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35-24-07

GEOTECHNICAL EVALUATION

24.7E.35

## MEMORANDUM

**To:** Jim Lutz

**From:** Robert M. Pride

**Date:** August 22, 1995

**Subject:** Snoqualmie Ridge - 1040 Reservoir

Field exploration and testing has been completed at the site of a proposed concrete reservoir tank to be constructed east of Snoqualmie Parkway (now being graded) at about station 45+00. The field investigation was accomplished by excavating eight exploratory trenches and one test boring. Depths of the trenches varied from 8 to 18 feet, and were terminated on hard bedrock materials. The test boring was drilled to 30 feet using rock coring equipment in order to extend the hole below the proposed tank foundation level (elev.  $\pm 1015$  ft).

### Site Conditions

Topographically, the area of the reservoir site slopes generally downward to the east with an overall gradient of about 6H:1V. An old logging road provides access to the west (upper) side of the site, and new trails were cleared for equipment access to other exploration locations. A moderate growth of trees and shrubs covered the proposed 1040 reservoir site area.

Prior exploration along the Parkway alignment disclosed the presence of bedrock near the existing ground surface. Backhoe test pits were excavated in and around the preferred tank site to determine the top of the bedrock surface and its resistance to penetration using a track-mounted backhoe. Rock core was obtained for visual examination of the unweathered bedrock and to document fracture and joint systems.

Subsurface conditions consist of an upper soil layer comprised of glacial till and colluvium underlain by weathered andesitic bedrock. The soil deposits vary in depth from 4 to 15 feet and were moderately dense to very dense sands, gravels, cobbles, and boulders. Excavation into the weathered bedrock was accomplished with some difficulty until refusal was met on the unweathered, hard bedrock material. Penetration depths ranged from 2 to 5 feet using the John Deere 790 backhoe.

Groundwater seepage was only encountered on Test Pit No. 3 at a depth of 14 to 15 feet (elev.  $\pm 996$  ft), but water can be expected to percolate through the upper soils and migrate down slope over the top of the weathered bedrock surface. Summary logs of the test pits and test borings are shown on Figures A-1 to A-9.

### Conclusions and Recommendations

Siting of the 1040 reservoir tank dictates that it will be founded on bedrock. A slight structure relocation into the slope will assure that the entire tank will be supported on rock as shown on the attached Figure No. 1. Surveyed test pit and boring locations indicate that blasting will be required within the tank perimeter to remove the hard unweathered rock and to reach final tank subgrade elevation. It is expected that excavation of the upper soil layer and the weathered bedrock zone can be accomplished with heavy earthmoving equipment.

It is recommended that an experienced blasting consultant be hired to determine drill hole spacing, charge size and depth, etc., that will result in a controlled program for bedrock removal. The intent of this drilling and blasting program must be based on minimizing rock disturbance at the reservoir tank foundation level and providing a relatively smooth final rock slope surface above the tank site. Recent slope construction blasting along the Parkway resulted in very irregular and unsatisfactory slope surfaces, requiring regrading and field modifications to achieve an acceptable final slope contour.

The presence of jointing and bedrock fracturing will tend to produce large and irregular rock fragments and erratic bedrock surfaces unless special care is given to the blasting program. Steep bedrock slopes are not recommended due to the potential for localized block failures along steeply dipping joint and fracture systems. Based on stability analyses, final bedrock slopes should not be constructed steeper than 1.5H:1V, and temporary rock slopes should not exceed 1H:1V. Drain benches should be included at mid-height for slopes greater than 25 to 30 feet for control of surface water runoff and miscellaneous debris fall.

Some rock disturbance should be expected at the base elevation of the tank as a result of blasting and rock removal. After removal of all loose rock fragments, the exposed foundation surface should be inspected for excessive fracturing to determine the need for application of a slurry grout. Proportions of sand, cement, and water should be based on the requirement for filling fractures and binding disturbed rock fragments that are left in place.

Foundations placed on undisturbed bedrock (slurry grouted where necessary) can be designed for an allowable bearing pressure of 5000 psf. Penetration into the rock is not required, as long as the exterior ring wall footings are protected with a 95% compacted backfill. Total and differential settlements will be less than 0.1 inch. Resistance to lateral loads (earth, wind, seismic) can be provided by friction (0.5), and by passive pressures for compacted fill (300 pcf) or undisturbed rock (1000 pcf). It is recommended that the upper foot of soil or rock be ignored when computing passive resistance.

Compacted backfill will be placed around the exterior walls of the concrete tank up to elevation 1032 to 1036 (or possibly higher). Lateral earth pressures generated by placement of compacted fill against the tank walls will approximate at-rest values. It is recommended that either a trapezoidal (38H) or rectangular (35H) pressure distribution be used in design. Adequate drainage must be installed between the rock slope and the backfill to prevent hydrostatic pressure buildup. Temporary seismic loads can be resisted by using an equivalent fluid pressure of 18 pcf in wall design, in addition to the recommended lateral earth pressure value.

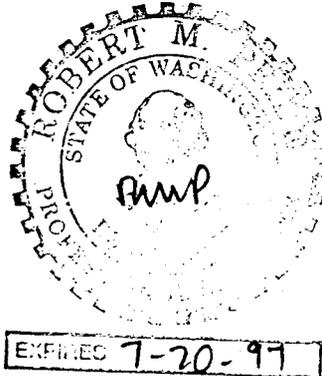
**Memorandum to:** Jim Lutz  
August 22, 1995  
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Surface and subsurface drainage systems will be required to intercept storm water runoff and groundwater seepage conditions at this site. Locations and types of subdrains should be established after the tank system has been selected and final slope conditions determined. A subfloor drain system is not considered necessary as long as the appropriate perimeter footing drains and slope subdrains are installed.

Compacted roadway and tank backfill should be placed in 8- to 10-inch lifts, brought to near optimum moisture and compacted to 95% of the maximum density. A majority of the onsite soils (except for the near clean sand-gravels) are moisture sensitive and should be used as fill during the drier summer months. Blast rock should not be incorporated into the compacted fill/backfill, except in non-structural areas designated for rock disposal.

Grading specifications for this reservoir site should be reviewed for compliance with the intent of these geotechnical recommendations.

*Robert M. Prude*





# LOG OF TEST PIT NO. TP-1

Surface Conditions: West edge of reservoir at 2H:1V slope, vegetated with moderate growth of firs and low underbrush

Elevation (Approx.): 1030

Depth, ft	Elev., ft	Samples	Moisture Content, %	Other tests	Graphic Symbol	DESCRIPTION
	1030					<p>This log is part of the report prepared by Yonemitsu Geological Services (YGS) for the named project and should be read together with that report for complete interpretation. This summary applies only that the location of this trench at the time of excavation. Subsurface conditions may at this location with the passage of time. The data presented are a simplification of actual conditions encountered.</p> <p style="text-align: center;"><b>DESCRIPTION</b></p>
1					--- --- ---	<p style="text-align: center;"><b>Forest Duff</b></p> <p>ORGANIC DEBRIS; dark brown, little sand, trace gravel; loose, moist</p>
2					. . . . . . . . . . . . . . .	<p style="text-align: center;"><b>Colluvium</b></p> <p>SILTY SAND WITH GRAVEL; Reddish-brown, fine to medium, fine to coarse gravel, trace roots, scattered cobbles to 11-inch diameter; medium dense, moist</p>
3						
4					◆ ◆ ◆ ◆ ◆ ◆ ◆ ◆ ◆ ◆ ◆ ◆ ◆ ◆ ◆	<p style="text-align: center;"><b>Bedrock</b></p> <p>ANDESITE BRECCIA; gray, medium grained, medium hard to hard, very weathered; grading with depth to medium weathered; very close fractures at high angle fractures, planar, closed infilled with iron oxide and soil</p>
5	1025					
6						
7						
8						becomes medium weathered
9						<p>Bottom of test pit at depth 9 feet, dug to refusal; completed and backfilled on 5/20/95. No groundwater encountered</p>

Snoqualmie Ridge 1040 Reservoir  
Snoqualmie, Washington  
For Barrett Consulting Group

Project No.  
  
95-10004

# LOG OF TEST PIT NO. TP-2

Surface Conditions: **NE edge of reservoir, sloped at 2H:1V, vegetated with moderate growth of fir and low underbrush**

Elevation (Approx.): **1014**

Depth, ft	Elev., ft	Samples	Moisture Content, %	Other tests	Graphic Symbol	DESCRIPTION
						<p>This log is part of the report prepared by Yonemitsu Geological Services (YGS) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may at this location with the passage of time. The data presented are a simplification of actual conditions encountered.</p> <p style="text-align: center;"><b>DESCRIPTION</b></p>
1					[Forest Duff Symbol]	<p style="text-align: center;"><b>Forest Duff</b></p> <p>ORGANIC DEBRIS; dark brown, little sand, trace gravel; loose, moist</p>
2					[Colluvium Symbol]	<p style="text-align: center;"><b>Colluvium</b></p> <p>SILTY SAND WITH GRAVEL; Reddish-brown, fine to medium, fine to coarse, trace roots, scattered cobbles to 11-inch diameter; medium dense, moist</p>
3					[Glacial Till Symbol]	<p style="text-align: center;"><b>Glacial Till</b></p> <p>SILTY SAND WITH GRAVEL; gray-brown, fine to medium, fine to coarse gravel, scattered cobbles to 8-inch diameter; very dense, moist</p>
4	1010				[Glacial Till Symbol]	
5					[Glacial Till Symbol]	
6					[Glacial Till Symbol]	
7					[Bedrock Symbol]	<p style="text-align: center;"><b>Bedrock</b></p> <p>ANDESITE BRECCIA; gray, medium grained, medium hard to hard, very weathered; grading with depth to medium weathered; very close fractures as high angle fractures, planar, closed infilled with iron oxide and soil</p>
8					[Bedrock Symbol]	
9	1005				[Bedrock Symbol]	
10					[Bedrock Symbol]	
11					[Bedrock Symbol]	becomes medium weathered
12					[Bedrock Symbol]	<p>Bottom of test pit at depth 12 feet, dug to refusal; completed and backfilled on 5/20/95.</p> <p>No groundwater encountered</p>

Snoqualmie Ridge 1040 Reservoir  
Snoqualmie, Washington  
For Barrett Consulting Group

Project No.  
**95-10004**

# LOG OF TEST PIT NO. TP-3

Surface Conditions: Southeast edge of reservoir, sloped at 4H:1V, vegetated moderate growth of fir low underbrush

Elevation (Approx.): 1011

Depth, ft	Elev., ft	Samples	Moisture Content, %	Other tests	Graphic Symbol	DESCRIPTION
<p>This log is part of the report prepared by Yonemitsu Geological Services (YGS) for the named project and should be read together with that report for complete interpretation. This summary applies only that the location of this trench at the time of excavation. Subsurface conditions may at this location with the passage of time. The data presented are a simplification of actual conditions encountered.</p>						
<b>DESCRIPTION</b>						
1	1010				---	Forest Duff
2					---	ORGANIC DEBRIS, dark brown. trace roots, scattered gravel; soft, moist
3					---	Topsoil
4					---	SILTY SAND WITH GRAVEL; red brown, fine to medium, fine to coarse gravel, trace roots, scattered cobbles to 8 diameter; medium dense, moist
5					---	Glacial Till (weathered)
6	1005				---	SILTY SAND WITH GRAVEL; gray brown, fine to medium, fine to coarse gravel, scattered cobbles and boulders to 12-inch diameter; very dense, moist
7					---	
8					---	becomes unweathered
9					---	
10					---	
11	1000				---	
12					---	
13					---	
14					---	moderate seepage encountered at 14 feet
15					---	SANDY SILT; gray mottled rust, fine sand, very thinly laminated with clayey silt; hard, very moist
16	995				◆◆◆	Bedrock
17					◆◆◆	Andesite (Tuff); dark gray, fine grained, hard, medium weathered grading with depth to unweathered, medium fractured as low angle fractures, planar, smooth partially open infilled with iron oxide
18					◆◆◆	becomes unweathered and widely fractured
Bottom of test pit at depth of 18 feet, dug to refusal; completed and backfilled on 5/20/95.						
Moderate seepage encountered at depth 15 feet.						

Snoqualmie Ridge 1040 Reservoir  
Snoqualmie, Washington  
For Barrett Consulting Group

Project No.

95-100: 4

Yonemitsu Geological Services (YGS) Engineering Geology and Applied Earth Sciences

Figure No.  
A-3

# LOG OF TEST PIT NO. TP-4

Surface Conditions:

South edge of reservoir Sloped at 6H:1V,  
vegetated with moderate growth of fir and low  
underbrush

Elevation (Approx.): **2026**

Depth, ft	Elev., ft	Samples	Moisture Content, %	Other tests	Graphic Symbol	DESCRIPTION
						<p>This log is part of the report prepared by Yonemitsu Geological Services (YGS) for the named project and should be read together with that report for complete interpretation. This summary applies only that the location of this trench at the time of excavation. Subsurface conditions may at this location with the passage of time. The data presented are a simplification of actual conditions encountered.</p> <p style="text-align: center;"><b>DESCRIPTION</b></p>
1	2025					<p style="text-align: center;">Forest Duff</p> <p>ORGANIC DEBRIS; dark brown, little sand, trace gravel; loose, moist</p>
2						<p style="text-align: center;">Colluvium</p> <p>SILTY SAND WITH GRAVEL; Reddish-brown, fine to medium, fine to coarse gravel, trace roots, scattered cobbles to 11-inch diameter; medium dense, moist</p>
3						
4						<p style="text-align: center;">Bedrock</p> <p>ANDESITE BRECCIA; gray, fine grained, medium hard to hard, very weathered; grading with depth to medium; very close fractures as high angle fractures, planar, closed infilled with iron oxide and soil</p>
5						
6	2020					
7						becomes medium weathered
8						
9						<p>Bottom of test pit at depth 9.0 feet, dug to refusal; completed and backfilled on 5/20/95. No groundwater encountered</p>

Snoqualmie Ridge 1040 Reservoir  
Snoqualmie, Washington  
For Barrett Consulting Group

Project No.

95-10004

# LOG OF TEST PIT NO. TP-5

Surface Conditions:

North edge trial 2 reservoir, sloped at 4H:1V, vegetated with moderate growth of firs and low underbrush

Elevation (Approx.): 1019

Depth, ft	Elev., ft	Samples	Moisture Content, %	Other tests	Graphic Symbol	DESCRIPTION
						<p>This log is part of the report prepared by Yonemitsu Geological Services (YGS) for the named project and should be read together with that report for complete interpretation. This summary applies only that the location of this trench at the time of excavation. Subsurface conditions may at this location with the passage of time. The data presented are a simplification of actual conditions encountered.</p> <p style="text-align: center;"><b>DESCRIPTION</b></p>
1					- - - - -	<p style="text-align: center;">Forest Duff</p> <p>ORGANIC DEBRIS; dark brown, little sand, trace gravel; loose, moist</p>
2					. . . . .	<p style="text-align: center;">Colluvium</p> <p>SILTY SAND WITH GRAVEL; Reddish-brown, fine to medium, fine to coarse gravel, trace roots, scattered cobbles to 11-inch diameter; medium dense, moist</p>
3					. . . . .	
4	1015				. . . . .	
5					◆ ◆ ◆ ◆ ◆	<p style="text-align: center;">Bedrock</p> <p>ANDESITE BRECCIA; gray, fine grained, medium hard to hard, completely weathered soil-like</p>
6					◆ ◆ ◆ ◆ ◆	
7					◆ ◆ ◆ ◆ ◆	<p>Becomes very weathered grading with depth to medium weathered; medium grained, medium hard, very close fractures as high angle fractures, planar, closed infilled with iron oxide and soil</p>
8					◆ ◆ ◆ ◆ ◆	
9	1010				◆ ◆ ◆ ◆ ◆	<p>Bottom of test pit at depth 9.0 feet, dug to refusal; completed and backfilled on 5/23/95. No groundwater encountered</p>

Snoqualmie Ridge 1040 Reservoir  
Snoqualmie, Washington  
For Barrett Consulting Group

Project No.  
  
95-10004

# LOG OF TEST PIT NO. TP-6

Surface Conditions:

Northeast edge of trial 2 reservoir sloped at 4H:1V, vegetated with moderate growth of fir and low underbrush

Elevation (Approx.): **1013**

Depth, ft	Elev., ft	Samples	Moisture Content, %	Other tests	Graphic Symbol	DESCRIPTION
						<p>This log is part of the report prepared by Yonemitsu Geological Services (YGS) for the named project and should be read together with that report for complete interpretation. This summary applies only that the location of this trench at the time of excavation. Subsurface conditions may at this location with the passage of time. The data presented are a simplification of actual conditions encountered.</p> <p style="text-align: center;"><b>DESCRIPTION</b></p>
1						<p style="text-align: center;">Forest Duff</p> <p>ORGANIC DEBRIS; dark brown, little sand, trace gravel; loose, moist</p>
2					●●●	<p style="text-align: center;">Recessional Outwash Deposits</p> <p>GRAVELLY SAND; gray, fine to coarse, fine to coarse gravel, trace roots, scattered cobbles to 11-inch diameter; medium dense, moist</p>
3	1010					
4						
5						
6						
7						
8	1005				◆◆◆	<p style="text-align: center;">Bedrock</p> <p>ANDESITE BRECCIA; gray, fine grained, medium hard to hard, very weathered grading with depth to medium weathered, thinly layered with andesitic tuff; very close fractures as high angle fractures, planar, closed infilled with iron oxide and soil becomes medium weathered</p>
9						
10						
11						<p>Bottom of test pit at depth 11.0 feet, dug to refusal; completed and backfilled on 5/23/95. No groundwater encountered</p>

Snoqualmie Ridge 1040 Reservoir  
Snoqualmie, Washington  
For Barrett Consulting Group

Project No.

95-10004

# LOG OF TEST PIT NO. TP-7

Surface Conditions:

Eastern edge of trial 2 reservoir sloped at 4H:1V, vegetated with moderate growth of firs and low underbrush

Elevation (Approx.): 1015

Depth, ft	Elev., ft	Samples	Moisture Content, %	Other tests	Graphic Symbol	DESCRIPTION
	1015					<p>This log is part of the report prepared by Yonemitsu Geological Services (YGS) for the named project and should be read together with that report for complete interpretation. This summary applies only that the location of this trench at the time of excavation. Subsurface conditions may at this location with the passage of time. The data presented are a simplification of actual conditions encountered.</p> <p style="text-align: center;"><b>DESCRIPTION</b></p> <p style="text-align: center;">Forest Duff</p> <p>ORGANIC DEBRIS; dark brown, little sand, trace gravel; loose, moist</p>
1					[Symbol: Dotted pattern]	<p style="text-align: center;">Glacial Till (Weathered)</p> <p>SILTY SAND WITH GRAVEL; gray brown, fine to medium, fine to coarse gravel, trace roots, scattered cobbles to 11-inch diameter, scattered boulders up to 2-foot diameter; dense, moist</p>
2					[Symbol: Dotted pattern]	
3					[Symbol: Dotted pattern]	
4					[Symbol: Dotted pattern]	
5	1010				[Symbol: Dotted pattern]	
6					[Symbol: Dotted pattern]	
7					[Symbol: Dotted pattern]	
8					[Symbol: Dotted pattern]	
9					[Symbol: Diamond pattern]	<p style="text-align: center;">Bedrock</p> <p>ANDESITE BRECCIA; gray, fine grained, medium hard to hard, very weathered grading with depth to medium weathered, very close fractures as high angle fractures, planar, closed infilled with iron oxide and soil</p>
10	1005				[Symbol: Diamond pattern]	<p>Bottom of test pit at depth 11.0 feet, dug to refusal; completed and backfilled on 5/23/95.</p> <p>No groundwater encountered</p> <p>Note trench 22 feet long; bedrock surface was encountered in the south end of trench at depth of 1 foot and dips to the north to a depth of 8 feet</p>

Snoqualmie Ridge 1040 Reservoir  
Snoqualmie, Washington  
For Barrett Consulting Group

Project No.  
  
95-10004

# LOG OF TEST PIT NO. TP-8

Surface Conditions: South of trial 2 reservoir sloped 4H:1V, vegetated with moderate growth of firs and low underbrush

Elevation (Approx.): 1019

Depth, ft	Elev., ft	Samples	Moisture Content, %	Other tests	Graphic Symbol	DESCRIPTION
						<p>This log is part of the report prepared by Yonemitsu Geological Services (YGS) for the named project and should be read together with that report for complete interpretation. This summary applies only that the location of this trench at the time of excavation. Subsurface conditions may at this location with the passage of time. The data presented are a simplification of actual conditions encountered.</p> <p style="text-align: center;"><b>DESCRIPTION</b></p>
1					--- --- ---	<p style="text-align: center;">Forest Duff</p> <p>ORGANIC DEBRIS; dark brown, little sand, trace gravel; loose, moist</p>
2					..... ..... .....	<p style="text-align: center;">Colluvium</p> <p>SILTY SAND WITH GRAVEL; gray brown, fine to medium, fine to coarse gravel, trace roots, scattered cobbles to 11-inch diameter, scattered boulders up to 2-foot diameter; dense, moist</p>
3					..... ..... .....	
4	1015				◆◆◆◆ ◆◆◆◆ ◆◆◆◆	<p style="text-align: center;">Bedrock</p> <p>ANDESITE BRECCIA; gray, fine grained, medium hard to hard, very weathered grading with depth to medium weathered, very close fractures as high angle fractures, planar, closed infilled with iron oxide and soil</p>
5					◆◆◆◆ ◆◆◆◆ ◆◆◆◆	
6					◆◆◆◆ ◆◆◆◆ ◆◆◆◆	
7					◆◆◆◆ ◆◆◆◆ ◆◆◆◆	becomes medium weathered
8					◆◆◆◆ ◆◆◆◆ ◆◆◆◆	<p>Bottom of test pit at depth 8.0 feet, dug to refusal; completed and backfilled on 5/23/95. No groundwater encountered.</p>

Snoqualmie Ridge 1040 Reservoir  
Snoqualmie, Washington  
For Barrett Consulting Group

Project No.  
  
95-10004

# Geological Services (YGS)

Project Number  
95-10004

Boring Number  
B-1

Sheet  
1 of 1

Project Feature: 1040 Reservoir  
 Driller / Equipment: PTL Simco Versadrill  
 Sampler / Method: Nx Wireline Core  
 Coordinates: \_\_\_\_\_

Elevation: 1037.00  
 Start Date: May 25, 1995  
 Finish Date: May 26, 1995  
 Hole Diameter: 3.5

Elev.	Depth (feet)	Box #	Run #	%Rec./RQD	Graphic Log	Classification and Physical Condition	Rock Mass Rating		PL or UCS*	Remarks
							RMR	Q		
1035						<b>Fall</b> SANDY GRAVEL; gray fine to coarse, fine to medium sand, trace to little silt; medium dense, moist				
	5					<b>Colluvium</b> SILTY SAND WITH GRAVEL; gray brown, fine to medium, fine to coarse gravel, scattered cobbles to 6-inch diameter; medium dense, moist				
1030						(open voids between 7.5 and 8.5 feet)				Nw casing installed to a depth 15.5 feet
		1	run 1	% 40/0		<b>Bedrock</b> GRAYWACKE SANDSTONE (tuffaceous); gray-brown mottled rust, fine to medium grained, soft completely weathered; indistinct bedding; extremely close fractures at 40 to 80 degrees to the horizontal, infilled with clay and iron oxide				Complete water loss during drilling operations
1025						rehealed fracture at 80 to horizontal, infilled with calcite and quartz				
			run 2	% 80/0		Becomes very weathered; very close fractures at 60 to 90 degrees to the horizontal infilled with clay				
	15					13.0 - 2-inch clay seam (13.2 - 13.8) completely weathered zone, extremely close fractures 60 to 90 degrees to the horizontal, infilled with clay				
						becomes medium weathered, medium hard; very close fractures, planar rough infilled with iron oxide and clay				
1020			run 3	% 100/0		(16.2 - 16.8) 2-inch clay seams				
						(17.0 - 18.0) fracture at 80 degrees to the horizontal infilled with slickensides, quartz and calcite				
	20	2	run 4	% 100/20		Becomes dark gray, fine to medium grained, hard, unweathered poorly bedded at 80 degrees to the horizontal; medium fractured 20, 30, and 70 to the horizontal, planar, rough, tight, clean				
						rehealed fractures at 80 to 90 degrees to the horizontal infilled with quartz and calcite				
1015										
			run 5	% 100/95						
	25					carbonaceous laminations 80 degrees to the horizontal				
1010										
			run 6	% 100/88		rehealed fractures scattered throughout at 80 to 90 degrees to the horizontal infilled with quartz				
	30									
1005						Bottom of boring at depth 30 feet completed and backfilled with bentonite chips on 5/26/95. No groundwater encountered during drilling operations.				

Snoqualmie Ridge 1040 Reservoir  
 Snoqualmie, Washington  
 For Barrett Consulting Group

Logged by: \_\_\_\_\_  
 Approved by: **DAY**  
 Figure No. **A-9**

\*Rock Strength Tests (in psi):  
 PL = Point Load Test  
 UCS = Unconfined Compressive Strength