 44' 41" W
STA 27+33
26+63
25+93



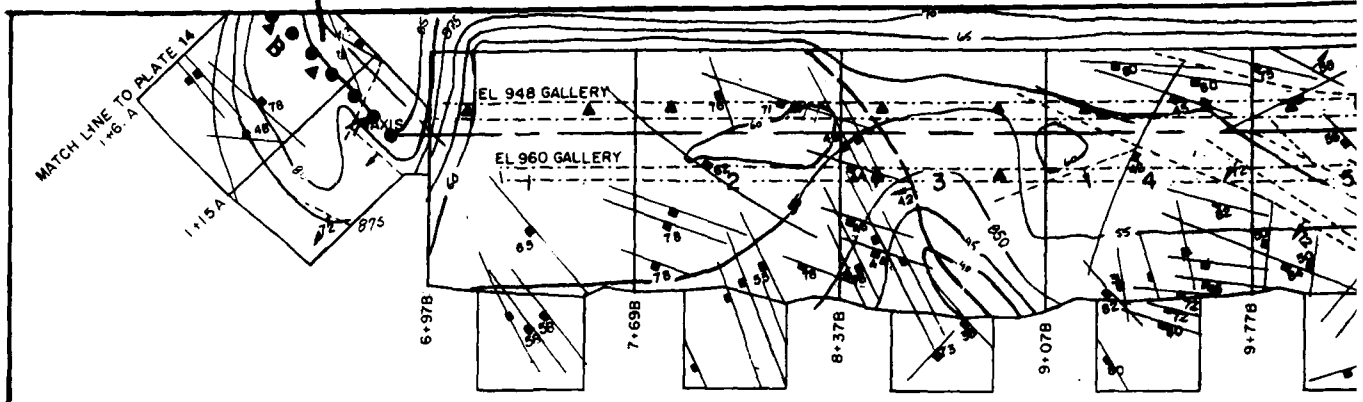
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

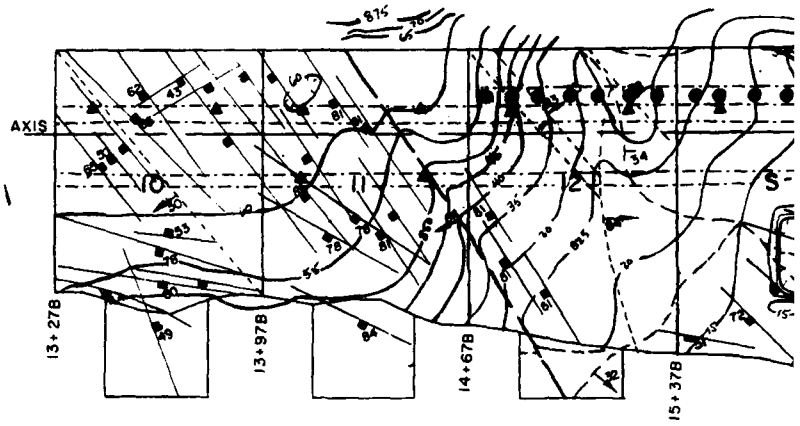
ADDITIONAL UNITS AND STRUCTURAL MODIFICATION
FOUNDATION REPORT

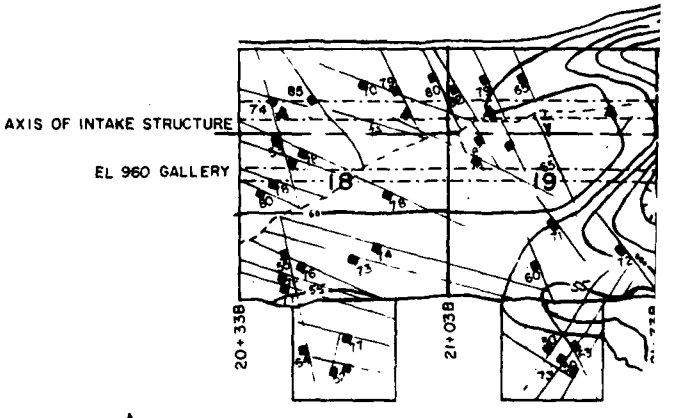
POWERHOUSE (UNITS 21-27)
GEOLOGIC PLAN

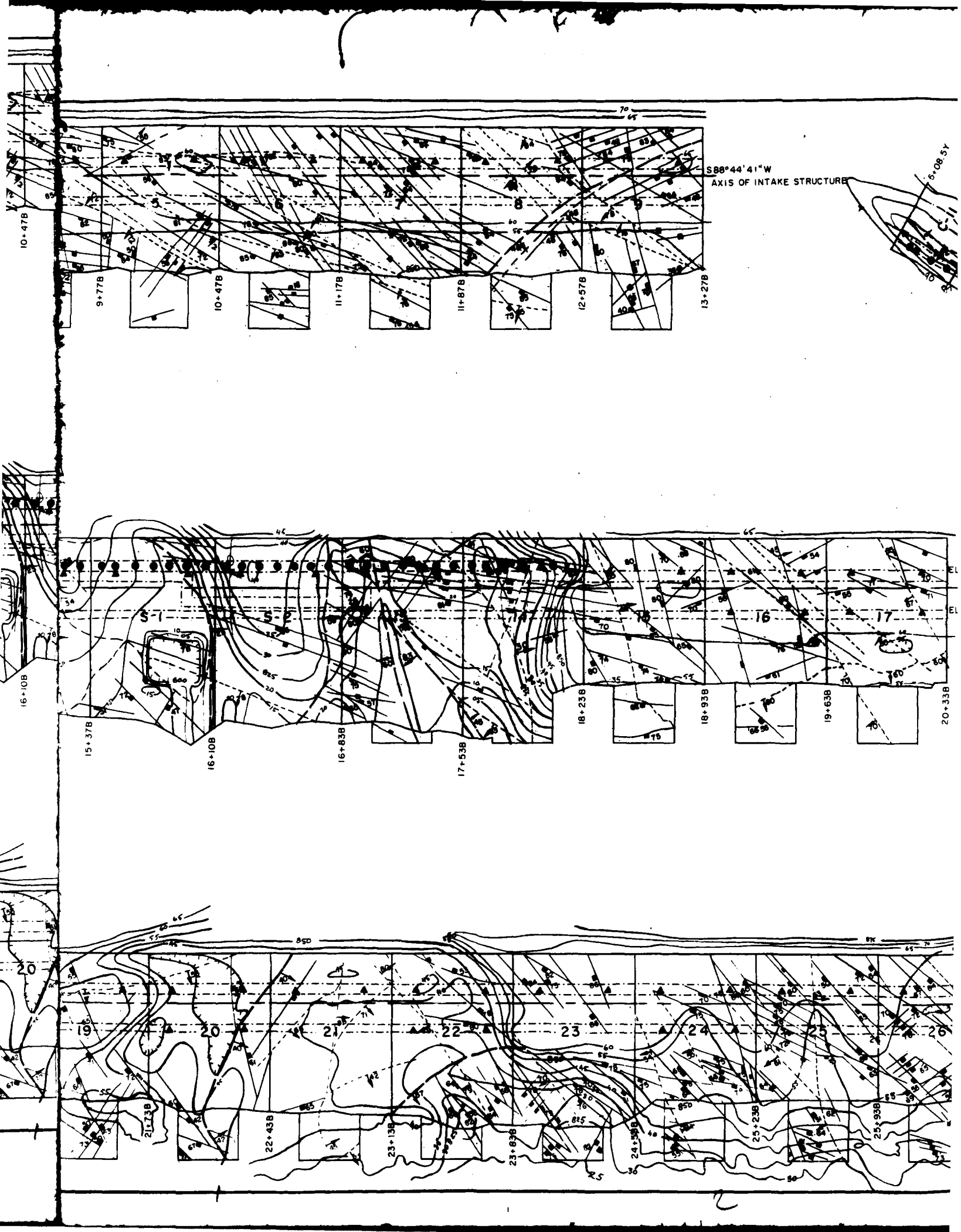
CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

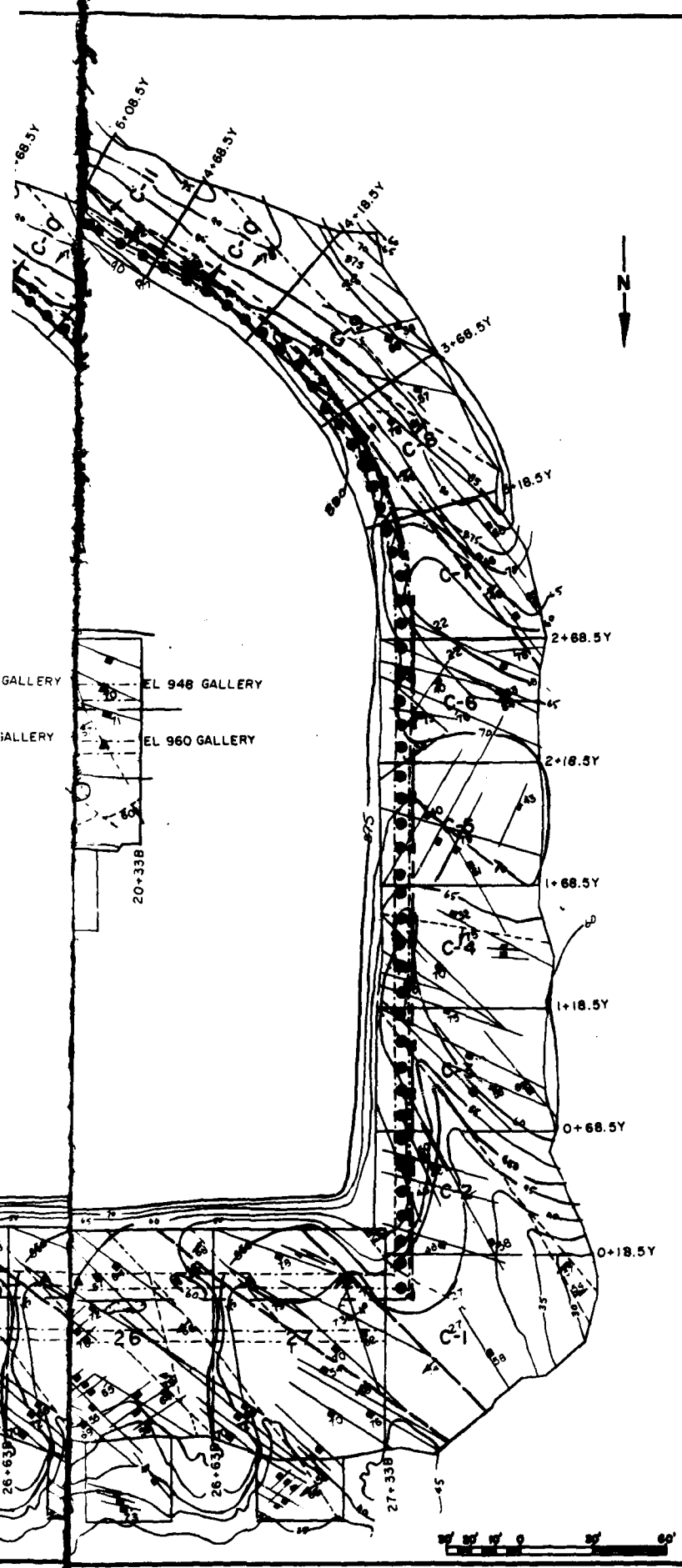
SIZE	INVITATION NO	FILE NO	DATE	PLATE
D		E-51-6-57	NOV. 1987	11
DSGN ECKERLIN		CHK GEMBALA	SHEET	


MATCH LINE TO PLATE 14
1+6. A
1+15 A
AXIS
EL 948 GALLERY
EL 960 GALLERY
6+97B
7+69B
8+37B
9+07B
9+77B


AXIS
13+27B
13+97B
14+67B
15+37B


AXIS OF INTAKE STRUCTURE
EL 960 GALLERY
20+33B
21+03B


S88°44'41"W
AXIS OF INTAKE STRUCTURE
9+77B
10+47B
11+17B
11+87B
12+57B
13+27B
15+37B
16+10B
16+83B
17+53B
18+23B
18+93B
19+63B
20+33B
21+73B
22+43B
23+13B
23+83B
24+53B
25+23B
25+93B



LEGEND

- INDICATE TREND AND DIP OF MAJOR JOINT SYSTEMS.
- MINOR FAULT TREND WITH DEGREE OF DIP
- MAJOR FAULT TREND WITH DEGREE OF DIP
- FOUNDATION DRAIN HOLE
- UPLIFT PRESSURE CELL

NOTES:

1. FOR NOTES, SEE PLATE 8
2. SEE PLATE 13 FOR ROCK TYPES IN THIS AREA.
3. FIVE FOOT CONTOUR INTERVAL

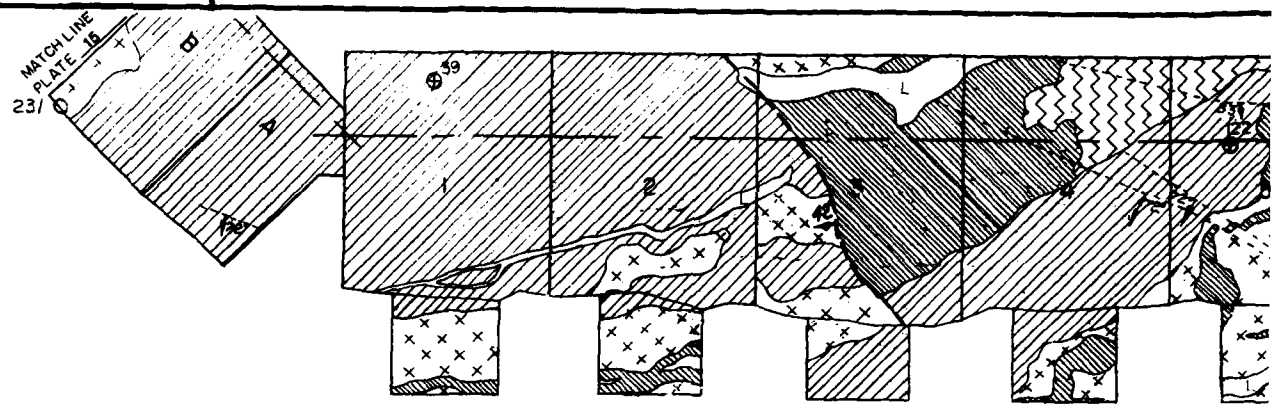
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

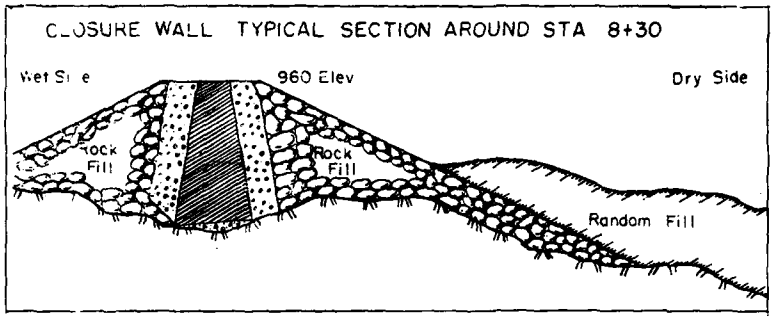
ADDITIONAL UNITS & STRUCTURAL MODIFICATION
FOUNDATION REPORT

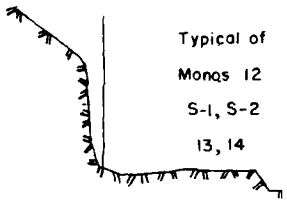
INTAKE & CLOSURE WALL
GEOLOGIC STRUCTURE

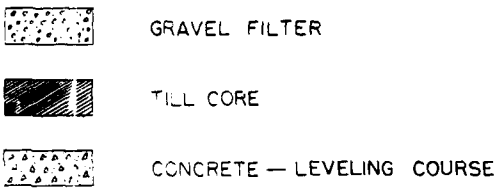
CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

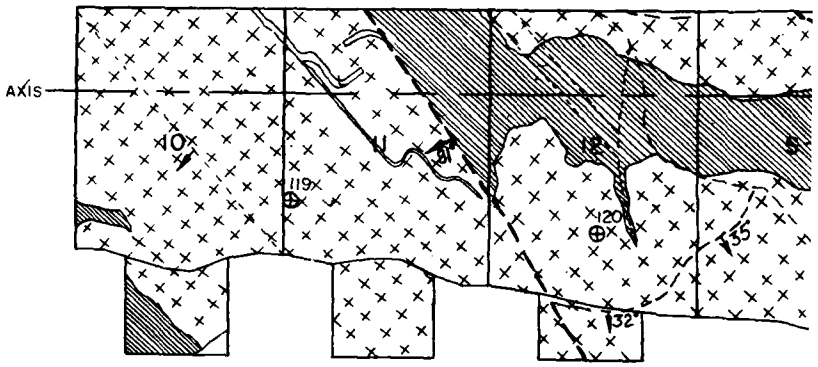
SIZE	INVITATION NO.	FILE NO	DATE	PLATE
D		E-51-6-67	NOV. 1967	12
DSGN ECKERLIN		CHK SEMBALA	SHEET	

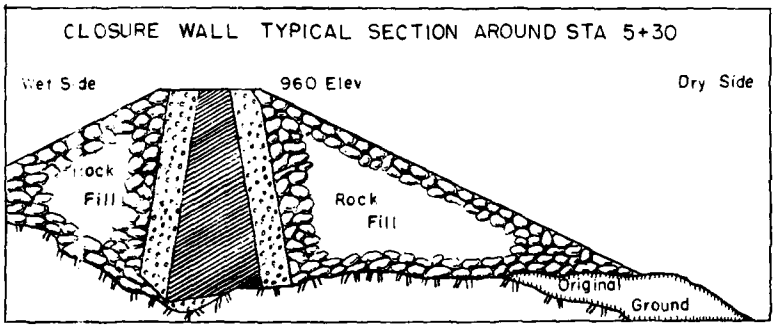

MATCH LINE
PLATE 15
23/
39
1
2
L

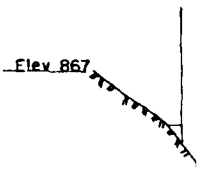

CLOSURE WALL TYPICAL SECTION AROUND STA 8+30
Wet Side
960 Elev
Dry Side
Rock Fill
Rock Fill
Random Fill

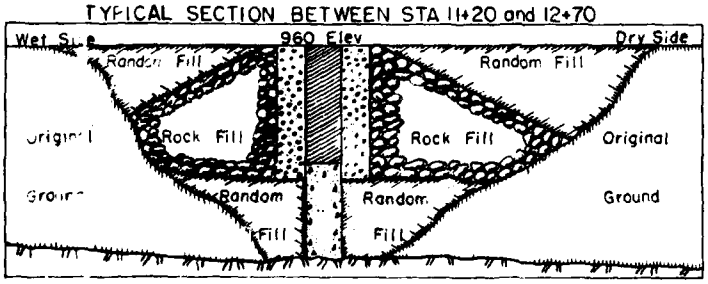

Typical of
Monqs 12
S-1, S-2
13, 14

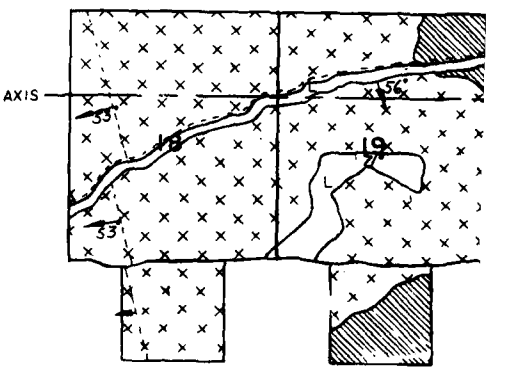

GRAVEL FILTER
TILL CORE
CONCRETE — LEVELING COURSE

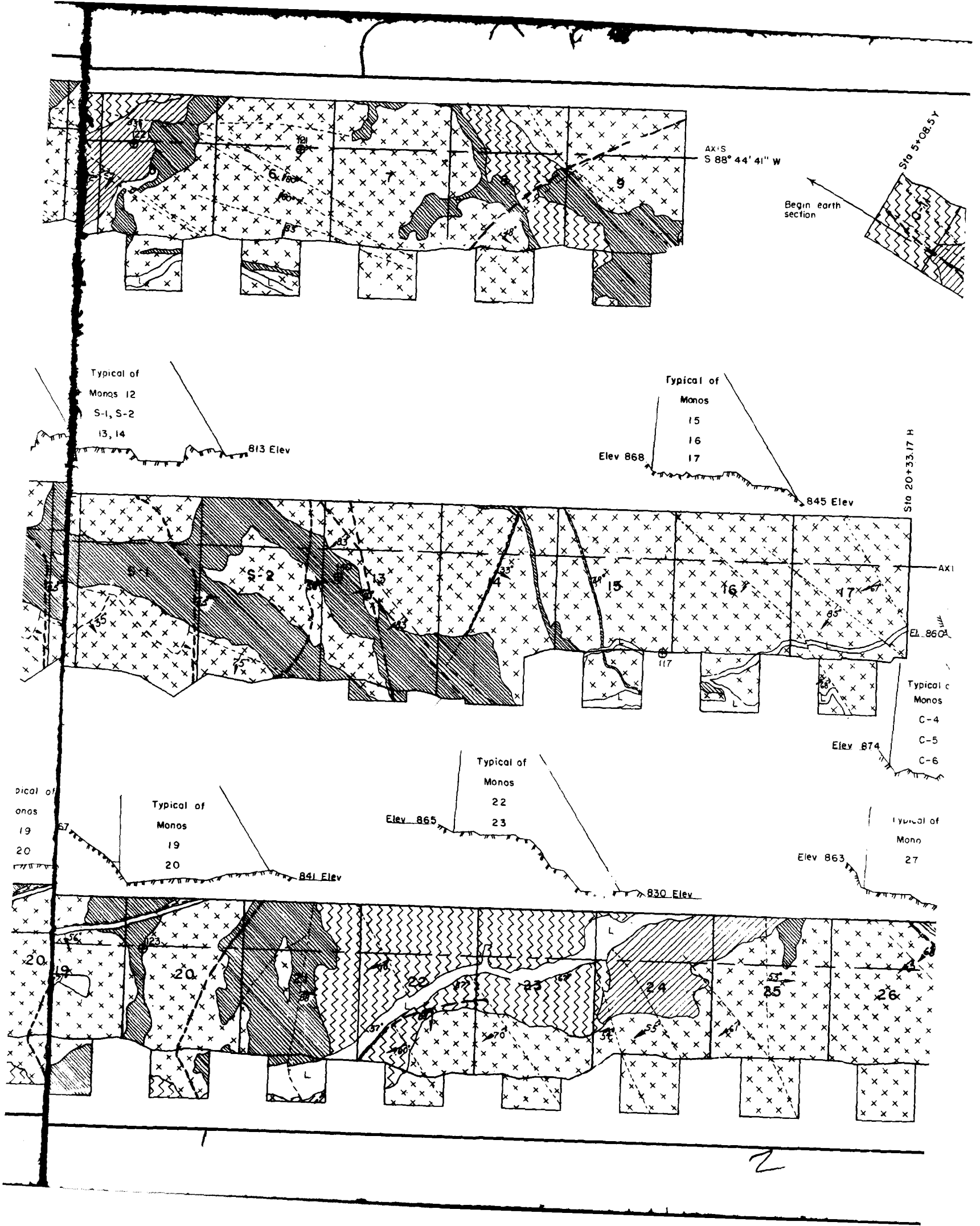

AXIS
10
119
12
120
35
32

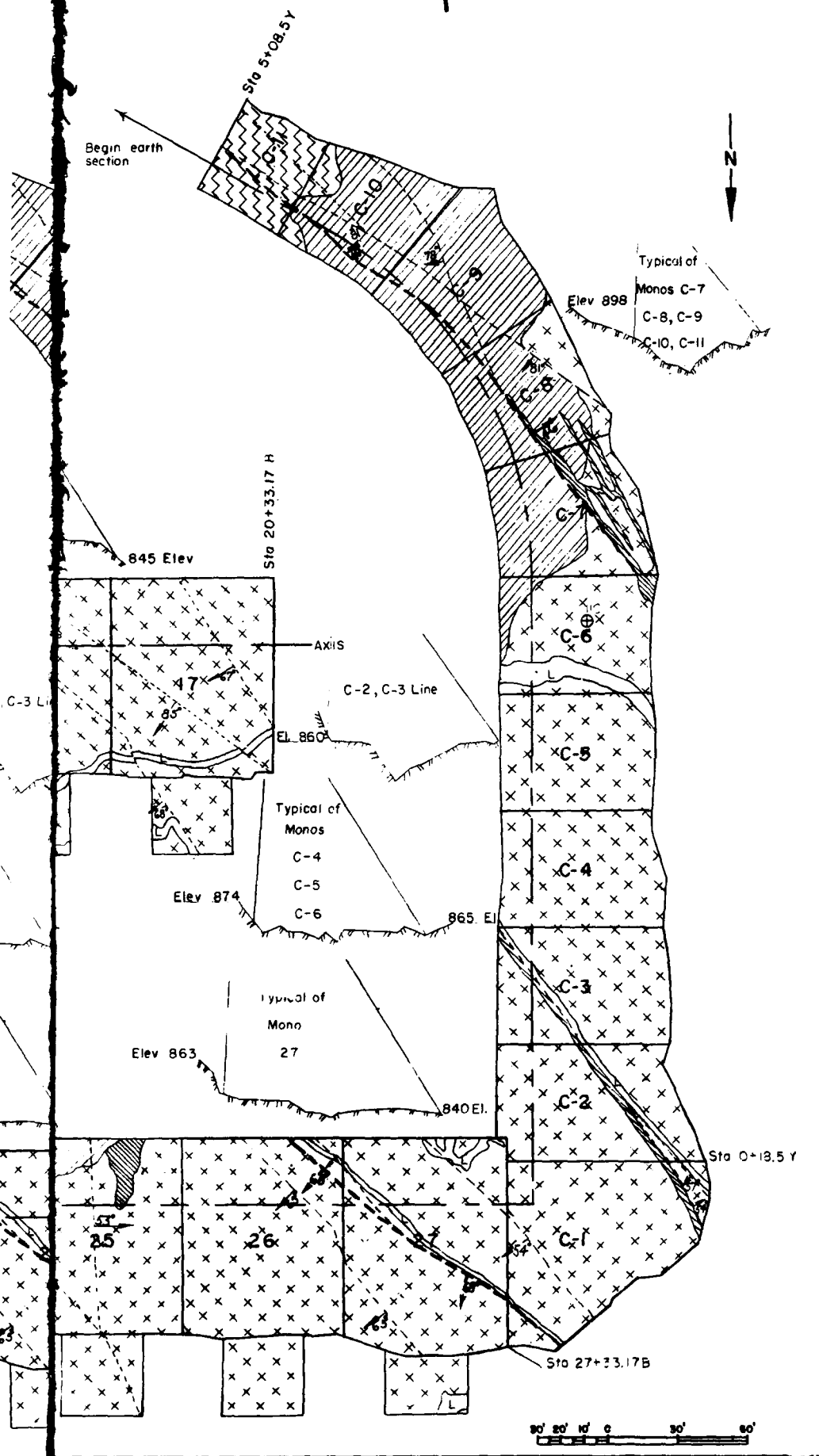

CLOSURE WALL TYPICAL SECTION AROUND STA 5+30
Wet Side
960 Elev
Dry Side
Rock Fill
Rock Fill
Original Ground


Elev 867


TYPICAL SECTION BETWEEN STA 11+20 and 12+70
Wet Side
960 Elev
Dry Side
Random Fill
Random Fill
Original Ground
Rock Fill
Rock Fill
Original Ground
Random Fill
Random Fill


AXIS
33
56
18
19
33


AXIS
S 88° 44' 41" W
Sta 5+08.5Y
Begin earth section
Typical of
Monos 12
S-1, S-2
13, 14
813 Elev
Typical of
Monos
15
16
17
Elev 868
845 Elev
Sta 20+33.17 H
AXI
El. 860
Typical c
Monos
C-4
C-5
C-6
Elev 874
Typical of
Monos
19
20
841 Elev
Typical of
Monos
22
23
Elev 865
830 Elev
Typical of
Mono
27
Elev 863
S-1
S-2
13
14
15
16
17
19
20
20a
21
22
23
24
25
26



LEGEND

- GRANODIORITE GNEISS
- GRANODIORITE
- DARK SCHISTOSE GRANODIORITE
- LAMPROPHYRE
- HORNBLENDE GRANODIORITE
- DRILL HOLES, CONSTRUCTION
- DRILL HOLES, PRE-CONSTRUCTION
- MINOR FAULT TREND WITH DEGREE OF DIP
- MAJOR FAULT TREND WITH DEGREE OF DIP

NOTES:

1. THIS DRAWING HAS BEEN MODIFIED FROM THE NOV. 1957 FOUNDATION REPORT.
2. FAULT STRIKES ARE DISTORTED, HOWEVER, ALL DIP ANGLES ARE TRUE. FAULT PLANES ARE PLOTTED AT THEIR INTERSECTION WITH AN IMAGINARY PLANE SURFACE PARALLELING THE AVERAGE SLOPING TOPOGRAPHIC SURFACE OF THE ROCK FOUNDATION.

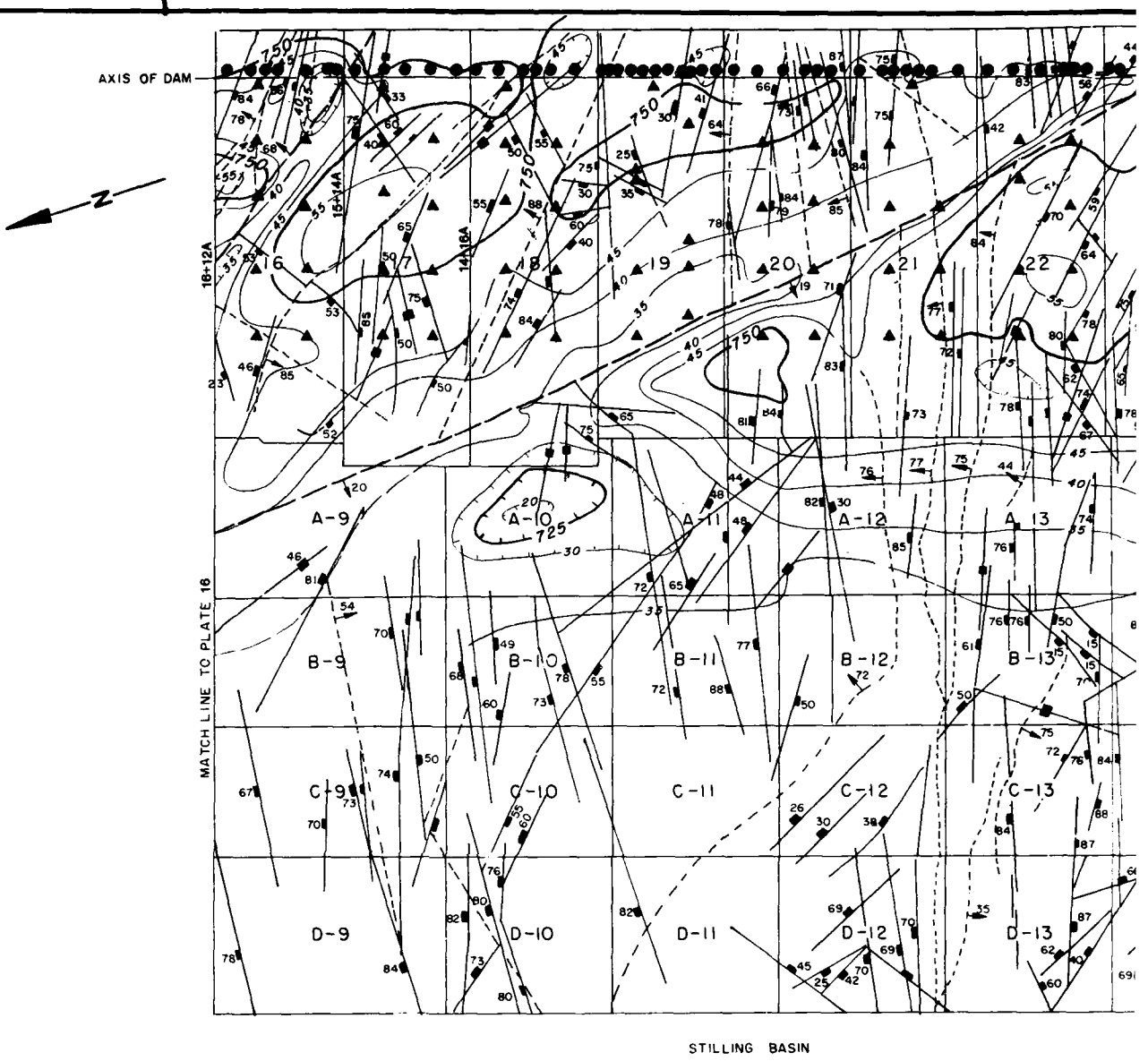
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

ADDITIONAL UNITS & STRUCTURAL MODIFICATION
FOUNDATION REPORT

INTAKE & CLOSURE WALL
GEOLOGIC PLAN
CHIEF JOSEPH DAM

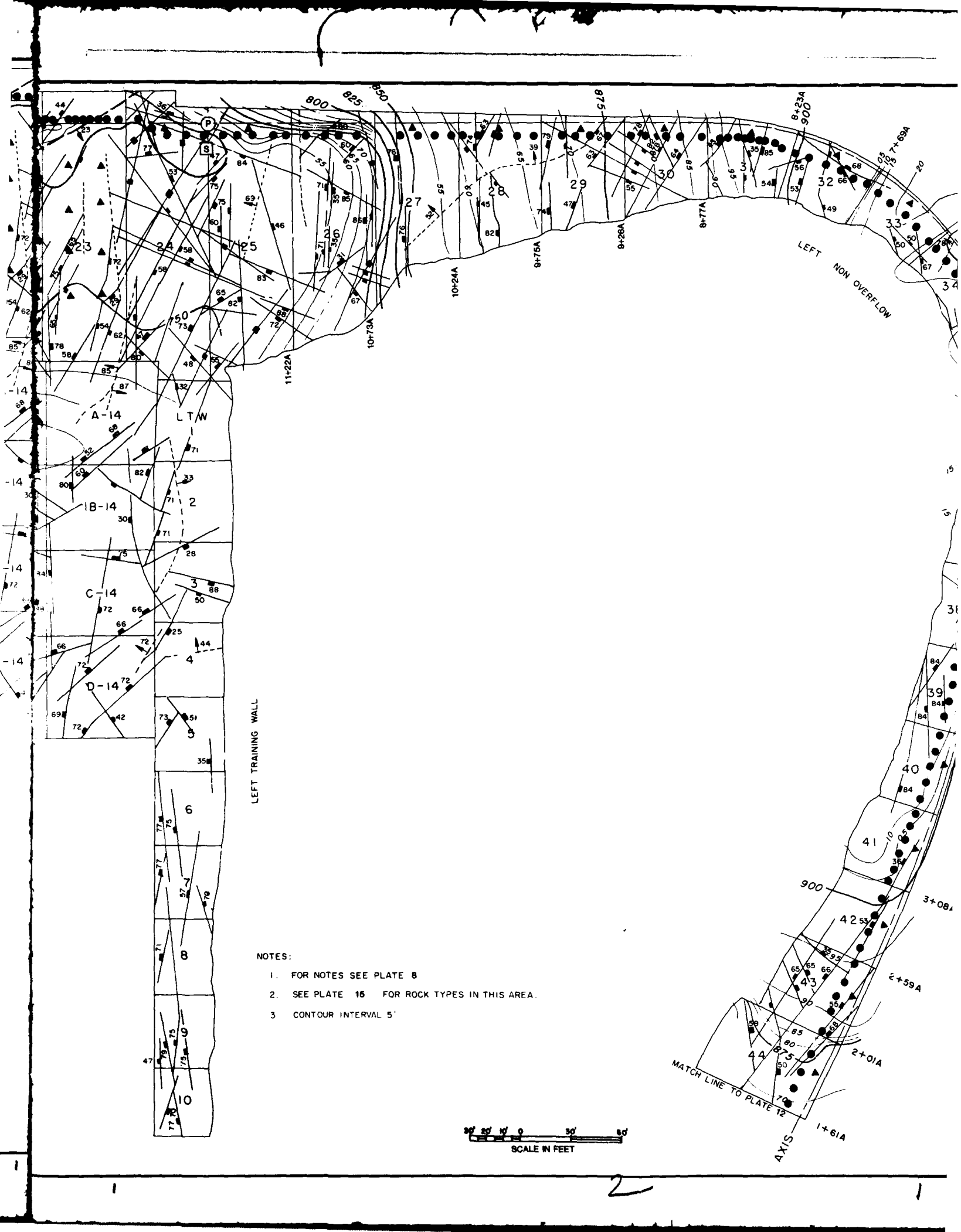
COLUMBIA RIVER WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE	PLATE
D		E-51-6-57	NOV. 1987	13
DSGN ECKERLIN		CHK GEMBALA	SHEET	



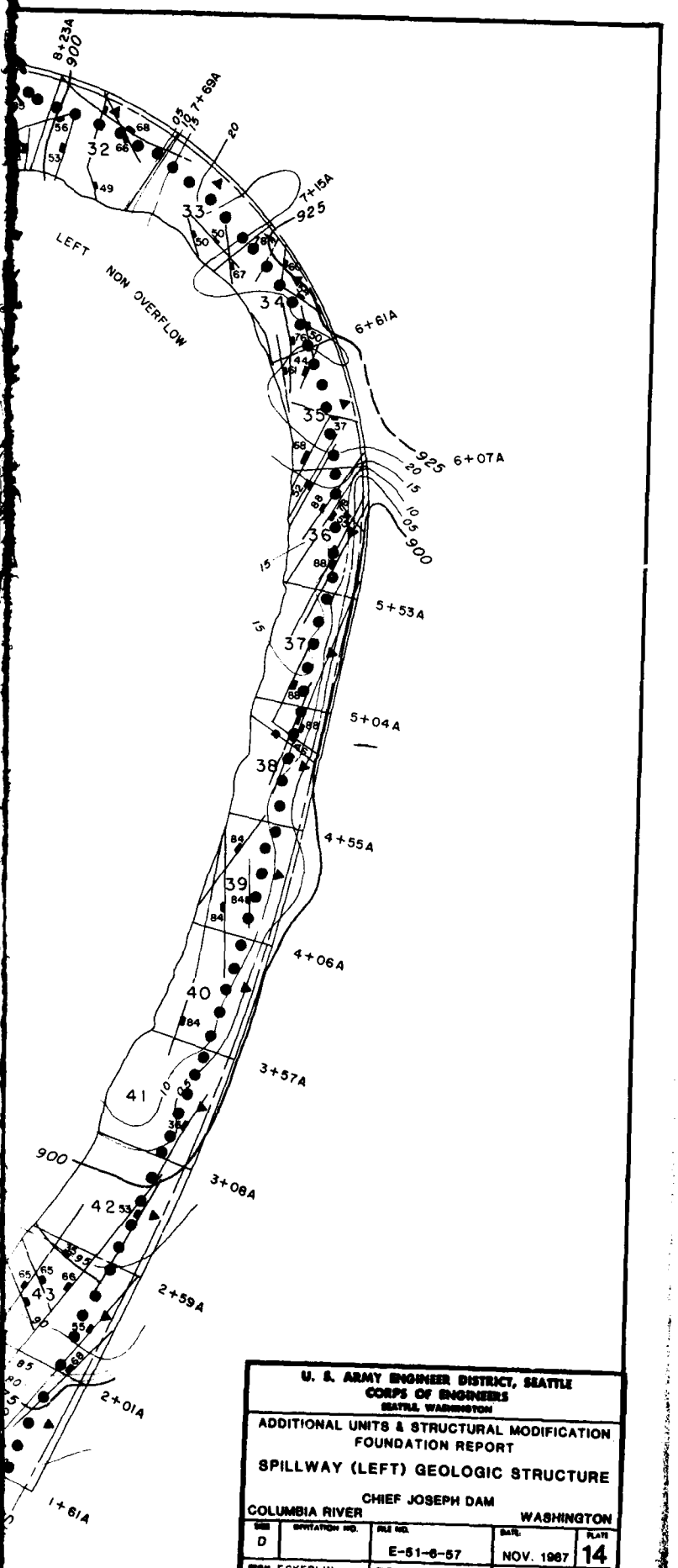
LEGEND

- INDICATE TREND AND DIP OF MAJOR JOINT SYSTEMS
- MINOR FAULT TREND WITH DEGREE OF DIP
- MAJOR FAULT TREND WITH DEGREE OF D.P
- FOUNDATION DRAIN HOLE
- FOUNDATION UPLIFT PRESSURE CELL
- (P) PLUMBLINE ASSEMBLY (EL. 767' to 957')
  READOUT STATIONS AT ELEVATIONS 770 AND 836'.
- [S] STRONG MOTION INSTRUMENT IN MONOLITH 24 AT ELEVATIONS
  764' AND 950'



NOTES:

1. FOR NOTES SEE PLATE 8
2. SEE PLATE 15 FOR ROCK TYPES IN THIS AREA.
3. CONTOUR INTERVAL 5'



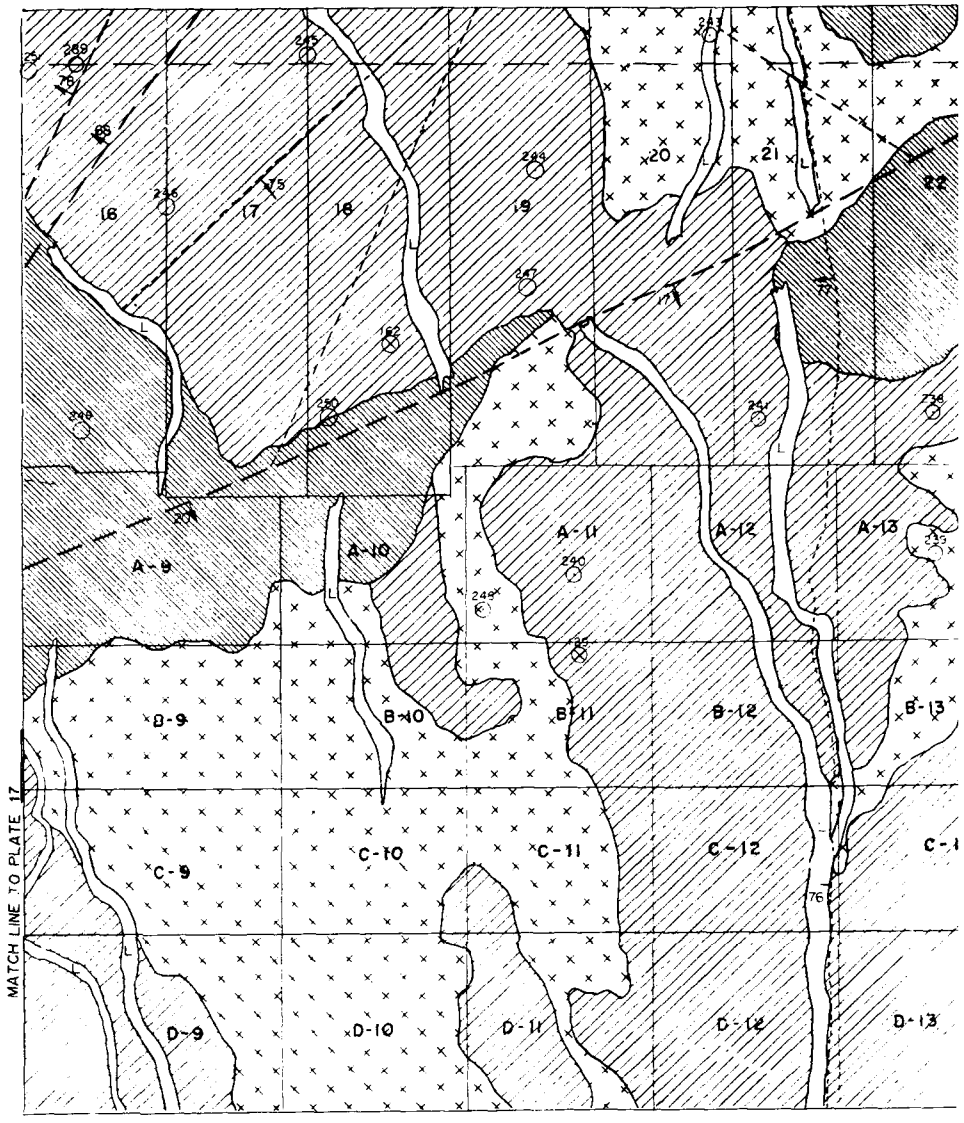
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

ADDITIONAL UNITS & STRUCTURAL MODIFICATION
FOUNDATION REPORT

SPILLWAY (LEFT) GEOLOGIC STRUCTURE

CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE	PLATE
D		E-51-6-57	NOV. 1967	14
DSGN ECKERLIN		CHK GEMBALA	SHEET	



LEGEND

- GRANODIORITE GNEISS
- GRANODIORITE
- DARK SCHISTOSE GRANODIORITE
- L — LAMPROPHYRE
- 239 — DRILL HOLES, CONSTRUCTION
- 130 — DRILL HOLES, PRE-CONSTRUCTION
- 77 — MINOR FAULT TREND WITH DEGREE OF DIP
- 20 — MAJOR FAULT TREND WITH DEGREE OF DIP

NOTES:

1. THIS DRAWING HAS BEEN MODIFIED FROM THE FOUNDATION REPORT.
2. FAULT STRIKES ARE DISTORTED, HOWEVER, ARE TRUE. ON SLOPING SURACES, FAULT P PLOTTED AT THEIR INTERSECTION WITH AN I SURFACE PARALLELING THE AVERAGE SLOPI SURFACE OF THE ROCK FOUNDATION.

LOOKING UPSTREAM

1957

DIP ANGLES
NES ARE
GINARY PLANE
TOPOGRAPHIC

U. S.

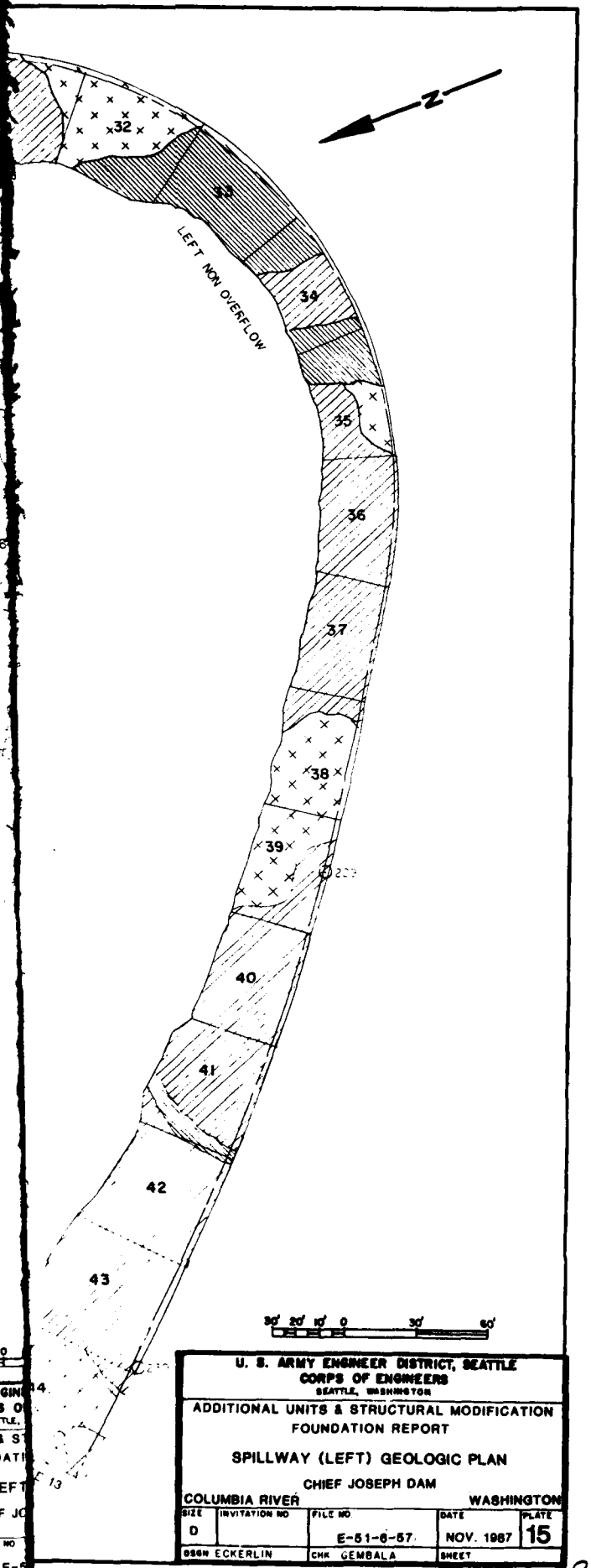
ADDITIONAL

SPILL

COLUMBIA RI

SIZE D | INVITATION

DSGN ECKERLIN



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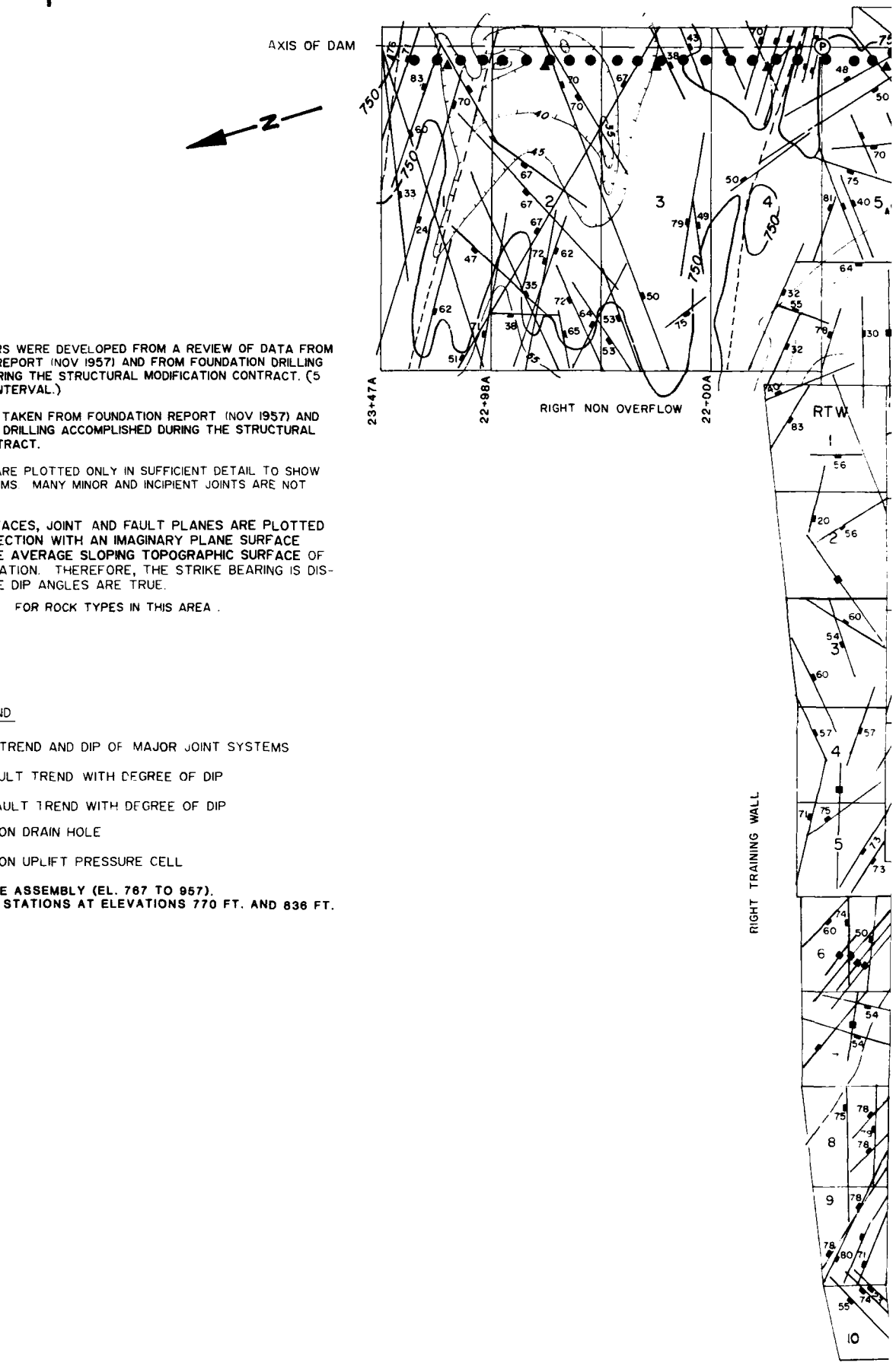
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

ADDITIONAL UNITS & STRUCTURAL MODIFICATION
FOUNDATION REPORT

SPILLWAY (LEFT) GEOLOGIC PLAN

CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

SIZE	INVITATION NO	FILE NO	DATE	PLATE
D		E-51-6-57	NOV. 1987	15
DSGN ECKERLIN		CHK GEMBALA	SHEET	

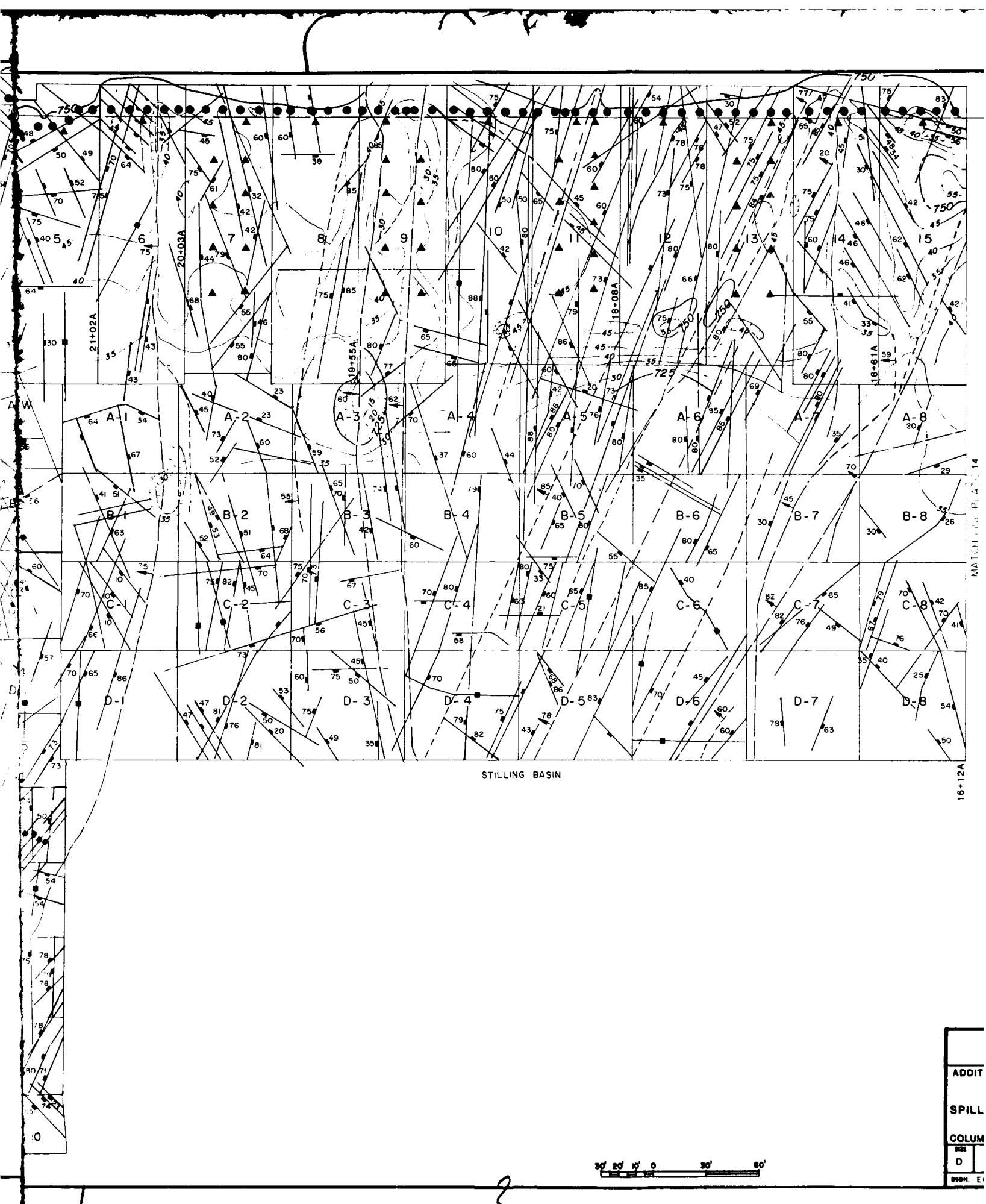


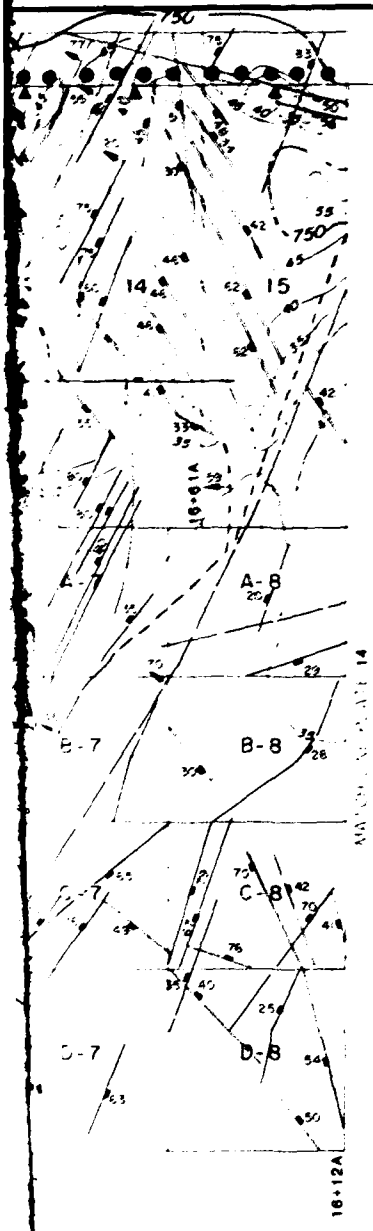
NOTES:

1. BEDROCK CONTOURS WERE DEVELOPED FROM A REVIEW OF DATA FROM THE FOUNDATION REPORT (NOV 1957) AND FROM FOUNDATION DRILLING ACCOMPLISHED DURING THE STRUCTURAL MODIFICATION CONTRACT. (5 FOOT COUNTOUR INTERVAL.)
2. GEOLOGIC DATA IS TAKEN FROM FOUNDATION REPORT (NOV 1957) AND FROM FOUNDATION DRILLING ACCOMPLISHED DURING THE STRUCTURAL MODIFICATION CONTRACT.
3. JOINT PATTERNS ARE PLOTTED ONLY IN SUFFICIENT DETAIL TO SHOW THE MAJOR SYSTEMS. MANY MINOR AND INCIPIENT JOINTS ARE NOT SHOWN.
4. ON SLOPING SURFACES, JOINT AND FAULT PLANES ARE PLOTTED AT THEIR INTERSECTION WITH AN IMAGINARY PLANE SURFACE PARALLELING THE AVERAGE SLOPING TOPOGRAPHIC SURFACE OF THE ROCK FOUNDATION. THEREFORE, THE STRIKE BEARING IS DISTORTED, BUT THE DIP ANGLES ARE TRUE.
5. SEE PLATE 17 FOR ROCK TYPES IN THIS AREA .

LEGEND

- 65 / 90 — INDICATE TREND AND DIP OF MAJOR JOINT SYSTEMS
- 85 — MINOR FAULT TREND WITH DEGREE OF DIP
- 75 — MAJOR FAULT TREND WITH DEGREE OF DIP
- ● FOUNDATION DRAIN HOLE
- ▲ FOUNDATION UPLIFT PRESSURE CELL
- Ⓟ **PLUMBLINE ASSEMBLY (EL. 767 TO 957). READOUT STATIONS AT ELEVATIONS 770 FT. AND 836 FT.**


A-1
A-2
A-3
A-4
A-5
A-6
A-7
A-8
B-1
B-2
B-3
B-4
B-5
B-6
B-7
B-8
C-1
C-2
C-3
C-4
C-5
C-6
C-7
C-8
D-1
D-2
D-3
D-4
D-5
D-6
D-7
D-8
STILLING BASIN
MATCH LINE PLATE 14
16+12A
16+61A
18+08A
19+55A
20+03A
21+02A
30' 20' 10' 0 30' 60'
ADDIT
SPILL
COLUM
D



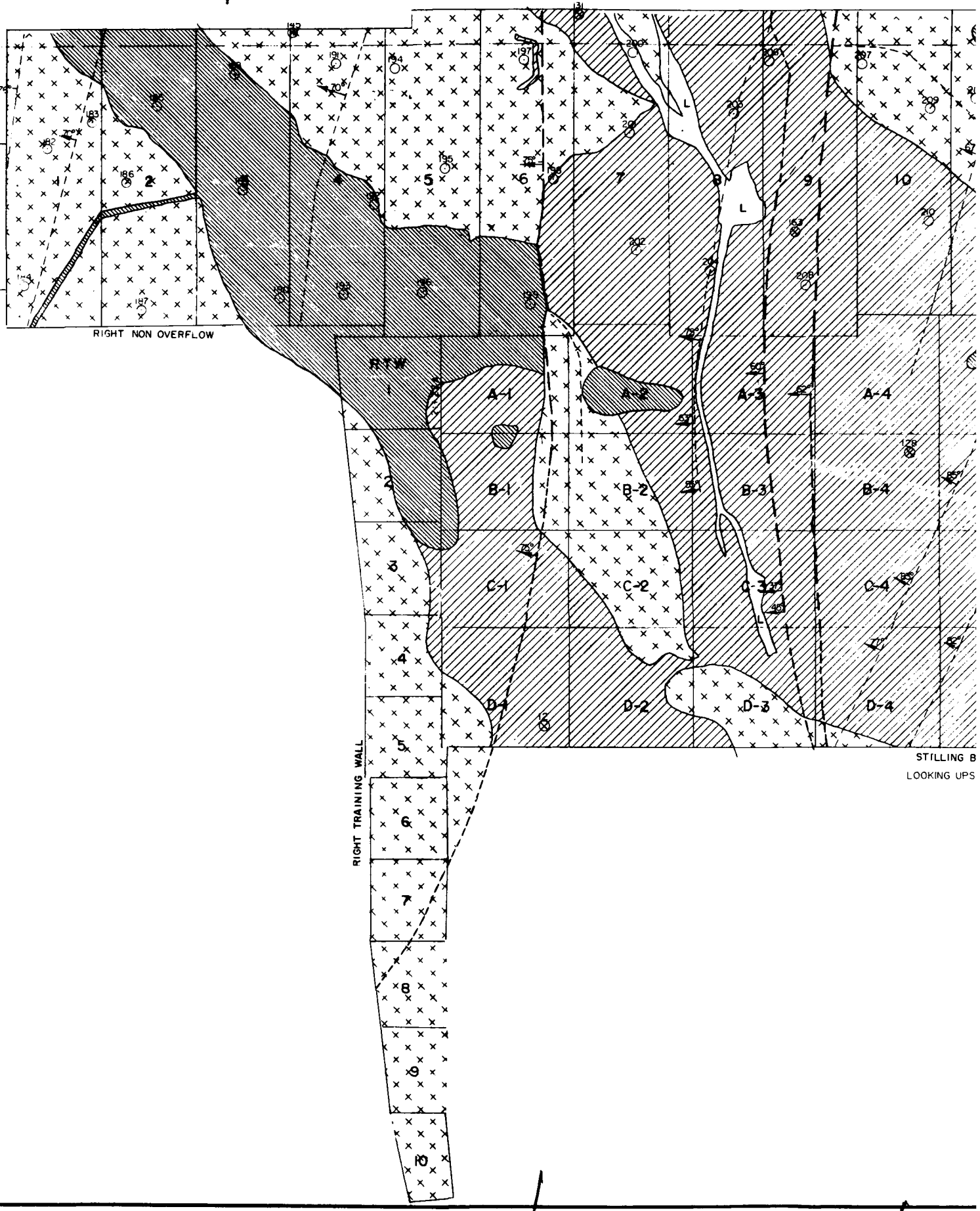
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

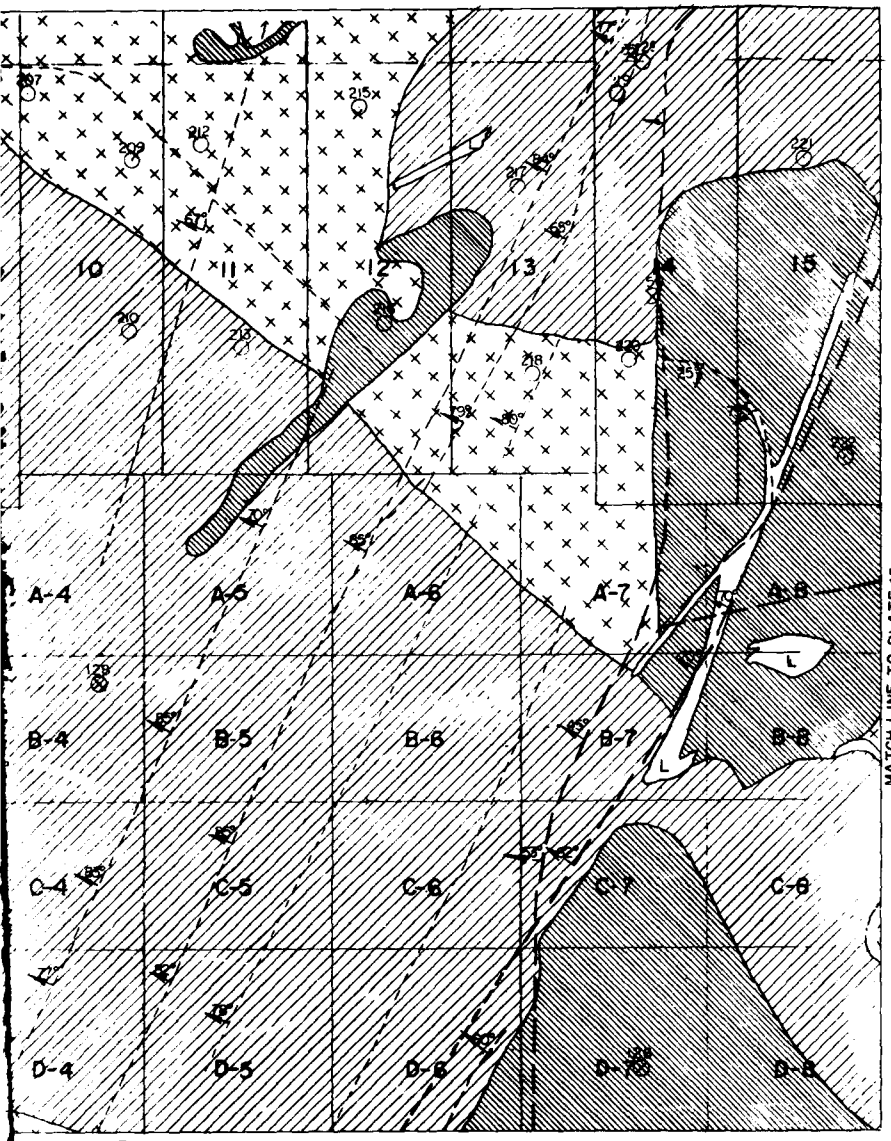
ADDITIONAL UNITS & STRUCTURAL MODIFICATION
FOUNDATION REPORT

SPILLWAY (RIGHT) GEOLOGIC STRUCTURE

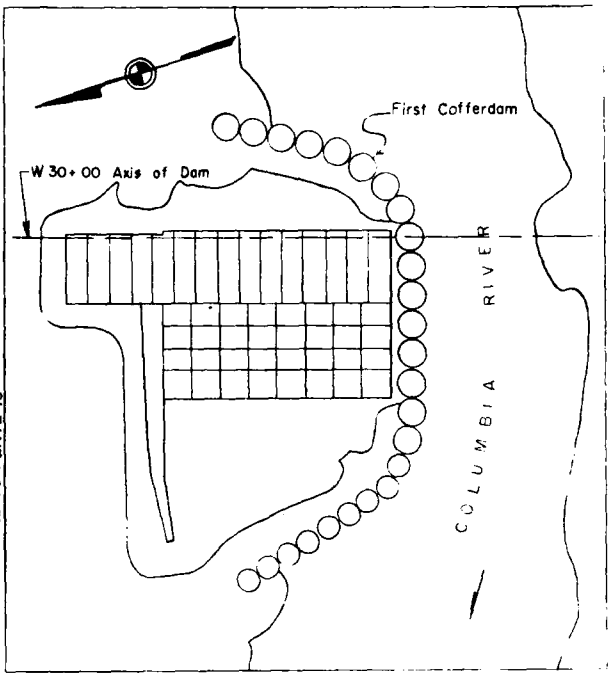
CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

SIZE	CLASSIFICATION NO.	FILE NO.	DATE	PLATE
D		E-51-6-57	NOV. 1967	16
DESIGNED ECKERLIN		DRAWN GEMBALA	CHECKED	


RIGHT NON OVERFLOW
R.T.W.
RIGHT TRAINING WALL
A-1
A-2
A-3
A-4
B-1
B-2
B-3
B-4
C-1
C-2
C-3
C-4
D-1
D-2
D-3
D-4
L
L
STILLING B
LOOKING UPS



STILLING BASIN
LOOKING UPSTREAM



LEGEND

- GRANODIORITE GNEISS
- GRANODIORITE
- DARK SHISTOSE GRANODIORITE
- L — LAMPROPHYRE
- ○182 — DRILL HOLES, CONSTRUCTION
- ⊗126 — DRILL HOLES, PRE-CONSTRUCTION
- 83 — MINOR FAULT TREND WITH DEGREE OF DIP
- 82 — MAJOR FAULT TREND WITH DEGREE OF DIP

NOTES:

1. DRAWING HAS BEEN MODIFIED FROM NOV. 1957 FOUNDATION REPORT.
2. FAULT STRIKES ARE DISTORTED, HOWEVER, ALL DIP ANGLES ARE TRUE. ON SLOPING SURFACES, FAULT PLANES ARE PLOTTED AT THEIR INTERSECTION WITH AN IMAGINARY PLANE SURFACE PARALLELING THE AVERAGE SLOPING TOPOGRAPHIC SURFACE OF THE ROCK FOUNDATION.

30' 20' 10' 0 30' 60'

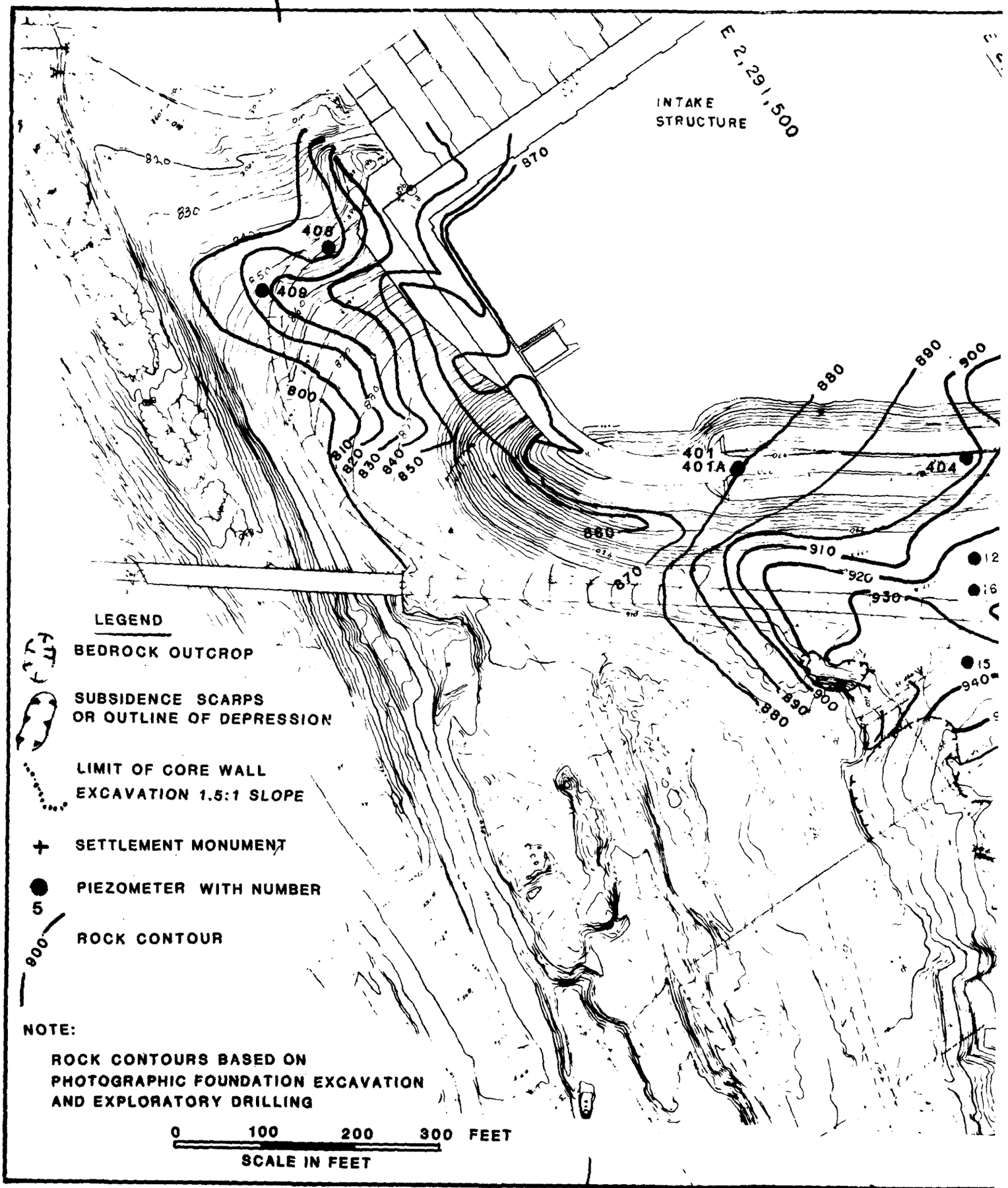
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

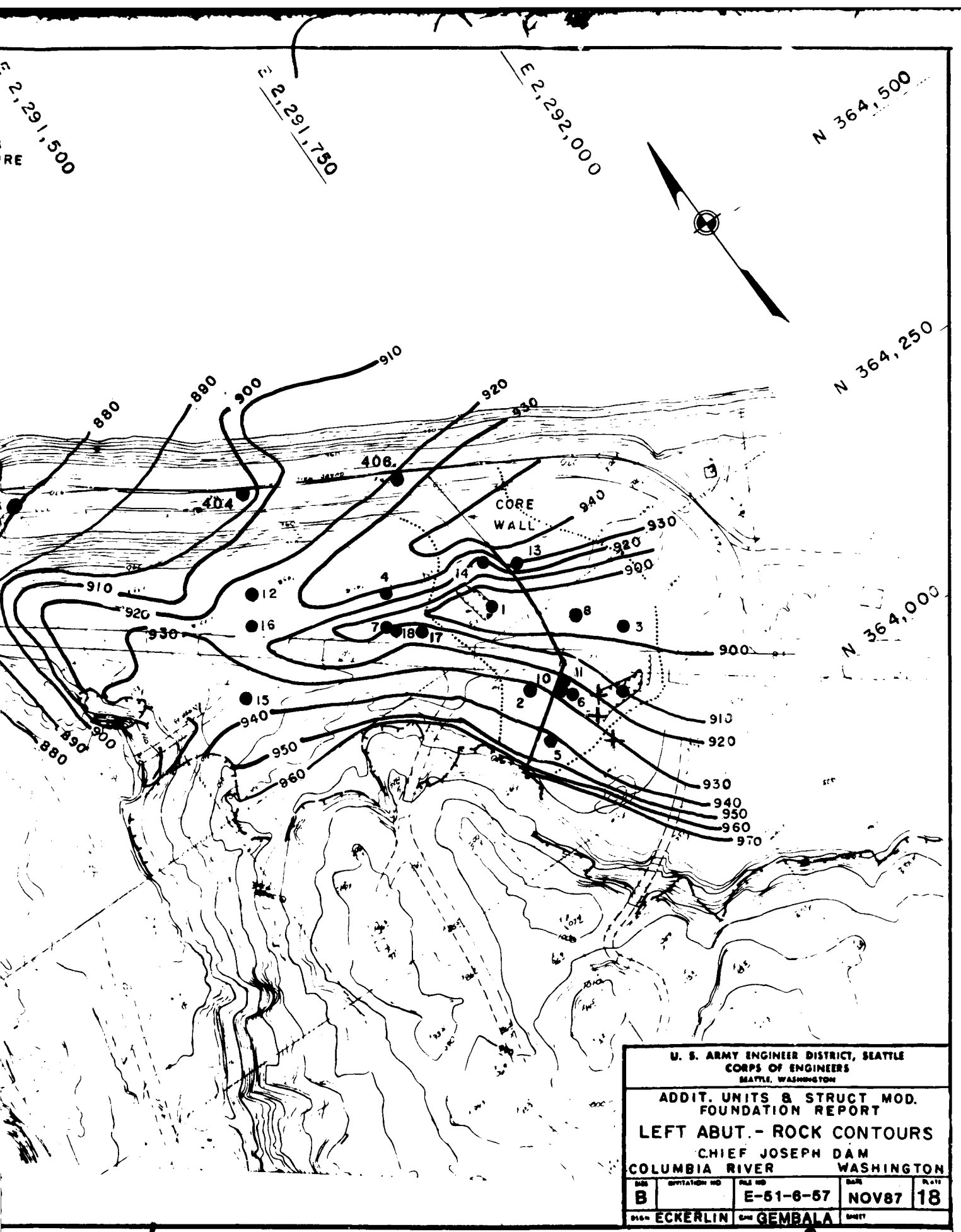
ADDITIONAL UNITS & STRUCTURAL MODIFICATION
FOUNDATION REPORT

SPILLWAY (RIGHT) GEOLOGIC PLAN

CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE	PLATE
D		E-51-6-57	NOV. 1967	17
DSGN ECKERLIN		CHK GEMBALA	SHEET	


E 2,291,500
INTAKE STRUCTURE
870
820
830
840
850
860
880
890
900
910
920
930
940
408
409
401
401A
404
LEGEND
BEDROCK OUTCROP
SUBSIDENCE SCARPS OR OUTLINE OF DEPRESSION
LIMIT OF CORE WALL EXCAVATION 1.5:1 SLOPE
SETTLEMENT MONUMENT
PIEZOMETER WITH NUMBER
5
ROCK CONTOUR
900
NOTE:
ROCK CONTOURS BASED ON PHOTOGRAPHIC FOUNDATION EXCAVATION AND EXPLORATORY DRILLING
0 100 200 300 FEET
SCALE IN FEET



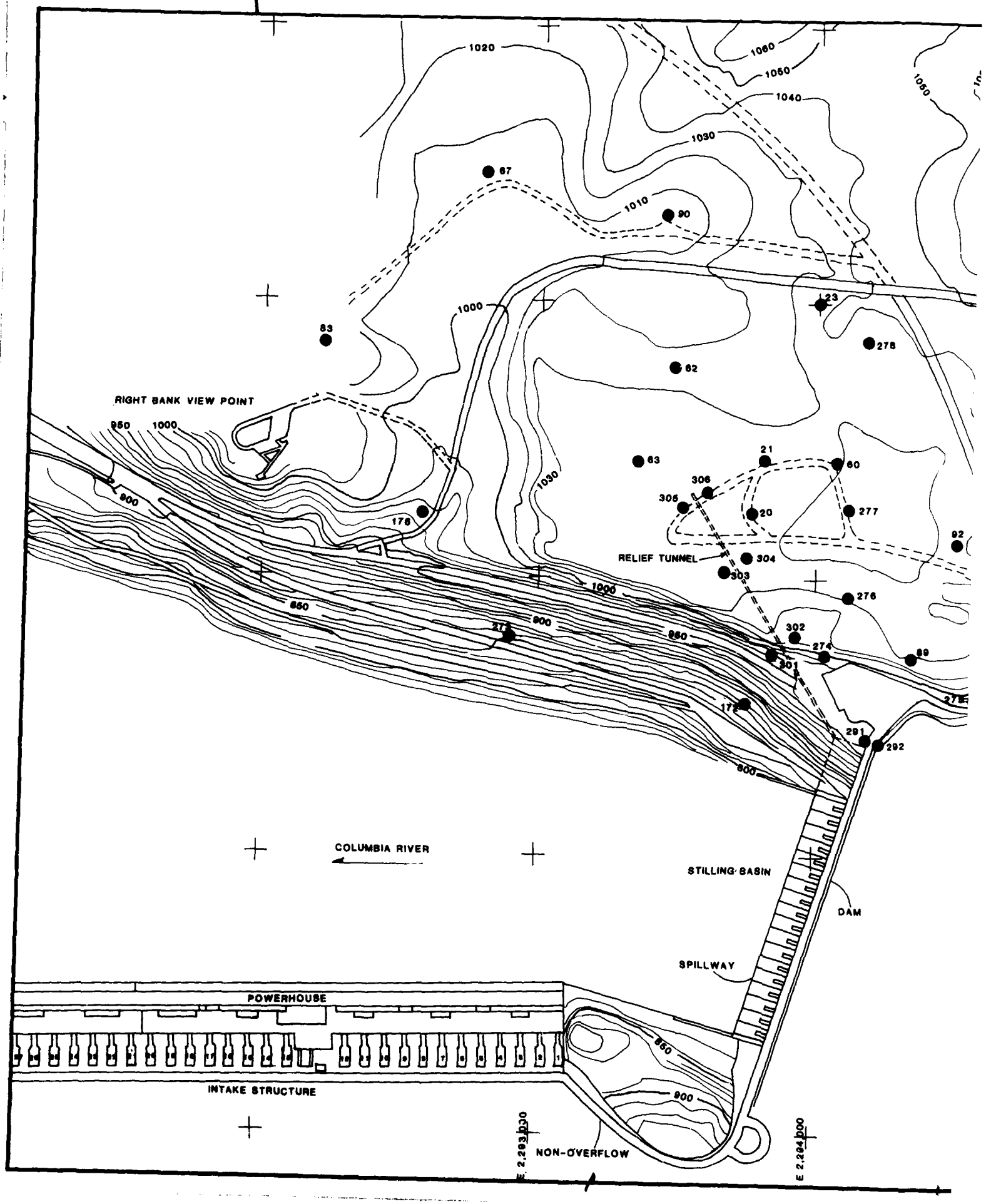
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

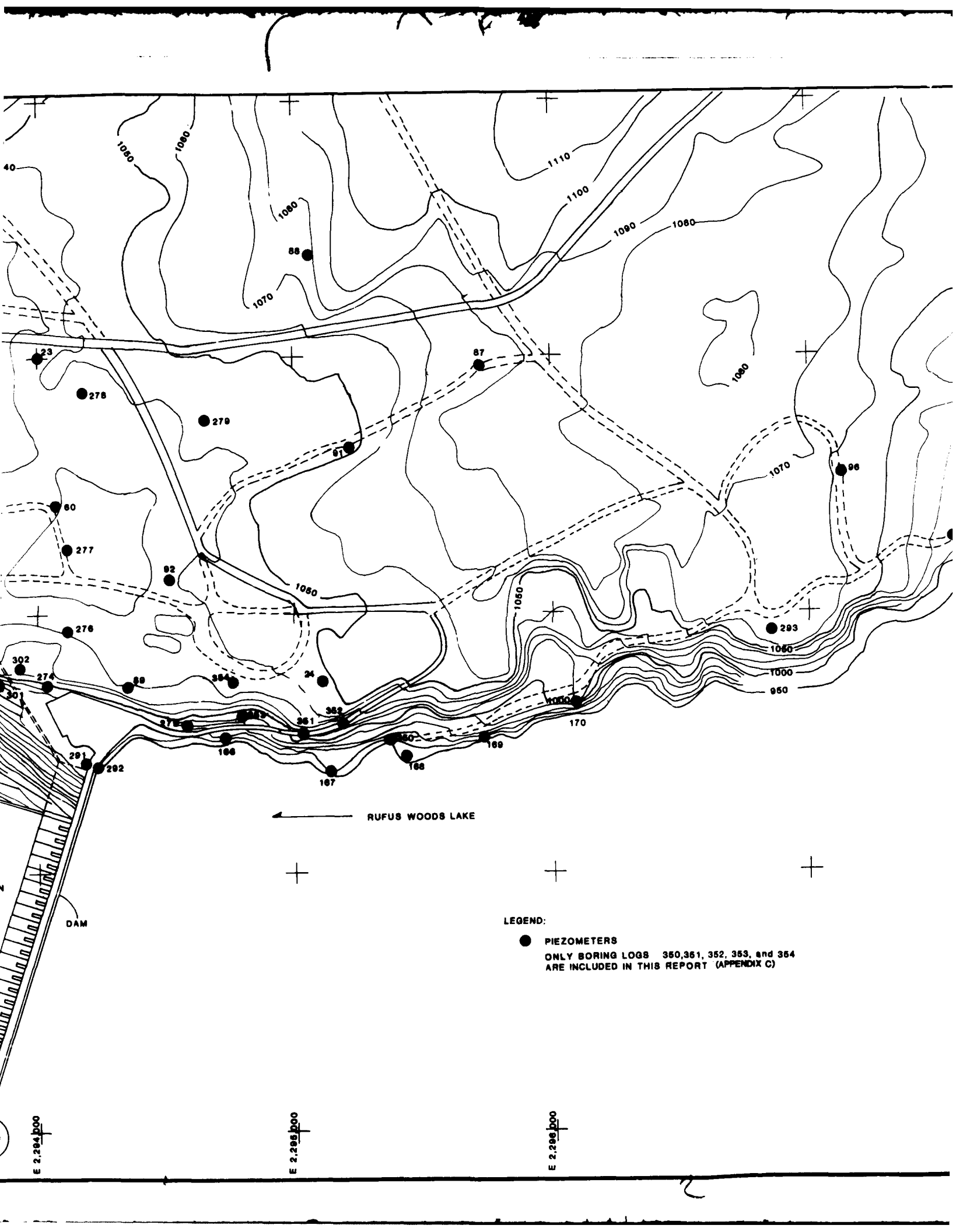
ADDIT. UNITS & STRUCT MOD.
FOUNDATION REPORT

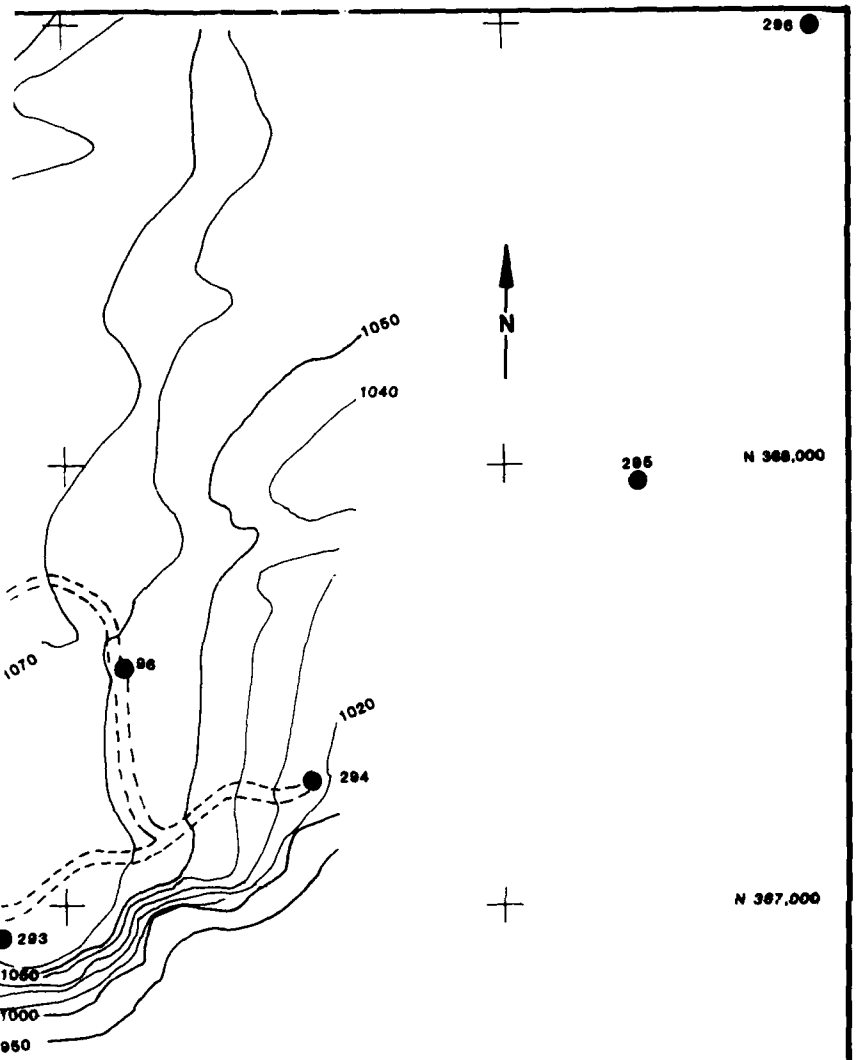
LEFT ABUT. - ROCK CONTOURS

CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

DWG	DOCUMENTATION NO	FILE NO	DATE	PLATE
B		E-51-6-57	NOV87	18
DSGN ECKERLIN	DWN GEMBALA	CHKD	SHEET	


1020
1060
1050
1040
1030
1010
1000
1030
1050
87
90
83
23
278
62
RIGHT BANK VIEW POINT
950
1000
900
176
63
21
60
306
305
20
277
92
RELIEF TUNNEL
304
303
1000
850
900
276
302
274
89
301
176
291
292
800
COLUMBIA RIVER
STILLING BASIN
DAM
SPILLWAY
POWERHOUSE
850
900
INTAKE STRUCTURE
NON-OVERFLOW
E 2,293,000
E 2,294,000


1050
1080
1110
1100
1090
1080
1070
1080
1070
1050
1050
1000
950
1000
88
23
278
279
87
61
96
60
277
92
276
293
302
274
301
89
354
24
275
361
352
170
169
166
291
292
167
168
RUFUS WOODS LAKE
DAM
LEGEND:
PIEZOMETERS
ONLY BORING LOGS 350,351, 352, 353, and 354
ARE INCLUDED IN THIS REPORT (APPENDIX C)
E 2,294,000
E 2,296,000
E 2,298,000



200' 0 200' 400'

SCALE IN FEET

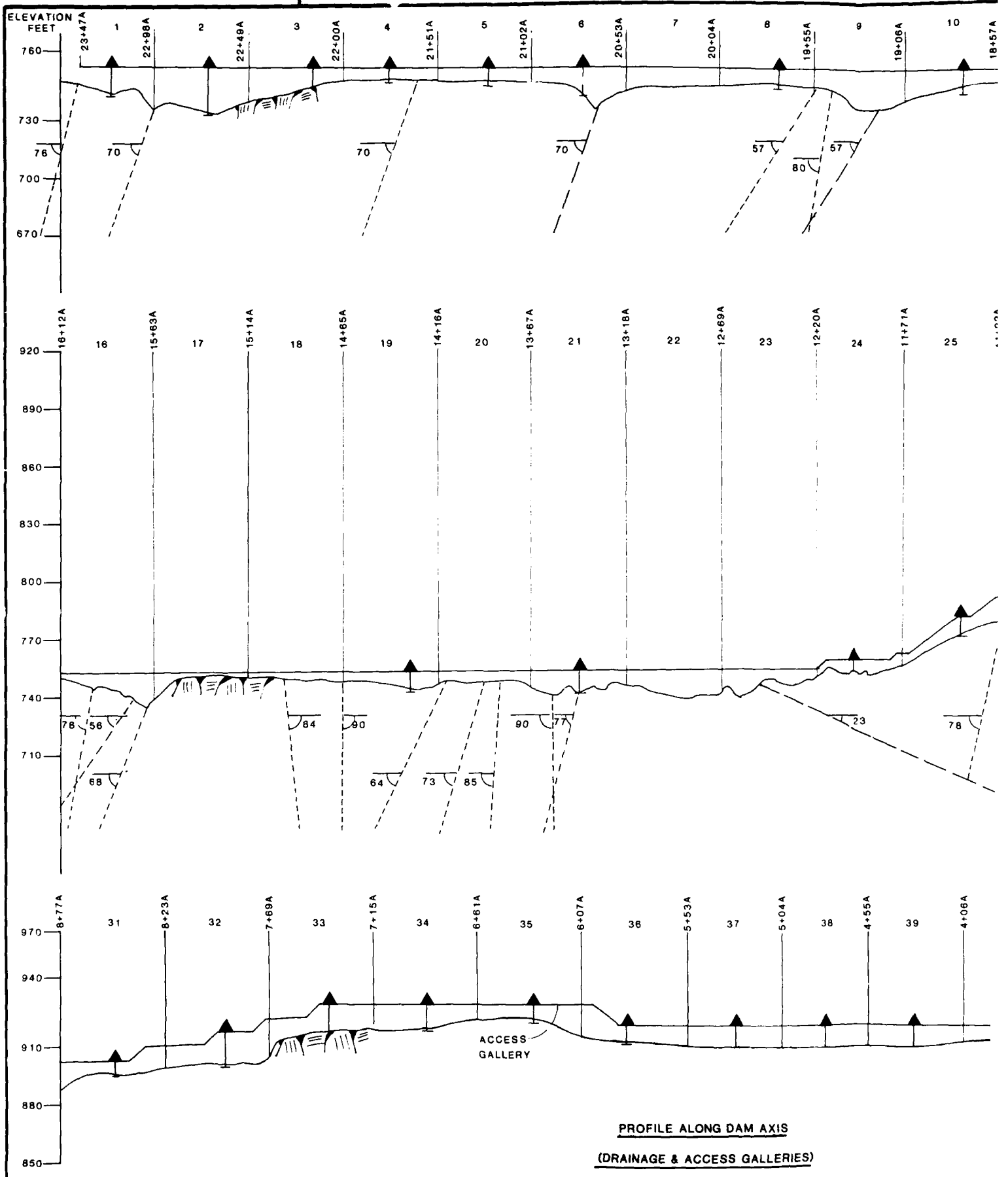
U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

ADDITIONAL UNITS AND STRUCTURAL MODIFICATION
FOUNDATION REPORT

RIGHT ABUTMENT PIEZOMETERS

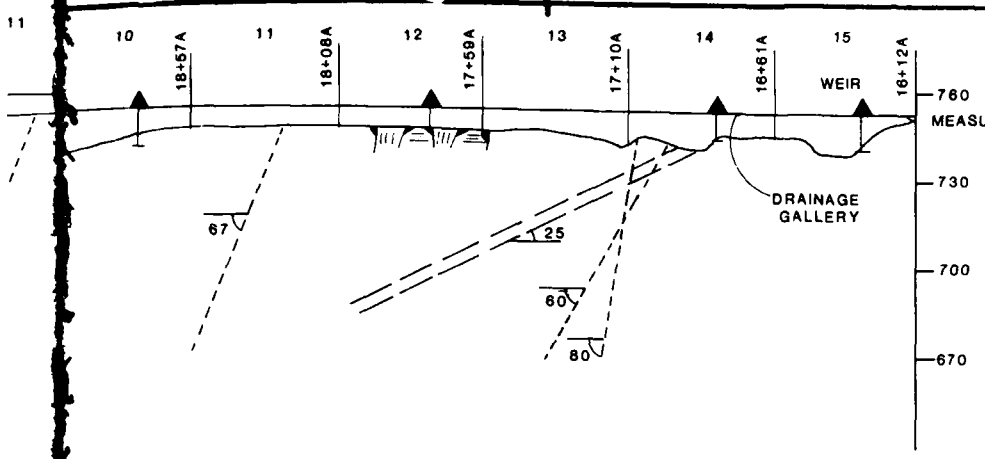
CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

SHEET	DIVISION NO.	FILE NO.	DATE	PLATE
D		E 51-6-57	NOV. 1967	19
DESIGNED ECKERLIN		CHK. GEMBALA	DRAWN	

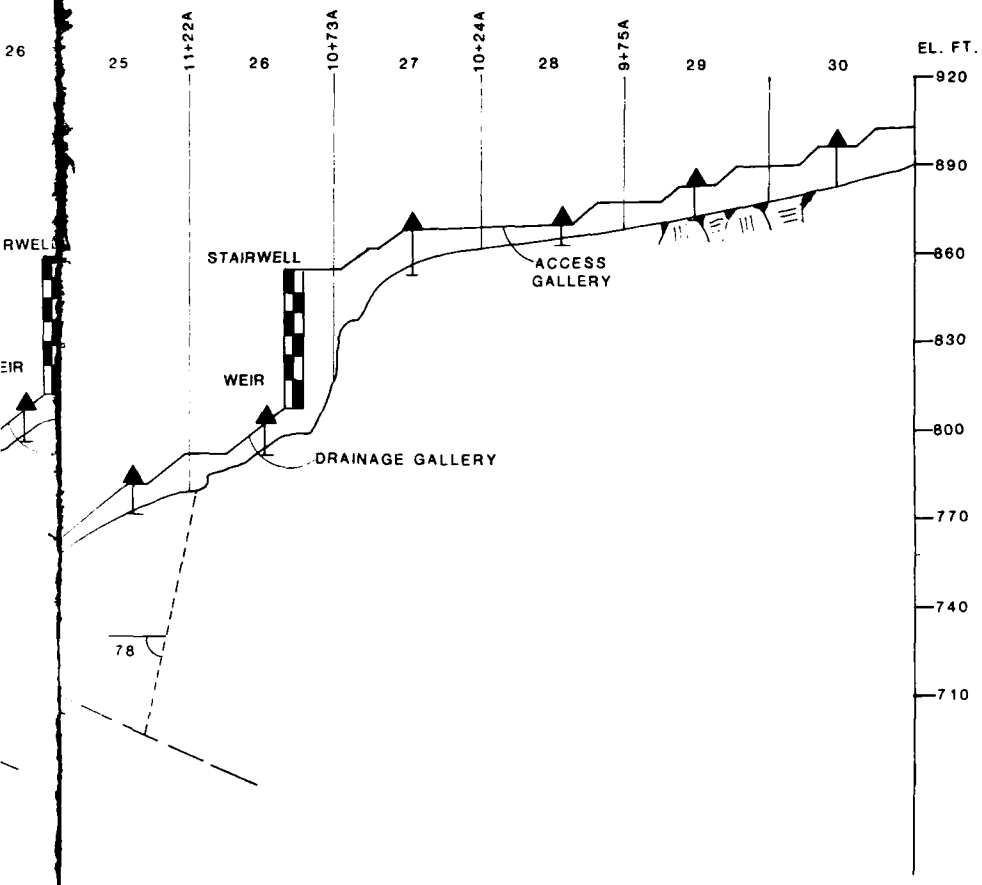


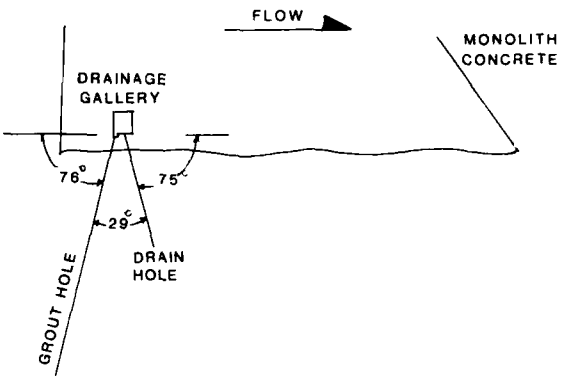
PROFILE ALONG DAM AXIS

(DRAINAGE & ACCESS GALLERIES)

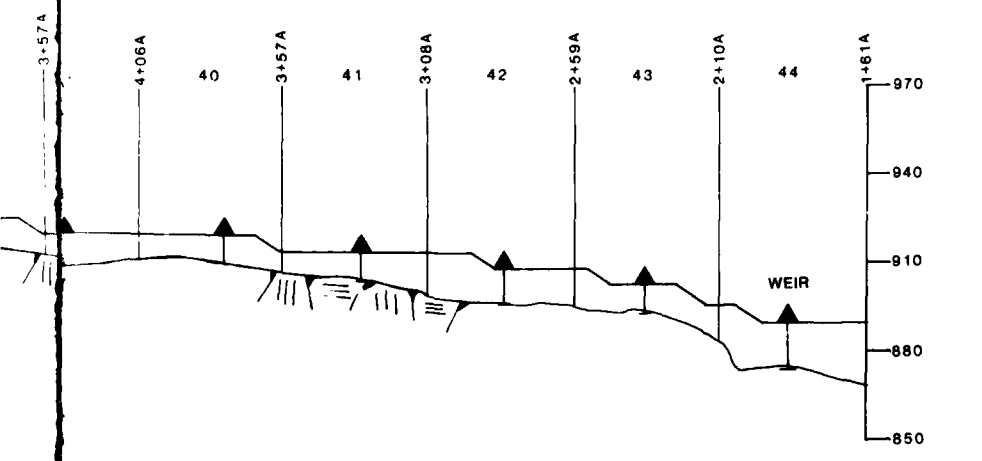


MAIN DAM





TYPICAL GROUT AND DRAIN HOLE RELATIONSHIP



▲ UPLIFT PRESSURE CELL EX SIZE HOLE

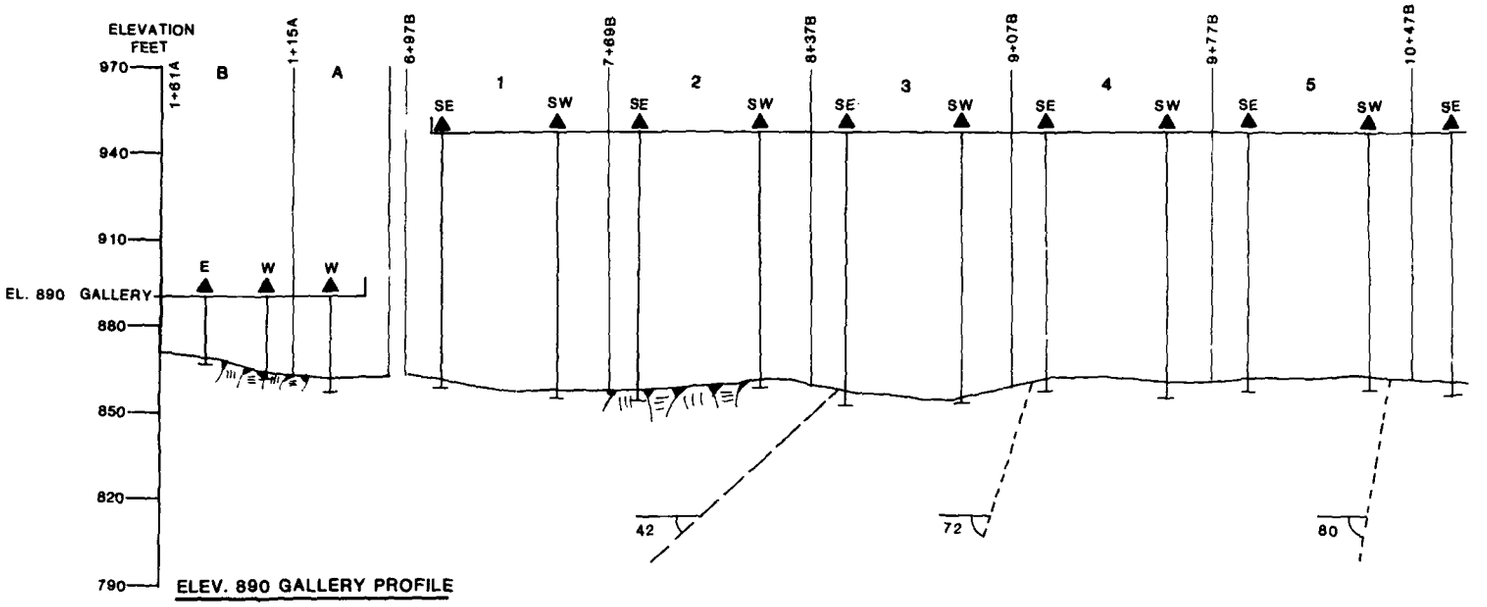
NOTE: SEE PLATE 21 FOR LEGEND.

SCALE IN FEET

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

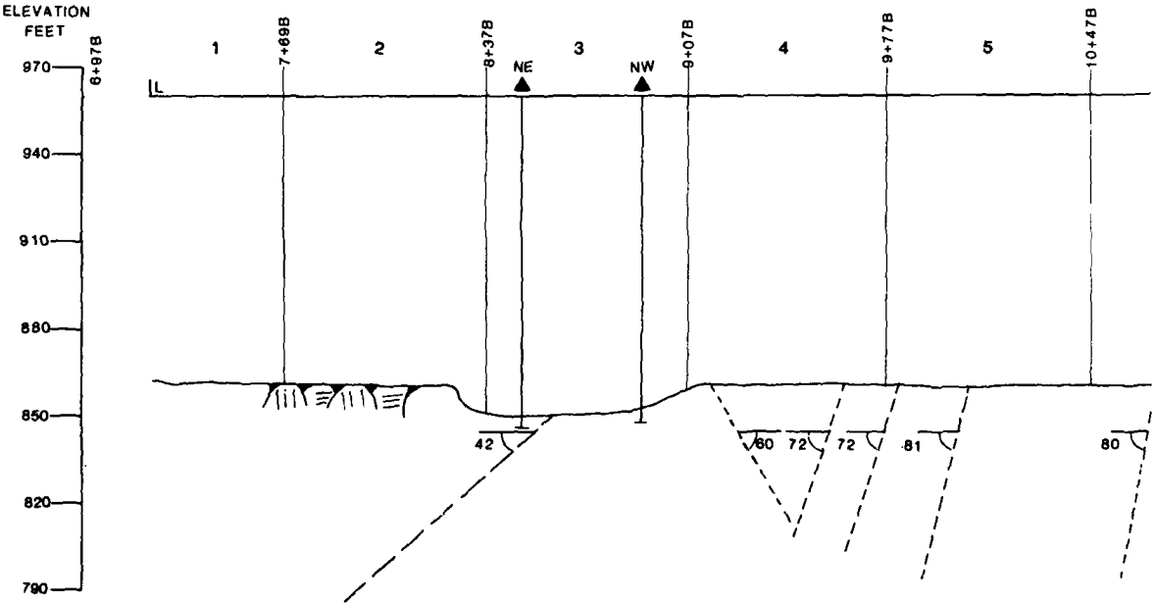
ADDITIONAL UNITS AND STRUCTURAL MODIFICATION
FOUNDATION REPORT
MAIN DAM PROFILE OF DRAINAGE AND ACCESS GALLERIES
CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

SIZE	INVITATION NO	FILE NO	DATE	PLATE
D		E 51-6-57	NOV. 1987	20
DSGN ECKERLIN	CHK GEMBALA	SHEET		

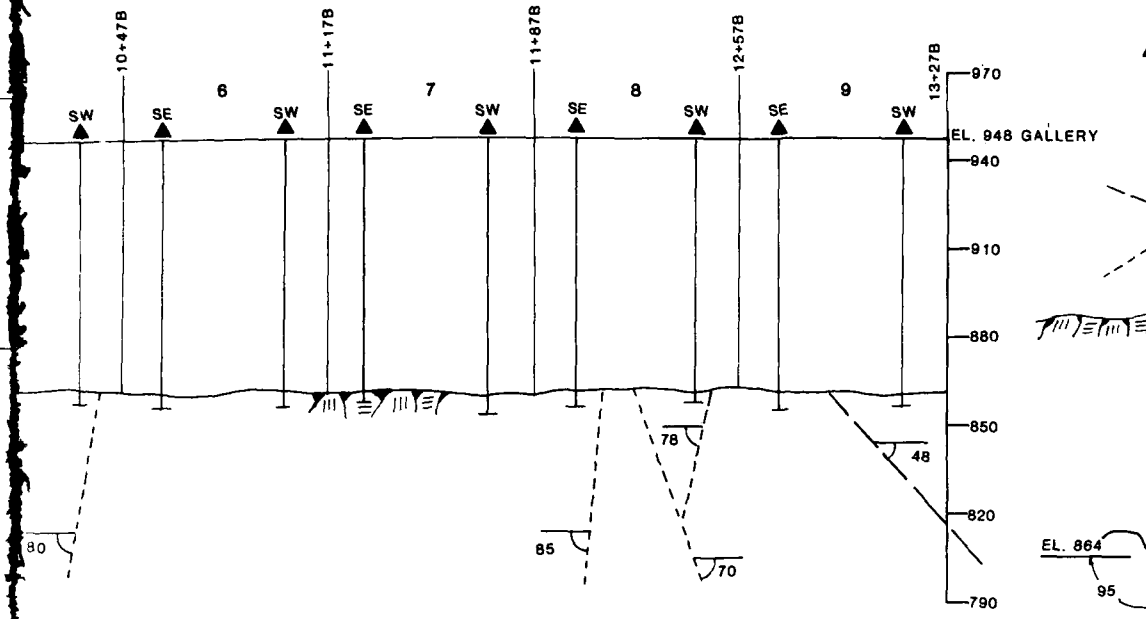


ELEV. 890 GALLERY PROFILE

ELEV. 948 GALLERY PROI



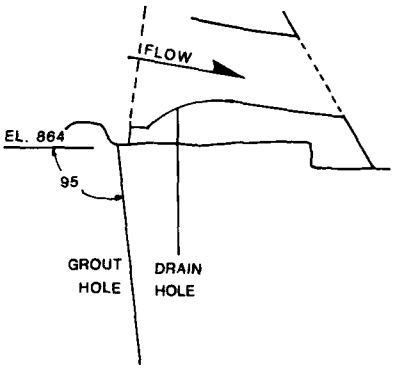
ELEV. 960.75 GALLERY



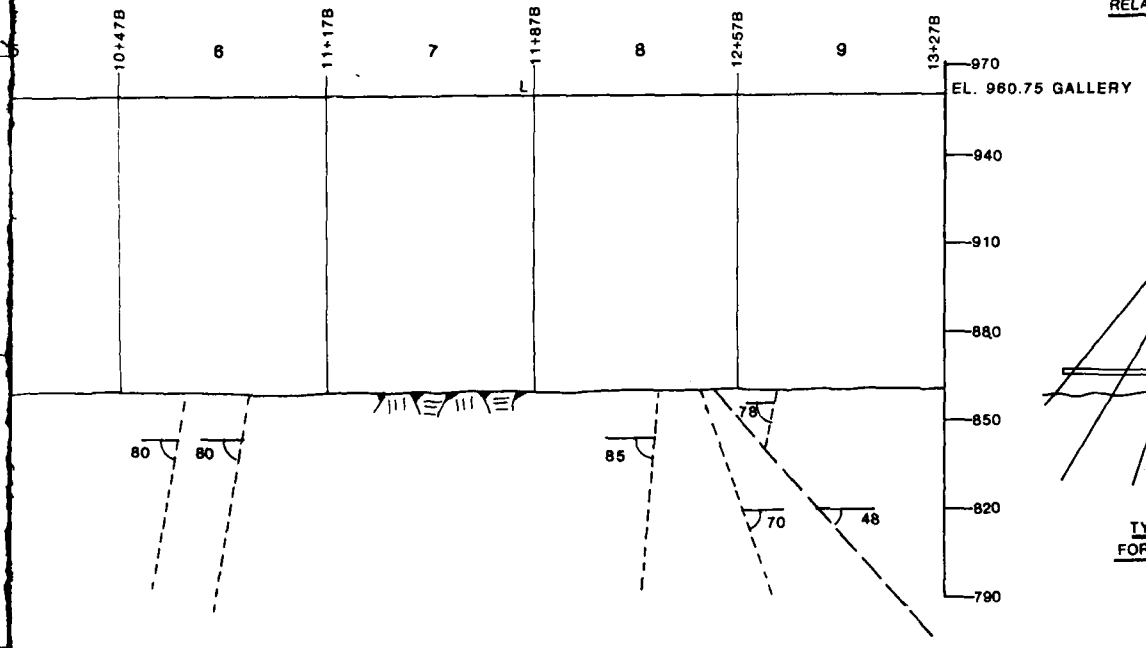
8 GALLERY PROFILE

LEGEND:

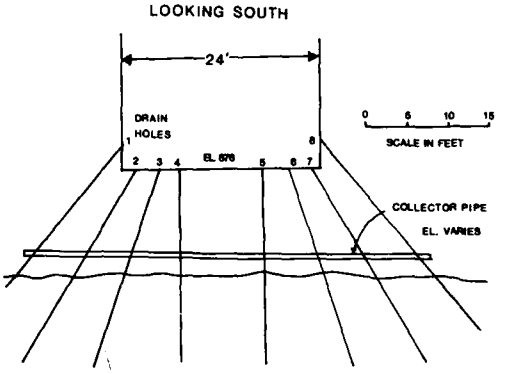
- ▲ UPLIFT PRESSURE CELL -DESIGNATED BY MONOLITH NUMBER AND DIRECTIONAL LOCATION (SE - SOUTHEAST)
- L LASER STATION
- MAJOR FAULT SHOWING DEGREE OF DIP
- MINOR FAULT SHOWING DEGREE OF DIP
- APPROXIMATE TOP OF ROCK



TYPICAL GROUT AND DRAIN HOLE RELATIONSHIP FOR INTAKE MONOLITHS 1 THROUGH 9



960.75 GALLERY PROFILE



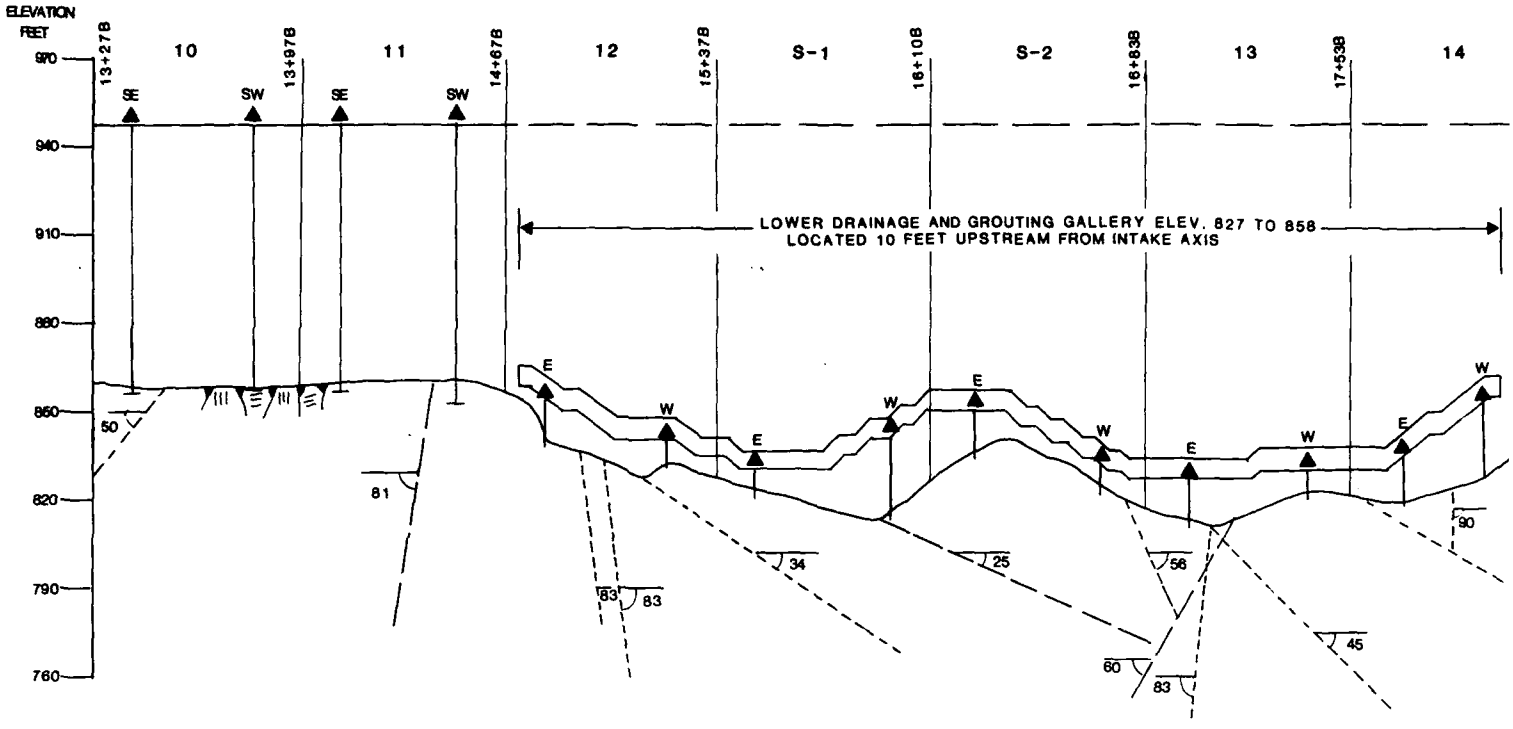
TYPICAL DRAIN HOLE CONFIGURATION FOR INTAKE MONOLITHS 1 THROUGH 9

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

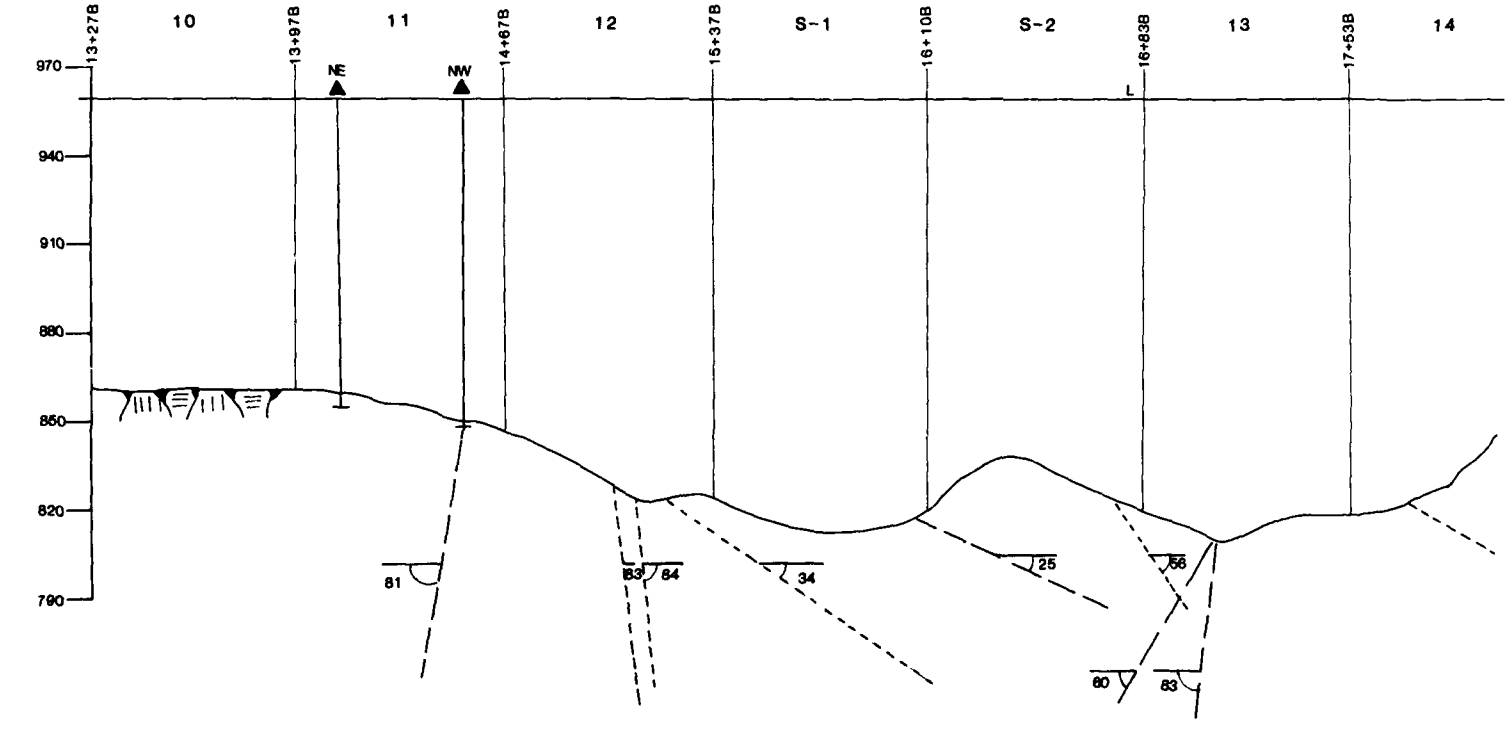
ADDITIONAL UNITS AND STRUCTURAL MODIFICATION
FOUNDATION REPORT

INTAKE MONOLITHS 1 - 9
GALLERY PROFILES
CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

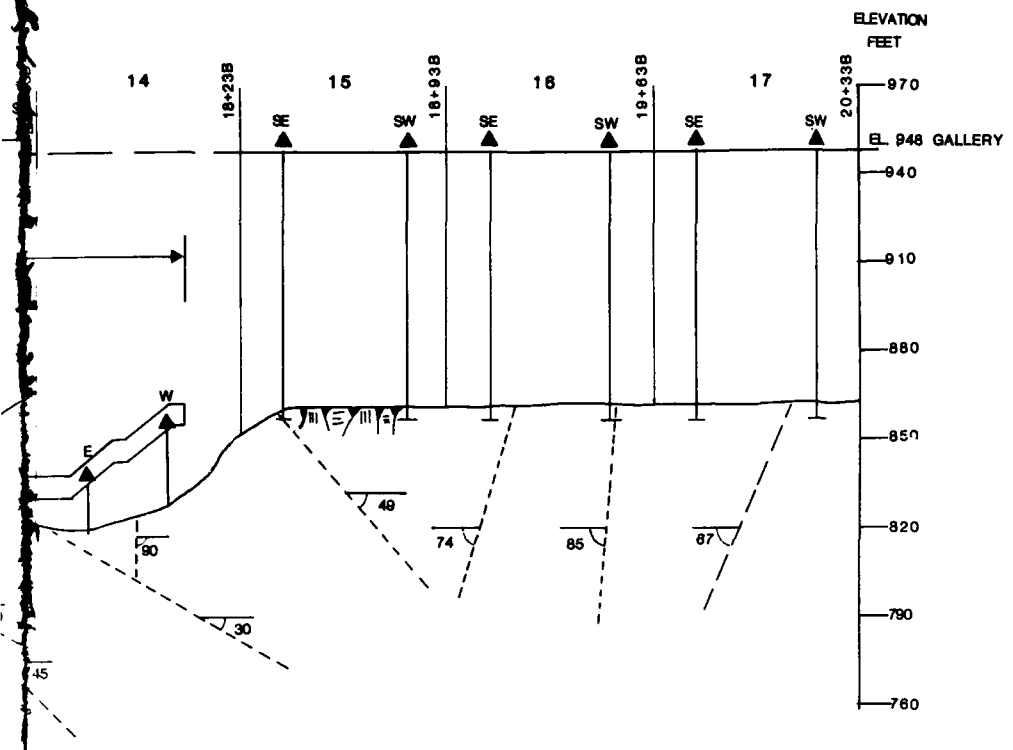
SIZE	INVITATION NO	FILE NO	DATE	PLATE
D		E 51-6-57	NOV. 1987	21
DSGN ECKERLIN		CHK GEMBALA	SHEET	

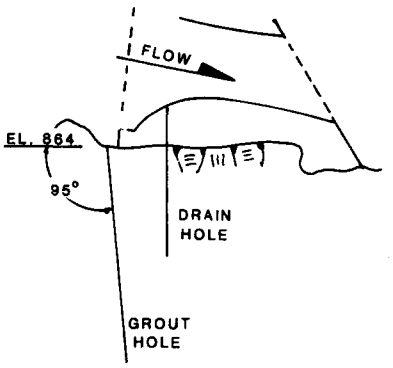


ELEV. 948 GALLERY PROFILE



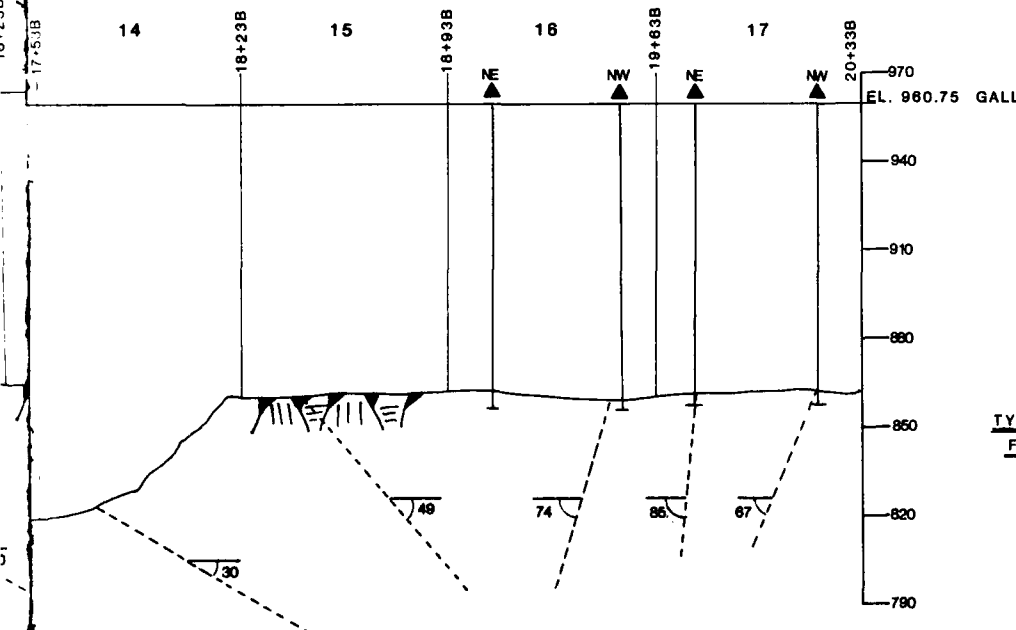
ELEV. 960.75 GALLERY PROFIL

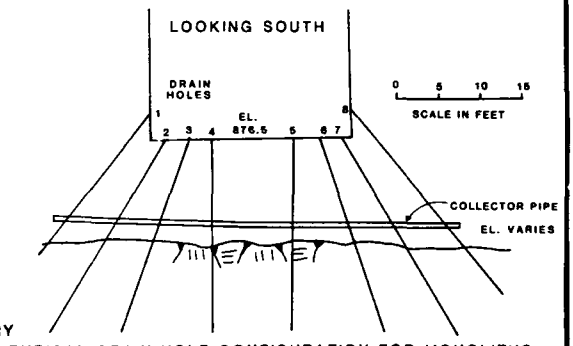




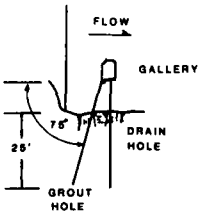
TYPICAL GROUT AND DRAIN HOLE RELATIONSHIP
FOR MONOLITHS 10, 11, 15, 16, AND 17

OFILE

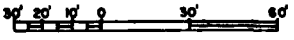




TYPICAL DRAIN HOLE CONFIGURATION FOR MONOLITHS
10, 11, 15, 16, AND 17



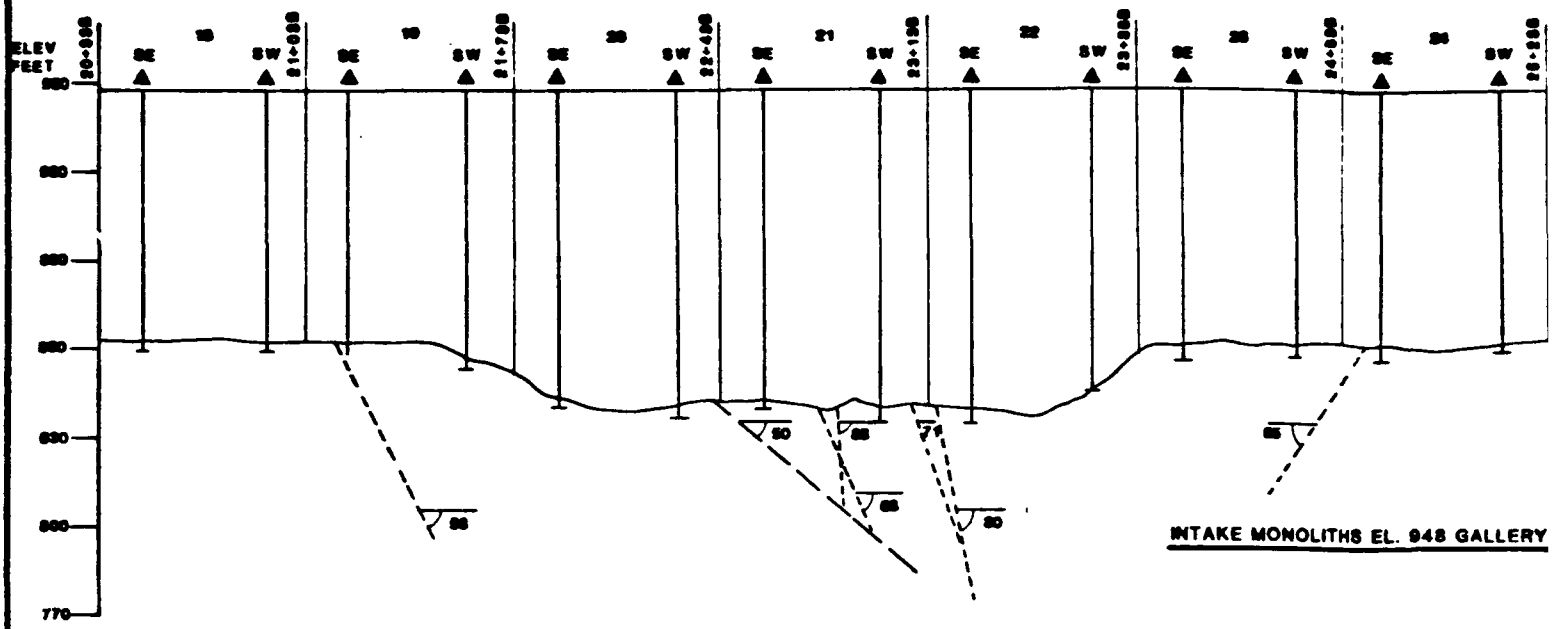
TYPICAL GROUT AND DRAIN HOLE RELATIONSHIP
FOR MONOLITHS 12, S-1, S-2, 13, and 14

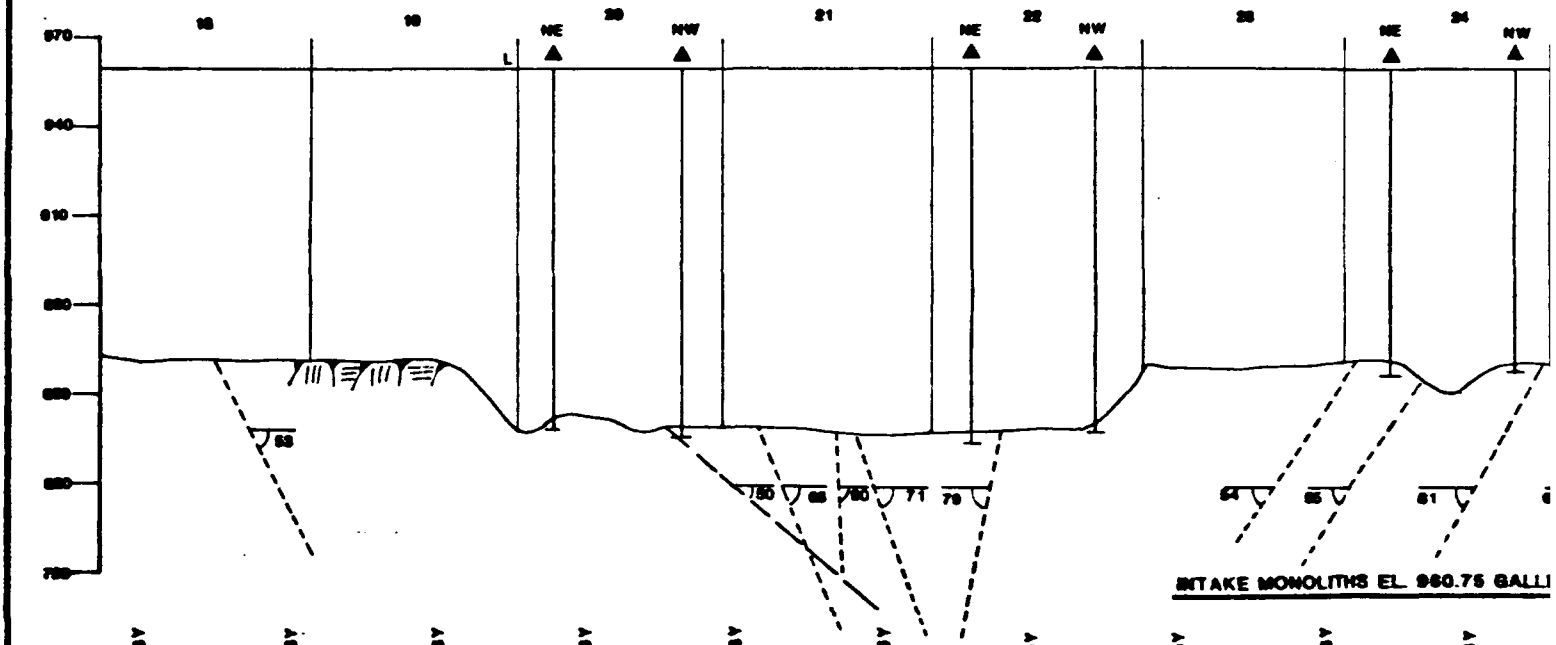


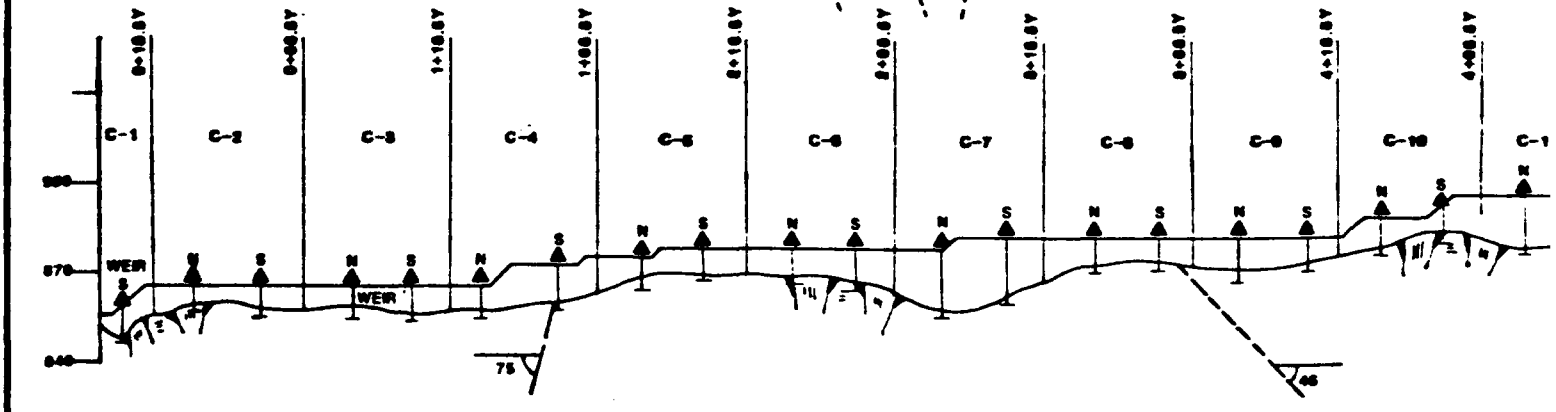
LLERY PROFILE

NOTE: SEE PLATE 21 FOR LEGEND

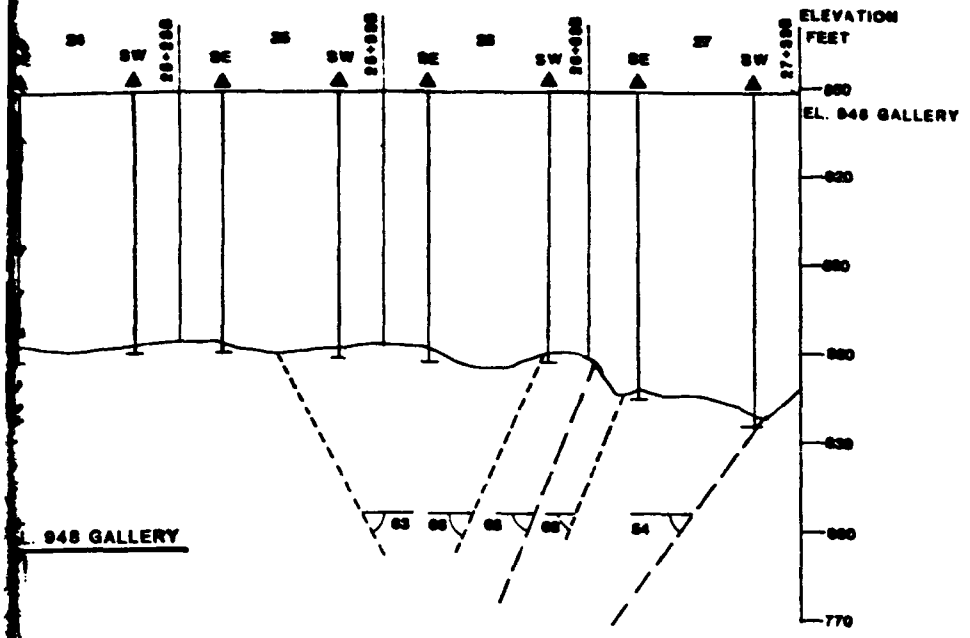
U. S. ARMY ENGINEER DISTRICT, SEATTLE CORPS OF ENGINEERS SEATTLE, WASHINGTON	
ADDITIONAL UNITS AND STRUCTURAL MODIFICATION FOUNDATION REPORT INTAKE MONOLITHS 10-17 GALLERY PROFILES CHIEF JOSEPH DAM COLUMBIA RIVER WASHINGTON	
SIZE D / INVITATION NO / FILE NO E 51-6-57 / DATE NOV. 1987	PLATE 22
DSGN ECKERLIN / CHK GEMBALA	SHEET

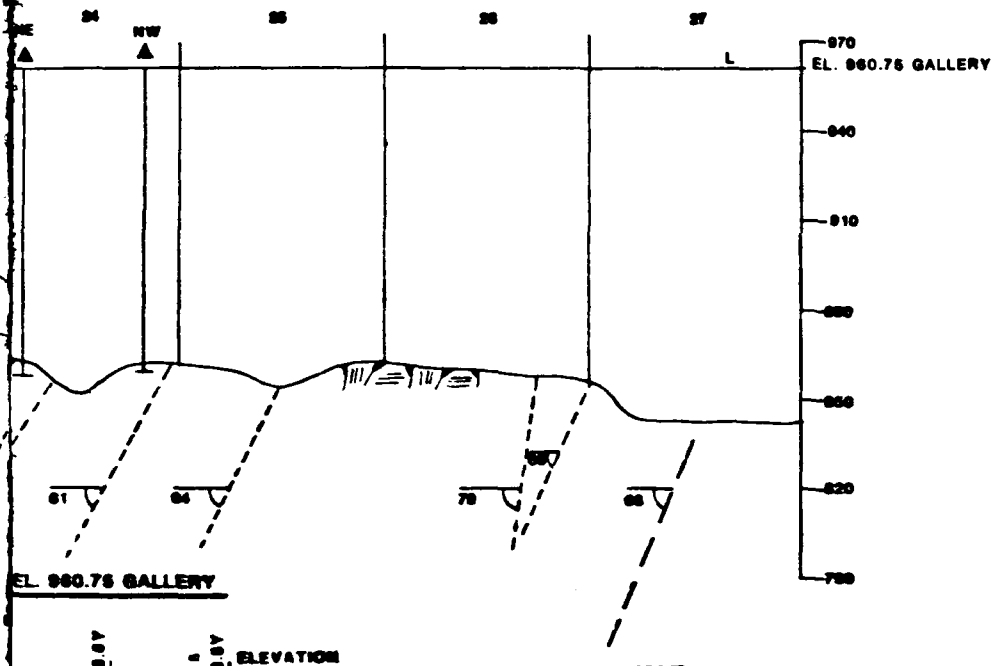


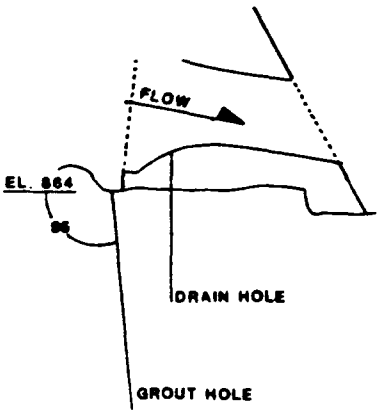




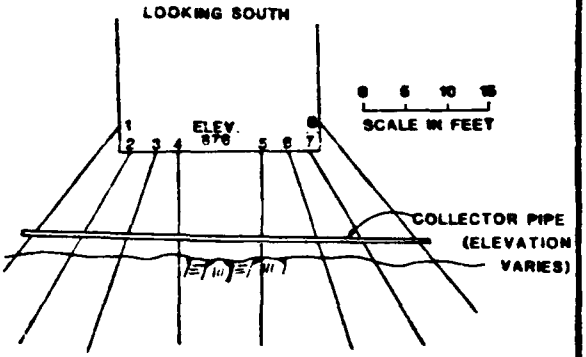
INTAKE CLOSURE MONOLITHS



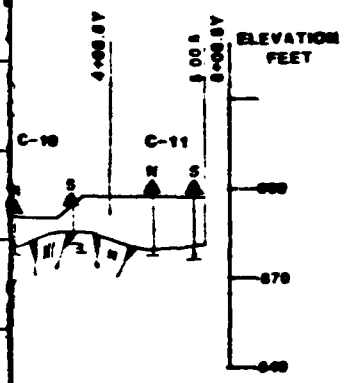


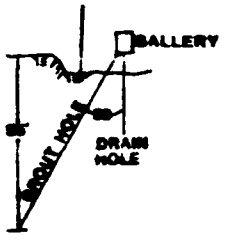


TYPICAL GROUT AND DRAIN HOLE RELATIONSHIP FOR INTAKE MONOLITHS 18 THROUGH 27



TYPICAL DRAIN HOLE CONFIGURATION FOR INTAKE MONOLITHS 18 THROUGH 27





TYPICAL GROUT AND DRAIN RELATIONSHIP FOR CLOSURE SECTION

LEGEND

SE ▲ UPLIFT PRESSURE CELL - DESIGNATED BY MONOLITH NUMBER AND DIRECTIONAL LOCATION (SE - SOUTHEAST)

MAJOR FAULT SHOWING DEGREE OF DIP

MINOR FAULT SHOWING DEGREE OF DIP

APPROXIMATE TOP OF ROCK

L LASER STATION

SCALE IN FEET

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

ADDITIONAL UNITS AND STRUCTURAL MODIFICATION
FOUNDATION REPORT
INTAKE MONOLITHS 18 - 27 AND CLOSURE WALL GALLERY PROFILES
CHIEF JOSEPH DAM
COLUMBIA RIVER WASHINGTON

SIZE	INVITATION NO	FILE NO	DATE	PLATE
D		E 51-6-67	NOV. 1967	23
DESIGN GOSELIN		CHK GEMBALA	SHEET	

APPENDIX B

CONSTRUCTION PHOTOGRAPHS

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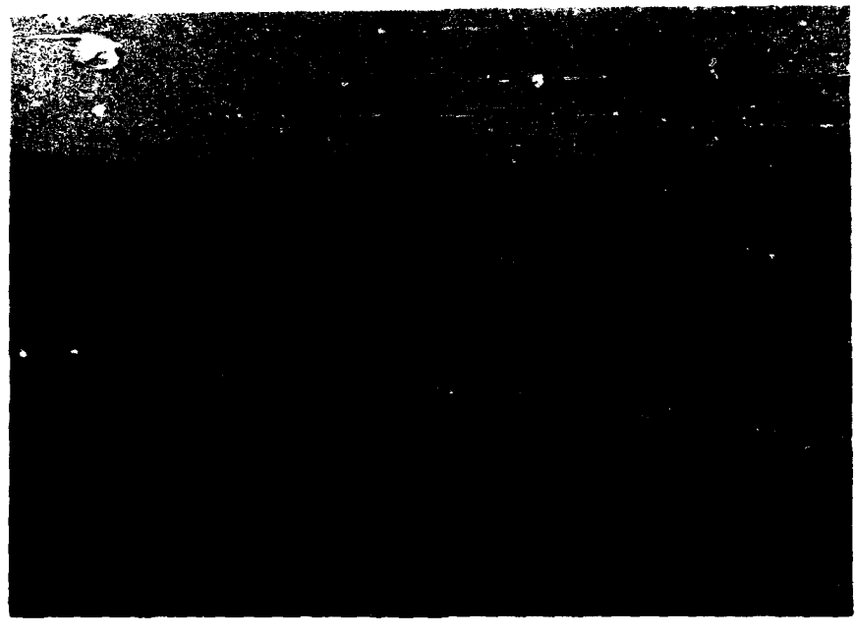
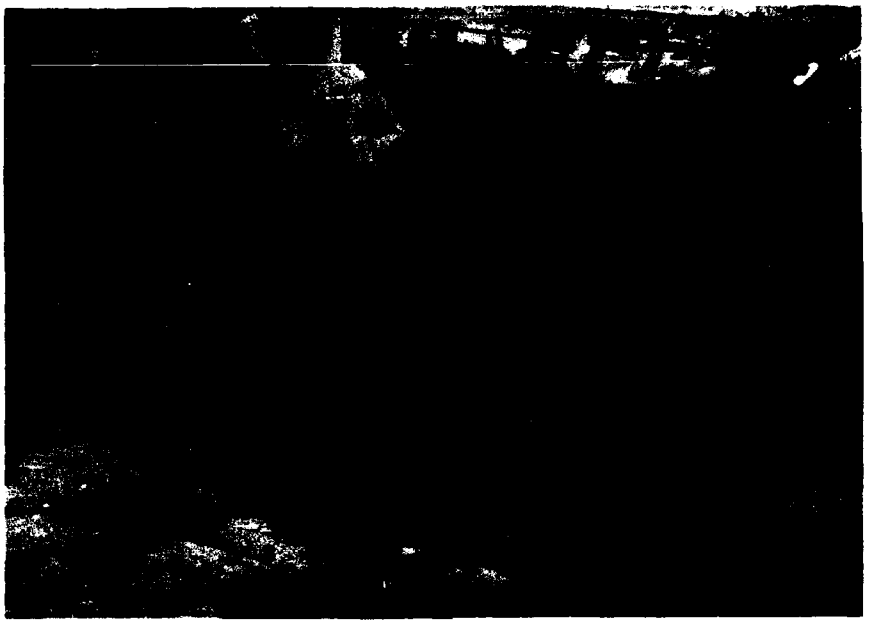


Penstock openings prior to additional units construction (Aug. 1974)

Cofferdam enclosure looking downstream (Feb. 1976)

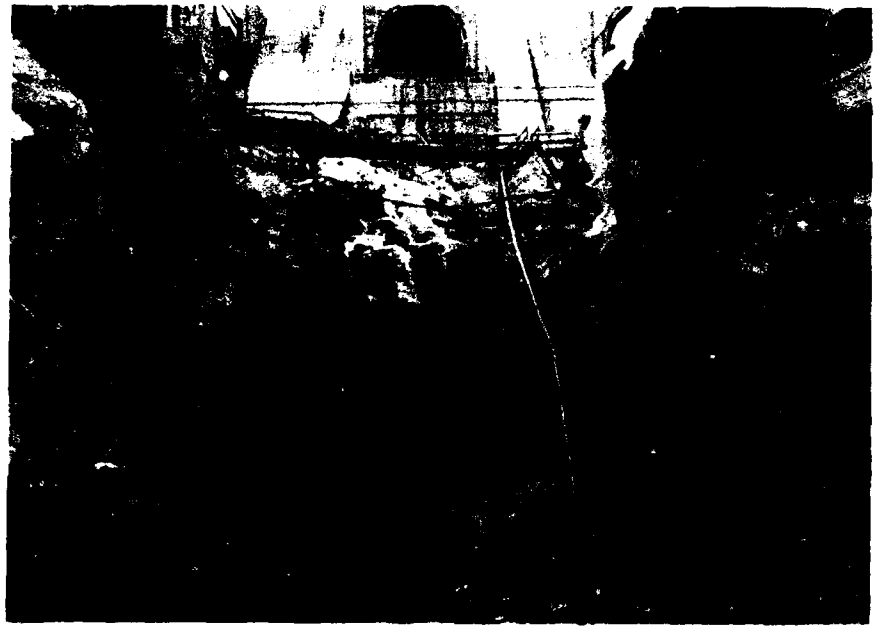
View of west side of penstock slot 21 showing service deck pier resting on old bridge abutment concrete. (Feb.76)

Clean-up in progress for powerhouse bay 21 (Feb. 76)



West side of penstock slot 22 (Feb. 76)

East side of penstock slot 22 (Feb. 76)



Penstock slot 22 (Feb. 76)

Penstock slot 23 (Feb. 76)

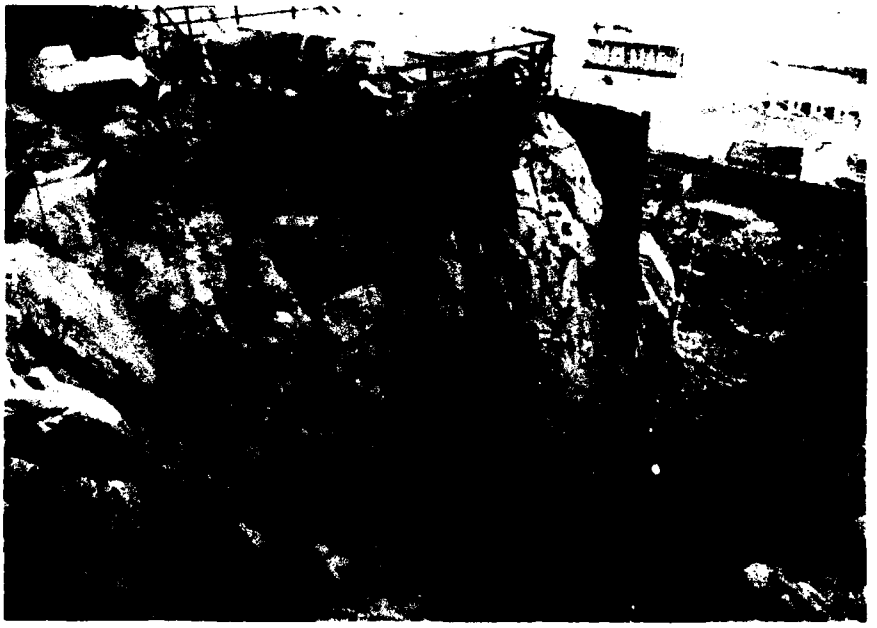
East of side penstock slot 23 (Feb. 76)

East side of penstock slot 23 showing service deck concrete forms (Feb. 76)

East side of penstock slot 24 (Nov. 75)

East side of penstock slot 24 showing service bridge pier forms (Feb. 76)

East side of penstock slot 24 (Feb. 76)



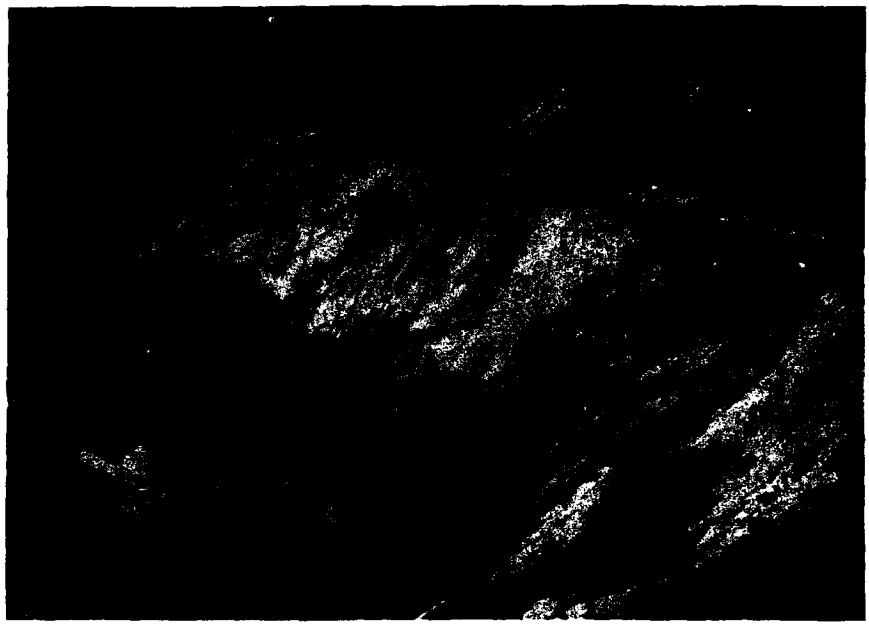
West side of penstock slot 24 (Feb. 76)

East side of penstock slot 25 (Nov. 75)

East side of penstock slot 25 showing service deck and pier forms (Feb. 75)

West side of penstock slot 25 (Feb. 76)

Penstock slot 25 (Feb. 76)



East side of penstock slot 26 (Nov. 75)

East side of penstock slot 26 showing service bridge pier forms (Feb. 76)

West side of penstock 26 (Nov. 75)

West side of penstock 26 showing service deck concrete piers (Feb. 76)

Penstock slot 26 (Feb. 76)

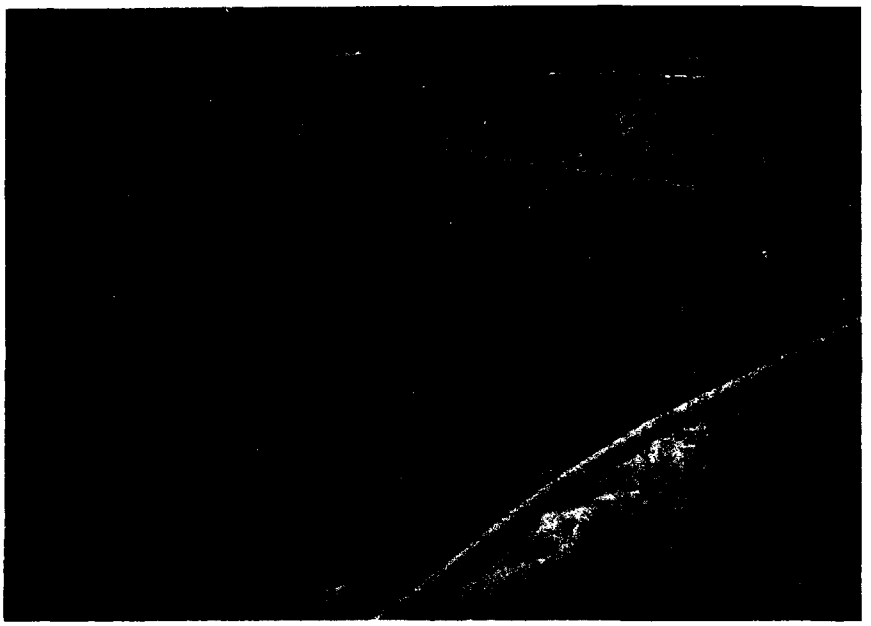
Penstock slots 26 and 27 (July 76)

Penstock slots 24-27 (right to left) showing service bridge pier forms (Feb. 76)

Penstock slots 21-24 (right to left) showing service bridge pier forms (Feb. 76)

View looking west of service deck pier forms founded on bedrock "Dragon's Teeth" (Feb. 76)

View looking east of Dragon's Teeth and right side of penstock slot 27 in foreground (Feb. 76)



East side of penstock slot 27 (Nov. 75)

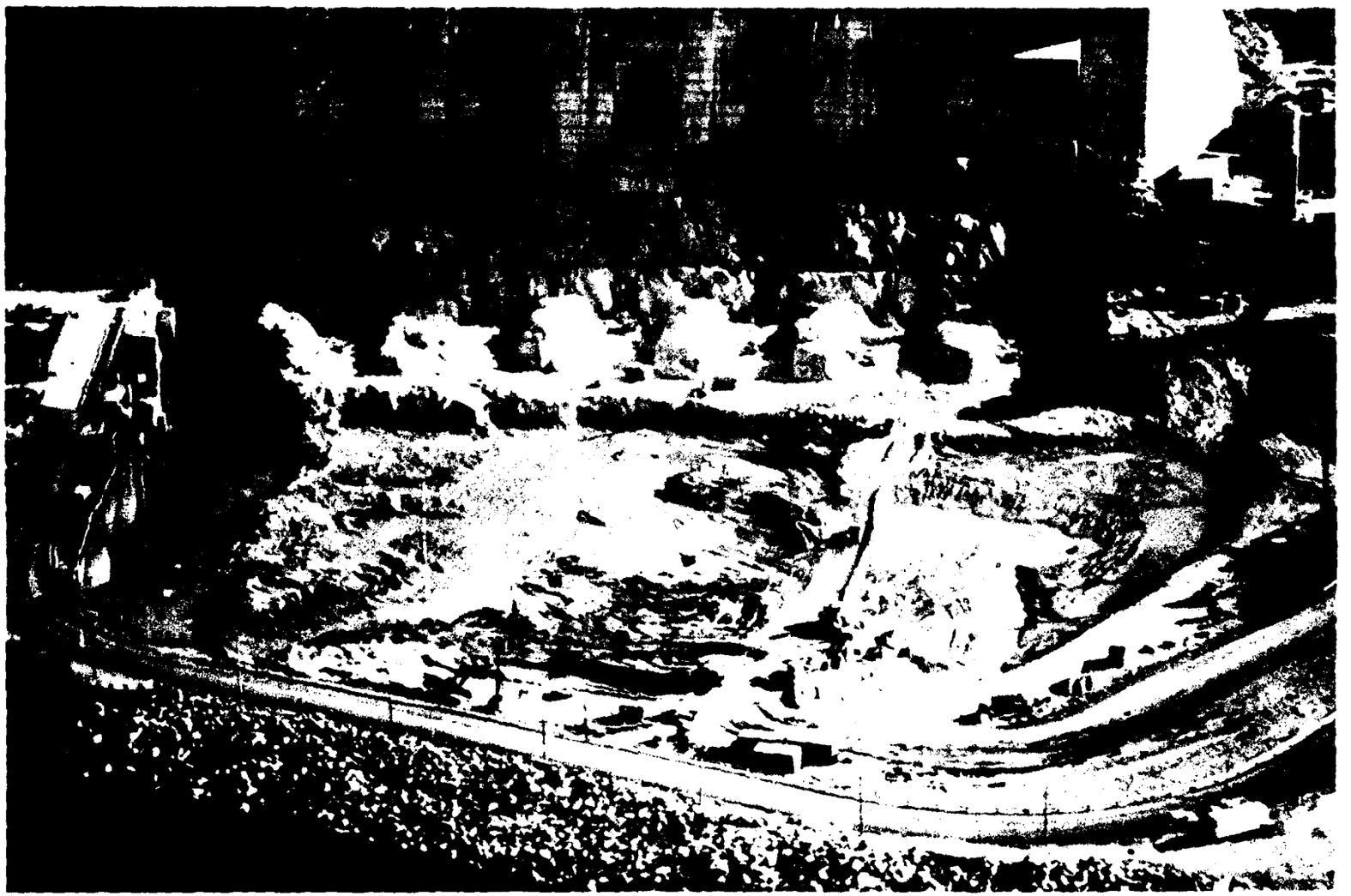
East side of penstock slot 27 showing service bridge concrete pier (Feb. 75)

West side of penstock slot 27 (Feb. 76)

Slope below intake structure at penstock slot 27 (Feb. 76)

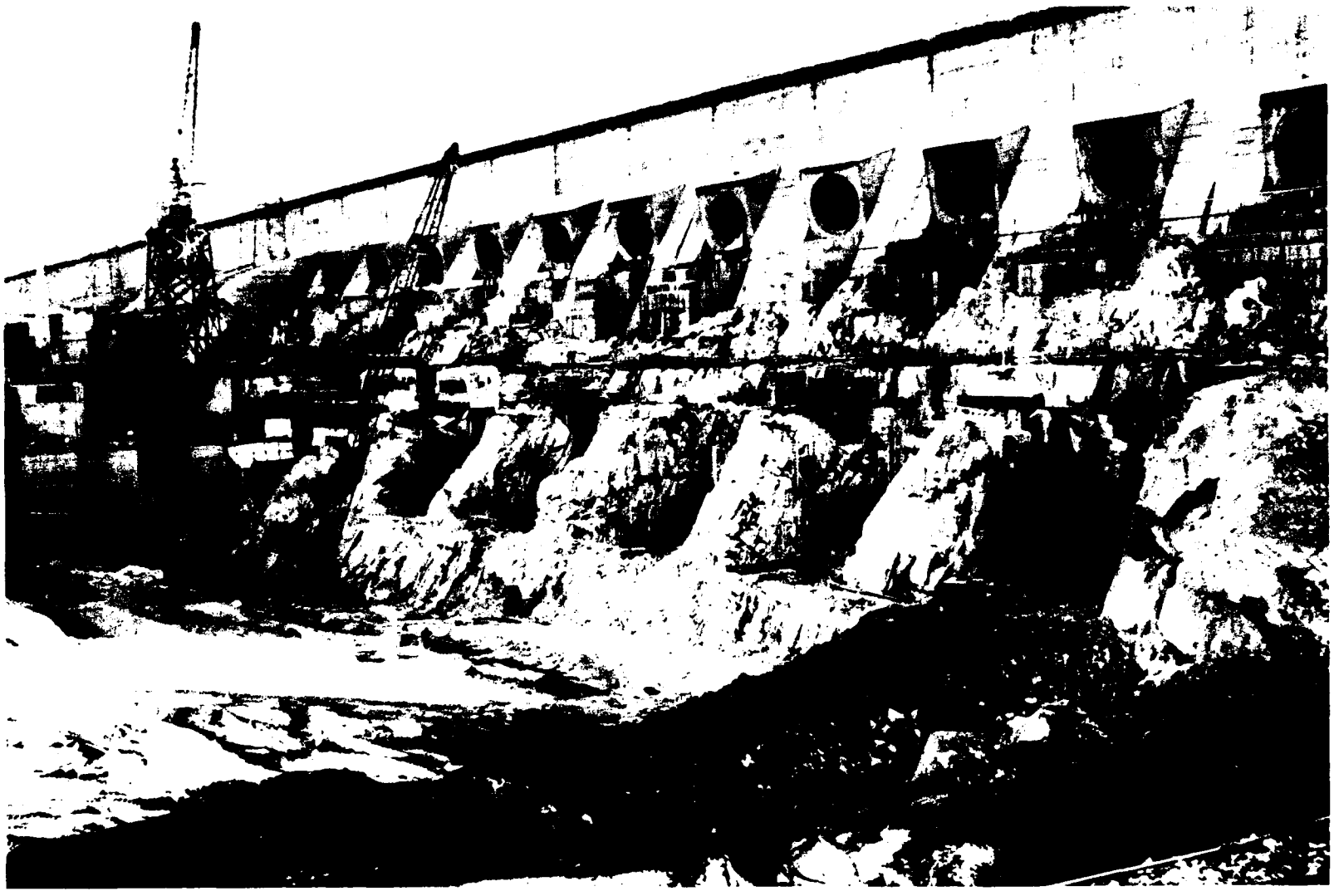
West side of penstock slot 23 (Feb. 76)

West side of penstock slot 23 (Feb. 76)
Note lamprophyre dike below forms



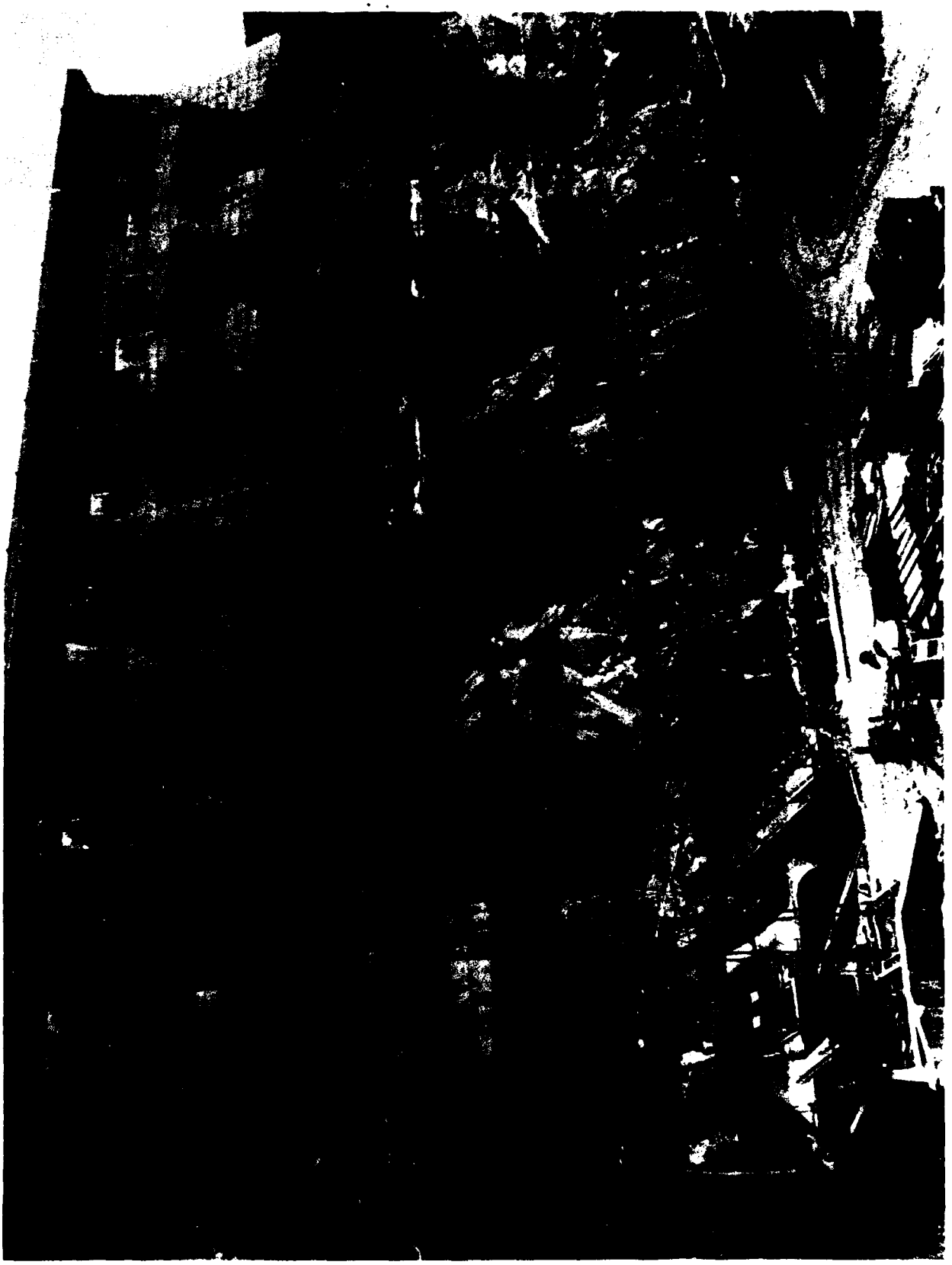
Excavation for powerhouse units 20 through 27 looking south (Sep 1975)

View looking northwest of service deck pier between units 24 and 25 (19 January 1976)



View looking east showing penstock units 21 through 27 (6 Feb 1976)

View looking south of powerhouse bays 26 and 27 (January 1976)



View looking south of service deck piers (18 Mar 76)

View looking east of powerhouse units 17 through 24 (23 Jul 76)

View looking northeast showing service deck bedrock piers 22-27 (11 December 1975)

View looking northeast showing Chief Joseph Dam and Rufus Woods Lake (20 October 1978)

APPENDIX C

FOUNDATION EXPLORATION

BORING LOGS

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 89.6 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 65.0 DATE STARTED 24 March 1967
ROCK DRILLED 24.6 DATE COMPLETED 4 April 1967
% CORE RECOVERED 100 CONTRACTOR Leaf Drilling Co.

SURFACE EL 810.4 HOLE NO 67-CD-307 N 365,909 E 2,290,995

ELEVATIONS 810.4	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
		GM		Silty Sandy GRAVEL w/numerous cobbles & boulders	6" Casing to rock
801.4	10	SP		SAND, fine, gray	
799.4		GM	I	Silty Sandy GRAVEL w/numerous cobbles & boulders	Boulder at 16' to 18' depth
	20				
785.4		GM	I	Silty Sandy GRAVEL w/occasional cobbles & boulders, gray	
	30		I		
	40		I		Water level 38.1'
	50				
754.4		SP		SAND, fine to medium, gray	
752.4	60	SP	I	SAND, fine, gray	
				Top of rock 65.0'	
745.4				GRANODIORITE, medium to coarse-grained, light-gray, hard	NX casing to 66.0'
	70			Most joints at 0.1' to 1.0' intervals w/ horizontal to 60 degree dips	No core loss 100% water return
	80				
	90				
720.8				Bottom 89.6'	

CHIEF JOSEPH DAM ___ PROJECT COLUMBIA ___ RIVER

DEPTH OF HOLE 137.6 DIAMETER OF HOLE 6"OB & NX in rock

DEPTH OF O.B. 110.0 DATE STARTED 16 March 1967

ROCK DRILLED 27.6 DATE COMPLETED 23 March 1967

% CORE RECOVERED 98.6 CONTRACTOR Leaf Drilling Co.

SURFACE EL 809.8 HOLE NO 67-CD-308 N 365,825 E 2,291,132

ELEVATIONS 809.8	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
	10	GM		Sandy Silty GRAVEL w/cobbles & boulders, gray	7" gravel road surface 6" casing to rock
	20		I		
	30		I	(decreasing cobbles & boulders below 28')	
	40				Water level 39.3'
	50				
744.8	60	SM		Gravelly Silty SAND, gray	
	70				
	80				
	90		I		Boulder at 90' to 91' & at 95' to 97'
	100				Material runs up in casing 7' w/casing @ 97'

SURFACE EL 809.8	HOLE NO 67-CD-308	N 365,825 E 2,291,132

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
702.8		SM		Gravelly Silty SAND, gray	
699.8	110	GM	I	Silty Sandy GRAVEL	
				Top of rock 110.0'	NX casing to 110.4'
	120			GRANODIORITE, coarse-grained, green-gray Minor gouge at 111.3' Irregular slickensides at 117.0' Slightly altered zone, 119.9' - 121.3'	Core loss 0.3' at 121.3 by grinding. 100% water return
	130			GRANODIORITE, gneissic, medium to coarse-grained, green-gray, hard; several small pegmatite veins Most joints at 0.3' to 2.5' intervals w/horizontal to 80 degree dips	
672.2	140			Bottom 137.6'	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 140.0 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 114.0 DATE STARTED 10 March 1967
ROCK DRILLED 26.0 DATE COMPLETED 4 April 1967
% CORE RECOVERED 98.4 CONTRACTOR Leaf Drilling Co.

SURFACE EL 809.9 HOLE NO 67-CD-309 N 365,709 E 2,291,060

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
809.9					6" gravel road surface 6" casing to rock
	10	GP-GM		Sandy GRAVEL (coarse) w/silt & occasional cobbles (12"), dense, gray	
797.9					
		GM		Silty Sandy GRAVEL (coarse) w/ occasional cobbles (8"), dense, gray	
	20				
789.9			I	Silty Sandy GRAVEL (coarse) w/ occasional cobbles & boulders, (16"), loose to dense, gray	
	30		I		
		GM			Water level 34.3'
	40		I		
	50				
751.9					
	60		I	SAND (medium) w/silt, moist, brown	
		SP-SM			
741.9	70			Silty Sandy GRAVEL (coarse) w/ occasional cobbles (12") gray-brown	
	80	GM			
	90				Material heaved 6' while driving casing. Boulder at 94' to 95.7'.
714.2					
		GM		Silty Sandy GRAVEL (coarse), loose, wet, gray	
710.9	100	SP	I	SAND (fine), wet, gray	

SURFACE EL 809.9 HOLE NO 67-CD-309 N 365,709 E 2,291,860

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
707.9		SP		SAND (fine), wet, gray	
	110	GM		Silty Sandy GRAVEL w/numerous cobbles & boulders (24")	
695.9				Top of rock 114.0'	
	120			GRANODIORITE, fine to coarse-grained, light-gray, medium hard to hard.	NX casing to 115.0'
				Most joints at 0.5' to 4.0' intervals w/horizontal to 70 degree dips; all joints slickensided w/minor chlorite alteration.	100% water return, brown from 115.0-118.0
	130			Contacts dip 60 degrees	
				LAMPROPHYRE, fine-grained, dark, hard	
669.9	140			GRANODIORITE as above	Core loss as 0.4' stub in bottom of hole
				Bottom 140.0	

CHIEF JOSEPH DAM ___ PROJECT COLUMBIA ___ RIVER

DEPTH OF HOLE 88.4 ___ DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 62.0 ___ DATE STARTED 7 March 1967
ROCK DRILLED 26.4 ___ DATE COMPLETED 16 March 1967
% CORE RECOVERED 100 ___ CONTRACTOR Leaf Drilling Co.

SURFACE EL 812.0 HOLE NO 67-CD-310 N 365,618 E 2,291,260

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
812.0					
808.0		GM		Sandy Silty GRAVEL (coarse) gray	6" gravel surfacing 6" casing to rock
	10	SP-SM	I	SAND (fine) w/silt, gray	
796.0					
	20	GM		Sandy Silty GRAVEL (coarse) w/ occasional cobbles (6"), compact, gray	
	30				
779.0					Water level at 33.0'
	40	SP-SM	I	SAND (fine) w/silt, brown	
	50		I		
752.0	60				
750.0		GM		Sandy Silty GRAVEL (coarse) wet, brown	
				Top of rock 62.0'	Churn drill to 65.0'
	70			GRANODIORITE, medium grained, light gray, mod. hard to hard Joints at 0.1 to 1.5' intervals w/ horizontal to 60 degree dips, most joints slickensided.	NX casing to 65.4' Water return 100% to 80.0' & 80% below No core loss
	80				
	90			Bottom 88.4'	
723.6					

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 113.0 DIAMETER OF HOLE 6"OB, & NX in rock
DEPTH OF O.B. 55.0 DATE STARTED 31 May 1967
ROCK DRILLED 58.0 DATE COMPLETED 15 June 1967
% CORE RECOVERED 100% CONTRACTOR Leaf Drilling Co.

SURFACE EL 810.2 HOLE NO 67-CD-311 N 365,512 E 2,291,065

ELEVATIONS 810.2	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
805.2		BLDR & COB		BOULDERS & COBBLES w/silty sandy gravel, loose, dry	6" casing to rock
800.7	10	GM	I	Silty Sandy GRAVEL w/occasional cobbles	
793.2		SM		Silty SAND (fine) loose, dry, tan	
789.2	20	BLDR & COB	I	BOULDERS & COBBLES w/silty sandy gravel	
787.7		GM		Silty Sandy GRAVEL, loose, damp	
		SM		Silty SAND (fine) loose, brown	
	30				
772.2	40	SM	I	Silty SAND (fine) w/occasional gravel	Water level 37.5'
		SM		Silty SAND, loose, brown	
	50				
755.2				Top of rock 55.0'	
	60			GRANODIORITE, medium to coarse grained, light gray, hard Few minor aplite and pegmatite veins, hard Most joints at 0.2' to 3.0 intervals w/ 0 degrees to 90 degree dip	NX casing to 55.2' No core loss.
	70			Minor slickensides on joints at 66.7, 67.1 73.7, 77.3, 79.0, 81.0, 90.0, 97.8, 108.8	Inflow test 58.0-70.0 No inflow at 50# Inflow test 68.0 - 79.0 Inflow 0.03 CFM at 60# Inflow test 77.8 - 88.8' No inflow at 70#
	80				
	90			Lamprophyre dike, fine-grained, dark-gray, hard, contacts dip 45 degrees	Inflow test 88.8'- 104.0' No inflow at 60#
	100				

SURFACE EL 810.2	HOLE NO 67-CD-311	N 365,512 E 2,291,065	
ELEVATIONS	DEPTH / GRAPHIC LOG / CORE %	DESCRIPTION OF MATERIALS	REMARKS
	110	GRANODIORITE as above	
697.2		Bottom 113.0	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 110.0 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 44.0 DATE STARTED 23 March 1967
ROCK DRILLED 66.0 DATE COMPLETED 3 April 1967
% CORE RECOVERED 100 CONTRACTOR Leaf Drilling Co.

SURFACE EL 811.3 HOLE NO 67-CD-312 N 365,512 E 2,291,210

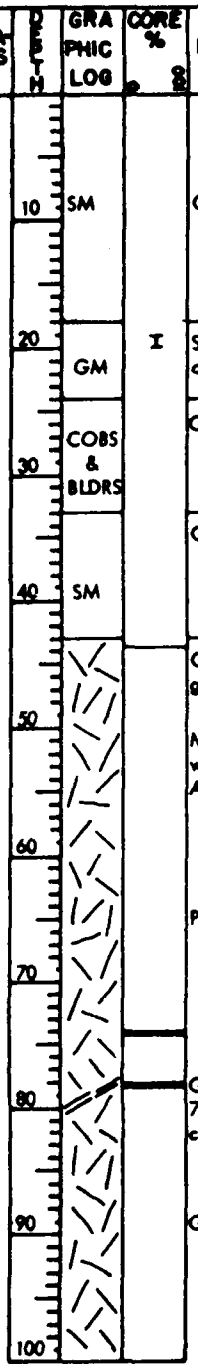
ELEVATIONS 811.3	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
		GM		Silty Sandy GRAVEL (coarse), gray	2" Asphalt pavement at surface 6" Casing to rock
802.3	10	SP	I	SAND (fine) moist, gray	
796.3		GM		Silty Sandy GRAVEL, gray	
793.3	20	SP	I	SAND (fine) moist, gray	
	30	SP		SAND (fine), w/occasional gravel, gray	
	40	SP	I	SAND (fine) Top of Rock 44.0'	
767.3	50			GRANODIORITE, medium to coarse-grained, light-gray, hard. Most joints at 0.2 to 4.0' intervals w/horizontal to 80 degree dips	NX casing to 45.7 No core loss 100% water return In flow test, 49.3 - 60.5 No inflow at 60#
	60				Inflow test, 59.1 - 70.3 No inflow at 70#
	70				In flow test 66.9 - 78.1 No inflow at 70#
	80			Lamprophyre, very fine-grained, dark, hard	In flow test 76.7 - 87.9 0.03 CFM at 80#
	90			GRANODIORITE as above	Inflow test 85.9 - 101.1 0.27 CFM at 80#
	100				

SURFACE EL 811.3	HOLE NO 67-CD-312	N 365,512 E 2,291,210	
ELEVATIONS	DEPTH / GRAPHIC LOG / CORE %	DESCRIPTION OF MATERIALS	REMARKS
		GRANODIORITE as above	Inflow test 99.0 - 110.0 No inflow at 80'
701.3	110	Bottom 110.0'	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 110.8 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 43.0 DATE STARTED 22 March 1967
ROCK DRILLED 67.8 DATE COMPLETED 29 March 1967
% CORE RECOVERED 98.8 CONTRACTOR Leaf Drilling Co.

SURFACE EL 811.9 HOLE NO 67-CD-313 N 365,515 E 2,291,316



DESCRIPTION OF MATERIALS	REMARKS
Gravelly Silty SAND, gray	4" Asphalt pavement w/12" gravel subbase at surface. 6" casing to rock
Silty Sandy GRAVEL w/occasional cobbles	
Cobbles & boulders w/silty sandy gravel	Water level 31.6'
Gravelly Silty SAND, gray	
Top of Rock 43.0'	
GRANODIORITE, medium coarse-grained, light-gray to gray-green, hard	NX casing to 43.6 Inflow test 48.0-64.1 0.03 CFM at 50#
Most joints at 0.3' to 6.0' intervals w/horizontal to 80 degree dips *All joints slickensided w/chlorite coatings*	Inflow test 63.0 - 74.0 No inflow at 60#
Pegmatite, 1' wide, at depth 66.0	Inflow test 73.5 - 84.5 0.05 CFM at 80#
	Core losses of 0.3' 0.5' by grinding at 74.0 & 78.0
GRANODIORITE GNEISS, 1' wide at 79' depth, fine-grained, durk-gray, hard, contacts dip 15 degrees	Inflow test 83.2 - 94.0 No inflow at 80#
GRANODIORITE as above	Inflow test 94.1 - 110.8 No inflow at 80#

SURFACE EL 811.9'	HOLE NO 67-CD-313	N 365,515 E 2,291,316

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
				GRANODIORITE as above	
701.1	110			Bottom 110.8'	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 111.8 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 50.6 DATE STARTED 25 May 1967
ROCK DRILLED 61.2 DATE COMPLETED 7 June 1967
% CORE RECOVERED 99.0 CONTRACTOR Leaf Drilling Co.

SURFACE EL 809.8 HOLE NO 67-CD-314 N 365,458 E 2,291,106

ELEVATIONS 809.8	DEPTH	GRAPHIC LOG	CORE % OB	CORE % NX	DESCRIPTION OF MATERIALS	REMARKS
		GM			Silty Sandy GRAVEL	6" casing to rock
801.8	10	SM			Silty SAND (fine), tan	
798.8		GM			Silty Sandy GRAVEL, gray	
	20		I			
784.8						Water level 24.0'
		SM			Silty SAND (fine), loose, tan	
	30					
	40		I			
760.8	50	SM		X	Gravelly Silty SAND, gray	
759.2					Top of Rock 50.6'	NX casing to 51.4
					GRANODIORITE, medium to coarse-grained, light-gray, hard; trace foliation at 30 - 40 degree dip	Water return 100%
	60					
					Joints at 0.1' to 4.0' intervals w/20 to 80 degree dips, many joints slickensided & chloritized	Inflow test 54.2 - 67.2 0.11 CFM at 60#
	70					Inflow test 67.2 - 79.7 0.11 CFM at 80#
					1/16" to 1/8" gauge at 53.2, 61.8, 67.2, 89.2, 89.6, 103.0 & 111.0	Inflow test 76.0 - 87.0 No inflow at 80#
	80					
	90					Inflow test 85.3 - 100.3 No inflow at 80#
	100					

SURFACE EL 809.8 HOLE NO 67-CD-314 N 365,458 E 2,291,106

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
	110			GRANODIORITE as above	
698.0				LAMPROPHYRE, fine-grained, dark-gray, mod. hard, 0.1' pieces w/several showing gouge	Core loss 0.7' as stub
				Bottom 111.8'	
	120				

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 74.0 DIAMETER OF HOLE 6" OB &NX in rock
DEPTH OF O.B. 46.5 DATE STARTED 17 May 1967
ROCK DRILLED 27.5 DATE COMPLETED 19 May 1967
% CORE RECOVERED 100% CONTRACTOR Leaf Drilling Co.

SURFACE EL 810.8 HOLE NO 67-CD-315 N 365,457 E 2,291,177

ELEVATIONS 810.8	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
807.8		GM		Silty Sandy GRAVEL	12" Asphalt concrete at surface 6" casing to rock
	10	SM	I	Gravelly Silty SAND	
798.8				Silty SAND (fine) loose	
	20	SM			
786.8		GM		Silty Sandy GRAVEL w/cobbles & boulders	
782.8	30	SM	I	Gravelly Silty SAND	
780.8		SM		Silty SAND, loose, tan	
771.8	40	GM	I	Silty Sandy GRAVEL compact, dry, gray	
764.3				Top of Rock 46.5'	NX casing to 47.1 100% water return No core loss
	50			GRANODIORITE, med. to coarse-grained, light-gray, hard	
				Joints at 0.2 to 2.0' intervals w/ horizontal to 85 degree dips Slickensides 55.9, 56.7, 58.2, 59.3, 61.0	
	60				
	70			SCHIST, biotite, hornblende-rich fine-grained, dark, med. hard	
736.8				GRANODIORITE as above	
	80			Bottom 74.0'	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 109.5 DIAMETER OF HOLE 6" OB & NX in rock

DEPTH OF O.B. 30.0 DATE STARTED 29 March 1967

ROCK DRILLED 79.5 DATE COMPLETED 7 April 1967

% CORE RECOVERED 100 CONTRACTOR Leaf Drilling Co.

SURFACE EL 811.8 HOLE NO 67-CD-316 N 365,459 E 2,291,244

ELEVATIONS 811.8	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
804.8		GM		Silty Sandy GRAVEL w/occasional cobbles & boulders	3" Asphalt pavement at surface 6" casing to rock
	10	SM	I	Silty SAND (very fine)	
	20		I		Water level 27.7'
783.8 781.8	30	GM	I	Silty Sandy GRAVEL, gray Top of Rock 30.0'	Angular materials NX casing to 30.7
	40			GRANODIORITE, medium to coarse-grained, light-gray, hard. Joints at 0.1' to 2.0' intervals w/ horizontal to 85 degree dips, most joints show trace to definite slickensides	Water return 100% No core loss Inflow test 34.9 - 45.9 No inflow at 40'
	50				Inflow test, 44.4 - 55.4 No inflow at 50'
	60				Inflow test, 54.0 - 65.0 Inflow 0.01 CFM at 60' Inflow test 63.8 - 74.8 Inflow 0.03 CFM at 70'
	70			Trace gouge in broken zone, 73.2'	Inflow test 74.4 - 86.4 Inflow 0.03 CFM at 80'
	80			Minor gouge at contact LAMPROPHYRE DIKE, fine-grained, dark, med. hard, horizontal contacts	Inflow test 84.7 - 99.7 Inflow 0.05 CFM at 80'
	90			GRANODIORITE as above	
	100				

SURFACE EL 811.8	HOLE NO 67-CD-316	N 365,459 E 2,291,244

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
				GRANODIORITE as above	Inflow test 98.5 - 109.5 No inflow at 80'
702.3	110			Bottom 109.5	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 59.8 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 34.0 DATE STARTED 28 March 1967
ROCK DRILLED 25.8 DATE COMPLETED 10 April 1967
% CORE RECOVERED 99.6 CONTRACTOR Leaf Drilling Co.

SURFACE EL 811.9 HOLE NO 67-CD-317 N 365,460 E 2,291,316

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
811.9					
		GM		Silty Sandy GRAVEL w/cobbles & boulders (24"), gray	Lawn at surface 6" Casing to rock Boulder at 3' to 5' depth
802.9	10		I		
		SM		Silty SAND (very fine)	Water level 26.5'
	20				
	30				
777.9				Top of Rock 34.0'	
				GRANODIORITE, med. to coarse grained, light-gray, hard	NX casing to 34.6'
	40			Joints at 0.2' to 1.5' intervals w/ horizontal to 80 degree dips, all joints slickensided and w/trace of chlorite coatings	Water return 100%
	50			LAMPROPHYRE dikes, fine-grained, dark, hard from 55.5 to 56.9 & 58.3 to 59.8, contacts 20 degree dip	Core loss 0.1' as stub in bottom of hole
752.1	60			Bottom 59.8'	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 113.8 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 29.0 DATE STARTED 27 March 1967
ROCK DRILLED 84.8 DATE COMPLETED 18 April 1967
% CORE RECOVERED 99.5 CONTRACTOR Leaf Drilling Co.

SURFACE EL 811.3 HOLE NO 67-CD-318 N 365,462 E 2,291,387

ELEVATIONS 811.3	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
	10	GM	I	Silty Sandy GRAVEL, gray	6" casing to rock
794.3	20	SP	I	SAND (fine) w/occasional gravel, gray	
782.3	30			Top of Rock 29.0'	
				GRANODIORITE, medium to coarse-grained, light-gray, hard Joints at 0.1' to 2.0' intervals w/ horizontal to 80 degree dips, most joints show trace to well-developed slickensides for entire hole	NX casing to 30.4' core loss 0.3' Water return 100% Inflow test 34.5 - 47.5 No inflow at 40'
	40			LAMPROPHYRE, fine-grained, dark, mod. hard, contacts dip 30 degrees	Inflow test 46.4-57.4 No inflow at 50'
	50			GRANODIORITE as at 33.0'	Inflow test 55.0 - 66.0 No inflow at 60'
	60			LAMPROPHYRE as above	
	70			GRANODIORITE, fine to medium-grained, dark to medium gray, hard, trace to moderately developed foliation and banding, few thin pegmatite and aplite veins. Veins and foliation dip 15 degrees to 30 degrees	Inflow test 65.0-76.0 No inflow at 80'
	80				Inflow test 74.6-85.6 Inflow 1.7 CFM at 80' but pressure duration test negates inflow.
	90			1/4" soft zones at 83.0' & 83.7' w/ 30 degree dips	Inflow test 83.8-94.8 No inflow at 80'
	100				Inflow test 93.4-106.4 Inflow 0.11 CFM at 80'

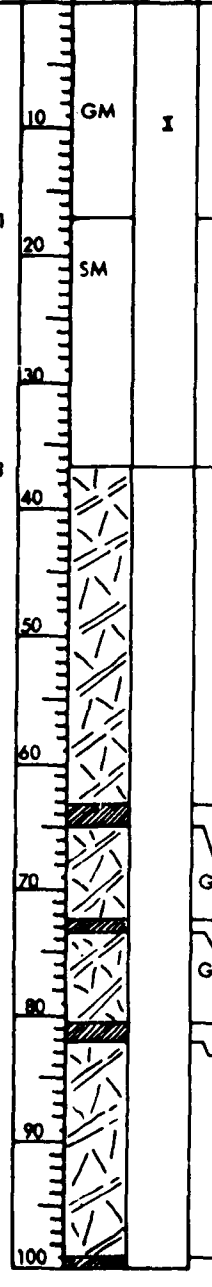
SURFACE EL 811.3	HOLE NO 67-CD-318	N 365,462 E 2,291,387

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
					Inflow test 102.8 - 113.8
	110			GRANODIORITE, medium to coarse grained, light-gray, hard	Inflow 0.13 CFM at 80#
697.5					Core loss 0.4' as stub in bottom of hole
				Bottom 113.8'	
	120				

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 108.1 DIAMETER OF HOLE 6" OB & NX in OB & rock
DEPTH OF O.B. 36.8 DATE STARTED 27 March 1967
ROCK DRILLED 71.3 DATE COMPLETED 24 April 1967
% CORE RECOVERED 99.6 CONTRACTOR Leaf Drilling Co.

SURFACE EL 810.1 HOLE NO 67-CD-319 N 365,474 E 2,291,452



DESCRIPTION OF MATERIALS	REMARKS
Silty Sandy GRAVEL, loose, gray (Probably fill)	2" Asphalt surfacing 6" casing & churn Drill hole to 17' depth. NX casing reamed to 27.0' depth
	Hole advanced w/NX Bit to 36.0'
Silty SAND, compact	Cuttings show sand 100% water return (Possible till) NX casing reamed to rock
Top of Rock 36.8'	Water level 35.0'
GRANODIORITE, medium to coarse-grained, light-gray, hard, trace foliation at 20 degrees to 40 degree dip, brecciated to depth 45.0' & breaks healed w/chlorite	NX casing to 36.8 Water return 100%
Joints mostly at 0.1' intervals to depth 45', below 45' joints at 0.1' to 5.0' intervals w/many slickensided	Inflow test 39 - 55' No inflow at 50'
	Inflow test 54.2 - 65.2' Neg. inflow at 60' No inflow at 30'
Contact dips 35 degrees	
SCHIST, fine-grained, dark-gray, mod hard, biotite-hornblende-quartz feldspar, foliation dips 35 degrees	Inflow test 64.3 - 79.3' No inflow at 70'
GRANODIORITE as above	
Contact dips 35 degrees	
Schist as above	
GRANODIORITE as above	Inflow test 78 - 89' No inflow at 80'
Contact dips 25 degrees	
Schist as above	
GRANODIORITE as above	
	Inflow test 90 - 101' No inflow at 80'
Contact dips 30 degrees	

SURFACE EL 810.1				HOLE NO 67-CD-319	N 365,474 E 2,291,452
ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
				SCHIST as above	Inflow test 97 - 108'
				GRANODIORITE as above	No inflow at 80'
702.0	110				Core loss 0.3' as stub in bottom of hole
				Bottom 108.1	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 53.6 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 24.0 DATE STARTED 9 May 1967
ROCK DRILLED 29.6 DATE COMPLETED 9 June 1967
% CORE RECOVERED 100% CONTRACTOR Leaf Drilling Co.

SURFACE EL 819.2 HOLE NO 67-CD-320 N 365,400 E 2,291,084

ELEVATIONS 819.2	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
	10	CBLS & BLDRS		COBBLES & BOULDERS w/silty sandy gravel	6" casing to rock
801.2	20	GM	I	Silty Sandy GRAVEL w/cobbles, dry, brown	Water level 21.0'
795.2				Top of Rock 24.0'	
	30			GRANODIORITE, medium to coarse-grained, light-gray, hard Joints at 0.1' to 4.0' intervals w/5 to 85 degree dips, many joints iron-stained many slickensided. 1/8" gouge at 34.8, 39.0	NX casing to 28.2' Water return slight to 31.0 and good below 31.0 No core loss
	40				
	50				
765.6	60			Bottom 53.6'	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 69.7 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 15.0 DATE STARTED 23 May 1967
ROCK DRILLED 54.7 DATE COMPLETED 26 May 1967
% CORE RECOVERED 100 CONTRACTOR Leaf Drilling Co.

SURFACE EL 815.2 HOLE NO 67-CD-321 N 365,401 E 2,291,144

ELEVATIONS 815.2	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
813.2		SM		Silty SAND	
		GM		Silty Sandy GRAVEL w/cobbles & boulders	6" casing to rock
808.2	10	SM	I	Silty SAND (fine), loose, tan	
803.2		GM		Silty Sandy GRAVEL	
800.2				Top of Rock 15.0'	Sloping rock surface
	20			GRANODIORITE, medium to course-grained, light-grey, hard	Churn drilled to 22.2'
				Joints mostly at 0.1' to 1.0' intervals w/5 to 85 degree dips, several iron-stained, few slickensides above 52.0' & many below, no joints from 40.1 to 51.9.	NX casing to 22.4
	30				Water return 100% to 27.0', 70% from 27.0 to 32.0', no return below 32.0'
					Inflow test 25.3 - 36.3' 1.82 CFM at 30#
	40				
					No core loss
	50				Inflow test 35 - 50.1' No inflow at 30#
					Inflow test 47.5 - 58.5' No inflow at 40#
				SCHIST, biotite-hornblende, dip 20 degree dark-grey, mod hard	
	60			GRANODIORITE as above	Inflow test 56.7 - 69.7' No inflow at 60#
				Brecciated and re-healed from 64.5 to 69.7	
745.5	70			Bottom 69.7	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 50.5 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 25.0 DATE STARTED 2 May 1967
ROCK DRILLED 25.5 DATE COMPLETED 8 May 1967
% CORE RECOVERED 100 CONTRACTOR Leaf Drilling Co.

SURFACE EL 812.1 HOLE NO 67-CD-322 N 365,403 E 2,291,214

ELEVATIONS 812.1	DEPTH	GRAPHIC LOG	CORE % RQD	DESCRIPTION OF MATERIALS	REMARKS
	10	SM		Silty SAND (fine), loose, tan	6" casing to rock
794.1	20	GM	I	Silty Sandy GRAVEL w/cobbles	Water level 23.4'
787.1				Top of Rock 25.0	
	30			GRANODIORITE, medium to coarse-grained, light gray, soft to hard from 25.9 to 30.2, hard below 30.2	NX casing to 25.9 1/4" gouge in crushed zone at 27.3
	40			Joints at 0.1' to 2.0' intervals w/5 to 85 degree dips, many iron-stained & few slickensided.	1/16" gouge, dip 75 degrees at 29.0' Water return 100%
				SCHIST, biotite-hornblende, dip 50°	
	50			GRANODIORITE as above	No core loss
761.6				Bottom 50.5'	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 70.1 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 8.0 DATE STARTED 18 May 1967
ROCK DRILLED 62.1 DATE COMPLETED 23 May 1967
% CORE RECOVERED 100 CONTRACTOR Leaf Drilling Co.

SURFACE EL 811.3 HOLE NO 67-CD-323 N 365,405 E 2,291,285

ELEVATIONS 811.3	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
		GM		Silty Sandy GRAVEL w/cobbles & boulders	6" Asphalt conc on surface
		COBBLES BLDR		COBBLES & BOULDERS w/silty sandy gravel	6" casing to rock
803.3	10			Top of Rock 8.0' GRANODIORITE, medium to coarse-grained, light-gray, hard	NX casing to 11.0 Water return 100% to depth 59.2 50 to 80% below
	20			Joints at 0.1 to 5.0' intervals w/5 to 85 degree dip, most joints slickensided w/chlorite coatings Gouge, 1/8" at 21.5' & 21.6', dip 70 degrees	Inflow test 23.8 - 36.8' No inflow at 30#
	30				Inflow test 34.4 - 45.4' No inflow at 30#
	40			Contact 15° LAMPROPHYRE, fine-grained, dark gray, hard	Inflow test 43.2 - 59.2' 0.13 CFM at 40#
	50			GRANODIORITE, medium to coarse-grained, light-gray, hard	
	60			1/8" gouge at 58.7', dip 70 degrees Contacts 25 degrees LAMPROPHYRE, fine-grained dark gray, hard	Inflow test 59.1 - 70.1 0.27 CFM at 60# Dike closely jointed
	70			GRANODIORITE, medium to coarse-grained, light-gray, hard, trace foliation at 20 - 40 degrees	
741.2				Bottom 70.1	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 48.3 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 15.0 DATE STARTED 28 April 1967
ROCK DRILLED 33.3 DATE COMPLETED 9 May 1967
% CORE RECOVERED 98.5 CONTRACTOR Leaf Drilling Co.

SURFACE EL 811.5 HOLE NO 67-CD-324 N 365,404 E 2,291,347

ELEVATIONS 811.5	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
		SM		Silty SAND w/boulders	6" casing to rock
807.5		CBLS		COBBLES & BOULDERS	
805.5	10	GM	I	Silty Sandy GRAVEL w/cobbles & boulders	
796.5	20			Top of Rock 15.0' GRANODIORITE, medium to coarse-grained, light-gray, hard	NX casing to 20.4
	30			Joints at 0.1' to 2.0' intervals w/10 to 85 degree dip, few iron stains, most slickensided	Water return 100%
	40			Gouge, 1/8", dip 45 degrees, 34.1'	Core loss 0.5' as stub in bottom of hole
763.2	50			Bottom 48.3'	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

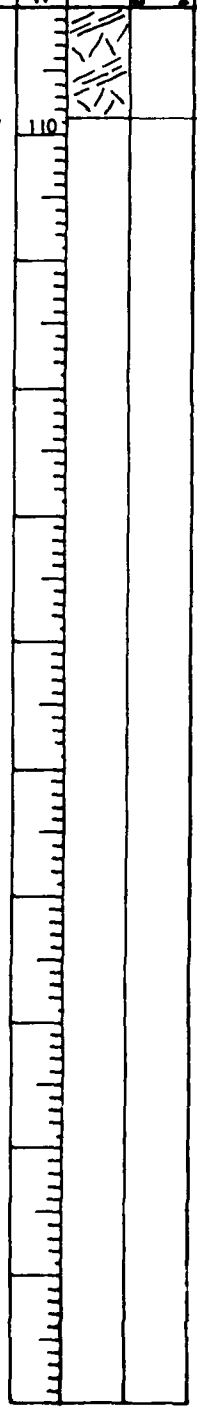
DEPTH OF HOLE 108.4 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 26.0 DATE STARTED 31 March 1967
ROCK DRILLED 82.4 DATE COMPLETED 13 April 1967
% CORE RECOVERED 100 CONTRACTOR Leaf Drilling Co.

SURFACE EL 811.1 HOLE NO 67-CD-325 N 365,407 E 2,291,423

ELEVATIONS 811.1	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
806.1		SM		Silty SAND (fine), gray	6" casing to rock
	10	GM	I	Silty Sandy GRAVEL w/cobbles	Gravel mostly angular
795.1	20	ML	I	Gravelly Sandy SILT, compact, gray	(possible till)
				Top of Rock 26.0	
785.1	30			LAMPROPHYRE, dark, hard	NX casing to 26.0
				GRANODIORITE, light-gray, hard	Water return 100%
				LAMPROPHYRE, fine-grained, dark-gray, hard, contacts dip 60-70 degrees	No core loss Inflow test 30.1 - 44.1' No inflow at 40#
	40			GRANODIORITE, medium to coarse-grained light-gray, mod. hard, brecciated and rehealed.	Jointed at 0.1 to 1.0' intervals from 26.0'-70.0' w/horizontal to 80 degree dips, many slickensided
				GRANODIORITE, part coarse-grained & light gray, part fine-grained & dark-gray reaction zones	
	50			GRANODIORITE, medium to coarse-grained, light-gray, hard	Inflow test 43.0 - 54.0' 0.29 CFM at 50# 1/8" gouge at 58.0'
	60			Mixed GRANODIORITES, as at 42'	Inflow test 53 - 64' No inflow at 60#
	70				Inflow test 63.3 - 74.3' Inflow 0.27 CFM at 35#
				LAMPROPHYRE as at 32'	Jointed at 0.1' intervals, from 70.0 - 74.0, most dip 30 degrees
	80			GRANODIORITE as at 50'	Inflow test 73.3 - 86.3' 0.70 CFM at 80#
				Mixed GRANODIORITE as at 42'	Jointed at 0.1' to 4.0' intervals below 74.0' w/horizontal to vertical dips, most joints slickensided
	90			GRANODIORITE, medium to coarse-grained, light-gray, hard, trace to mod. gneissic banding w/15 degree dip	Inflow tests at 84.2 - 99.2 & 97.4 - 108.4 No inflow at 80#
	100				

SURFACE EL 811.1	HOLE NO 67-CD-325	N 365,407 E 2,291,423

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
				GRANODIORITE, gneissic as above	
702.7	110			Bottom 108.4'	



CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 119.3 DIAMETER OF HOLE 6"OB & NX in rock
DEPTH OF O.B. 35.5 DATE STARTED 30 March 1967
ROCK DRILLED 83.8 DATE COMPLETED 1 May 1967
% CORE RECOVERED 98.7 CONTRACTOR Leaf Drilling Co.

SURFACE EL 823.8 HOLE NO 67-CD-326 N 365,538 E 2,290,673

ELEVATIONS 823.8	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
	10	BLDRS		BOULDERS w/cobbles and silty sandy gravel, gray	6" casing to rock Drill water runs out through boulders
807.8	20	CBLS	I	COBBLES & coarse GRAVEL w/silty sand, gray	
799.8	30	SM		Silty Sand, w/occasional gravel or cobbles	
788.3	40			Top of Rock 35.5' GRANODIORITE, medium to coarse-grained light-gray, hard, trace foliation at 30- 40 degrees	NX casing to 36.8 Water return 100% Inflow test 38.0 - 49.0' 0.19 CFM at 40#
	50			Jointed at 0.1' to 3.0' intervals w/5 to 85 degree dips, most joints slickensided iron stains on most joints to 50.0' and on few to 96.0'	Water level 48.0' Inflow test 47.6 - 60.6' 0.03 CFM at 60#
	60			Gouge, 1/8", dip 65 degrees at 48.5 Gouge, 1/8", dip 85 degrees at 59.0 & 61.0 Rock shattered and chlorite healed 60.4-61.7, 73.4 - 74.5, 92.0 - 99.9	Inflow test 59.0 - 70.0' No inflow at 70#
	70				Inflow test 69 - 80' 0.05 CFM at 80#
	80				Inflow test 78.2 - 93.2' 0.16 CFM at 80#
	90			Irregular contacts	
	100			SCHIST, fine-grained, gray-green, mod. hard, chloritized GRANODIORITE as above	Inflow test 91.6 - 102.6' 0.16 CFM at 80#

SURFACE EL 823.8	HOLE NO 67-CD-326	N 365,538 E 2,290,673

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
	110			GRANODIORITE as above Gouge, 1/8", dip 75 degrees, 114.5'	Inflow test 101.2-114.2' No inflow at 80# Inflow test 108.3-119.3' 0.08 CFM at 80# Core loss 1.0' as stub in bottom of hole
704.5	120			Bottom 119.3'	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 79.8 DIAMETER OF HOLE 6" OB &NX in rock
DEPTH OF O.B. 53.0 DATE STARTED 3 April 1967
ROCK DRILLED 26.8 DATE COMPLETED 28 April 1967
% CORE RECOVERED 100% CONTRACTOR Leaf Drilling Co.

SURFACE EL 828.3 HOLE NO 67-CD-327 N 365,326 E 2,290,677

ELEVATIONS 828.3	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
	10	BLDRS & CBLS		BOULDERS & COBBLES w/silty sandy gravel, gray	6" casing to rock Large boulder at 9' to 14' depth
	20				Water level 22.0'
803.3	30	GM	I x	Silty Sandy GRAVEL with occasional cobbles & boulders	
	40		x		
	50		x		
				Top of Rock 53.0'	
775.3	60			GNEISSIC GRANODIORITE, medium-grained, dark-gray, mod. hard, thin pegmatite stringers Most joints Fe-stained to depth 59.0'	NX casing to 54.4' Water return 100% No core loss
	70			GRANODIORITE, medium to course-grained, light-gray, hard Joints at 0.1' to 2.0' intervals w/ horizontal to 70 degree dips. Pyrite & iron-stains at 69.4' & 70.1'	
748.5	80			Bottom 79.8'	

CHIEF JOSEPH DAM ____ PROJECT __ COLUMBIA _____ RIVER

DEPTH OF HOLE __ 90.5 ____ DIAMETER OF HOLE 6" OB & NX in rock ____
DEPTH OF O.B. __ 64.0 ____ DATE STARTED __ 4 May 1967 _____
ROCK DRILLED __ 26.5 ____ DATE COMPLETED 8 June 1967 _____
% CORE RECOVERED __ 100 ____ CONTRACTOR __ Leaf Drilling Co. _____

SURFACE EL 842.5 HOLE NO 67-CD-328 N 365,155 E 2,290,845

ELEVATIONS 842.5	DEPTH	GRAPHIC LOG	CORE % OB	DESCRIPTION OF MATERIALS	REMARKS
	10	CBLS & BLDRS		COBBLES & BOULDERS w/silty sandy gravel	6" casing to rock
	20		I		Losing drill water
	30				Water level 34.0'
	40				
	50				Boulder 47' to 52'
790.5	60	GM		Silty Sandy GRAVEL w/cobbles & boulders	
778.5				Top Rock 64.0'	
	70			SCHIST, biotite-hornblende-rich, dark-gray, mod. hard w/1' GRANODIORITE zones.	NX casing to 66.3
	80			GRANODIORITE, medium to coarse-grained, light-gray, hard, Joints at 0.2' - 5.0' intervals w/ 5 - 85 degree dips Gouge, 1/8" - 3 16", dips 65, 80, 85 degrees at 67.3, 67.8, 68.2	Water return 100% No core loss
	90				
752.0				Bottom 90.5'	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 192.3 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 167.0 DATE STARTED 4 April 1967
ROCK DRILLED 25.3 DATE COMPLETED 15 July 1967
% CORE RECOVERED 95.2 CONTRACTOR Leaf Drilling Co.

SURFACE EL 965.2 HOLE NO 67-CD-329 N 364,936 E 2,290,047

ELEVATIONS 965.2	DEPTH	GRAPHIC LOG	CORE % RQD	DESCRIPTION OF MATERIALS	REMARKS
963.2		SM		Silty SAND (fine), loose, tan	Churn drilled w/6" casing to 147.5' NX below 147.5
	10	CBLS & BLDRS		COBBLES & BOULDERS w/silty sandy gravel	Boulder 9' - 12'
	20		I		
937.2	30	GM	I	Silty Sandy GRAVEL, occasional cobbles	
	40		I		
	50		I		
907.2	60	SM	I	Gravelly Silty SAND, gray	
896.2	70	SM	I	Silty SAND (fine) compact, dry, orange & tan	
893.2		GM		Silty Sandy GRAVEL w cobbles	
	80		I		
	90		I		
870.2	100	SP		SAND (fine) w/silt	

SURFACE EL 965.2	HOLE NO 67-CD-329	N 364,936 E 2,290,047

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
862.2		SP	I	SAND (fine) w/silt	
	110	SM	I	Gravelly Silty SAND	
	120		I		
845.2		GM	I	Silty Sandy GRAVEL	
835.2	130	SM		Gravelly Silty SAND	
828.2	140	GM	I	Silty Sandy GRAVEL compact, dry, gray, (till)	
817.2	150	GP		Sandy GRAVEL	No water return 148.3 - 150.5
813.2		SM		Silty SAND (fine)	
810.2		GM		Silty Sandy GRAVEL w/cobbles	
807.7	160	SM		Silty SAND (fine) Top of Rock 167.0	
798.2	170			GRANODIORITE, medium to coarse-grained, light-gray, soft 167.0 - 168.0, soft to mod. hard 168.0 - 172.0, hard below 172	NX casing to 167.0
	180			Joints at 0.1' to 4.0' intervals w/5 to 75 degrees dips, most joints iron-stained, many slickensided Gouge, 1/8", dip 65 degrees, 179.2' Gouge, 1/8", dip 65 degrees, 184.3'	
	190				Core loss 1.2' as stub in bottom of hole
772.9				Bottom 192.3'	

CHIEF JOSEPH DAM PROJECT COLUMBIA RIVER

DEPTH OF HOLE 93.0 DIAMETER OF HOLE 6" OB & NX in rock
DEPTH OF O.B. 67.0 DATE STARTED 16 March 1967
ROCK DRILLED 26.0 DATE COMPLETED 3 May 1967
% CORE RECOVERED 99.2 CONTRACTOR Leaf Drilling Co.

SURFACE EL 994.8 HOLE NO 67-CD-330 N 364,670 E 2,189,524

ELEVATIONS 994.8	DEPTH	GRAPHIC LOG	CORE %	DESCRIPTION OF MATERIALS	REMARKS
991.8		SM		Silty Sand (fine) loose, moist, tan	6" casing to rock
989.8		CBLS		COBBLES & BOULDERS	
	10	GM		Silty Sandy GRAVEL w/many cobbles & boulders	
979.8		GM		Silty Sandy GRAVEL, w/occasional cobbles	
975.8	20	SP	I	SAND (fine), gray	
971.8		GM		Silty Sandy GRAVEL, w/occasional cobbles, loose, gray	
	30		I		
	40		I		
	50		I		
	60		I		Hole dry
926.8		SP		SAND (fine) loose, gray	
927.8	70			Top of Rock 67.0	NX casing to 67.5'
				GRANODIORITE, medium to coarse-grained, light-gray, hard	Water return 100%
	80			Joints at 0.1 to 1.5' intervals w/ horizontal to 80 degree dips, many joints slickensided. Joints iron-stained at 75.5, 84.4. 87.0, 87.2, 88.6, 88.9, 89.1, 89.2, 89.6, 89.9, 90.2, 92.0	
				LAMPROPHYRE, fine-grained, dark, mod. hard	
	90			GRANODIORITE & joints as above	Core loss 0.2' as stub in bottom of hole
901.8				Bottom 93.0	
	100				

Hole No. 72-D-350

DRILLING LOG

DIVISION: NPD

INSTALLATION: NPS

SHEET 1 OF 2 SHEETS

1. PROJECT: Chief Joseph Dam
2. LOCATION (Coordinates or Station): N 366,505 E 2,295,360
3. DRILLING AGENCY: Smith Drilling & Associates
4. HOLE NO. (As shown on drawing title and file number): 72-D-350
5. NAME OF DRILLER: Carl Smith
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 198
8. DEPTH DRILLED INTO ROCK: 9
9. TOTAL DEPTH OF HOLE: 207
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: CP-650 Air Rotary, Star 71 Churn Drill
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 12; UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 7 August 1972; COMPLETED 19 Oct 1972
17. ELEVATION TOP OF HOLE: 949.5
18. TOTAL CORE RECOVERY FOR BORING: _____ %
19. SIGNATURE OF INSPECTOR: D. Kellum

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
949.5	0	GM	Sandy Silty GRAVEL w/ cobbles and boulders, dense, gray			Hole drilled with CP-650 Air Rotary to 42'. Churn Drill Star 71 drilled from 42' to T.D.
						SWL 8' 8-7-72
	10					SWL dry
						Hole making water @ 20'
						SWL 16' 8-8-72
927.5	20					SWL 45'
		MH	Clayey SILT with cobbles, tan			SWL 15' 8-10-72
						SWL 6'
	30					
911.5						
	40	CL	Silty CLAY, micaceous, gray to black			8-11-72
905.5				I		SWL 15'
		MH	Clayey SILT, micaceous, tan	I		N=90/18"
901.5						N=90/18"
	50					SWL 20.3 9-23-72
		GM	Silty GRAVEL, dense, gray			SWL 14.5
895.8						9-24-72
						SWL 24.3
893.5		CL	Silty CLAY, gray to black			9-25-72
						SWL 19.6
		GP	BOULDER, basaltic, dense, gray			
	60					SWL 29.5 9-26-72
886.5						SWL 23
		MH	SILT, laminated, micaceous, gray	I		N=100/12", 100/6"
						N= 50/18"
	70					
877.5						
		CH	CLAY, gray to tan	I		SWL 70' 9-27-72
						SWL 69.2
868.5	80					Hole making water ? 81'
		GM	Silty GRAVEL, angular rock fragments, yellow to gray	I		N 100/12"
858.5	90					SWL 40' 9-28-72
		CH	Silty CLAY, plastic, yellow to tan			SWL 29.6 Lost tools No advance until 10-3-72
						SWL 14.6
849.5	100					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Chief Joseph Dam

HOLE NO. 72-D-350

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 949.5 | **Hole No.** 72-D-350

PROJECT Chief Joseph Dam | INSTALLATION NPS | SHEET 2 OF 3 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV. ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
849.5	100	CL	Silty Sandy CLAY, yellow			
844.5						SWL 20
			Clayey Sandy GRAVEL, tan to gray-brown			SWL 19.5 10-4-72
						Replaced all 6" casing
	110	GC		I		N=120/12", 60/6"
						SWL 48.8 10-7-72
						SWL 22.6
832.5						Hole caving - Drive casing ahead of drilled hole.
	120	SP-GP	Gravelly SAND to Sandy GRAVEL, gray			
819.5	130					
			Sandy GRAVEL with occasional cobbles, gray to tan			SWL 53.7' 10-9-72
						SWL 26'
				I		N=150/12"
	140					SWL 27' 10-10-72
						SWL 18'
				I		N=50/12", 86/12"
						SWL 29.5' 10-11-72
	150	GP				SWL 18'
	160			I		N=40/12", 60/12"
	170					
						SWL 23' 10-12-72
				I		SWL 18.2'
	180					N=225/12", 170/12"
	190					
						SWL 19.7' 10-13-72
				I		SWL 15.8'
754.5						N=25/12", 25/12"
		GM	Silty Sandy GRAVEL			
751.5				I		SWL 21.5' 10-16-72
749.5	200		Top of Rock - GRANODIORITE			SWL 15.4'
						N=500/5"
						SWL 20.3' 10-17-72

ENG FORM 1836-A (ER 1110-1-1801) GPO 1969 OF - 620 - 665

PROJECT Chief Joseph Dam | HOLE NO. 72-D-350

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 949.5 | Hole No 72-D-350

PROJECT: Chief Joseph Dam | INSTALLATION: NPS | SHEET 3 OF 3 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV. ERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
749.5	200		GRANODIROITE			SWL 18.9' 10-18-72 SWL 15.0'
742.5	210		Bottom of hole @ 207'			10-19-72 Casing @ 198' *Note: N=blow counts inches driven

Hole No. 72-D-351

DRILLING LOG | DIVISION NPD | INSTALLATION NPS | SHEET 1 OF 3 SHEETS

1. PROJECT	Chief Joseph Dam
2. LOCATION (Coordinates or Station)	N 366,535 E 2,295,025
3. DRILLING AGENCY	Smith Drilling & Assoc.
4. HOLE NO. (As shown on drawing title and file number)	72-D-351
5. NAME OF DRILLER	Carl Smith
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	247.0
8. DEPTH DRILLED INTO ROCK	11.5
9. TOTAL DEPTH OF HOLE	258.0
10. SIZE AND TYPE OF BIT	8" & 6"
11. DATUM FOR ELEVATION SHOWN (USGS or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	CP-650 Air Rotary; Star 71 Churn Drill
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 13 / UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED 3 Aug 1972 / COMPLETED 30 Oct 1972
17. ELEVATION TOP OF HOLE	1002
18. TOTAL CORE RECOVERY FOR BORING	- %
19. SIGNATURE OF INSPECTOR	D. Kellum S. Wright

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
1002	0		Sandy Gravelly SILT, dense, well-graded, with cobbles and boulders, gray			Hole drilled with CP-650 Air Rotary to 52.0' Cable Tool Star 71 drilled from 52' to 259.5'
	10					
	20					NOTE: N= blow counts / inches driven
	30					
		ML	Sandy SILT - irregular zones of contorted, crudely bedded silts			6-3-72
	40					
	50					8-4-72
				I		8-7-72
						SWL 46.7
						SWL 53 9-23-72
						SWL 51
	60					SWL 50.5 9-24-72
						SWL 50.5
	70			I		N=175/7
						SWL 69.5 9-25-72
						SWL 69.5
	80					
	90			I		N=212/12
902	100					SWL 86.5 9-26-72

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Chief Joseph Dam | HOLE NO. 72-D-351

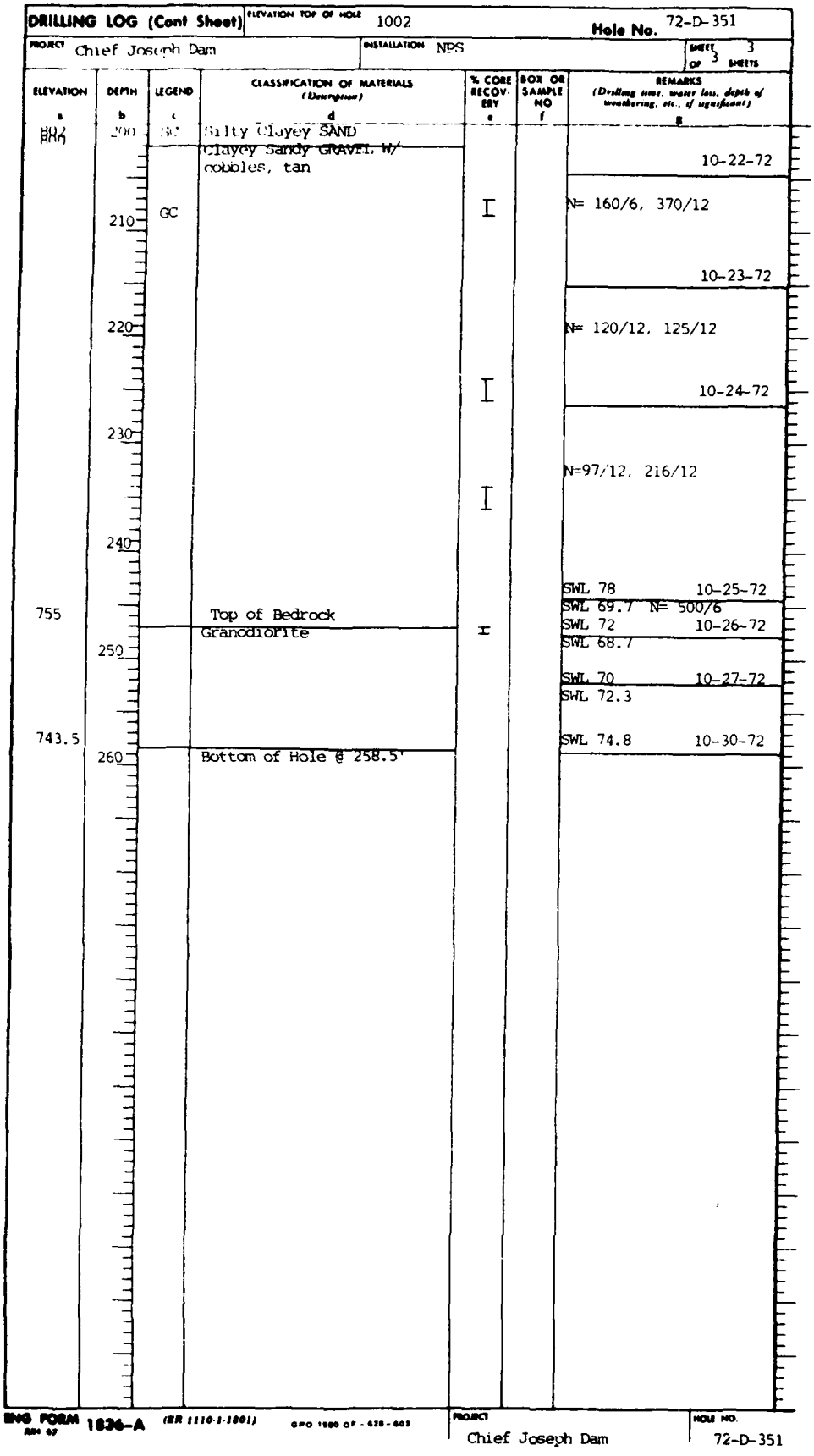
DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 1002 | Hole No. 72-D-351

PROJECT: Chief Joseph Dam | INSTALLATION: NPS | SHEET 2 OF 3 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV. ERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
902	100	ML	Sandy Gravelly SILT, dense, gray			N=200/8
898			Silty Sandy GRAVEL, w/ cobbles and boulders, basaltic, dense gray water bearing	I		SWL 75.5 9-27-72 SWL 72 9-28-72
	110	GM				SWL 78 10-01-72 SWL 72
				II		N=400/5" 10-2-72 SWL 69.5
	120					SWL 70 10-3-72
876						10-4-72
			Boulder, basalt, dense, gray			SWL 69.5
	130	GP				SWL 68.7 10-5-72
868			Silty Sandy GRAVEL, w/ boulders, anrular dense, gray	I		N= 200/12, 200/12 SWL 69 10-6-72 SWL 69
						SWL 68.8 10-7-72 SWL 71.9
	140	GM				SWL 80.3 10-9-72 SWL 80.3 10-10-72 SWL 78.5
						SWL 83.9 10-11-72
						SWL 83.7 10-12-72
	150					10-13-72 to 10-17-72
847						SWL 80
		SC	Clayey Silty SAND, basaltic, black to gray			SWL 85.7 10-18-72 SWL 84.8
842	160					SWL 90 10-19-72
		GC	Sandy Clayey GRAVEL	I		SWL 87.9
835						N=220/16
833.5		GP	COBBLES			
	170		Silty Clayey SAND with some gravel, gray	I		N= 93/12, 115/12
						SWL 85.7 10-20-72
	180	SC				SWL 80 N= 300/24 Filled hole w/ water
				I		SWL 17.5 10-21-72
	190					SWL 19.5
802	200					

ENG FORM 1836-A APR 67 (ER 1110-1-1801) GPO 1968 O-F - 626 - 503

PROJECT: Chief Joseph Dam | HOLE NO. 72-D-351


DRILLING LOG (Cont Sheet)
ELEVATION TOP OF HOLE 1002
Hole No. 72-D-351
PROJECT Chief Joseph Dam
INSTALLATION NPS
SHEET 3 OF 3 SHEETS
ELEVATION
DEPTH
LEGEND
CLASSIFICATION OF MATERIALS (Description)
% CORE RECOVERY
BOX OR SAMPLE NO
REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
200
Silty Clayey SAND
Clayey Sandy GRAVEL, w/ cobbles, tan
10-22-72
GC
210
N= 160/6, 370/12
10-23-72
220
N= 120/12, 125/12
10-24-72
230
N=97/12, 216/12
240
SWL 78 10-25-72
755
Top of Bedrock
SWL 69.7 N= 500/6
Granodiorite
SWL 72 10-26-72
250
SWL 68.7
SWL 70 10-27-72
SWL 72.3
743.5
SWL 74.8 10-30-72
260
Bottom of Hole @ 258.5'
ENG FORM 1836-A (ER 1110-1-1801)
PROJECT Chief Joseph Dam
HOLE NO. 72-D-351

Hole No. 72-D-352A

DRILLING LOG	DIVISION NPD	INSTALLATION NPS	SHEET 1 OF 3 SHEETS
1. PROJECT Chief Joseph Dam		10. SIZE AND TYPE OF BIT 8" TRB & 6" bit	
2. LOCATION (Coordinates or Station) N 466,565 E 2,295,780		11. DATUM FOR ELEVATION SHOWN (USM or MSL)	
3. DRILLING AGENCY Smith Drilling & Assoc.		12. MANUFACTURER'S DESIGNATION OF DRILL CP-650 Air Rotary; Star 71 Churn Drill	
4. HOLE NO. (As shown on drawing title and file number) 72-D-352A		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 13	UNDISTURBED 0
5. NAME OF DRILLER Carl Smith		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE: STARTED 1 Aug 1972	COMPLETED 21 Sept 1972
7. THICKNESS OF OVERBURDEN 269		17. ELEVATION TOP OF HOLE 1019	
8. DEPTH DRILLED INTO ROCK 5		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 274		19. SIGNATURE OF INSPECTOR S. Wright, D. Kellum	

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
1019	0		Clayey Sandy Gravelly SILT with cobbles and boulders very dense, gray			Hole drilled with CP-650 Air Rotary to 115'. Cable Tool Star 71 used from 114' to 274.'
	10					
	20					SWL dry 8-1-72
	30					SWL dry NOTE: N= blow counts / inches driven
		ML				
	40					
	50					Zones of faster drilling 76-83', 95-97', 99-103'.
	60					
	70					
	80					
	90					
919	100					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Chief Joseph Dam | HOLE NO. 72-D-352A

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 1019 | Hole No. 72-D-352A

PROJECT: Chief Joseph Dam | INSTALLATION: NPS | SHEET 2 OF 3 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
919	100	ML	Clayey Sandy SILT, with cobbles and boulders, gray			N= 130/12
	110					8-2-72
904.5		ML	Sandy SILT w/ gravel micaceous, dry, orange-brown	I		SWL 90'
898.5	120					N= 100/18
		ML to SP	Sandy SILT with interbeds of clean SAND	I		8-9-72
						8-11-72
	130					SWL 92
						SWL 101 8-14-72
						SWL 100
						8-15-72
	140					
875						8-16-72
		GP	Sandy GRAVEL clean, water bearing > 50 GPM			N = 285 Blows; no recovery
868.5	150					SWL 137 8-17-72
		SM	Silty SAND, light brown, water bearing	I		SWL 85.7
864.5						SWL 98.2 8-18-72
		GM	Silty GRAVEL, with sand, brown	I		SWL 85.7 N= 300/7
	160					SWL 97.5 8-21-72
						SWL 85.7
855						
		SP	Gravelly SAND with cobbles and boulders, brown	I		N= 100/12
	170					SWL 101 8-22-72
						SWL 86'
						SWL 100 8-23-72
						SWL 88'
841	180	SP	SAND, clean, fine to coarse, water bearing	I		N= 75/18
832						8-24-72
	190	SM	Silty SAND, with some gravel, brown-gray			SWL 88'
						Hole heaved badly @ 188'. Sand heaved inside casing to 141'.
819	200					

ENG FORM 1836-A (ER 1110-1-1801) GPO 1980 OF - 620-903

PROJECT: Chief Joseph Dam | HOLE NO. 72-D-352A

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE 1019 **Hole No.** 72-D-352A

PROJECT Chief Joseph Dam | INSTALLATION NPS | SHEET 3 OF 3 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
819	200	SM	Silty SAND, with trace of small gravel, brown-gray			SWL 119'
						SWL 87'
	210					Hole heaved badly from 200'-250'
808		SP	Gravelly SAND, water bearing gray-brown			SWL 97.5' 8-28-72
	220					SWL 97'
799		GM	Silty Sandy GRAVEL, compact to loose, gray-brown	I		N= 55/18
793		GP to GM	Interbeds of clean, Sandy GRAVEL w/ Silty GRAVEL			SWL 91.6' 8-29-72
	230			I		SWL 87.4'
						N= 66/24
				I		N= 42/22
778.5	240	SP	Gravelly SAND, clean, water bearing			SWL 92.6' 8-30-72
						SWL 86'
						N= 250/22
769	250	GM	Sandy Silty GRAVEL with clay and cobbles	I		SWL 89.6' 8-31-72
						SWL 87.7'
	260			I		N=142/18
						SWL 93.5 9-1-72
750			Top of Bedrock	I		SWL 88'
	270		Granodiorite			N= 250/2
746				R		N= 400/0 refusal
			Bottom of Hole @ 273'			9-4 to 9-14-72 - Fished Lost tools and seated casing @ 269'
	280					NOTE: Sand entered hole around casing shoe - Back filled with gravel to 268'. Placed grout cap on gravel to 240'. Cleaned out grout to 263'.
	290					

ENG FORM 1836-A (ER 1110-1-1801) GPO 1980 OP - 620 - 603

PROJECT Chief Joseph Dam | HOLE NO. 72-D-352A

Hole No. 72-D-353A

DRILLING LOG	DIVISION NPD	INSTALLATION NPS	SHEET 1 OF 3 SHEETS
1. PROJECT: CHIEF JOSEPH DAM		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station): N 366,600 E 2,294,795		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY: SMITH DRILLING & ASSOC.		12. MANUFACTURER'S DESIGNATION OF DRILL: CP-650 AIR ROTARY & STAR 71 CABLE TOOL	
4. HOLE NO. (As shown on drawing Title and File number): 72-D-353A		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 9	UNDISTURBED
5. NAME OF DRILLER: CARL SMITH		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED 0 DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE: STARTED 24 AUG 1972	COMPLETED 13 MAR 1973
7. THICKNESS OF OVERBURDEN: 228		17. ELEVATION TOP OF HOLE: 979.5	
8. DEPTH DRILLED INTO ROCK: 12		18. TOTAL CORE RECOVERY FOR BORING: X	
9. TOTAL DEPTH OF HOLE: 240		19. SIGNATURE OF INSPECTOR: D. KELLUM	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	X CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
979.5	0	SM	Silty SAND w/ gravel and cobbles			Hole drilled w/ CP-650 Air Rotary to 105 ft. Churn Drill Star-71 drilled from 105 to 240'.
976.5			Sandy Gravelly SILT, w/ num. cobbles & boulders very dense, dry, gray. Deposit contains local thin Layers of clean sand w/ gravel-can contain perched water.	I		
	10					
	20					
	30			I		Local sand layer- Hole making water: approx. 1 gpm.
	40					
		ML				
	50			I		
	60					Hole Blown Dry 8-8-72
						S.W.L. 34.2 ft
	70					
	80					
	90					
879.5	100					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT: Chief Joseph Dam | HOLE NO. 72-D-353A

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 979.5 | Hole No. 72-D-353A

PROJECT: Chief Joseph Dam | INSTALLATION: NPS | SHEET 2 OF 3 SHEETS

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
879.5	100	ML	Bottom of Glacial Till			S.W.L. 58'
			Clayey Silty SAND, w/ num. angular basalt cobbles and boulders; water bearing.	I		S.W.L. 78.2 11-7 72
						S.W.L. 66.5
	110					S.W.L. 75' 11-8-72
				I		S.W.L. 66.8 11-9-72
						S.W.L. 57.3 11-10-72
	120	SM				S.W.L. 61.7'
						11-11 to 11-21-72
	130					S.W.L. 62' 11-22 to 11-27-72
						11-28 to 12-2-72
839.5	140	ML	Clayey SILT, w/ minor sand soft, black.			S.W.L. 56.5'
834.5		SP	Gravelly SAND, coarse, tan.			Easy drilling to 149'. Hole caved to 141'. 12-3-72
	150					S.W.L. 60.5' 12-5-72
827.5		ML	Sandy SILT w/ gravel, gray			
	160					S.W.L. 61' 12-6-72
818.0		SM	Silty SAND w/ gravel	I		
						S.W.L. 58.4' 12-7 to 12 15-72
809.5	170	GP	GRAVEL with cobbles and boulders.	H		S.W.L. 57.6' Hole caving below casing
801.5						S.W.L. 58.5' 12-16-72
	180	SM	Silty SAND, fine to coarse, tan	I		12-17 to 2-28-73
	190					S.W.L. 65' 3-2-73
						S.W.L. 66.8'
						S.W.L. 78.4' 3-3-73
779.5	200					

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

PROJECT: Chief Joseph Dam | HOLE NO. 72-D-353A

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE: 979.5 | Hole No. 72-D-353A

PROJECT: Chief Joseph Dam | INSTALLATION: NPS | SHEET 3 OF 3 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)
779.5	200		Silty SAND with occas. gravel, sd-f. to c., tan			
						Hole caves and heaves 3-5-73
	210	SM				S.W.L. 62.6'
						S.W.L. 59.3' 3-6-73
						S.W.L. 63.5'
	220					3-7 to 3-8-73
						S.W.L. 61.5' 3-9-73
751.0			TOP of BEDROCK			
	230		Granodiorite	H		S.W.L. 56' 6" csng seated in rock @ 228.1'
						S.W.L. 60.4'
						3-13-73
739.5	240		Bottom of hole @ 240'			

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

PROJECT: Chief Joseph Dam | HOLE NO. 72-D-353A

Hole No. 72-D-354

DRILLING LOG

DIVISION: NPD	INSTALLATION: NPS
	SHEET 3 OF 3 SHEETS
1. PROJECT: Chief Joseph Dam	10. SIZE AND TYPE OF BIT: 8" button bit; 6" bit
2. LOCATION (Coordinates or Station): N 366,725 E 2,294,755	11. DATUM FOR ELEVATION SHOWN (USGS or MSL):
3. DRILLING AGENCY: Smith Drilling & Assoc.	12. MANUFACTURER'S DESIGNATION OF DRILL: CP-650 Air Rotary; Star 71 Cable Tool
4. HOLE NO. (As shown on drawing title and file number): 72-D-354	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER: Carl Smith	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 14 Aug 1972 COMPLETED 13 March 1973
7. THICKNESS OF OVERBURDEN: 289.0	17. ELEVATION TOP OF HOLE: 1032
8. DEPTH DRILLED INTO ROCK: 19.5	18. TOTAL CORE RECOVERY FOR BORING: %
9. TOTAL DEPTH OF HOLE: 308.5	19. SIGNATURE OF INSPECTOR: D. Kellum

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
1032	0	GM	Silty Sandy GRAVEL, tan			Hole drilled with CP-650 Air Rotary to 100'. Star 71 Cable Tool used from 100' - 308.5'
1029			Sandy Gravelly SILT, with numerous cobbles and boulders, very dense, basaltic, dark gray			NOTE: N= blow counts / inches driven
	10					
	20			I		SWL dry 8-14-72
		ML				SWL dry
	30					
	40					
	50			I		
	60					SWL dry 8-15-72
						SWL dry 8-16-72 & 8-17-72
						SWL 61'
	70					
	80					
	90					NOTE: 8-21-72 WL was 65' with hole depth @ 95'. Water source may be perched zone @ 60'
932	100					SWL 93.5' 8-18-72

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Chief Joseph Dam HOLE NO: 72-D-354

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 1032 | **Hole No.** 72-D-354

PROJECT Chief Joseph Dam | INSTALLATION NPS | SHEET 2 OF 3 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
932	100		Sandy Gravelly SILT, with numerous cobbles and boulders, very dense, dark gray	I		SWL 61' N= 125/12 Reamed hole 10-20 to 10-24-72
	110	ML				N= 300/18 10-25-72
				I		SWL 68'
	120			I		N= 175/12 SWL 82' 10-26/27-72 SWL 78.5'
						SWL 115.6' 10-30-72 SWL 115'
	130	ML				SWL 74' 10-31-72 SWL 72'
						SWL 88.5' 11-1-72
				I		SWL 88.5' N= 225/11
885.5	140					SWL 83.8' 11-2-72
	150	GP	Basalt Boulder, very dense, dark gray			SWL 105' SWL 90' 11-3-72
878						SWL 88' SWL 117' 11-6-72
	160	SC	Silty Clayey SAND with cobbles and boulders, very dense, dark gray	I		SWL 108' N= 280/20 SWL 130' 11-7-72
867						SWL 107.5'
	170	SM	Silty SAND w/ scattered gravel, moist dense, water bearing, tan			Hole began to heave SWL 132' 11-8-72
				I		SWL 128'
853	180					N= 175/18 SWL 140 11-9-72
849		SC	Clayey Silty SAND, dense, gray			
845		GM	Silty Sandy GRAVEL, very dense, gray	I		N= 500/9 SWL 107' 11-10-72
	190	SC	Clayey Silty SAND w/ minor gravel, yellow			SWL 107' SWL 181.5 11-13/19- 72
839						N= 247/12 11-20-72
		GM	Silty Sandy GRAVEL w/ cobbles very dense, tan	I		SWL 108' SWL 114.3' 11-21-72
832	200					

ENG FORM 1836-A (ER 1110-1-1801) OPO 1980 O-F-686-969

PROJECT Chief Joseph Dam | HOLE NO. 72-D-354

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE 1032 **Hole No.** 72-D-354

PROJECT: Chief Joseph Dam | INSTALLATION: NPS | SHEET 3 OF 3 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV. ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
832	200	GM	Silty Sandy GRAVEL w/ cobbles, very dense, tan	I		N= 245/12 SWL 112.2' 11-26-72
	210					
817						SWL 126.3 12-21-72
		SM	Silty SAND w/ small gravel sones, moist, dense, tan	I		SWL 128 N= 210/18 2-9-73 SWL 128.5 2-10-73 SWL 128.7' 2-12-73 SWL 129.1' 2-13-73
803	230	GM	Silty Sandy GRAVEL w/ trace of clay	I		SWL 130 2-14-73 SWL 114.7' 2-15-73 N= 295/18 SWL 108.5 2-16-73 SWL 115' 2-17-73
792	240	SM	Silty SAND W/ small gravel			SWL 107' Heaving problems from 225'-240' & 265'285'
	250					SWL 115' 2-19-73 SWL 108.2'
	260					SWL 112.8' 2-20-73 SWL 110.5'
767						SWL 115' 2-21-73 N= 310/18
	270	GM	Silty Sandy GRAVEL with cobbles	I		SWL 112.5 2-22-73 SWL 118.4' 2-23-73 SWL 110.8' 2-26-73 SWL 113' 2-27-73 SWL 105.5'
	280					SWL 114.9' 2-28-73 SWL 105.6'
						SWL 108.9' 3-1-73
743	290		Top of Bedorck Granodiorite	=		N= 120/3 3-2 to 3-13-73 Drilled bedrock and seated casing @ 289.6'
	300					
723.5	310		Bottom of hole @ 308.5'			

ENG FORM 1836-A (ER 1110-1-1801) OPO 1980 OP - 620 - 503 PROJECT: Chief Joseph Dam HOLE NO. 72-D-354

PROJECT	Chief Joseph Dam	HOLE NO.	74-RD-355
LOCATION	Powerhouse	INSPECTOR	Zirkle
DEPTH OF HOLE	97.8	CONTRACTOR	Government
DEPTH OF O.B.	71.2	DATE STARTED	1 March 74
ROCK DRILLED	26.6	DATE COMPLETED	6 March 74
% CORE RECOVERED	100	SURFACE EL.	810.0
DIAM. HOLE	4" in O.B., 3" Core	N 365,719	E 2,291,334
EQUIPMENT	Sprague & Henwood Diamond Drill 43.4		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 100 0 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Day, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Field Data, etc.)
810.0	0				
	10	GP		Sandy Gravel w/ numerous cobbles (5"), loose, brown to gray (Fill)	
	20	GM	I	Silty Sandy Gravel w/ few cobbles, dense to very dense, brown	
		SP	I	Sand w/ gravel, dense to very dense, brownish-gray	
	30		I		WL. 32.0' 6 Mar. 74
		SP-SM	I	Silty Sand, dense to very dense, brownish-gray	
	40		I		
			I		
	50		I		
		ML	I	Silt, hard, brown	
	60	GM		Silty Sandy Gravel w/ blocks (20"), dense, brown	
		SP		Sand w/ gravel, dense gray	
738.8	70			TOP BEDROCK	
				GRANITE, light, hard	NX CORE below 71.2'. Most core lengths 0.1-1.3'; from 77.2'-78.0', pieces 1/4". Water return 100%
	80	DIKE		DIKE, dark, hard CONTACTS dip 70 degrees	
	90			GRANITE, light, hard 1/8" Gauge	Installed 1" pvc piezometer pipe perforated 45'-65'.
712.2	100			Bottom of Boring @ 97.8'	

PROJECT	Chief Joseph Dam	HOLE NO.	73-RD-356
LOCATION	Powerhouse	INSPECTOR	Zirkle, Eckerlin
DEPTH OF HOLE	119.6	CONTRACTOR	Government
DEPTH OF O.B.	93.0	DATE STARTED	12 December 73
ROCK DRILLED	26.6	DATE COMPLETED	10 January 74
% CORE RECOVERED	100	SURFACE EL.	810.5
DIAM. HOLE	4"	N 365,740	E 2,291,300
EQUIPMENT	Sprague & Henwood Diamond Drill 43.3		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
810.5	0				
	10	GM		Silty Sandy Gravel w/ numerous cobbles (10"), boulders (24") and blocks (24"), loose, brown (Fill)	
	20				
	30	SM	88 72 76	Silty Sand w/ gravel, very dense, brown	
	40				
	50	ML	70 89 68 144 146	Sandy Silt, very dense, gray	
	60				
	70	GM	141 136	Silty Sandy Gravel w/ occasional cobbles (5"), very dense, bluish gray	
	80	SP	164 195	Sand w/ gravel, very dense, gray	
	90	GM		Silty Sandy Gravel w/ occasional cobbles (4"), very dense, gray	
717.5				GRANITE, light, hard	NX CORE Core lengths 0.05' to 1.0'
	100			DIKE, dark, hard	Water return 100%

PROJECT Chief Joseph Dam HOLE NO. 73-RD-356

LOCATION Powerhouse SN 2 of 2

ELEVATIONS	DEPTH 100'	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS Soils Classification Plasticity Condition Moisture Color	REMARKS Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Rec, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Field Data, etc.
	110			DIKE, dark, hard	
690.9	120			GRANITE, light, hard	
				Bottom of Boring @ 119.6'	Installed two 1" pvc piezometer pipes - perforated 36'-46' and 83'-93'.

SN ___ of ___

PROJECT	Chief Joseph Dam	HOLE NO.	73-RD-357
LOCATION	Powerhouse	INSPECTOR	Zirkle, Eckerlin
DEPTH OF HOLE	114.3	CONTRACTOR	Government
DEPTH OF O.B.	88.5	DATE STARTED	15 November 73
ROCK DRILLED	25.8	DATE COMPLETED	8 December 73
% CORE RECOVERED	98.5	SURFACE EL.	810.9
DIAM. HOLE	4"	N 365,740	E 2,291,250
EQUIPMENT	Sprague & Henwood Diamond Drill 43.4		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0-100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
810.9	0				
	10	GP		Sandy Gravel w/ occasional blocks (24"), loose, gray (Fill)	
	20	GP	I 72	Sandy Gravel w/ numerous cobbles, very dense, grayish-black	
			I 92		
	30	GM	I	Silty Sandy Gravel, very dense, gray	WL. 30.0' 8 Dec. 73
			I 89		
	40	SP-SM	I 38	Silty Sand, dense, grey	
	50	GP	I	Sandy Gravel, very dense, gray	
			I		
		SP		Sand, dense, gray	
		SP	I	Gravelly Sand, dense, gray	
	60	ML	I 113	Sandy Silt, dense, brownish-gray	
		SP	I 80	Sand, very dense, gray	
	70	GP		Sandy Gravel, very dense	
			I 112		
		SP		Sand w/ some gravel and occasional cobbles, very dense, gray	
	80				
		GP		Sandy Gravel w/ occasional cobbles (6"), dense, gray	
722.4	90			DIKE, dark, hard	NX CORE Core lengths 0.1'-3.5' Water return 50 to 100%
	100				

PROJECT Chief Joseph Dam HOLE NO. 73-RD-357

LOCATION Powerhouse SH 2 of 2

ELEVATIONS	DEPTH IN 100	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS Soils Classification Plasticity Condition Moisture Color	REMARKS Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Pwp, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.
	110			DIKE as above	
696.6					
	120			Bottom of Boring @ 114.3'	Installed two 1" pvc piezometer pipes, perforated 41-51' and 82'-92'.

SH ___ of ___

PROJECT	Chief Joseph Dam	HOLE NO.	73-CD-358
LOCATION	Powerhouse	INSPECTOR	Zirkle, Johnson
DEPTH OF HOLE	91.0	CONTRACTOR	Floyd's Well Drilling
DEPTH OF O.B.	85.0	DATE STARTED	23 January 74
ROCK DRILLED	6.0	DATE COMPLETED	14 February 74
% CORE RECOVERED	———	SURFACE EL.	810.9
DIAM. HOLE	12"	N 365,740-	E 2,291,235
EQUIPMENT	Bucyrus Erie Churn Drill 22 W		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
810.9	0				
	10	GP		Sandy Gravel w/ numerous cobbles (12"), occasional boulders (15") and blocks (36"), loose to dense, gray to brown (Fill)	
	20	GP		Sandy Gravel w/ scattered cobbles (10"), loose to dense, brown	
	30	SM		Silty Sand, dense, brown	WL. 29.7' 15 Feb. 74
		SW-SM		Si Gr Sand, very dense, brown	
	40	SP		Sand, medium dense to dense, brown	
		SP		Gravelly Sand, dense, brown	
	50	GP-GM		Silty Sandy Gravel, dense brown	
		SM		Silty Sand, dense to very dense, brown to gray	
	60	ML		Sandy Silt, dense to very dense, brown to gray	
	70				Installed 10" steel well screen 75-85'. Unable to develop well due to infiltration of fine sand.
		GP		Sandy Gravel, brownish gray	
		SW-SM		Gr, Si Sand, very dense, brown	
	80	GP		Sandy Gravel, grayish brown	
		GM		Silty Sandy Gravel, ver, dense, gray	
725.9		GP		Sandy Gravel, very dense, gray	Installed 6" pvc slotted well screen 25'-85', backfilled w/ concrete sand as 12" casing was withdrawn.
719.9	90			GRANITE	
				Bottom of Boring 91.0'	Pumped ± 21 GPM for 8 hours. Maximum drawdown in well ± 50'.
	100				

PROJECT	Chief Joseph Dam	HOLE NO.	73-RD-359
LOCATION	Powerhouse	INSPECTOR	Zirkle
DEPTH OF HOLE	125.2	CONTRACTOR	Government
DEPTH OF O.B.	95.0	DATE STARTED	16 November 73
ROCK DRILLED	30.2	DATE COMPLETED	21 November 73
% CORE RECOVERED	100	SURFACE EL.	810.3
DIAM. HOLE	4"	N 365,740	E 2,291,175
EQUIPMENT	Sprague & Henwood Diamond Drill 43.4		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0-100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
810.35	0				
	10	GP		Sandy Gravel w/ numerous cobbles (8") and occasional boulders & blocks, loose, gray (Fill)	
	20	GP		Sandy Gravel w/ numerous cobbles (8"), dense to very dense, gray	
	30	SP		Sand, very dense, brownish gray	WL 29.2 21 Nov. 73
	40	GP		Sandy Gravel , dense to very dense, gray to grayish brown	
	50				
	60	SW		Gravelly Sand, very dense, gray	
	70				
	80	SM		Silty Sand, very dense, grayish brown	
	90	SP		Gravelly Sand, very dense, grayish brown	
715.3		GP		Sandy Gravel, very dense, gray	
	100			GRANITE, light; with DIKES, dark and light; all hard	NX CORE Core pieces 0.1' to 2' Water return 100%

PROJECT Chief Joseph Dam HOLE NO. 73-RD-359

LOCATION Powerhouse SH 2 of 2

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS Soils Classification Plasticity Condition Moisture Color	REMARKS Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Pwr, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.
	100			Rock as above	
	110				
	120			— 1/8" gauge	
685.1					
	130			Bottom of Boring @ 125.2'	Installed 1" pvc piezometer pipe, perforated 77'-97'.

SH ___ of ___

PROJECT	Chief Joseph Dam	HOLE NO.	74-RD-360
LOCATION	Powerhouse	INSPECTOR	Zirkle
DEPTH OF HOLE	136.4	CONTRACTOR	Government
DEPTH OF O.B.	110.0	DATE STARTED	14 January 74
ROCK DRILLED	26.4	DATE COMPLETED	23 January 74
% CORE RECOVERED	100	SURFACE EL.	810.2
DIAM. HOLE	4"	N 365,740	E 2,291,125
EQUIPMENT	Longyear Diamond Drill Truck Mounted		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
810.2	0				
	10	GP		Sandy Gravel w/ numerous cobbles (6"), loose, brown (Fill)	
	20	GP		Sandy Gravel w/ occasional cobbles (8"), dense to very dense, gray to brown	WL. 33.0' 24 Jan. 74
	30				
	40	SP-SM		Silty Gravelly Sand, very dense, gray	
	50	SP-SM		Silty Gravelly Sand, very dense, brown	
	60	GW		Sandy Gravel, very dense, gray	
	70	SP		Gravelly Sand, dense to very dense, gray	
	80	ML-SM		Sandy Silt, very dense, brown and Silty Sand	
	90	GP		Sandy Gravel, very dense, gray	
	100	SP		Sand, dense, gray	

PROJECT Chief Joseph Dam HOLE NO. 74-RD-360

LOCATION Powerhouse SH 2 of 2

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
	100	GP	I	Sandy Gravel w/ numerous cobbles, dense to very dense, gray	
700.2	110	SP		Sand w/ gravel, dense, gray	
	120			GRANITE, light, hard w/ DIKES, dark, hard 0.4' fault breccia	NX CORE Core lengths 0.05'-1.8' Water return 100%
673.8	130				
	140			Bottom of Boring @ 136.4'	Installed two 1" pvc piezometer pipes, perforated 40'-50' and 95'-105'.

SH ___ of ___

PROJECT	Chief Joseph Dam	HOLE NO.	74-RD-361
LOCATION	Powerhouse	INSPECTOR	Zirkle
DEPTH OF HOLE	118.1	CONTRACTOR	Government
DEPTH OF O.B.	92.9	DATE STARTED	1 February 74
ROCK DRILLED	25.2	DATE COMPLETED	8 February 74
% CORE RECOVERED	96.8	SURFACE EL.	810.3
DIAM. HOLE	4"	N 365,700	E 2,290,990
EQUIPMENT	Sprague & Henwood Diamond Drill 43.4		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0-100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
810.3	0				
	10	GP		Sandy Gravel w/ cobbles (12") and occasional blocks (36"), loose, gray (Fill)	
	20	GP	I I I	Sandy Gravel w/ scattered cobbles, dense to very dense, gray	
	30	GP		Sand Gravel, very dense, brown	WL. 28.2 8 Feb. 74
	40	SP	I	Sand w/ gravel, very dense, gray	
	50	GP	I I I I	Sandy Gravel, very dense, gray	
	60				
	70	SP	I I I	Gravelly Sand, very dense, gray	
	80				
	90	GP	I I I	Sandy Gravel, very dense, gray	
717.4	100	DIKE		GRANITE, light, hard with minor Dike, dark, hard	NX CORE Core lengths 0.05'-2.0' Water return 100%

PROJECT Chief Joseph Dam HOLE NO. 74-RD-361

LOCATION Powerhouse SH 2 of 2

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS Soils Classification Plasticity Condition Moisture Color	REMARKS Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Hrs, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.
	100			ROCK as above	
	110				
692.2	120			Bottom of Boring @ 118.1	Installed two 1" pvc piezometer pipes, perforated 45'-55' and 80'-90'.

SH ___ of ___

PROJECT	Chief Joseph Dam	HOLE NO.	74-RD-362
LOCATION	Powerhouse	INSPECTOR	Zirkle
DEPTH OF HOLE	136.2	CONTRACTOR	Government
DEPTH OF O.B.	106.4	DATE STARTED	21 January 74
ROCK DRILLED	29.8	DATE COMPLETED	30 January 74
% CORE RECOVERED	100	SURFACE EL.	809.9
DIAM. HOLE	4"	N 365,660	E 2,290,960
EQUIPMENT	Sprague & Henwood Diamond Drill 43.4		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
809.9	0				
	10	GP		Sandy Gravel w/ numerous cobbles (8"), loose to dense, gray	
	20				
	30				WL. 24.8' 31 Jan. 74
	40	GP		Sandy Gravel, dense, gray	
	50	SP		Gravelly Sand, dense brown	
		GP		Sandy Gravel, very dense, gray	
	60	SP-SM		Silty Gravelly Sand, very dense, brown to gray	
	70				
	80	GP		Sandy Gravel, dense to very dense, gray to brown	
	90				
	100				

PROJECT Chief Joseph Dam HOLE NO. 74-RD-362

LOCATION Powerhouse SH 2 of 2

ELEVATIONS	DEPTH in 100	GRAPHIC LOG	CORE % 0-100 / BLOWS/FT	DESCRIPTION OF MATERIALS Soils Classification Plasticity Condition Moisture Color	REMARKS Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Res, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Field Data, etc.
703.5	110			GRANITE, light, hard w/ DIKE, dark, hard	NX CORE Core lengths 0.1'-3.0' Water return 100%
	120				
	130				
673.7	140			Bottom of Boring @ 136.2'	Installed two 1" pvc piezometer pipes perforated 35'-40' and 70'-90'.

SH ___ of ___

PROJECT	Chief Joseph Dam	HOLE NO.	73-RD-363
LOCATION	Powerhouse	INSPECTOR	Zirkle, Eckerlin
DEPTH OF HOLE	140.9	CONTRACTOR	Government
DEPTH OF O.B.	112.0	DATE STARTED	24 November 73
ROCK DRILLED	28.9	DATE COMPLETED	11 December 73
% CORE RECOVERED	100	SURFACE EL.	810.0
DIAM. HOLE	4"	N 365,606	E 2,290,940
EQUIPMENT	Sprague & Henwood Diamond Drill 43.4		

ELEVATION 810.0	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
	10	GP		Sandy Gravel w/ occasional cobbles (4"), and numerous blocks (12"), loose, gray to brown (Fill)	
	20	GP-GM	I	Sandy Gravel w/ silt and occasional cobbles (6") and blocks (16"), very dense, brownish gray	WL. 22.0' 12 Dec. 74
	30	SP-SM	I 16	Gravelly Sand w/ silt, medium dense to very dense, grayish blue	
			I 55		
	40	GP	I	Sandy Gravel w/ numerous cobbles (6"), dense to very dense, grayish brown	
	50		I		
			I 32		
	60		I 65		
			I 75		
	70	GP	I 143/0.8	Sandy Gravel w/ cobbles and boulders, very dense, gray	
			50/0.2		
	80	GP		Sandy Gravel, dense to very dense, grayish brown	
			74/0.5		
			I 115		
	90	SM		Silty Sand, very dense, gray	
		GM	I 155	Silty Sandy Gravel, dense, brownish gray	
	100	SP-SM		Sand w/ silt, medium dense, brownish gray	

PROJECT Chief Joseph Dam HOLE NO. 73-RD-363

LOCATION Powerhouse SH 2 of 2

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0-100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Rec. Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water C[illegible] Drilling Fluid Data, etc.)
	100				
	110	GP		Sandy Gravel w/ blocks (21"), dense, gray	
698.0					
	120			GRANITE, light, hard with DIKE, dark, hard	NX CORE Core lengths 0.1'-4.5' No water retrun to 122' w/ loss at bottom of casing. Reamed casing to 112' and got full water return
	130			DIKE, dark, hard	
669.1	140			Bottom of Boring @ 140.9'	Installed 1" pvc pipe perforated 60'-80'.
	150				

SH ___ of ___

PROJECT	Chief Joseph Dam	HOLE NO.	74-CD-364
LOCATION	Powerhouse	INSPECTOR	Zirkle, Johnson, Eckerlin
DEPTH OF HOLE	112.0	CONTRACTOR	Floyd's Well Drilling
DEPTH OF O.B.	110.0	DATE STARTED	19 February 74
ROCK DRILLED	2.0	DATE COMPLETED	23 March 74
% CORE RECOVERED	——	SURFACE EL.	810.0
DIAM. HOLE	12"	N 365,619	E 2,290,945
EQUIPMENT	Bucyrus Erie Churn Drill 22 W		

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Additives, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Rec. Drilling Time, Size & Type of Bit, Arrive of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
810.0	0				
	10	GM		Silty Sandy Gravel w/ numerous boulders and blocks (48"), loose, gray (Fill)	
	20	GM		Silty Sandy Gravel w/ numerous cobbles (10"), medium dense, brown	
		SP		Gravelly Sand, dense, brownish gray	
		GP		Sandy Gravel, dense, gray	
	30	GC		Clayey Sandy Gravel, very dense, gray	WL. 31.0' 23 Mar. 74
		GP		Sandy Gravel w/ scattered cobbles, dense to very dense, gray	
	40	SM		Silty Gravelly Sand, dense, gray	
		SP		Gravelly Sand, dense, gray	
	50	GP GM		Silty Sandy Gravel w/ occasional cobbles (5"), dense, gray	
		SP SM		Silty Gravelly Sand, loose, gray to brown	
	70	SM		Silty Sand w/ gravel, very dense, brownish gray	
		GP		Sandy Gravel, very dense, grayish brown	
		GP-GM		Silty Sandy Gravel, very dense, brownish gray	
	80	SP		Sand, dense, brownish gray	
	90	GM		Sandy Gravel, dense, brownish gray to brown	
	100	GP		Sandy Gravel, very dense, brown	

PROJECT Chief Joseph Dam HOLE NO. 74-CD-364

LOCATION Powerhouse SH 2 of 2

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
	100	GM	L	Silty Sandy Gravel, brown	
		SP		Gravelly Sand, brown	
700.0	110	GP		Sandy Gravel w/ boulders (18'	
698.0				GRANITE	
				Bottom of Boring 112.0	Installed 10" Dia pvc Well Screens (0.1" slots) 45'-55' and 75'-85'. Pumped 1350 GPM for 9 hours. Maximum well drawdown 16 feet.
	120				

SH ___ of ___

PROJECT	Chief Joseph Dam	HOLE NO.	73-RD-365
LOCATION	Powerhouse	INSPECTOR	Zirkle
DEPTH OF HOLE	102.1	CONTRACTOR	Government
DEPTH OF O.B.	75.0	DATE STARTED	13 December 73
ROCK DRILLED	27.1	DATE COMPLETED	18 January 74
% CORE RECOVERED	99.3	SURFACE EL.	809.8
DIAM. HOLE	4"	N 365,548	E 2,290,942
EQUIPMENT	Sprague & Henwood Diamond Drill 43.4		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Why, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Lost or Return, Water Color, Drilling Fluid Data, etc.)
809.8	0	GM		Silty Sandy Gravel w/ numerous cobbles (12") and boulders, loose, brownish gray (Fill)	
	10	GP		Sandy Gravel w/ scattered cobbles (8"), medium dense, grayish brown	
		SM		Silty Sand, dense, brownish gray	
	20				WL. 25.0' 19 Jan. 74
	30	GP		Sandy Gravel w/ numerous cobbles (12") and boulders, very dense to loose, gray	
	40				
		SP		Sand, dense, gray	
	50				
	60	GP		Sandy Gravel, dense to very dense, brown to gray	
	70				
734.8				GRANITE, light, hard	NX CORE Water return Installed two 1" pvc piezometer pipes perforated 30-40' and 47'-67'
	80				
	90				
707.7	100			Bottom of Boring 102.1'	

PROJECT	Chief Joseph Dam	HOLE NO.	74-RD-366
LOCATION	Powerhouse	INSPECTOR	Zirkle
DEPTH OF HOLE	113.6	CONTRACTOR	Government
DEPTH OF O.B.	85.2	DATE STARTED	12 February 74
ROCK DRILLED	28.4	DATE COMPLETED	21 February 74
% CORE RECOVERED	87.3	SURFACE EL.	817.2
DIAM. HOLE	4"	N 365,465	E 2,290,881
EQUIPMENT	Sprague & Henwood Diamond Drill 43.4		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
817.2	0				
	10	GP		Sandy Gravel w/ numerous cobbles and blocks (3-4"), loose, gray (Fill)	
	20	SP	I I	Gravelly Sand, loose, gray to brown	
	30				WL, 31.2' 21 Feb. 74
	40	GP	x x	Sandy Gravel, very dense, gray	
	50				
	60	GP		Sandy Gravel w/ cobbles, very dense, grayish black	
		SP		Sand, dense, grayish black	
	70	GP		Sandy Gravel, very dense, grayish black	
	80	SP	x	Sand, dense, brownish gray	
		GP		Sandy Gravel, very dense, brown	
732.2				GRANITE, light, hard w/ gouge	NX CORE below Core lengths 0.2'-0.4' Core lengths 1'8"-0.2' caves 100% water return
	90				
	100				

PROJECT Chief Joseph Dam HOLE NO. 74-PD-366

LOCATION Powerhouse Sh 2 of 2

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing, Depth of Hole at Start, Depth to Water Level at Start, Time Spent Drilling, Drill Rate, Loss or Return Water, Fluid Type, etc.)
	100			GRANITE, light, hard	Core lengths 0.1'-9.8'
	110				
703.6				DIKE, dark, hard, 12"	
				GRANITE, light, hard	
				Bottom of Boring 113.4'	Installed two 1" pvc piezometer pipes, perforated at 65-75' and 45-55'.
	120				

PROJECT	Chief Joseph Dam	HOLE NO.	74-RD-367
LOCATION	Powerhouse	INSPECTOR	Zirkle
DEPTH OF HOLE	94.2	CONTRACTOR	Government
DEPTH OF O.B.	67.2	DATE STARTED	22 February 74
ROCK DRILLED	27.0	DATE COMPLETED	27 February 74
% CORE RECOVERED	95.2	SURFACE EL.	822.8
DIAM. HOLE	4"	N 365,390	E 2,290,935
EQUIPMENT	Sprague & Henwood Diamond Drill 43.4		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0-100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Density (D), Consistency, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at start & End of Shift, Water Level at start & End of Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Add'd, Drilling Fluid Data, etc.)
822.8	0				
	10	GM		Silty Sandy Gravel w/ numerous cobbles (12"), loose, brownish gra	
		GP		Sandy Gravel, loose, gray	
	20	GP		Sandy Gravel w/ cobbles, loose, gray	
	30	SP		Gravelly Sand, medium dense to dense, gray	
	40	SP		Gravelly Sand w/ scattered cobbles and blocks, dense, gray	WL. 35.8 28 Feb. 74
	50				
	60	GP		Sandy Gravel, dense to very dense, gray	
755.6	70			GRANITE, light, hard Gouge 0.2' Gouge 0.1'	NX CORE Core lengths 1/10"-1.3' Water return 100%
	80				
	90				
728.6	100			Bottom of Boring 94.2'	Installed 2-1" pvc piezometer pipes, perforated at 55'-65' and 42-47'.

PROJECT	Chief Joseph Dam	HOLE NO.	74-RD-368
LOCATION	Powerhouse	INSPECTOR	Zirkle
DEPTH OF HOLE	122.7	CONTRACTOR	Government
DEPTH OF O.B.	97.0	DATE STARTED	25 January 74
ROCK DRILLED	25.7	DATE COMPLETED	6 February 74
% CORE RECOVERED	100	SURFACE EL.	810.2
DIAM. HOLE	4"	N 365,600	E 2,291,060
EQUIPMENT	Longyear Diamond Drill Truck Mounted		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit & Kind of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Cuttings, Fluid Loss, etc.)
810.2	0				
	10	GP		Sandy Gravel w/ scattered cobbles (8") and blocks, loose, gray	
	20	GP		Sandy Gravel, medium dense to very dense, gray	
	30				WL 30.4' 7 Feb. 74
		SP-SM		Silty Sand, very dense, brown to gray	
	40	GW		Sandy Gravel, very dense, brown	
	50	SM		Silty Sand, very dense, brown	
	60	GP		Sandy Gravel, very dense, gray	
	70				
		SP		Sand, dense, gray	
		SP		Gravelly Sand, very dense gray	
	80				
		SP-SM		Silty Gravelly Sand, very dense, brown	
	90				
		GP		Sandy Gravel, very dense, grayish brown	
713.2	100			GRANITE, light, hard	NX CORE Core lengths 1"-4.5' Water return 100%

PROJECT Chief Joseph Dam HOLE NO. 74-PD-368

LOCATION Powerhouse SH 2 of 2

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 100 0 / BLOWS /FT	DESCRIPTION OF MATERIALS Soils Classification Plasticity Condition Moisture Color	REMARKS Casing Depth, Depth of Hole at Start & End of Drill, Water Level at Start & End of Each Shift & Pwe, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.
	100			GRANITE as above	
				DIKE, dark, hard	
	110			GRANITE, light, hard	
	120				
687.5				Bottom of Boring @ 122.7'	Installed two pvc piezometer pipes perforated at 90-97' and 60'-70'.
	130				

SH ___ of ___

PROJECT	Chief Joseph Dam	HOLE NO.	74-RD-370
LOCATION	Powerhouse	INSPECTOR	Zirkle
DEPTH OF HOLE	67.8	CONTRACTOR	Government
DEPTH OF O.B.	42.5	DATE STARTED	8 February 74
ROCK DRILLED	25.3	DATE COMPLETED	12 February 74
% CORE RECOVERED	100	SURFACE EL.	796.2
DIAM. HOLE	4"	N 365,685	E 2,291,400
EQUIPMENT	Longyear Diamond Drill Truck Mounted		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Unified Classification, Density, Consistency, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Drill, Water Level at Start & End of Drill, Drilling Time, Size & Type of Bit, Type of Drill, Rate of Penetration, Water Loss or Return, Water Color, Fissures, Fluid Loss, etc.)
796.2	0				
	10	GP		Sandy Gravel w/ scattered cobbles (8"±) and blocks, loose, brown	
	20	SP		Gravell, Sand, loose, gray	Wtr. 14.9' 13 Feb. 74
		ML		Sa. Silt, dense, brown	
		ML		Silt, soft, tan	
	30	SM		Si. Sand, dense, gray	
	40	GP		Sandy Gravel w/ boulders and blocks, very dense, gray	
753.7				GRANITE, light, hard	NX CORE Core lengths 0.1'-1.0' Water return 100%
	50			Gouge 1/16", dip 85 degrees	
	60				Core lengths 0.1'-2.0'
728.4	70			Bottom of Boring 67.8'	

PROJECT	Tendon Hole Chief Joseph Dam	HOLE NO.	75-RD-2
LOCATION	STA 20+00 Monolith 8 Spillway 3	INSPECTOR	Zirkle
DEPTH OF HOLE	330.4	CONTRACTOR	Government
DEPTH OF CONCRETE	211.8	DATE STARTED	6 May 75
ROCK DRILLED	118.6	DATE COMPLETED	24 Jun 75
% CORE RECOVERED	75.8	SURFACE EL.	960.0
DIAM. HOLE	10.132 inches	N	E
EQUIPMENT	Failing Holemaster truck mount		

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
960.0 S					
959.4				0–0.6 ft. concrete w/rebar	14 3/8 in. calyx w/shot
	10				
	20				12 in. I.D. casing to 60 ft. grouted w/seal 1.5 ft. into concrete at top of ogee – seal broke loose and leaked throughout drilling.
	30			Air between bottom of roadway bridge deck and ogee of spillway.	
	40				
	50				At 60.0 ft. begin drilling w/10.132 in. single tube core barrel w/o core spring, fabrication by Corps of Engineers. Water circulation.
901.5				Top of ogee 58.5	
900.0	60		A	12 in. casing to 60.0	14 3/8 in. calyx w/shot
			B		
			C	Concrete	Runs A-D D10.7 C23.3 L8.4 D70.7
				3-inch aggregate.	W.L. 12 May 0.0
890.9	70		D	70.0 lift joint unbonded	W.L. 13 May 11.0
			E		Runs E-H D28.0 C23.3 L4.7 D93.7
	80		F		W.L. 17 May 66.2 W.L. 18 May 64.2
			G		20 May Water level drop 0 min W.L. 0.0 3 min W.L. 24.7 8 min W.L. 52.2 13 min W.L. 59.2
	90				
865.0			H	95.0 rebar and lift joint unbonded	W.L. 24 May 0.0
860.0	100		I	100.0 lift joint unbonded	W.L. 26 May 59.5

PROJECT Tendon Hole Chief Joseph Dam HOLE NO. 75-RD-2

LOCATION 4.67' D/S Axis STA 20+00 Mono 8 Spillway 3 SH 2 of 4

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
	100		I	Concrete	Runs I, J D20.3 C6.8 L13.5 D119.0 112.2 Gravity grouted 35 sacks
850.0	110		J	110.0 lift joint unbonded leaking	W.L. 29 May 0.0 W.L. 30 May 58.5
					Triconed with 9-7/8 in. bit 118.95 - 119.30 149.25 - 149.60
	120		K	Hole triconed ahead in black	Runs K, L D19.3 C19.3 L0.0 D138.6 Water level drop 59.0 - 100.4 approx 1 ft/min 138.6 gravity grouted 12 sacks sealed leak
832.0	130			130.0 lift joint unbonded w/gravel	upper gallery
830.0			L	pocket - leaking in gallery elev 832.0	
	140		M	Hole triconed ahead in black	W.L. 1 Jun 65.5 W.L. 2 Jun 69.3 Run M D10.7 C0.0 L10.7 D149.3
810.0	150		N	150.0 lift joint unbonded	W.L. 2 Jun 65.5 W.L. 3 Jun 69.3 W.L. 3 Jun 14.0 W.L. 4 Jun 64.0
800.0	160		O	160.0 lift joint unbonded	Runs N, O D11.7 C3.5 L8.2 D161.3
			P		Runs P, S D10.6 C10.6 L0.0 D172.0
			Q		
	170		R		
790.0			S	170.0 lift joint, unbonded	
			T		
785.0			U	175.0 lift joint unbonded	174.6 gravity grouted 10 sacks
780.0	180		V	180.0 lift joint unbonded	Runs T, W D25.8 C22.3 L3.5 D197.7 W.L. 7 Jun 0.0 W.L. 8 Jun Dry
770.0	190		W	190.0 lift joint unbonded Leaking in gallery elev 763.0 at 3.6 gpm	188.5 gravity grouted 12 sacks sealed leak in lower gallery
763.0	200		X		

SH 2 of 4

PROJECT Tendon Hole Chief Joseph Dam — HOLE NO. 75-Rd-2

LOCATION 4.67' D/S Axis STA 20+00 Mono 8 Spillway 3 — SH 3 of 4

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
	200		X		Runs X-AG D53.0 C47.7 L5.3 D250.6
748.2	210		Y	Top of bedrock 211.8	
			Y	Closely jointed zone	216.8 gravity grouted with 6 sacks
			Z		
			AA		
	220		AB		
			AC		W.L. 12 Jun 59.3
			AD		W.L. 13 Jun 81.1
	230		AE		Triconed with 9-7/8 in. bit 256.7 - 257.0 260.0 - 262.4 271.9 - 272.5 281.5 - 282.1 290.3 - 292.3
			AF		
	240				W.L. 13 Jun 0.0 W.L. 14 Jun 67.5
			AG		Run AH D6.1 C3.5 L2.6 D256.7
	250		AH	Hole triconed ahead in black	Run AI D3.1 C0.4 L2.7 D260.0 W.L. 14 Jun 0.0 W.L. 15 Jun 84.6 W.L. 15 Jun 0.0 W.L. 16 Jun 86.3
			AI		
	260			262.4 to 303.2 6X7 3/4" double tube standard core barrel w/core spring, reamed w/9 7/8 in tricone bit and reamed again w/10.132 in. core barrel	
697.6			AJ		Run AJ D9.5, C9.5 L0.0 D271.9
	270				
					Run AK D9.0 C9.0 L0.0 D281.5
	280		AK		281.5 gravity grouted 6 sacks
			AL		Run AL D8.2 C6.6 L1.6 D290.3
	290				
			AM		Run AM D9.5 C9.5 L0.0 D301.7
	300				

SH 3 of 4

PROJECT Tendon Hole Chief Joseph Dam HOLE NO. 75-RD-2

LOCATION 4.67' D/S Axis STA 20+00 Mona 8 Spillway 3 SH 4 of 4

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
656.8	300				W.L. 19 Jun 59.1
					W.L. 20 Jun 81.2
			AN	10.122 in. commercial single tube barrel w/core spring, bit cracked at 309.7	Runs AN, AO D6.5 C5.8 L0.7 D309.7
630.3	310		AO		
			AP	6X7 3/4" double tube standard core barrel w/core spring, reamed w/9 7/8 in. tricone bit, reamed again w/10.132 in. core barrel	Runs AP, AQ D16.1 C15.1 L1.0 D330.2
	320		AQ		
629.6	330				W.L. 32 Jun 0.0
627.3					W.L. 24 Jun 82.4
				Bottom of hole 332.7	

Triconed with 9-7/8 in. bit
301.7 - 303.2
309.7 - 313.9
321.2 - 321.4
330.2 - 332.7
Triconed core included in core loss

NOTE:
1. Black zones in graphic log indicate triconed areas.

SH 4 of 4

PROJECT Tendon Hole Chief Joseph Dam — HOLE NO. 75 DHH 3

LOCATION Monolith 11 Intake — INSPECTOR Zirkle

DEPTH OF HOLE 201.5 — CONTRACTOR Government

DEPTH OF Concrete 119.1 — DATE STARTED 23 Jun 75

ROCK DRILLED 82.4 — DATE COMPLETED 2 Jul 75

% CORE RECOVERED -- — SURFACE EL. 960.8

DIAM. HOLE 11.875 inch — N ____ E ____

EQUIPMENT Failing 1500; Drilling w/Mission Series 100-10 Hammerdrill

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
960.0				ROADWAY Concrete	13 inch diamond bit
956.0				*Top of gallery*	23 Jun 75
	10				
948.0				Floor of gallery Concrete	13 inch diamond bit W.L. Dry
					W.L. Dry 24 Jun 75
	20			Penetration rate in concrete from 15.0 ft to 55.0 ft. ranged from about 2 min. to 6 min. per foot.	12 inch I.D. casing grouted 3 ft. into concrete. Bottom of casing at elev. 945.0
	30			12.0 ft - 128.4 ft hammer drilling at 16 RPM, 110 pounds air pressure at 60 strokes per minute, foam added.	Hole was first cored with a $2^{3}/_{4}$ $3^{7}/_{8}$ inch diamond bit to 251.4 ft. Hole was then grouted to elevation 948.0 ft and redrilled with a downhole hammer with 11.875 inch button bit to depth 201.5 ft Cored hole was not used as pilot for downhole hammer.
	40			Powered by two 900 C.F.M. compressors. 8 inch drill pipe.	
	50				
905.0					W.L. Dry
					W.L. Dry 25 Jun 75
	60		4 4	Penetration rate in concrete from 55.0 ft. to 119.1 ft. averaged about 6 min. per foot	
	70		4 5 7	Significant deviations from this average rate are shown in minutes per foot of penetration beside a tick mark at the proper depth. These rates are for the foot of boring immediately above the tick mark	
	80		5 7		
	90		9 7 10 8 4 7		
860.0	100		5		

PROJECT Tendon Hole Chief Joseph Dam — HOLE NO. 75-DHH-3

LOCATION Monolith 11 Intake — SH 2 of 2

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
	110		5 5 8 9 7		W.L. 0.0 (Pumped in) W.L. 6.2 26 Jun 75
	120		5 4 5 5 9 11		
840.9	120		5	Top of bedrock 119.1	119.0 ft - 129.0 ft Penetration rate 16 min/ft
	130			128.4 ft - 201.5 ft hammer drilling at 36 RPM, 115 pounds air pressure using air, water and foam.	W.L. 0.0 (Pumped in) W.L. 4.0 27 Jun 75 129.0 ft - 138.0 ft Penetration rate 6 min/ft
	140				139.0 ft - 154 ft Penetration rate 12 min/ft
	150				
	160				W.L. 0.0 (Pumped in) W.L. 37.6 28 Jun 75
	170				155.0 ft - 174.0 ft Penetration rate 20 min/ft 175.0 ft - 185.0 ft Penetration rate 12 min/ft
	180				186.0 ft - 187.0 ft Penetration rate 17 min/ft 187.0 ft - 201.5 ft Penetration rate 30 min/ft At 201.5 gage on bit shows wear
	190			29 Jun through 2 Jul tested hole for alinement and leakage - hole off alinement - stopped drilling at 201.5 ft.	W.L. 0.0 (Pumped in) W.L. 33.3 29 Jun 75
758.5	200 201.5			Bottom of hole 201.5	W.L. 195.3 3 Jul 75 Filled hole to 12.0 ft with 5 yards 6 sacks ready mix concrete.

SH 2 of 2

PROJECT Chief Joseph Dam — HOLE NO. 75-D4H-4
LOCATION Closure Monolith C-2 Tendon Hole — INSPECTOR Zirkle
DEPTH OF HOLE 168.1 — CONTRACTOR Government
DEPTH OF CONCRETE 101.0 — DATE STARTED 22 July 1975
ROCK DRILLED 67.1 — DATE COMPLETED 6 August 1975
% CORE RECOVERED Not cored — SURFACE EL. 960.0' @ roadway deck
DIAM. HOLE 11.875" — N _____ E _____
EQUIPMENT FAILING 2000 DRILL, MISSION A100-10 HAMMERDRIL

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color ROADWAY)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
960.0	0				
956.0				Concrete w/rebar	
				Top of gallery	Drilled to 14.1 feet w/16 inch calyx bit. Drilled a 2 13/16 inch hole for pulling core.
	10				
948.0				Bottom of gallery	
				3 inch aggregate concrete 14 to 101 ft	W.L. 24 Jul Dry
			7	Penetration rate in all concrete averaged about 9 min/ft.	12 inch casing to 14.1 ft.
	20		4		14.1 - 85.5 ft Drilling w/11-7/8 in. button bit on downhole hammer drill, using 120 pounds air pressure, 21 RPM, at 60 strokes per min., using air, water and foam to clean hole.
			7	Average penetration rates in concrete	
				14.0 ft-32.0 ft 9.0 min/ft	
				32.0 ft-46.0 ft 7.0 min/ft	
	30			47.0 ft-57.0 ft 9.5 min/ft	
			3	57.0 ft-61.0 ft 19.5 min/ft	2 compressors, 900 C.F.M. each. Drill pipe 8 inch.
			14	61.0 ft-100.0 ft 9.0 min/ft	
	40				W.L. 24 Jul 0.0 (Pumped in)
			5		W.L. 25 Jul 3.4
					Hole to 40.0 ft. At 29.1 ft water running in.
			23		Gravity grouted to 23.0 ft w/9 sacks cement and 1 sack Fondu.
	50			Significant deviations from the average rates are shown in minutes per foot of penetration beside a tick mark at the proper depth. These rates are for the foot immediately above the tick mark.	
			13		57.0 to 61.0 feet operating on 1 compressor.
			17		
	60				
	70				
			6		94.0 - 95.0 drilled w/16 inch calyx bit for 12 inch casing seat at bottom of gallery.
	80				
873.0			13	Rebar over gallery	W.L. 26 Jul Dry
					W.L. 27 Jul Dry
	90			Top of gallery	12 inch casing grouted in gallery ceiling and floor
866.0				Bottom of gallery	
				95.0 - 97.2 drilled w/2-3/4X3-7/8 diamond bit for concrete density analysis	W.L. 27 Jul Dry
860.0	100		13		W.L. 25 Jul Dry

PROJECT Chief Joseph Dam — HOLE NO. 75-DHH-4

LOCATION Tendon Hole Closure Monolith C-2 — SH 2 of 2

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Lame or Return, Water Color, Drilling Fluid Data, etc.)
859.0	100			Top of bedrock 101.0	
			11	Hard granite, Penetration rate in rock from 104.0 – 168.1 averaged about 27.5 min/foot.	101.0 gravity grouted 12 sacks
	110		16		11-7/8 inch bit change at 104.0 ft.
848.0			23		
			11		104.0 – 109.0
			18	Significant deviations from this average rate are shown in minutes per foot of penetration beside a tick mark at the proper depth. These rates are for the foot immediately above the tick mark	Drilling with 120 pounds air at 60 strokes per minute with water.
	120		16		
			20		112.0 no water or air return. Gravity grouted 10 sacks.
836.0			4		
832.0			8	At 112.0 jointed granite	124.0 – 128.0 Penetration rate 5 min/ft
	130		30	124.0 – 128.0 soft granite zone	128.0 – 149.0 Penetration rate 25 min/ft
			28		152.0 – 168.1 Penetration rate 57 min/ft
			18		
	140		25		153.0 – 154.0 Drilling with 120 pounds air, 5 gallons water/min and 5000 pounds down pressure.
			17		
			41		
	150		5		
807.0					
806.0			120		
	160		33		
			32		
			26		
			82	Bottom of hole 168.1	W.L. 162' 6 Aug 75
791.9	170				

	Depths, water levels and dates as below.
101.0	No W.L. 28 July No W.L. 30 July
109.0	No W.L. 30 July No W.L. 31 July
112.0	W.L. 95' 31 July W.L. 95' 1 Aug
129.0	No W.L. 1 Aug No W.L. 2 Aug
148.0	No W.L. 2 Aug No W.L. 4 Aug
161.0	No W.L. 4 Aug No W.L. 5 Aug
163.0	No W.L. 5 Aug No W.L. 6 Aug

SH 2 of 2

PROJECT Tendon Hole Chief Joseph Dam — HOLE NO. 25-DHH-5

LOCATION Spillway Monolith 8 STA 19+87 — INSPECTOR Moran

DEPTH OF HOLE 340.5 — CONTRACTOR Government

DEPTH OF Concrete 210.0 — DATE STARTED 9 Sep 1975

ROCK DRILLED 130.5 — DATE COMPLETED 27 Sep 1975

% CORE RECOVERED Not cored — SURFACE EL. 960.0 ft.

DIAM. HOLE 11 7/8" Button bit — N ____ E ____

EQUIPMENT Reich Drill, Mission Series A100-10 Hammerdrill

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
960				0.0-0.6 ft., roadway, concrete w/rebar	Failing 1500 drill, 16 inch calyx bit from 0.0-0.6 ft and 58.5-61.2 ft.
	10				12 inch I.D. casing to 61.9 ft. Casing grouted in at bridge deck and ogee
	20				
	30			Air between bridge deck and spillway ogee	
	40				Downhole hammer with 11-7/8 in button bit. 8 inch drill pipe.
	50				Two 900 C.F.M. 125 P.S.I. compressors to 211.5 ft, two 750 C.F.M., 250 P.S.I. compressors below.
901.5				Top of ogee 58.5 ft.	Water and detergent added to air. 7-20 R.P.M.
	60			Concrete, 6 inch aggregate	Drill rate, 38 min./ft.
				Rebar	9-12-75 67.8'
	70				9-15-75
					18 min./ft.
	80				
				Rebar	86.0'
				Rebar	9-16-75
	90			Few soft zones	25 min./ft.
860	100				

PROJECT Tendon Hole Chief Joseph Dam HOLE NO. 75-DHH-5

LOCATION Spillway Monolith 8 STA 19+87 SH 2 of 4

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS Soils Classification Plasticity Condition Moisture Color	REMARKS Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.
	100				Changed bit, 4 buttons missing 9-16-75 106.0
	110				9-18-75
	120			Seep into upper gallery	16 min./ft.
	130				
	140				Stuck on rebar @ 146 ft.
714	150			Rebar	9-18-75 146 ft 9-19-75 five hours pulling drill pipe included in next day's drill rate. 146 ft
	160				9-20-75 60 min./ft. 156 ft
	170				9-21-75 11 min./ft.
	180				
	190				
760	200				

SH 2 of 4

PROJECT Tendon Hole Chief Joseph Dam HOLE NO. 75-DHH-5

LOCATION Spillway Monolith 8 STA 19+87 SH 3 of 4

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS Soils Classification Plasticity Condition Moisture Color	REMARKS Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.
	200				
750	210			Base concrete 210 ft. Top rock. Hard granite with hard dikes, jointed and faulted.	New bit at 211.5 9-21-75 211.5 ft 9-22-75 to 9-25-75 No drilling. Drill rate and bit change times in 9-25-75 drill rate below.
	220				9/25-75 211.5 ft Rate 99 min.ft. with bit change. Rate for drilling only 13 min./ft.
	230				222.0 ft
	240				9-26-75 222.0 6 min./ft.
	250				
	260			Soft zones	
	270			Clay gouge	
	280				
	290				
660	300				

SH 3 of 4

PROJECT Tendon Hole Chief Joseph Dam — HOLE NO. 75-DHH-5

LOCATION Spillway Monolith 8 STA 19+87 — SH 4 of 4

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS Soils Classification Plasticity Condition Moisture Color	REMARKS Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.
	300				
	310				9-26-75 316'
					9-27-75
	320				Rate 21 min./ft.
	330			Soft zone	
619.5	340				9-27-75 340.5 ft
				Bottom 340.5	
	350				

NOTES:

1. Drill rates include time required to add drill pipe, change bits and clean hole.
2. Drill rates do not include down time for fabrication of equipment, and digitilt surveys and repairs.

PROJECT	Chief Joseph Dam		HOLE NO. 75-RD-6
LOCATION	Spillway Sta 20+08 Mono 7	INSPECTOR	Zirkle
DEPTH OF HOLE	341.2	CONTRACTOR	Mobile C of E
DEPTH OF CONCRETE	213.6	DATE STARTED	5 Sep 75
ROCK DRILLED	127.6	DATE COMPLETED	10 Oct 75
% CORE RECOVERED	98%	SURFACE EL.	960.0 feet
DIAM. HOLE	3-25/32 inch HQ, Reamed to 11-7/8 inch	N	E
EQUIPMENT	Failing 1500 for HQ Wireline, Failing 2000 for Reaming		

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS/FT	DESCRIPTION OF MATERIALS Soils Classification Plasticity Condition Moisture Color Bridge Deck	REMARKS Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.
960.0S	0				
959.4				0.0 - 0.6 ft concrete w/rebar	Drilled with 16 inch calyx & steel shot
	10				
	20			Air between Bridge Deck and Spillway Ogee	Drilled with 16 inch calyx bit from 58.5 ft to 62.3 ft, pulled core plug and set 12 inch casing to 62.3 ft. Aligned casing, wedged and grouted bottom.
	30				4 inch casing installed inside 12 inch casing using disc spacers. 4 inch casing to 62.4 ft
	40				
	50				62.3-341.2 ft Hole drilled with Failing 1500 drill using wireline with HQ diamond bit, 3-25/32" dia. Rotation, circulation and weight on bit varied by driller.
901.5				Top of Ogee 58.5	
	60			Concrete from 58.5 to 213.6	62.3 begin drilling with diamond bit 03B1050
897.7					
	70		A	65.0 ft unbonded lift joint	No water levels. Run A D9.2 C9.2 L0.0 D71.5
			B	75.0 ft unbonded lift joint	Runs B-D D27.1 C27.1 L0.0 D98.6 Rates of penetration include rod in and out times 62.3-89.0. Rate of penetration averages about 16 min/ft
	80		C	85.0 ft unbonded lift joint	
	90		D		89.0 installed new diamond bit 03B539; old bit has flat surface
860.0	100				

PROJECT Chief Joseph Dam — HOLE NO. 75-RD-6

LOCATION Monolith 7, Spillway 3, Sta 20+08 — SH 2 of 4

ELEVATION	DEPTH	LOG GRAPHIC	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
860.0	100		E	6 inch minus aggregate concrete	Runs E-I D38.0 C38.0 L0.0 D136.6
	110		F	105.0-109.0 ft soft zone	89.0-127.1 rate of penetration averages about 11 min/ft
	120		G	115.0 ft unbonded lift joint	
			H	125.0 ft unbonded lift joint	127.1 installed new diamond bit 03B529
	130		I	130.0 ft unbonded lift joint	
	140				Runs J-M D36.8 C36.8 L0.0 D173.4
			J	145.0 ft unbonded lift joint	127.1-154.9 rate of penetration averages about 13 min/ft
	150		K		154.9 installed new diamond bit 03B532
	160		L	160.0 ft unbonded lift joint	
			M	165.0 ft unbonded lift joint	
	170				
			N	175.0 ft unbonded lift joint	Runs N-Q D29.0 C29.0 L0.0 D202.4
	180				181.5 installed new diamond bit 9PC2069
	190		O		
			P		194.2 installed new diamond bit 03B1049
760.0	200		Q		

SH 2 of 4

PROJECT Chief Joseph Dam — HOLE NO. 75-RD-6

LOCATION Monolith 7, Spillway 3, Sta 20+08 — SH 3 of 4

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
760.0	200				
			Q	205.0 ft unbonded lift joint	Runs R-S D19.1 C19.1 L0.0 D221.5
	210		R	Concrete tightly bonded at rock contact.	
				Top of Bedrock 213.6 ft	
			S		
	220				
			T		Runs T-V D29.3 C29.3 L0.0 D250.8
	230				154.9-305.0 rate of penetration averaged about 11 min/ft
			U		
	240				
			V		
	250				
			W		Run W-Y D18.1 C18.1 L0.0 D288.9
	260				
			X		
	270		Y		269.0 installed new diamond bit 9PC2080 old bit flattened out
			Z		Runs Z-AA D16.6 C16.6 L0.0 D285.5
	280				
			AA	285.5-288.9 ft gouge zone	285.5 installed used diamond bit 0381049
	290		AB		Run AB D5.8 C2.4 L3.4 D291.3
			AC	295.0-300.0 ft soft zone	
			AD		291.3 installed new diamond bit OPC1459
660.0	300		AE		Runs AC-AF D14.7 C14.5 L0.2 D306.0

SH 3 of 4

PROJECT Chief Joseph Dam — HOLE NO. 75-RD-6

LOCATION Monolith 7, Spillway 3, Sta 20+08 — SH 4 of 4

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
660.0	300		AE		Runs AG-AI D13.1 C12.9 L0.2 D319.1
			AF		
			AG		Installed used bit 03B1050 @ 306.0, new bit QPC1461 @ 308.1, used bit 03B529 @ 316.3, new bit QPC1460 @ 319.1.
	310		AH	315.0–317.0 ft closely jointed zone	305.9 - 341.2 ft. Rate of penetration average about 42 min/ft.
	320		AI		
			AJ		Run AJ D9.2 C9.2 L0.0 D328.3
	330		AK AL AM AO		Runs AK-AO D2.8 C2.8 L0.0 D331.1
			AP		Run AP D10.1 C10.1 L0.0 D341.2
618.8	341			Bottom of hole 341.2 ft	W.L. 22 Sep 82.8'

HQ hole grouted with 30 sacks type III HyEarly cement (3 sacks to 33 gallons of water)

Grout drilled out with HQ wireline, 43.1-340.0 ft.

HQ hole reamed to 11-7/8 inch diameter with Hughes Quadracone bits with center guide to follow the HQ hole. The Quadracone bits were weighted with 27,000-43,000 pounds drill collars and rods and powered with a Failing 2000 truck-mounted drill, water circulation.

Bit Model	Depth	Reaming Rate
J-44	60.0-140.0 ft	17 min/ft
J-55	140.0-227.9 ft	8 min/ft
J-33	227.9-341.0 ft	7 min/ft

At 224.0, HQ pilot hole clogged with cuttings. Washed out hole with 3-7/8 inch tricone bit, water and air to 296.0 ft. Installed 3-7/8 inch tricone bit on center guide of J-33 model. Drilling went smoothly to bottom - 341.0 ft, water circulation.

The rotation, circulation and weight on bit was varied by driller.

SH 4 of 4

Tendon Hole 75-RD-2 in Spillway Monolith 8.

Major Equipment.

The hole was drilled vertically with a Failing 1500 truck-mounted rig with both Kelley rod, chuck and a 42-foot mast. A single-tube, 10-foot long core barrel and bits were fabricated by the Corps of Engineers from stock 10 inch casing. Bit dimensions were 10.132-inches O.D., 9.125 inches I.D., and 8-inches long. Diamonds were sieve size D-E, track 6-7, face stones 2010, O.D. gage and O.D. kick 160, I.D. gage and kick 160 and total stones 2650. Above the diamonds, the bit shell I.D. was machined to 9.275 inches to retain core springs of several designs. A commercial single tube barrel with bit 10.122 inch O.D. diameter, a 6x7-3/4 inch standard double tube core barrel and a 9-7/8 inch tricone bit were also used. Two trolls or drill collars of hole diameter were used above all barrels.

Drilling Procedures.

A 14-3/4 inch diameter hole was drilled through the roadway bridge deck and into the concrete of the ogee to elevation 900 feet with calyx barrel and steel shot. All drilling was done with stoplogs in place and tainter gate closed. Twelve-inch I.D. casing was placed through the roadway deck and grouted 1-1/2 feet into the concrete ogee. Concrete and rock were drilled with the 10.132-inch O.D. barrel to elevation 698 feet. Core springs froze, heated and failed to lift core. Runs were short and, after the first few feet, drilling was without core springs. Core was removed with worn slotted bits or worn bits with sand poured down the rods. Core was broken with downhole wedges. Where core could not be removed, it was triconed out with a 9-7/8 inch bit. To avoid the core lifting problems, the hole was advanced from elevation 698 feet to elevation 656.8 feet with a standard 6x7-3/4-inch double tube core barrel, reamed with a 9-7/8-inch tricone bit and reamed to final tolerance with the single tube 10.132-inch barrel. A commercial single tube 10.122-inch barrel, with bit and shell was used from elevation 656.8 feet to 650.3 feet. Below elevation 650.3 feet, the hole was advanced again with the 6x7-3/4-inch barrel, and reamed as before with a 9-7/8-inch tricone and 10.132-inch core barrel.

Bit Footage.

The Corps of Engineers-fabricated 10.132-inch bits drilled from 2.3 feet to 8.3 feet per bit. Commercial 10.132-inch bits, with slightly larger diamonds, drilled 3.3 feet to 19.6 feet per bit. Bit footage was generally limited by diamond crushing or diamonds tearing out of the matrix. The diamonds generally were not flattened or polished by wear. One new commercial 10.132-inch bit and shell, used with a single-tube barrel, broke after 6.5 feet of drilling with the diamonds showing no apparent wear. The standard 6x7-3/4-inch bit with double tube barrel obtained 36.2 feet of hole advance.

Time Studies.

Overall coring rate with 10.132 inch diamond bit in concrete and rock was 39 minutes per foot actual drilling time. Core retrieval was 28 minutes per foot. Downtime for repairs, waiting for replacement bits, and field fabrication of tools and parts, plus all other downtime, was 50 minutes per foot. The total of all operations was approximately 2 hours per foot. Standard 6x7-3/4-inch core barrels showed a rate of approximately 30 minutes per foot including core recovery and removal from barrel.

Alinement. Hole alinement was checked at intervals with a Digitilt (inclinometer with aluminum rods for azimuth) run down the drill rods. A Digitilt survey to elevation 650 feet and a plumb-bob survey to elevation 820 feet showed hole alinement to be within one foot horizontal to 200 feet vertical overall.

Water Leakage.

Rate of water loss with casing full was used to determine leakage in the hole. This method was abandoned when leaks developed at the base of the 12-inch casing where it was grouted into the ogee concrete. Morning and evening water levels were then used to determine overnight leakages. The hole was checked after completion by blowing out the water with compressed air and measuring the rate of water rise in the hole. The highest rate of inflow for the entire hole was 9 gallons per minute.

Grouting.

Leaks were gravity-grouted as the hole advanced. After completion, the hole was gravity-grouted up to depth of 171 feet. The grout was drilled out. Water inflow for the entire hole was reduced to 3 gallons per minute.

Major Equipment. Single tube barrels with core spring heated the spring and rendered it valueless. Core blocks occurred at short intervals. Bit footage generally was limited by diamonds being broken or pulled from the matrix and not by diamond wear. The runs were limited by core blocking in barrel. Core breaking with in-hole wedge and removal from hole with slotted "old bit" plus sand poured down rods was costly in time. Removal of bit and shell from barrel with chain tongs frequently bent the shell and barrel and removal by cutting torch was commonly required. Hence, metal thickness of bit, shell and barrel was not adequate. Drilling with double tube core barrel followed by reaming was satisfactory.

Tendon Hole 75-DHH-3, Intake Monolith 21.

Drilling Data.

A 3-7/8-inch hole (75-RD-3) was cored to a depth of 251.4 to obtain information on concrete and rock. An 11-7/8 inch diameter downhole hammer hole (75-DDH-3) was drilled in this same location. The cored hole was grouted and not used as a pilot hole for the downhole hammer. An 11-7/8-inch button bit, actuated by a 100-10

Series, Mission Hammerdrill and two 900 cubic foot per minute capacity air compressors, was used to drill through the concrete and rock to a depth of 201.5. Drill pipe was 8-inches in diameter. Drill rates ranged from 5 minutes per foot with new bits to 60 minutes per foot with worn bits. Two bits were used. Drill rate averages were approximately 6 minutes per foot in concrete and 16 minutes per foot in rock. Downtime for all reasons was approximately 13 minutes per foot. Twelve feet of casing was misaligned and deflection of hole from vertical exceeded specified alignment tolerance from top to bottom of hole. The hole was backfilled with concrete. Redrilling started on 16 July 1975 and continued until 20 July. The drilling was halted when the redrilled hole followed the initial plugged hole. Equipment for redrilling was modified prior to an attempt to improve alignment of the hole. The top and bottom of the hammerdrill were enlarged to 11-7/8 inch diameter and the lower 20 feet of the 8-inch diameter drill pipe was stabilized with a 11-1/2 inch diameter sleeve.

Tendon Hole 75-DHH-4, Closure Monolith 2, Drilling Data. The hole was drilled to a total depth of 168 feet, of which 100 feet were in concrete and the remainder in rock. Equipment used was a Mission Series 100-10 Hammerdrill built up to 11-3/4 inch diameter, with an 11-7/8 inch button Hammerbit, 8 inch drill pipe and 11-3/4-inch drill collars, powered by a Failing 1500 drill and two 900 CFM, 100 to 120 psi, Compressors. Drill rates averaged 34 minutes per foot including bit changes, adding drill pipe and cleaning the hole. Hole alignment was within one foot horizontal to 200 feet vertical overall.

Tendon Hole 75-DHH-5, Spillway Monolith 8, Drilling Data. The hole was drilled to a total depth of 340.5 feet, of which 210 feet were in concrete and the remainder in rock. Equipment used was a Mission Series 100-10 Hammerdrill built up to 11-7/8 inch diameter, with a 11-7/8 inch diameter botton Hammerbit, 8 inch drill pipe and 11-3/4 inch drill collars, powered by a Reich T-750 drill. Two 900 CFM compressors were used for drilling to a depth of 211.5 feet and below 211.5 feet, two 750 CFM compressors rated at 250 psi were used. Drill rates averaged 18 minutes per foot in concrete and 17 minutes per foot in rock, including bit changes, adding drill pipe and cleaning the hole. Hole alinement was within one foot horizontal to 200 feet vertical overall.

Tendon Hole 75-RD-6, Spillway Monolith 7, Drilling Data. The hole was cored to a total depth of 341.2 feet, of which 213.6 were in concrete and the remainder in rock. A HQ wireline powered with a Failing 1500 drill was used. The hole was then reamed to 11-7/8 inches with Hester modified Hughes Quadracone bits, Models J-33, J-44 and J-55, with guides following the HQ pilot hole. The quadracone bits with drill collars were powered by a Failing 2000 drill. HQ drill rates averaged 21 minutes per foot and reaming rates averaged 24 minutes per foot. Repairs and other downtimes were not included in these rates. Hole alinement was within one foot horizontal to 200 feet vertical overall.

Hole No. 75-RD-50

DRILLING LOG	Division: NPD	Installation: NPS	Sheet 1 of 1 sheets
1. Project: Chief Joseph Dam		10. Size and type of bit	
2. Location (Coordinates or Station): N 365,008.32 E 2,293,820.99		11. Datum for elevation shown (USGS or MSL)	
3. Drilling agency		12. Manufacturer's designation of drill	
4. Hole no. (As shown on drawing title and file number): 75-RD-50		13. Total no. of overburden samples taken: Disturbed / Undisturbed	
5. Name of driller		14. Total number core boxes	
6. Direction of hole: ☐ Vertical ☐ Inclined ____ deg. from vert.		15. Elevation ground water	
7. Thickness of overburden: 72.5		16. Date hole: Started 9 Oct 1975 / Completed 15 Oct 1975	
8. Depth drilled into rock: 17.2		17. Elevation top of hole: 959.2	
9. Total depth of hole: 89.7		18. Total core recovery for boring: %	
		19. Signature of inspector	

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)
959.2	0					
	10					
	20					
	30					
	40					
	50					
899.2	60	SP	SAND w/ gravel, wet, brown	I		N=32
894.2		GP	Sandy GRAVEL w/ cobbles (10") dense, wet, gray	I		
886.7	70		Top of Bedrock granite, gray			
	80					
869.5	90		Bottom of hole @ 89.7'			
	100					

ENG FORM 1836 MAR 71 — PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

Project: Chief Joseph Dam — Hole No. 75-RD-50

Hole No. 75-RD-50A

DRILLING LOG	DIVISION: NPD	INSTALLATION: NPS	SHEET 1 OF 1 SHEETS
1. PROJECT: Chief Joseph Dam		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station): N 365,009.89 E 2,293,818.77		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number): 75-RD-50A		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED	
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
7. THICKNESS OF OVERBURDEN: 60		16. DATE HOLE: STARTED 16 Oct 1975 / COMPLETED 17 Oct 1975	
8. DEPTH DRILLED INTO ROCK: 0		17. ELEVATION TOP OF HOLE: 959.2	
9. TOTAL DEPTH OF HOLE: 60		18. TOTAL CORE RECOVERY FOR BORING: %	
		19. SIGNATURE OF INSPECTOR	

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
959.2	0	GP	Alternating layers of Sandy GRAVEL and Asphalt Concrete			
952.2						
949.2	10	GP	Sandy GRAVEL w/ cobbles & boulders			
		SP	Gravelly SAND, medium, moist, brown	I		N=21
940.2						
939.2	20	SP	Gravelly SAND w/ cobbles			
		GP	Sandy GRAVEL w/ cobbles, v. dense, wet, brown	I		N=57
928.20	30					
926.7		SP	SAND, dense, wet, gray	I		N=42
		GP	Sandy GRAVEL w/ cobbles, v. dense, wet, gray			
919.2	40					
		GM	Silty Sandy GRAVEL, V. dense, wet, gray	I		N=34
	50					
906.7				I		N=65
		SP	SAND w/ gravel medium, wet, brown			
899.2	60					
			Bottom of hole @ 60.0'			
	70					
	80					
	90					
	100					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Chief Joseph Dam | HOLE NO.: 75-RD-50A

Hole No. 75-RD-51

DRILLING LOG	DIVISION: NPD	INSTALLATION: NPS	SHEET 1 OF 1 SHEETS
1. PROJECT: Chief Joseph Dam		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station): N 364,950.18 E 2293793.17		11. DATUM FOR ELEVATION SHOWN (USE or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number): 75-RD-51		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED	
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
7. THICKNESS OF OVERBURDEN: 56		16. DATE HOLE: STARTED 18 Oct 1975 / COMPLETED 21 Oct 1975	
8. DEPTH DRILLED INTO ROCK: 17		17. ELEVATION TOP OF HOLE: 959.3	
9. TOTAL DEPTH OF HOLE: 73		18. TOTAL CORE RECOVERY FOR BORING: %	
		19. SIGNATURE OF INSPECTOR	

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
959.3	0		Alternating Layers of Sandy GRAVEL and asphalt concrete			
953.3						
	10	GP	Sandy GRAVEL, medium, moist, brown	I		N=20
944.8				I		N=23
		GP	Sandy GRAVEL w/ occ. cobbles, dense, wet	I		N=40+
940.3	20		Silty Sandy GRAVEL, dense, wet, gray	I		N=36
		GM				
	30			I		N=31
925.3						
			Gravelly SAND, medium-dense, wet, gray	I		N=28
919.8	40	SP		I		N=34
914.8						
			Gravelly SAND, medium, wet, brownish-gray	I		N=25
	50	SP				
903.1				I		N=26
			Top of Bedrock Granite, hard, gray			
	60					
893.5						
889.8			Basalt, dark gray			
	70		Granite, gray			
885.8						
			Bottom of hole @ 73.5'			
	80					
	90					
	100					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Chief Joseph Dam | HOLE NO.: 75-RD-51

Hole No. 75-RD-52

DRILLING LOG	DIVISION NPD	INSTALLATION NPS	SHEET 1 OF 1 SHEETS
1. PROJECT: Chief Joseph Dam		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station): N 365,048.91 E 2,293,835.12		11. DATUM FOR ELEVATION SHOWN (USGS or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number): 74-RD-52		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED	
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE: STARTED 22 Oct 1975 / COMPLETED 29 Oct 1975	
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE 949.0	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 81.8		19. SIGNATURE OF INSPECTOR	

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
949.0	0		Rockfill w/ Silty Sandy GRAVEL, brown			
945.0			Rockfill w/ Sandy GRAVEL, dense, wet, gray	I		
	10					
	20					
921						
	30	SM	Silty SAND (fine) w/ fine gravel, loose, wet, brown	I		N=5
909	40	GM	Silty Sandy GRAVEL, medium, wet, brown	I		N=17
	50	GM	Silty Sandy GRAVEL, dense, wet, gray	I		N=40
896.0		SP	SAND w/ fine gravel, medium, wet, brown			
889.5	60	SP	SAND w/ gravel dense, wet, brown	I		N=20+
885.3		GP	Boulder			
			Top of Bedrock			
	70		Granite, close jointed, hard, gray			
867.2	80					
			Bottom of hole @ 81.8'			
	90					
	100					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Chief Joseph Dam | HOLE NO. 75-RD-51

PROJECT	Chief Joseph Dam	HOLE NO.	82-RD-1B
LOCATION	Left Abutment	INSPECTOR	Karaba
DEPTH OF HOLE	57.5'	CONTRACTOR	Government
DEPTH OF O.B.	57.5'	DATE STARTED	1 Sep 82
ROCK DRILLED	0.0'	DATE COMPLETED	4 Sep 82
% CORE RECOVERED	N/A	SURFACE EL.	956.2'
DIAM. HOLE	4"	N 364,284	E 2,291,635
EQUIPMENT	Mobile B-80 Rotary Wash		

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Rec. Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
952.7	10		A	Silty Sandy GRAVEL, GM, w/ numerous cobbles, occ boulders (1.5'), (angular) (loose), dry, lt. brown. (Rock Rubble Fill).	Drilled w/4" casing, water circulation and 3-1/2" tricone bit. Drilling generally very slow and difficult. 0-20% DFR, 80-90% DFR from 37.7-57.5 Shot 2, 1/3 lb sticks kinepack @ 10.0' and 16.0'
	20		B	Sandy GRAVEL w/silt, GP-GM numerous cobbles, occ. boulders (1.5'), (angular) loose - medium, lt. brown (Rock Rubble Fill).	1 Sep 82 W.L. Dry 2 Sep 82 W.L. Dry
932.2			C		Shot 2, 1/3 lb. sticks kinepack @ 23.0'. Casing deflected, 26.0'.
	30		D	Sandy GRAVEL, GP, w/numerous cobbles, occ. boulders (1.5'), (angular), medium, wet, lt. br. (Rock Rubble Fill).	2 Sep 82 W.L. 30.1' 3 Sep 82 W.L. Dry
918.7			E		3 Sep 82 W.L. 30.0'
913.2	40		F	Silty SAND, SM, (v. fine), sl. p., wet, medium, gr./ br., isolated thin laminae of clayey silt.	4 Sep 82 W.L. 29.3'
	50		G		Twisted 7.0' of drill tools off in hole - retrieved. Broke casing @ 32.5' joint while driving to 49.7'. Retrieved casing leaving 17.5'+ shoe in hole, 32.2'-49.7'.
898.7	60			SAND, SP, (fine), wet, dense, orange/brown, occ. indistinct bedding. Top of rock 57.5'. Total depth 57.5'.	4 Sep 82 W.L. 38.2'
	70			Samples A-G w/3" split spoon drive sampler using 360# hammer.	Installed 2-1/2" I.D., Sch 80 PVC pipe. Slotted @ 1.0' intervals, 37.3'-57.3'. 11 Sep 82 W.L. 37.9' Blew water from piezometer for 8 min. W.L. returned from 47.7'39.4' in 126 min. S.W.L. (37.7') reached by 1300 hrs., 13 Sep 82.
	80				
	90				
	100				

PROJECT Chief Joseph Dam — HOLE NO. 82-RD-2
LOCATION Left Abutment — INSPECTOR Karaba
DEPTH OF HOLE 50.6' — CONTRACTOR Gov't
DEPTH OF O.B. 29.0' — DATE STARTED 5 Sept 82
ROCK DRILLED 21.6' — DATE COMPLETED 7 Sept 82
% CORE RECOVERED 100% — SURFACE EL. 962.0
DIAM. HOLE 4"/3" — N 364,178 E 2,291,620
EQUIPMENT Mobile B-80 Rotary Wash

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
	10			Sandy GRAVEL w/Silt, GP-GM Numerous cobbles, (11"), Occ. Boulders (1.5'-2.0'), (angular), ND, (loose), (dry) Lt. Br. (ROCK RUBBLE FILL)	Overburden drilled with 3-1/2" tricone bit, water circulation 4" casing,
	20			Grades to cobbly sandy GRAVEL w/silt, 16.0'-29.0'.	Drilling gen. v. slow and difficult. 0-20% DFR. Hole deviating from vertical
				Void in rubble fragments, 23.5'-25.2'.	5 Sept 82 WL DRY 6 Sep 82 WL DRY Cont'd difficult drill.
			A	Top of rock 29.0	Shot 3, 1/3 Lb. sticks Kinepack 16.5' and 23.5'.
933.0	30			"GRANITE" (LAMPROPHYRE to	
			A	45.0')	
			B	Dark gray to white, gen. fresh, very hard, widely	6 Sept 82 WL 24.2' 7 Sept 82 WL 28.0'
	40		C	spaced joints, generally smooth-moderately rough, slightly FeO stained, OCC.	Began coring @ 29.1 w/NXMW core bbl. & diamond bit. Runs A-E 0% DFR (poor casing seat on top of rock).
			D	lightly infilled w/calcite, faintly slickensided. Joint angles gen. 20°-40° from horiz. occ. 60°-70°.	Installed 2-1/2" I.D. Sch 80, PVC Pipe, slotted @ 1.0' intervals, 20.4'-50.4'.
882.4	50		E		Removed drill casing.
					7 Sept 82 WL 24.2' 8 Sept 82 WL 28.1'.
	60			Total depth, 50.6' soil descriptions based on surface observation, DFR and drill action	11 Sept 82 WL 28.5'
				Soil sample "A" attempted w/3" split spoon drive sampler using 360# surface hammer. Recovery 0% and destroyed sampler shoe in attempt.	Blew water from piezometer for 8 min. WL returned from 45.0'-30.8' in 150 min. S.W.L. (28.5') was reached by 1300 hrs 13 Sept 82.
	70				
	80			Bedrock sampled continuously w/NX core barrel, diamond bit.	
	90				
	100				

PROJECT Chief Joseph Dam — HOLE NO. 82-BD-3B

LOCATION Left Abutment — INSPECTOR Forehs

DEPTH OF HOLE 84.7' — CONTRACTOR Gov't

DEPTH OF O.B. 66.8' — DATE STARTED 10 Sept 82

ROCK DRILLED 17.9' — DATE COMPLETED 16 Sept 82

% CORE RECOVERED 100% — SURFACE EL. 965.9'

DIAM. HOLE 4"/3" — N 364,180 E 2,291,744

EQUIPMENT Mobile B-80 Rotary Wash

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Size, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
962.6	10			Silty Sandy cobbly (11") GRAVEL, GM (fine-coarse, angular), ND (loose) dry, Lt. Br. (ROCK RUBBLE FILL)	Overburden drilled with 3-1/2" tricone bit, water circulation 4" casing reduced to NX (3") casing and 2-15/16" tricone @ 51.5'. Samples A-E w/3" split spoon drive sample (360# hammer) samples F-H w/2" split spoon drive sampler (140# hammer)
	20			Cobbly sandy GRAVEL w/silt, GP-GM, occ. boulders (2.0'), (angular), (loose), dry-wet, Lt. Br. (ROCK RUBBLE FILL).	
	30				
			A	Silty SAND, SM, (fine), NP, Loose, wet, GR/BR, to orange/br mottled. High mica content,	Drilling gen. v. slow and difficult, DFR-0%. Shot 3, 1/3 lb sticks kinepack, 5.6'
	40		B		10 Sept 82 WL 11.6'
					11 Sept 82 WL 11.3'
			C		Shot 3, 1/3 lb. sticks kinepack 22.2'
920.9					11 Sept 82 WL 10.8'
			D	SAND, (SP), (fine), isolated gravel (fine-coarse rounded) medium-dense, wet, medium brown.	13 Sept 82 WL 11.7' Drilling somooth and even. Easy penetration, 9.0% DFR
	50		E		13 Sept 82 WL 13.2'
				Thinly laminated w/sandy SILT.	15 Sept 82 WL 11.9'
			F		
	60			Moderately plastic clayey SILT, 65.5-66.8.	
			G		
899.1				Top of rock 66.8	
			H	"GRA NITE" white, fresh,	Begin coring @ 66.8, w/NXHW core bbl. & diamond bit. 60% DFR
	70			very hard occ. pyrite crystals, joints widely	15 Sept 82 WL 7.3'
			A	spaced, smooth to moderately	16 Sept 82 WL 10.1'
			B	rough, fresh to slightly stained w/FeO, occ. slickensided. Joint angles 35°-45° from horiz.	60% DFR
	80		C		
881.2			D		
				Total depth 84.7' rock rubble fill descriptions based on observation of surface conditions, DFR and drill action.	16 Sept 82 WL 7.0' 17 Sept 82 WL 11.2' Installed 2-1/2" ID., Sch 80, PVC Pipe slotted @ 1.0' intervals, 49.4'-74.4'. Removed drill casing.
	90				
	100				

PROJECT	Chief Joseph Dam	HOLE NO.	82-RD-4
LOCATION	Left Abutment	INSPECTOR	Karaba
DEPTH OF HOLE	42.6'	CONTRACTOR	Govt.
DEPTH OF O.B.	22.5'	DATE STARTED	17 Sep 82
ROCK DRILLED	20.1	DATE COMPLETED	18 Sep 82
% CORE RECOVERED	100%	SURFACE EL.	948.5'
DIAM. HOLE	4"/3"	N 364,364	E 2,291,545
EQUIPMENT	Mobile B-80 Rotary Wash		

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
	10			Silty Sandy GRAVEL, GM w/ numerous cobbles (11") Occ. boulders (2.5'), (angular), NP, (loose), dry, lt. br. (ROCK RUBBLE FILL).	Overburdent drilled with 3½" tricone bit, water circulation, 4" casing.
936.1			A	SAND, SP (fine-medium), dense, (wet), mod. br.	Drilling, rough, grinding to 12.1', smooth to 18.1 60%-80% DFR. Drill action grinding, 18.1'-22.5', DFR 0%.
930.5	20		B	Sandy GRAVEL, GP (fine-coarse rounded), (wet).	17 Sep 82 WL 6.7'
926.0				TOP OF ROCK —— 22.3	
			A	"GRANITE," (LAMPROPHYRE to 30.0') dark gray, fresh, hard, joints widely spaced,	18 Sep 82 WL 22.3' Began coring @ 22.3 w/NXBW core bbl. & diamond bit.
	30		B		
			C	fresh to slightly FeO stained	Runs A-E 80-100% DFR.
			D	Occ. filled w/calcite.	
	40		E	Fracture spacing close to very close @ 30.0'. Trace Gouge @ 41.0'. Fracture	18 Sep WL 14.7'
905.9				angles gen. 20-30 degrees from horizontal.	Installed 2½" I.D., SCH. 80, PVC Pipe Slotted @ 1.0' intervals, 11.0-42.0'. Removed drill casing.
	50			TOTAL DEPTH 42.6'	20 Sep WL 23.7' 23 Sep WL 25.2'
				Sample A w/2" splitspoon drive sampler using a 140# hammer. Sample B attempted w/3" splitspoon drive sampler using a 360# hammer. Soils descriptions largely based on DFR and drill action.	Blew water from piezometer for 8 min. WL returned, 39.7' - 35.6' in 8 hours. SWL (28.6') 1600 hrs 27 Sep 82
	60				
	70				
	80				
	90				
	100				

PROJECT Chief Joseph Dam — HOLE NO. 82-RD-5B

LOCATION Left Abutment — INSPECTOR Raraba

DEPTH OF HOLE 25.0' — CONTRACTOR Government

DEPTH OF O.B. 23.6' — DATE STARTED 20 Sep 82

ROCK DRILLED 1.4' — DATE COMPLETED 21 Sep 82

% CORE RECOVERED N/A — SURFACE EL. 965.4'

DIAM. HOLE 4" — N 364,117 E 2,291,608

EQUIPMENT Mobile B-80 Rotary Wash.

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
957.3	10		A B	Cobbly silty sandy GRAVEL, GM, w/ occ. boulder (1.5'), (angular), (loose), lt. br. (rock rubble fill).	Drilled with 3¼" tricone bit, water circulation, 4" Ø casing Samples A-B taken by 3" split spoon drive sampler using 360# hammer. Drill action rough, grinding 30% to 50% DFR.difficult to clean out hole prior to sampling.
942.1	20			Sandy GRAVEL, GP, (fine to coarse, rounded) medium, wet, med. brown. (GRAVEL FILTER).	20 Sep 82 WL 9.9 21 Sep 82 WL 10.9
940.4				Top of rock 23.6	Installed 2½" ID, Sch. 80 PVC pipe slotted @ 1.0' intervals, 10.0'-23.6'. Removed drill casing.
	30			"GRANITE"	21 Sep 82 WL 10.3 22 Sep 82 WL 12.1
				Total depth 25.0'	
	40				
	50				
	60				
	70				
	80				
	90				
	100				

PROJECT Chief Joseph Dam — HOLE NO. 82-RD-6

LOCATION Left Abutment — INSPECTOR Karaba

DEPTH OF HOLE 39.8' — CONTRACTOR Government

DEPTH OF O.B. 37.7' — DATE STARTED 22 Sep 82

ROCK DRILLED 2.1 — DATE COMPLETED 23 Sep 82

% CORE RECOVERED N/A — SURFACE EL. 963.9

DIAM. HOLE 4" — N 364,147 E 2,291,655

EQUIPMENT Mobile B-80 Rotary Wash

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0-100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Rec. Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
955.9	10		A	Cobbly, silty sandy GRAVEL, GM, w/ occ. boulders (2.0') (angular), (loose), (dry), lt. br. (rock rubble fill).	Drilled with 3¼" tricone bit, water circulation, 4" ∅ casing. Samples A-D taken by 3" split spoon drive sampler using 360# hammer.
	20		B	Sandy GRAVEL GP, (fine-coarse, rounded), w/ numerous cobble (5"), medium, wet, multicolored, (GRAVEL FILTER).	Drill action gen. rough, grinding, 40-80% DFR, 0% @ 0-10' & 33.0'-37.0'. Difficult to clean out hole prior to samp. 22 Sep 82 WL 7.8' 23 Sep 82 WL 8.8' Installed 2½" ID, Sch. 80, PVC pipe slotted @ 1.0' intervals, 10.0'-37.7'. Removed drill casing.
	30		C		
926.2			D	Top of rock 37.7	
924.1	40			"GRANITE"	23 Sep 82 WL 9.2' 24 Sep 82 SWL 9.1'
				Total depth, 39.8'	
	50				
	60				
	70				
	80				
	90				
	100				

PROJECT Chief Joseph Dam — HOLE NO. 82-RD-7
LOCATION Left Abutment — INSPECTOR Kerabs
DEPTH OF HOLE 61.9' — CONTRACTOR Govt.
DEPTH OF O.B. 44.7' — DATE STARTED 24 Sep 82
ROCK DRILLED 17.2' — DATE COMPLETED 27 Sep 82
% CORE RECOVERED 100% — SURFACE EL. 951.5'
DIAM. HOLE 4"/3" — N 364,334 E 2,291,522
EQUIPMENT Mobile B-80 Rotary Wash

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
	10			Silty, Sandy, Cobbly, GRAVEL, GM, w/Occ, Boulders (1.5') (Angular), NP, (Loose) Lt. Br. (ROCK RUBBLE FILL)	Overburden drilled w/3½" tricone bit, water circulation, 4" casing. Soil samples A-C by 3" splitspoon drive sampler using 360# hammer.
938.0					
			A	Silty SAND, SM (very fine), NP, loose, wet, Med. Br.	Drilling rough, grinding DFR. 80%
934.0	20				24 Sep WL DRY
				Sandy GRAVEL, GP, (fine-coarse, rounded), loose, wet, med. br.	25 Sep WL DRY
	30				Continued rough, ginding drill DFR-0-10%. Difficult in cleaning out hole prior to sampling.
	40		B		25 Sep WL 32.1'
907.2			C	TOP OF ROCK 44.7	27 Sep WL 33.5'
	50		A	"GRANITE," (LAMPROPHYRE , 56.0'-61.9') Dark Gray to White, gen. fresh, hard-very hard, widely spaced joints, Gen. Smooth, fresh to Sl. stained (green), faintly slicken slided, isolated gouge @ 53'. Joint angles gen. 35-55 degrees.from horizontal.	Cored Bedrock. Began coring @ 47.0 w/NXHW core bbl. & diamond bit.
			B		Installed 2½" I.D., SCH 80 PVC Pipe Slotted @ 1.0' intervals, 10.0'-61.7'.
	60		C		Removed drill casing. 27 Sep WL @ 26.1'
889.6				TOTAL DEPTH 61.9'	8 Oct SWL 32.25
	70				
	80				
	90				
	100				

PROJECT Chief Joseph Dam — HOLE NO. 82-RD-8

LOCATION Left Abutment — INSPECTOR Karaba

DEPTH OF HOLE 16.0' — CONTRACTOR Government

DEPTH OF O.B. N/A — DATE STARTED 28 Sep 82

ROCK DRILLED N/A — DATE COMPLETED 29 Sep 82

% CORE RECOVERED N/A — SURFACE EL. 965.4'

DIAM. HOLE 4" — N 364,219 E 2,291,710

EQUIPMENT Mobile B-80 Rotary Wash

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
957.4	10			Silty, sandy, cobbly GRAVEL, GM. w/ occ. boulders (1.5') (angular), np, (loose) lt. br. (ROCK RUBBLE FILL).	Drilled with 5-7/8" tricone bit to 11.0' reduced to 3¾" tricone, 4" casing. Circulation fluid was water.
				Sandy GRAVEL,GP, cobbly (angular?), (loose). (Rock rubble fill?).	Very slow difficult drilling 0% DFR casing deflecting @ 9-10'.
946.4	20				28 Sep 82 WL 12.7' 29 Sep 82
	30			Total depth 19.0'.	1-1/8" ID, Sch. 40 PVC pipe slotted @ 0.5' intervals from 16.0'-13.0' and 1.0' intervals from 13.0'-6.0'. Removed drill casing.
	40				
	50				
	60				
	70				
	80				
	90				
	100				

PROJECT	Chief Joseph Dam	HOLE NO.	82-RD-9
LOCATION	Left Abutment	INSPECTOR	Karaba
DEPTH OF HOLE	73.2'	CONTRACTOR	Govt.
DEPTH OF O.B.	55.8'	DATE STARTED	29 Sep 82
ROCK DRILLED	17.4'	DATE COMPLETED	1 Oct 82
% CORE RECOVERED	100%	SURFACE EL.	965.2
DIAM. HOLE	4"/3"	N	364,116 E 2,291,708
EQUIPMENT	Mobile B-80 Rotary Wash		

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Hrs, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
959.8	10			Silty Sandy Cobbly GRAVEL GM w/Occ Boulders (1.5'), (Angular), Loose, Dry, Lt. Br. (ROCK RUBBLE FILL)	Overburden Drilled by 3½" Tricone Bit, Water Circulation 4" Casing, Samples A-C w/3" Split Spoon Drive Sampler & 360# Hammer. Samples D-G w/2" Split Spoon Drive Sampler & 140# Hammer.
			A	Sandy Cobbly GRAVEL GP w/Occ Boulders (1.5), (Angular-Rounded), Very Loose-Loose, (ROCK RUBBLE FILL)	
	20		B		Slow Difficult Drill w/DFR 90% to 5.5; 0% from 5.5 to 26.0' 29 Sep 82
938.7					30 Sep 82
	30		C	Gravelly (Fine) SAND SP, (Med.-Coarse), NP, Very Loose-Loose, Wet, M. Brn.	Drilling Becoming Rapid & Easy, DFT 20-50%
			D		
931.2			E	Grades to Fine Sand w/ Scattered Fine Gravel @ 29.0	
927.2	40			SAND (Fine) w/Silt SP-SM, ND Medium, Wet, Med. Br.	
922.8				Sandy GRAVEL GP, (Fine-coarse), (Medium), Wet.	30 Sep 82 WL 10.9'
	50		F	SAND SP, (V. Fine-Fine), Occ Fine Gravel, Medium, Wet, Med. Brown. Thinly Lam. w/ Silt. Grades fine to med. @ 54.0'	1 Oct 82 WL 13.6' Began Coring @ 58.0 w/NXBW Corebbl & diamond bit. Runs A-E 80% DFR 0% @ 72.5'.
909.7			G		
	60		A	Top of Rock 55.8'	1 Oct 82 WL 9.7
			B		
			C		
	70		D		
			E		
892.0	80			"GRANITE," White, Fresh, Very Hard, Gen. Widely spaced joints w/Close to V. Close joint spacing @ 66.5'-68.7', Smooth, Slickensided Slightly F O (or Chlorite) Stained, Traces of Gouge & Infilling w/Calcite, Joint Angles Gen. 35-65 degrees. From Horiz.	2 Oct 82 Installed 2½" I.D., SCH 80 PVL Pipe Slotted @ 1.0' Intervals, 10.0' - 62.5'. Removed drill casing. 2 Oct 82 SWL 10.7'
	90				
	100			Total Depth 73.2'	

PROJECT Chief Joseph Dam — HOLE NO. 82-RD-10

LOCATION Left Abutment — INSPECTOR Karaba

DEPTH OF HOLE 56.8' — CONTRACTOR Government

DEPTH OF O.B. 33.3' — DATE STARTED 2 Oct 82

ROCK DRILLED 36.1'-56.8' — DATE COMPLETED 5 Oct 82

% CORE RECOVERED 98% — SURFACE EL. 963.2'

DIAM. HOLE 4"/3" — N 364,158 E 2,291,646

EQUIPMENT Mobile B-80 Rotary Wash

ELEVATION	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Hrs. Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
				Sandy Cobble GRAVEL w/silt GM-GP, NP, loose, dry, (ROCK RUBBLE FILL).	Overburden drilled w/3½ tricone bit, water circulation 4" casing. Sample A w/3" splitspoon drive sampler & samples B-I w/2" splitspoon drive sampler & 140# hammer.
954.2	10			Sandy clayey SILT, ML, w/ gravel (fine-coarse, rounded to angular), SL-PL, very stiff to hard, moist, GR/BR. (IMPERVIOUS CORE)	Rough, grinding, drill action. DFR 0% to 9.0', 100% 9.0' to 36.1'.
			A		
			B		
	20		C		2 Oct 82 WL 1.2'
			D		
			E		
			F		
	30		G		
			H		
930.0			I		
				CONCRETE TOP OF ROCK 36.0	4 Oct 82 WL 4.7'
927.2		//=\\=	A	"GRANITE" white, very hard, flesh to FeO Stained, gen. widely spaced joints becoming closely to very closely spaced @ 42.3'-46.0', smooth to moderately rough, FeO stained, Occ. slickenslided, iso. oxidized iron pyrite crystals. Joint angles gen. 40-60 degrees from horizontal.	Continued rough, grinding drill action
	40		B		4 Oct 82 WL +1.3'
			C		5 Oct 82 WL 3.7 Began coring @ 34.5 w/NXHW core bbl. & diamond bit. Runs A-E, DFR 90% btm.
	50		D		5 Oct 82 WL -+1.3'
			E		
906.4	60			TOTAL DEPTH 56.8'	6 Oct 82 WL 8.2'
					Installed 2½" I.D. SCH 80 PVC pipe slotted @ 1.0' intervals 41.7'-56.7'. Placed sand filter pack, 56.7'-33.7'. Placed grout seal (cement + Al. powder), 33.7'-37.0'. Installed 1-1/8" I.D. SCH 40 PVC pipe slotted @ 1.0' intervals, 24.0'-5.0'. 6 Oct
	70				19 Oct WL 17.5 Blew water out of both piezometers for 8 min. V. slow recharge (101/1 hr.
	80				29 Oct SWL 12.1/15.5
	90				
	100				

PROJECT	Chief Joseph Dam	HOLE NO.	82-RD-11
LOCATION	Left Abutment	INSPECTOR	Karaba
DEPTH OF HOLE	20.3'	CONTRACTOR	Govt.
DEPTH OF O.B.	N/A	DATE STARTED	6 Oct 82
ROCK DRILLED	N/A	DATE COMPLETED	7 Oct 82
% CORE RECOVERED	N/A	SURFACE EL.	963.1
DIAM. HOLE	4"	N	364,164 E 2,291,655
EQUIPMENT	Mobile B-80 Rotary Wash		

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS/FT	DESCRIPTION OF MATERIALS Soils Classification Plasticity Condition Moisture Color	REMARKS Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.
958.1	10		A B	Sandy cobbly GRAVEL w/silt, GP-GM, Occ. boulders (1.5') (angular), (loose), (dry) lt. br. (ROCK RUBBLE FILL).	Drilled w/3½" tricone bit, water circulation, 4" casing.
					Samples A-B taken w/2" split-spoon drive sampler using 140# hammer.
					Drilling slow, DFR 0% to 5.0'
					6 Oct WL DRY
				Sandy clayey SILT,ML, w/ gravel (fine-coarse, rounded angular), SL. Plastic, Hard, Moist, GR/BR. (Impervious Core)	7 Oct WL DRY
942.8	20				Drilling becomes easy, rapid DFR. 100%
					7 Oct WL - 14.3'
				TOTAL DEPTH 20.3'	8 Oct
	30				Installed 2½" I.D. SCH 80, PVC Pipe slotted, 10.0'-19.4.
					Placed surface seal (cement + AL. Powder), GS to 6.5'.
	40				Blew water from piezometer for 5 min.
					Removed drill casing.
	50				
	60				
	70				
	80				
	90				
	100				

PROJECT	Chief Joseph Dam	HOLE NO.	82-RD-12
LOCATION	Left Abutment	INSPECTOR	Karaba
DEPTH OF HOLE	28.2'	CONTRACTOR	Govt.
DEPTH OF O.B.	15.9'	DATE STARTED	12 Oct 82
ROCK DRILLED	12.3'	DATE COMPLETED	13 Oct 82
% CORE RECOVERED	100%	SURFACE EL.	939.1
DIAM. HOLE	4"/3"	N 364,449	E 2,291,417
EQUIPMENT	Mobile B-80, Rotary Wash		

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Sun, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
928.7	10			Silty sandy, cobbly GRAVEL, GM, w/Occ. boulders (1.5') (angular), loose, dry, lt. br. (ROCK RUBBLE FILL).	Overburden drilled w/3½" tricone bit, water circulation, 4" casing. Sample A attempted w/3" split spoon drive sampler & 360# hammer.
923.3	20		A A B C	Sandy cobbly GRAVEL w/silt, GP-GM, Occ. boulders (1.5) (angular), NP, (loose), lt. br. (ROCK RUBBLE FILL). TOP OF ROCK 15.9	Rough grinding drill, DFR 50% 12 Oct WL-G.S.
910.9	30		D	"GRANITE," white, v. hard, fresh, widely spaced joints, moderately rough, v. slightly FeO stained, Occ. lightly infilled w/calcite, joint angles gen. 5-20 degrees from horizontal. TOTAL DEPTH 28.2'	13 Oct. WL DRY Began coring w/NXBW core bbl. & diamond bit. Runs A-D DFR 90% 13 Oct WL 9.9' 14 Oct WL 15.98 Installed 2½" I.D., SCH 80, PVC pipe slotted, @ 1.0' intervals, 10.0'-28.1'. Removed drill casing. Blew water out of piezometer for 5 min. 14 Oct WL 21.9' 29 Oct SWL 22.6'
	40				
	50				
	60				
	70				
	80				
	90				
	100				

PROJECT Chief Joseph Dam — HOLE NO. 82-RR-13

LOCATION Left Abutment — INSPECTOR Kersha

DEPTH OF HOLE 56.4' — CONTRACTOR Govt.

DEPTH OF O.B. 33.2' — DATE STARTED 14 Oct 82

ROCK DRILLED 23.2' — DATE COMPLETED 18 Oct 82

% CORE RECOVERED 96% — SURFACE EL. 965.6

DIAM. HOLE 4"/3" — N 364,305 — E 2,201,687

EQUIPMENT Mobile B-80 Rotary Wash

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0-100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Rec. Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
959.1	10		A	Sandy cobbly (11") GRAVEL w/silt GP-GM, occ. boulders (1.5'), loose, dry, lt. br. (ROCK RUBBLE FILL)	Overburden drilled with 3¼" tricone bit, water circulation, 4" casing. Sample A w/3" splitspoon drive sampler & 360# hammer. Samples B-D w/2" splitspoon drive sampler & 140# hammer. Drilling slow, difficult DFR. 80%
	20		B	Sandy GRAVEL, GP, Fine-coarse, rounded, scattered cobbles (5"), med., wet, lt. br. Isolated gravelly, sandy SILT, ML, 25.0-26.0' & 27.8-29.7'. (GRAVEL FILTER)	14 Oct WL GS 15 Oct WL 5.3' Drilling, grinding, easy DFR. 40% 15 Oct WL 8.1
	30		C		
			D	TOP OF ROCK 33.2	
932.4	40		A	GRANITE bedrock white, very hard, fresh, closely spaced joints 35.0'-44.0' & 54.0'-56.4', v. closely spaced 44.4'-45.6' & 51.5'-52.4', widely spaced 46.0'-51.5'. Joints gen. smooth to moderately rough, SL. FeO stained, Occ. infilled by calcite, slickenslided 150 gouge, 41.5'. Joint angels gen. 30-40 degrees from horizontal.	16 Oct WL 10.2 Began coring @ 35.5 w/NXHW core bbl. & diamond bit. Runs A-B DFR. 90% 16 Oct WL 9.7
			B		
	50		C		18 Oct WL 11.2 Runs C-E DFR. 90% Installed 2½" I.D. SCH. 80 PVC pipe.slotted at 1.0' intervals, 46.0'-56.0'. Placed seal (bentonite pellets) 30.0'-40.0'. Installed 1-1/8" I.D. SCH 40, PVC pipe slotted at 1.0' intervals, 10.0'-25.0'. Removed drill casing. 18 Oct WL 11.9'
			D		
909.2			E		
	60				
	70			TOTAL DEPTH - 56.4'.	19 Oct 0800 WL 14.6' Blew water out of lower stage for 10 min. WL returned from 57.2'-13.1' in 30 min. 19 Oct 1600 SWL 11.3'
	80				
	90				
	100				

PROJECT Chief Joseph Dam — HOLE NO. 82-RD-16
LOCATION Left Abutment — INSPECTOR Karaba
DEPTH OF HOLE 40.0' — CONTRACTOR Govt
DEPTH OF O.B. 37.1' — DATE STARTED 20 Oct 82
ROCK DRILLED 2.9' — DATE COMPLETED 23 Oct 82
% CORE RECOVERED N/A — SURFACE EL. 956.3'
DIAM. HOLE 4" — N 364,330 E 2,291,653
EQUIPMENT Mobile B-80

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
953.3				Sandy, Cobbly Gravel, w/Silt GP-GM Occ Boulders (1.5'), Loose, Dry, (ROCK RUBBLE FILL)	Overburden Drilled w/3½" Tricone, Water Circulation, 4" Casing. Samples A-B w/3" Split Spoon Drive Sampler & 360# Hammer.
	10		A	Sandy, Cobbly GRAVEL, GP, w/Occ. Boulder (1.5'), Loose-Dense, Lt. Br. (ROCK RUBBLE FILL).	Very Difficult Slow Drilling. DFR 40%
					20 Oct 82 WL DRY
			B		21 Oct 82 WL DRY
	20				Difficult Drill DFR 0%
					21 Oct 82 WL DRY
					22 Oct 82 WL DRY
	30				Difficult Drill DFR 0%
					22 Oct 82 WL 20.7
922.3				(Sandy GRAVEL, GP, Dense, Wet, Lt. Br.)	23 Oct 82 WL 29.5'
919.3				Top of Rock 37.0'	23 Oct 82
916.3	40			"GRANITE"	
				Total Depth 40.0'	28 Oct 82 WL 35.7 Blew Water Out of Piezometer for 8 Min.
	50				28 Oct 82 WL 35.7
					29 Oct 82 SWL 35.7
	60				Installed 2½ I.D., SCH. 80, P.V.C. Pipe Slotted @ 1.0' Intervals, 10.0'-40.0'.
	70				Removed drill casing.
	80				
	90				
	100				

PROJECT Chief Joseph Dam — HOLE NO. 82-RD-15

LOCATION Left Aburment — INSPECTOR Kiraha

DEPTH OF HOLE 32.5' — CONTRACTOR Cour

DEPTH OF O.B. 72' — DATE STARTED 25 Oct 82

ROCK DRILLED 25.3' — DATE COMPLETED 27 Oct 82

% CORE RECOVERED 100% — SURFACE EL. 942.8'

DIAM. HOLE 4"/3" — N 364,355 E 2,291,368

EQUIPMENT Mobile B-80 Rotary Wash.

ELEVATIONS	DEPTH	LOG SYMBOLIC	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
				Silty SAND, SM, Very Fine, NP, Medium, Dry, Lt. Brown.	Overburden drilled w/3½" Tri-cone Bit, Water Circulatio 4" Casing. Sample "A" Taken w/2" Split Spoon Drive Sampler using 140# Hammer.
			A	Top of Rock 7.2	
935.6	10		A	"Granite" (Lamprophyre, 7.2'-10.8'). Dark Gray-White, Fresh, Hard-V. Hard, Joints Widely Spaced 7.2' - 24.5';	Smooth, Even, Easy Drill.DFR-80%
			B		25 Oct 82 WL 1.4'
	20		C	Closely Spaced 24.5' - 27.3'; Very Closely Spaced 27.3' - 32.5'.	
			D		
			E		
	30		F		26 Oct 82 WL DRY
910.3					Begin Coring at 8.1 w/NXHW Corebbl & Diamond Bit.
	40			Gen. Smooth to Moderately Rough, Slightly FEO Stained, Occ. Lightly Infilled w/ Calcite, Faintly Slickensided. Joint Angles Gen. 45 - 70 degrees from Horiz.	Core Runs H-E DFR 100% 26 Oct 82 WL 5.8
					27 Oct 82 WL 22.6 Run F DFR 100%
					27 Oct 82 WL 22.6'
	50			Total Depth 32.5'	28 Oct 82 WL 29.0' Blew Water From Piezometer for 8 min.
					28 Oct 82 WL 29.0'
	60				29 Oct 82 SWL 29.1
					Installed 2½" I.D. SCH 80 P.V.C. Pipe, Slotted @ 1.0' Intervals, 7.0'-32.5'. Removed drill casing.
	70				
	80				
	90				
	100				

PROJECT Chief Joseph Dam	HOLE NO. 82-RD-16
LOCATION Left Abutment	INSPECTOR Karaba
DEPTH OF HOLE 28.3'	CONTRACTOR Govt.
DEPTH OF O.B. 16.8'	DATE STARTED 27 Oct 82
ROCK DRILLED 11.5'	DATE COMPLETED 28 Oct 82
% CORE RECOVERED 100%	SURFACE EL. 941.6
DIAM. HOLE 4"/3"	N 364,420 E 2,291,396
EQUIPMENT Mobile B-80 Rotary Wash	

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS/FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Hrs. Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
932.6	10			Sandy, cobbly GRAVEL w/silt, GP-GM (angular) (loose), (dry), Lt. Br. (ROCK RUBBLE FILL)	Overburden drilled w/3½" tricone bit, water circulation 4" casing. Sample A w/2" split spoon drive sampler & 140# hammer.
				Sandy GRAVEL, GP, (fine to coarse, rounded), w/occ. cobbles), dense.	Drilling slow difficult DFR 90%
			A	TOP OF ROCK 16.8	27 Oct 82 WL 1.4'
924.8	20		A	"GRANITE" (LAMPROPHYRE, 16.8' to 25.0') dark gray to white, fresh, hard-v. hard. Joints widely spaced, smooth to moderately rough, very slightly FeO stained, angles gen. 35–50 degrees from horizontal.	28 Oct 82 WL DRY Drilling continues slow, difficult DFR 0% Began coring @ 18.2 w/NXHW core bbl. & diamond bit.
913.3	30		B		Installed 2½"I.D., SCH 80, PVC pipe slotted @ 1.0' intervals, 10.0'–28.3'. Removed drill casing. Blew water from piezometer for 8 min. 28 Oct WL 22.7'
	40			TOTAL DEPTH 28.3'	29 Oct. SWL 22.2'
	50				
	60				
	70				
	80				
	90				
	100				

PROJECT Chief Joseph Dam — HOLE NO. 82-CD-17

LOCATION Left Abutment — INSPECTOR R. Bailey

DEPTH OF HOLE 42.8' — CONTRACTOR Carl Pitts

DEPTH OF O.B. 40.5' — DATE STARTED 8 November 1982

ROCK DRILLED 2.3' — DATE COMPLETED 11 November 1982

% CORE RECOVERED N/A — SURFACE EL. 955.5

DIAM. HOLE 10" — N 364,305 E 1,191,554

EQUIPMENT Buoyrus-Erie 24L with 2,150 lbs. string of tools

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0–100 / BLOWS /FT	DESCRIPTION OF MATERIALS (Soils Classification, Plasticity, Condition, Moisture, Color)	REMARKS (Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Hrs, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, & Water Loss or Return, Water Color, Drilling Fluid Data, etc.)
	10			Silty SAND, SM with minor gravels and cobbles to 12" (angular)	12" starter casing to 11.4' set with backhoe. Drilled to 12' with 12" bit. Reduced to 10"
					W.L, Dry
					9-Nov 1982
					9 Nov 1982
					W.L. Dry
	20				
930.5					
	30			Silty, sandy GRAVEL, GM (1"-1-1/2") with occasional cobble to 8", brown	Casing at 30'
					W.L. Dry
					9-Nov 1982
					10 Nov 1982
					W.L. Dry
				Top of rock	37' Drilling mud thinned out
915.0	40			Bedrock or boulder?	indicates water. Hole was
912.8					bailed clean of drilling mud
				Total depth 42.7'	10 Nov 1982
					11 Nov 1982
					W.L. @ 34.1'
	50				
					Installed 1-1/2" PVC pipe to 42.7. Slotted 32.0-42.0
	60				
	70				
	80				

PROJECT	Chief Joseph Dam	HOLE NO.	82-CD-18
LOCATION	Left Abutment	INSPECTOR	E. Bailey
DEPTH OF HOLE	44.0'	CONTRACTOR	Carl Pitts
DEPTH OF O.B.	42.0'	DATE STARTED	16 Nov 82
ROCK DRILLED	2.0'	DATE COMPLETED	19 Nov 82
% CORE RECOVERED	N/A	SURFACE EL.	953.0
DIAM. HOLE	10"	N 364,324	E 2,291,518
EQUIPMENT	Bucyrus-Erie 24 L w/2,150 lbs. string of tools		

ELEVATIONS	DEPTH	GRAPHIC LOG	CORE % 0 100 / BLOWS /FT	DESCRIPTION OF MATERIALS Soils Classification Plasticity Condition Moisture Color	REMARKS Casing Depth, Depth of Hole at Start & End of Shift, Water Level at Start & End of Each Shift & Run, Drilling Time, Size & Type of Bit, Action of Drill, Rate of Penetration, % Water Loss or Return, Water Color, Drilling Fluid Data, etc.
	0			Silty SAND, SM, w/gravels, some cobbles to 8" and occ boulder to 2.0' (angular), medium brown, moist.	12" starter casing to 11.0' set with backhoe.
	10				
938.9				Silty sandy GRAVEL, GM, 1" - 1-1/2" w/occ. cobble to 8-10", loose to dense, brown.	Casing following bit. W.L. Dry 16 Nov 82
	20				17 Nov 82 W.L. Dry Hole and casing @ 29' 17 Nov 82 W.L. Dry
	30				18 Nov 82 W.L. Dry
	40				Bailed hole dry. 18 Nov 92
911.0				Top of rock 42.0'	
909.0				Granite	19 Nov 82
	50			Bottom @ 44.0'	W.L. 36.7' Backfilled to 43.0' with sandy gravel. Set Johnson 10" nom. telescoping, low carbon alloy screen 38.0-43.0'. Pulled casing to 38'. Bailed for 3 hours averaged 2-2-1/2 g.p.m.

Hole No. 87-PA-401

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT: CHIEF JOSEPH DAM LT. EMBANKMENT		10. SIZE AND TYPE OF BIT: 8" HOLLOW STEM	
2. LOCATION (Coordinates or Station): PIEZOMETER INSTALLATION		11. DATUM FOR ELEVATION SHOWN (TBM or MSL):	
3. DRILLING AGENCY: GOVERNMENT		12. MANUFACTURER'S DESIGNATION OF DRILL: MOBILE B-80 POWER AUGER	
4. HOLE NO. (As shown on drawing title and file number): 87-PA-401		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 15; UNDISTURBED 0	
5. NAME OF DRILLER: BALES		14. TOTAL NUMBER CORE BOXES: 0	
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		15. ELEVATION GROUND WATER: 931'	
7. THICKNESS OF OVERBURDEN: 74'		16. DATE HOLE: STARTED 4/17/87; COMPLETED 4/20/87	
8. DEPTH DRILLED INTO ROCK: 0		17. ELEVATION TOP OF HOLE: 970'	
9. TOTAL DEPTH OF HOLE: 74"		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)
970			2" ASPHALTIC CONCRETE ON 4" BASE COURSE			
		GP	SANDY GRAVEL W/COBBLES (6") MEDIUM, MOIST, BROWN			
		SC	CLAYEY SAND W/GRAVEL (FINE), DENSE, MOIST, LT. BROWN		A N=49	2" SPLIT SPOON SAMPLER DRIVEN BY 140# HAMMER 30" DROP (TYP)
	10					
		SC	CLAYEY SAND W/GRAVEL, COBBLES, & OCC. BOULDERS, VERY DENSE, MOIST, LT. BROWN		B N=70	N= NUMBER OF BLOWS TO DRIVE SAMPLE BARREL 1 FT.
					C N=32	
	20				D N=54	
				1-1/2" SOLID PVC PIPE		
				SM CEMENT GROUT SEAL	E N=52	
	30			GRAVELLY SAND	F N=54	
		SC	CLAYEY SAND W/GRAVEL (FINE) DENSE, MOIST TO SATURATED, LT. BROWN		G N=31	
931			WATER @39.0' 4/18/87		H N=47	
	40		POOL @954.0'		I N=45	
				1-1/2" PERF. PVC PIPE		
	50		CLAYEY SAND W/OCC. GRAVEL (2"), VERY DENSE, MOIST, LT. BROWN		J N=54	
					K N=48	
	60	SC	CLAYEY SAND W/OCC. GRAVEL (2"), SATURATED, LT. BROWN	MAT'L HEAVED AND CAVED	L N=67	
		SC	CLAYEY SAND, MEDIUM TO DENSE, LT. BROWN		M N=23 N=36	
	70				N	
894.5			BOTTOM @75.5' ON BOULDER POSSIBLY CONCRETE		O N=36	AUGER HEAD SHEARED
	80					
	90					
	100					

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PROJECT: CH. JOSEPH DAM LT. EMB. HOLE NO. 87-PA-401

FILENAME: C-L OG.DGN

Hole No. 87-RD-401A

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT: CHIEF JOSEPH DAM LT. EMBANKMENT		10. SIZE AND TYPE OF BIT: 4" TRICONE	
2. LOCATION (Coordinates or Station): PIEZOMETER INSTALLATION		11. DATUM FOR ELEVATION SHOWN (TBM or MSL):	
3. DRILLING AGENCY: GOVERNMENT		12. MANUFACTURER'S DESIGNATION OF DRILL: MOBILE B-80 POWER AUGER	
4. HOLE NO. (As shown on drawing title and File number): 87-RD-401A		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0	UNDISTURBED
5. NAME OF DRILLER: BALES		14. TOTAL NUMBER CORE BOXES: 2	
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		15. ELEVATION GROUND WATER: 931	
		16. DATE HOLE: STARTED 4/21/87	COMPLETED 4/25/87
7. THICKNESS OF OVERBURDEN: 79.5'		17. ELEVATION TOP OF HOLE: 970	
8. DEPTH DRILLED INTO ROCK: 2.5 W/10.2 CONCRETE		18. TOTAL CORE RECOVERY FOR BORING: 12.7'	%
9. TOTAL DEPTH OF HOLE: 92.2'		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)
970			2" ASPHALTIC CONCRETE ON 4" BASE COURSE			
		GP	SANDY GRAVEL W/ COBBLES, MEDIUM, MOIST, BROWN			
	10	SC	CLAYEY SAND W/GRAVEL & OCC COBBLES, MED TO DENSE MOIST, BROWN			
		SC	CLAYEY SAND W/ GRAVEL & COBBLES & OCC BOULDERS, DENSE, MOIST, LT. BROWN			
	20					
	30	SC	CLAYEY SAND W/GRAVEL & COBBLES (8"), DENSE, MOIST, LT. BROWN			
	40					
		SC	CLAYEY SAND W/GRAVEL & OCC. COBBLES (6"), DENSE, SATURATED, LT. BROWN	1 1/2" PVC SOLID PIPE; CEMENT GROUT SEAL		
	50					
	60			SM		
	70	SC	CLAYEY SAND W/GRAVEL & NUMEROUS COBBLES & OCC BOULDERS (18"), DENSE, SATURATED, LT. BROWN			
890.5	80		CONCRETE	1 1/2" PERF PVC PIPE; GRAVELLY SAND	A, B	DIAMOND BIT CORE BARREL (TYP)
880.3	90		BEDROCK		C	
877.8			BOTTOM AT 92.2' ON BEDROCK			
	100					

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PROJECT: CH. JOSEPH DAM LT. EMB. HOLE NO. 87-RD-401A

Hole No. 87-RD-404

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT: CHIEF JOSEPH DAM LT. EMBANKMENT		10. SIZE AND TYPE OF BIT: 4" TRICONE	
2. LOCATION (Coordinates or Station): PIEZOMETER INSTALLATION		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY: GOVERNMENT		12. MANUFACTURER'S DESIGNATION OF DRILL: MOBILE B-80 POWER AUGER	
4. HOLE NO. (As shown on drawing title and File number): 87-RD-404		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 3	UNDISTURBED 0
5. NAME OF DRILLER: BALES		14. TOTAL NUMBER CORE BOXES: 1	
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
7. THICKNESS OF OVERBURDEN: 64.8'		16. DATE HOLE: STARTED 5/1/87	COMPLETED 5/5/87
8. DEPTH DRILLED INTO ROCK: 1.3' +8.7' CONCRETE		17. ELEVATION TOP OF HOLE: 970'	
9. TOTAL DEPTH OF HOLE: 74.8'		18. TOTAL CORE RECOVERY FOR BORING: 10'	%
		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)
970			2" ASPHALTIC CONCRETE ON 4" BASE COURSE			
		GM	SILTY SANDY GRAVEL W/COBBLES (10"), MEDIUM, MOIST, BROWN	1/4" BENTONITE PELLETS & SAND		
	10	SC	CLAYEY SAND W/GRAVEL & COBBLES DENSE, MOIST, LT. BROWN			
		GP	SANDY GRAVEL W/COBBLES (6") DENSE, MOIST, BROWN		A N=39	2" SPLIT SPOON SAMPLE DRIVEN BY 140# HAMMER, 30" DROP, (TYP)
					B N=43	N=NUMBER OF BLOWS TO DRIVE SAMPLER 1 FT.
	20	SC	CLAYEY SAND W/GRAVEL & COBBLES (6"), DENSE, MOIST, LT. BROWN		C N=60	
	30			CAVE-IN MAT'L		
	40			1-1/2" SOLID PVC PIPE		
	50					
	60					
905.2			CONCRETE		D	DIAMOND BIT CORE BARREL
	70			GRAVELLY SAND		
896.5			BEDROCK			
895.2			BOTTOM @ 74.8' IN BEDROCK			
	80			1-1/2" PERF. PVC PIPE		
	90					
	100					

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PROJECT: CH. JOSEPH LT. EMBANK. HOLE NO. 87-RD-404

Hole No. 87-RD-406

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT: CHIEF JOSEPH DAM LT. EMBANKMENT		10. SIZE AND TYPE OF BIT: 4" TRICONE	
2. LOCATION (Coordinates or Station): PIEZOMETER INSTALLATION		11. DATUM FOR ELEVATION SHOWN (TBM or MSL):	
3. DRILLING AGENCY: GOVERNMENT		12. MANUFACTURER'S DESIGNATION OF DRILL: MOBILE B-80 POWER AUGER	
4. HOLE NO. (As shown on drawing title and File number): 87-RD-406		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 1	UNDISTURBED 0
5. NAME OF DRILLER: BALES		14. TOTAL NUMBER CORE BOXES: 1	
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		15. ELEVATION GROUND WATER:	
7. THICKNESS OF OVERBURDEN: 49.0'		16. DATE HOLE: STARTED 4/29/87	COMPLETED 4/30/87
8. DEPTH DRILLED INTO ROCK: 5.5'		17. ELEVATION TOP OF HOLE: 970'	
9. TOTAL DEPTH OF HOLE: 54.5'		18. TOTAL CORE RECOVERY FOR BORING: 5.5'	%
		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)
970	0		2" ASPHALTIC CONCRETE ON 4" BASE COURSE			
		GM	RIPRAP W/SILTY SANDY GRAVEL MATRIX SILTY SANDY GRAVEL (3"O), MED., MOIST, BROWN	1/4" BENTONITE PELLETS		
	10	SC	CLAYEY SAND W/ GRAVEL & OCC COBBLES (6"), DENSE, MOIST, LT. BROWN		A N=40	2" SPLIT SPOON SAMPLER DRIVEN BY 140# HAMMER, 30" DROP N=NUMBER OF BLOWS TO DRIVE SAMPLER 1 FT.
	20	SC	CLAYEY SAND W/GRAVEL, NUMEROUS COBBLES, & OCC. BOULDERS (18"), DENSE, MOIST, LT. BROWN	1-1/2" SOLID PVC PIPE		
	30			CAVE-IN MAT'L		
	40					
921	50		BEDROCK	GRAVELLY SAND	B	DIAMOND BIT CORE BARREL
915.1			BOTTOM @ 54.9' IN BEDROCK	1-1/2" SOLID PVC PIPE		
	60					
	70					
	80					
	90					
	100					

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PROJECT: CH. JOSEPH DAM LT. EMBANK. HOLE NO. 87-RD-406

Hole No. 87-RD-408

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT: CHIEF JOSEPH DAM LT. ABUT.		10. SIZE AND TYPE OF BIT: 4" TRICONE	
2. LOCATION (Coordinates or Station): PIEZOMETER INSTALLATION		11. DATUM FOR ELEVATION SHOWN (TBM or MSL):	
3. DRILLING AGENCY: GOVERNMENT		12. MANUFACTURER'S DESIGNATION OF DRILL: MOBILE B-80 POWER AUGER	
4. HOLE NO. (As shown on drawing title and file number): 87-RD-408		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN:	DISTURBED: 0 / UNDISTURBED: 0
5. NAME OF DRILLER: BALES		14. TOTAL NUMBER CORE BOXES: 1	
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		15. ELEVATION GROUND WATER: 821.4'	
7. THICKNESS OF OVERBURDEN: 27.5'		16. DATE HOLE	STARTED: 6/4/87 / COMPLETED: 6/6/87
8. DEPTH DRILLED INTO ROCK: 11.0'		17. ELEVATION TOP OF HOLE: 846'	
9. TOTAL DEPTH OF HOLE: 38.5'		18. TOTAL CORE RECOVERY FOR BORING: 9'	%
		19. SIGNATURE OF INSPECTOR: MORAN	

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)
846		GM	SILTY SAND GRAVEL W/NUMEROUS COBBLES & BOULDERS (30"), VERY DENSE, DRY, GRAY-TAN	1-1/2" SOLID PVC PIPE; 1/4" BENTONITE PELLETS		PVC STICK-UP=2.2'
	10					
			OCCASIONAL VOIDS			
	20	GM	SILTY SANDY GRAVEL W/NUMEROUS COBBLES, VERY DENSE, GRAY (TILL LIKE MAT'L)			
821.4			WATER @ 24.6' 6/8/87			
818.5			BEDROCK	GRAVELLY SAND	A	DIAMOND BIT CORE BARREL (TYP)
	30				B	
807.5			BOTTOM @ 38.5' IN BEDROCK	1-1/2" PERF. PVC PIPE		
	40					
	50					
	60					
	70					
	80					
	90					
	100					

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PROJECT: CHL JOSEPH DAM LT. ABUT. | HOLE NO. 87-RD-408

Hole No. 87-RD-409

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS
1. PROJECT: CHIEF JOSEPH DAM LT. ABUT.		10. SIZE AND TYPE OF BIT: 4" TRICONE	
2. LOCATION (Coordinates or Station): PIEZOMETER INSTALLATION		11. DATUM FOR ELEVATION SHOWN (TBM or MSL):	
3. DRILLING AGENCY: GOVERNMENT		12. MANUFACTURER'S DESIGNATION OF DRILL: MOBILE B-80 POWER AUGER	
4. HOLE NO. (As shown on drawing title and File number): 87-RD-409		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0	UNDISTURBED 0
5. NAME OF DRILLER: BALES		14. TOTAL NUMBER CORE BOXES: 2	
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		15. ELEVATION GROUND WATER: 812'	
		16. DATE HOLE: STARTED 6/6/87	COMPLETED 6/11/87
7. THICKNESS OF OVERBURDEN: 26.5'		17. ELEVATION TOP OF HOLE: 855'	
8. DEPTH DRILLED INTO ROCK: 19.2'		18. TOTAL CORE RECOVERY FOR BORING: 17.7'	%
9. TOTAL DEPTH OF HOLE: 45.7'		19. SIGNATURE OF INSPECTOR: MORAN	

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	PIEZ. INST.	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
855	0	GM	SILTY SANDY GRAVEL W/NUMEROUS COBBLES & BOULDERS (30"), DENSE, DRY TO MOIST, TAN	1-1/2" SOLID PVC PIPE; 1/4" BENTONITE PELLETS		PVC STICK-UP=2'
	10	GM	SILTY SANDY GRAVEL W/NUMEROUS COBBLES & OCC. BOULDERS, VERY DENSE, MOIST, TAN			
	20	GM	SILTY SANDY GRAVEL W/NUMEROUS COBBLES & BOULDERS, VERY DENSE, GRAY (TILL LIKE MAT'L)			
828.5	26.5		BEDROCK		A	DIAMOND BIT CORE BARREL (TYP)
	30				B	
	40			GRAVELLY SAND	C	
812			▼ WATER @ 43.0' 6/11/87		D	
809.3	45.7		BOTTOM @45.7' IN BEDROCK	1-1/2" PERF. PVC PIPE		
	50					
	60					
	70					
	80					
	90					
	100					

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PROJECT: CH. JOSEPH DAM LT. ABUT. | HOLE NO. 87-RD-409

APPENDIX D

BLASTING CRITERIA

Structural Excavation
Pre-Shear Testing
Chief Joseph Dam Additional Units
Contract DACW67-75-C-0077

This report is being prepared per request of Office Chief of Engineers and the Seattle District Office, F & M Branch. This report will also be included as part of the foundation report to be prepared at a later date. This report covers the pre-shear testing for excavation of the penstock slots and powerhouse addition excavation.

With the excavation in close proximity to an operating powerhouse and directly beneath an intake structure with 75-feet of reservoir, stringent blasting requirements were imposed in the contract.

The first requirement prior to any production pre-shearing was the establishing of blasting criteria, hole spacing, loading, which included spacing of explosives and weight of charges, and particle velocity in both adjacent rock and concrete.

The specifications limited the contractor to 2-inch nominal diameter blast holes, line holes or cushion blast holes. At the option of the contractor, the diameter of the perimeter or pre-shear holes drilled along the final design slopes could be increased up to 2 3/4-inches in diameter provided the velocity of the explosive charge was the same or higher and the size of the explosive charge was not greater than that used in the 2-inch diameter holes.

Eight-foot maximum production lifts were established in critical areas. Critical areas were those in which pre-shearing was to be accomplished to produce neat line and final grades. Maximum lift thickness for non-critical areas was 12-feet. Pre-shearing was accomplished with 24-foot deep holes.

Particle velocities were established allowing the maximum particle velocity at 20-feet to be 2-inches/second in rock and 4-inches/second in adjacent concrete.

To allow the contractor maximum flexibility under the contract, specific bid items were established. In both production and pre-shearing in critical areas the contractor was paid by the lineal foot of drill hole for rock excavation. In non-critical areas rock excavation was paid for by the cubic yard. Production holes were required to be loaded whereas pre-shear holes, either vertical or on a 45^{o} slope, would be paid for loaded or unloaded.

Rock in the excavation area is predominately a granodiorite. It is moderately hard to hard. Joint spacing varies from less than 1" to 6-feet with an average of 1-2-feet. Some minor intrusions are scattered throughout the excavation with variations of the granodiorite ranging from a schistose to gneissic structure.

The major joint sets are striking north 40-45° west and dipping 60-70° to the east and north 35-40° east and dipping 65-70° to the east.

This report basically covers the first portion of the blasting requirements which was the pre-shear testing. The objective of the pre-shear testing was to obtain relatively smooth undamaged backslopes and to eliminate any possible structural damage to the adjacent structures through excessive particle velocities.

At the time test blasting was required there was not a suitable area for experimentation outside the critical penstock slots. Testing, therefore, was conducted in the penstock slots of Units 24, 25, and 27. To minimize damaging the final backslopes of the future 35-foot wide penstock slots, the center portions were used.

Dimensions were 18-feet long by 18-19-feet wide. Due to the close-moderate jointing of the rock 12 and 18-inch hole spacing was selected although 9-inch hole spacing was used in one case. Upon completion of testing the remaining portion of the penstock slot was shot to final design slope using the optimum spacing and loading found in the testing.

The following is a description of each shot and the results. For specific details of each shot, see the attached blasting report and tabulation.

Pre-shear Test Shots Nos. 1 and 2

The first two tests were conducted in Penstock Slot 25. Due to the structure of the rock, to better compare results and to expedite the testing program, comparable loadings and hole spacings were used in the same slot but reversed between Shots 1 and 2. Pre-shear holes were shot simultaneously. Production holes were shot 150 milliseconds after the pre-shear holes.

Upon removal of the production shot, there was very little difference between the backslope as produced by the 12 and 18-inch center holes. Some pre-shear hole casts were visible; complete drill holes were left in the more massive rock. Some overbreak did occur, 6-9-inches, between the 18-inch spacing but no more than could be found between the 12-inch spaced holes. This indicated that the difference in hole spacing in either shot had little effect on the backslope. Overbreak of 1-3-feet did occur at the top of the slope and was attributed to previous excavation, the single explosive charges at the bottom of each hole or the confinement of the charge at a shallow depth with full stemming.

Pre-shear Shot No. 3

Penstock Slot 24 was drilled with pre-shear holes spaced at 18-inches on the right side and 12-inches on the left. Feeling that the production shot was to close in time to the pre-shear and may have inhibited the development of the maximum pre-shear plane in Shots 1 and 2, pre-

shearing in Shot No. 3 was accomplished without a production shot. Hole depths were increased to 24-feet as it was felt that the shallowness of the holes in Shots 1 and 2 may have contributed to some of the overbreak and that 24-foot deep holes would approximate that used in actual production pre-shearing. As seismic vibration had been exceeded in Shots 1 and 2, 9 millisecond delays were used between every third loaded hole. On the side with 18-inch hole spacing every hole was loaded and the same delay pattern as the 12-inch hole spacing.

Upon excavation, it was evident that the 18-inch pre-shear backslope was much better developed than the 12-inch pre-shear backslope. Overbreak between holes and at the top of the slope were reduced over Test Shots Nos. 1 and 2. Approximately 85% of the 18-inch pre-shear holes were in evidence throughout the section. The 12-inch pre-shear wall was irregular due to the intermediate hole being unloaded and the shear plane did not in all cases pass through the unloaded hole. Breakage occured both in front and behind the drill hole. Failure of the shear plane to break through the unloaded hole was due to hole spacing and not the structure of the rock. About 80% of the loaded holes were left as casts.

Pre-shear Test Shot No. 4

Penstock Slot 24 was used for Test Shot No. 4. Hole spacing was reversed from Test Shot No. 3. All holes were loaded. String charges of 70% Gelex No. 2 were taped to detonating cord. Again, to reduce seismic vibration, 9 millisecond delays were used between every third hole. Charges were staggered in adjacent holes. Stemming was used in the top 4-feet of the hole.

After excavation little difference was noted between the 12 and 18-inch pre-shear walls. Between 80-85% of the holes were in evidence. Breakage between holes was good, with minimal overbreak occuring. Overbreak at the top of the backslope was 1-2-feet behind the pre-shear line.

Pre-shear Test Shot No. 6

In Penstock Slot 25 all pre-shear holes were shot instantaneously with 150 millisecond delay between the pre-shear and production. This method was necessary as it would have been difficult to have drilled the production shot area at a later date. The backslope was well developed with minimal overbreak. Approximately 85-90% of the pre-shear holes were left as casts. Loading of pre-shear holes was reduced from .15 lbs/ft^2 to .06 lbs/ft^2. Stemming was reduced to 2-feet in pre-shear holes to allow more venting and reduce overbreak at the top of the backslope. Pre-shearing was as well developed in Shot No. 6 as that in Shot Nos. 1, 2, 3, and 4 for 18-inch hole spacing.

Pre-shear Test Shot No. 7

The remainder of Penstock Slot 24 was shot in Shot No. 7. Shot No. 7 was loaded identically to that of Shot No. 6, the difference being a 5 millisecond delay placed between each fifth hole. Shot No. 7 was delayed in this manner to compare pre-sheared backslopes developed by firing instantaneously, as against backslopes developed by delaying between holes. In examining the backslope of Shot No. 7 and comparing it to other 18-inch backwalls, there appears to be very little difference.

Pre-shear Test Shot No. 8

To evaluate the possibility of eliminating overbreak at the top of the backslope, Penstock Slot 27 was drilled with alternating 12-foot and 24-foot deep holes on 9-inch centers with the 24-foot deep holes loaded. Powder factors were reduced from .06 lbs/ft^2 to .04 lbs/ft^2, anticipating that the unloaded holes would provide additional relief. Unloaded holes were not stemmed. With the completion of excavation, it could be seen that either the charge per hole was to light, or the unloaded holes did not provide the relief expected. The pre-shear plane broke in front of and behind the anticipated neat line and only occasionally broke through the relief hole. The general condition of the backslope was quite irregular and the overbreak at the top of the backslope was not eliminated.

Test Shot No. 8 concluded the testing program. The following conclusions were used as criteria to establish basic pre-shear blasting:

1. In all test shots, 18-inch hole spacing developed backslopes as well as 12-inch pre-shear backslopes. With economics of drilling involved, 18-inch hole spacing was selected.

2. Stemming of pre-shear holes was minimized. Stemming depths varied from a maximum of 9-feet to 2-feet in testing with 4-feet to 0 used during actual production pre-shearing. Due to the closely-to-moderately jointed rock, it was felt that gases were causing some of the overbreak, not only in the backslope, but at the top of the slope. All pre-shear shots were henceforth allowed to vent.

3. Explosive charges per square foot were varied from .03 lb to .15 lb. Optimum was felt to range between .07 of a lb to .12 lb per square foot. As production pre-shearing progressed, explosive charges were reduced to .07 lb per square foot.

4. Pre-shear was shot separately and well in advance of any production shot. A delay sequence was not used as pre-shear was accomplished 2-3 days prior to production blasting.

5. The question arose in regard to benefits from firing simultaneously or with some delay sequence between holes. It was shown in test shots where little relief for pre-shear was available, particle velocities exceeded the specification requirements of 2-inches per second at 20 feet. Delay sequences did attenuate the particle velocity, but again not below specification requirements. A majority of readings fell in the range of 4-5-inches per second. In production pre-shearing, delays were held to 5 millisecond delays to minimize time lapse. Pre-sheared backslopes created by delayed shots show little difference than those of simultaneously fired backslopes.

In conclusion, the pre-shear backslopes are well developed. Some overbreak did occur, not only in the backslope but at the top of the slope. This overbreak was attributed mainly to the structure of the rock, both in joint spacing and attitude at which the joints intersected the pre-shear wall.

POWDER DESCRIPTION

Dupont Tovex 200

Weight per stick $1\frac{1}{4}$" x 12" = .58 lbs.
$1\frac{1}{2}$" x 12" = .85 lbs.

Dupont Trimtex

Weight per stick 7/8" x 24" = .5 lbs.

Dupont Gelex 2 - 70% attached to 25 grain detonating cord

Weight per stick 1" x 8" = .33 lbs.

Spacing 36" centers

Initiation of a firing sequence was accomplished by safety fuse and cap with the safety fuse having a burning rate of 120 seconds per yard.

Detonating cord Ensign & Bickford 200 grain primacord & 25 grain E cord for down lines

Delay sequences were established with both MS delay caps & MS connectors.

Stemming - Clean, minus No. 4 concrete sand.

Test Shot	Hole Spacing	Total Shot p.s.	Total Shot prod.	lbs/delay p.s.	lbs/delay prod.	Delay Sequence	Particle Velocity @ 201
1	12"	15.30 lbs					
	18"	10.20 lbs		25.5		0	
	Production		76.5 lbs		10.0	0-8	
2	12"	10.20 lbs					
	18"	6.80 lbs		17.0		0	
	Production		37.24 lbs			0-4	
3	12"	53.35 lbs				9 m.s.	4"+
	18"	72.75 lbs				9 m.s.	
4	12"	48.00 lbs				5 m.s.	7"+
	18"	33.00 lbs				5 m.s.	
5	12"	22.32 lbs		3.6		9 m.s.	10"+
	Production		41.18 lbs		8.71	0-8	
6	18"	76.56 lbs		76.56		0	7.8"
	Production		59.7 lbs		5.8	1-12	
7	18"	50.2 lbs		13.2		5 m.s.	4"
	Production		38.4 lbs		4.6	0-8	
8	9"	26.6 lbs		3.99		5 m.s.	9"

6.2 Objectives: Primary objective is to remove rock materials in a manner that will leave rock outside of the excavation limits undisturbed and conforming as nearly as possible to lines and grades shown on the drawings, or as directed. Breakage of rock, ease of handling and conservation of effort are recognized as objectives, but shall be considered as secondary to the objectives stated above. It is the responsibility of the Contractor to conduct his operations so that the stated objectives are achieved.

6.3 Method of Excavation: Rock excavation shall be accomplished by systematic drilling and blasting within the limitations specified herein, except that rock excavation within existing powerhouse skeleton bays 17 through 20 shall be accomplished by methods other than blasting and in a manner as approved by the Contracting Officer. Contractor shall employ 2-inch nominal diameter holes, for blast holes, line holes and presplit or cushion blast holes. At the option of the Contractor, the diameter of the perimeter holes drilled along final design slopes in areas 1 and 2 may be increased up to 2-3/4-inch diameter maximum provided the velocity of explosives is the same or higher than that used for 2-inch holes and the size of the explosive charge is no greater than that used for the 2-inch holes. Payment for the larger size holes shall be at the unit price of the 2-inch diameter holes. Deviation in hole alinement shall not exceed one-quarter of the distance of the hole spacing or 6 inches, whichever is greater. Blasting shall be to existing or "V"-cut blasted free faces. Existing free faces shall be progressively modified to face easterly or westerly. "V"-cut blasted faces shall face east and west at right angles to the Intake Structure and shall be initially created by blast holes not steeper than 45 degrees (See sketch attached at end of this Section). With the approval of the Contracting Officer, other blast patterns may be used in excavating the penstock slots. Such proposed patterns shall have been demonstrated to be patterns of least damage to rock slopes in noncritical areas prior to their use in the penstock slots. Contractor shall employ controlled blasting techniques such as but not limited to, line drilling, cushion blasting and presplitting to control damage to the final cut faces. Prior to excavation of the final face, Contractor shall conduct such controlled experimental blasts in areas to be excavated away from the face to acertain the optimum method of controlling rock damage. Contracting Officer will monitor all blasting operations to preclude damage to final rock faces and structures. Contracting Officer will use vibration monitoring, photo comparisons, instrumental structural alinement observations, deformeters and water inflow data in rock slopes to control the blasting and prevent progressive damage. Because damage to the Intake Structure and underlying rock is the cumulative sum of damage caused by this and earlier contracts, plus stress changes induced by structural additions and pool rise, each blast must be accomplished without any recordable damage to the adjacent concrete structures, the foundation rock supporting the structures or to final design

slopes. Rock farther than 10 feet from any final design slope shall be blasted in lifts that do not exceed 12 feet using vertical or near vertical blast holes (rock in rock excavation areas 1 and 2). Rock within 10 feet horizontally of any final design cut slope (areas 2 and 3) shall be blasted in lifts 8 feet deep. Blast holes in area 3 shall be inclined 45 degrees and paralles to the design slope. These 8-foot lifts shall not be blasted until the adjacent area 2 lift has been blasted and excavated. Area 2 blast holes along the final excavation line shall penetrate to the final design grade in area 3 but shall not be loaded in area 3 except as may be permitted by the Contracting Officer. Inflow test holes of 3 inches diameter shall be drilled from the top of each 8-foot lift, as shown,

before blasting adjacent rock. Gravity water inflow tests shall be made before and after blasting as directed by the Contracting Officer. Test consists of filling the hole with water and recording the rate at which the water level drops.

6.3.1 All rock excavation in each penstock area shall be completed to final grade and peripheral rock bolting completed prior to construction of concrete pier for service deck or any temporary piers on adjacent rock surfaces.

6.4 Blasting:

6.4.1 General: All blasting operations shall be performed in accordance with the applicable provisions of Corps of Engineers Manual EM 385-1-1, titled "GENERAL SAFETY REQUIREMENTS," as amended except that firing of blasts electrically will not be permitted. If one of the ammonium nitrate compound type of explosives is used, storage and procedures for use shall conform to the requirements set forth in the Bureau of Mines information Circular 8179, SAFETY RECOMMENDATIONS FOR SENSITIZED AMMONIUM NITRATE BLASTING AGENTS. Blasting shall be used only as necessary to loosen rock. Explosives shall not be used as a means to reduce size of material or as a means of transporting material. The Contractor shall submit his drilling and blasting plans to the Contracting Officer for approval at least three (3) working days prior to initiation of drilling operations in the applicable area. Plans shall show hole positions, angles and depths, type and quantity of explosives to be used and firing sequence, all relative to existing stations and grades. No drilling or blasting will be permitted without the Contracting Officer's approval. The work shall be conducted in such a manner that rock outside excavation limits and concrete structures will be undisturbed and the shape of the excavation will conform as nearly as possible to lines and grades shown on the drawings or as directed. No blasting shall be done within 100 feet of concrete which has been in place less than 7 days. If, in the opinion of the Contracting Officer, the size of any proposed shot outside the 100-foot area will disturb fresh concrete, the size of such shot shall be reduced. When oncrete is older than 7 days, shots within 100 feet of the concrete shall be reduced as necessary so as not to damage the concrete structure. Mats or other approved means shall be employed as necessary to control flying rock and prevent damage to structures or equipment. Whenever, in the opinion of the Contracting Officer, further blasting, the method of blasting, or size of a proposed shot may damage the permanent rock face, rock bolts and drain holes; the existing concrete; or the rock upon or against which concrete is to be placed, the method or size of shot shall be modified to his satisfaction or the use of explosives shall be discontinued and the excavation shall be completed by wedging, barring, channeling, and broaching or other suitable means.

6.4.2 Vibration Limitations: Proximity of rock excavation to the intake structure and the necessity to maintain the structural

integrity of the rock slope requires that limitations be placed on Contractor's blasting operations so that damaging ground vibrations will not be generated. At no time will blasting be permitted which creates a vectorial sum of peak particle velocity greater than 4 inches per second as measured on any of the adjacent concrete structures or appurtenances or 2 inches per second on all final design rock faces at a distance of 20 feet from the blast. Blasts shall be relatively small with respect to pounds of explosives per delay and each delay shall be separated by a minimum interval of 10 milliseconds. The Contracting Officer will instrumentally monitor any and all blasts to determine the Contractor's compliance with peak particle velocity limitations as specified and will promptly advise the Contractor regarding required changes in his procedures.

6.4.3 Coordination: Contractor shall notify Contracting Officer at least 2 hours in advance of each intended blast and shall be responsible for coordination of detonation with the monitoring station. Contractor shall maintain constant telephone or other approved communication with personnel manning the monitoring station during the final 5 minutes prior to detonation to assure adequate monitoring. The blasting shall not interfere with work of other Contractors or Government operations.

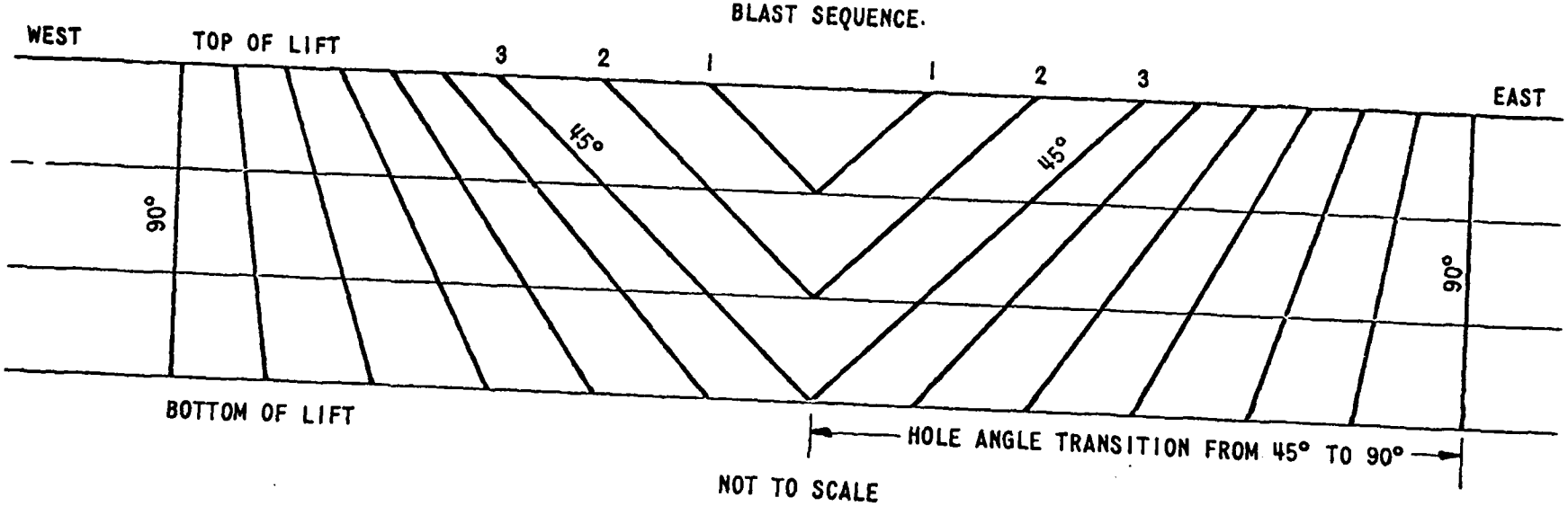
6.5 Wire mesh protective screen shall be installed on excavated rock faces 60 degrees or steeper vertical where the faces are 10 feet high or greater to protect personnel against possible falling of loose or spalled rock until concrete is placed.

6.5.1 Wire mesh shall be chain link fabric conforming to Federal Specifications RR-F-191G and RR-F-191/1A, Type I or II, 2-inch mesh, 9 gage wire, knuckled selvage with 1.2 ounce coating for type I and 0.40 ounce coating for type II.

6.5.2 Installation: Wire mesh shall be anchored at top edge with anchor bars as shown. Wire mesh shall extend to within 2 feet of bottom of rock faces at all times until the rock is covered with concrete. Mesh may be removed as concrete is placed or may be left in place. All wire mesh exposed to view after all concrete is placed shall be removed and will become property of the Contractor and shall be removed from the project site.

6.5.3 Payment: No separate payment will be for wire mesh and all costs for furnishing installing and removal shall be included in and considered incidental to rock excavation.

7. DENTAL EXCAVATION: Unsatisfactory material shall be removed and disposed of as specified here-in-before in Paragraph Excavation, Dental. The holes or cavities in the rock resulting



TYPICAL "V" SECTION SHOWING BLAST HOLES

(TO BE FIELD ADJUSTED WITH APPROVAL OF CONTRACTING OFFICER. DELAYS WITHIN EACH BLAST TO BE FIELD ADJUSTED. REMOVAL OF BLASTED ROCK MUST BE ACCOMPLISHED PRIOR TO DETONATION OF SUCCESSIVE BLASTS.)

CHIEF JOSEPH DAM

DATE: 10 JAN. 79

POWERHOUSE EXCAVATION QUANTITIES – FINAL

BID ITEM	AREA #1	AREA #2	AREA #3	AREA #4	REMARKS	PAY QUANTITY
(2) EXCAVATION, COMMON	1,972	134,999	13,317	64,344		214,632
(2.6) EXCAVATION, ROCK AREA #4	NONE	89,055	7,891	242		97,188
(3) TRANSPORTING ROCK	45,265	35,678	7,037	NONE		87,980
(3.1) EXCAVATION, UNDERWATER	NONE	103,915	NONE	35,849	DEDUCT FROM NEATLINE 14,350	125,414
(7) DERRICK STONE REMOVAL	NONE	4,305	NONE	NONE		4,305
(8) GRANULAR FILL	379	NONE	23,233	3,722	GRANULAR FILL, CONC. DEDUCT 2528	24,806
(9) ROCK BLANKET	NONE	*	*	*	* SEE DWG. & COMP. SH. FILED IN AREA #4	4,669
(10) DERRICK STONE PLACEMENT	NONE	*	*	*	* SEE TOTAL LISTING IN AREA #4	7,659
(13) ROCK FILL	NONE	NONE	NONE	NONE	SEE SEPARATE LISTING AREA #3	40,915
(13) SHOT ROCK ELEV 800 TO 810 ON TAILRACE LEFT	TAILRACE LEFT BANK *			*	* SEE AREA #4 COMP. SH.	2,751 TOT. 43,666