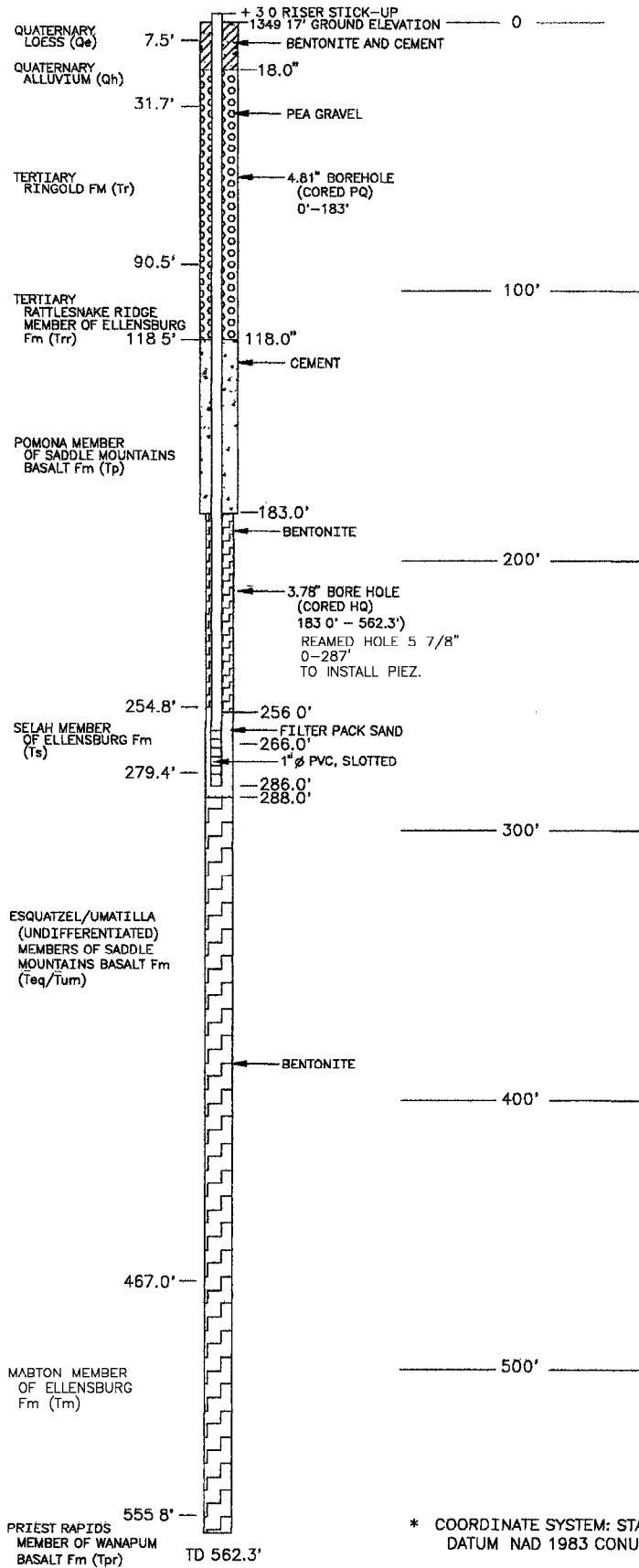


Appendix A – Geologic Logs, Geophysical Logs and As-Built Drawing  
For Drill Holes DH-04-01 and DH-04-02

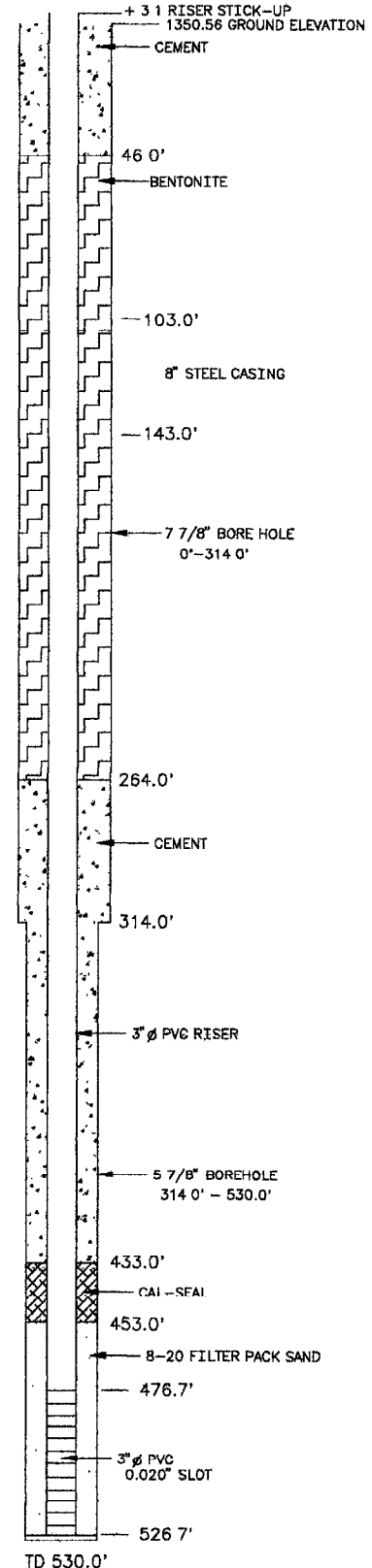
# AS-BUILT OF DRILL HOLES DH-04-01 AND DH-04-02

GENERALIZED  
GEOLOGIC LOG

DH-04-01  
N 439357.05 \*  
E 1790478.44



DH-04-02  
N 439391.49 \*  
E 1790479.23



\* COORDINATE SYSTEM: STATE PLANE, WA. SOUTH  
DATUM NAD 1983 CONUS

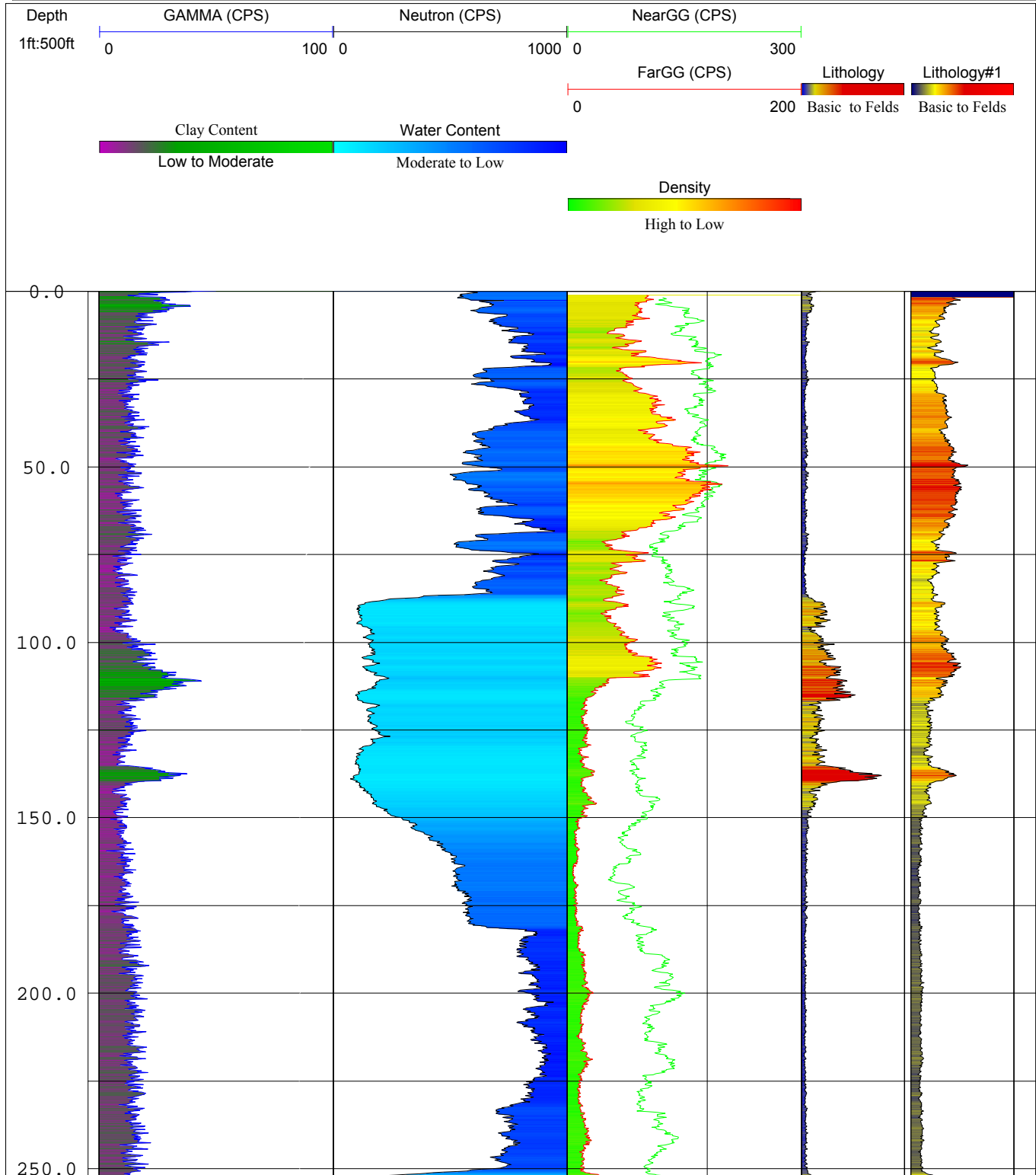


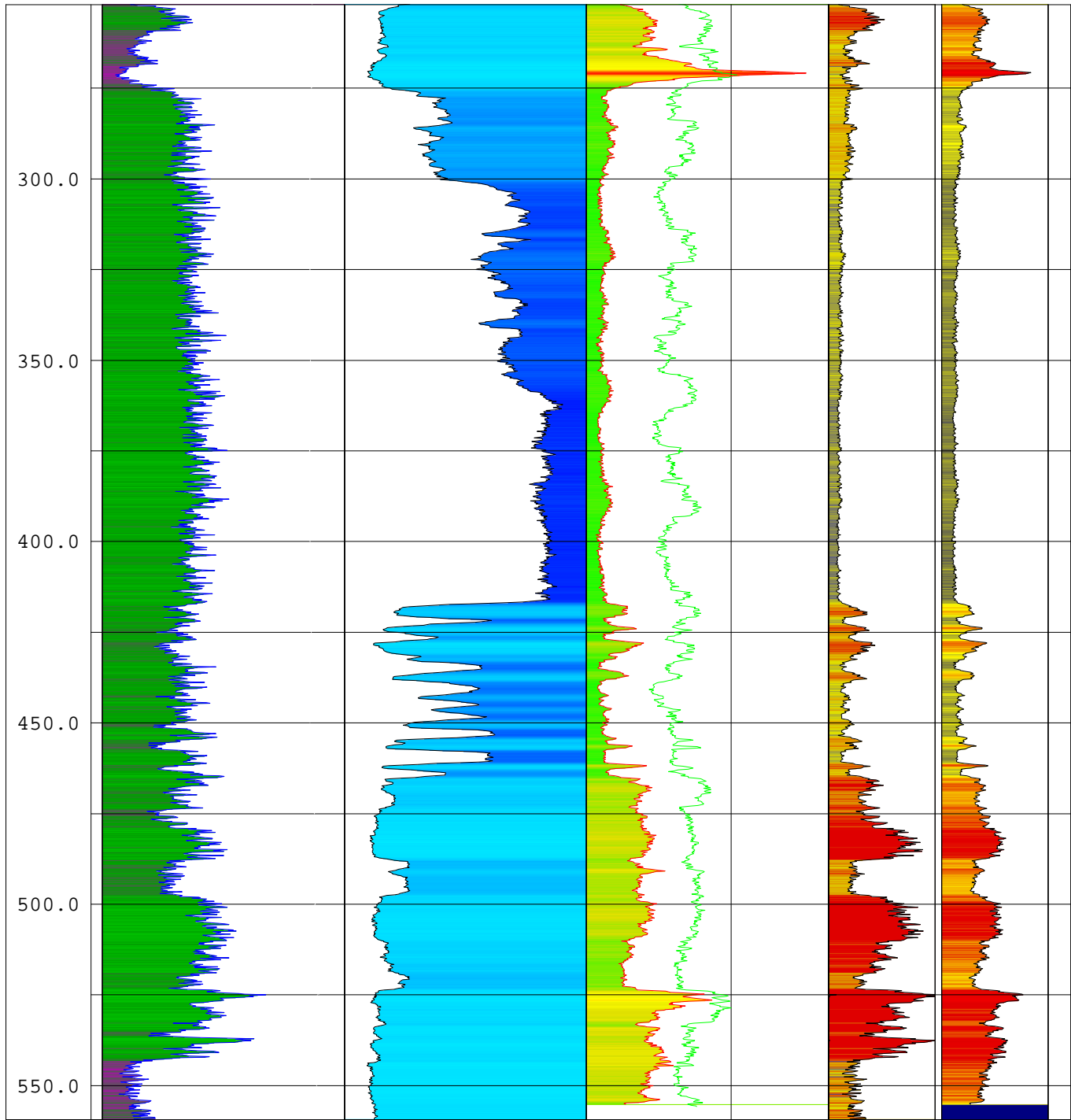
# BUREAU OF RECLAMATION

PROJECT Black Rock

HOLE NO.

DH04-01





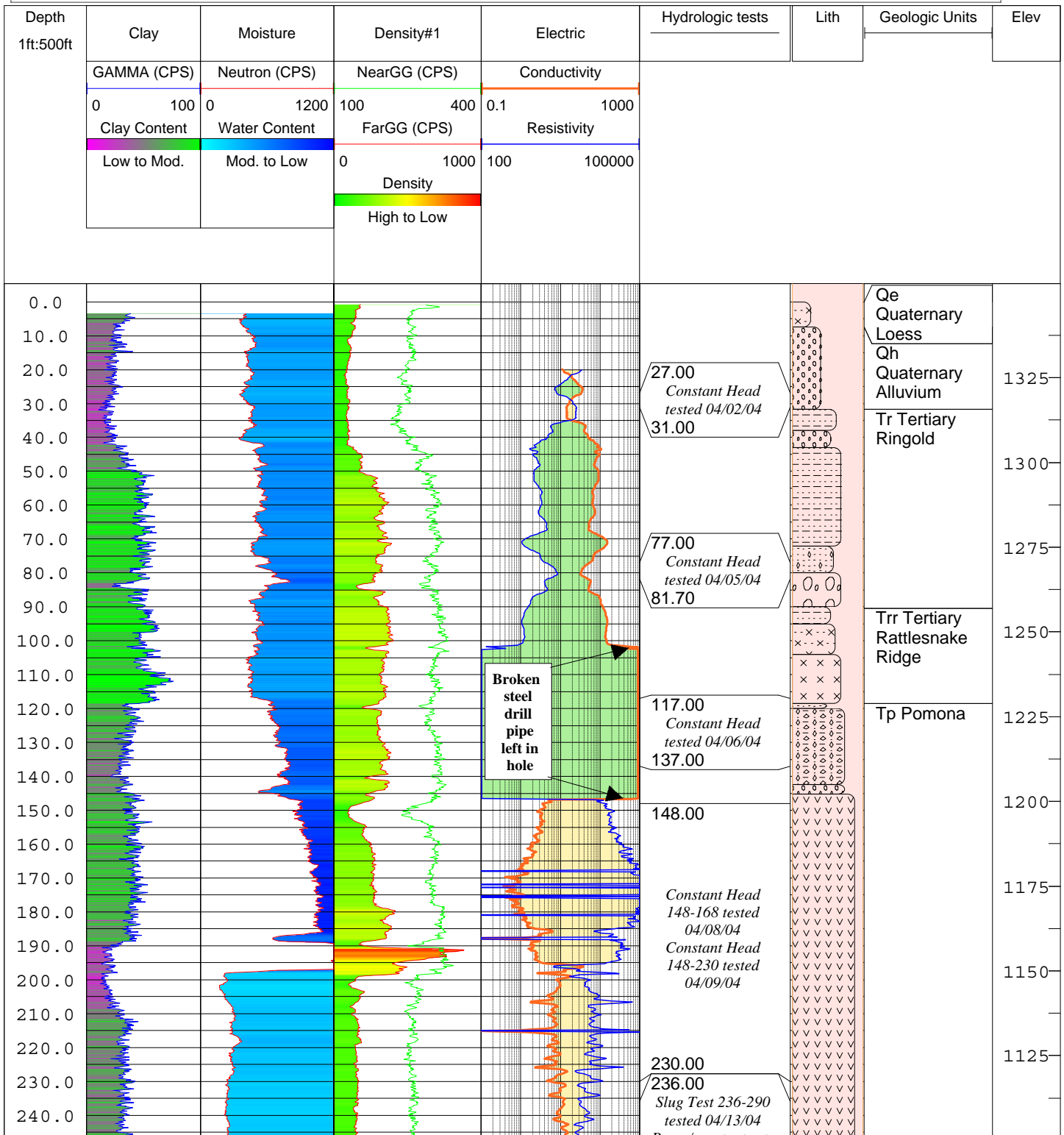


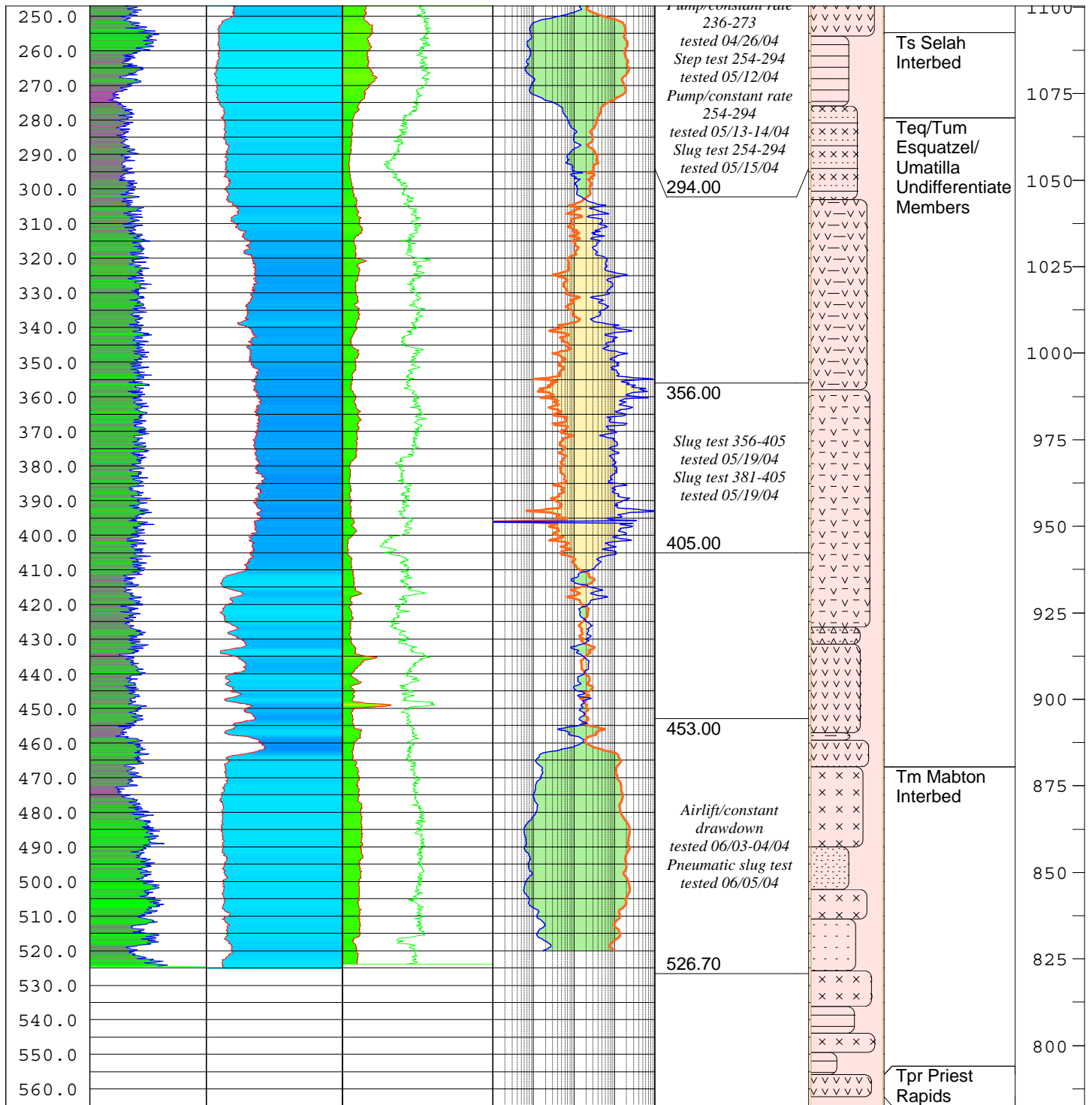
# BUREAU OF RECLAMATION

PROJECT Black Rock

HOLE NO.

DH-04-02





## GEOLOGIC LOG OF DRILL HOLE NO. DH-04-1

SHEET 1 OF 10

FEATURE: Black Rock Alternate Dam Site  
 LOCATION: North of Washington State Highway 24  
 BEGUN: 1/30/04 FINISHED: 3/31/04  
 DEPTH AND ELEV OF WATER  
 LEVEL AND DATE MEASURED: 190.9 (1156.45) 3/31/04

PROJECT: Yakima R. Basin Water Storage Feas. Study  
 COORDINATES: N 439,357.5 E 1,790,476.4  
 TOTAL DEPTH: 562.3  
 DEPTH TO BEDROCK: 145.3

STATE: Washington  
 GROUND ELEVATION: 1347.4  
 ANGLE FROM HORIZONTAL: AZIMUTH:  
 HOLE LOGGED BY: Stelma/McAfee/Lyon  
 REVIEWED BY: R. A. Link

NOTES	DEPTH	% RECOVERY	SPT	ENGINEERING PROPERTIES				FIELD CLASSIFICATION	LAB CLASSIFICATION	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
				WEATHERING	HARDNESS	FRACTURE DENSITY	RQD						
<p>All elevations measured from ground surface and are same as driller reported.</p> <p>PURPOSE OF HOLE: To determine foundation stratigraphy and rock fracturing characteristics for hydrogeologic testing.</p> <p>DRILL SETUP: Setup on original ground surface approximately 200 feet north of Washington State Highway 24.</p> <p>DRILLING EQUIPMENT: 0.0-562.3': Truck mounted Ingersoll-Rand T-2 Truck mounted drill.</p> <p>DRILLER: Chris Peterson</p> <p>DRILLING METHODS: 0.0-183.0': Advanced hole with PQ wireline core barrel (3.336" I.D.) using using polymer (EZ Mud) as circulating fluid. Advanced 6-inch surface casing to 148.0' to stabilize hole and enhance fluid return. Attempted to obtain drive samples (3" I.D.) at 13.2' and 22.0', both met refusal.</p> <p>183.0-562.3': Advanced hole with HQ wireline core barrel (2.50" I.D.) using using polymer (EZ Mud) as circulating fluid.</p> <p>DRILLING CONDITIONS: 0.0-13.2': Fast and smooth. 13.2-31.7': Slow to fast and rough. 31.7-75.0': Fast and smooth. 75.0-90.0': Slow and rough. 90.0-120.0': Fast and smooth. 120.0-145.5': Slow and rough, blocking. 145.5-180.0': Slow, smooth and hard with occasional blocking. 180.0-183.0': Slow and rough with frequent blocking. 183.0-211.4': Slow,</p>	5	8						SM		Qe			<p>0.0-7.5': <b>QUATERNARY LOESS DEPOSITS (Qe).</b> Surficial deposits of silt with lesser amounts of clay, composed primarily of wind-blown silt with small amounts of fine sand and volcanic ash. Description is based on PQ-size core samples and cuttings returned.</p> <p>0.0-7.5': <b>SILTY SAND.</b> About 70% nonplastic fines; about 30% fine sand; dry, light brown, organics (abundant small diameter roots).</p> <p>7.5-31.7': <b>QUATERNARY ALLUVIUM DEPOSITS (Qh).</b> Undifferentiated coarse to medium-grained sand with fines, gravels, cobbles and boulders composed primarily of basaltic detritus from local sources. Description is based on PQ-size core samples and cuttings returned.</p> <p>7.5-31.7': <b>POORLY GRADED GRAVEL WITH COBBLES (GP)c.</b> About 100% coarse, hard, subrounded gravel; dry, black (basalt) with white coatings (caliche).</p> <p>TOTAL SAMPLE (BY VOLUME): About 40% 3- to 5-inch, hard, subrounded cobbles; remainder minus 3 inch; maximum dimension, 125 mm.</p> <p>31.7-90.5': <b>TERTIARY RINGOLD FORMATION (Tr).</b> Composed of fluviolacustrine sand, silt and clay, with layers of hard, gray to black, angular to subrounded cobbles and gravels in a matrix of coarse to fine sand and fines near the middle and base of the unit. Material is generally well-indurated. Descriptions are based on PQ-size core samples.</p> <p>31.7-38.0': <b>POORLY GRADED SAND WITH CLAY (SP-SC).</b> About 90% medium to fine, hard, subangular sand; about 10% medium plastic fines; dry, tan, homogeneous.</p> <p>38.0-39.0': <b>POORLY GRADED SAND WITH CLAY (SP-SC).</b> About 90% medium to fine, hard, subrounded to subangular sand; about 10% fines with medium plasticity and medium toughness; dry to moist, gray to white, homogenous.</p> <p>39.0-43.0': <b>CLAYEY GRAVEL WITH SAND AND COBBLES (GC)sc.</b> About 60% predominantly fine, hard, subrounded gravel; about 20% coarse to fine, soft to hard, subrounded sand; about 20% fines with medium plasticity and medium toughness; dry to moist, reddish brown, abundant iron oxide, soft weathered medium sand sized plagioclase and mafic fragments, homogenous, no reaction with HCl.</p> <p>TOTAL SAMPLE (BY VOLUME): About 40% 3- to 4-inch, hard, subrounded cobbles; remainder minus 3 inch; maximum dimension, 100 mm.</p> <p>43.0-72.0': <b>CLAYEY SAND WITH GRAVEL (SC)g.</b> About 60% coarse to fine, hard, subrounded sand; about 20% fines with medium plasticity and medium toughness; about 20% fine, hard, subrounded gravel; moist, reddish brown to brown, abundant iron oxide, scattered tuffaceous clasts (weathered basalt, cinder, pumice fragments), homogenous, no</p>
	10	80											
	15	40											
	20	19											
	25	48						(GP)c		Qh			
	30	8											
	35	100						SP-SC					
	40	100						SP					
	45	67						(GC)sc					
	50	88											
	55	94											
	60	0											
	65	94											
	70	100						(SC)g		Tr			
	75	100											
	80	100											
	85	100											
	90	100						Cobbles					
	95	100											
	100	100						SC					
								(SM)g					

COMMENTS: **Geology Field Manual, Volume 1, Second Edition, distributed February 1999.**

Samples were logged in the field using Designation USBR 5005-86, "Procedures for Determining Unified Soil Classification (Visual Method)"; laboratory classifications have been prepared using Designation USBR 5000-86, "Procedures for Determining Unified Soil Classification (Laboratory Method)".

Cs = Casing Sz = Size of Casing I.D. = Inside Diameter O.D. = Outside diameter

Geologic unit descriptions and stratigraphy based partially on geologic interpretations presented in the following report:

"Black Rock Reservoir Study, Initial Geotechnical Investigation, Prepared for Benton County Sustainable Development by Washington Infrastructures Services, Inc., Dated January 2003.

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## GEOLOGIC LOG OF DRILL HOLE NO. DH-04-1

SHEET 2 OF 10

FEATURE: Black Rock Alternate Dam Site  
 LOCATION: North of Washington State Highway 24  
 BEGUN: 1/30/04 FINISHED: 3/31/04  
 DEPTH AND ELEV OF WATER  
 LEVEL AND DATE MEASURED: 190.9 (1156.45) 3/31/04

PROJECT: Yakima R. Basin Water Storage Feas. Study  
 COORDINATES: N 439,357.5 E 1,790,476.4  
 TOTAL DEPTH: 562.3  
 DEPTH TO BEDROCK: 145.3

STATE: Washington  
 GROUND ELEVATION: 1347.4  
 ANGLE FROM HORIZONTAL: AZIMUTH:  
 HOLE LOGGED BY: Stelma/McAfee/Lyon  
 REVIEWED BY: R. A. Link

NOTES	DEPTH	% RECOVERY	SPT	ENGINEERING PROPERTIES				FIELD CLASSIFICATION	LAB CLASSIFICATION	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
				WEATHERING	HARDNESS	FRACTURE DENSITY	RQD						
<p>smooth and hard. 211.4-255.8': Slow, smooth to rough with occasional blocking. 255.8-276.0': Slow and smooth. 276.0-303.2': Slow and smooth to rough with occasional blocking. 303.2-421.5': Slow, smooth and hard. 421.5-431.5': Slow and smooth to rough with occasional blocking. 431.5-451.5': Slow, smooth and hard. 451.5-471.2': Slow and smooth to rough with occasional blocking. 471.2-494.0': Slow, smooth and moderately hard. 494.0-500.0': Fast, smooth and moderately rough. 500.0-555.8': Slow and smooth with occasional blocking. 555.8-562.3': Slow, smooth and hard.</p> <p>CASING RECORD: 2004 Cs Depth Depth Date Sz Hole Cs</p> <p>01/30 6" 19.8' N/A 01/31 6" 19.8' 12.5' 02/02 6" 22.4' 22.0' 02/03 6" 31.7' 31.7' 02/04 6" 50.5' 31.7' 02/05 6" 50.5' 51.5' 02/06 6" 80.0' 51.5' 02/07 6" 105.0' 51.5' 02/09 6" 130.7' 51.5' 02/10 6" 132.0' 81.5' 02/11 6" 132.0' 132.0' 02/18 6" 142.5' 132.0' 02/19 6" 152.4' 142.0' 02/20 6" 155.0' 148.0' 02/21 6" 175.0' 148.0' 02/23 6" 183.0' 148.0' 02/24 4" 211.4' 183.0' 02/25 4" 238.2' 183.0' 02/26 4" 252.0' 183.0' 02/27 4" 271.4' 183.0' 02/28 4" 289.7' 183.0' 03/01 4" 310.3' 183.0' 03/02 4" 340.4' 183.0' 03/03 4" 358.2' 183.0' 03/09 4" 385.6' 183.0' 03/10 4" 411.5' 183.0' 03/11 4" 441.5' 183.0' 03/12 4" 469.6' 183.0' 03/13 4" 488.8' 183.0' 03/15 4" 509.6' 183.0' 03/16 4" 539.6' 183.0' 03/17 4" 562.3' 183.0'</p> <p>FLUID COLOR: 0.0-562.3': Drill mud (EZ mud with Diamond Seal).</p> <p>FLUID RETURN: 0.0-12.5': 100% 12.5-22.0': 75% 22.0-27.0': 80% 27.0-31.7': 90% 31.7-75.0': 100% 75.0-80.0': 95%</p>	98												reaction with HCl.
	105	100					Siltstone		Trr				72.0-80.0': CLAYEY SAND WITH GRAVEL AND COBBLES (SC)gc. About 50% coarse to fine, hard, subrounded sand; about 30% fine, hard, subrounded gravel; about 20% fines with medium plasticity and medium toughness; moist, reddish brown, abundant iron oxide, homogenous, no reaction with HCl.
	110	100											TOTAL SAMPLE (BY VOLUME): About 20% 3- to 4-inch, hard, subrounded cobbles; remainder minus 3 inch; maximum dimension, 100 mm.
	115	100											80.0-90.5': COBBLES WITH CLAYEY SAND. TOTAL SAMPLE (BY VOLUME): About 90% 3- to 6-inch, hard, subrounded cobbles; remainder minus 3 inch; maximum dimension, 150 mm.
	120	100						Peperite					MINUS 3-inch FRACTION (BY VOLUME): About 80% coarse to fine, hard, subrounded sand; about 20% fines with medium plasticity and medium toughness; brown, abundant iron oxide, homogeneoues, no reaction with HCl.
	125	96											90.5-118.5': TERTIARY RATTLESNAKE RIDGE MEMBER (Trr)of the Ellensburg Formation, Miocene Columbia River Basalt Group (CRB). Unconsolidated gravel, sand and cobbles with silt and clay. Black, gray to mottled, weathered basalt and tuffaceous sediments (?). Descriptions are based on PQ-size core samples.
	130	65											90.5-95.0': CLAYEY SAND (SC). About 60% fine to medium, hard, subrounded sand; about 40% fines with medium plasticity and medium toughness; moist, gray to tan, blocky structure, firm to dense, homogenous, no reaction with HCl.
	135	90											95.0-104.0': SILTY SAND WITH GRAVEL (SM)g. About 70% fine to medium, hard, subrounded to subangular sand; about 20% fines with medium plasticity and medium toughness; about 10% fine, hard, subangular gravel; moist, gray, scattered white and yellow stringers of weathered plagioclase (pasty texture), traces of caliche, homogenous, firm to dense; weak reaction with HCl.
	140	18						(GC)s					104.0-118.5': SILTSTONE (TUFACEOUS). Reworked pumicite. Fine to medium grained, heterogenous, well indurated silt to medium sand sized lithic fragments, pumice and ash. <u>Intensely Weathered</u> , material is altering to clay, core scratches with light to moderate knife pressure.
	145	64											118.5-254.8': POMONA MEMBER (Tp)of the Saddle Mountains Basalt Formation, Miocene Columbia River Basalt Group (CRB). Black to gray, hard, mostly fine grained dense basalt with plagioclase phenocrysts comprising less than 5% of the rock. Descriptions are based on PQ and HQ-size core samples.
	150	90						GP					118.5-132.0': INVASIVE FLOW TOP (PEPERITE) CONSISTING OF SELAH INTERBED (Ts) of the Saddle Mountains Basalt Formation, Miocene Columbia River Basalt Group (CRB). Pumicite material rafted to the top of the Pomona Basalt, composed of reddish orange, black to gray, moderately soft tuffaceous clay, silt, sand and gravel. Descriptions are based on HQ-size core samples.
	155	100											118.5-120.0': SILTY GRAVEL WITH SAND (GM)s (Pumicite). About 50% fine to coarse, hard, angular gravel; about 30% medium to coarse, hard, angular sand; about 20% fines with low plasticity; moist, greenish yellow to reddish brown (mottled), abundant iron oxide, clasts composed of moderately weathered dense to slightly vesicular basalt, chert nodules, cinder and pumice, heterogenous, no reaction with HCl.
	160	100					FD7	6					
	165	100											
	170	100					FD8	0					
	175	100											
	180	100											
	185	100					FD7	10					
	190	100											
	195	100											
	200	100					FD9	0					
	205	100											
	210	100											
	215	100					FD6	21					

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## GEOLOGIC LOG OF DRILL HOLE NO. DH-04-1

SHEET 3 OF 10

FEATURE: Black Rock Alternate Dam Site  
 LOCATION: North of Washington State Highway 24  
 BEGUN: 1/30/04 FINISHED: 3/31/04  
 DEPTH AND ELEV OF WATER  
 LEVEL AND DATE MEASURED: 190.9 (1156.45) 3/31/04

PROJECT: Yakima R. Basin Water Storage Feas. Study  
 COORDINATES: N 439,357.5 E 1,790,476.4  
 TOTAL DEPTH: 562.3  
 DEPTH TO BEDROCK: 145.3

STATE: Washington  
 GROUND ELEVATION: 1347.4  
 ANGLE FROM HORIZONTAL: AZIMUTH:  
 HOLE LOGGED BY: Stelma/McAfee/Lyon  
 REVIEWED BY: R. A. Link

NOTES	DEPTH	% RECOVERY	SPT	ENGINEERING PROPERTIES				FIELD CLASSIFICATION	LAB CLASSIFICATION	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
				WEATHERING	HARDNESS	FRACTURE DENSITY	RQD						
80.0-105.0': 100% 105.0-120.0': 95% 120.0-125.0': 100% 125.0-130.0': 70% 130.0-142.5': 0% 142.5-152.4': 97% 152.4-155.0': 80% 155.0-165.0': 95% 165.0-221.4': 100% 221.4-230.1': 95% 230.1-271.4': 100% 271.4-275.1': 70% 275.1-283.1': 90% 283.1-297.7': 85% 297.7-298.4': 80% 298.4-300.3': 75% 300.3-310.3': 90% 310.3-320.4': 85% 320.4-340.4': 70% 340.4-349.4': 75% 349.4-358.2': 70% 358.2-361.5': 75% 361.5-381.5': 80% 381.5-391.5': 85% 391.5-421.5': 90% 421.5-426.6': 80% 426.6-469.6': 90% 469.6-561.6': 95% 561.6-562.3': 0%  WATER LEVEL DURING DRILLING: (Drill fluid level from ground surface at start of shift)  Date Fluid Level 01/31: Dry 02/02: 8.2' 02/03: 10.2' 02/04: 0.0' 02/05: +3.9' 02/06: 4.6' 02/07: 4.7' 02/09: 22.4' 02/10: 95.4' 02/11: Dry 02/18: Dry 02/19: 135.9' 02/20: 1.9' 02/21: 69.6' 02/23: 0.0' 02/24: 0.8' 02/25: +2.3' 02/26: 1.1' 02/27: 20.3' 02/28: 136.7' 03/01: 121.3' 03/02: 122.9' 03/03: 192.1' 03/09: 192.2' 03/10: 115.2' 03/11: 94.5' 03/12: 40.2' 03/13: 7.8' 03/15: 21.6' 03/16: 20.4' 03/17: Dry  WATER LEVEL AFTER DRILLING: 3/30: 203.3' 3/31: 190.9' 4/02: 192.8'  DRILLING TIME: Drilling: 32 days. Moving: 4 days.	220	100				FD5	61						120.0-132.0': CLAYEY GRAVEL WITH SAND AND COBBLES (GC)sc (Pumicite). About 50% predominantly fine, hard, angular gravel; about 30% medium to coarse, hard, angular sand; about 20% fines with medium plasticity; moist, greenish yellow to reddish brown (mottled), abundant iron oxide, clasts composed of moderately weathered (palagonite on surfaces) dense to slightly vesicular basalt, chert nodules, cinder and pumice, heterogenous, no reaction with HCl.  TOTAL SAMPLE (BY VOLUME): About 30% 3- to 4-inch, hard, angular cobbles; remainder minus 3 inch; maximum dimension, 100 mm.  132.0-145.3': ALTERED UPPER FLOW CONTACT. Volcanic glass. Descriptions is based on HQ-size core samples.  132.0-145.3': POORLY GRADED GRAVEL (GP). About 100% predominantly fine, hard, subrounded to subangular gravel; dry to moist, gray, clasts composed of slightly weathered (palagonite on surfaces) glassy basalt.  145.3-150.8': BASALT. Black to gray, fine grained aphanitic, slightly to moderately vesicular basalt. Most vesicles 1/4 to 1/2", largest 1-1/2" across, coated or filled with soft clay. <u>Slightly Weathered (W3)</u> . Oxidation (iron and manganese) limited to fracture surfaces. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Intensely Fractured (FD7)</u> . Core recovered in lengths from 0.1 to 0.4, mostly in lengths less than 0.3', joints are mostly horizontal with rough and irregular surfaces. Prior to removal from core barrel (undisturbed) the joints were mostly tight to slightly open.  Magnetic Polarity on Sample at 150.0': <u>Reverse</u> .  150.8-160.0': BASALT. Black to gray, fine grained aphanitic, dense basalt. <u>Slightly Weathered (W3)</u> . Oxidation (iron and manganese) limited to fracture surfaces. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Intensely Fractured (FD7)</u> . Core recovered in lengths from fragments to 0.6, mostly in lengths less than 0.3', joints dip 45 to 60 degrees, surfaces range from smooth and planar to rough and irregular. Prior to removal from core barrel (undisturbed) the joints were mostly tight to slightly open.  160.0-170.0': BASALT. Black to gray, fine grained aphanitic, dense basalt. <u>Slightly Weathered (W3)</u> . Oxidation (iron and manganese) limited to fracture surfaces. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Very Intensely to Intensely Fractured (FD8)</u> . Core recovered in lengths from fragments to 0.4, mostly in lengths less than 0.3', a single subvertical joint (with associated horizontal joints) runs the entire length of the interval, the subvertical joint surface ranges from smooth and planar to rough and irregular. Prior to removal from core barrel (undisturbed) the joints were mostly tight to slightly open.  170.0-180.0': BASALT. Black to gray, fine grained aphanitic, dense basalt. <u>Slightly Weathered (W3)</u> . Oxidation (iron and manganese) limited to fracture surfaces. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Intensely Fractured (FD7)</u> . Core recovered in lengths from fragments to 0.6, mostly in lengths less than 0.3', the joint surfaces range from smooth and planar to rough and irregular. Prior to removal from core barrel (undisturbed) the joints were mostly tight to slightly open.  180.0-183.0': BASALT. Black to gray, fine grained aphanitic, dense basalt. <u>Slightly Weathered (W3)</u> .
	225	100				FD7	18						
	230					FD5	78						
	235	100					20						
	240	100				FD6	18						
	245												
	250	27				FD9	9						
	255	100				FD6	66						
	260	100			H5	FD3	100	Claystone					
	265	100			H6	FD6	44						
	270	97		W7	H4	FD3	70	Siltstone		Ts			
	275	100						(GC)s					
	280	97			H4	FD7	23						
	285	85											
	290	98				FD6	33						
	295	93											
	300	95				FD9	5						
	305	100											
	310					FD2	96						
	315	99											
	320												
	325	100				FD7	31						
	330												
	335	100				FD3	99						

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## GEOLOGIC LOG OF DRILL HOLE NO. DH-04-1

SHEET 4 OF 10

FEATURE: Black Rock Alternate Dam Site

PROJECT: Yakima R. Basin Water Storage Feas. Study

STATE: Washington

LOCATION: North of Washington State Highway 24

COORDINATES: N 439,357.5 E 1,790,476.4

GROUND ELEVATION: 1347.4

BEGUN: 1/30/04 FINISHED: 3/31/04

TOTAL DEPTH: 562.3

ANGLE FROM HORIZONTAL: AZIMUTH:

DEPTH AND ELEV OF WATER

DEPTH TO BEDROCK: 145.3

HOLE LOGGED BY: Stelma/McAfee/Lyon

LEVEL AND DATE MEASURED: 190.9 (1156.45) 3/31/04

REVIEWED BY: R. A. Link

NOTES	DEPTH	% RECOVERY	SPT	ENGINEERING PROPERTIES				FIELD CLASSIFICATION	LAB CLASSIFICATION	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
				WEATHERING	HARDNESS	FRACTURE DENSITY	RQD						
<b>HOLE COMPLETION:</b> 0.0-18.0': Bentonite and cement surface seal. 18.0-118.0': Pea gravel. 118.0-183.0': Grout (cement) seal. 183.0-256.0': Bentonite seal. 256.0-266.0': Filter sand. 266.0-286.0': Slotted pipe (with 1" diameter pvc riser) and filter sand. 286.0-288.0': Filter sand. 288.0-562.3': Bentonite seal.	340												Oxidation (iron and manganese) limited to fracture surfaces. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Very Intensely Fractured (FD9)</u> . Core recovered mostly as fragments, a single subvertical joint (with associated horizontal joints) runs the entire length of the interval, the subvertical joint surface is rough and irregular and coated with iron and manganese oxide. Prior to removal from core barrel (undisturbed) the joints were mostly tight to slightly open.  183.0-201.4': <b>BASALT</b> . Black to gray basalt, mostly fine grained with plagioclase phenocrysts up to 1-3 mm diameter. Phenocrysts comprise less than 5% of the rock. <u>Slightly Weathered (W3)</u> . Oxidation (iron and manganese) limited to fracture surfaces, phenocrysts are soft and discolored to a grayish white color. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Intensely to Moderately Fractured (FD6)</u> . Core recovered in lengths from fragments to 0.6, mostly in lengths less than 0.4', the joint surfaces are mostly smooth and planar to irregular. Prominent subvertical joints were observed from 190.0-191.1', 191.7-194.0' and 192.3-195.3'. Prior to removal from core barrel (undisturbed) the joints were mostly tight to slightly open.  201.4-210.7': <b>BASALT</b> . Black to gray basalt, mostly fine grained with plagioclase phenocrysts up to 1-2 mm diameter. Phenocrysts comprise less than 5% of the rock. <u>Slightly Weathered (W3)</u> . Oxidation (iron and manganese) limited to fracture surfaces, phenocrysts are soft and discolored to a grayish white color. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Moderately Fractured (FD5)</u> . Core recovered in lengths from fragments to 1.7', mostly in lengths less than 0.7', the joint surfaces are mostly smooth and planar to irregular. Numerous joints were weakly rehealed (silica), but separated upon handling. A single subvertical joints was observed from 208.0-209.3. Prior to removal from core barrel (undisturbed) the joints were tight to slightly open.  Magnetic Polarity on Sample at 201.4': <u>Reverse</u> .  210.7-216.5': <b>BASALT</b> . Black to gray basalt, mostly fine grained with plagioclase phenocrysts up to 1-2 mm diameter. Phenocrysts comprise less than 5% of the rock. <u>Slightly Weathered (W3)</u> . Oxidation (iron and manganese) limited to fracture surfaces, phenocrysts are soft and discolored to a grayish white color. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Intensely Fractured (FD7)</u> . Core recovered in lengths from fragments to 0.4, mostly in lengths less than 0.3', the joint surfaces are mostly smooth and planar to irregular. Numerous joints were weakly rehealed (silica), but separated upon handling. A single subvertical joints was observed extending through the entire interval. Prior to removal from core barrel (undisturbed) the joints were tight to slightly open.  216.5-222.2': <b>BASALT</b> . Black to gray basalt, mostly fine grained with plagioclase phenocrysts up to 1-2 mm diameter. Phenocrysts comprise less than 5% of the rock. <u>Slightly Weathered (W3)</u> . Oxidation (iron and manganese) limited to fracture surfaces, phenocrysts are soft and discolored to a grayish white color. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Moderately Fractured (FD5)</u> . Core recovered in lengths from 0.2 to 0.9', mostly in lengths of 0.7', the joint surfaces are mostly smooth and planar to irregular. Numerous joints were weakly rehealed (silica), but separated upon handling. Prior to removal from core barrel (undisturbed) the joints were tight to slightly open.  222.2-224.4': <b>BASALT</b> . Black to gray basalt, mostly
	345	100				FD7	20						
	350			W3	H3								
	355	99				FD4	78						
	360	97											
	365												
	370	100					100	Basalt		Teq/Tum			
	375												
	380	100											
	385						95						
	390	100				FD3	98						
	395	100					92						
	400												
	405	100											
	410						100						
	415	100											
	420												
	425	92			H5		77						
	430	100		W4									
	435												
	440	100					90						
	445					FD4							
	450	100		W2	H3								
	455	100					98						

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## GEOLOGIC LOG OF DRILL HOLE NO. DH-04-1

SHEET 5 OF 10

FEATURE: Black Rock Alternate Dam Site  
 LOCATION: North of Washington State Highway 24  
 BEGUN: 1/30/04 FINISHED: 3/31/04  
 DEPTH AND ELEV OF WATER  
 LEVEL AND DATE MEASURED: 190.9 (1156.45) 3/31/04

PROJECT: Yakima R. Basin Water Storage Feas. Study  
 COORDINATES: N 439,357.5 E 1,790,476.4  
 TOTAL DEPTH: 562.3  
 DEPTH TO BEDROCK: 145.3

STATE: Washington  
 GROUND ELEVATION: 1347.4  
 ANGLE FROM HORIZONTAL: AZIMUTH:  
 HOLE LOGGED BY: Stelma/McAfee/Lyon  
 REVIEWED BY: R. A. Link

NOTES	DEPTH	% RECOVERY	SPT	ENGINEERING PROPERTIES				FIELD CLASSIFICATION	LAB CLASSIFICATION	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
				WEATHERING	HARDNESS	FRACTURE DENSITY	RQD						
	460	100					100						fine grained with plagioclase phenocrysts up to 1-2 mm diameter. Phenocrysts comprise less than 5% of the rock. <u>Slightly Weathered (W3)</u> . Oxidation (iron and manganese) limited to fracture surfaces, phenocrysts are soft and discolored to a grayish white color. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Intensely Fractured (FD7)</u> . Core recovered in lengths from fragments to 0.3, joint surfaces are mostly smooth and planar to irregular and coated with brownish-red clay. Prior to removal from core barrel (undisturbed) the joints were tight to slightly open.
	465	97					35						
	470	100											224.4-228.1': BASALT. Black to gray basalt, mostly fine grained with plagioclase phenocrysts up to 1-2 mm diameter. Phenocrysts comprise less than 5% of the rock. <u>Slightly Weathered (W3)</u> . Oxidation (iron and manganese) limited to fracture surfaces, phenocrysts are soft and discolored to a grayish white color. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Moderately Fractured (FD5)</u> . Core recovered in lengths from 0.4 to 1.1', mostly in lengths of 0.8', the joint surfaces are mostly smooth and planar to irregular. Numerous joints were weakly rehealed (silica), but separated upon handling. Prior to removal from core barrel (undisturbed) the joints were tight to slightly open.
	475	100		W7	H5	FD3	79	Siltstone					
	480												228.1-242.3': BASALT. Black to gray basalt, mostly fine grained with plagioclase phenocrysts up to 1-2 mm diameter. Phenocrysts comprise less than 5% of the rock. <u>Slightly Weathered (W3)</u> . Oxidation (iron and manganese) limited to fracture surfaces, phenocrysts are soft and discolored to a grayish white color. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Intensely to Moderately Fractured (FD6)</u> . Core recovered in lengths from fragments to 0.6, joint surfaces are mostly smooth and planar to irregular. Numerous joints were weakly rehealed (silica), but separated upon handling. Prominent subvertical joints were observed from 228.1-232.2' and 232.3-236.9'. Prior to removal from core barrel (undisturbed) the joints were tight to slightly open.
	485	100											
	490	89											242.3-251.4': BASALT ( <u>Poor Recovery</u> ). Black to gray basalt, mostly fine grained with plagioclase phenocrysts up to 1-2 mm diameter. Phenocrysts comprise less than 5% of the rock. <u>Slightly Weathered (W3)</u> . Oxidation (iron and manganese) limited to fracture surfaces, phenocrysts are soft and discolored to a grayish white color. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Very Intensely Fractured (FD9)</u> . Core recovered in lengths from fragments to 0.4, mostly fragments, the joint surfaces are mostly smooth and planar to irregular.
	495			W9	H6	FD9	0	SP					
	500	82											251.4-254.8': BASALT. Black to gray basalt, mostly fine grained with plagioclase phenocrysts up to 1-2 mm diameter. Phenocrysts comprise less than 5% of the rock. Fairly sharp contact with underlying claystone. <u>Slightly Weathered (W3)</u> . Oxidation (iron and manganese) limited to fracture surfaces, phenocrysts are soft and discolored to a grayish white color. <u>Hard (H3)</u> . Core breaks with heavy hammer blow. <u>Intensely to Moderately Fractured (FD6)</u> . Core recovered in lengths from fragments to 0.9, mostly less than 0.4', the joint surfaces are mostly smooth and planar to irregular. Numerous joints were weakly rehealed (silica), but separated upon handling. Prior to removal from core barrel (undisturbed) the joints were tight to slightly open.
	505							Siltstone					
	510									Tm			254.8-279.4': <b>SELAH INTERBED (Ts)</b> of the Ellensburg Formation, Miocene Columbia River Basalt Group (CRB). Reddish orange, black to gray, moderately soft tuffaceous siltstone and claystone. Descriptions are based on HQ-size core samples.
	515	99											
	520							Sandstone					255.8-258.2': CLAYSTONE (TUFFACEOUS). Fine
	525	100				FD3	100						
	530			W7	H5			Siltstone					258.2-258.2': CLAYSTONE (TUFFACEOUS). Fine
	535	100											
	540							Claystone					258.2-258.2': CLAYSTONE (TUFFACEOUS). Fine
	545	100				FD5	58	Siltstone					
	550	100					48	Claystone					258.2-258.2': CLAYSTONE (TUFFACEOUS). Fine
	555	90				FD6							
	560	100		W3	H4		47	Basalt		Tpr			258.2-258.2': CLAYSTONE (TUFFACEOUS). Fine
BOTTOM OF HOLE													
254.8-279.4': <b>SELAH INTERBED (Ts)</b> of the Ellensburg Formation, Miocene Columbia River Basalt Group (CRB). Reddish orange, black to gray, moderately soft tuffaceous siltstone and claystone. Descriptions are based on HQ-size core samples.													
255.8-258.2': CLAYSTONE (TUFFACEOUS). Fine													

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## GEOLOGIC LOG OF DRILL HOLE NO. DH-04-1

SHEET 6 OF 10

FEATURE: Black Rock Alternate Dam Site  
 LOCATION: North of Washington State Highway 24  
 BEGUN: 1/30/04 FINISHED: 3/31/04  
 DEPTH AND ELEV OF WATER  
 LEVEL AND DATE MEASURED: 190.9 (1156.45) 3/31/04

PROJECT: Yakima R. Basin Water Storage Feas. Study  
 COORDINATES: N 439,357.5 E 1,790,476.4  
 TOTAL DEPTH: 562.3  
 DEPTH TO BEDROCK: 145.3

STATE: Washington  
 GROUND ELEVATION: 1347.4  
 ANGLE FROM HORIZONTAL: AZIMUTH:  
 HOLE LOGGED BY: Stelma/McAfee/Lyon  
 REVIEWED BY: R. A. Link

NOTES	DEPTH	% RECOVERY	SPT	ENGINEERING PROPERTIES				FIELD CLASSIFICATION	LAB CLASSIFICATION	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
				WEATHERING	HARDNESS	FRACTURE DENSITY	RQD						
													<p>to medium grained, reddish orange to greenish yellow, heterogenous, well indurated clay-size to medium sand-sized lithic fragments, pumice, ash and chert. <u>Intensely Weathered (W7)</u>. Material has been thermally altered and oxidized. <u>Moderately Soft (H5)</u>. Core scratches with light to moderate knife pressure. <u>Slightly Fractured (FD3)</u>. Core recovered mostly in lengths from 1.0 to 3.0'.</p> <p>258.2-263.0': SILTSTONE AND SANDSTONE (TUFFACEOUS). Fine to medium grained, black, heterogenous, well indurated silt-size to medium sand-sized lithic fragments, pumice, ash and chert. <u>Intensely Weathered (W7)</u>. Material has been thermally altered and oxidized. <u>Soft (H6)</u>. Core breaks with light manual pressure. <u>Intensely to Moderately Fractured (FD6)</u>. Core recovered in lengths from fragments to 0.8", and mostly in lengths less than 0.4'.</p> <p>263.0-273.6': SILTSTONE AND SANDSTONE (TUFFACEOUS). Fine to medium grained, white to light brown and gray (mottled), heterogenous, well indurated silt-size to coarse sand-sized (5 mm) lithic fragments, pumice, ash and chert. <u>Intensely Weathered (W7)</u>. Abundant calcium carbonate nodules and stringers present due to extensive leaching and solutioning of rock (strong reaction with HCl). <u>Moderately Hard (H4)</u>. Core breaks with heavy manual pressure. <u>Slightly Fractured (FD3)</u>. Core recovered mostly in lengths from 1.0 to 2.0'. Possible brecciated zone.</p> <p><u>Slickensides</u> (striations) noted on joint surfaces at 271.6', 271.9', 272.5', 272.7' 272.8 and 273.0'.</p> <p>273.6-276.0': CLAYEY GRAVEL WITH SAND (GC)s (TUFFACEOUS). About 70% fine, moderately soft, angular sand; about 20% fines with medium plasticity; about 10% fine, moderately soft, angular gravel; moist, brown to dark brown, clasts composed of chert and claystone(?).</p> <p><u>Slickensides</u> (striations) noted on joint surface at 273.8'.</p> <p>276.0-279.4': BASALT. Black to gray, mostly fine grained dense basalt. Fairly sharp contact with overlying sediment. <u>Moderately Weathered (W3)</u>. Extensive oxidation (iron and manganese) and clay deposits on fracture surfaces, body of rock is weakened by weathering. <u>Moderately Hard (H4)</u>. Core breaks with moderate hammer blow. <u>Intensely Fractured (FD7)</u>. Core recovered in lengths from fragments to 1.0, mostly less than 0.3', the joint surfaces are mostly smooth and planar to irregular.</p> <p>279.4-467.0': <b>ESQUATZEL/UMATILLA UNDIFFERENTIATED MEMBERS (Teq/Tum)</b> of the Saddle Mountains Basalt Formation, Miocene Columbia River Basalt Group (CRB). Black to gray, hard, mostly fine grained dense basalt. Descriptions are based on HQ-size core samples.</p> <p>279.4-295.9': BASALT. Black to gray, mostly fine grained dense basalt. Slightly vesicular from 287.5-289.7'. <u>Slightly Weathered (W3)</u>. Oxidation (iron and manganese) and coatings on fracture surfaces. <u>Hard (H3)</u>. Core breaks with heavy hammer blow. <u>Intensely to Moderately Fractured (FD6)</u>. Core recovered in lengths from fragments to 0.9, and mostly in lengths greater than 0.5', the joint surfaces are mostly smooth and planar to irregular. Prominent vertical joint and associated fracture zone from 290.2-293.0'. Numerous joints were weakly rehealed (silica), but separated upon handling. Prior to removal from core barrel (undisturbed) the joints were tight to slightly open.</p>

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## GEOLOGIC LOG OF DRILL HOLE NO. DH-04-1

SHEET 7 OF 10

FEATURE: Black Rock Alternate Dam Site  
 LOCATION: North of Washington State Highway 24  
 BEGUN: 1/30/04 FINISHED: 3/31/04  
 DEPTH AND ELEV OF WATER  
 LEVEL AND DATE MEASURED: 190.9 (1156.45) 3/31/04

PROJECT: Yakima R. Basin Water Storage Feas. Study  
 COORDINATES: N 439,357.5 E 1,790,476.4  
 TOTAL DEPTH: 562.3  
 DEPTH TO BEDROCK: 145.3

STATE: Washington  
 GROUND ELEVATION: 1347.4  
 ANGLE FROM HORIZONTAL: AZIMUTH:  
 HOLE LOGGED BY: Stelma/McAfee/Lyon  
 REVIEWED BY: R. A. Link

NOTES	DEPTH	% RECOVERY	SPT	ENGINEERING PROPERTIES				FIELD CLASSIFICATION	LAB CLASSIFICATION	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
				WEATHERING	HARDNESS	FRACTURE DENSITY	RQD						
													<p><u>Slickensides</u> (poorly defined striations) noted on subvertical joint surface from 287.5-289.7, surface is extensively oxidized with abundant clayey material.</p> <p>Magnetic Polarity on Sample at 285.5': <u>Normal</u>.</p> <p>295.9-303.2': BASALT. Black to gray, mostly fine grained dense basalt. <u>Slightly Weathered (W3)</u>. Extensive oxidation (iron and manganese) and greenish yellow clay coatings on fracture surfaces. <u>Hard (H3)</u>. Core breaks with heavy hammer blow. <u>Very Intensely Fractured (FD9)</u>. Core recovered mostly as fragments, fracture surfaces are mostly smooth and planar to irregular. Prior to removal from core barrel (undisturbed) the joints were tight to slightly open.</p> <p>303.2-322.6': BASALT. Black to gray, mostly fine grained dense basalt. <u>Fresh to Slightly Weathered (W2)</u>. Minor oxidation (iron and manganese) limited to fracture surfaces. <u>Hard (H3)</u>. Core breaks with heavy hammer blow. <u>Slightly to Very Slightly Fractured (FD2)</u>. Core recovered in lengths ranging from 0.4' to 4.0', mostly in lengths greater than 3.0', fracture surfaces are mostly smooth and irregular to smooth and planar. Prior to removal from core barrel (undisturbed) the joints were mostly tight.</p> <p>322.6-326.7': BASALT. Black to gray, mostly fine grained dense basalt. <u>Slightly Weathered (W3)</u>. Oxidation (iron and manganese) limited to fracture surfaces. <u>Hard (H3)</u>. Core breaks with heavy hammer blow. <u>Intensely Fractured (FD7)</u>. Core recovered in lengths from fragments to 1.7', mostly in lengths less than 0.3', the joint surfaces are mostly smooth and planar to irregular to rough and irregular. A single subvertical joint and associated horizontal joints were observed through the entire interval. Prior to removal from core barrel (undisturbed) the joints were generally tight to slightly open.</p> <p>326.7-341.1': BASALT. Black to gray, mostly fine grained dense basalt. <u>Fresh to Slightly Weathered (W2)</u>. Minor oxidation (iron and manganese) limited to fracture surfaces. <u>Hard (H3)</u>. Core breaks with heavy hammer blow. <u>Slightly Fractured (FD3)</u>. Core recovered in lengths ranging from 0.5' to 2.4', mostly in lengths between 1.0 and 1.5', fracture surfaces are mostly smooth and planar to smooth and irregular. Prior to removal from core barrel (undisturbed) the joints were mostly tight.</p> <p>341.1-349.9': BASALT. Black to gray, mostly fine grained dense basalt. <u>Slightly Weathered (W3)</u>. Oxidation (iron and manganese) limited to fracture surfaces. <u>Hard (H3)</u>. Core breaks with heavy hammer blow. <u>Intensely Fractured (FD7)</u>. Core recovered in lengths from fragments to 1.7', mostly in lengths less than 0.3', the joint surfaces are mostly smooth and planar to irregular to rough and irregular. A single subvertical joint and associated horizontal joints were observed through the entire interval. Prior to removal from core barrel (undisturbed) the joints were generally tight to slightly open.</p> <p>349.9-358.2': BASALT. Black to dark green, mostly fine grained dense basalt. <u>Slightly Weathered (W3)</u>. Oxidation (iron and manganese) generally limited to fracture surfaces. <u>Hard (H3)</u>. Core breaks with heavy hammer blow. <u>Moderately to Slightly Fractured (FD4)</u>. Core recovered in lengths from fragments to 1.6, mostly in lengths around 0.8', the joint surfaces are mostly smooth and planar to irregular to rough and irregular. A single subvertical joint and associated horizontal joints were observed through most of the interval. Prior to removal from</p>

## GEOLOGIC LOG OF DRILL HOLE NO. DH-04-1

SHEET 8 OF 10

FEATURE: Black Rock Alternate Dam Site  
 LOCATION: North of Washington State Highway 24  
 BEGUN: 1/30/04 FINISHED: 3/31/04  
 DEPTH AND ELEV OF WATER  
 LEVEL AND DATE MEASURED: 190.9 (1156.45) 3/31/04

PROJECT: Yakima R. Basin Water Storage Feas. Study  
 COORDINATES: N 439,357.5 E 1,790,476.4  
 TOTAL DEPTH: 562.3  
 DEPTH TO BEDROCK: 145.3

STATE: Washington  
 GROUND ELEVATION: 1347.4  
 ANGLE FROM HORIZONTAL: AZIMUTH:  
 HOLE LOGGED BY: Stelma/McAfee/Lyon  
 REVIEWED BY: R. A. Link

NOTES	DEPTH	% RECOVERY	SPT	ENGINEERING PROPERTIES				FIELD CLASSIFICATION	LAB CLASSIFICATION	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
				WEATHERING	HARDNESS	FRACTURE DENSITY	RQD						
													<p>core barrel (undisturbed) the joints were generally tight to slightly open.</p> <p>358.2-421.5': BASALT. Black to gray, mostly fine grained dense basalt. <u>Slightly Weathered (W3)</u>. Oxidation (iron and manganese) generally limited to fracture surfaces. <u>Hard (H3)</u>. Core breaks with heavy hammer blow. <u>Slightly Fractured (FD3)</u>. Core recovered in lengths from 0.1' to 2.8', mostly in lengths about 1.4', the joint surfaces are mostly smooth and planar to irregular to rough and irregular. Prior to removal from core barrel (undisturbed) the joints were generally tight to slightly open.</p> <p>Magnetic Polarity on Sample at 360.3': <u>Normal</u>.</p> <p>Magnetic Polarity on Sample at 384.7': <u>Normal</u>.</p> <p>421.5-426.6': BASALT. Black to gray, fine grained aphanitic, slightly to moderately vesicular basalt. <u>Slightly Weathered (W3)</u>. Oxidation (iron and manganese) generally limited to fracture surfaces. <u>Hard (H5)</u>. Core breaks with moderate to heavy hammer blow. <u>Moderately to Slightly Fractured (FD4)</u>. Core recovered in lengths from fragments to 0.9', mostly in lengths around 0.4', the joint surfaces are mostly smooth and planar to irregular to rough and irregular.</p> <p>426.6-431.5': BASALT (FLOW BRECCIA). Dark green to black, fine grained aphanitic, moderately to strongly vesicular basalt. <u>Moderately to Slightly Weathered (W4)</u>. Numerous indurated clay and silty clay seams, body of rock is slightly weathered. <u>Hard (H5)</u>. Core breaks with moderate to heavy hammer blow. <u>Moderately to Slightly Fractured (FD4)</u>. Core recovered in lengths from 0.2' to 1.9', mostly in lengths about 0.4', the joint surfaces are mostly rough and irregular.</p> <p>431.5-461.5': BASALT. Black to gray, mostly fine grained dense to very slightly vesicular basalt. <u>Slightly Weathered (W2)</u>. Oxidation (iron and manganese) generally limited to fracture surfaces, some vesicles infilled with calcium carbonate (strong reaction with HCl). <u>Hard (H3)</u>. Core breaks with heavy hammer blow. <u>Moderately to Slightly Fractured (FD4)</u>. Core recovered in lengths from fragments to 0.1' to 2.8', mostly in lengths about 1.4', the joint surfaces are mostly smooth and planar, with scattered irregular to rough and irregular surfaces.</p> <p>Magnetic Polarity on Sample at 455.5': <u>Normal</u>.</p> <p>457.0-459.2': <u>LEAN CLAY</u>. (Inclusion of underlying Mabton Interbed). About 100% fines with medium plasticity, slow dilatancy and medium toughness, green, moist.</p> <p>467.0-555.8': <b>MABTON INTERBED (Tm)</b> of the Ellensburg Formation, Miocene Columbia River Basalt Group (CRB). Light green to to dark brown, moderately soft tuffaceous siltstone, sandstone and claystone. Descriptions are based on HQ-size core samples.</p> <p>467.0-490.0': SILTSTONE. Fine grained, light green to gray, homogeneous, well indurated silt-size to some medium sand-sized fragments with abundant mafic and micaceous material. <u>Intensely Weathered (W7)</u>. Material is partially altered to clay. <u>Moderately Soft (H5)</u>. Core scratches with light to moderate knife pressure. <u>Slightly Fractured (FD3)</u>. Core recovered mostly in lengths from 1.0 to 3.0'.</p> <p>490.0-502.4': POORLY GRADED SAND (SP). About 100% predominantly medium, hard, subangular to angular sand; dry to moist, gray with reddish brown lenses, abundant iron oxide.</p>

## GEOLOGIC LOG OF DRILL HOLE NO. DH-04-1

SHEET 9 OF 10

FEATURE: Black Rock Alternate Dam Site  
 LOCATION: North of Washington State Highway 24  
 BEGUN: 1/30/04 FINISHED: 3/31/04  
 DEPTH AND ELEV OF WATER  
 LEVEL AND DATE MEASURED: 190.9 (1156.45) 3/31/04

PROJECT: Yakima R. Basin Water Storage Feas. Study  
 COORDINATES: N 439,357.5 E 1,790,476.4  
 TOTAL DEPTH: 562.3  
 DEPTH TO BEDROCK: 145.3

STATE: Washington  
 GROUND ELEVATION: 1347.4  
 ANGLE FROM HORIZONTAL: AZIMUTH:  
 HOLE LOGGED BY: Stelma/McAfee/Lyon  
 REVIEWED BY: R. A. Link

NOTES	DEPTH	% RECOVERY	SPT	ENGINEERING PROPERTIES				FIELD CLASSIFICATION	LAB CLASSIFICATION	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
				WEATHERING	HARDNESS	FRACTURE DENSITY	RQD						
													<p>502.4-510.9': SILTSTONE. Fine grained, light green to tan, homogeneous, well indurated silt-size material. <u>Intensely Weathered (W7)</u>. Some minerals altered to clay due to extensive leaching and solutioning of rock. <u>Moderately Soft (H5)</u>. Core scratches with light to moderate knife pressure. <u>Slightly Fractured (FD3)</u>. Core recovered mostly in lengths ranging from 1.0 to 3.0'.</p> <p>510.9-525.8': SANDSTONE. Fine to medium grained, green to black, homogeneous, well indurated silt-size to medium sand-sized fragments with abundant mafic and micaceous material. <u>Intensely Weathered (W7)</u>. Some of the minerals are altered to clay due to extensive leaching and solutioning of rock. <u>Moderately Soft (H5)</u>. Core scratches with light to moderate knife pressure. <u>Slightly Fractured (FD3)</u>. Core recovered in lengths from 1.0 to 3.0'.</p> <p>525.8-536.1': SILTSTONE. Fine grained, light green to white, homogeneous, well indurated silt-size material. <u>Intensely Weathered (W7)</u>. Some minerals altered to clay due to extensive leaching and solutioning of rock. <u>Moderately Soft (H5)</u>. Core scratches with light to moderate knife pressure. <u>Slightly Fractured (FD3)</u>. Core recovered mostly in lengths ranging from 0.5 to 5.0'.</p> <p>536.1-543.9': CLAYSTONE. Fine grained, greenish gray to black, homogeneous, well indurated clay-size material. <u>Intensely Weathered (W7)</u>. Sample is mostly clay due to extensive leaching and solutioning of rock. <u>Moderately Soft (H5)</u>. Core scratches with light to moderate knife pressure. <u>Slightly Fractured (FD3)</u>. Core recovered mostly in lengths ranging from 0.9 to 1.8'.</p> <p>543.9-549.4': SILTSTONE. Fine grained, mottled dark brown to black, well indurated silt-size material. Abundant organics, wood and coal (lignite) fragments up to 25 mm. <u>Intensely Weathered (W7)</u>. Some minerals altered to clay due to due to extensive leaching and solutioning of rock. <u>Moderately Soft (H5)</u>. Core scratches with light to moderate knife pressure. <u>Moderately Fractured (FD5)</u>. Core recovered mostly in lengths ranging from 0.4 to 1.0'.</p> <p><u>Slickensides</u> (striations) noted on subvertical joint surfaces at 543.9', 546.4', 546.6' and at 549.4'.</p> <p>549.4-555.8': CLAYSTONE. Fine grained, mottled greenish brown, well indurated clay-size material. Trace of organics, wood fragments up to 10 mm. <u>Intensely Weathered (W7)</u>. Sample is mostly clay due to extensive leaching and solutioning of rock. <u>Moderately Soft (H5)</u>. Core scratches with light to moderate knife pressure. <u>Slightly Fractured (FD3)</u>. Core recovered mostly in lengths ranging from 0.9 to 1.8'.</p> <p><u>Slickensides</u> (striations) noted on joint surfaces at 550.5', 553.2', 553.3', 554.2' and at 555.8'.</p> <p>555.8-562.3': <b>PRIEST RAPIDS MEMBER (Tpr)</b> of the Wanapum Basalt Formation, Miocene Columbia River Basalt Group (CRB). Black to gray, hard, fine grained to porphyritic, vesicular basalt. Descriptions are based on HQ-size core samples.</p> <p>556.0-562.3': BASALT. Black to gray moderately vesicular basalt, mostly fine grained with abundant elongate and angular plagioclase phenocrysts up to 1 mm diameter. Phenocrysts comprise about 10% of the rock. Fairly sharp contact with overlying claystone. <u>Slightly Weathered (W3)</u>. Oxidation (iron and manganese) limited to fracture surfaces; vesicles are infilled with bluish silt and clay;</p>

# GEOLOGIC LOG OF DRILL HOLE NO. DH-04-1

SHEET 10 OF 10

FEATURE: Black Rock Alternate Dam Site  
 LOCATION: North of Washington State Highway 24  
 BEGUN: 1/30/04 FINISHED: 3/31/04  
 DEPTH AND ELEV OF WATER  
 LEVEL AND DATE MEASURED: 190.9 (1156.45) 3/31/04

PROJECT: Yakima R. Basin Water Storage Feas. Study  
 COORDINATES: N 439,357.5 E 1,790,476.4  
 TOTAL DEPTH: 562.3  
 DEPTH TO BEDROCK: 145.3

STATE: Washington  
 GROUND ELEVATION: 1347.4  
 ANGLE FROM HORIZONTAL: AZIMUTH:  
 HOLE LOGGED BY: Stelma/McAfee/Lyon  
 REVIEWED BY: R. A. Link

NOTES	DEPTH	% RECOVERY	SPT	ENGINEERING PROPERTIES				FIELD CLASSIFICATION	LAB CLASSIFICATION	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
				WEATHERING	HARDNESS	FRACTURE DENSITY	RQD						
													<p>abundant iron pyrite noted on fracture surface and within vesicles; all phenocrysts are discolored to a grayish white color. <u>Hard (H3)</u>. Core breaks with moderate hammer blow. <u>Intensely to Moderately Fractured (FD6)</u>. Core recovered in lengths from fragments to 0.9', mostly less than 0.4', the joint surfaces are mostly rough and planar to rough and irregular. Prior to removal from core barrel (undisturbed) the joints were moderately open (1 to 3 mm).</p> <p>Magnetic Polarity on Sample from 560.0-560.7': <u>Reverse</u>.</p> <p>562.3': BOTTOM OF HOLE</p>



# GEOLOGIC LOG OF DRILL HOLE NO. DH-04-2

SHEET 1 OF 5

FEATURE: Black Rock Alternate Dam Site  
 LOCATION: North of Washington State Highway 24  
 BEGUN: 4/1/04 FINISHED: 6/3/04  
 DEPTH AND ELEV OF WATER  
 LEVEL AND DATE MEASURED: 194.1 (1156.46) 6/03/04

PROJECT: Yakima River Basin Water Storage Project  
 COORDINATES: N 439,391.5 E 1,790,479.2  
 TOTAL DEPTH: 530.0  
 DEPTH TO BEDROCK: 144.0

STATE: Washington  
 GROUND ELEVATION: 1350.6  
 ANGLE FROM HORIZONTAL: AZIMUTH:  
 HOLE LOGGED BY: Didricksen/McAffee  
 REVIEWED BY: R. Link

NOTES	DEPTH	% RECOVERY	SPT	MC	FIELD CLASSIFICATION	USCS LAB	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
<p>All elevations measured from ground surface and are same as driller reported.</p> <p>PURPOSE OF HOLE: Hydro-geologic testing</p> <p>DRILL SETUP: Setup on original ground surface approximately 230 feet north of Washington State Highway 24.</p> <p>DRILLER: Chris Peterson</p> <p>DRILLING EQUIPMENT: Ingersoll-Rand T-2 Truck mounted drill.</p> <p>DRILLING METHODS:  <b>0.0-149.0':</b> Advanced hole with 7-7/8" rock bit and 8" casing using air as circulating fluid to remove the cuttings from 0-87.0' and 97.0-129.0'. Air and water with foam was used to remove cuttings from 87.0-97.0' and 129.0-149.0'. Constant Head tests were conducted at the intervals of 27.0-31.0', 77.0-81.7' and 117.0-137.0'.  <b>149.0-230.0':</b> Advanced hole with 5-7/8" downhole hammer to 230.0', using air and water with foam to remove the cuttings from 149.0-230'. Constant Head tests were conducted from 148.0-168.0' and 148.0-230.0'.  <b>230.0-314.0':</b> Advanced hole with 5-7/8" downhole hammer using air and water with foam to remove the cuttings to 290.0'. Bottom of packer was set at 235.7', and a Slug test was conducted from 236.0-290.0'. Packer removal was difficult due to slight caving from 190.0-200.0'. Hole was cleaned out from 148.0-200.0' with 7-7/8" downhole hammer and stabilizers. Stabilizers came apart at 200.0'. After retrieving stabilizers and downhole hammer, the hole was cleaned out</p>	<div>5</div> <div>10</div> <div>15</div> <div>20</div> <div>25</div> <div>30</div> <div>35</div> <div>40</div> <div>45</div> <div>50</div> <div>55</div> <div>60</div> <div>65</div> <div>70</div> <div>75</div> <div>80</div> <div>85</div> <div>90</div> <div>95</div>						<div>Qe</div> <div>Qh</div> <div>Tr</div>			<p>Refer to the log of companion hole DH-04-1 for detailed descriptions of the materials present at this site.</p> <p>All descriptions of material in this log are based on drilling conditions and cuttings returned.</p> <p><b>0.0-7.0': QUATERNARY LOESS DEPOSITS (Qe).</b> Surficial deposits of silt with lesser amounts of clay, composed primarily of wind-blown silt with small amounts of fine sand and volcanic ash.</p> <p><b>0.0-7.0': SILT AND SAND.</b></p> <p><b>7.0-28.0': QUATERNARY ALLUVIUM DEPOSITS (Qh).</b> Undifferentiated medium to coarse-grained sand with fines, gravels, cobbles and boulders composed primarily of basaltic detritus from local sources.</p> <p><b>7.0-28.0': SILT, SAND, AND GRAVEL.</b></p> <p><b>28.0-87.0': TERTIARY RINGOLD FORMATION (Tr).</b> Composed of fluvio lacustrine sand, silt and clay, with cobbles and gravels in a matrix of coarse to fine sand and fines near the middle and base of the unit.</p> <p><b>28.0-40.0': SILT, SAND, AND GRAVEL.</b></p> <p><b>40.0-70.0': SILT SAND AND CLAY.</b></p> <p><b>70.0-82.0': SILT, SAND, AND GRAVEL.</b></p> <p><b>82.0-87.0': SILT, SAND, GRAVEL, AND COBBLES.</b></p> <p><b>87.0-144.0': TERTIARY RATTLESNAKE RIDGE MEMBER (Trr) AND INVASIVE FLOW TOP (PEPERITE) CONSISTING OF SELAH INTERBED (Ts) UNDIFFERENTIATED MEMBERS</b> of the Ellensburg Formation. The upper section is comprised of unconsolidated gravel and sand with silt and clay, and the lower section is comprised of pumice material rafted to the top of the Pomona Basalt, composed of tuffaceous clay, silt, sand and gravel.</p> <p><b>87.0-97.0': SILT AND CLAY.</b></p> <p><b>97.0-119.0': SILT AND SAND.</b></p> <p><b>119.0-129.0': CLAY.</b></p> <p><b>129.0-132.0': CLAY, SAND, AND GRAVELS.</b></p> <p><b>132.0-137.0': CLAY, SAND, AND GRAVELS.</b></p> <p><b>137.0-144.0': SAND, GRAVELS AND COBBLES.</b></p> <p><b>144.0-249.0': POMONA MEMBER (Tp) of the Saddle Mountains Basalt Formation, Miocene Columbia River Basalt Group (CRB).</b> Black to gray, hard, mostly fine grained dense basalt with plagioclase phenocrysts comprising less than 5% of the rock.</p> <p><b>144.0-249.0': BASALT.</b></p> <p><b>249.0-280.0': SELAH INTERBED (Ts) of the</b></p>

COMMENTS: Samples were logged in the field using Designation USBR 5005-88, "Procedures for Determining Unified Soil Classification (Visual Method)."

Center column descriptors are defined in the Reclamation Engineering Geology Field Manual, Volume 1, Second Edition, distributed February 1999.

Cs = Casing Sz = Size of Casing I.D. = Inside Diameter O.D. = Outside diameter

Geologic unit descriptions and stratigraphy based partially on consulting discussions with Dr. Bentley and geologic interpretations presented in the following reports:

"Black Rock Reservoir Study, Initial Geotechnical Investigation, Prepared for Benton County Sustainable Development by Washington Infrastructures Services, Inc., Dated January 2003.

"Geologic Investigation Black Rock Dam, Alternate Dam Site, Yakima County, Washington, Prepared for U.S. Bureau of Reclamation by Columbia Geotechnical Associates, Inc., Dated February 12, 2004."

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# GEOLOGIC LOG OF DRILL HOLE NO. DH-04-2

SHEET 2 OF 5

FEATURE: Black Rock Alternate Dam Site  
 LOCATION: North of Washington State Highway 24  
 BEGUN: 4/1/04 FINISHED: 6/3/04  
 DEPTH AND ELEV OF WATER  
 LEVEL AND DATE MEASURED: 194.1 (1156.46) 6/03/04

PROJECT: Yakima River Basin Water Storage Project  
 COORDINATES: N 439,391.5 E 1,790,479.2  
 TOTAL DEPTH: 530.0  
 DEPTH TO BEDROCK: 144.0

STATE: Washington  
 GROUND ELEVATION: 1350.6  
 ANGLE FROM HORIZONTAL: AZIMUTH:  
 HOLE LOGGED BY: Didricksen/McAfee  
 REVIEWED BY: R. Link

NOTES	DEPTH	% RECOVERY	SPT	MC	FIELD CLASSIFICATION	USCS LAB	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
with 7-7/8" downhole hammer to 215.0', and 5-7/8" downhole hammer 314.0', using air and water with foam to remove the cuttings. Pump and packer were set at 235.7', and a constant rate pump test was conducted from 236.0-273.0'. Following the test, the hole had caved from 270.0-285.0'. Hole was cleaned out with 7-7/8" downhole hammer using air and water with foam to remove cuttings. Cut slots in 6" casing with plasma cutter and began installing in hole, but could not get it to bottom due to caving. Casing was removed and hole was cleaned with a 7-7/8" tri-cone rockbit to 291.6'. 6" casing was cleaned out with a 5-7/8" rockbit and advanced with a casing hammer to 314.0'. Slotted section is 254.0-294.0'. Pump was set at 245.0', and a step test, pump/constant rate, and slug tests were conducted from 254.0-294.0'. 314.0-405.0': Advanced hole with 5-7/8" downhole hammer using air to remove to cuttings to 405.0'. Top of packer was set at depths 362.0' and 372.0', but would not seal. Packer sealed with the top at 352.0', and slug test were conducted at 356.0-405.0' and 381.0-405.0'. 405.0-530.0': Advanced hole with 5-7/8" downhole hammer using air to remove cuttings. Encountered heaving sand at 515.0-520.0'. Installed 3" PVC screen and riser to stabilize hole before conducting hydro tests. 8" casing broke while extracting, left in hole from 103.0-143.0'. An airlift/constant drawdown test was conducted in the Mabton unit, and pneumatic slug test were conducted in DH-04-2 and DH-04-1.	105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215						Trr/Ts			Ellensburg Formation.  249.0-280.0': SAND AND GRAVELS.  280.0-466.0': <b>ESQUATZEL/UMATILLA UNDIFFERENTIATED MEMBERS (Teq/Tum)</b> of the Saddle Mountains Basalt Formation, Miocene Columbia River Basalt Group (CRB). Black to gray, hard, mostly fine grained dense basalt.  280.0-466.0': BASALT.  466.0-530.0': <b>MABTON INTERBED (Tm)</b> of the Ellensburg Formation. Light green to to dark brown, tuffaceous siltstone and sandstone.  466.0-515.0': SANDSTONE AND SILT STONE.  515.0-520.0': SAND.  520.0-530.0': SAND AND CLAY.
DRILLING CONDITIONS: 0.0-7.0': Fast and smooth. 7.0-70.0': Slow to fast and moderately rough. 70.0-87.0': Slow and rough. 87.0-129.0': Moderately fast and smooth. 129.0-168.0': Moderately slow and rough. 168.0-245.0': slow and rough to smooth. Caving was noted at depths of							Tp			

# GEOLOGIC LOG OF DRILL HOLE NO. DH-04-2

SHEET 3 OF 5

FEATURE: Black Rock Alternate Dam Site  
 LOCATION: North of Washington State Highway 24  
 BEGUN: 4/1/04 FINISHED: 6/3/04  
 DEPTH AND ELEV OF WATER  
 LEVEL AND DATE MEASURED: 194.1 (1156.46) 6/03/04

PROJECT: Yakima River Basin Water Storage Project  
 COORDINATES: N 439,391.5 E 1,790,479.2  
 TOTAL DEPTH: 530.0  
 DEPTH TO BEDROCK: 144.0

STATE: Washington  
 GROUND ELEVATION: 1350.6  
 ANGLE FROM HORIZONTAL: AZIMUTH:  
 HOLE LOGGED BY: Didricksen/McAffee  
 REVIEWED BY: R. Link

NOTES	DEPTH	% RECOVERY	SPT	MC	FIELD CLASSIFICATION	USCS LAB	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
176.0', 190.0'- 200.0', and 240.0' 245.0-249.0': Slow and rough, blocking. 249.0-285.0': Moderately slow and rough. Caving was noted at depths of 270.0'-285.0' 285.0-466.0': Slow and moderately rough. 466.0-515.0': Moderately fast and smooth. 515.0-530.0': Fast and smooth.  CASING RECORD: 2004 Cs Depth Depth Date Sz Hole Cs  4/1 8" 7.0' 7.0' 4/2 8" 31.0' 27.0' 4/3 8" 82.0' 77.0' 4/5 8" 97.0' 97.0' 4/6 8" 137.0' 227.0' 4/7 8" 165.0' 148.0' 4/8 8" 200.0' 148.0' 4/9 8" 230.0' 148.0' 4/10 8" 290.0' 148.0' 4/23 8" 314.0' 148.0' 5/11 6" 314.0' 314.0' 5/17 6" 374.0' 314.0' 5/18 6" 405.0' 314.0' 5/20 6" 434.0' 314.0' 5/21 6" 530.0' 314.0'  FLUID COLOR: 0.0-31.0': Brown 31.0-40.0': Tan 40.0-82.0': Reddish brown 82.0-119.0': Brown 119.0-129.0': Gray 129.0-137.0': Brown 137.0-144.0': Gray 144.0-249.0': Black 249.0-290.0': Brown 290.0-314.0': Gray 314.0-374.0': Gray 374.0-405.0': Not reported 405.0-466.0': Gray 466.0-515.0': Light brown 515.0-520.0': White 520.0-530.0': Green  FLUID RETURN: N/A  WATER LEVEL DURING DRILLING: (from ground surface at start of shift)  Date FL Level Hole Dpth 04/02: Dry 7.0' 04/05: Dry 82.0' 04/07: Dry 117.0' 04/08: 161.3" 148.0' 04/09: 196.4" 200.0' 04/10: 177.4" 230.4' 04/12: 206.5' 290.0' 04/13: 206.5' 290.0' 04/14: 206.5' 290.0' 04/20: 205.6' 290.0' 04/21: 205.6' 290.0' 04/23: 205.6' 290.0' 04/24: 202.0' 314.0' 04/27: 197.4' 314.0'	220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335						Ts			

# GEOLOGIC LOG OF DRILL HOLE NO. DH-04-2

SHEET 4 OF 5

FEATURE: Black Rock Alternate Dam Site  
 LOCATION: North of Washington State Highway 24  
 BEGUN: 4/1/04 FINISHED: 6/3/04  
 DEPTH AND ELEV OF WATER  
 LEVEL AND DATE MEASURED: 194.1 (1156.46) 6/03/04

PROJECT: Yakima River Basin Water Storage Project  
 COORDINATES: N 439,391.5 E 1,790,479.2  
 TOTAL DEPTH: 530.0  
 DEPTH TO BEDROCK: 144.0

STATE: Washington  
 GROUND ELEVATION: 1350.6  
 ANGLE FROM HORIZONTAL: AZIMUTH:  
 HOLE LOGGED BY: Didricksen/McAffee  
 REVIEWED BY: R. Link

NOTES	DEPTH	% RECOVERY	SPT	MC	FIELD CLASSIFICATION	USCS LAB	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
04/28 199.7' 314.0' 04/29: 200.5' 314.0' 05/05: 195.8' 314.0' 05/11: 196.0' 314.0' 05/12: 196.0' 314.0' 05/13: 196.0' 314.0' 05/17: 196.0' 314.0' 05/18: 194.7' 374.0' 05/19: 194.7' 405.0' 05/20: 193.3' 405.0' 05/21: 193.3' 434.0' 05/22: 195.3' 530.0' 06/02: 191.8' (?) 526.7' 06/03: 194.1' 526.7'  * Water level may be influenced from water added by drillers to clean out the hole at the end of shift the previous day.  First water was noted at 254.0, producing about 10 GPM.  WATER LEVEL AFTER DRILLING: 06/09: 197.4'  DRILLING TIME: Drilling: 32 days. hydrotesting: 13days Travel/moving: 30 hrs  HOLE COMPLETION: The hole was completed with 3-inch PVC and a transducer as follows:  526.7-453.0': Sand pack with slotted (0.020" slot) schedule 40 PVC (3.068" ID) with cap at 526.7-476.7'.  453.0-433.0': Cal-seal cement.  433.0-264.0': Cement.  264.0-46.0': Bentonite chips, with 8-inch casing left from 143.0-103.0'.  46.0-0.0': Cement.  Installed standpipe wellhead with about 3.1' stickup. Top of riser at elevation 1353.66'.  Aquistar PT2X pressure trasnducer, 30 psi range installed for long-term monitoring.	340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455						Teq/Tum			

GEOLOGIC LOG OF DRILL HOLE NO. DH-04-2

SHEET 5 OF 5

FEATURE: Black Rock Alternate Dam Site  
LOCATION: North of Washington State Highway 24  
BEGUN: 4/1/04 FINISHED: 6/3/04  
DEPTH AND ELEV OF WATER  
LEVEL AND DATE MEASURED: 194.1 (1156.46) 6/03/04

PROJECT: Yakima River Basin Water Storage Project  
COORDINATES: N 439,391.5 E 1,790,479.2  
TOTAL DEPTH: 530.0  
DEPTH TO BEDROCK: 144.0

STATE: Washington  
GROUND ELEVATION: 1350.6  
ANGLE FROM HORIZONTAL: AZIMUTH:  
HOLE LOGGED BY: Didricksen/McAffee  
REVIEWED BY: R. Link

NOTES	DEPTH	% RECOVERY	SPT	MC	FIELD CLASSIFICATION	USCS LAB	GEOLOGIC UNIT	GRAPHIC	HOLE COMPLETION	CLASSIFICATION AND PHYSICAL CONDITION
	460									
	465									
	470									
	475									
	480									
	485									
	490									
	495									
	500						Tm			
	505									
	510									
	515									
	520									
	525									
	530									
	BOTTOM OF HOLE									

## Appendix B – Sampling Plan for Groundwater Monitoring and Sampling of DH-04-02

## Black Rock Assessment Study DH-04-02 Sampling Plan

Field Measurements	Method				
Flow rate	flow meter				
Pumping Level	pressure transducer				
Temperature, water	Hanna meter				
Barometric Pressure	Barometer				
Eh	Hach tester				
pH	Hanna meter				
EC	Hanna meter				
DO	YSI meter				
Alkalinity	Hach digital titrator				
Laboratory Measurements					
Parameter	Analysis	Container	Filtered (Y/N)	Preservation	When sampled
Major Ions	Cl	250-mL Poly bottle	Y	Store cool at 4°C	early in pumping test*
	SO4	-	-	-	-
	F	-	-	-	-
	CO3	-	-	-	-
	HCO3	-	-	-	-
	NO3 + NO2	-	-	-	-
	Ca	250-mL Poly, acid rinsed	Y	HNO3 to pH <2	-
	Mg	-	-	-	-
	Na	-	-	-	-
	K	-	-	-	-
	Fe	-	-	-	-
	Mn	-	-	-	-
* if EC is different after pumping, then re-sample at end of pumping test					
Send above listed samples in ice chests with ice packs to USBR water laboratory(Boise) after sampling/pumping each test zon					
Dissolved Gases	He	Serum bottle	N	Store cool at 4°C	If DO<1, sample early in pumping test
	Methane	-	-	-	-
	Excess nitrogen	-	-	-	-
Tritium		1-L amber glass	N	Store room temp.	-
Carbon-14		1-L amber glass w/ poly lid	-	Store room temp.	-
DOC		150-mL amber glass	N	Store cool at 4°C	if DO<1, sample early in pumping test
Stable Isotopes	oxygen-18	50-mL glass w/poly lids	N	Store room temp.	early in pumping test <b>and</b> end of pumping test
	deuterium		-	-	-
Extra sample		1-L poly bottle	N	Store cool at 4°C	end of pumping test
Send above listed samples in ice chests with ice packs to USGS Water Resources (Tacoma) after sampling/pumping each test zon					