CH2M HILL

PROJECT NUMBER: P15600.A5.00

SOIL BORING LOG

PROJECT: TRI CITY STP LOCATION: OREGON CITY, OREGON

DRILLING METHOD: MUD ROTARY DRILLERS & EQUIPMENT: D. KENNER OF OREGON, INC

ELEVATION: 42.50 FT BORE HOLE: B-11

WATER LEVEL: SEE TEXT DATE: START: 12/28/81 FINISH: 12/28/81 INSPECTOR: G.LUHL

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (INCHES)	STANDARD PENETRATION TEST RESULTS BLOWS 6"-6"-6"	BPF "N"	SOIL DESCRIPTION (COLOR, RELATIVE DENSITY OR CONSISTENCY, MOISTURE, GRAIN SHAPE AND TYPE, STRUCTURE, CEMENTATION, ORGANICS, MATERIAL)	GRAPHIC LOG	UNIFIED SOIL CLASSIFICATION SYMBOL	COMMENTS (DRILLING PROGRESS, LOST CIRCULATION, TYPE OF DEPOSIT, PROBLEMS, ETC.)
	30.0 – 30.9	S-6	4	20-60/5"	80/11"	SANDY GRAVEL, POORLY GRADED, ROUNDED GRAVEL TO AT LEAST 1 INCH, 20-30% FINE TO COARSE SAND, 5-10% NONPLASTIC FINES, BROWN, WET, VERY DENSE.		GP-GM	SLOW, ROUGH DRILLING TO 35 FT.
35	35.0 – 35.8	S-7	4	45-60/3"	105/9"	SANDY GRAVEL, SAME AS S-6		GP-GM	SAMPLER BOUNCES DURING SPT FOR S5-7
									DRILLER NOTES CHANGE IN DRILLING RATE (UP) AT 37.5 FT
40	40.0 – 41.5	S-8	12	13-50-60/3"	110/9"	SILTSTONE, HIGHLY WEATHERED TO SILT AND CLAY-SIZED PARTICLES WITH 5-10% FINE SAND, SOME SLIGHTLY BRITTLE, INTACT LAYERS + FRAGMENTS 1/8-1/4-INCH THICK, GRAY, SLIGHTLY MOIST.			
45	45.0 – 45.8	S-9	5	14-60/4	74/10"	SILTSTONE, SAME AS S-8			
						END BORING AT 45.8 FEET			FINISH DRILLING AT 1:40.

PIEZOMETER INSTALLATION: (see notes on Boring Log Legend)

PLACEMENT OF PERVIOUS TIP: TOP AT 33 FT, BOTTOM AT 34.5 FT

GRAVEL PACK: FROM 46.5 FT TO GROUND SURFACE

BENTONITE SEAL: FROM 18 TO 20 FEET

RISER PIPE LENGTHS: 35 FEET

FORM D 1586 5/78

CH2M HILL

PROJECT NUMBER P15600.A5

SOIL BORING LOG

PROJECT TRI CITY STP LOCATION OREGON CITY, OREGON
DRILLING METHOD ROTARY MUD, CME-75 DRILLERS & EQUIPMENT D KENNER OF OREGON
ELEVATION 38.87 FEET BORE HOLE: B-13
WATER LEVEL SEE TEXT DATE: ____ START: 12/28/81 FINISH: 12/29/81 INSPECTOR CWH

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (INCHES)	STANDARD PENETRATION TEST RESULTS BLOWS 6"-6"-6"	BPF "N"	SOIL DESCRIPTION (COLOR, RELATIVE DENSITY OR CONSISTENCY, MOISTURE, GRAIN SHAPE AND TYPE, STRUCTURE, CEMENTATION, ORGANICS, MATERIAL)	GRAPHIC LOG	UNIFIED SOIL CLASSIFICATION SYMBOL	COMMENTS (DRILLING PROGRESS, LOST CIRCULATION, TYPE OF DEPOSIT, PROBLEMS, ETC.)
									BEGIN DRILLING AT 1:55
5	5.0 – 6.5	S-1	10	1-2-2	4	SILT, LOW TO MEDIUM PLASTICITY ABOUT 5% FINE SAND, BROWN, MOIST, SOFT.		ML	
10	10.0 – 11.5	S-2	14	1-1-1	2	SANDY SILT, LOW TO MEDIUM PLASTICITY 15-20% FINE SAND, BROWN, MOIST, SOFT		ML	
	13.0 – 15.0	ST-1	14	---	—	SANDY SILT, SIMILAR TO S-2			
15	15.0 – 16.5	S3	12	1-1-1	2	SILT, LOW TO MEDIUM PLASTICITY, 5-10% FINE SAND, BROWN, MOIST, SOFT.		ML	
20	20.0 – 21.5	S-4	18	1-1-1	2	SILT, LOW TO MEDIUM PLASTICITY ABOUT 5% FINE SAND, BROWN, MOIST, SOFT.		ML	
25	25.0 – 26.5	S-5	10	2-11-28	39	UPPER 6 INCHES: SILT, SAME AS SS-4 LOWER 4 INCHES: SILTY SAND, FINE TO MEDIUM SAND, 20-25% SLIGHTLY PLASTIC FINES, BROWN, MOIST, DENSE.		ML SM	DRILLER NOTES GRAVEL AT 26FT. SLOW, ROUGH DRILLING TO 47.5FT.
30									

FORM D 1586 5/78

SHEET 2 OF 3

CH2M HILL

PROJECT NUMBER P15600.A5-

SOIL BORING LOG

PROJECT TRI CITY STP LOCATION OREGON CITY, OREGON

DRILLING METHOD ROTARY MUD, CME-75 DRILLERS & EQUIPMENT D. KENNER OF OREGON

ELEVATION 38.87 FEET BORE HOLE: B-13

WATER LEVEL SEE TEXT DATE: START: 12/28/81 FINISH: 12/29/81 INSPECTOR CWH

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (INCHES)	STANDARD PENETRATION TEST RESULTS BLOWS 6"-6"-6"	BPF "N"	SOIL DESCRIPTION (COLOR, RELATIVE DENSITY OR CONSISTENCY, MOISTURE, GRAIN SHAPE AND TYPE, STRUCTURE, CEMENTATION, ORGANICS, MATERIAL)	GRAPHIC LOG	UNIFIED SOIL CLASSIFICATION SYMBOL	COMMENTS (DRILLING PROGRESS, LOST CIRCULATION, TYPE OF DEPOSIT, PROBLEMS, ETC.)
30	30.0 – 30.6	S-6	4	41-60/4"	101/10"	SANDY GRAVEL, POORLY GRADED, ROUNDED GRAVEL TO AT LEAST 1 1/4 INCH, 10-15% FINE TO MEDIUM SAND, 5-10% NON TO SLIGHTLY PLASTIC FINES, BROWN, VERY MOIST, VERY DENSE.		GP-GM	
35	35.0 – 35.5	S-7	4	56/6"	56/6"	SAME AS S-6		GP-GM	
40	40.0 – 40.4	S-8	1	60/4"	60/4"	SAME AS S-7		GP-GM	
45	45.0 – 45.3	S-9	0	60/3"	60/3"	NO RECOVERY			DRILLER NOTES END OF GRAVEL AT 47.5 FT.
50	50.0 – 50.8	S-10	6	43-60/2"	103/8"	SILTSTONE, HIGHLY WEATHERED TO SILT AND CLAY SIZED PARTICLES, WITH 10-15% FINE SAND AND GRAVEL, BLUE-GREEN WITH ORANGE-BROWN MOTTLING, SLIGHTLY MOIST.			1-2 INCH ROUNDED COBBLE WAS LODGED IN THE END OF SAMPLER FOR ST-10
55	55.0 – 56.5	S-11	15	25-46-60/3"	106/9"	SILTSTONE, HIGHLY WEATHERED TO SILT AND CLAY SIZED PARTICLES SOME BRITTLE, INTACT LAYERS AND FRAGMENTS, RELICT TEXTURE OF PARENT ROCK IS EVIDENT.			FINISH DRILLING AT 10:05

FORM D 1586 5/78

CH2M HILL

SHEET 3 OF 3

PROJECT NUMBER P15600. A5

SOIL BORING LOG

PROJECT TRI CITY STP LOCATION OREGON CITY, OREGON

DRILLING METHOD ROTARY MUD, CME-75 DRILLERS & EQUIPMENT D.KEUNER OF OREGON, INC.

ELEVATION 38.87 FEET BORE HOLE: B-13

WATER LEVEL SEE TEXT DATE: START: 12/28/81 FINISH: 12/29/81 INSPECTOR CWH

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS		SOIL DESCRIPTION (COLOR, RELATIVE DENSITY OR CONSISTENCY, MOISTURE, GRAIN SHAPE AND TYPE, STRUCTURE, CEMENTATION, ORGANICS, MATERIAL)	GRAPHIC LOG	UNIFIED SOIL CLASSIFICATION SYMBOL	COMMENTS (DRILLING PROGRESS, LOST CIRCULATION, TYPE OF DEPOSIT, PROBLEMS, ETC.)
	INTERVAL	NUMBER	RECOVERY (INCHES)	BLOWS 6"-6"-6"	BPF "N"				

PIEZOMETER INSTALLATION: (See notes on Boring Log Legend)

PLACEMENT OF PERVIOUS TIP: TOP AT 38.5 FT, BOTTOM AT 40.FT

GRAVEL PACK: FROM 56.5FT TO GROUND SURFACE

BENTONITE SEAL: FROM 20 TO 22 FT.

RISER PIPE LENGTH: 40 FT.

FORM D 1586 5/79

CH2M HILL

PROJECT NUMBER P15600.A5

SOIL BORING LOG

PROJECT TRI CITY STP LOCATION OREGON CITY, OREGON
DRILLING METHOD ROTARY MUD, FISHTALE & TRICONE BIT DRILLERS & EQUIPMENT D. KENNER CME -75
ELEVATION 44.70 FEET BORE HOLE: B-14
WATER LEVEL SEE TEXT DATE: 5/24/82 START: 5/18/82 FINISH: 5/18/82 INSPECTOR CWH

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER	RECOVERY (INCHES)	STANDARD PENETRATION TEST RESULTS BLOWS 6"-6"-6"	BPF "N"	SOIL DESCRIPTION (COLOR, RELATIVE DENSITY OR CONSISTENCY, MOISTURE, GRAIN SHAPE AND TYPE, STRUCTURE, CEMENTATION, ORGANICS, MATERIAL)	GRAPHIC LOG	UNIFIED SOIL CLASSIFICATION SYMBOL	COMMENTS (DRILLING PROGRESS, LOST CIRCULATION, TYPE OF DEPOSIT, PROBLEMS, ETC.)
									START DRILLING AT 9:40
	2.5–4.0	S-1	4	2-1-1	2	SILT LOW PLASTICITY, ABOUT 5-10% FINE SAND, DARK BROWN, MOIST, SOFT		ML	
5	5.0–6.5	S-2	7	1-1-1	2	SANDY SILT, SIMILAR TO S-1, EXCEPT IT GRADES INTO A SILTY SAND WITH 30-50% FINE SAND TOWARD BOTTOM.		ML	DRILLER NOTES ALTERNATING SOFTER & FIRMER DRILLING 5-10 FT.
	7.5–9.0	S-3	5	2-3-4	7	SILTY SAND, FINE SAND, 20-25% FINES WITH LOW PLASTICITY, BROWN, WET, SOFT TO FIRM.		SM	
10	10.0–11.5	S-4	7	2-1-1	2	SILTY SAND, SIMILAR TO S-3, EXCEPT WITH 30-35% FINES WITH LOW PLASTICITY.		SM	
	–13.5	ST-5	24	---	—	SILT, LOW PLASTICITY, ABOUT 10% FINE SAND, BROWN, WET, SOFT.		ML	ML IS AT VERY BOTTOM OF ST-5
15	15.0–16.5	S-6	5	3-2-4	6	SANDY SILT, LOW PLASTICITY ABOUT 20% FINE SAND, DARK BROWN, MOIST, FIRM		ML	
20	20.0–21.5	S-7	6	3-22-22	44	UPPER 2"; SILT LOW PLASTICITY, 5-10% FINE SAND, DARK BROWN MOIST LOWER 4"; SILTY SAND, FINE TO MEDIUM SAND, ABOUT 15% FINES BROWN, WET, DENSE.		ML SM	DRILLER NOTES GRAVEL AT 21.5 FT.
25	25.0–25.5	S-8	4	60/5½"	60/5½"	GRAVELLY SAND, POORLY GRADED, 25-30% SUBROUNDED GRAVEL TO ATLEAST 1¼ INCH, FINE TO COARSE SAND, MOSTLY COARSE, 5-10% FINES, BROWN, WET, DENSE.		SP-SM	SAMPLER BOUNCED IN FIRST 6 INCHES OF S-8 SLOW, ROUGH, DRILLING TO 30 FT.

FORM D 1586 5/78

CH2M HILL

SHEET 2 OF 2

PROJECT NUMBER P15600.A5

SOIL BORING LOG

PROJECT TRI CITY STP LOCATION OREGON CITY, OREGON

DRILLING METHOD ROTARY MUD; FISHTAIL & TRICONE BIT DRILLERS & EQUIPMENT D KENNER OF OREGON

ELEVATION 44.70 FEET BORE HOLE: B-14

WATER LEVEL SEE TEXT DATE: 5/24/82 START: 5/18/82 FINISH: 5/18/82 INSPECTOR CWH

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER	RECOVERY (INCHES)	STANDARD PENETRATION TEST RESULTS BLOWS 6"-6"-6"	BPF "N"	SOIL DESCRIPTION (COLOR, RELATIVE DENSITY OR CONSISTENCY, MOISTURE, GRAIN SHAPE AND TYPE, STRUCTURE, CEMENTATION, ORGANICS, MATERIAL)	GRAPHIC LOG	UNIFIED SOIL CLASSIFICATION SYMBOL	COMMENTS (DRILLING PROGRESS, LOST CIRCULATION, TYPE OF DEPOSIT, PROBLEMS, ETC.)
30	30.0 30.9	S-9	5	32-60/5"	92/11"	SANDY GRAVEL, WELL GRADED ANGULAR AND SUBROUNDED GRAVEL TO ATLEAST 20-25% FINE TO COARSE SAND, LESS THAN 5% FINES, BROWN AND BLACK, WET DENSE.		GP	SLOW ROUGH DRILLING TO 35 FT.
35	35.0 35.8	S-10	2	35-60/4½	95/10½"	SANDY GRAVEL SIMILAR TO S-9 BUT TOO LITTLE RECOVERY TO PROVIDE A THOROUGH DESCRIPTION.		GP	DRILLER POUNDED SAMPLER DOWN 3FT. TO GET IT IN POSITION; SOME OF SAMPLE S-10 MIGHT BE CAVINGS LOSE CIRCULATION AT 35.5 FT; MIX MUD SLOW, ROUGH DRILLING TO 40FT.
40	40.0 41.2	S-11	8	25-31-60/2½	91/8½"	SANDY GRAVEL, SAME AS S-9		GP	LOST CIRCULATION AT 42 FT, MIX MUD SLOW, ROUGH DRILLING TO 47 FT.
45	45.0 45.2	S-12	0	60/3"	60/3"	NO RECOVERY			SAMPLER BOUNCES IN FIRST 6INCH INTERVAL OF S-12. DRILLER NOTES END OF GRAVELLY MATERIAL AT 47 FT.
50	50.0 51.5	S-13	18	23-41-36	77	SILTSTONE HIGHLY WEATHERED, FRACTURES INTO ANGULAR, BLOCKY PIECES ABOUT 1/4" ON A SIDE; CONTAINS ABOUT 10% FINE SAND, AND LOCAL PIECES OF THOROUGHLY WEATHERED GRAVEL TO ~1/2 INCH; GRAY W/BLUE-GREEN MOTTLING AT TOP, MOIST.			FINISH DRILLING AT 2'20
						END BORING AT 51.5 FEET			

PIEZO INSTALLATION: (see notes on Boring Log Legend)

PLACEMENT OF PERVIOUS TIP: TOP AT 38.5 FT, BOTTOM AT 40 FT.

GRAVEL PACK: FROM 51.5 FEET TO GROUND SURFACE

BENTONITE SEAL: FROM 15.5 to 17.5 FT, AND FROM ABOUT 7 TO 8 FEET

RISER PIPE DIMENSIONS: 40 FEET

FORM D 1586 5/78

CH2M HILL

SHEET 1 OF 1

PROJECT NUMBER P15600.A5

SOIL BORING LOG

PROJECT: TRI CITY STP LOCATION: OREGON CITY, OREGON
DRILLING METHOD: ROTARY MUD, FISH TAIL BIT DRILLERS & EQUIPMENT: D. KENNER OF OREGON.
ELEVATION: 46.69 FT. BORE HOLE: B-15
WATER LEVEL: NOT MEASURED DATE: START: 5/18/82 FINISH: 5/18/82 INSPECTOR: CWH

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER	RECOVERY (INCHES)	STANDARD PENETRATION TEST RESULTS BLOWS 6"-6"-6"	BPF "N"	SOIL DESCRIPTION (COLOR, RELATIVE DENSITY OR CONSISTENCY, MOISTURE, GRAIN SHAPE AND TYPE, STRUCTURE, CEMENTATION, ORGANICS, MATERIAL)	GRAPHIC LOG	UNIFIED SOIL CLASSIFICATION SYMBOL	COMMENTS (DRILLING PROGRESS, LOST CIRCULATION, TYPE OF DEPOSIT, PROBLEMS, ETC.)
									START DRILLING AT 3:35
	2.5–4.0	S-1	5	2-2-2	4	SILT LOW PLASTICITY, 10-15% FINE SAND, BROWN, WET, SOFT.		ML	
5	5.0–6.5	S-2	8	1-2-2	4	SANDY SILT, LOW PLASTICITY, ABOUT 15% FINE SAND, BROWN, WET, LOOSE, SOME ROOTS PRESENT		ML	
	8.0–10.0	ST-3	24	---	–	SANDY SILT, SIMILAR TO S-2		ML	
10	10.0–11.5	S-4	5	2-2-3	5	SANDY SILT LOW PLASTICITY, ABOUT 15% FINE SAND, DARK BROWN, MOIST, SOFT TO FIRM.		ML	
15	15.0–16.5	S-5	7	2-2-3	5	SILT, LOW TO MEDIUM PLASTICITY, LESS THAN 5% FINE SAND BROWN, WET, SOFT TO FIRM		ML	
20	20.0–21.5	S-6	10	2-3-4	7	SANDY SILT LOW PLASTICITY 35-45% FINE SAND, DARK BROWN, MOIST, FIRM		ML	
25	25.0–26.5	S-7	12	8-19-58	77	UPPER 9": SAND, UNIFORMLY GRADED, FINE SAND, 5-12% FINE WITH LOW PLASTICITY, BROWN, WET LOWER 3": SANDY GRAVEL, WELL GRADED GRAVEL TO 1¼ INCH, 20-30% FINE TO COARSE SAND, LESS THAN 5% FINE. END BORING AT 26.5 FT		SP-SM GP	FINISH DRILLING AT 4:20

FORM D 1586 5/78

CH2M HILL

SHEET 1 OF 1

PROJECT NUMBER P15600.A5

SOIL BORING LOG

PROJECT TRI CITY STP LOCATION OREGON CITY, OREGON

DRILLING METHOD ROTARY MUD FISHTAIL BIT DRILLERS & EQUIPMENT D. KENNER OF OREGON

ELEVATION 40.20 FEET BORE HOLE: B-16

WATER LEVEL NOT MEASURED DATE: START: 5/19/82 FINISH: 5/19/82 INSPECTOR CWH

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (INCHES)	STANDARD PENETRATION TEST RESULTS BLOWS 6"-6"-6"	BPF "N"	SOIL DESCRIPTION (COLOR, RELATIVE DENSITY OR CONSISTENCY, MOISTURE, GRAIN SHAPE AND TYPE, STRUCTURE, CEMENTATION, ORGANICS, MATERIAL)	GRAPHIC LOG	UNIFIED SOIL CLASSIFICATION SYMBOL	COMMENTS (DRILLING PROGRESS, LOST CIRCULATION, TYPE OF DEPOSIT, PROBLEMS, ETC.)
	2.5 – 4.0	S-1	7	2-2-1	3	SILT LOW TO MEDIUM PLASTICITY, DARK BROWN, MOIST, SOFT		ML	START DRILLING AT 11:10
5	5.0 – 6.5	S-2	9	1-1-2	3	SILT, SIMILAR TO S-1, EXCEPT WITH 5-10% FINE SAND		ML	
	7.5 – 9.0	S-3	12	1-1-1	2	SILT LOW TO MEDIUM PLASTICITY, ABOUT 10% FINE SAND DARK BROWN, MOIST, SOFT.		ML	
10	10.0 – 12.0	ST-4	24	---	—	SANDY SILT, LOW PLASTICITY 18% FINE TO MEDIUM SAND, MOSTLY FINE 65% SILT, 17% CLAY, MOIST, SOFT.		ML	
	12.0 – 13.5	S-5	18	1-1-1	2	SILT, SIMILAR TO S-1, EXCEPT ABOUT 5% FINE SAND		ML	
15	15.0 – 16.5	S-6	18	1-1-2	3	SILT, LOW PLASTICITY, DARK BROWN, MOIST, SOFT		ML	
20	20.0 – 21.5	S-7	12	2-2-1	3	SANDY SILT, LOW PLASTICITY, 15-20% FINE SAND, BROWN, MOIST, SOFT.		ML	
25	25.0 – 26.5	S-8	5	7-7-8	15	SAND, UNIFORMLY GRADED, FINE TO MEDIUM SAND, MOSTLY FINE, 5-12% FINES, BROWN, MOIST, COMPACT		SP-SM	DRILLER NOTES GRAVEL AT 27.5FT
	27.5 – 28.5	S-9	2	41-60/6"	101/12"	SANDY GRAVEL, POORLY GRADED GRAVEL TO AT LEAST 1 1/4 INCH, 10-15% FINE TO COARSE SAND, 5-12% FINES, WET, BROWN, DENSE,		GP-GM	FINISH DRILLING AT 1:50
						END BORING @ 29.0 FT			

FORM D 1586 5/78

CH2M HILL

PROJECT NUMBER P15600.A5

SOIL BORING LOG

PROJECT TRI CITY STP LOCATION OREGON CITY, OREGON
DRILLING METHOD ROTARY MUD, FISHTAIL & TRICONE BIT DRILLERS & EQUIPMENT D. KENNER OF OREGON
ELEVATION 40.52 FEET BORE HOLE: B-17
WATER LEVEL NOT MEASURED DATE: START: 5/20/82 FINISH: 5/20/82 INSPECTOR CWH

DEPTH BELOW SURFACE (Ft)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (INCHES)	STANDARD PENETRATION TEST RESULTS BLOWS 6"-6"-6"	BPF "N"	SOIL DESCRIPTION (COLOR, RELATIVE DENSITY OR CONSISTENCY, MOISTURE, GRAIN SHAPE AND TYPE, STRUCTURE, CEMENTATION, ORGANICS, MATERIAL)	GRAPHIC LOG	UNIFIED SOIL CLASSIFICATION SYMBOL	COMMENTS (DRILLING PROGRESS, LOST CIRCULATION, TYPE OF DEPOSIT, PROBLEMS, ETC.)
									START DRILLING AT 8:45
5	5.0 – 6.5	S-1	5	1-2-2	4	SILT, LOW PLASTICITY, ABOUT 5% FINE SAND, BROWN, WET, SOFT TO FIRM.		ML	
10	10.0 – 11.5	S-2	12	1-1-1	2	SANDY SILT, LOW PLASTICITY, 25-30% FINE SAND, BROWN, WET, SOFT.		ML	
	13.0 – 15.0	ST-3	24	---	–	SILT, LOW TO MEDIUM PLASTICITY, 6% FINE SAND, 73% SILT, 21% CLAY, BROWN, SOFT.		ML	
15	15.0 – 16.5	S-4	18	1-1-1	2	SANDY SILT, SIMILAR TO S-2, EXCEPT WITH 20-25% FINE SAND.		ML	
	18.0 – 20.0	ST-5	24	---	–	SANDY SILT, SIMILAR TO S-2, EXCEPT WITH 10-15% FINE SAND.		ML	
20	20.0 – 21.5	S-6	15	1-1-1	2	SANDY SILT, SIMILAR TO S-2, EXCEPT WITH 10-15% FINE SAND		ML	DRILLER NOTES SLIGHTLY FIRMER DRILLING 20-23 FT.
	23.0 – 25.0	ST-7	20	---	–	SANDY SILT, SIMILAR TO S-2, EXCEPT WITH 10-20% FINE SAND		ML	
25	25.0 – 26.5	S-8	18	3-2-2	4	SANDY SILT, SIMILAR TO S-2, EXCEPT WITH 15-20% FINE SAND, AND ORANGE-BROWN MOTTLING IN LOWER 6 INCHES		ML	
30									DRILLER NOTES GRAVEL AT 29 FT.

FORM D 1586 5/78

CH2M HILL

PROJECT NUMBER P15600.A5

SOIL BORING LOG

PROJECT: TRI CITY STP LOCATION: OREGON CITY, OREGON
DRILLING METHOD: ROTARY MUD, DRAG & ROLLER BITS DRILLERS & EQUIPMENT: D. KENNER OF OREGON
ELEVATION: 40.52 FEET BORE HOLE: B-17
WATER LEVEL: NOT MEASURED DATE: START: 5/20/82 FINISH: 5/20/82 INSPECTOR: CLWH

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER	RECOVERY (INCHES)	STANDARD PENETRATION TEST RESULTS BLOWS 6"-6"-6"	BPF "N"	SOIL DESCRIPTION (COLOR, RELATIVE DENSITY OR CONSISTENCY, MOISTURE, GRAIN SHAPE AND TYPE, STRUCTURE, CEMENTATION, ORGANICS, MATERIAL)	GRAPHIC LOG	UNIFIED SOIL CLASSIFICATION SYMBOL	COMMENTS (DRILLING PROGRESS, LOST CIRCULATION, TYPE OF DEPOSIT, PROBLEMS, ETC.)
30	30.3	S-9	3	60/3"	60/3"	SANDY GRAVEL, POORLY GRADED, SUBANGULAR GRAVEL TO AT LEAST 1 1/4 INCH, 12-15% FINE TO COARSE SAND, 5-10% FINES, BROWN AND BLACK, WET, DENSE		GP-GM	SLOW, ROUGH DRILLING TO 46.5 FT.
									DRILLER NOTES SLIGHTLY SOFTER DRILLING AT 35 FT, PROBABLY A SAND LENS, HE THINKS
35	35.0 / 35.5	S-10	5	60/5 1/2"	60/5 1/2"	SANDY GRAVEL, SIMILAR TO S-9 EXCEPT FOR 35-40% FINE TO COARSE SAND.		GP-GM	
									LOSE CIRCULATION AT 38 FT, MIX MUD
40	40.0 / 40.5	S-11	5	56/6"	56/6"	SANDY GRAVEL, SIMILAR TO S-9, EXCEPT FOR 20-25% FINE TO COARSE SAND		GP-GM	LOSE CIRCULATION AT 42 FT, MIX MUD; DRILLER THINKS GROUNDWATER IS DILUTING MUD MIXTURE.
45	45.0 / 45.1	S-12	0	60/1/2"	60/1/2"	NO RECOVERY			DRILLER NOTES BOTTOM OF GRAVEL AT 46.5 FT.
	47.5 / 48.5	S-13	11	29-60/5 1/2"	89/11 1/2"	SILTSTONE, WEATHERED, FRACTURES INTO BLOCKY, ANGULAR PIECES ALMOST 1/4 INCH ON A SIDE, BLUE-GREEN, MOIST.			
50									
	52.5 / 53.5	S-14	11	16-59/6"	75/12"	SILTSTONE, SAME AS S-13 EXCEPT CONTAINS THOROUGHLY WEATHERED PEBBLES (COARSE SAND) WEATHERED TO BLUE GREEN YELLOW AND REDDISH BROWN; SILTSTONE IS BLUE GREEN IN UPPER 4 INCHES, GRAY IN LOWER 7 INCHES			DM-15 IS A 2 INCH OD TUBE; 300 LB DOWN-HOLE HAMMER WAS USED, HAD TO END AFTER 4.5 INCH DRIVE BECAUSE OF CAVING.
	57.5 / 58.0	DM-15	0	32/5"	32/5"	NO RECOVERY			
						END BORING AT 58.0 FT.			

FORM D 1586 5/78

SHEET 1 OF 1

CH2M HILL

PROJECT NUMBER P15600.A5

SOIL BORING LOG

PROJECT TRI CITY STP LOCATION OREGON CITY, OREGON

DRILLING METHOD ROTARY MUD DRILLERS & EQUIPMENT D. KENNER OF OREGON

ELEVATION 44.19 FEET BORE HOLE: B-18

WATER LEVEL NOT MEASURED DATE: START: 5/19/82 FINISH: 5/19/82 INSPECTOR CWH

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (INCHES)	STANDARD PENETRATION TEST RESULTS BLOWS 6"-6"-6"	BPF "N"	SOIL DESCRIPTION (COLOR, RELATIVE DENSITY OR CONSISTENCY, MOISTURE, GRAIN SHAPE AND TYPE, STRUCTURE, CEMENTATION, ORGANICS, MATERIAL)	GRAPHIC LOG	UNIFIED SOIL CLASSIFICATION SYMBOL	COMMENTS (DRILLING PROGRESS, LOST CIRCULATION, TYPE OF DEPOSIT, PROBLEMS, ETC.)
									START DRILLING AT 9:45
	2.5–4.0	S-1	6	2-2-2	4	SILT, LOW PLASTICITY, 5-10% FINE SAND, DARK BROWN, MOIST, FIRM.		ML	
5	5.0–6.5	S-2	5	1-1-1	2	SANDY SILT, LOW PLASTICITY, 10-15% FINE SAND, BROWN, MOIST, SOFT,		ML	
	7.5–9.0	S-3	5	1-2-2	4	SILT, LOW PLASTICITY, ABOUT 5% FINE SAND, DARK BROWN, MOIST, FIRM.		ML	
10	10.0–12.0	ST-4	14	---	—	SILTY SAND, 53% FINE TO MEDIUM SAND MOSTLY FINE, 35% SILT, 12% CLAY, BROWN, MOIST, LOOSE		SM	
	12.0–13.5	S-5	2	3-2-2	4	SILT, SAME AS S-3		ML	
15	15.0–16.5	S-6	8	2-2-3	5	SILT, SIMILAR TO S-3, EXCEPT NO FINE SAND.		ML	
20	20.0–21.5	S-7	7	3-5-3	8	SILT, LOW PLASTICITY, ABOUT 5% FINE SAND, BROWN, MOIST, FIRM,		ML	DRILLER NOTES FIRMER DRILLING 20-25 FT.
25	25.0–26.5	S-8	6	3-3-5	8	UPPER 3 INCHES; SILT, SAME AS S-3 LOWER 3 INCHES; SILTY SAND, FINE SAND, 5-12% FINES, DARK BROWN, MOIST, LOOSE,		ML SP-SM	DRILLER NOTES GRAVEL AT 27.5 FT
	27.5–28.0	S-9	5	60/4.5"	60/4.5"	SILTY GRAVEL, POORLY GRADED GRAVEL TO AT LEAST 1 1/4 INCH, 10-15% SAND, 20-25% FINES WITH LOW PLASTICITY COMPACT		GM	FINISH DRILLING AT 10:45
						END [illegible]NG AT 29.0 FT			

FORM D 1586 5/78

CH2M HILL

SHEET 1 OF 2

PROJECT NUMBER P15600.A5

SOIL BORING LOG

PROJECT: TRI CITY STP LOCATION: OREGON CITY, OREGON

DRILLING METHOD: ROTARY; WATER DRILLERS & EQUIPMENT: D. KENNER OF OREGON - CME-75

ELEVATION: 41.58 FEET BORE HOLE: B-21

WATER LEVEL: SEE TEXT DATE: START: 5/24/82 FINISH: 5/24/82 INSPECTOR: CWH

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (INCHES)	STANDARD PENETRATION TEST RESULTS BLOWS 6"-6"-6"	BPF "N"	SOIL DESCRIPTION (COLOR, RELATIVE DENSITY OR CONSISTENCY, MOISTURE, GRAIN SHAPE AND TYPE, STRUCTURE, CEMENTATION, ORGANICS, MATERIAL)	GRAPHIC LOG	UNIFIED SOIL CLASSIFICATION SYMBOL	COMMENTS (DRILLING PROGRESS, LOST CIRCULATION, TYPE OF DEPOSIT, PROBLEMS, ETC.)
									START DRILLING AT 9:00 DRILL TO 8 FT WITH WATER, CIRCULATED CUTTING OUT; LOSING SOME WATER INTO HOLE
5									SET 8 IN I.D. CASING TO 8 FT, THEN DRILLED TO 10 FT. FALLING HEAD PERMEABILITY TEST #1 PERFORMED WITH 8 TO 10 FT AS TEST INTERVAL
10	10.0–12.0	ST-1	24	---	—	SANDY SILT, SAME AS S-2 (SEE BELOW)		ML	
	12.0–13.5	S-2	15	1-1-1	2	SANDY SILT, LOW TO MEDIUM PLASTICITY, 20-25% FINE SAND, DARK BROWN, WET, SOFT.		ML	
15									DRILLED TO 18 FEET WITH WATER, SET CASING AT 18 FEET, THEN DRILLED TO 20 FT. FALLING HEAD PERMEABILITY TEST #2 PERFORMED WITH 18 TO 20 FT AS TEST INTERVAL
20	20.6–22.0	ST-3	24	---	—	UPPER PART: SAME AS S-2 LOWER PART: SAME AS S-4		ML / SM	DRILLER NOTES ABOUT 3 INCHES OF SLOUGH SETTLED ON BOTTOM OF HOLE DURING TEST NO 2
	22.0–23.5	S-4	12	5-7-7	14	SILTY SAND, FINE SAND, 15-20% FINES WITH LOW PLASTICITY, MORE FINES TOWARD TOP OF SAMPLE, DARK BROWN, WET, COMPACT.		SM	DRILLED TO 28 FT WITH WATER, NO LOST CIRCULATION AT 28 FT WHEN BIT ENCOUNTERED GRAVEL.
25									DRILLER NOTES VERY SOFT MATL 26.5 TO 28 FT.
30								GP	DRILLER NOTES GRAVEL AT 28 FT, SET CASING TO 28 FT, PERMEABILITY TEST #4 FROM 28 to 30 FT.

FORM D 1586 5/78

CH2M HILL

PROJECT NUMBER P15600.A5

SOIL BORING LOG

PROJECT TRI CITY STP LOCATION OREGON CITY, OREGON

DRILLING METHOD ROTARY, WATER DRAG BIT DRILLERS & EQUIPMENT D. KENNER OF OREGON CME-75

ELEVATION 41.58 FEET BORE HOLE: B-21

WATER LEVEL SEE TEXT DATE: START: 5/24/82 FINISH: 5/24/82 INSPECTOR CWH.

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (INCHES)	STANDARD PENETRATION TEST RESULTS BLOWS 6"-6"-6"	BPF "N"	SOIL DESCRIPTION (COLOR, RELATIVE DENSITY OR CONSISTENCY, MOISTURE, GRAIN SHAPE AND TYPE, STRUCTURE, CEMENTATION, ORGANICS, MATERIAL)	GRAPHIC LOG	UNIFIED SOIL CLASSIFICATION SYMBOL	COMMENTS (DRILLING PROGRESS, LOST CIRCULATION, TYPE OF DEPOSIT, PROBLEMS, ETC.)
30	30.0 / 30.2	S5	0	60/3"	60/3"	NO RECOVERY		GP	
						END BORING 30.5 FT			FINISH DRILLING AT 1:20
35									

PIEZOMETER INSTALLATION:

PLACEMENT OF PERVIOUS TIP: TOP AT 28.5 FT, BOTTOM AT 30.FT

GRAVEL PACK: FROM 31.5 FT TO GROUND SURFACE

BENTONITE SEAL: FROM 24.7 TO 26.7 FT

RISER PIPE LENGTH: 30 FT

FORM D 1586 5/78

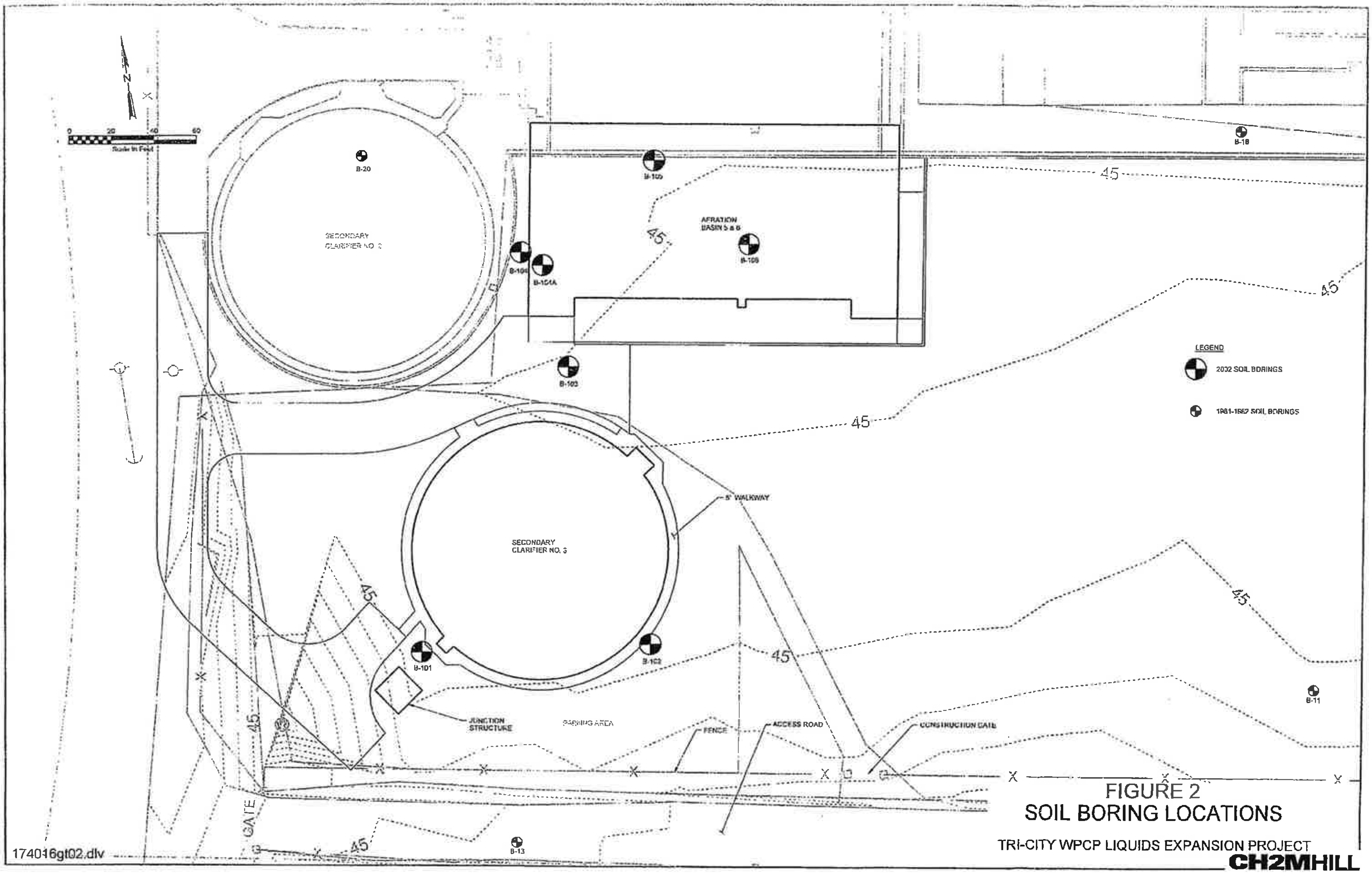


FIGURE 2
SOIL BORING LOCATIONS

TRI-CITY WPCP LIQUIDS EXPANSION PROJECT

CH2MHILL

CH2MHILL

PROJECT NUMBER: 174016 **BORING NUMBER:** B-101
Sheet: 1 of 2

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** SW of clarifier no. 3
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: N/A **START:** 8/5/02 **FINISH:** 8/5/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	TYPE AND NUMBER	RECOVERY (IN)	6"-6"-6"	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	140-pound safety hammer, rope and cathead with 1½ wraps around cathead
	2.5 4.0	SS-1	9	6-11-12 (23)	**SILT (ML)** dark brown and gray-brown, moist, very stiff, medium plasticity, one piece of 1" subangular gravel in shoe (FILL)	w = 30%
5	5.0 6.5	SS-2	2	17-18-32 (50)	Poor Recovery **POORLY GRADED GRAVEL (GP)** black, wet, very dense, fine to coarse angular and subangular gravel up to 1½" (FILL)	Native material at 8 ft
10	10.0 11.5	SS-3	3	6-5-6 (11)	**SILT (ML)** gray, wet, stiff, low to medium plasticity,one piece of 1" black gravel in shoe	Stiffer silt at 12 ft
15	15.0 16.5	SS-4	12	6-7-10 (17)	**SANDY SILT (ML)** mottled gray and red, moist, very stiff, low to medium plasticity, 15% very fine sand at top of sample grading to 40% at bottom of sample	Scattered gravel from 16.5-17.5 ft, then back into silt
20	20.0 21.5	SS-5	15	5-5-6 (11)	**SILT (ML)** reddish brown, moist, stiff, nonplastic to low plasticity, trace of very fine sand	
	23.0 25.0	SH-6	NR	PUSH	**No Recovery**	
25	25.0 26.5	SS-7	15	2-2-4 (6)	**SILT (ML)** reddish brown, moist, firm, nonplastic to low plasticity, 5-10% very fine sand	PP = 1.5, 2.0, 2.5 tsf
	27.5 29.0	SS-8	18	3-3-4 (7)	**SILT (ML)** Same as SS-7	LL, PL, PI = 42, 31, 11; w = 45%
30						

CH2MHILL

PROJECT NUMBER: 174016 **BORING NUMBER:** B-101

Sheet: 2 of 2

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** SW of clarifier no. 3
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: N/A **START:** 8/5/02 **FINISH:** 8/5/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	TYPE AND NUMBER	RECOVERY (IN)	6"-6"-6"	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	30.0 31.5	SS-9	6	2-4-14 (18)	<u>SILT (ML)</u> reddish brown, wet, very stiff, 1 piece of black 1½" gravel in shoe	
						Dense gravel at 32.8 ft Driller indicates cemented gravel (Troutdale formation?)
35	35.0 35.5	SS-10	3	100/6"	<u>POORLY GRADED GRAVEL WITH SAND (GP)</u> black and red gravel, red sand, wet, very dense, fine gravel with one piece 1½" gravel, subangular and fractured, one piece of fine angular quartzite gravel	
	38.0 38.3	SS-11	NR	50/3"	<u>No Recovery</u>	End Boring at 38.3 ft Boring backfilled in accordance with OAR 690-240
40					BOTTOM OF BORING	
45						
50						
55						
60						

CH2MHILL

PROJECT NUMBER: 174016 **BORING NUMBER:** B-102
Sheet: 1 of 3

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** SE of clarifier no. 3
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: 22.95' **START:** 8/6/02 **FINISH:** 8/7/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	TYPE AND NUMBER	RECOVERY (IN)	6"-6"-6"	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	140-pound safety hammer, rope and cathead with 1½ wraps around cathead
	2.5 4.0	SS-1	11	15-15-15 (30)	**SILTY GRAVEL (GM)** black gravel, brown silt, moist, medium dense, gravel up to 1", low to medium plasticity silt (FILL)	
5	5.0 6.5	SS-2	14	18-15-23 (38)	**GRAVELLY SILT (ML)** brown with black gravel, moist, hard, low plasticity silt, angular gravel up to 1", trace organics (FILL)	
						Native material at 8.5 ft
10	10.0 11.5	SS-3	12	7-5-6 (11)	**SILT (ML)** brown with gray and rust mottling, moist, stiff, low plasticity, trace very fine sand	PP = 2.0 tsf w = 42%
15	15.0 16.5	SS-4	15	3-7-5 (12)	**SANDY SILT (ML)** brown with gray mottling, moist, stiff, nonplastic, 15% very fine sand	
20	20.0 21.5	SS-5	18	2-3-6 (9)	**SILT (ML)** mottled brown and gray, moist, stiff, low plasticity, 5% very fine sand at top of sample grading to 10% at bottom of sample	
	22.5 24.5	SO-6	24	PUSH	**SILT (ML)**	Osterberg piston sampler TV = 0.35 tsf; PP = 2.0, 2.0, 1.5 tsf LL, PL, PI = 48, 32, 16; w = 43% Consolidation test
25						

CH2MHILL

PROJECT NUMBER: 174016 **BORING NUMBER:** B-102

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** SE of clarifier no. 3
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: 22.95' **START:** 8/6/02 **FINISH:** 8/7/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE INTERVAL	SAMPLE TYPE AND NUMBER	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6"	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	24.5 26.0	SS-7	18	4-4-5 (9)	<u>SILT (ML)</u> brown, moist, stiff, low plasticity	PP = 1.25, 1.25, tsf (SS-7) w = 45%
	27.5 29.0	SS-8	18	3-4-7 (11)	<u>SILT TO SANDY SILT (ML)</u> Upper 12": same as above; Lower 6": brown, wet, stiff, nonplastic to low plasticity, 15% very fine sand	Bagged upper 12" as sample SS-8A, lower as SS-8B
30	29.5 30.4	SO-9	12	PUSH	<u>SILTY SAND (SM)</u>	Push bottomed out at 30.4 ft Hit dense gravel at 30.4 ft; silty sand at bottom of SO-9
	30.5 32.0	SS-10	16	22-16-11 (27)	<u>SILTY SAND (SM)</u> black with some white and red grains, moist, medium dense, fine grained sand, 1" zone of cemented sand at top of sample, 15% silt, 2" sandy silt layer near bottom of sample	P200 = 19% Driller indicates silt and sand seams to 34 ft
35	35.0 35.8	SS-11	NR	42-50/4"	<u>POOR RECOVERY</u> one piece of 1½" black gravel wedged in shoe	
						Drilling rate increased from 39-40 ft; lost 10-15 gallons of mud
40	40.0 41.5	SS-12	5	23-20-20 (40)	<u>POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)</u> black gravel and sand, brown silt, wet, dense, fractured and angular gravel ¾" up to 1½", 10% sand, 10% silt	Reamed out hole and continued with 6" tri-cone bit
45	45.0 45.2	SS-13	NR	50/2"	<u>POOR RECOVERY</u> one piece of black 1½" angular gravel in shoe, black, wet, very dense	Slow drilling, approx. 20 min/ft
50						

CH2MHILL

PROJECT NUMBER: 174016 **BORING NUMBER:** B-102
Sheet: 3 of 3

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** SE of clarifier no. 3
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: 22.95' **START:** 8/6/02 **FINISH:** 8/7/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	TYPE AND NUMBER	RECOVERY (IN)	6"-6"-6"	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	50.0 50.3	SS-14	NR	50/3"	<u>POOR RECOVERY</u> 1" slough in sampler	Bagged up slough to show gravel type; mostly black with 2-3 pieces of quartzite
						Hit siltstone at 53.5 ft Shut down at 4:30, start drilling on 8/7/02 at 6:00
55	54.5 55.9	SS-15	17	28-32-50/5"	<u>SILTSTONE</u> brown with 1" blue-green seam and blue and rust mottling, moist, hard	PP = no penetration at 4.5 tsf End Boring at 55.9 ft
					BOTTOM OF BORING	Installed Piezometer in accordance with OAR 690-240 Finished piezo install at 7:00 moved to B-103 Took reading in piezo on 8/9/02 groundwater at 22.95 ft
60					<u>Piezometer Materials:</u> 2" OD schedule 40 PVC pipe 5' 20-slot machine-slotted screen with end cap 3/4 bentonite chips 8/12 Colorado silica sand Grout mix: 30 gal. water 70 lbs. portland cement 20 lbs. bentonite powder	
65					<u>Piezometer Configuration:</u> 54.5-53.5 bentonite chips 53.5-45.2 sand 52.5-47.5 screen 45.2-42.2 chips 42.2-1.5 grout (50-55 gallons used) 1.5-0 flush-mount monument set in concrete	
70						
75						

CH2MHILL

PROJECT NUMBER: 174016 BORING NUMBER: B-103

Sheet: 1 of 2

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** N of clarifier no. 3
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: N/A **START:** 8/7/02 **FINISH:** 8/7/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE INTERVAL	SAMPLE TYPE AND NUMBER	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6"	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	140-pound safety hammer, rope and cathead with 1½ wraps around cathead
	2.5 3.1	SS-1	4	29-12/1"	SILTY GRAVEL (GM) black gravel, brown silt, moist, very dense, fine angular gravel, 25-35% silt, 5-10% sand (FILL)	Big cobble pushing sampler to side, stopped SPT after 7"
5	5.0 6.5	SS-2	NR	17-18-19 (37)	No Recovery	Gravel fill Into native material at 7 ft
10	10.0 11.5	SS-3	13	2-2-1 (3)	SILT (ML) brown, moist, very soft, low plasticity	
15	15.0 16.5	SS-4	15	1-1-1 (2)	SILT (ML) Same as SS-3	LL, PL, PI = 44, 31, 14; w = 50%
20	20.0 21.5	SS-5	14	2-1-3 (4)	SILT (ML) same as SS-3	PP = 1.5, 1.25, 1.25 tsf
	22.5 24.0	SS-6	17	3-2-2 (4)	SILT (ML) same as SS-3	PP = 1.0, 1.75, 1.75 tsf w = 46%
25	25.0 27.0	SO-7	24	PUSH	SILT (ML) (top) SILTY SAND (SM) (bottom)	
	27.0 28.5	SS-8	14	3-5-10 (15)	SILTY SAND (SM) brown, moist, medium dense, fine sand, 45% silt at top of sample grading to 25% in shoe	P200 = 29%
30						Hit gravel at 30 ft

CH2MHILL

PROJECT NUMBER: 174016 **BORING NUMBER:** B-103
Sheet: 2 of 2

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** N of clarifier no. 3
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: N/A **START:** 8/7/02 **FINISH:** 8/7/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	TYPE AND NUMBER	RECOVERY (IN)	6"-6"-6"	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	30.0 31.0	SS-9	3	34-50/6"	<u>POORLY GRADED GRAVEL WITH SILT (GP-GM)</u> black and red, wet, very dense, subrounded to subangular gravel, 10% silt, 5-10% sand	Smoother, faster drilling (5 ft/20 min) in gravel than in B-101 and 102; driller indicates smaller gravel size (<2")
35	35.0 35.4	SS-10	2	100/5"	<u>POORLY GRADED GRAVEL (GP)</u> black and red, wet, very dense, rounded to angular gravel up to 2"	Poor recovery in SS-10, so drilled out and went right back down with 3" splitspoon and 300-pound hammer to get SS-11
	36.0 37.5	SS-11	6	16-16-19 (35)	<u>SILTY GRAVEL WITH SAND (GM)</u> black and red, wet, dense, gravel up to 2½", 15% sand, 15% silt	P200 = 6% End Boring at 37.5 ft
40					BOTTOM OF BORING	Boring backfilled in accordance with OAR 690-240
45						
50						
55						
60						

CH2MHILL

PROJECT NUMBER: 174016 **BORING NUMBER:** B-104

Sheet: 1 of 1

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** SW corner of aeration basins 5 and 6
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: **START:** 8/7/02 **FINISH:** 8/7/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE INTERVAL	SAMPLE TYPE AND NUMBER	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6"	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	140-pound safety hammer, rope and cathead with 1½ wraps around cathead
	2.5 4.0	SS-1	14	10-8-7 (15)	<u>SILT (ML)</u> gray with brown mottling, moist, stiff, low to medium plasticity (FILL)	
5	5.0 6.5	SS-2	15	7-16-43 (59)	<u>SILT (ML)</u> brown with black mottling, low plasticity, black fractured gravel in shoe (FILL)	Very slow drilling in fill; drilling through backfill material at existing clarifier
10	10.0 10.8	SS-3	4	20-50/3"	<u>GRAVELLY SILT (ML)</u> brown with black gravel, moist, hard, gravel up to 1" BOTTOM OF BORING	End Boring at 10.8 ft Boring backfilled in accordance with OAR 690-240 Moved 8' to the east and 6' to the south to get out of clarifier backfill zone (See boring 104A)
15						
20						
25						
30						

CH2MHILL

PROJECT NUMBER: 174016 **BORING NUMBER:** B-104A
Sheet: 1 of 2

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** SW corner of aeration basins 5 and 6
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: N/A **START:** 8/7/02 **FINISH:** 8/7/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	TYPE AND NUMBER	RECOVERY (IN)	6"-6"-6"	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	140-pound safety hammer, rope and cathead with 2 wraps around cathead
5	5.0 5.9	SS-1	5	4-50/5"	SILT (ML) brown, moist, hard, one piece 1" angular gravel in shoe (FILL)	w = 34%
						Into native material at 9 ft
10	10.0 11.5	SS-2	10	2-3-3 (6)	SILT (ML) brown with gray and red mottling, moist, firm, low plasticity	Quick, easy drilling
15	15.0 16.5	SS-3	15	2-2-2 (4)	SILT (ML) brown , moist, soft, low plasticity, 5% very fine sand	
20	20.0 21.5	SS-4	13	2-3-4 (7)	SILT (ML) Same as SS-3	
	22.5 24.0	SS-5	14	3-3-3 (6)	SILT (ML) Same as SS-3	
25	24.0 26.0	SO-6	24	PUSH	SANDY SILT (ML)	Osterberg sampler TV = 0.15 tsf
	26.0 27.5	SS-7	16	3-4-5 (9)	SANDY SILT (ML) at top of sample grading to SILTY SAND (SM) at bottom of sample brown, wet, firm/loose, fine sand, low plasticity silt, 30% sand at top, 30-40% silt at bottom	P200 = 47%
30						Gravel at 29.9 ft

CH2MHILL

PROJECT NUMBER: 174016 **BORING NUMBER:** B-104A
Sheet: 2 of 2

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** SW corner of aeration basins 5 and 6
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: N/A **START:** 8/7/02 **FINISH:** 8/7/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	TYPE AND NUMBER	RECOVERY (IN)	6"-6"-6"	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	30.0 31.0	SS-8	6	34-50/6"	<u>SILTY GRAVEL (GM)</u> black gravel, red silt, wet, very dense, angular gravel, 15% silt, 5-10% medium sand	
35	35.0 35.9	SS-9	8	46-50/5"	<u>SILTY GRAVEL (GM)</u> black and red gravel, reddish brown silt, wet, very dense, 15-20% silt, 10% sand BOTTOM OF BORING	End Boring at 35.9 ft Boring backfilled in accordance with OAR 690-240
40						
45						
50						
55						
60						

CH2MHILL

PROJECT NUMBER: 174016 **BORING NUMBER:** B-105

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** N edge of aeration basins 5 and 6
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: N/A **START:** 8/8/02 **FINISH:** 8/8/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	TYPE AND NUMBER	RECOVERY (IN)	6"-6"-6"	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	140-pound safety hammer, rope and cathead with 1½ wraps around cathead
5	5.0 6.5	SS-1	15	10-9-10 (19)	**SILT (ML)** brown, moist, very stiff, medium plasticity, trace very fine sand, one piece of 1" gravel at top of sample (FILL)	w = 32%
	7.5 9.0	SS-2	15	9-14-15 (29)	**GRAVELLY SILT (ML)** brown and black, moist, very stiff, medium plasticity, 30% black fractured gravel up to 1" (FILL)	Large cobble at 9.5 ft
10	10.0 11.5	SS-3	14	11-17-25 (42)	**GRAVELLY SILT (ML)** brown with black gravel, moist, hard, 30% rounded and angular gravel up to 1", 10% fine to coarse sand (FILL)	Hit rubble or boulder at 12.2 ft Into native material at 12.5 ft
15	15.0 16.5	SS-4	NR	3-3-3 (6)	**NO RECOVERY** went back down with 3" splitspoon sampler and recovered gravelly silt (ML), brown, moist, firm, low plasticity 15% black angular gravel up to 2-1/2"	Driller indicates no recovery because sampler was pushing a piece of coarse gravel; went right back down hole with 3" splitspoon sampler and recovered 8" on 1.5 ft push from 15-16.5 ft; w = 35%
20	20.0 21.5	SS-5	8	4-4-5 (9)	**SILT (ML)** brown, moist, stiff, low plasticity, trace very fine sand	
	23.0 25.0	SO-6	22	PUSH	**SANDY SILT (ML)**	TV = 0.15 tsf
25	25.0 26.5	SS-7	18	2-3-3 (6)	**SILT (ML)** brown, moist, firm, low plasticity	LL, PL, PI = 42, 36, 6; w = 47%
	27.5 28.0	SS-8	18	21-11-9 (20)	**SILTY SAND (SM)** brown silt, black, red and white sand grains, moist, medium stiff, fine sand, 25-30% silt	4" gravel seam at 27.5 ft
30						

CH2MHILL

PROJECT NUMBER: 174016 **BORING NUMBER:** B-105
Sheet: 2 of 2

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** N edge of aeration basins 5 and 6
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: N/A **START:** 8/8/02 **FINISH:** 8/8/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	TYPE AND NUMBER	RECOVERY (IN)	6"-6"-6"	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	30.0 31.3	SS-9	12	8-45-50/3"	<u>SILTY SAND (SM)</u> same as above except some rust staining and ¾" rounded gravel in shoe	Gravel at 30.5 ft Slow, difficult drilling
35	35.0 36.5	SS-10	NR	21-15-7 (22)	<u>POOR RECOVERY</u> one piece of 1½" black angular gravel in shoe	Lost circulation, lost 30 gal. mud, faster drilling, driller indicates looser gravel from 35-38 ft Back into very dense gravel at 38 ft
40	40.0 40.5	SS-11	3	50/6"	<u>POORLY GRADED GRAVEL (GP)</u> black and red, wet, very dense, angular to rounded gravel up to 1½" BOTTOM OF BORING	End Boring at 40.5 ft Boring backfilled in accordance with OAR 690-240
45						
50						
55						
60						

CH2MHILL

PROJECT NUMBER: 174016 **BORING NUMBER:** B-106
Sheet: 1 of 2

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** near center of aeration basins 5 and 6
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: N/A **START:** 8/8/02 **FINISH:** 8/8/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE INTERVAL	SAMPLE TYPE AND NUMBER	SAMPLE RECOVERY (IN)	STANDARD PENETRATION TEST RESULTS 6"-6"-6"	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Ground Surface	140-pound safety hammer, rope and cathead with 1½ wraps around cathead
5	5.0 6.5	SS-1	10	9-7-6 (13)	**SILT (ML)** gray with red staining, moist, stiff, medium plasticity (FILL), material in tip is low plasticity, brown native silt	Last 2" of SS-1 is native silt Scattered gravel at top of sample
	7.5 9.0	SS-2	10	2-4-6 (10)	**SILT (ML)** brown, moist, stiff, low plasticity, one piece of 1" black angular gravel	
10	10.0 11.5	SS-3	NR	2-2-2 (4)	**NO RECOVERY** some silt stuck to sample catcher	Driller indicates samples lost at SS-3 and SS-4 probably due to scattered coarse gravel in silt; sampler is probably pushing a piece of gravel
15	15.0 16.5	SS-4	NR	2-2-2 (4)	**NO RECOVERY** some silt stuck to sample catcher	
20	20.0 21.5	SS-5	15	2-3-3 (6)	**SILT TO SANDY SILT (ML)** brown, moist, firm, nonplastic, 10-20% very fine sand	
	23.0 25.0	SO-6	24	PUSH	**SILT (ML)** at top and bottom of shelby tube	Osterberg sampler TV = 0.2 tsf LL, PL, PI = 47, 38, 9; w = 47% Consolidation test
25	25.0 26.5	SS-7	18	1-2-2 (4)	**SILT (ML)** brown, moist, soft, low plasticity, trace very fine sand	
	27.5 29.0	SS-8	13	9-6-6 (12)	**SILTY SAND (SM)** red, black, brown, moist, medium dense, 25% nonplastic to low plasticity silt	Driller indicates sand at 27.5 ft P200 = 35%
30						

CH2MHILL

PROJECT NUMBER: 174016 **BORING NUMBER:** B-106
Sheet: 2 of 2

SOIL BORING LOG

PROJECT: Tri-City WPCP Liquids Expansion **LOCATION:** near center of aeration basins 5 and 6
ELEVATION: 45' **DRILLING CONTRACTOR:** Geo-Tech Explorations, Tualatin, Oregon
DRILLING METHOD AND EQUIPMENT: Mobile B-59 rubber-tire drill rig, mud rotary, 4-7/8" tri-cone bit
WATER LEVELS: N/A **START:** 8/8/02 **FINISH:** 8/8/02 **LOGGER:** R. Wilcock

DEPTH BELOW GROUND SURFACE	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	TYPE AND NUMBER	RECOVERY (IN)	6"-6"-6"	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	30.0 31.5	SS-9	9	20-20-41 (61)	<u>SILTY SAND (SM)</u> black and red sand, brown silt, wet, very dense, 15% silt, 2" silt lens near top of sample, bottom 2" of sample is gravel	Gravel at 31.4 ft 30 gal. mud loss at 32 ft; lost circulation at 32.5 ft; added bentonite to thicken mud Slow, difficult drilling from 30-35 ft
35	35.0 35.3	SS-10	NR	50/4"	<u>POOR RECOVERY</u> fractured black gravel in shoe	End Boring at 35.3 ft Boring backfilled in accordance with OAR 690-240
					BOTTOM OF BORING	
40						
45						
50						
55						
60						

APPENDIX E
IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL REPORT

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Attachment to and part of Tri-City WPCP Draft
Geotechnical Design Report

Date: September, 2008
To: MWH Global
Americas, Inc.

Important Information About Your Geotechnical/Environmental Report

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors, which were considered in the development of the report, have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

ALASKA
CALIFORNIA
COLORADO
FLORIDA
MISSOURI
OREGON
WASHINGTON
WISCONSIN

October 26, 2016

Steve Hyland, PE
MWH Global, Inc.
806 SW Broadway, Suite 200
Portland, Oregon 97205

**RE: GROUNDWATER MONITORING PROGRAM REPORT
TRI-CITY WATER RESOURCE RECOVERY FACILITY
SOLIDS HANDLING IMPROVEMENT PROJECT
CLACKAMAS COUNTY, OREGON**

Dear Mr. Hyland:

This letter presents our field explorations, laboratory test results, and groundwater level monitoring data for the Solids Handling Improvement Project at the Tri-City Water Resource Recovery Facility (WRRF) in Clackamas County, Oregon. The project location is shown on the Vicinity Map, Figure 1. Clackamas County Water Environment Services (WES) is planning the improvements to the Tri-City WRRF with their engineering consultant, MWH Global, Inc. (MWH). As a subconsultant to MWH, Shannon & Wilson, Inc., is providing geotechnical services to support the project under Master Consulting Services Subcontract, No. MSA-S&WINC-05202011. We performed our services in accordance with Task Order T10508587-104357-OM, dated January 20, 2016. Our current scope of services, called Phase 700.2, Groundwater Monitoring Program, focused on establishing a groundwater monitoring program and included:

- Drilling two 70-foot deep borings in the vicinity of the proposed solids handling facility;
- Installing 2-inch diameter wells in the boreholes;
- Developing the wells and installing automated dataloggers in them to monitor the groundwater level through October 2016;
- Performing laboratory testing of select samples from the borings; and
- Preparing this report.

FIELD EXPLORATIONS

The field exploration program included two geotechnical borings, designated SH-1 and SH-2. The borings were drilled to depths of 70 feet below the existing ground surface, in the vicinity of the proposed solids handling facility. Locations of the borings were measured in the field relative to existing site features, and their approximate locations are shown on the Site and Exploration Plan, Figure 2. Drilling was accomplished on January 27 and 28, 2016, using a track-mounted Boart Longyear Mini-Sonic drill rig provided and operated by Cascade Drilling, LP, of Clackamas, Oregon. Shannon & Wilson geology staff were on site during drilling to locate the borings, log the materials encountered, and collect samples. Observation wells were installed to depths of 50 feet below the ground surface in each boring, to allow ongoing collections of groundwater level measurements. On January 29, 2016, a Shannon & Wilson engineering geologist developed the wells and installed fully encapsulated dataloggers that were programmed to record groundwater level measurements at one hour intervals. Details of the field exploration program, including techniques used to advance and sample the borings, as well as logs and photographs of the materials encountered, are presented in Appendix A, Field Explorations. Groundwater level data recorded in the observation wells are presented in Figure 3, Groundwater Level Data.

LABORATORY TESTING

The 4-inch diameter sonic core samples obtained during our field explorations were boxed and transported to the lower level of the Tri-City WRRF Screenings Building for further evaluation and long-term storage. During a site visit to review and photograph the sonic core, we selected representative samples for a suite of laboratory tests. The testing program included particle-size analyses and unconfined compressive strength tests. Particle-size analyses were performed by Shannon & Wilson. Unconfined compressive strength testing was performed by FEI Testing and Inspection, Inc. (FEI) of Corvallis, Oregon. All test procedures were performed in accordance with applicable ASTM International (ASTM) standards. Results of the laboratory tests and brief descriptions of the test procedures are presented in Appendix B, Laboratory Test Results.

SUBSURFACE UNITS AND GROUNDWATER

Subsurface Units

We grouped the materials encountered in the geotechnical borings into five geotechnical units. Generalized descriptions of the units are as follows:

- **Fill:** Soft to medium stiff Lean Clay (CL) and Silt (ML) with varying amounts of sand; trace roots and organics; few pockets of Silty Sand (SM); includes pavement sections.

- **Fine-Grained Alluvium:** Soft to medium stiff Silt with Sand to Sandy Silt (ML); stratified with few interbeds of Silty Sand (SM); micaceous.
- **Sand Alluvium:** Loose Silty Sand (SM); micaceous.
- **Gravel Alluvium:** Medium dense to very dense Silty Gravel with Sand and Cobbles (GM) to Poorly Graded Gravel with Silt and Sand, with Cobbles (GP-GM); Well-Graded Gravel with Sand, with Cobbles; trace 12-inch-thick layers of Lean Clay (CL); trace layers of mostly cobbles.
- **Sandy River Mudstone:** Stiff to hard Lean Clay (CL), Elastic Silt (MH), and Fat Clay (CH) with varying amounts of sand; lesser amounts of Clayey Sand (SC); contains zones with relict vesicular basalt texture; contains trace strong to very strong (R4-R5) basaltic and granitic cobbles and boulders.

These geotechnical units were grouped based on their engineering properties, geologic origins, and their distribution in the subsurface as encountered in the borings. Contacts between the units may be more gradational than shown on the boring logs in Appendix A, and may vary significantly between the borings.

Groundwater

Observation wells were installed in borings SH-1 and SH-2 to allow ongoing groundwater level measurements. Shannon & Wilson staff developed the wells to improve communication with the aquifer and then installed automated dataloggers, set to record groundwater levels at one hour intervals. Data collected from January 29, 2016 to October 13, 2016, are presented in Figure 3, Groundwater Level Data.

Based on the materials we encountered in the borings and the apparent correlation between recorded groundwater levels and nearby river gauge data, we infer that the groundwater table throughout the site is hydraulically connected to the Clackamas River. Groundwater levels should be expected to vary with changes in precipitation as well as river levels. Shallower zones of perched water may be present within the Fine-Grained Alluvium. Groundwater highs typically occur from late winter to spring, and groundwater lows typically occur in the early to mid-fall season, before the onset of significant rainfall.

LIMITATIONS

This report provides a compilation of field exploration, laboratory data, and preliminary groundwater level data, for use by MWH in the Tri-City WRRF Solids Handling Improvement Project. Interpretations contained in this report are based on site conditions as interpreted from the explorations. We have assumed that the explorations are representative of the subsurface conditions at the site of the proposed improvements and that subsurface conditions everywhere are not significantly different from those disclosed by the explorations.

This report was prepared for the exclusive use of MWH and their design team. It should be made available to prospective contractors for data information only. This report is not a warranty of subsurface conditions, such as those interpreted from the exploration logs, including interpretations of subsurface conditions in this report. We make no warranty, either express or implied.

If, during final design and construction, subsurface conditions different from those encountered in the field explorations are observed or appear to be present, we should be advised at once so that we can review these conditions and reconsider our interpretations where necessary. If there is substantial lapse of time between the submission of this report and completion of the final design and the start of work at the site, or if conditions have changed because of natural or manmade forces, we recommend that this report be reviewed with respect to the time lapse or changed conditions. If we are not consulted after factors that were considered in the development of the report change, we cannot accept responsibility for problems that may occur.

Unanticipated soil conditions are commonly encountered and cannot fully be determined by merely taking soil samples from borings. Such unexpected conditions frequently require that additional expenditures be made to attain properly constructed projects. Therefore, some contingency fund is recommended to accommodate the potential for extra costs.

The scope of our geotechnical services did not include any environmental assessment or evaluation regarding the presence or absence of hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below the site, or for evaluation of disposal of contaminated soils or groundwater, should any be encountered, except as noted in this report.

Shannon & Wilson, Inc., has prepared a document, "Important Information About Your Geotechnical/Environmental Report," to assist you and others in understanding the use and limitations of our report. This document is included in Appendix C.

Sincerely,

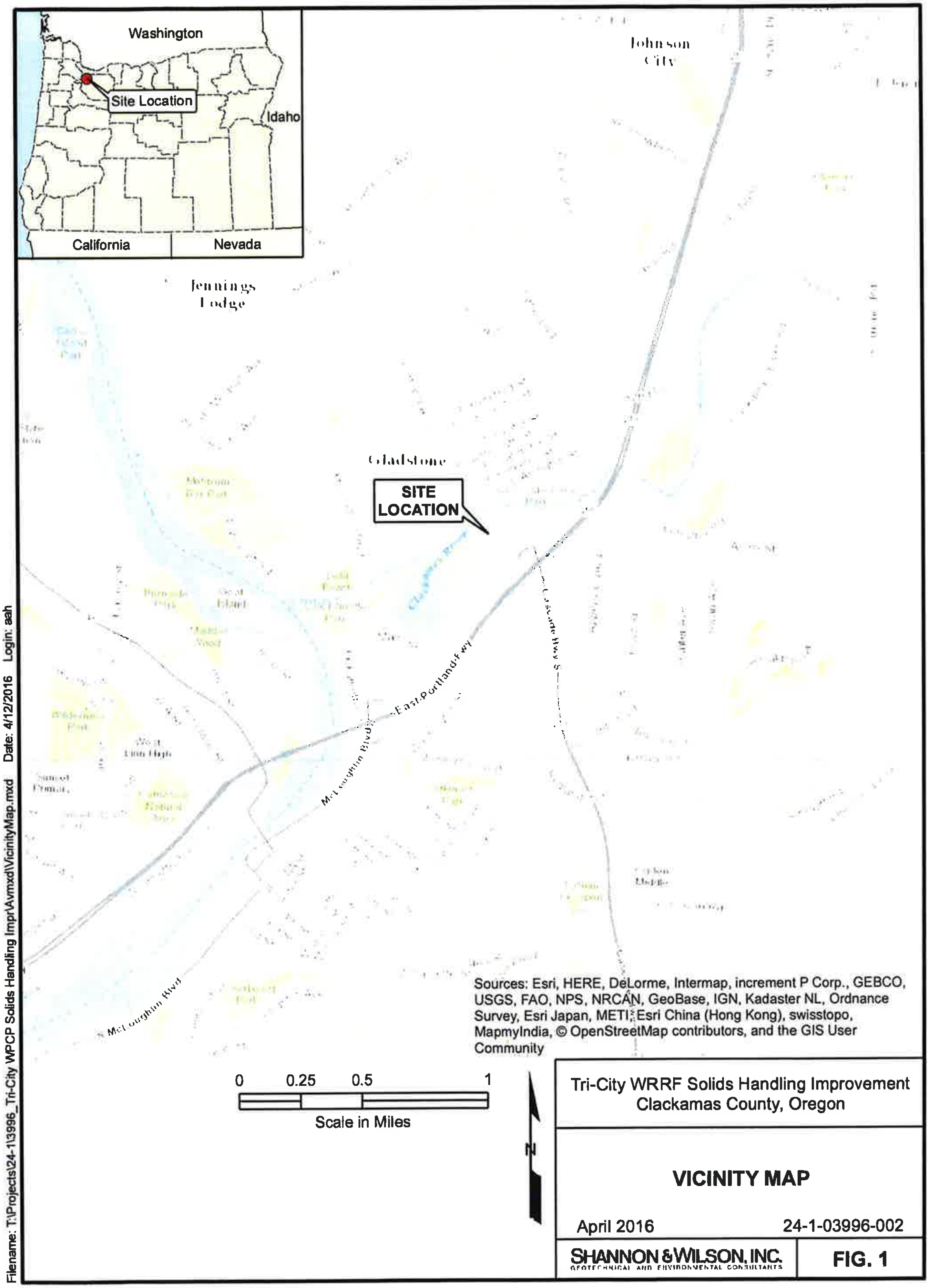
SHANNON & WILSON, INC.

Adrian A.J. Holmes, CEG
Senior Engineering Geologist

Jerry L. Jacksha, PE, GE
Senior Associate | Geotechnical Engineer

AAJH/JLJ:hrj/aeb

Encl.: Figure 1, Vicinity Map
Figure 2, Site and Exploration Plan
Figure 3, Groundwater Level Data
Appendix A - Field Explorations
Appendix B - Laboratory Test Results
Appendix C - Important Information About Your Geotechnical/Environmental Report



Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

VICINITY MAP

April 2016 24-1-03996-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 1

Filename: T:\Projects\24-1\3996_Tri-City WPCP Solids Handling Impr\Avmxd\VicinityMap.mxd Date: 4/12/2016 Login: aah

0 100 200 400

Scale in Feet

LEGEND

SH-1 Designation and Approximate Location of Boring with Observation Well

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

SITE AND EXPLORATION PLAN

April 2016 24-1-03996-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 2

Filename: T:\Projects\24-1-13996_Tri-City WPCP Solids Handling Impr\Avmxd\SitePlan.mxd Date: 4/12/2016 Login: aah

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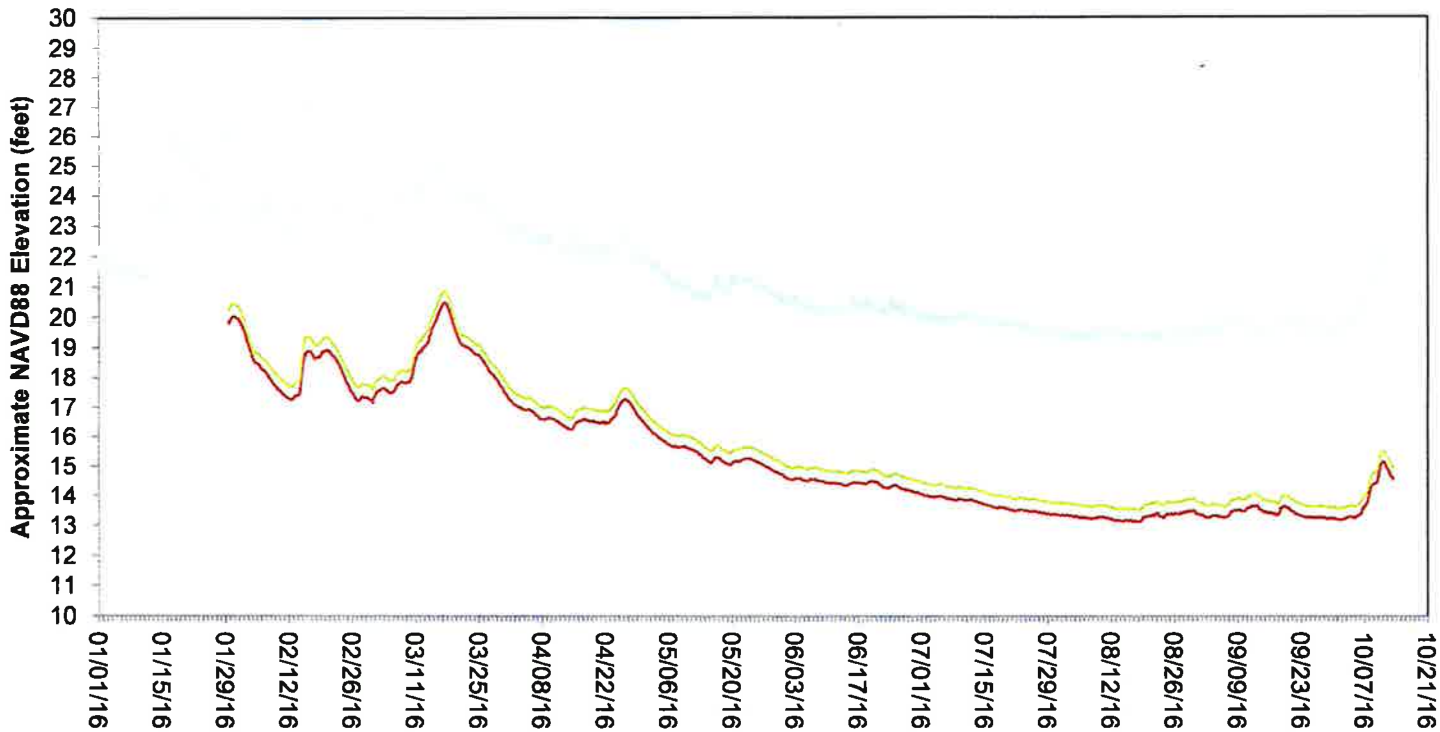

Note: Data last collected October 13, 2016

SH-1 (assumed NAVD88 ground surface elevation = 49.0 feet)

SH-2 (assumed NAVD88 ground surface elevation = 49.0 feet)

Clackamas River Gauge (0.8 miles upstream)

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

GROUNDWATER LEVEL DATA

October 2016 24-1-03996-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 3

FIG. 3

APPENDIX A

FIELD EXPLORATIONS

TABLE OF CONTENTS

FIGURES

APPENDIX A

FIELD EXPLORATIONS

A.1 GENERAL

Shannon &Wilson, Inc., explored subsurface conditions at the project site with two geotechnical borings, designated SH-1 and SH-2. Borehole locations were measured in the field relative to existing site features using a tape-measure. Approximate locations of the explorations are shown on the Site and Exploration Plan, Figure 2. This appendix describes the techniques used to advance and sample the borings and presents logs and photographs of the materials encountered.

A.2 SONIC DRILLING AND SAMPLING

The geotechnical borings were drilled between January 27 and January 28, 2016, using a track-mounted Boart Longyear Mini-Sonic drill rig provided and operated by Cascade Drilling, L.P. (Cascade), of Clackamas, Oregon. The borings were advanced to depths of 70 feet below the existing ground surface using sonic drilling techniques. A Shannon & Wilson geologist was present during the explorations to locate the borings, observe the drilling, collect soil and rock core samples, and log the materials encountered.

Sonic drilling combines high frequency vibrations, downward pressure, and relatively slow rotations to advance through and sample soil and rock. Typically, a core barrel is advanced first. Then, to maintain borehole integrity, a larger-diameter outer casing is advanced over the core barrel. If the borehole will reliably remain open, the outer casing is not required. Hardened steel casing shoe-type bits are attached to the bottom of both the core barrel and the outer drill casing. The bits have several carbide buttons around the tips and outer edges that cut through the soil and rock as the drill string is vibrated and rotated. Drilling can be completed without the use of drill fluids, but water is commonly used to flush material from the annular space between the core barrel and outer casing, while the outer casing is driven.

To retrieve core sample, the core barrel is withdrawn from the hole and the sample is extruded into tubular plastic bags using vibration. During this exploration program, the boreholes were advanced in five-foot intervals while continuously core sampling. The bags of approximately 4-inch diameter core were placed into wooden boxes. A Shannon & Wilson geologist labeled the boxes, cut open the plastic bags, collected sealed jar samples at selected depths, and recorded a preliminary log of the materials encountered. Pieces of intact Sandy River Mudstone were carefully wrapped in plastic to retain native moisture and integrity for unconfined compressive strength testing. The wooden core boxes were loaded onto pallets and transported to the lower level of the Screenings Building at the Tri-City Water Resource Recovery Facility for further evaluation, photographing (discussed below), and long-term storage.

A.3 OBSERVATION WELL INSTALLATIONS

Observation wells were installed in both boring SH-1 and boring SH2 to allow ongoing groundwater level measurements. The wells were each installed to depths of approximately 50 feet below the existing ground surface using 2-inch diameter schedule 40 polyvinyl chloride (PVC) pipe. Portions of the hole below approximately 50 feet were backfilled with bentonite chips. The bottom 20 feet of the pipes (approximately) were machine slotted to allow groundwater to enter. The annuli around the screened sections were backfilled with sand filter packs. Above the screened section, the annuli around the solid PVC pipes were backfilled with additional bentonite chips. The wells are protected at the surface with flush-mount monuments set in concrete. Well construction details and measured water levels are shown on the Logs of Borings in this appendix.

On January 29, 2016, after the observation wells were installed, we developed them by running a surge block up and down the screened sections and purging numerous well-volumes of water. This improves the consistency of the communication between the wells and the aquifer. After well development, we installed a fully encapsulated groundwater level datalogger (Solinst Levelogger®) in each well. The dataloggers were programmed to record groundwater level measurements at 1-hour intervals. Data obtained from the dataloggers are presented in Figure 3 of the main text.

A.4 MATERIAL DESCRIPTIONS

Soil samples were described and identified visually in the field in general accordance with ASTM D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). The specific terminology used is defined in the Soil Description and Log Key, Figure A1. Consistency, color, relative moisture, degree of plasticity, peculiar odors, and other distinguishing characteristics of the samples were noted. The samples were re-examined at the Tri-City Water pollution Control Plant facility after drilling, and the field descriptions and identifications were modified where necessary.

A.5 BORING LOGS AND CORE PHOTOGRAPHS

Summary logs of borings are presented in Figures A2 and A3. Material descriptions and interfaces on the logs are interpretive, and actual changes may be gradual. The left-hand portion of the boring logs gives our description, identification, and geotechnical unit designation for the materials encountered in the boring. The right-hand portion of the boring logs shows a graphic log, sample locations and designations, and a graphical representation sample recovery, moisture content, and fines content. Photographs of the continuous sonic core samples are presented in Figures A4 and A5. Some sonic core runs recovered less than 100 percent of the depth interval sampled. This may occur in loose material or when a cobble becomes lodged in the cutting shoe, preventing material from entering the core barrel. In sonic core runs where less than 100 percent sample recovery was achieved, some empty spaces or gaps are apparent in the core box photographs.

Shannon & Wilson, Inc. (S&W), uses a soil identification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following pages. Soil descriptions are based on visual-manual procedures (ASTM D2488) and laboratory testing procedures (ASTM D2487), if performed.

S&W INORGANIC SOIL CONSTITUENT DEFINITIONS

CONSTITUENT[2]	FINE-GRAINED SOILS (50% or more fines)[1]	COARSE-GRAINED SOILS (less than 50% fines)[1]
Major	***Silt, Lean Clay, Elastic Silt,*** or ***Fat Clay***[3]	***Sand*** or ***Gravel***[4]
Modifying (Secondary) Precedes major constituent	30% or more coarse-grained: ***Sandy*** or ***Gravelly***[4]	More than 12% fine-grained: ***Silty*** or ***Clayey***[3]
Minor Follows major constituent	15% to 30% coarse-grained: ***with Sand*** or ***with Gravel***[4]	5% to 12% fine-grained: ***with Silt*** or ***with Clay***[3]
	30% or more total coarse-grained *and* lesser coarse-grained constituent is 15% or more: ***with Sand*** or ***with Gravel***[5]	15% or more of a second coarse-grained constituent: ***with Sand*** or ***with Gravel***[5]

[1]All percentages are by weight of total specimen passing a 3-inch sieve.
[2]The order of terms is: *Modifying Major with Minor.*
[3]Determined based on behavior.
[4]Determined based on which constituent comprises a larger percentage.
[5]Whichever is the lesser constituent.

MOISTURE CONTENT TERMS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

STANDARD PENETRATION TEST (SPT) SPECIFICATIONS

Hammer:	140 pounds with a 30-inch free fall. Rope on 6- to 10-inch-diam. cathead 2-1/4 rope turns, > 100 rpm
Sampler:	10 to 30 inches long Shoe I.D. = 1.375 inches Barrel I.D. = 1.5 inches Barrel O.D. = 2 inches
N-Value:	Sum blow counts for second and third 6-inch increments. Refusal: 50 blows for 6 inches or less; 10 blows for 0 inches.

NOTE: Penetration resistances (N-values) shown on boring logs are as recorded in the field and have not been corrected for hammer efficiency, overburden, or other factors.

PARTICLE SIZE DEFINITIONS

DESCRIPTION	SIEVE NUMBER AND/OR APPROXIMATE SIZE
FINES	< #200 (0.075 mm = 0.003 in.)
SAND	
Fine	#200 to #40 (0.075 to 0.4 mm; 0.003 to 0.02 in.)
Medium	#40 to #10 (0.4 to 2 mm; 0.02 to 0.08 in.)
Coarse	#10 to #4 (2 to 4.75 mm; 0.08 to 0.187 in.)
GRAVEL	
Fine	#4 to 3/4 in. (4.75 to 19 mm; 0.187 to 0.75 in.)
Coarse	3/4 to 3 in. (19 to 76 mm)
COBBLES	3 to 12 in. (76 to 305 mm)
BOULDERS	> 12 in. (305 mm)

RELATIVE DENSITY / CONSISTENCY

COHESIONLESS SOILS		COHESIVE SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
< 4	Very loose	< 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
> 50	Very dense	15 - 30	Very stiff
		> 30	Hard

WELL AND BACKFILL SYMBOLS

Bentonite Cement Grout	Surface Cement Seal
Bentonite Grout	Asphalt or Cap
Bentonite Chips	Slough
Silica Sand	Inclinometer or Non-perforated Casing
Gravel	Vibrating Wire Piezometer
Perforated or Screened Casing	

PERCENTAGES TERMS [1, 2]

Trace	< 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

[1]Gravel, sand, and fines estimated by mass. Other constituents, such as organics, cobbles, and boulders, estimated by volume.

[2]Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

SOIL DESCRIPTION AND LOG KEY

April 2016 24-1-03996-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A1
Sheet 1 of 3

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(Modified From USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL IDENTIFICATIONS
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Gravel *(less than 5% fines)*	GW		Well-Graded Gravel; Well-Graded Gravel with Sand
			GP		Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(more than 12% fines)*	GM		Silty Gravel; Silty Gravel with Sand
			GC		Clayey Gravel; Clayey Gravel with Sand
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Sand *(less than 5% fines)*	SW		Well-Graded Sand; Well-Graded Sand with Gravel
			SP		Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(more than 12% fines)*	SM		Silty Sand; Silty Sand with Gravel
			SC		Clayey Sand; Clayey Sand with Gravel
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML		Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL		Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
		Organic	OL		Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH		Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
			CH		Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
		Organic	OH		Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat or other highly organic soils (see ASTM D4427)

FILL	Placed by humans, both engineered and nonengineered. May include various soil materials and debris.		The Fill graphic symbol is combined with the soil graphic that best represents the observed material

NOTE: No. 4 size = 4.75 mm = 0.187 in.; No. 200 size = 0.075 mm = 0.003 in.

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, Sand with Silt)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the *CL-ML* area of the plasticity chart.

2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, Lean Clay to Silt; SP-SM/SM, Sand with Silt to Silty Sand)* indicate that the soil properties are close to the defining boundary between two groups.

3. The soil graphics above represent the various USCS identifications (i.e., *GP*, *SM*, etc.) and may be augmented with additional symbology to represent differences within USCS designations. *Sandy Silt (ML)*, for example, may be accompanied by the *ML* soil graphic with sand grains added.

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

SOIL DESCRIPTION AND LOG KEY

April 2016 | 24-1-03996-002

SHANNON & WILSON, INC.
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FIG. A1
Sheet 2 of 3

GRADATION TERMS

Poorly Graded	Narrow range of grain sizes present or, within the range of grain sizes present, one or more sizes are missing (Gap Graded). Meets criteria in ASTM D2487, if tested.
Well-Graded	Full range and even distribution of grain sizes present. Meets criteria in ASTM D2487, if tested.

CEMENTATION TERMS[1]

Weak	Crumbles or breaks with handling or slight finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

PLASTICITY[2]

DESCRIPTION	VISUAL-MANUAL CRITERIA	APPROX. PLASITICTY INDEX RANGE
Nonplastic	A 1/8-in. thread cannot be rolled at any water content.	< 4%
Low	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.	4 to 10%
Medium	A thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.	10 to 20%
High	It take considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.	> 20%

ADDITIONAL TERMS

Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

PARTICLE ANGULARITY AND SHAPE TERMS[1]

Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width/thickness ratio > 3.
Elongated	Length/width ratio > 3.

[1]Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.
[2]Adapted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

ACRONYMS AND ABBREVIATIONS

ATD	At Time of Drilling
approx.	Approximate/Approximately
Diam.	Diameter
Elev.	Elevation
ft.	Feet
FeO	Iron Oxide
gal.	Gallons
Horiz.	Horizontal
HSA	Hollow Stem Auger
I.D.	Inside Diameter
in.	Inches
lbs.	Pounds
MgO	Magnesium Oxide
mm	Millimeter
MnO	Manganese Oxide
NA	Not Applicable or Not Available
NP	Nonplastic
O.D.	Outside Diameter
OW	Observation Well
pcf	Pounds per Cubic Foot
PID	Photo-Ionization Detector
PMT	Pressuremeter Test
ppm	Parts per Million
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
rpm	Rotations per Minute
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
q_u	Unconfined Compressive Strength
VWP	Vibrating Wire Piezometer
Vert.	Vertical
WOH	Weight of Hammer
WOR	Weight of Rods
Wt.	Weight

STRUCTURE TERMS[1]

Interbedded	Alternating layers of varying material or color with layers at least 1/4-inch thick; singular: bed.
Laminated	Alternating layers of varying material or color with layers less than 1/4-inch thick; singular: lamination.
Fissured	Breaks along definite planes or fractures with little resistance.
Slickensided	Fracture planes appear polished or glossy; sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Homogeneous	Same color and appearance throughout.

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

SOIL DESCRIPTION AND LOG KEY

April 2016 24-1-03996-002

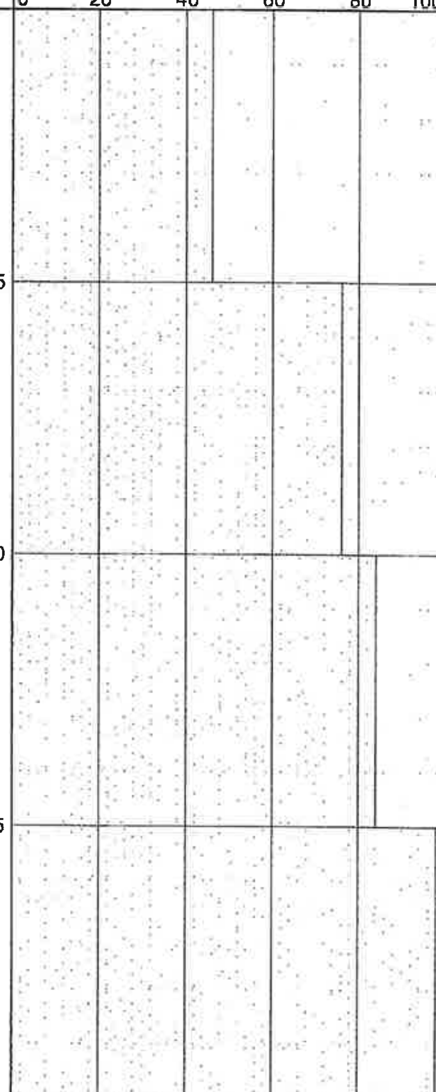
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A1
Sheet 3 of 3

2013 BORING CLASS3 24-1-03996-001.GPJ SW2013LIBRARYPDX.GLB SWNEW.GDT 4/12/16

Total Depth:	70 ft.	Northing:	~	Drilling Method:	Rotosonic	Hole Diam.:	6 in.
Top Elevation:	~ 49 ft.	Easting:	~	Drilling Company:	Cascade Drilling	Rod Type:	~
Vert. Datum:		Station:	~	Drill Rig Equipment:	BL Minisonic	Hammer Type:	N/A
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.*	Elev. Depth (ft.)	Symbol	Samples	Ground Water	Depth, ft.
Soft to medium stiff, brown, *Lean Clay to Lean Clay with Sand (CL)*; moist; fine sand; medium plasticity; trace organics in upper 1 ft; micaceous. **FILL**			R-1 S-1		5
Soft to medium stiff, brown, *Silt with Sand to Sandy Silt (ML)*; moist; fine sand; nonplastic to low plasticity; micaceous. **FINE-GRAINED ALLUVIUM**	42.0 7.0		R-2 S-2 R-3 S-3 R-4		10 15
Loose, brown, *Silty Sand (SM)*; moist; fine to medium sand; nonplastic fines.	30.0 19.0		S-4		



CONTINUED NEXT SHEET

LEGEND

- Soil Core - Sonic
- Jar Sample
- Grab Sample
- Groundwater Level on Date Shown

- Recovery (%)
- ◇ % Fines (<0.075mm)
- ● % Water Content
- Plastic Limit ⊢——⊣ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations, and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

LOG OF BORING SH-1

April 2016 24-1-03996-002

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FIG. A2
Sheet 1 of 4

REV 3

MASTER LOG E 24-1-03996-001.GPJ SW2013LIBRARYPDX.GLB SHANWIL_PDX.GDT 4/12/16 Log: AAJH Rev: AAJH Typ: AAJH

Total Depth:	*70 ft.*	Northing:	~	Drilling Method:	*Rotosonic*	Hole Diam.:	*6 in.*
Top Elevation:	*~ 49 ft.*	Easting:	~	Drilling Company:	*Cascade Drilling*	Rod Type:	~
Vert. Datum:		Station:	~	Drill Rig Equipment:	*BL Minisonic*	Hammer Type:	*N/A*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

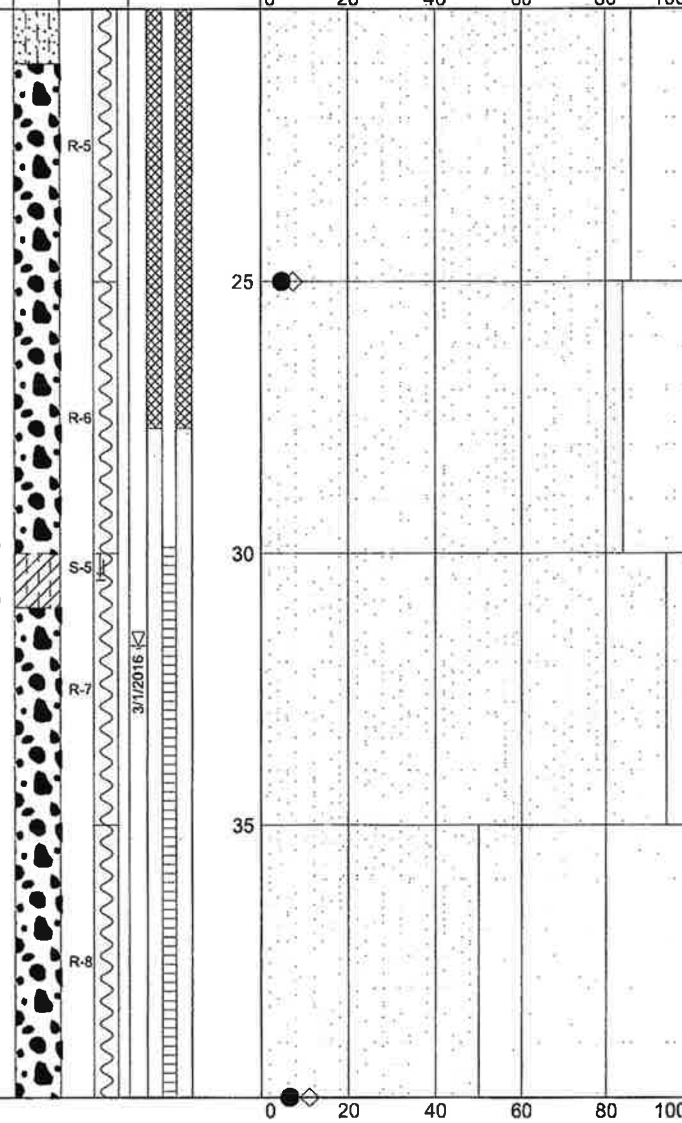
Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Hammer Wt. & Drop: *lbs / inches*

140 lbs / 30 inches

Soil Description	Elev. / Depth (ft.)
Continued: Loose, brown, *Silty Sand (SM)*; moist; fine to medium sand; nonplastic fines. **SAND ALLUVIUM**	*28.0* / 21.0
Medium dense to very dense, gray and brown, *Poorly Graded Gravel with Silt and Sand, with Cobbles (GP-GM)*; moist; few cobbles; fine to coarse, subrounded to rounded gravel; fine to coarse sand; nonplastic fines. **GRAVEL ALLUVIUM**	*19.0* / 30.0
Brown, *Lean Clay (CL)*; moist; trace fine to coarse, subrounded to rounded gravel; trace fine sand; medium plasticity.	*18.0* / 31.0
Medium dense to very dense, gray and brown, *Poorly Graded Gravel with Silt and Sand, with Cobbles (GP-GM)*; moist; few cobbles; fine to coarse, subrounded to subangular gravel; fine to coarse sand; nonplastic fines. 2 ft thick layer of *Silty/Clayey Gravel with Sand (GM/GC)* at 35 ft. *Cobbles stuck in bit likely caused poor recovery in R-8*	*9.0*



CONTINUED NEXT SHEET

LEGEND

- Soil Core - Sonic
- Jar Sample
- Grab Sample
- ∇ Groundwater Level on Date Shown
- □ Recovery (%)
- ◇ % Fines (<0.075mm)
- ● % Water Content
- Plastic Limit ├──┤ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations, and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

LOG OF BORING SH-1

April 2016 — 24-1-03996-002

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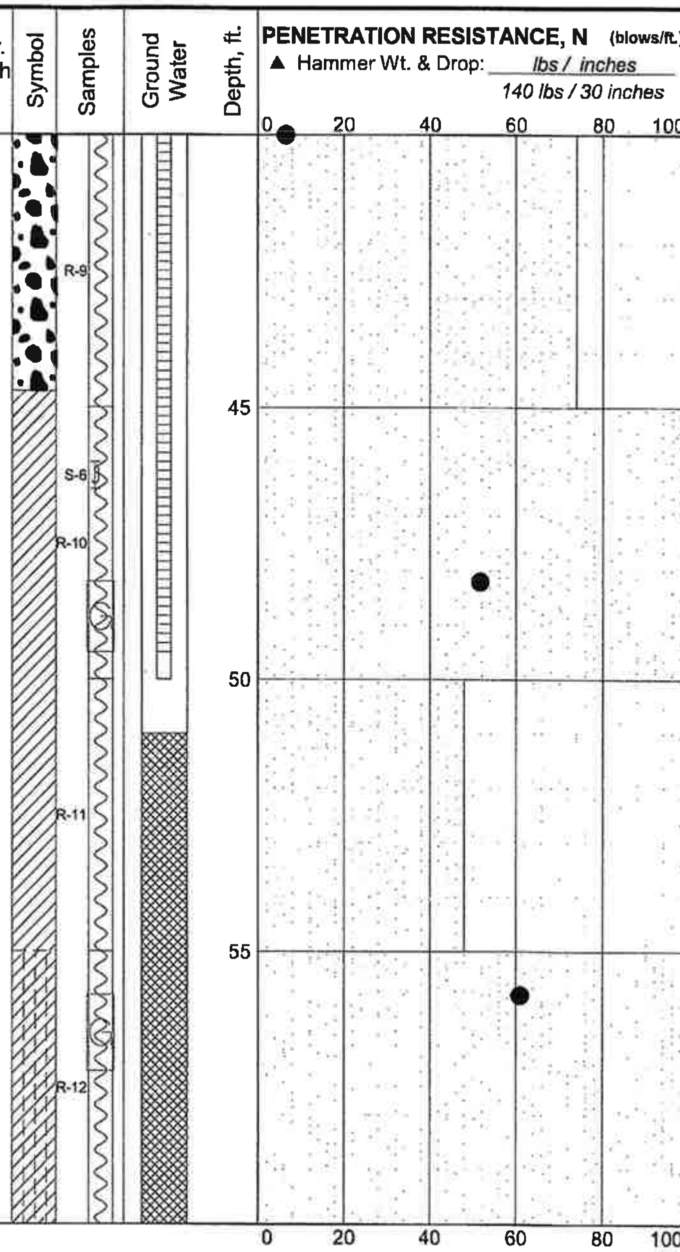
FIG. A2
Sheet 2 of 4

REV 3

Total Depth: 70 ft. | Northing: ~ | Drilling Method: Rotosonic | Hole Diam.: 6 in.
Top Elevation: ~ 49 ft. | Easting: ~ | Drilling Company: Cascade Drilling | Rod Type: ~
Vert. Datum: | Station: ~ | Drill Rig Equipment: BL Minisonic | Hammer Type: N/A
Horiz. Datum: | Offset: ~ | Other Comments:

SOIL DESCRIPTION	Elev. Depth (ft.)
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.	
	40.0
Medium dense to very dense, gray and brown, *Poorly Graded Gravel with Silt and Sand, with Cobbles (GP-GM)*; moist; few to little cobbles; fine to coarse, subrounded to subangular gravel; mostly medium to coarse sand; trace nonplastic fines. **GRAVEL ALLUVIUM**	4.3 44.7
Stiff to very stiff, red and blue-gray, *Lean Clay to Fat Clay (CL/CH)*; moist; medium to high plasticity. **SANDY RIVER MUDSTONE** *48.2-49.5 ft: UCS = 50 psi Dry Density = 72 pcf* Basaltic cobble (fresh, R4-R5) encountered at 54 ft.	-6.0 55.0
Stiff to hard, blue-gray and brown, *Lean Clay to Lean Clay with Sand (CL)*; moist; fine sand; medium to high plasticity; contains zones of relict vesicular basalt texture and relict mudstone texture. *55.8-57.2 ft: UCS = 71 psi Dry Density = 65 pcf*	



CONTINUED NEXT SHEET

LEGEND

- Soil Core - Sonic
- Jar Sample
- Grab Sample
- ⊻ Groundwater Level on Date Shown
- ☐ Recovery (%)
- ◇ % Fines (<0.075mm)
- ● % Water Content
- Plastic Limit ├──┤ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations, and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

LOG OF BORING SH-1

April 2016 24-1-03996-002

SHANNON & WILSON, INC.
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FIG. A2
Sheet 3 of 4

REV 3

Total Depth:	70 ft.	Northing:	~	Drilling Method:	Rotosonic
Top Elevation:	~ 49 ft.	Easting:	~	Drilling Company:	Cascade Drilling
Vert. Datum:		Station:	~	Drill Rig Equipment:	BL Minisonic
Horiz. Datum:		Offset:	~	Other Comments:	

Hole Diam.: 6 in.
Rod Type: ~
Hammer Type: N/A

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)
▲ Hammer Wt. & Drop: lbs / inches
140 lbs / 30 inches

0 20 40 60 80 100

Soil Description	Elev. / Depth (ft.)	Samples
Continued: Stiff to hard, blue-gray and brown, *Lean Clay to Lean Clay with Sand (CL)*; moist; fine sand; medium to high plasticity; contains zones of relict vesicular basalt texture and relict mudstone texture. **SANDY RIVER MUDSTONE**		S-7, R-13
Stiff to hard, blue-gray, *Lean Clay to Lean Clay with Sand (CL)*; moist; fine sand; medium to high plasticity; micaceous.	-18.0 / 67.0	R-14, S-8
Completed: January 28, 2016	-21.0 / 70.0	

Depth, ft.: 65, 70, 75

0 20 40 60 80 100

LEGEND

- Soil Core - Sonic
- Jar Sample
- Grab Sample
- Groundwater Level on Date Shown

- ☐ Recovery (%)
- ◇ % Fines (<0.075mm)
- ● % Water Content
- Plastic Limit |———| Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations, and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

LOG OF BORING SH-1

April 2016 24-1-03996-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A2

REV 3

MASTER LOG E 24-1-03996-001.GPJ SW2013LIBRARYPDX.GLB SHANWIL_PDX.GDT 4/12/16 Log: AAJH Rev: AAJH Typ: AAJH

Total Depth:	70 ft.	Northing:	~	Drilling Method:	Rotosonic	Hole Diam.:	6 in.
Top Elevation:	~ 49 ft.	Easting:	~	Drilling Company:	Cascade Drilling	Rod Type:	~
Vert. Datum:		Station:	~	Drill Rig Equipment:	BL Minisonic	Hammer Type:	N/A
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE, N (blows/ft.)

▲ Hammer Wt. & Drop: lbs / inches

0 20 40 60 80 100

Soil Description	Elev. / Depth (ft.)	Samples
Asphalt/Concrete	48.8 / 0.2	
Aggregate Base	48.1 / 0.9	
Soft to medium stiff, brown, *Silt with Sand to Sandy Silt (ML)*; moist to wet; fine to medium sand; low plasticity; trace rootlets and organics; few pockets of *Silty Sand (SM)*. **FILL**	46.0 / 3.0	S-1, R-1
Soft to medium stiff, brown, *Silt with Sand to Sandy Silt (ML)*; moist; fine sand; nonplastic to low plasticity; stratified with few interbeds of *Silty Sand (SM)*; micaceous. **FINE-GRAINED ALLUVIUM**	32.0 / 17.0	S-2, R-2, S-3, R-3
Loose, gray-brown, *Silty Sand (SM)*; moist; fine to medium sand; nonplastic fines; micaceous. **SAND ALLUVIUM**	31.5 / 17.5	S-4, R-4
Medium dense to very dense, *Silty Gravel with Sand and Cobbles (GM)*; little cobbles.	29.0	

Depth, ft.: 5, 10, 15

CONTINUED NEXT SHEET

0 20 40 60 80 100

LEGEND

- Soil Core - Sonic
- Jar Sample
- Grab Sample
- Groundwater Level on Date Shown

- □ Recovery (%)
- ◇ % Fines (<0.075mm)
- ● % Water Content
- Plastic Limit ├──┤ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations, and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

LOG OF BORING SH-2

April 2016 24-1-03996-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A3
Sheet 1 of 4

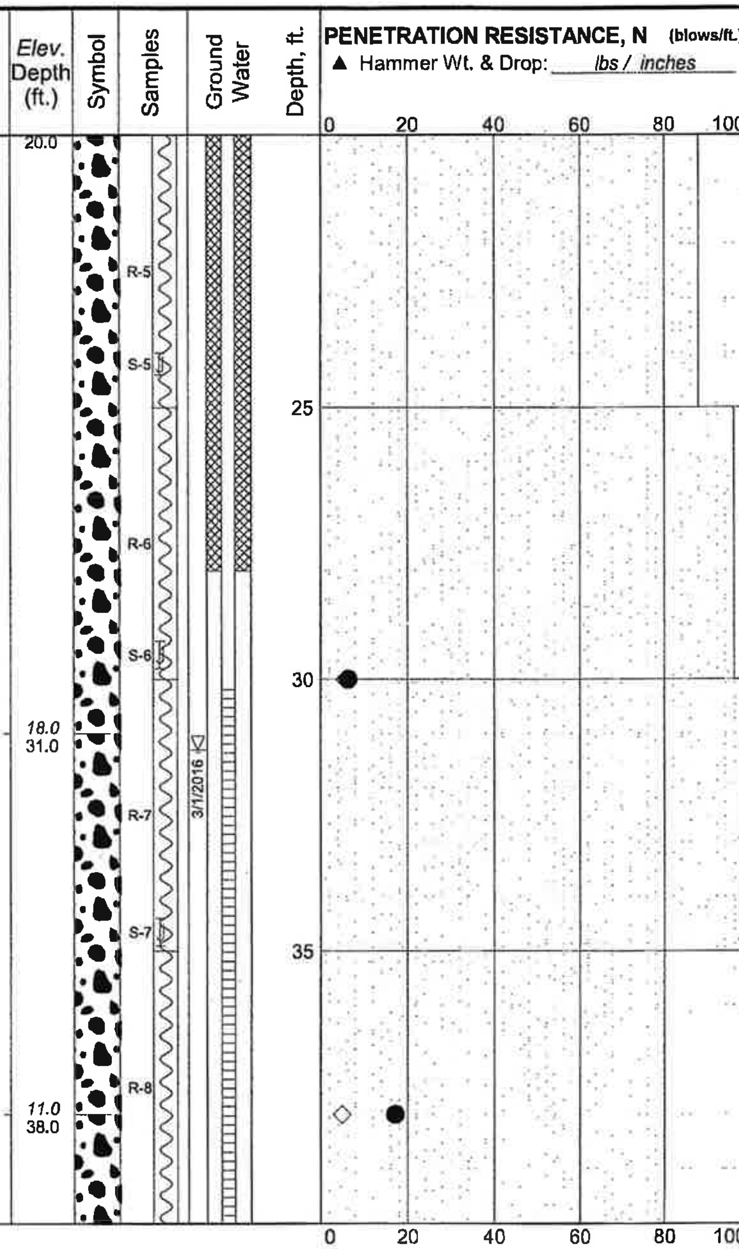
REV 3

Total Depth:	70 ft.	Northing:	~	Drilling Method:	Rotosonic	Hole Diam.:	6 in.
Top Elevation:	~ 49 ft.	Easting:	~	Drilling Company:	Cascade Drilling	Rod Type:	~
Vert. Datum:		Station:	~	Drill Rig Equipment:	BL Minisonic	Hammer Type:	N/A
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. / Depth (ft.)	Soil Description
20.0	Medium dense to very dense, gray and brown, *Poorly Graded Gravel with Silt and Sand, with Cobbles (GP-GM)*; moist; few to little rounded cobbles; fine to coarse, subrounded to rounded gravel; fine to coarse sand; nonplastic fines. **GRAVEL ALLUVIUM**
18.0 / 31.0	Medium dense to very dense, gray and brown, *Poorly Graded Gravel with Silt and Sand, with Cobbles (GP-GM)*; wet; few to little rounded cobbles; fine to coarse, subrounded to rounded gravel; mostly medium to coarse sand; nonplastic fines; trace to few interbeds of *Silty Gravel with Sand (GM)*. Cobbly zone from 37.5 feet to 39 feet.
11.0 / 38.0	Medium dense to very dense, gray and brown, *Well-Graded Gravel with Sand, with Cobbles (GW)*; little to some cobbles.



CONTINUED NEXT SHEET

LEGEND

- Soil Core - Sonic
- Jar Sample
- Grab Sample
- ⊻ Groundwater Level on Date Shown
- ☐ Recovery (%)
- ◇ % Fines (<0.075mm)
- ● % Water Content
- Plastic Limit ├──┤ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations, and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

LOG OF BORING SH-2

April 2016 — 24-1-03996-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A3
Sheet 2 of 4

REV 3

MASTER LOG E 24-1-03996-001.GPJ SW2013LIBRARYPDX.GLB SHANWIL PDX.GDT 4/12/16 Log: CKS Rev: AAJH Typ: SCS

Total Depth:	70 ft.	Northing:	~	Drilling Method:	Rotosonic	Hole Diam.:	6 in.
Top Elevation:	~ 49 ft.	Easting:	~	Drilling Company:	Cascade Drilling	Rod Type:	~
Vert. Datum:		Station:	~	Drill Rig Equipment:	BL Minisonic	Hammer Type:	N/A
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.

Elev. Depth (ft.) | Symbol | Samples | Ground Water | Depth, ft. | PENETRATION RESISTANCE, N (blows/ft.)

▲ Hammer Wt. & Drop: lbs / inches

0 20 40 60 80 100

Soil Description	Elev. / Depth (ft.)	Samples
Medium dense to very dense, gray and orange-brown to brown, *Well-Graded Gravel with Sand, with Cobbles (GW)*; wet; little to some subrounded to rounded cobbles; fine to coarse, subrounded to rounded gravel; mostly medium to coarse sand; nonplastic fines. **GRAVEL ALLUVIUM**	4.0 / 45.0	R-9
Soft, gray, *Lean Clay (CL)*; wet; trace fine sand; medium plasticity; some highly weathered to decomposed gravel and cobbles from 48.5 to 49.2 feet. **FINE-GRAINED ALLUVIUM**	-0.7 / 49.7	S-8, R-10
Stiff to very stiff, brown to yellow-brown, orange brown, and gray, *Fat Clay with Sand (CH)*; moist to wet; fine to coarse sand; medium to high plasticity; relict rock texture; secondary yellow and orange-brown mineralization; relict vesicular basalt texture from 52.5 to 54.5 feet. **SANDY RIVER MUDSTONE**	-6.0 / 55.0	S-9, R-11
Stiff to hard, brown to yellow to orange-brown to gray, *Lean Clay with Sand (CL) to Elastic Silt with Sand (MH)*; moist; fine to medium sand; medium to high plasticity; zones of relict vesicular basalt texture.		R-12, S-10

Depth, ft.: 45, 50, 55

CONTINUED NEXT SHEET

0 20 40 60 80 100

LEGEND

- Soil Core - Sonic
- Jar Sample
- Grab Sample
- ⊻ Groundwater Level on Date Shown

- ☐ Recovery (%)
- ◇ % Fines (<0.075mm)
- ● % Water Content
- Plastic Limit |———| Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations, and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

LOG OF BORING SH-2

April 2016 24-1-03996-002

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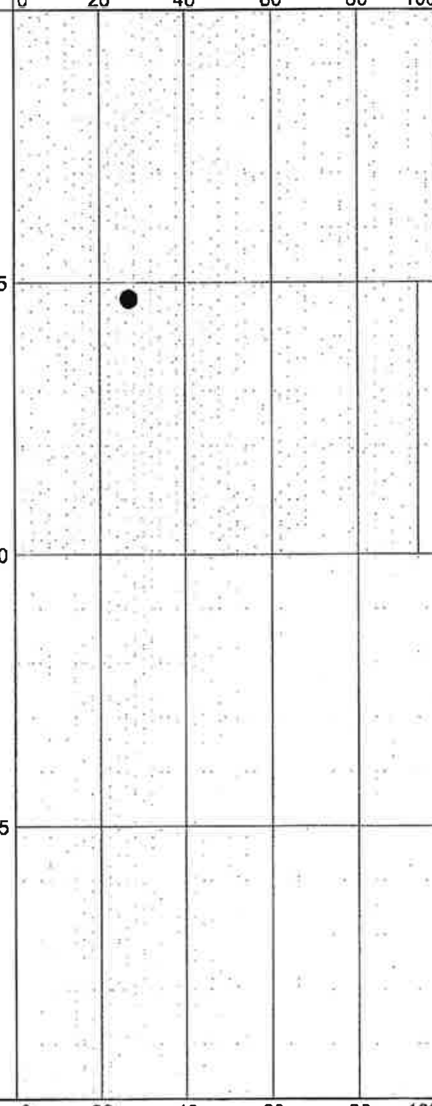
FIG. A3
Sheet 3 of 4

REV 3

Total Depth: 70 ft. | Northing: ~ | Drilling Method: Rotosonic | Hole Diam.: 6 in.
Top Elevation: ~ 49 ft. | Easting: ~ | Drilling Company: Cascade Drilling | Rod Type: ~
Vert. Datum: | Station: ~ | Drill Rig Equipment: BL Minisonic | Hammer Type: N/A
Horiz. Datum: | Offset: ~ | Other Comments:

SOIL DESCRIPTION *Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between soil types, and the transitions may be gradual.*	Elev. Depth (ft.)	Symbol	Samples	Ground Water	Depth, ft.
Continued: Stiff to hard, brown to yellow to orange-brown to gray, *Lean Clay with Sand (CL) to Elastic Silt with Sand (MH)*; moist; fine to medium sand; medium to high plasticity; zones of relict vesicular basalt texture. **SANDY RIVER MUDSTONE**	-15.0 64.0		R-13		
Stiff to hard, gray, *Clayey Sand (SC) to Sandy Lean Clay (CL)*; moist; fine to medium sand; medium to high plasticity; relict sandstone structure; slight iron-oxide staining. *65.3-66.3 ft: UCS = 29 psi* *Dry Density = 94 pcf*	-21.0 70.0		R-14		65 70
Completed: January 27, 2016					75

PENETRATION RESISTANCE, N (blows/ft.)
▲ Hammer Wt. & Drop: lbs / inches



LEGEND

- Soil Core - Sonic
- Jar Sample
- Grab Sample
- ⊻ Groundwater Level on Date Shown

☐ Recovery (%)
◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ├───┤ Liquid Limit

NOTES

1. Refer to KEY for explanation of symbols, codes, abbreviations, and definitions.
2. Groundwater level, if indicated above, is for the date specified and may vary.
3. Group symbol is based on visual-manual identification and selected lab testing.
4. The hole location and elevation should be considered approximate.

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

LOG OF BORING SH-2

April 2016 24-1-03996-002

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FIG. A3

REV 3

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DEPTH
(feet)

0 to 5

5 to 10

10 to 15

15 to 20

FIG. A4
(Sheet 1 of 4)

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

BORING SH-1
SONIC CORE PHOTOGRAPHS

April 2016   24-1-03996-002

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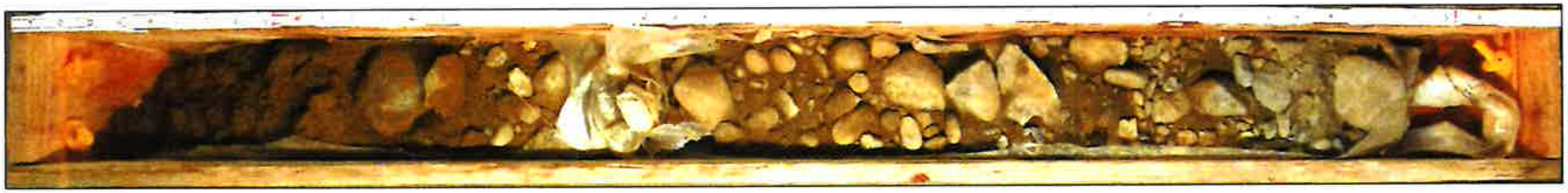
FIG. A4
(Sheet 1 of 4)

DEPTH
(feet)

20 to 25



25 to 30

30 to 35

35 to 40

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Clackamas County, Oregon

BORING SH-1
SONIC CORE PHOTOGRAPHS

April 2016 24-1-03996-002

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FIG. A4
(Sheet 2 of 4)

FIG. A4
(Sheet 2 of 4)

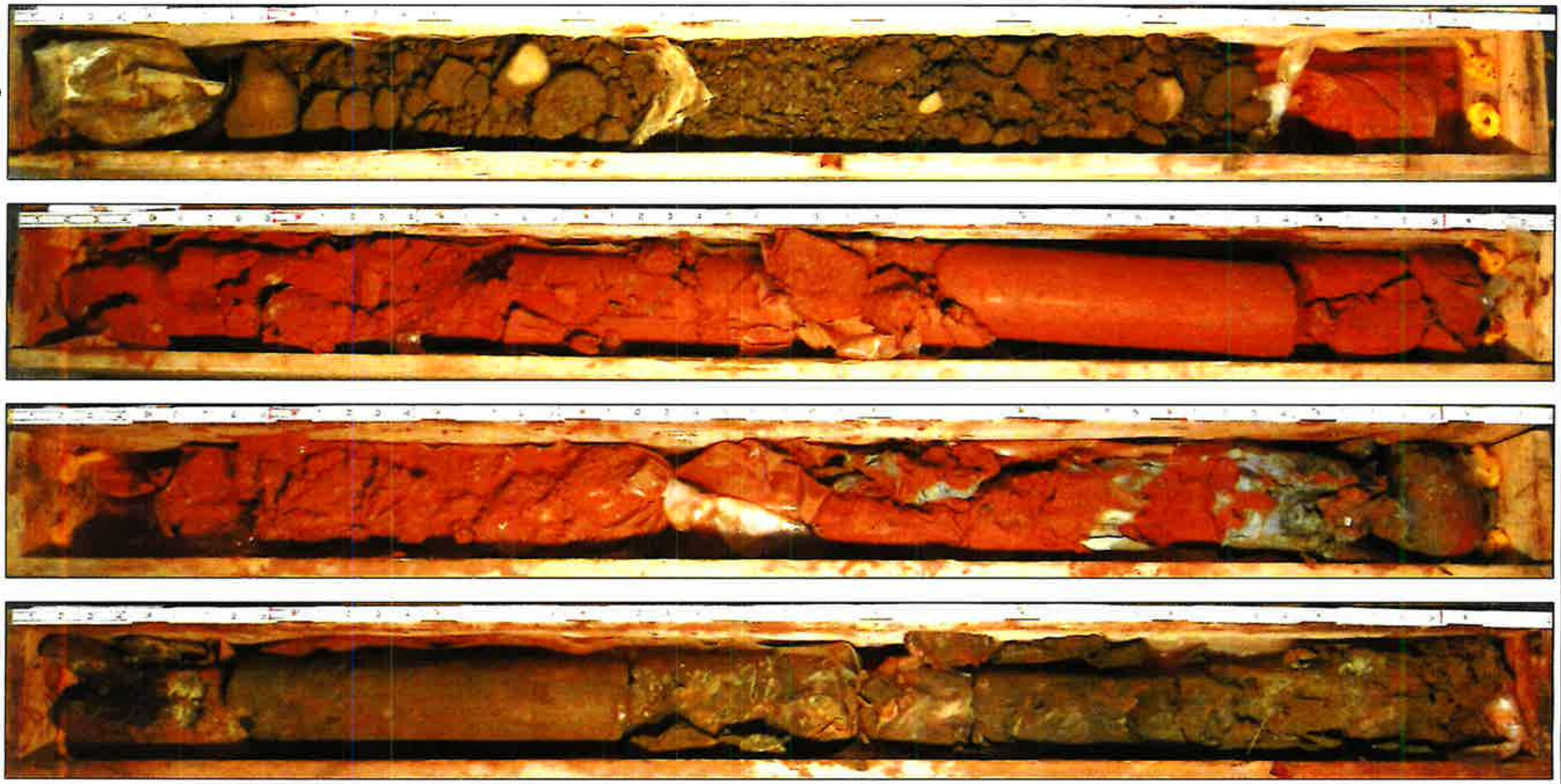
DEPTH (feet)

40 to 45

45 to 50

50 to 55

55 to 60



Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

BORING SH-1
SONIC CORE PHOTOGRAPHS

April 2016 24-1-03996-002

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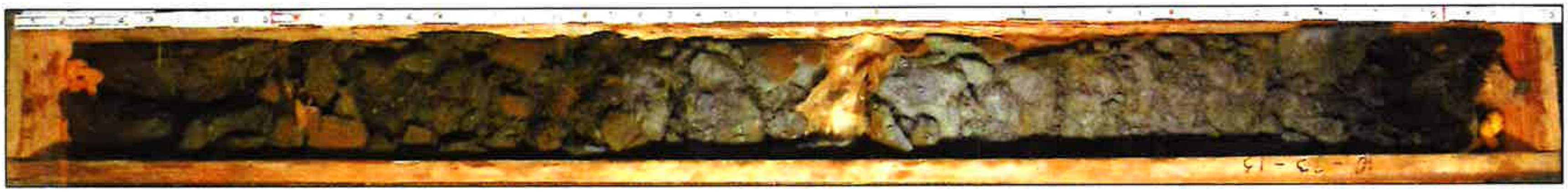
FIG. A4
(Sheet 3 of 4)

FIG. A4
(Sheet 3 of 4)

DEPTH
(feet)

60 to 65

65 to 70



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Clackamas County, Oregon

BORING SH-1
SONIC CORE PHOTOGRAPHS

April 2016 24-1-03996-002

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FIG. A4
(Sheet 4 of 4)

FIG. A4
(Sheet 4 of 4)

DEPTH
(feet)

0 to 5

5 to 10

10 to 15

15 to 20

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

BORING SH-2
SONIC CORE PHOTOGRAPHS

April 2016 24-1-03996-002

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FIG. A5
(Sheet 1 of 4)

FIG. A5
(Sheet 1 of 4)

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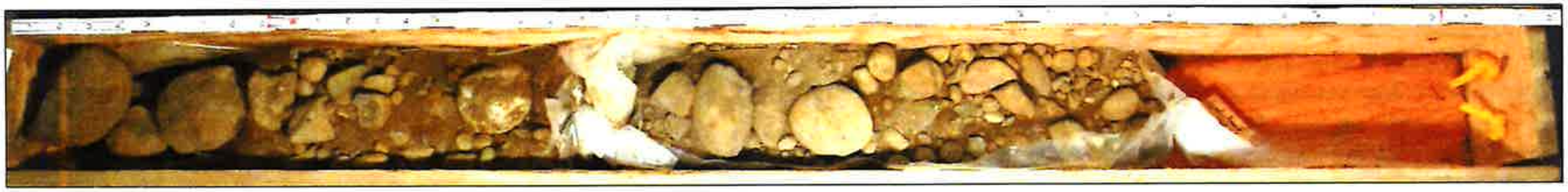
DEPTH (feet)

20 to 25



25 to 30

30 to 35

35 to 40

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

BORING SH-2
SONIC CORE PHOTOGRAPHS

April 2016 24-1-03996-002

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FIG. A5
(Sheet 2 of 4)

FIG. A5
(Sheet 2 of 4)

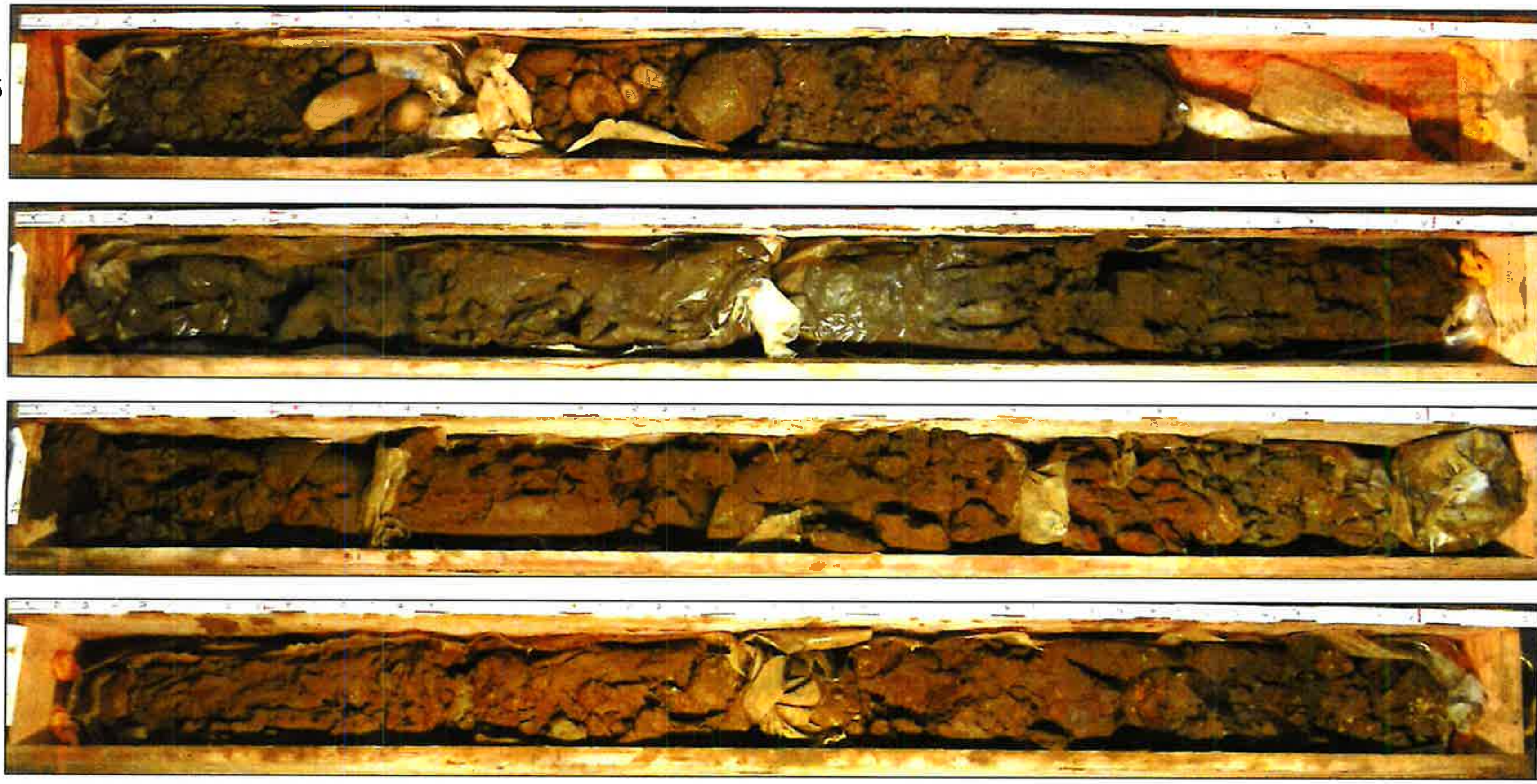
DEPTH (feet)

40 to 45

45 to 50

50 to 55

55 to 60



Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

BORING SH-2
SONIC CORE PHOTOGRAPHS

April 2016 24-1-03996-002

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FIG. A5
(Sheet 3 of 4)

FIG. A5
(Sheet 3 of 4)

DEPTH (feet)

60 to 65

65 to 70

FIG. A5
(Sheet 4 of 4)

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

BORING SH-2
SONIC CORE PHOTOGRAPHS

April 2016   24-1-03996-002

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FIG. A5
(Sheet 4 of 4)

APPENDIX B

LABORATORY TEST RESULTS

TABLE OF CONTENTS

FIGURES

ATTACHMENTS

APPENDIX B

LABORATORY TEST RESULTS

B.1 GENERAL

The soil samples obtained during the field explorations were described and identified in the field in general accordance with the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), ASTM D2488. The specific terminology used is presented in Appendix A, Figure A1. The samples were reviewed at the Tri-City Water pollution Control Plant after drilling. The physical characteristics of the samples were noted, and the field descriptions and identifications were modified where necessary in accordance with terminology presented in Appendix A, Figure A1. After core photographs were taken, representative samples were selected for various laboratory tests. We refined our visual-manual soil descriptions and identifications based on the results of the laboratory tests, using elements of the Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), ASTM D2487. The refined descriptions and identifications were then incorporated into the Logs of Borings, presented in Appendix A. Note that ASTM D2487 was not followed in full because it requires that a suite of tests be performed to fully classify a single sample.

The soil testing program included moisture content tests, unit weight determinations, particle-size analyses, and unconfined compressive strength testing. Particle-size analyses and associated moisture content tests were performed by Shannon & Wilson, Inc. Unconfined compressive strength testing, and associated unit weight and moisture content tests, were performed by FEI Testing & Inspection, Inc. (FEI), of Corvallis, Oregon. All test procedures were performed in accordance with applicable ASTM International (ASTM) standards. General testing procedures are summarized in the following paragraphs.

B.2 SOIL TESTING

B.2.1 Moisture (Natural Water) Content

Natural moisture content analyses were performed, in accordance with ASTM D2216, on samples that were selected for particle-size analyses and unconfined compressive strength testing. The natural moisture content is a measure of the amount of moisture in the soil at the time the explorations are performed, and is defined as the ratio of water weight to dry soil weight, expressed as a percentage. The results of all moisture content analyses are presented graphically on the Logs of Borings in Appendix A. Results of moisture content analyses performed by Shannon & Wilson as part of the particle-size analyses are also shown on Figure B1, Grain Size Distribution. Results of moisture content analyses performed by FEI as part of the unconfined compressive strength tests are also shown in the FEI Testing Results attached to this appendix.

B.2.2 Unit Weight Determinations

Some unit weights were determined during the course of FEI's unconfined compressive strength testing. The results of all unit weight determinations are presented on the Logs of Borings in Appendix A and in the FEI Testing Results attached to this appendix.

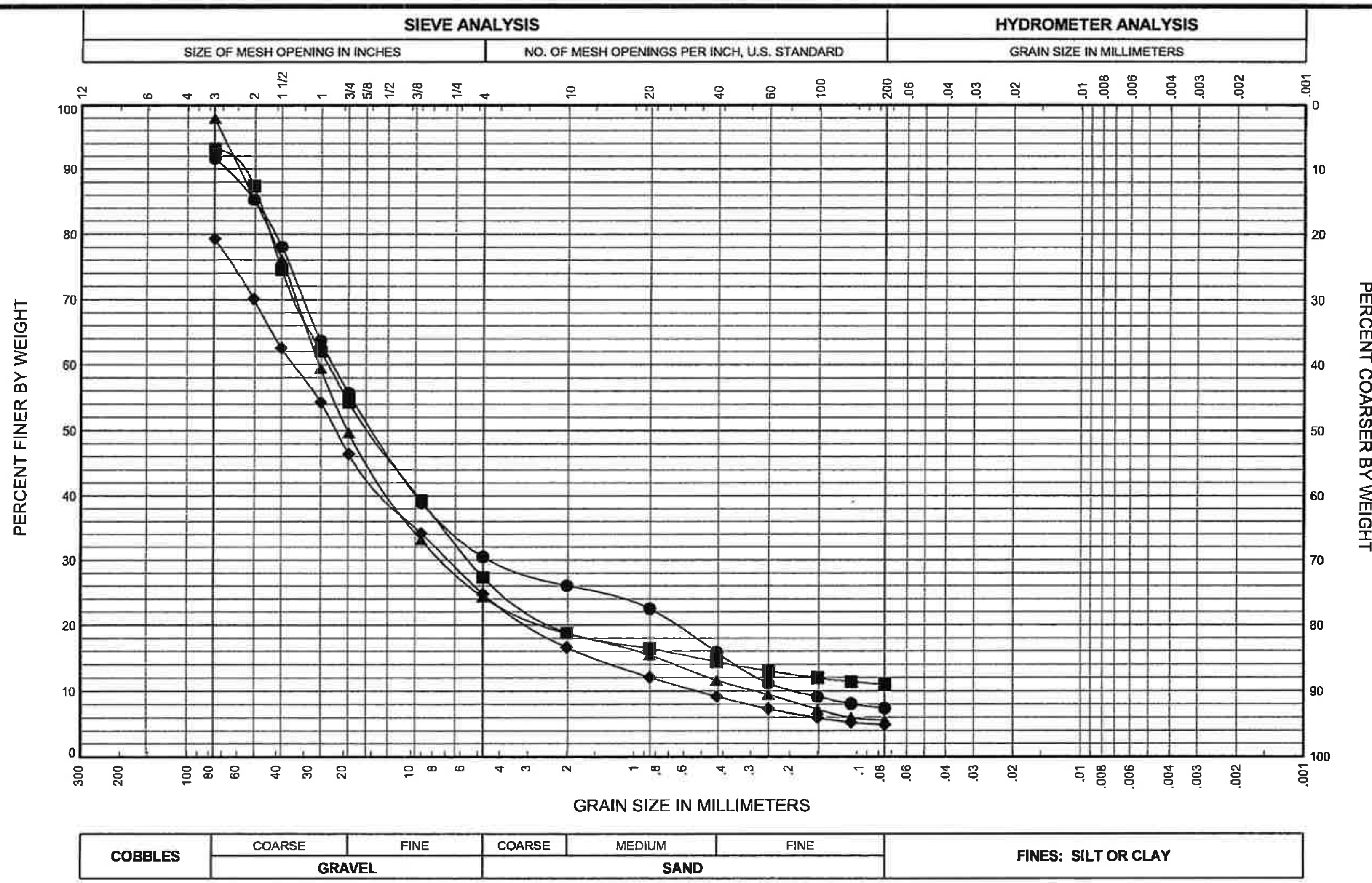
B.2.3 Particle-Size Analysis

Particle-size analyses were conducted on select samples in accordance with ASTM D6913. A wet sieve analysis was performed to determine a percentage (by weight) of the sample passing the No. 200 (0.075 mm) sieve. The material retained on the No. 200 sieve was shaken through a series of sieves to determine the distribution of the plus No. 200 fraction. The results of all particle-size analyses are plotted on Figure B1, Grain Size Distribution, and the amount of material passing the No. 200 sieve for each tested sample is indicated on the Logs of Borings in Appendix A.

B.2.4 Compressive Strength Testing

Selected sonic core samples of the Sandy River Mudstone were tested using ASTM D7012 (Method C), the Compressive Strength of Intact Rock Core Specimens. The test consists of placing a rock core specimen between two bearing plates and applying and measuring an axial load increasing at a constant rate until failure. During the application of increasing axial load, strain of the core sample is continuously measured with a dial indicator placed between the two bearing blocks, measuring the decreasing length of the rock core. The highest load achieved, and the length of the rock core at failure, are recorded. Measurements made during the test are used to calculate the uniaxial compressive strength, C_o, in psi. Results of the unconfined compressive strength tests are presented on the Logs of Borings in Appendix A and in the FEI Testing Results attached to this appendix.

NOTES:
1) Sieve analyses were performed in general accordance with ASTM D6913, sieve with hydrometer analyses were performed in general accordance with ASTM D422, and amount finer than #200 sieve analyses were performed in general accordance with ASTM D1140 unless otherwise noted in the report.
2) Group Name and Group Symbol are in accordance with ASTM D2488 and are refined in accordance with ASTM D2487 where appropriate laboratory tests are performed.



BORING AND SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL[2]	GROUP NAME[2]	GRAVEL %	SAND %	FINES %	NAT. W.C. %	DRY DENSITY PCF
● SH-1, R-6	25.0	*GP-GM*	*Poorly Graded Gravel with Silt and Sand, with Cobbles*	61	23	7	5	
■ SH-1, R-9	40.0	*GP-GM*	*Poorly Graded Gravel with Silt and Sand, with Cobbles*	66	16	11	7	
▲ SH-2, R-7	30.0	*GP-GM*	*Poorly Graded Gravel with Silt and Sand, with Cobbles*	74	19	6	6	
◆ SH-2, R-8/R-9	38.0	*GW*	*Well-Graded Gravel with Sand, with Cobbles*	55	20	5	17	

Tri-City WRRF Solids Handling Improvement
Clackamas County, Oregon

GRAIN SIZE DISTRIBUTION

April 2016 24-1-03996-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B1

FEI
TESTING & INSPECTION, INC.
Geotechnical & Construction Services

LETTER OF TRANSMITTAL

Date: February 16, 2016

To: Shannon & Wilson, Inc.
3990 Collins Way, Suite 100
Lake Oswego, OR 97035

Attn:

Project No.: 2166028-900
Report No.: C-34645

Re: Tri-City Solids WWTP

Enclosed are:

- ☐ Report
- ☐ Copy of Letter
- ☐ Other
- ☐ Drawings
- ☐ Specifications
- ☑ Test Results (4 Pages Total Incl. Cover)

These are transmitted as checked below:

- ☑ For your use
- ☑ As requested
- ☐ For your review/approval
- ☐ For your files

Remarks: Requested laboratory testing results attached. Please call if you have any questions.

Copy to:

Signature:

Rachel Rucker
President

FEI Testing & Inspection, Inc.
Project Name: Tri-City Solids WWTP
Client Project #24-1-03996-002
FEI Project # 2166028-600

Table 1. Unconfined Compression (ASTM D 7012)

Sample Number*	Sample Depth (ft)	Length (in)	Diameter (in)	Corrected Area (in^2)	Water Content (percent)	Load (lbs)	Compressive Strength (psi)
SH-1	48.2-49.5	8.90	4.18	13.72	51.7	690	50
SH-1	55.8-57.2	8.45	4.18	13.72	60.9	980	71
SH-2	65.3-66.3	9.26	4.16	13.59	26.8	400	29

Table 2. Unit Weight

Sample Number*	Sample Depth (feet)	Wet Density (pcf)	Dry Density (pcf)
SH-1	48.2-49.5	109.3	72.0
SH-1	55.8-57.2	104.5	64.9
SH-2	65.3-66.3	119.0	93.8

*FEI Sample No. 5964

48.2 – 49.5 (before)

48.2 – 49.5 (after)

48.2 – 49.5 (internal)

55.8 – 57.2 (before)

55.8 – 57.2 (after)

65.3 – 66.3 (before)

65.3 – 66.3 (after)

APPENDIX C

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL / ENVIRONMENTAL REPORT

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Attachment to and part of Report 24-1-03996-002
Groundwater Monitoring Program Report
Tri-City WRRF Solids Handling Improvement
Date: October 2016
To: MWH Global, Inc.
Attn: Mr. Steve Hyland, PE

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland

BLACK & VEATCH
Building a **world** of difference

LETTER OF TRANSMITTAL

To:	Corianne Hart, Brown and Caldwell	**Date:**	March 19, 2012
Organization:	C/O Lake Oswego Tigard Water Partnership	**Project #:**	175033
Address:	City of Lake Oswego-West End Building 4101 Kruse Way	**File #:**	43.2000
	Lake Oswego, OR 97034	**Phone #:**	503.977.6678

WE ARE SENDING YOU:

DATE	COPIES	DESCRIPTION
3/16/12	1 PDF	City of Lake Oswego– Design Engineering Services for Package 3 – **River Intake Pump Station, Work Order #204** **Tech Memo 011 – Geotechnical Report - *FINAL***, prepared by GRI

THESE ARE TRANSMITTED AS CHECKED BELOW:

☐ **For Approval** ☒ **For your use** ☐ **As Requested** ☐ **For Review & Comment**

REMARKS:

Distributed as Appendix of Final PDR.

CC/Distribution:
Alan Peck, B&V
Pat Van Duser, B&V
Jamie DuBois, B&V
Scott Schlechter, GRI
Mike Peebles, OTAK
Gary Rayor, OBEC
B&V File

SIGNED: [signature]

PRINTED: Patrick M. Van Duser

GRI
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Beaverton, OR 97005-3364
p| 503-641-3478 f| 503-644-8034

March 16, 2012

5262-A GEOTECHNICAL RPT

Black & Veatch
5885 Meadows Road, Suite 700
Lake Oswego, OR 97035

Attention: Patrick Van Duser, PE

SUBJECT: Geotechnical Report
River Intake Pump Station (RIPS)
Lake Oswego Tigard Water Partnership – Package 3
Gladstone, Oregon

At your request, GRI is providing geotechnical engineering services for the proposed river intake pump station (RIPS) along the Clackamas River in Gladstone, Oregon. The Vicinity Map, Figure 1, shows the proposed location of the RIPS. Our geotechnical services for this task included a review of existing data for the project, site reconnaissance, and engineering analyses. This report describes the work accomplished and provides our recommendations for design and construction of the proposed RIPS and associated improvements.

PROJECT DESCRIPTION

Replacement of the existing river intake pump station with a new RIPS is one element of the Lake Oswego Tigard Water Partnership – Package 3. The RIPS will be constructed just upstream of the existing river intake pump station on the right bank of the Clackamas River in Gladstone, Oregon, near Charles Ames Memorial Park. The approximate location of the proposed RIPS is shown on the Site Plan, Figure 2. Similar to the existing structure, an access bridge will be constructed for the new RIPS and will likely be supported by deep foundations on the riverbank end.

The existing river channel directly upstream of the RIPS (Area 1) may also be modified to increase the sweeping velocity in front of the proposed structure. As presently envisioned, this would include removing about 1,500 cy of material from the area shown on Figure 2. The depth of the excavation would vary from a few feet to a maximum depth of about 8 ft.

We understand the assumed design life for the new RIPS structure is 100 years. The Ordinary High Water (OHW), 10-, 100-, and 500-year flood elevations at the site are about 17, 34, 44.5, and 52.5 ft, respectively. All elevations provided in this report are in reference to the NGVD 29 datum.

GRI is the geotechnical subconsultant for the project to Black & Veatch (B&V), the prime design consultant. Additional subconsultants to the B&V team include R2 Resource Consultants, Inc. (R2) and OBEC Consulting Engineers (OBEC). To support preliminary design by the project's Program Management Team (PMT), GeoDesign prepared a geotechnical data report and a seismic hazard assessment for the project in March 2011. To further support the PMT, Northwest Hydraulic Consultants (NHC) evaluated riverbank stability within the project area and provided their findings in a July 2011 report. The baseline reports for the project are as follows:

> "Geotechnical Data Report, Proposed River Intake Pump Station, Gladstone, Oregon," dated March 7, 2011, prepared by GeoDesign.
>
> "Geotechnical Data Report, Seismic Hazard Assessment, City of Lake Oswego and Tigard Joint Water Supply System, Clackamas County, Oregon," dated March 11, 2011, prepared by GeoDesign.
>
> "Lake Oswego – Tigard Water Program, River Stability Assessment at River Intake Pump Station, Final Report - Revised," dated July 8, 2011, prepared by NHC.

As a separate task, GRI completed three additional borings to evaluate subsurface conditions in the vicinity of the proposed upstream rock removal. The results of this work are summarized in our December 12, 2011, data report entitled, "Geotechnical Data Report, Upstream Rock Removal for River Intake Pump Station (RIPS), Lake Oswego Tigard Water Partnership – Package 3, Gladstone, Oregon. This geotechnical data report is provided in Appendix A. The March 7, 2011, geotechnical data report prepared by GeoDesign is provided in Appendix B.

SITE DESCRIPTION

The proposed RIPS is located on the right bank of the Clackamas River in Gladstone, Oregon, near Charles Ames Memorial Park. Figure 2 shows the location of the existing river intake pump station and the approximate location of the new RIPS. During low water conditions, a relatively flat portion of the right riverbank is exposed just upstream of the existing pump station. Available topographic information indicates this area typically ranges in elevation from about +10 to +15 ft. The topography between the relatively flat portion of the riverbank and the park level near elevation+ 55 ft quickly transitions to nearly vertical in some areas.

Geology

The upland areas of the site are mantled by alluvial terrace deposits of the Clackamas River. The terrace deposits typically consist of gravel, cobbles, and boulders in a matrix of sand with a trace of silt; however, layers of sand and silt are present locally. Beneath the terrace deposits, volcanic rocks of the Tertiary Columbia River Basalt Group are exposed along the riverbank in the area of the proposed RIPS (Walker, 1991). Weathering of the basalt is highly variable horizontally and vertically and ranges from slightly weathered to predominately decomposed to residual clay, silt, and sand. In the project area, boulder-size corestones of relatively hard, unweathered rock are present in the more-weathered portions of the basalt.

SUBSURFACE CONDITIONS

General

Subsurface materials and conditions at the site were investigated through a review of existing subsurface information prepared by GeoDesign and supplemented with additional explorations and geologic reconnaissance completed by GRI. The locations of the borings completed by GRI (B-1 through B-3) and GeoDesign (CR-1 through CR-3, CR-7, and CR-8) are shown on Figure 2. The terms used to describe the rock encountered in the borings are defined in Table 1.

We have summarized the subsurface conditions based on the following three significant components of the project: 1) RIPS Foundation Area, 2) Bridge Foundations and Upper Riverbank, and 3) Area 1 Excavation. A more thorough discussion of the subsurface conditions can be found in the geotechnical data reports included in the appendices.

It should be noted that our interpretation of a portion of the subsurface conditions at the site varies from those disclosed in the GeoDesign reports. Where significant variations were observed, they are discussed in the following sections.

RIPS Foundation Area

The GeoDesign borings CR-1, CR-2, and CR-7 indicate the location of the new intake structure is underlain by basalt of variable rock hardness and weathering characteristics. The borings typically disclosed extremely soft to soft (R0 to R2) basalt from the ground surface to about elevation 2 ft. Medium hard to very hard (R3 to R5) basalt was encountered beneath the extremely soft to soft rock (R0 to R2) and extends to elevations between about -6 and -9 ft. Beneath the medium hard to very hard (R3 to R5) rock, extremely soft to soft (R0 to R2) basalt is present to about elevation -18 ft. Harder basalt was encountered below about elevation -18 ft to the maximum depth explored in the borings. Rock Quality Designation (RQD) typically ranges from about 15 to 55% in the extremely soft to soft (R0 to R2) basalt, indicating the rock quality is very poor to fair. RQD values in the medium hard to very hard (R3 to R5) basalt typically range from 30 to 95%, indicating the rock quality is excellent in some locations.

Bridge Foundations and Upper Riverbank

Based on review of GeoDesign boring CR-8 and our geologic reconnaissance of the site, the area of the proposed bridge foundations is mantled by an approximate 5-ft thickness of uncontrolled fill. Alluvial deposits of the Clackamas River are present beneath the fill between about elevation 28 ft and 51 ft. The alluvial deposits typically consist of gravel, cobbles, and boulders in a matrix of sand with a trace of silt. Variably weathered basalt was encountered beneath the alluvial deposits to the maximum depth explored. In some locations, the basalt has weathered to the consistency of a very stiff soil. Although not encountered in the GeoDesign boring, harder, less-weathered corestones are visible in portions of the weathered basalt riverbank.

It should be noted that the GeoDesign boring and reports classify the majority of the riverbank slopes between about elevation 10 ft and the overlying alluvial deposits as Troutdale Formation Silt. As described above, we have classified this material as weathered basalt based on our geologic reconnaissance. In this regard, the discussion of Troutdale Formation Silt presented in the GeoDesign boring logs, cross sections, and reports should be disregarded.

Area 1 Excavation

As disclosed by GeoDesign borings CR-2 and CR-3 and GRI borings B-2 and B-3, the footprint of the proposed channel modifications is underlain by basalt of widely varying rock hardness and weathering characteristics. In GRI borings B-2 and B-3, medium hard to very hard (R3 to R5) basalt was encountered from the ground surface to about elevation 4 to 7 ft. Beneath the medium hard to very hard (R3 to R5) rock, extremely soft to soft (R0 to R2) basalt was disclosed to the maximum depth explored. In GeoDesign borings CR-2 and CR-3, extremely soft to soft (R0 to R2) basalt was encountered from the ground surface to about elevation 2 ft. Approaching the location of the new intake structure, medium hard to very hard (R3 to R5) rock was encountered below the softer rock at elevation 2 ft in boring CR-2. RQD values up to 95% in the medium hard to very hard (R3 to R5) basalt indicate the rock quality is excellent in some locations. RQD values in the extremely soft to soft (R0 to R2) basalt range from about 0 to 60%, indicating the rock quality is generally very poor to fair.

Groundwater

Groundwater levels at the site are expected to fluctuate with the elevation of the Clackamas River. Perched groundwater conditions also develop on top of the less-permeable, weathered basalt during wet weather conditions. At the time of our reconnaissance in October 2011, heavy seepage was noted at this interface and through fractures in the weathered basalt.

CONCLUSIONS AND RECOMMENDATIONS

General

We anticipate the RIPS structure will be supported by shallow foundations in the underlying medium hard (R3) or harder basalt unit. Depending on the rock hardness encountered at the foundation subgrade elevation, some overexcavation of more-weathered basalt may be needed.

A cofferdam and dewatering system will be needed to complete the proposed excavation and foundation preparation. Methods to limit seepage and maintain stability will be a significant consideration for the contractor's selected cofferdam system.

The borings completed in the vicinity of the proposed Area 1 excavation indicate significant variability in the rock quality and hardness across the footprint of the proposed excavation.

The effect of erosion and raveling of the existing riverbank soils is a significant consideration for design of the proposed improvements. We anticipate the landside portion of the access bridge will be supported on deep foundations to limit the risk of long-term erosion issues adversely affecting the foundations.

The following sections of this report provide our preliminary conclusions and recommendations for design and construction of the RIPS and access bridge foundations, and related earthwork.

Seismic Considerations

We anticipate the proposed RIPS will be designed in accordance with the 2010 Oregon Structural Specialty Code, which is based on the 2009 International Building Code (IBC). The IBC design methodology uses two spectral response coefficients, S_S and S_1, corresponding to periods of 0.2 and 1.0 second, to develop the design earthquake spectrum. The S_S and S_1 coefficients for the site are 0.92 and 0.32 g, respectively. Based on the subsurface conditions disclosed by the borings completed for the project, we recommend using Site Class B, or rock site classification, for design of the new intake structure.

Based on our review of the subsurface explorations completed for the project, it is our opinion the risk of liquefaction of soils below the OHW level is very low. Based on the proximity of the closest mapped fault, in our opinion, the risk of ground rupture at the site is low. The risk of tsunami and seiches at the site is absent.

RIPS Shallow Foundation Support

As summarized in the subsurface conditions section of this report, the proposed RIPS footprint is underlain by basalt of variable rock hardness, ranging from extremely soft to very hard (R0 to R5). The subsurface explorations completed for the project disclosed medium hard to hard (R3 to R5) basalt below about elevation +2 ft in the vicinity of the proposed intake structure. However, softer, more-weathered basalt was encountered below the medium hard to hard (R3 to R5) basalt at about elevation -8 ft in the three borings completed by GRI for the RIPS. We understand the bottom of foundation for the RIPS structure will be at about elevation -4 ft.

To provide suitable, long-term support for the structure, we recommend the RIPS foundation be established in medium hard (R3) or harder rock. Shallow foundations established a minimum of 1 ft below the depth at which medium hard (R3) or harder basalt occurs can be designed to impose an allowable bearing pressure of up to 10 ksf. This value applies to the total of dead load plus frequently and/or permanently applied live loads and can be increased by one-third for the total of all loads. This value assumes spread footings will have a minimum width of 4 ft. The bottoms of footing excavations should be hand cleaned to remove all materials loosened during excavation. All footing excavations should be evaluated by the geotechnical engineer. We estimate that the settlement of spread footings established in accordance with the above recommendations will be on the order of 1/2 in. or less.

It should be noted that we have reduced our recommended allowable bearing pressure from typical values for medium hard (R3) rock. This recommendation is based on the likely presence of softer, more-weathered rock encountered in the borings at relatively shallow depths below the medium hard (R3) basalt at the proposed footing subgrade elevation. In addition, based on the likely variability of the rock hardness, it should also be anticipated that some overexcavation may be required below the design subgrade elevation of -4 ft to reach medium hard (R3) or harder rock. Any overexcavated areas should be backfilled using structural concrete to provide suitable support for the new structure.

Lateral loads (seismic, etc.) can be resisted by frictional forces developed between the base of the mat slab foundation and underlying bedrock. We recommend an ultimate value of 0.7 for the coefficient of friction for mass concrete cast directly on clean, intact basalt. If additional lateral resistance is required, passive earth pressures against foundations embedded in medium hard (R3) or harder basalt can be computed on the basis of an equivalent fluid having a unit weight of 500 pcf. Passive earth pressures against the backfilled pump station walls can be computed on the basis of an equivalent fluid having a unit weight of 150 pcf. These design passive earth pressure values are only applicable if the foundations are "neat-formed" against bedrock and the backfill for the pump station walls is placed as compacted granular structural fill. We do not recommend considering the frictional interaction of backfill against the pump station walls for design purposes.

We understand the bridge and abutment structures are also being considered to resist lateral loads. Additional discussion regarding lateral loading is provided in the Bridge Foundation Support section of this report.

Uplift Considerations

Based on our discussions with the design team, resistance to uplift forces will be a key consideration in the design of the RIPS. Common methods for resisting uplift forces acting on intake structures include increasing the thickness of walls and foundation elements, extending the base slab beyond the sidewalls of the structure, and installing ground anchors in the base of the structure.

If the base of the pump station is extended beyond the sidewalls of the structure, additional uplift resistance is provided by a combination of friction between the foundation and backfill and dead weight of the backfill above the foundation. Regarding the weight of backfill above the foundation, only the compacted backfill within the limits of the outside edge of the slab should be considered as additional load to resist the uplift force. The effective weight of the submerged backfill should be evaluated using a buoyant unit weight of 60 pcf for granular structural fill material. Shearing stresses in the backfill above the perimeter of the base slab should provide some additional uplift resistance; however, for the purpose of design, it is recommended that the shearing resistance of the backfill be neglected. Because of the limited embedment in medium hard (R3) or harder rock, we also do not recommend assuming additional resistance based on the rock/foundation interface.

We understand a system of permanent ground anchors will be used to provide some of the required uplift resistance and the design load of the anchors will likely be in the range of 100 to 200 kips. A performance-based specification is commonly used for ground anchors with criteria provided by the owner's engineer, and the actual design and installation accomplished by qualified specialty contractors. In our opinion, for the range of anticipated loads, epoxy-coated, #14 or #18, grade 75 steel bars grouted with neat cement (Class I corrosion protection), will likely provide the most economical uplift resistance. We acknowledge that a #18 bar is likely "oversized;" however, in our opinion it would be prudent to install a larger bar than necessary to limit the amount of strain in the system. We anticipate the bars will need to have a minimum length of 25 ft, which includes a bond length of 10 ft and a free, unbonded length of 15 ft. The minimum bond length is provided only for preliminary planning purposes, and the actual bond length required will need to be determined by the specialty contractor's anchor designer and verified by full-scale tests prior to production anchor installation. In this regard, we recommend performing at least one verification test that confirms the bond zone has a minimum factor of safety of 2. In addition, all production anchors should be proof loaded to 1.5 times the design load.

In general, we recommend that all anchor design, testing, and acceptance criteria follow the Federal Highway Administration (FHWA) guidelines for permanent ground anchors. After the anchor has been tested and passed the performance criteria, the specified lock-off load should be applied to the anchor. Each anchor should be proof tested and locked off at the load specified by structural engineer to satisfy the required deflection requirements. All anchor installation, testing, and acceptance criteria should meet the FHWA requirements for permanent ground anchors.

Structural Fill

We anticipate up to about 10 ft of backfill will be placed around the pump station walls following construction. We recommend granular structural fill is used to backfill the structure. Gravel or fragmental rock up to about 8-in. maximum size and having less than 5% passing the No. 200 sieve (washed analysis) would be suitable for this purpose. Crushed and/or processed, medium hard (R3) or harder rock excavated from on site could also be considered for backfill. Backfill should be compacted to a minimum of 92% of the maximum dry density determined in accordance with ASTM D 1556 or until the backfill is "well keyed." In this regard, if the backfill consists of fragmental rock greater than about 2-in. size, it will not be practical to accomplish meaningful field density testing in this type of material; therefore, we recommend that the geotechnical engineer observe the compaction of this material. The type of compaction equipment used may be dictated by access constraints and the type of backfill selected. Compaction within close proximity to the pump station walls should be accomplished with hand-operated or small compactors to limit additional stresses on the pump station walls. Appropriate lift thickness will depend on the type of compaction equipment used; however, we recommend a maximum loose lift thickness of 12 in.

To reduce the risk of erosion, we recommend the granular structural fill is capped with a minimum 2-ft thickness of Corps of Engineers Class III riprap. Depending on the gradation of rock used for backfill, an additional bedding material may be needed.

Lateral Earth Pressures

Design lateral earth pressures for embedded walls depend on the type of construction, i.e., the ability of the wall to yield. The two possible conditions are 1) a wall that is laterally supported at its base and top and therefore is unable to yield, and 2) a conventional cantilevered retaining wall that yields by tilting about its base. We anticipate the walls of the intake structure will be designed to resist yielding and will be backfilled with clean, granular material placed as structural fill. Non-yielding walls such as the RIPS structure should be designed using equivalent fluid pressures of 50 pcf and 25 pcf for above water and permanently submerged backfills, respectively. Horizontal pressures due to seismic loads may be estimated on the basis of an equivalent fluid having a unit weight of 18 pcf. The resultant of the seismic force acts at a distance of 0.6H above the base of the wall, where H is the height of the wall.

Cofferdam, Dewatering, and Temporary Excavation Considerations

General. Based on our discussions with design team, a temporary cofferdam system will be constructed to facilitate excavation for the RIPS in dry conditions. The cofferdam will be a bidder-designed element, with a conceptual design provided by the design team. The conceptual temporary cofferdam system consists of sheet piling laterally supported by a system of waler support piles and ring walers. Construction sequencing for this type of system typically consists of installation of the perimeter waler support piles and ring walers followed by installation of the sheet piles. The ring walers serve as a template for driving the sheet piles, as well as provide lateral support for the sheets. The temporary cofferdam will be installed about 15 to 20 ft outside the footprint of the new RIPS. We understand the cofferdam will be designed to the 10-year flood elevation of about 34 ft and will be allowed to flood during construction if a larger flood event occurs. Based on discussions with OBEC, we understand the template piles will be an HP14x89 or larger and the sheet piles will be an AZ-18 or larger with a minimum wall thickness of 1/2 in.

Figure 3 shows a cross section of the temporary cofferdam area, including relative rock hardness values from the borings completed in the area. We anticipate the support piles may be driven with tip protection to about the elevation of the soft (R2) basalt. The support piles may penetrate the soft (R2) rock; however, significant embedment into the medium hard (R3) basalt is not anticipated. The sheet piles will likely be driven without tip protection to increase their embedment. We anticipate the sheet piles will penetrate the extremely soft to very soft (R0 to R1) rock with limited penetration into soft (R2) basalt. These penetrations assume the piles will be driven with an impact hammer with a rated energy of at least 100,000 ft-lbs. It should be noted that harder, less-weathered basalt corestones are present in the softer, more-weathered rock, and may prevent penetration of the support and sheet piles to the desired depth. Where the sheet piles reach practical refusal with limited penetration, increased seepage should be anticipated. Potential remedial measures to deal with the increased seepage are discussed in the Dewatering Considerations section of this report.

Temporary Excavations and Earth Pressures. Based on the available bathymetry, the RIPS foundation excavation will vary from several feet up to about 15 ft. We recommend assuming temporary excavations in the extremely soft to very soft (R0 to R1) rock can initially be made at about 0.5H:1V. We have assumed the excavations in the soft (R2) or harder rock will be made near vertical. These temporary excavations and the recommended earth pressures for the cofferdam system are shown on Figure 4.

The stability of the temporary 0.5H:1V slopes when subject to seepage forces will be an important consideration for the performance of the cofferdam system. The earth pressures shown on Figure 4 conservatively assume the remaining cut slope material inside the sheets provides no passive resistance. As discussed further in the Dewatering Considerations section of this report, it should be anticipated that some remedial measures will likely be required to maintain the stability of the temporary excavation slopes in conjunction with the required dewatering within the cofferdam.

Dewatering Considerations. We understand the conceptual temporary cofferdam is being designed based on a 10-year flood at a river elevation of 34 ft. This corresponds to a head differential of approximately 38 ft if the excavation is advanced and dewatered to elevation -4 ft. The amount of dewatering that will be required on the inboard side of the cofferdam to accomplish the required construction in the dry is difficult to quantify with the available geotechnical information and the anticipated variability of subsurface conditions in the project area. Significant seepage should be anticipated in areas where the sheet pile tips reach shallow practical refusal with minimal embedment, and in areas where the sheet pile tips are damaged during installation. In these areas, the temporary excavation slopes may ravel or fail due to the increased seepage forces and some remedial measures will likely be needed to effectively dewater the cofferdam. Alternatives to help control seepage and maintain temporary slope stability include 1) placing large sandbags or "supersacks" on the inboard and outboard toe of the sheets, 2) a drilling and grouting program inside the cofferdam, and 3) shallow excavations along the inside of the sheet pile walls and backfilling these excavations with a lean-mix concrete seal.

Based on the subsurface conditions at the site and our experience with similar projects, we are of the opinion that dewatering can be completed with a system of sumps located within the limits of the excavation. Due to the anticipated variability in sheet pile penetration, it is not possible to estimate the actual quantity of water that will need to be pumped to accomplish the required dewatering. The number and size of the pumps needed to accomplish the required dewatering will need to be adjusted based on the actual conditions encountered during installation of the cofferdam.

The cofferdam and dewatering systems should be independently evaluated by the contractor and designed by a civil engineer licensed in the State of Oregon.

Rock Excavation

Significant amounts of rock excavation will be required to establish the RIPS foundation and complete the Area 1 excavation. We understand blasting will not be allowed for rock removal due to permitting issues and the proximity of the existing intake structure. The contractor should be responsible for independently evaluating the rock characteristics and selecting the appropriate equipment to remove the rock in accordance with the contract documents.

Riverbank Slope Stabilization

The March 2011 GeoDesign seismic hazard assessment report identifies areas of landslide hazard and slope instability in the vicinity of the proposed access bridge. The July 2011 NHC report recommends providing slope protection within the project area to minimize the risk of riverbank erosion. Their report included a preliminary design for slope stabilization that included riprap and large stones. Several conceptual alternatives for slope stabilization in the project area were provided in our draft technical memorandum entitled, "River Intake Pump Station (RIPS) Slope Stabilization Alternatives, Lake Oswego-Tigard Water Partnership – Package 3, Gladstone, Oregon," dated December 7, 2011.

Based on discussions with the design team, it is our understanding that any slope protection alternative that includes riprap placed below OHW is undesirable. In this regard, we provided several slope stabilization alternatives that do not include any modification to the existing riverbank below OHW, including placing riprap only on the upper portion of the slope, providing a mesh and soil-nail reinforcement on the upper part of the slope, and leaving the existing slope "as is" and providing additional set back to the landslide bridge foundation to allow for some future erosion.

After issuing our draft technical memorandum, the PMT and design team evaluated and selected an additional alternative that better accommodates site constraints and other project goals. This selected alternative involves construction of a secant pile wall at the location of the bridge abutment. The secant pile wall will serve to support the bridge foundation and limit the risk of future riverbank slope erosion adversely impacting the bridge abutment. Recommendations for the secant pile wall are discussed in the Bridge Foundation Support and Secant Pile Wall section of this report.

Bridge Foundation Support and Secant Pile Wall

General. In conjunction with the new RIPS, an access bridge will be constructed on the right bank of the river, similar to the existing intake structure. Based on discussions with OBEC, we understand foundation design loads are on the order of 100 to 200 kips. As discussed in the Riverbank Slope Stabilization section of this report, the bridge abutment will be supported by a secant pile wall. A secant pile wall consists of a series of overlapping primary and secondary drilled shafts that form a continuous wall. The primary drilled shafts are reinforced by either a rebar cage or steel section and are installed after the secondary drilled shafts have sufficiently set up. For preliminary planning purposes, we have assumed the secant pile wall will be drilled with 36-in.-diameter tooling.

We recommend about three of the drilled shafts that support the primary bridge loads extend through the gravels and weathered basalt a minimum distance of 5 ft into soft (R2) or harder basalt. In our opinion, 36-in.-diameter drilled shafts installed in accordance with these recommendations can achieve an ultimate compressive capacity of at least 900 kips. Ultimate uplift resistances can be assumed to be two-thirds of the ultimate compressive capacity. We recommend applying a factor of safety of 3 for dead load and permanently applied live loads. For transient loading conditions such as seismic conditions, we recommend using a factor of safety of 1.5 and 2 for compressive and uplift resistances, respectively. The capacity of these shafts is likely conservative due to the skin friction from the adjacent secondary piles.

The secondary piles can be terminated at shallower depths in the weathered basalt. The final depth of the secondary piles can be evaluated after the final geometry of the bridge abutment is determined. The available resistances, and design earth and water pressures should also be developed after the final wall location has been determined.

The alluvial gravels, cobbles, and boulders that mantle the site are in a matrix of sand with a trace of silt. We anticipate groundwater will be encountered in these materials, and caving of the pier walls may occur during drilling. As a result, it would be prudent for the foundation contractor to assume that casing will be necessary to support the overburden soils in the drilled shafts. All loose material should be removed from the bottom of each drilled pier before placing the concrete. If the inflow of water is sufficiently high to prevent removal of the water, the concrete should be placed using tremie methods. The bottom of the tremie pipe should be maintained at least 4 ft below the surface of the concrete.

It is important to note the secant pile design criteria discussed in this section are based on the assumption that the shafts will be installed in materials consistent with the descriptions provided in the Subsurface Conditions section of this report. Drilling and installation of the secant pile wall should be observed on a full-time basis by a geotechnical engineer to evaluate the subsurface materials and the contractor's procedures. In this regard, the recommended depths of penetration into the weathered rock should be considered a minimum depth. Based on our experience, the quality of the weathered basalt can vary significantly over relatively short distances, and it should be anticipated that it will be necessary to deepen some of the shafts to accommodate zones of more-weathered material. In this regard, the reinforcement lengths for the drilled shafts should contain an allowance for additional drilling length.

Lateral Resistance. Due to the proximity of the secant pile wall to the riverbank slope, we do not recommend designing the wall to resist significant lateral load in the direction of the riverbank. Based on our discussions with OBEC, we understand seismic loading on the intake structure may be partially resisted by an impact slab and drag key constructed at the north end of the access bridge. Horizontal forces can be resisted by a combination of frictional resistance between the slab and subgrade soil and passive earth pressure against the drag key. We recommend an ultimate value of 0.40 for the coefficient of friction for mass concrete cast directly on the silt subgrade. Passive earth pressures against the drag key can be computed on the basis of an equivalent fluid having a unit weight of about 300 pcf. This passive earth pressure assumes that the drag key will be backfilled with compacted granular structural fill or cast directly on undisturbed soil.

LIMITATIONS

This report has been prepared to aid the project team in design of the RIPS structure. The scope is limited to the specific project and location described herein, and our description of the project represents our understanding of the significant aspects of the project relevant to the RIPS. In the event that any changes in the design and location of the RIPS as outlined in this memorandum are planned, we should be given the opportunity to review the changes and to modify or reaffirm the conclusions and recommendations of this report in writing.

The alternatives submitted in this report are based in part on the subsurface information developed by GeoDesign. With respect to the work performed by others, we did not participate in the implementation of the work. We make no representations or warranty regarding instruments of service completed by others.

Please contact the undersigned if you have any questions or comments.

Submitted for GRI,

Renews 11/2013

Scott M. Schlechter, PE, GE
Associate

Michael J. Zimmerman, PE, GE, CEG
Senior Engineer /Geologist

H. Stanley Kelsay, PE, GE
Principal Consultant

Reference

Walker, G. W., and MacLeod, N. S., 1991, Geologic Map of Oregon, 1:500,000, USGS.

This document has been submitted electronically.

Table 1

GUIDELINES FOR CLASSIFICATION OF ROCK

RELATIVE ROCK WEATHERING SCALE:

Term	Field Identification
Fresh	Crystals are bright. Discontinuities may show some minor surface staining. No discoloration in rock fabric.
Slightly Weathered	Rock mass is generally fresh. Discontinuities are stained and may contain clay. Some discoloration in rock fabric. Decomposition extends up to 1 in. into rock.
Moderately Weathered	Rock mass is decomposed 50% or less. Significant portions of rock show discoloration and weathering effects. Crystals are dull and show visible chemical alteration. Discontinuities are stained and may contain secondary mineral deposits.
Predominantly Decomposed	Rock mass is more than 50% decomposed. Rock can be excavated with geologist's pick. All discontinuities exhibit secondary mineralization. Complete discoloration of rock fabric. Surface of core is friable and usually pitted due to washing out of highly altered minerals by drilling water.
Decomposed	Rock mass is completely decomposed. Original rock "fabric" may be evident. May be reduced to soil with hand pressure.

RELATIVE ROCK HARDNESS SCALE:

Term	Hardness Designation	Field Identification	Approximate Unconfined Compressive Strength
Extremely Soft	R0	Can be indented with difficulty by thumbnail. May be moldable or friable with finger pressure.	< 100 psi
Very Soft	R1	Crumbles under firm blows with point of a geology pick. Can be peeled by a pocket knife and scratched with fingernail.	100 - 1,000 psi
Soft	R2	Can be peeled by a pocket knife with difficulty. Cannot be scratched with fingernail. Shallow indentation made by firm blow of geology pick.	1,000 - 4,000 psi
Medium Hard	R3	Can be scratched by knife or pick. Specimen can be fractured with a single firm blow of hammer/geology pick.	4,000 - 8,000 psi
Hard	R4	Can be scratched with knife or pick only with difficulty. Several hard hammer blows required to fracture specimen.	8,000 - 16,000 psi
Very Hard	R5	Cannot be scratched by knife or sharp pick. Specimen requires many blows of hammer to fracture or chip. Hammer rebounds after impact.	> 16,000 psi

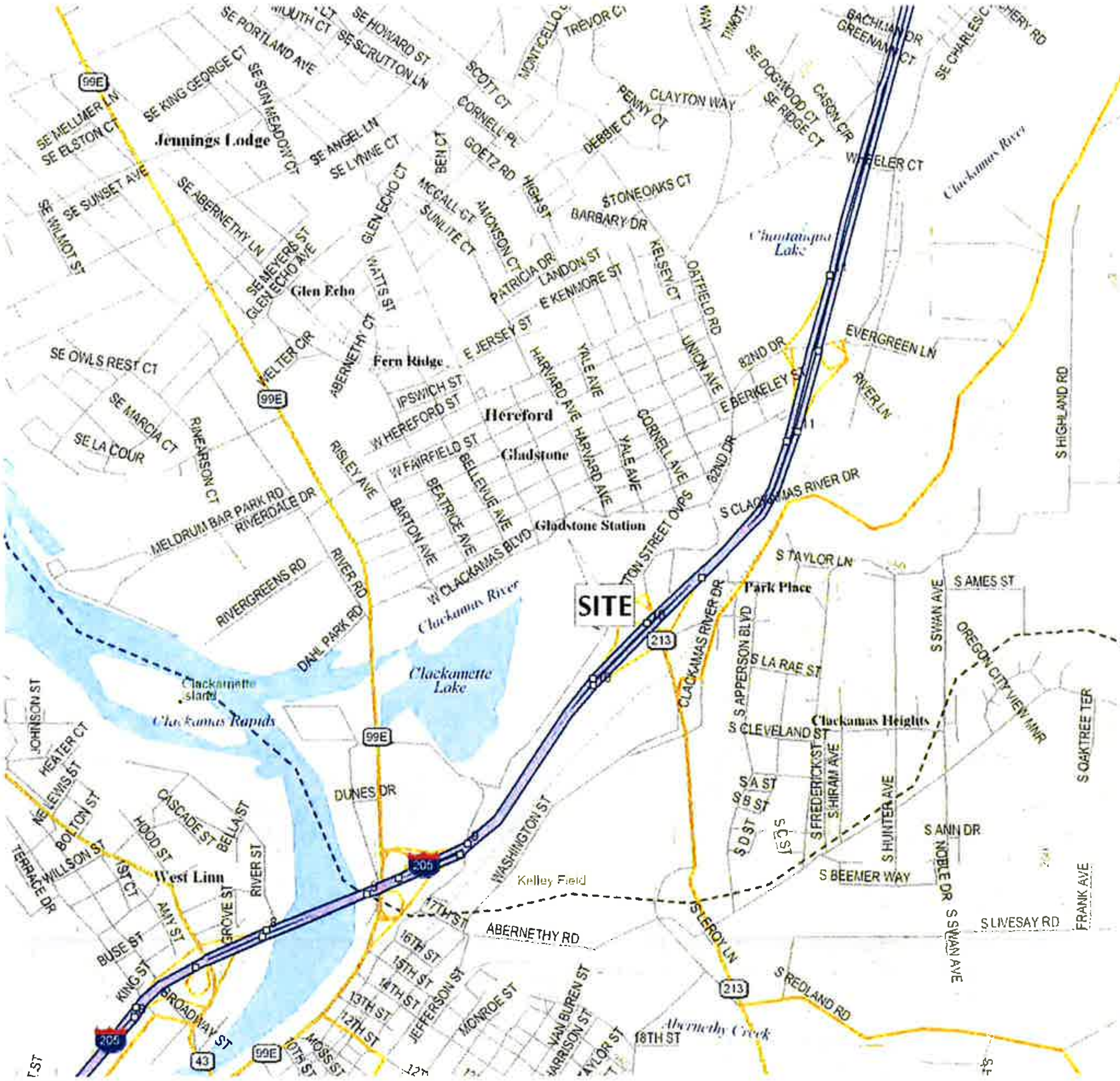
RQD AND ROCK QUALITY:

Relation of RQD and Rock Quality

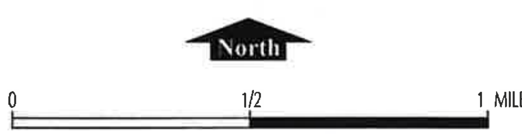
RQD (Rock Quality Designation), %	Description of Rock Quality
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

Terminology for Planar Surface

Bedding	Joints and Fractures	Spacing
Laminated	Very Close	< 2 in.
Thin	Close	2 in. – 12 in.
Medium	Moderately Close	12 in. – 36 in.
Thick	Wide	36 in. – 10 ft
Massive	Very Wide	> 10 ft



DELORME 3-D TOPOQUADS, OREGON
GLADSTONE, OREG. (3dc) 2004

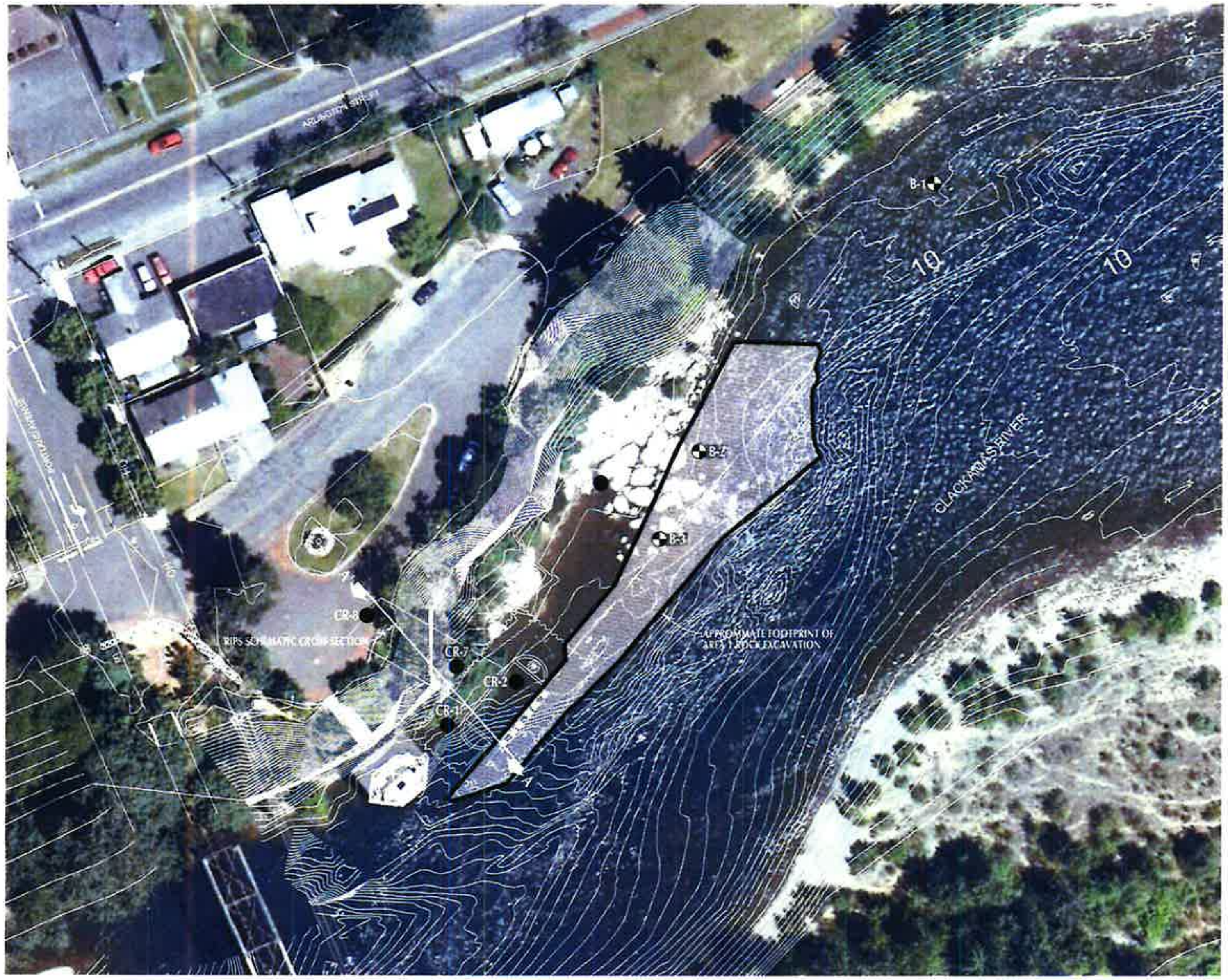


GRI

BLACK & VEATCH
LAKE OSWEGO TIGARD WATER PARTNERSHIP
RIVER INTAKE STATION

VICINITY MAP

JAN. 2012 | JOB NO. 5262-A | FIG. 1



BORING MADE BY GRI (OCTOBER 17 - 18, 2011)

BORING MADE BY GEODESIGN, INC. (MARCH 2011)

NOTE: FOR RIPS SCHEMATIC CROSS SECTION SEE FIGURE 3

SITE PLAN FROM GOOGLE EARTH, DATED AUGUST 20, 2011

North

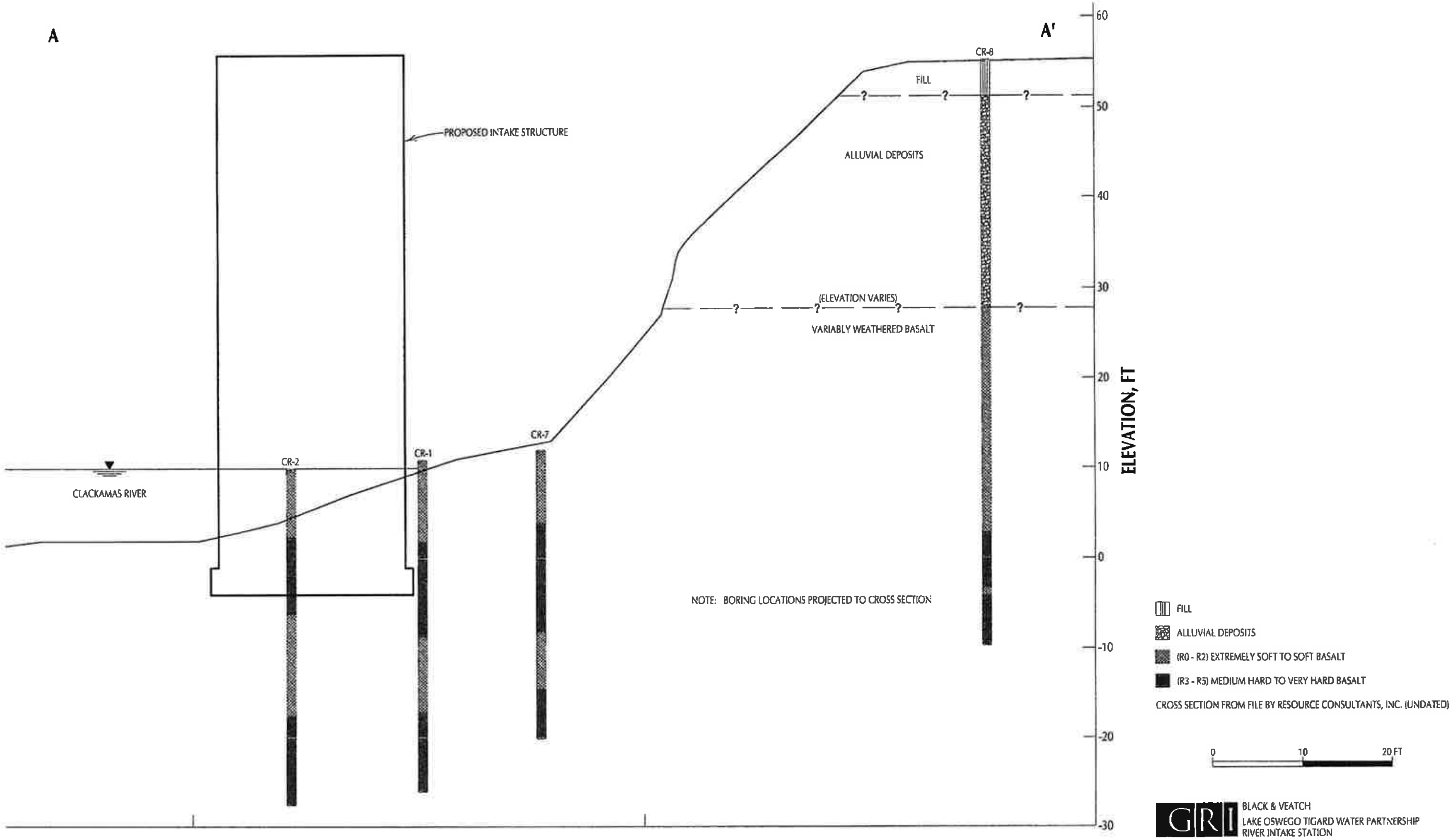
0 50 100 FT

GRI

BLACK & VEATCH
LAKE OSWEGO TIGARD WATER PARTNERSHIP
RIVER INTAKE STATION

SITE PLAN

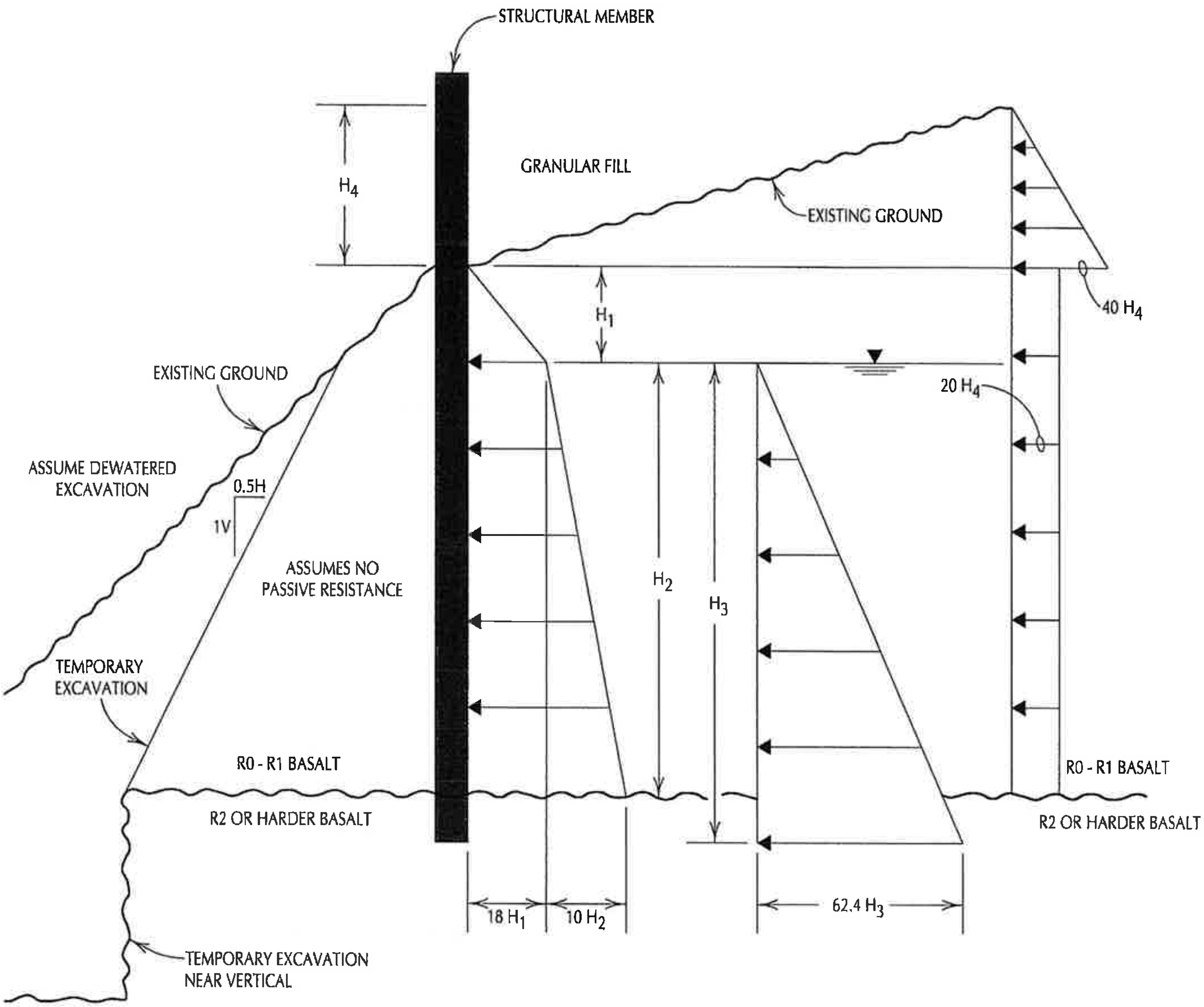
JAN. 2012 | JOB NO. 5262-A | FIG. 2



BLACK & VEATCH
LAKE OSWEGO TIGARD WATER PARTNERSHIP
RIVER INTAKE STATION

RIPS SCHEMATIC CROSS SECTION

JAN. 2012 | JOB NO. 5262-A | FIG. 3



NOTES:

1) SURCHARGE PRESSURES FROM CONSTRUCTION EQUIPMENT NOT SHOWN

2) STRUTS AND ANTICIPATED BRACING ARE NOT SHOWN

GRI

BLACK & VEATCH
LAKE OSWEGO TIGARD WATER PARTNERSHIP
RIVER INTAKE STATION

COFFERDAM EARTH PRESSURES

JAN. 2012 | JOB NO. 5262-A | FIG. 4

APPENDIX A

Geotechnical Data Report by GRI (December 12, 2011)

GRI
9725 SW Beaverton-Hillsdale Hwy, Suite 140
Beaverton, OR 97005-3364
p| 503-641-3478 f| 503-644-8034

December 12, 2011

5262-A GEOTECHNICAL DATA RPT
(REVISED)

Black & Veatch
4800 Meadows Road, Suite 200
Lake Oswego, OR 97035

Attention: Patrick Van Duser, PE

SUBJECT: Geotechnical Data Report
Upstream Rock Removal for River Intake Pump Station (RIPS)
Lake Oswego Tigard Water Partnership – Package 3
Gladstone, Oregon

GRI is conducting a geotechnical investigation for the proposed river intake pump station (RIPS) along the Clackamas River in Gladstone, Oregon. The Vicinity Map, Figure 1, shows the proposed location of the RIPS. This data report summarizes the results of the exploration program undertaken to characterize subsurface conditions upstream of the proposed intake, where rock may be removed to increase sweeping velocities for the proposed intake structure. The results of the explorations are summarized below.

Project Description

Replacement of the existing river intake pump station with a new RIPS is one element of the Lake Oswego Tigard Water Partnership – Package 3. The new RIPS will be constructed just upstream of the existing river intake pump station at the location shown on the Site Plan, Figure 2. GRI is currently preparing geotechnical design recommendations for the new RIPS structure as a subconsultant to Black & Veatch (B&V). Additional subconsultants to the B&V team include R2 Resource Consultants, Inc. (R2) and OBEC Consulting Engineers (OBEC).

Brown and Caldwell is the lead consultant for the Program Management Team (PMT) for the Lake Oswego Tigard Water Partnership. As a subconsultant to Brown and Caldwell, GeoDesign completed a series of borings to assist with preliminary design. The results of this exploration program are provided in GeoDesign's March 7, 2011, report entitled "Geotechnical Data Report, Proposed River Intake Pump Station."

Based on the modeling presented by R2 in their Technical Memorandum dated November 14, 2011, they propose removing material upstream of the new RIPS to improve the sweeping velocity across the intake screens. As presently envisioned this would include removing about 1,000 cy of material over a footprint of about 209 by 52 ft, as shown on Figure 2. The depth of the excavation would vary from a few feet to a maximum depth of about 8 ft.

Site Description

The proposed RIPS is located on the right bank of the Clackamas River in Gladstone, Oregon, near Charles Ames Memorial Park. The Site Plan, Figure 2, shows the location of the existing river intake pump station and the approximate location of the new RIPS. During low water conditions, a relatively flat portion of the right riverbank is exposed just upstream of the existing pump station. Available topographic information indicates this area typically ranges in elevation from about +10 to +15 ft. The topography between the relatively flat portion of the riverbank and the park level near elevation+ 55 ft quickly transitions to nearly vertical in some areas. All elevations are referenced to the NGVD 29 datum.

Geology

Volcanic rocks of the Tertiary Columbia River Basalt Group are exposed along the riverbank in the area of the proposed excavation (Walker, 1991). Weathering of the basalt is highly variable horizontally and vertically and ranges from slightly weathered to predominately decomposed into residual clay, silt, and sand. In the project area, boulder-size corestones of relatively hard, unweathered rock are present in the more weathered portions of the basalt.

Subsurface Conditions

General. GRI investigated subsurface materials and conditions in the area of the proposed excavation for the new RIPS with three borings, designated B-1 through B-3, between October 17 and 19, 2011. Figure 2 shows the locations of the borings completed by GRI and GeoDesign. A discussion of the field exploration and laboratory testing programs accomplished for this investigation is provided in Appendix A. Logs of GRI borings are provided on Figures 1A through 3A. Logs of GeoDesign's borings will be included with our geotechnical report for the proposed RIPS.

Basalt was encountered from the ground surface to the maximum depth explored in the three borings. The degree of weathering and hardness of the basalt vary widely. The basalt unit is described in more detail below; the terms used to describe the rock encountered in the borings are defined in Table 1A.

Basalt. Hard to very hard (R4 to R5) basalt was encountered at the ground surface of borings B-2 and B-3 and extends to a depth of about 6.5 to 7.5 ft, respectively. The hard to very hard basalt is light to dark gray, ranges from slightly weathered to fresh, and is vesicular. Unconfined compressive strength (UCS) testing completed on samples of the hard to very hard basalt ranged from 11,569 to 31,953 psi; the results are summarized in Appendix B. Fracture spacing ranges from close to wide, and the fractures are stained orange or filled with gray clay. Rock Quality Designations (RQD) typically range from 90 to 95% in the medium hard to hard basalt, indicating the rock quality is generally excellent. However, the RQD is 0% between a depth of about 5 and 6.5 ft in boring B-2. Below a depth of 5 ft in boring B-2, the medium hard to hard basalt becomes dark green to dark gray with very close to closely spaced fractures stained green, blue, and white. The basalt becomes increasingly weathered below 6.5 ft in boring B-2 and below 8.7 ft in boring B-3, and is classified as extremely soft to soft in hardness.

Extremely soft to soft (R0 to R2) basalt was observed at the ground surface in boring B-1 and below the medium hard to hard basalt in borings B-2 and B-3. These extremely soft to soft (R0 to R2) materials extend to the maximum depths explored of 15 to 16 ft in the three borings. The extremely soft to soft (R0 to R2) basalt ranges from dark gray to orangish gray to reddish brown and is predominately decomposed to slightly weathered. UCS testing completed on samples of the extremely soft to soft basalt ranged from 127 to 1,044 psi; the results are summarized in Appendix B. The rock is vesicular, and fractures are very close to close and typically filled with sand, silt, and clay. RQD values in the extremely soft to soft basalt vary from 0% to 75%, indicating the rock quality varies from very poor to fair.

Groundwater. Groundwater at the boring locations is expected to fluctuate with the elevation of the Clackamas River.

Limitations

This data report has been prepared to aid the project team in the evaluation of subsurface materials and conditions upstream of the proposed river intake pump station (RIPS) location. The scope is limited to the specific project and location described herein, and our description of the project represents our understanding of the significant aspects of the project relevant to the design and construction of the improvements.

Please contact the undersigned if you have any questions or comments.

Submitted for GRI,

REGISTERED PROFESSIONAL ENGINEER 74883PE OREGON May 11, 2004 SCOTT M. SCHLECHTER Renews 6/2012

Scott M. Schlechter, PE, GE
Associate

Michael J. Zimmerman, PE, GE, CEG
Senior Engineer /Geologist

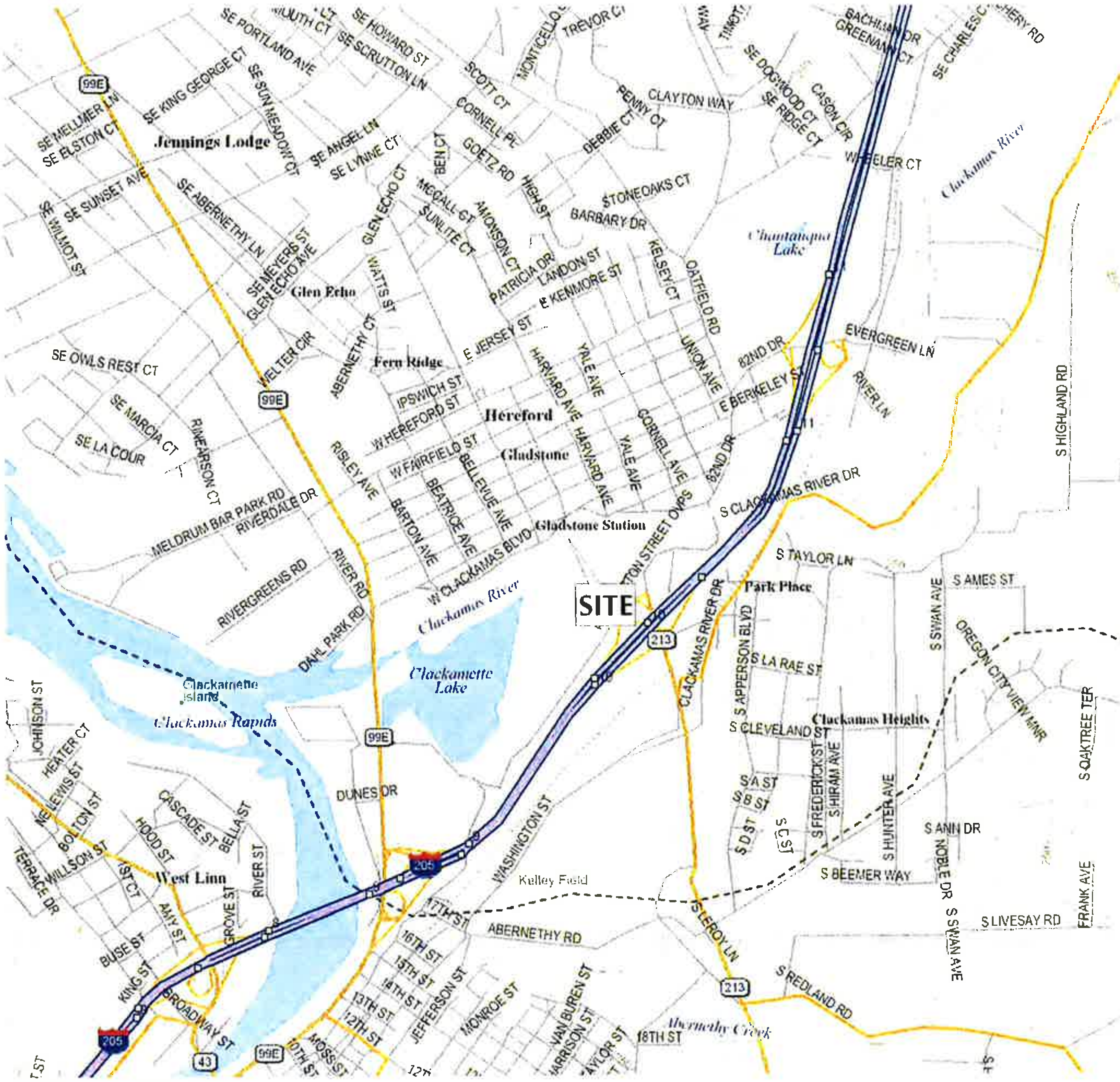
H. Stanley Kelsay, PE, GE
Principal Engineer

References

Hull, D. A., 1979, Geology and geologic hazards of northwestern Clackamas County, Oregon: Department of Geology and Mineral Industries Bulletin 99.

Walker, G. W., and MacLeod, N. S., 1991, Geologic map of Oregon, 1:500,000, USGS.

This document has been submitted electronically.



DELORME 3-D TOPOQUADS, OREGON
GLADSTONE, OREG. (3dc) 2004

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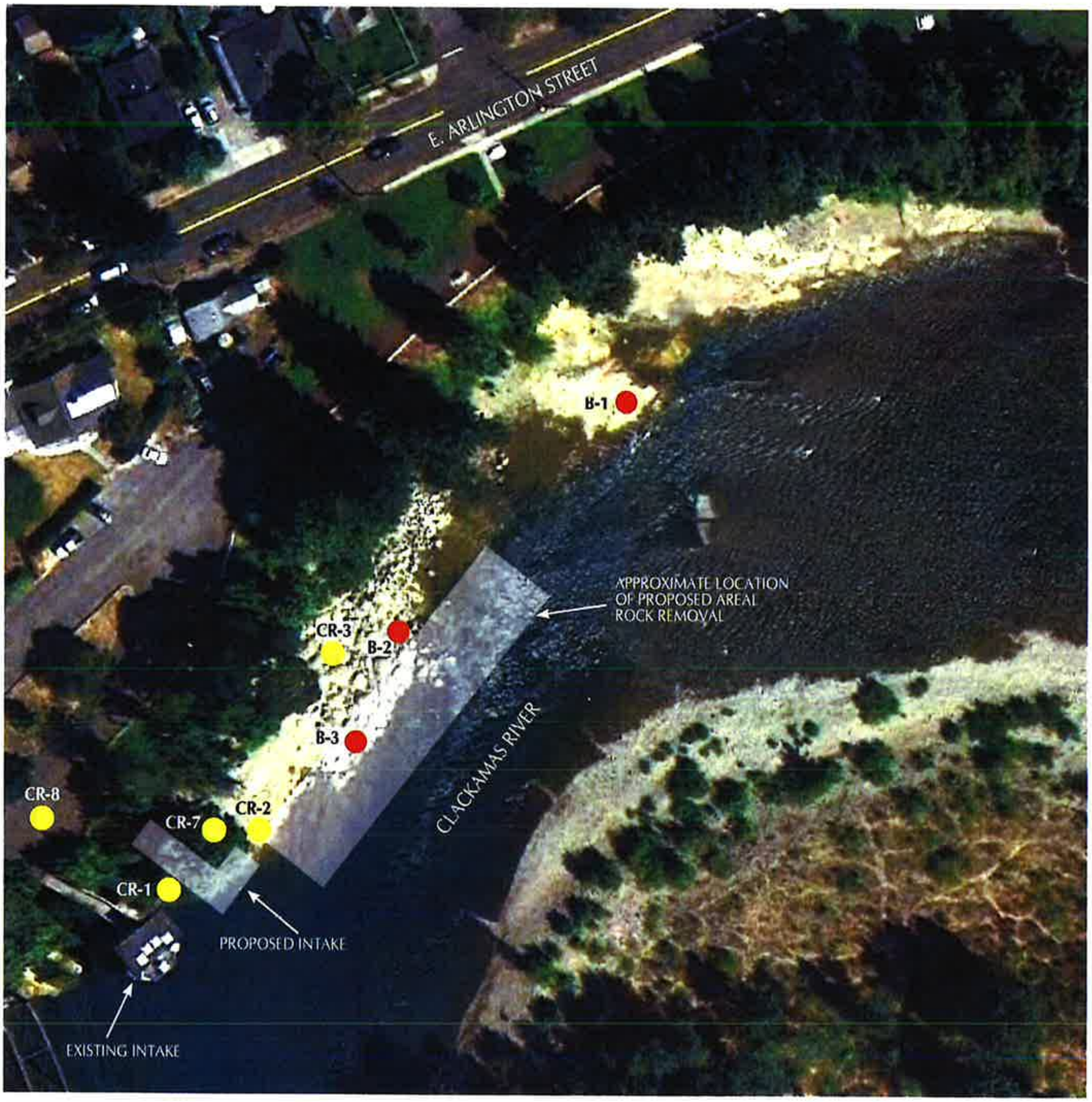
LAKE OSWEGO TIGARD WATER PARTNERSHIP
RIVER INTAKE STATION

VICINITY MAP

DEC. 2011 | JOB NO. 5262-A | FIG. 1



BASE MAP FROM GOOGLE EARTH (AUGUST 20, 2011)

NORTH

0 160 FT
(APPROXIMATE)

BORING MADE BY GRI
(OCTOBER 17-18, 2011)

BORING MADE BY GEODESIGN
(MARCH 2011)

GRI

BLACK & VEATCH
LAKE OSWEGO TIGARD WATER PARTNERSHIP
RIVER INTAKE STATION

SITE PLAN

DEC. 2011 JOB NO. 5262-A FIG. 2

APPENDIX A

Field Explorations

APPENDIX A

FIELD EXPLORATIONS

General

Subgrade materials and conditions for the Lake Oswego Tigard Water Partnership River Intake Pump Station (RIPS) were investigated by GRI between October 17 and 19, 2011, with three borings, designated B-1 through B-3. A geotechnical engineer from GRI maintained a detailed log of the materials and conditions encountered in the explorations. Logs of the borings are provided on Figures 1A through 3A. Each log provides a descriptive summary of the various types of materials encountered and notes the depth where the material and/or characteristics of the material change. The terms used to describe the rock encountered in the explorations are defined in Tables 1A. To the right of the descriptive summaries, the depths and types of samples taken are indicated. Where applicable, percent core recovery and Rock Quality Designation index are also summarized. To the left of the descriptive summary on the boring logs, a graphic log indicates the general soil or rock types encountered.

The borings were completed using NQ wireline coring techniques with a portable drill rig provided and operated by PLI Systems of Hillsboro, Oregon. The NQ wireline coring technique allows 5-ft-long, relatively unfractured and intact "runs" to be extracted from the ground and observed. The rock cores were classified in the field, including hardness, color, fractures, and other notable aspects. Field measurements of the rock samples include the length of rock recovered relative to the run length, as well as the Rock Quality Designation, which is a measure of the unfractured length of rock relative to the run length. The rock cores were saved in core boxes and returned to our laboratory for further examination and testing. Logs of the borings are provided on Figures 1A through 3A. Photographs of the samples obtained from the boring are provided after the boring logs.

Unconfined Compressive Strength

Seven unconfined compressive strength tests were conducted in conformance with ASTM D 2938 to obtain data on the strength characteristics of representative intact rock core samples. The Colorado School of Mines Earth Mechanics Institute in Golden, Colorado, performed the tests as a subcontractor to GRI. Unconfined compressive strength tests were performed with the load oriented along the axis of the core samples. The results of the compressive strength tests are tabulated below. Data forms for individual tests are provided in Appendix B.

SUMMARY OF UNCONFINED COMPRESSIVE ROCK STRENGTH

Boring	Core Run	Depth, ft	Unconfined Compressive Strength, psi	Failure Type (see Appendix B)	Rock Description
B-1	1	2.5	222	Non-Structural	BASALT; extremely soft to very soft (R0 to R1)
	1	7.0	127	Structural	BASALT; extremely soft to very soft (R0 to R1)
B-2	1	1.25	21,815	Non-Structural	BASALT; hard to very hard (R4 to R5)
	1	2.25	24,575	Non-Structural	BASALT; hard to very hard (R4 to R5)
B-3	1	1.0	31,953	Non-Structural	BASALT; hard to very hard (R4 to R5)
	2	5.0	11,569	Non-Structural	BASALT; hard to very hard (R4 to R5)
	3	8.0	1,044	Structural	BASALT; soft to medium hard (R2 to R3)

Table 1A

GUIDELINES FOR CLASSIFICATION OF ROCK

RELATIVE ROCK WEATHERING SCALE:

Term	Field Identification
Fresh	Crystals are bright. Discontinuities may show some minor surface staining. No discoloration in rock fabric.
Slightly Weathered	Rock mass is generally fresh. Discontinuities are stained and may contain clay. Some discoloration in rock fabric. Decomposition extends up to 1 in. into rock.
Moderately Weathered	Rock mass is decomposed 50% or less. Significant portions of rock show discoloration and weathering effects. Crystals are dull and show visible chemical alteration. Discontinuities are stained and may contain secondary mineral deposits.
Predominantly Decomposed	Rock mass is more than 50% decomposed. Rock can be excavated with geologist's pick. All discontinuities exhibit secondary mineralization. Complete discoloration of rock fabric. Surface of core is friable and usually pitted due to washing out of highly altered minerals by drilling water.
Decomposed	Rock mass is completely decomposed. Original rock "fabric" may be evident. May be reduced to soil with hand pressure.

RELATIVE ROCK HARDNESS SCALE:

Term	Hardness Designation	Field Identification	Approximate Unconfined Compressive Strength
Extremely Soft	R0	Can be indented with difficulty by thumbnail. May be moldable or friable with finger pressure.	< 100 psi
Very Soft	R1	Crumbles under firm blows with point of a geology pick. Can be peeled by a pocket knife and scratched with fingernail.	100 - 1,000 psi
Soft	R2	Can be peeled by a pocket knife with difficulty. Cannot be scratched with fingernail. Shallow indentation made by firm blow of geology pick.	1,000 - 4,000 psi
Medium Hard	R3	Can be scratched by knife or pick. Specimen can be fractured with a single firm blow of hammer/geology pick.	4,000 - 8,000 psi
Hard	R4	Can be scratched with knife or pick only with difficulty. Several hard hammer blows required to fracture specimen.	8,000 - 16,000 psi
Very Hard	R5	Cannot be scratched by knife or sharp pick. Specimen requires many blows of hammer to fracture or chip. Hammer rebounds after impact.	> 16,000 psi

RQD AND ROCK QUALITY:

Relation of RQD and Rock Quality

RQD (Rock Quality Designation), %	Description of Rock Quality
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

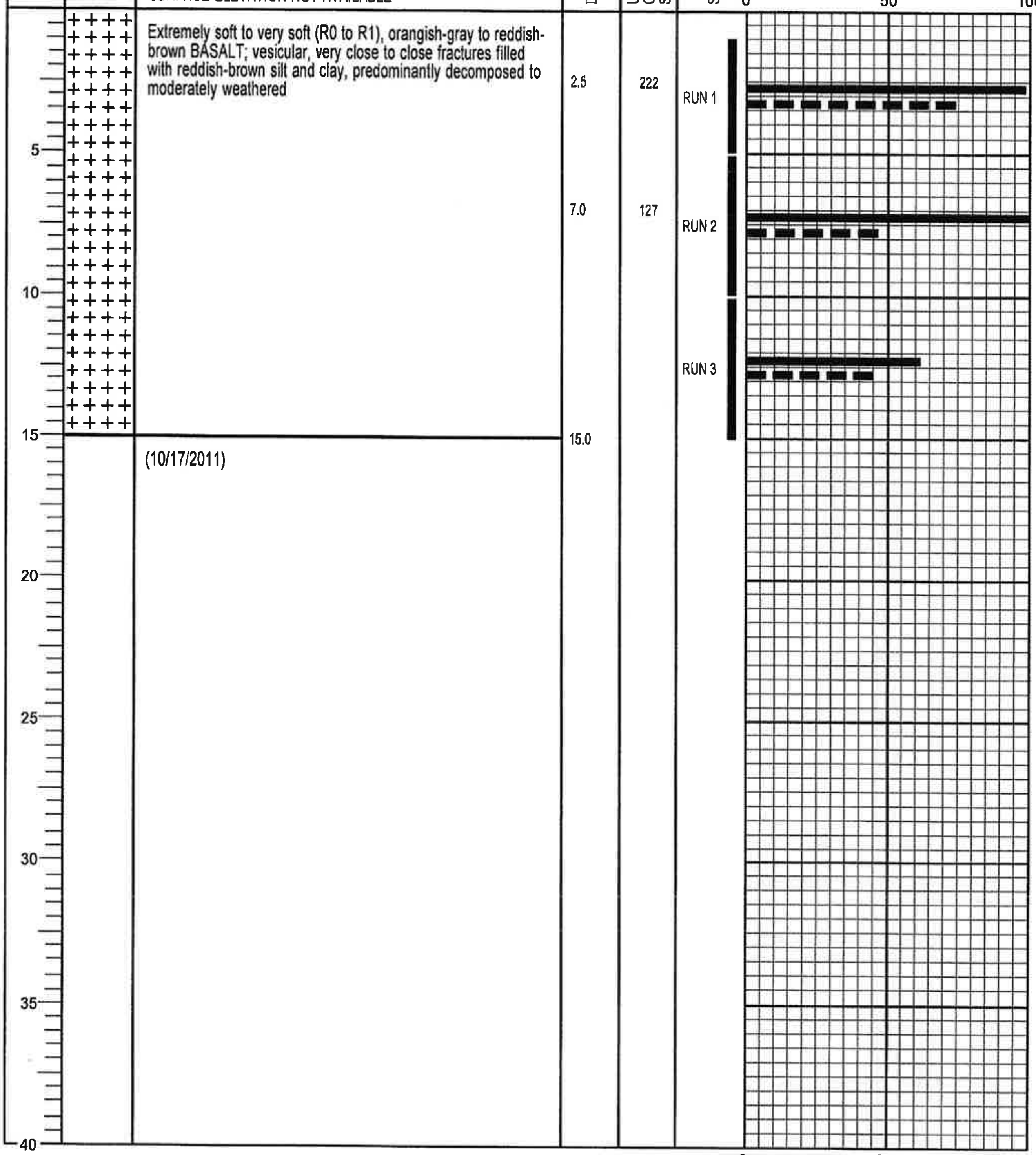
Terminology for Planar Surface

Bedding	Joints and Fractures	Spacing
Laminated	Very Close	< 2 in.
Thin	Close	2 in. – 12 in.
Medium	Moderately Close	12 in. – 36 in.
Thick	Wide	36 in. – 10 ft
Massive	Very Wide	> 10 ft

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL SURFACE ELEVATION NOT AVAILABLE	DEPTH, FT	UNCONFINED COMPRESSIVE STRENGTH, PSI	SAMPLES
0–15	+ + + +	Extremely soft to very soft (R0 to R1), orangish-gray to reddish-brown BASALT; vesicular, very close to close fractures filled with reddish-brown silt and clay, predominantly decomposed to moderately weathered	2.5	222	RUN 1
			7.0	127	RUN 2
					RUN 3
15		(10/17/2011)	15.0		

STD PENETRATION RESISTANCE
(140-LB WEIGHT, 30-IN. DROP)

▲ BLOWS PER FOOT
● MOISTURE CONTENT, %
CORE RECOVERY, %
RQD, %



I 2-IN.-OD SPLIT-SPOON SAMPLER
II 3-IN.-OD THIN-WALLED SAMPLER
G GRAB SAMPLE OF DRILL CUTTINGS
▮ NX CORE RUN
|—SLOTTED PVC PIPE
▼ Water Level (date)

◆ TORVANE SHEAR STRENGTH, TSF
□ PERCENT PASSING NO. 200 SIEVE (WASHED)
* NO RECOVERY
Liquid Limit
Moisture Content
Plastic Limit

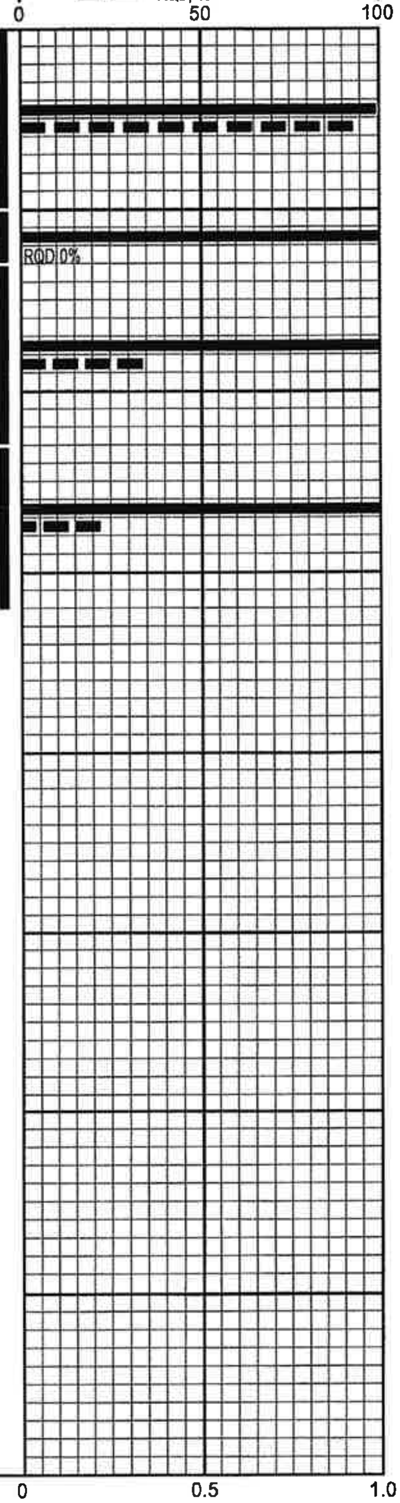
GRI

BORING B-1

DEC. 2011 | JOB. NO. 5262-A | FIG. 1A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL SURFACE ELEVATION NOT AVAILABLE	DEPTH, FT	UNCONFINED COMPRESSIVE STRENGTH, PSI	SAMPLES
0–16	+ + + +	Hard to very hard (R4 to R5), light to dark gray BASALT; vesicular, close to wide fractures stained orange or filled with gray clay, slightly weathered to fresh	1.25	21,815	
			2.25	24,575	RUN 1
5		---------dark green to dark gray, medium hard (R3), very close to close fractures stained green, blue, and white below 5 ft			RUN 2
		---------very soft to soft (R1 to R2), dark gray to dark brown, very close to close fractures filled with gray clay to clean, moderately weathered below 6.5 ft			
10					RUN 3
15					RUN 4
16		(10/18/2011)	16.0		
20, 25, 30, 35, 40					

STD PENETRATION RESISTANCE
(140-LB WEIGHT, 30-IN. DROP)
▲ BLOWS PER FOOT
● MOISTURE CONTENT, %
CORE RECOVERY, %
RQD, %



(TONS PER FT ²)

I 2-IN.-OD SPLIT-SPOON SAMPLER
II 3-IN.-OD THIN-WALLED SAMPLER
G GRAB SAMPLE OF DRILL CUTTINGS
▌ NX CORE RUN
|— SLOTTED PVC PIPE
▼ Water Level (date)

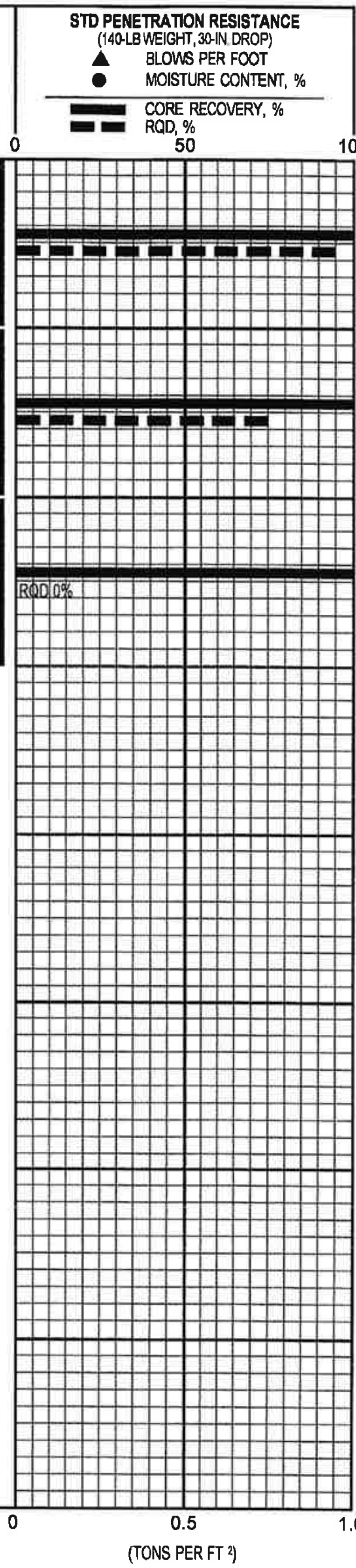
◆ TORVANE SHEAR STRENGTH, TSF
□ PERCENT PASSING NO. 200 SIEVE (WASHED)
* NO RECOVERY
Liquid Limit
Moisture Content
Plastic Limit

GRI

BORING B-2

DEC. 2011 JOB. NO. 5262-A FIG. 2A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL SURFACE ELEVATION NOT AVAILABLE	DEPTH, FT	UNCONFINED COMPRESSIVE STRENGTH, PSI	SAMPLES
0–15	+ + + +	Hard to very hard (R4 to R5), light to dark gray BASALT; vesicular, close to wide fractures stained orange or filled with gray clay, slightly weathered to fresh	1.0	31,953	RUN 1
			5.0	11,569	
		---------soft to medium hard (R2 to R3) below 7.5 ft	8.0	1,044	RUN 2
		---------extremely soft to very soft (R0 to R1), greenish gray to rust brown, very close to close fractures filled with sand, silt, and clay, moderately to slightly weathered below 8.7 ft			RUN 3
15		(10/18/2011)	15.0		

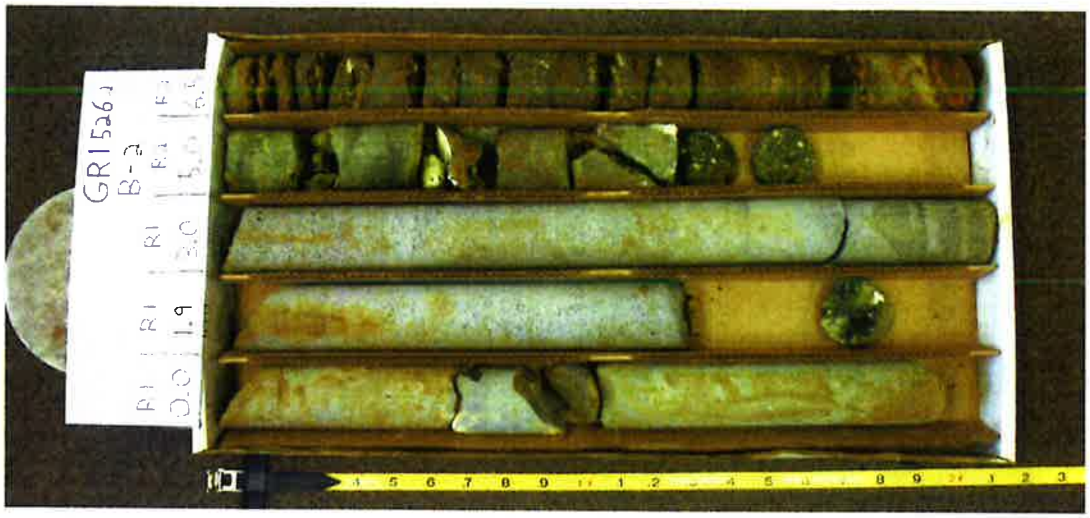


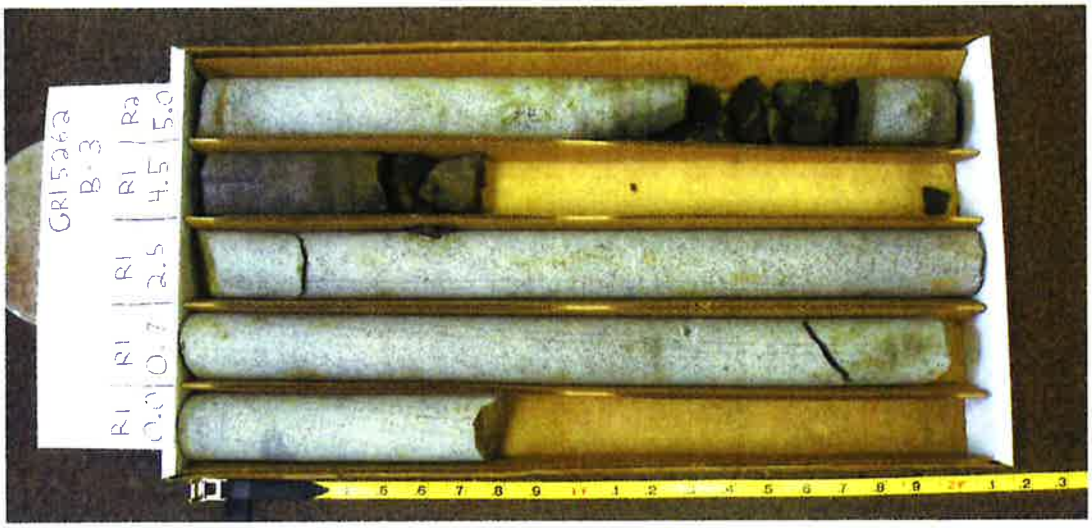
I 2-IN.-OD SPLIT-SPOON SAMPLER
II 3-IN.-OD THIN-WALLED SAMPLER
G GRAB SAMPLE OF DRILL CUTTINGS
▮ NX CORE RUN
—SLOTTED PVC PIPE
▼ Water Level (date)
◆ TORVANE SHEAR STRENGTH, TSF
□ PERCENT PASSING NO. 200 SIEVE (WASHED)
* NO RECOVERY
Liquid Limit
Moisture Content
Plastic Limit

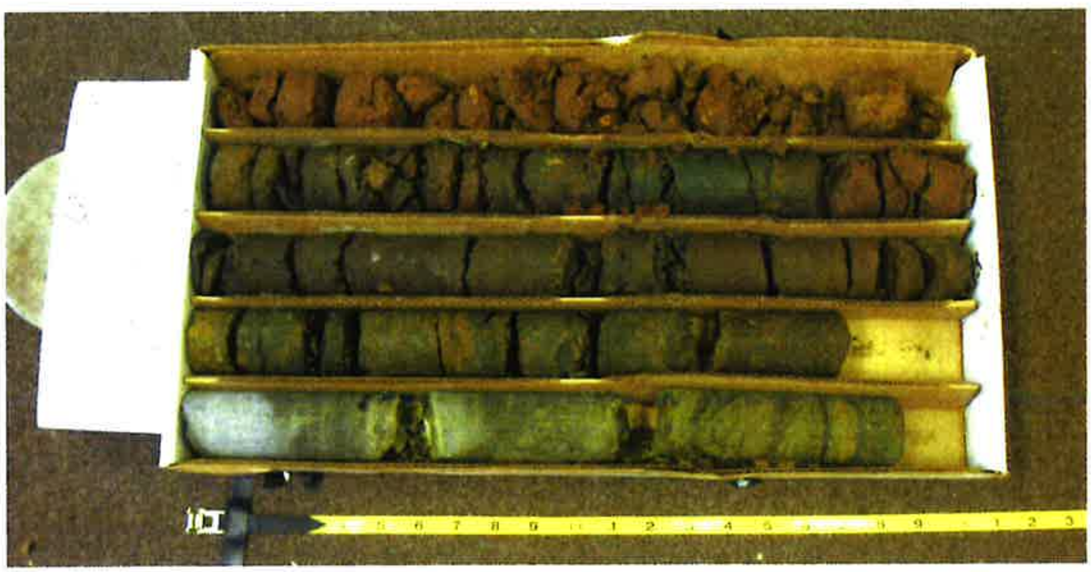
GRI

BORING B-3

DEC. 2011 JOB. NO. 5262-A FIG. 3A


GR15261
B-2





APPENDIX B

Unconfined Compressive Strength Testing

Earth Mechanics Institute

Client: GRI

Location: N/A

Project Name: 5262

Colorado School of Mines

Mining Engineering Department

Date: 11/28/2011							Uniaxial Compressive Strength			
Sample ID	Rock Type	Average Length	Average Diameter	Length to Diameter Ratio	Density	Failure Load	Failure Stress	UCS (2:1)		Notes *(Failure type)*
		(in)	(in)		(lbs/ft^3)	(lbs)	σ_c (psi)	(psi)	(MPa)	
B-1@2.5	Weathered	4.006	2.090	1.92	109	759	221	222	1.5	Non-Structural
B-1@7.0	Weathered	4.128	2.062	2.00	104	420	126	127	0.9	Structural
B-2@1.25	Igneous	4.029	2.048	1.97	159	71,350	21,659	21,815	150.4	Non-Structural
B-2@2.25	Igneous	3.991	2.048	1.95	163	80,421	24,425	24,575	169.4	Non-Structural
B-3@1.0	Igneous	4.010	2.043	1.96	172	103,970	31,732	31,953	220.3	Non-Structural
B-3@5.0	Igneous	4.030	2.043	1.97	155	37,624	11,483	11,569	79.8	Non-Structural
B-3@8.0	Weathered	3.964	2.041	1.94	118	3,394	1,038	1,044	7.2	Structural

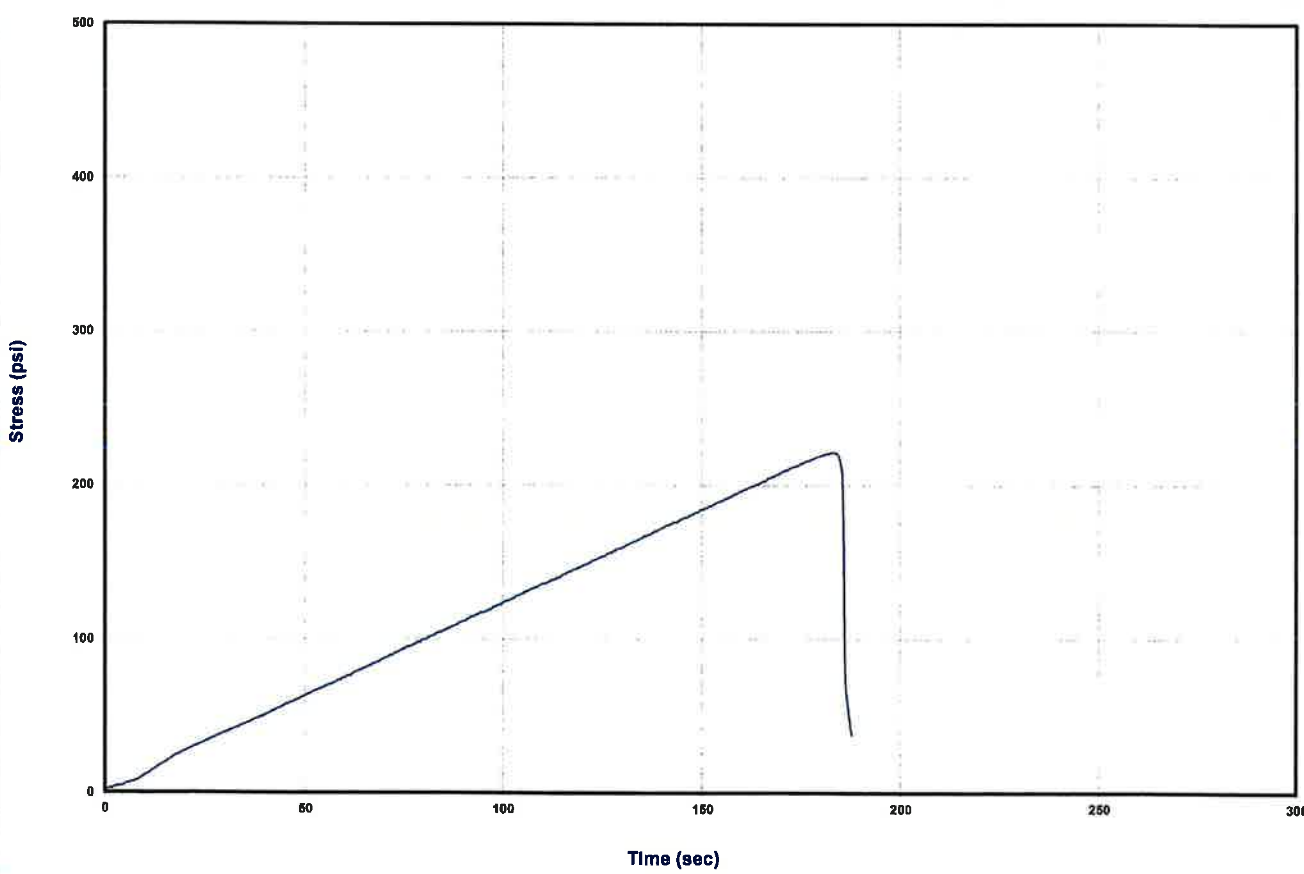
$$UCS_{2:1correction} = \frac{\sigma_c}{0.88 + 0.222(\frac{d}{l})}$$

Earth Mechanics Institute
Mining Engineering Department, CSM
Unconfined Compressive Strength

Client : GRI
Project : 5262
Location : N/A
Rock Type : Weathered
Rock Name : N/A
Characteristics : N/A
Core ID : B-1@2.5
File Name : B-1@2.5_UCS
Test Performed by : EAS
Date Tested : 11/16/11
Data Reduced by : EAS
Date Reduced : 11/28/11

Core Length		Diameter		L/D	Failure Load	Failure Stress	UCS 2:1		Failure Mode
in	cm	in	cm	Ratio	lbs	psi	psi	MPa	
4.006	10.18	2.090	5.31	1.92	759	221	222	1.5	Non-Structural

P-wave		S-wave		Dynamic E		Dynamic	Static E		Static	Density, ρ	
ft/sec	m/sec	ft/sec	m/sec	ksi	GPa	ν	ksi	GPa	ν	lb/ft^3	g/cm^3
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	109	1.75



Earth Mechanics Institute
Mining Engineering Department, CSM
Unconfined Compressive Strength

Client : GRI
Project : 5262
Location : N/A
Rock Type : Weathered
Rock Name : N/A
Characteristics : N/A
Core ID : B-1@7.0
File Name : B-1@7.0_UCS
Test Performed by : HH
Date Tested : 11/16/11
Data Reduced by : EAS
Date Reduced : 11/18/11

Core Length		Diameter		L/D	Failure Load	Failure Stress	UCS 2:1		Failure Mode
in	cm	in	cm	Ratio	lbs	psi	psi	MPa	
4.128	10.49	2.062	5.24	2.00	420	126	127	0.9	Structural

P-wave		S-wave		Dynamic E		Dynamic	Static E		Static	Density, ρ	
ft/sec	m/sec	ft/sec	m/sec	ksi	GPa	ν	ksi	GPa	ν	lb/ft³	g/cm³
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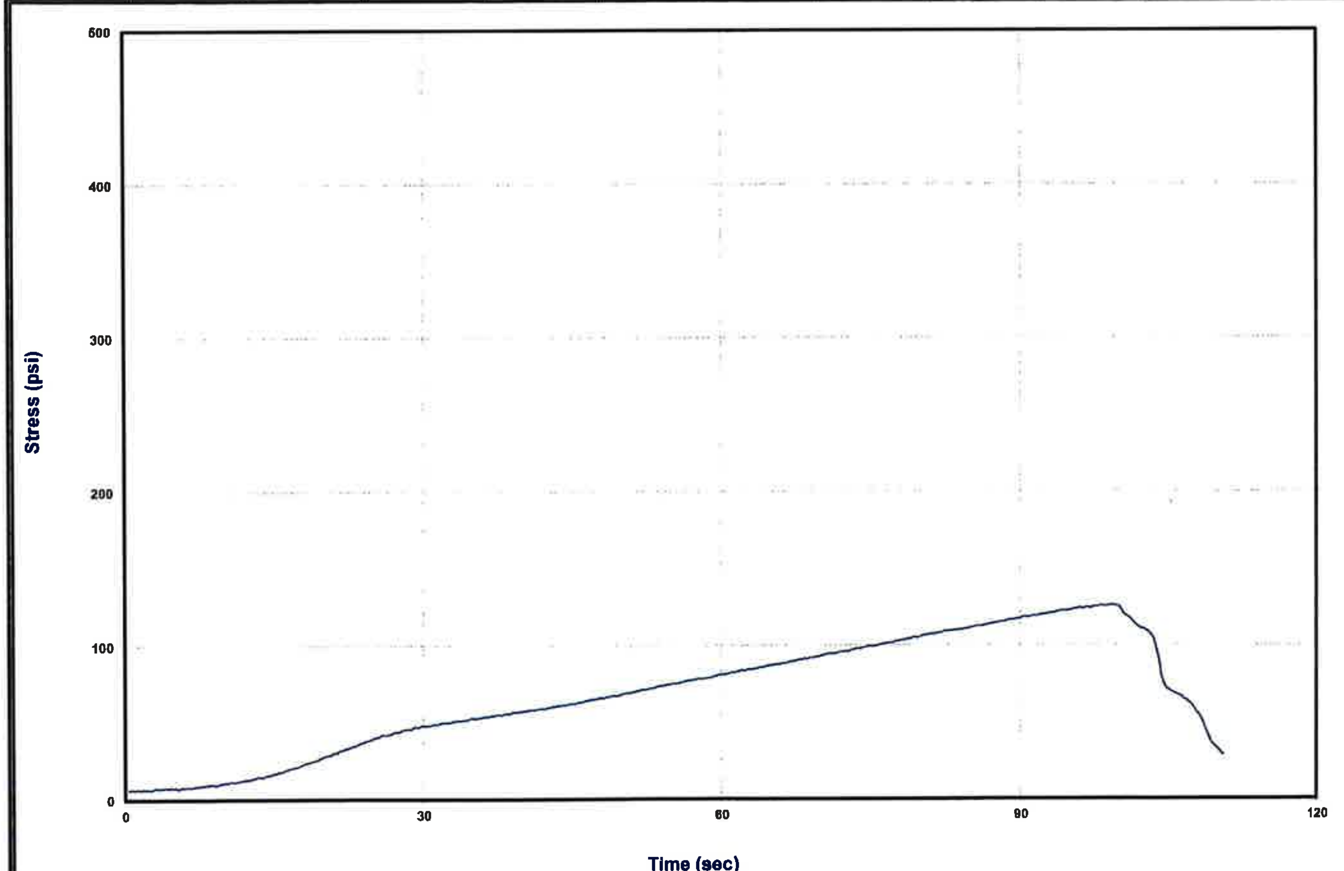


Earth Mechanics Institute

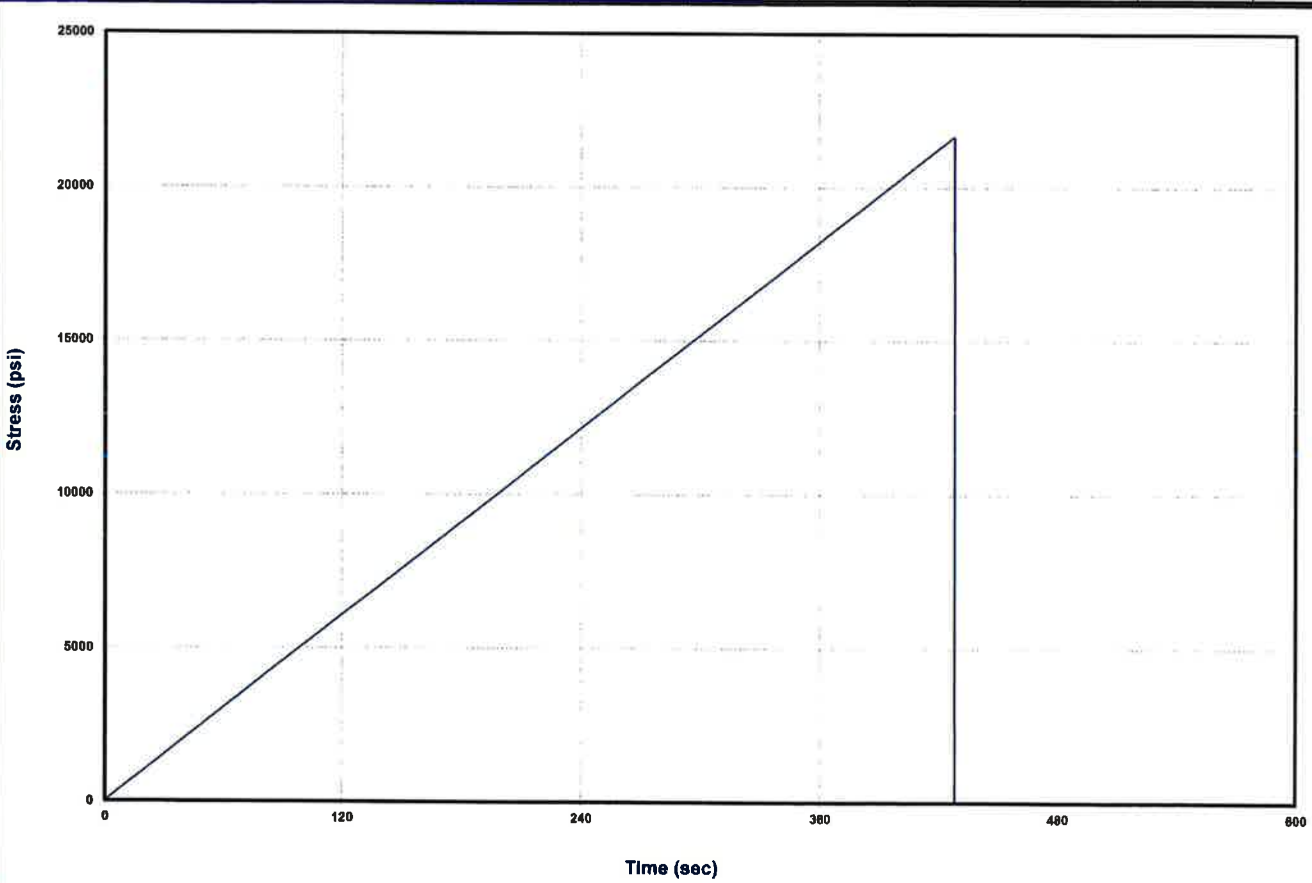
Mining Engineering Department, CSM

Unconfined Compressive Strength

Client : GRI
Project : 5262
Location : N/A
Rock Type : Igneous
Rock Name : N/A
Characteristics : N/A
Core ID : B-2@1.25
File Name : B-2@1.25_UCS
Test Performed by : EAS
Date Tested : 11/16/11
Data Reduced by : EAS
Date Reduced : 11/18/11

Core Length		Diameter		L/D	Failure Load	Failure Stress	UCS 2:1		Failure Mode
in	cm	in	cm	Ratio	lbs	psi	psi	MPa	
4.029	10.23	2.048	5.20	1.97	71,350	21,659	21,815	150.4	Non-Structural

P-wave		S-wave		Dynamic E		Dynamic	Static E		Static	Density, ρ	
ft/sec	m/sec	ft/sec	m/sec	ksi	GPa	ν	ksi	GPa	ν	lb/ft³	g/cm³
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	159	2.55

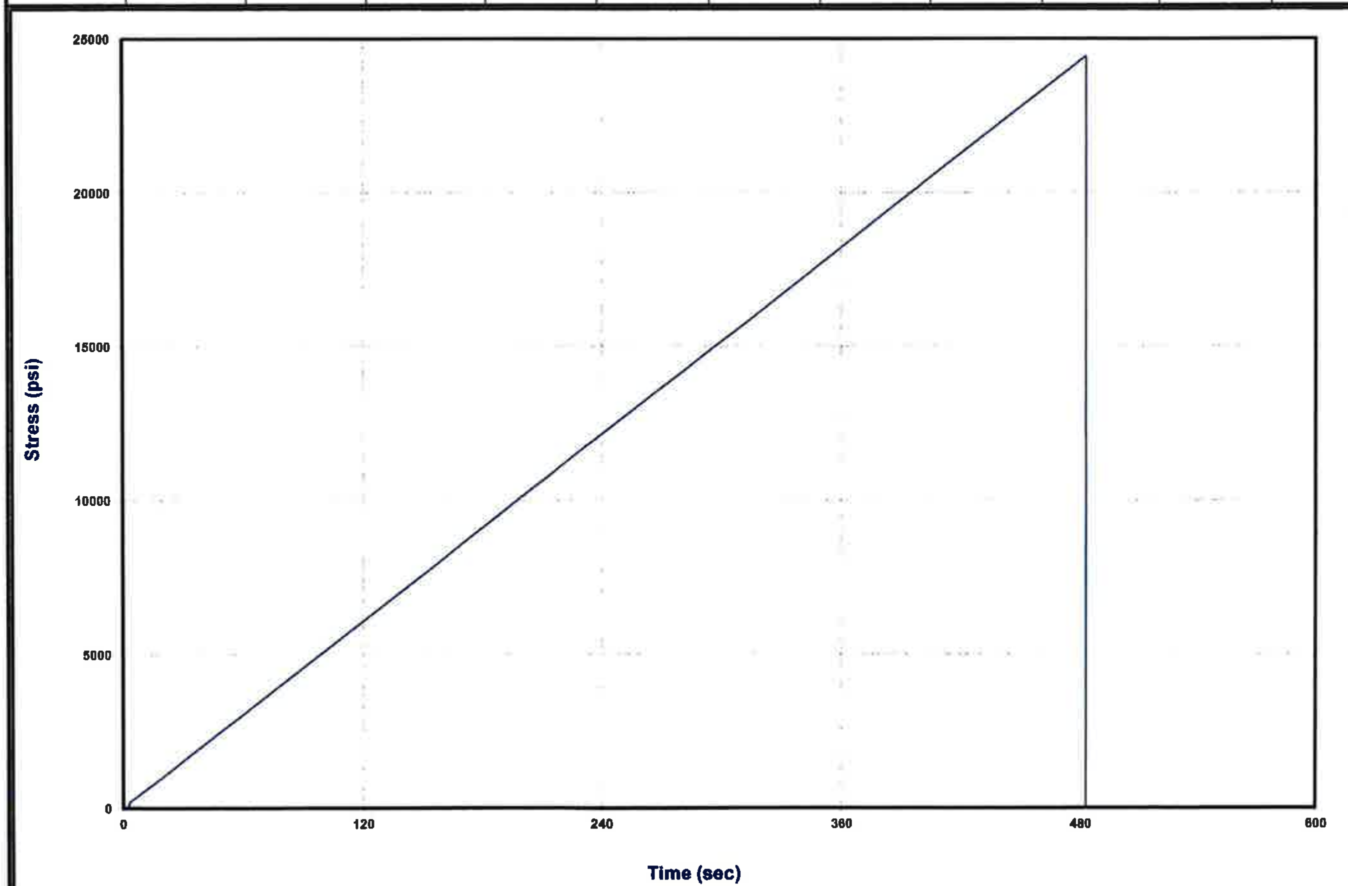


Earth Mechanics Institute
Mining Engineering Department, CSM
Unconfined Compressive Strength

Client : GRI
Project : 5262
Location : N/A
Rock Type : Igneous
Rock Name : N/A
Characteristics : N/A
Core ID : B-2@2.25
File Name : B-2@2.25_UCS
Test Performed by : EAS
Date Tested : 11/16/11
Data Reduced by : EAS
Date Reduced : 11/18/11

Core Length		Diameter		L/D	Failure Load	Failure Stress	UCS 2:1		Failure Mode
in	cm	in	cm	Ratio	lbs	psi	psi	MPa	
3.991	10.14	2.048	5.20	1.95	80,421	24,425	24,575	169.4	Non-Structural

P-wave		S-wave		Dynamic E		Dynamic	Static E		Static	Density, ρ	
ft/sec	m/sec	ft/sec	m/sec	ksi	GPa	ν	ksi	GPa	ν	lb/ft³	g/cm³
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	163	2.61



Earth Mechanics Institute

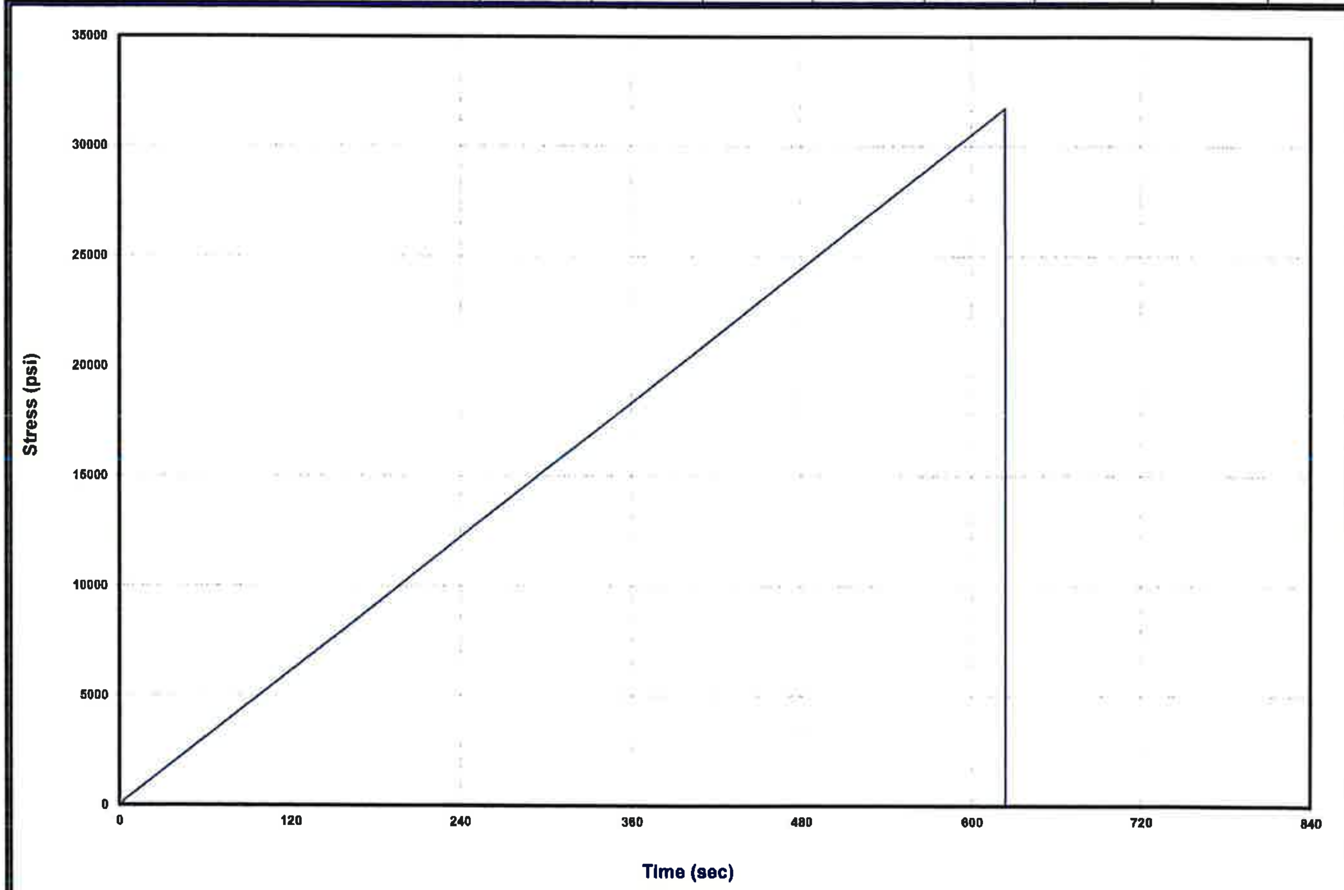
Mining Engineering Department, CSM

Unconfined Compressive Strength

Client : GRI
Project : 5262
Location : N/A
Rock Type : Igneous
Rock Name : N/A
Characteristics : N/A
Core ID : B-3@1.0
File Name : B-3@1.0_UCS
Test Performed by : HH
Date Tested : 11/16/11
Data Reduced by : EAS
Date Reduced : 11/18/11

Core Length		Diameter		L/D	Failure Load	Failure Stress	UCS 2:1		Failure Mode
in	cm	in	cm	Ratio	lbs	psi	psi	MPa	
4.010	10.19	2.043	5.19	1.96	103,970	31,732	31,953	220.3	Non-Structural

P-wave		S-wave		Dynamic E		Dynamic	Static E		Static	Density, ρ	
ft/sec	m/sec	ft/sec	m/sec	ksi	GPa	ν	ksi	GPa	ν	lb/ft^3	g/cm^3
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	172	2.76



Earth Mechanics Institute

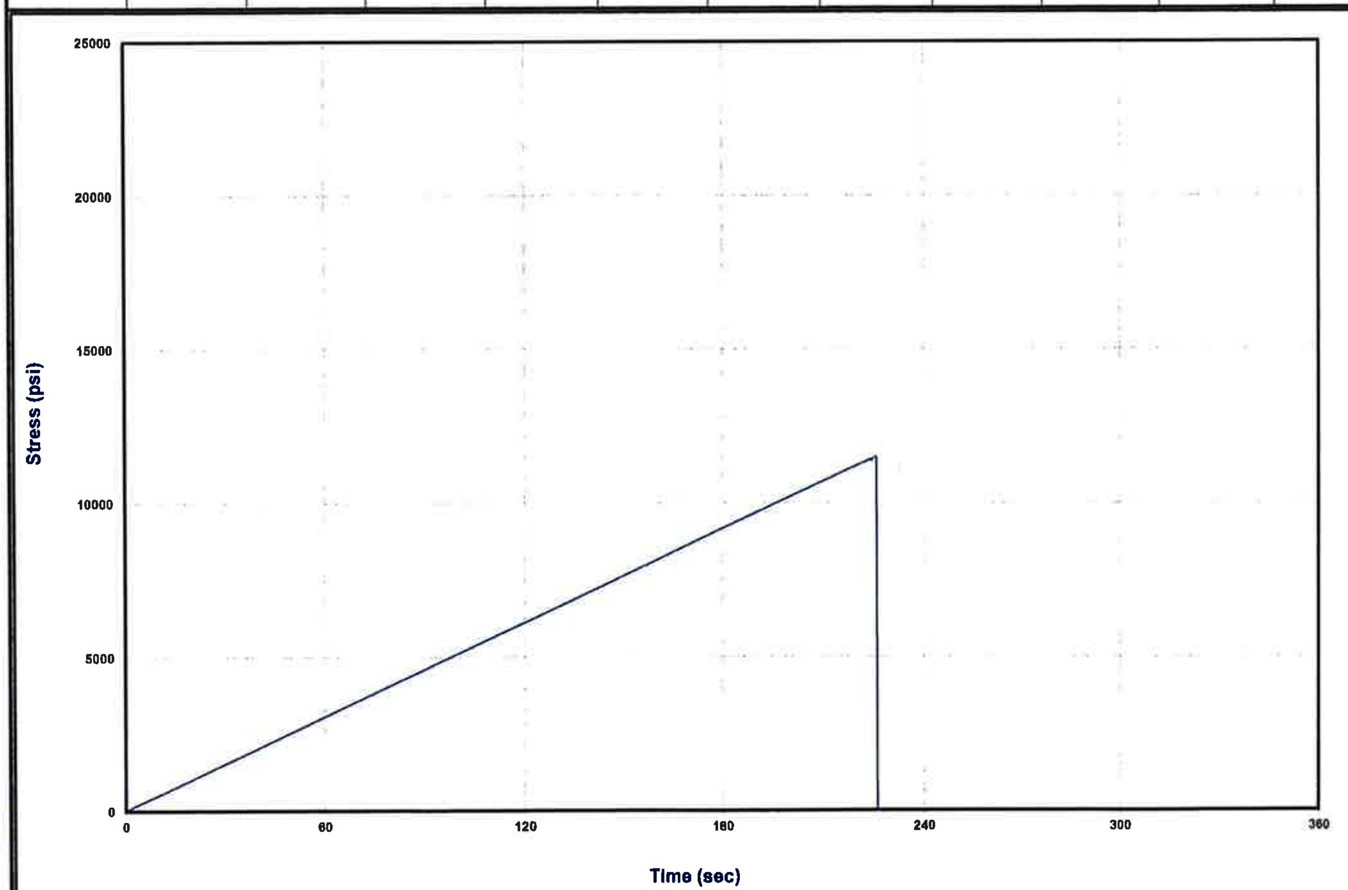
Mining Engineering Department, CSM

Unconfined Compressive Strength

Client : GRI
Project : 5262
Location : N/A
Rock Type : Igneous
Rock Name : N/A
Characteristics : N/A
Core ID : B-3@5.0
File Name : B-3@5.0_UCS
Test Performed by : HH
Date Tested : 11/16/11
Data Reduced by : EAS
Date Reduced : 11/18/11

Core Length		Diameter		L/D	Failure Load	Failure Stress	UCS 2:1		Failure Mode
in	cm	in	cm	Ratio	lbs	psi	psi	MPa	
4.030	10.24	2.043	5.19	1.97	37,624	11,483	11,569	79.8	Non-Structural

P-wave		S-wave		Dynamic E		Dynamic	Static E		Static	Density, ρ	
ft/sec	m/sec	ft/sec	m/sec	ksi	GPa	ν	ksi	GPa	ν	lb/ft³	g/cm³
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	155	2.48

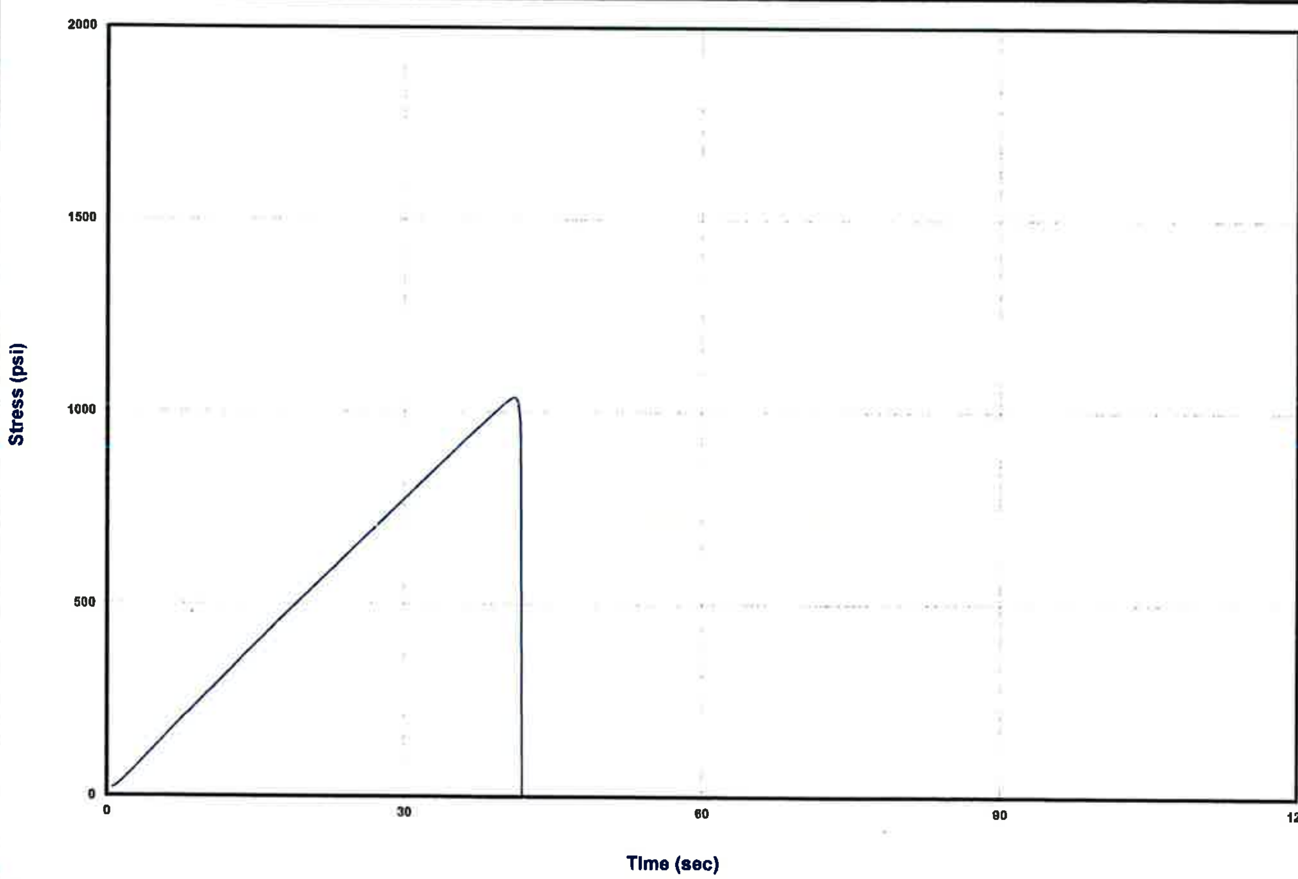


Earth Mechanics Institute
Mining Engineering Department, CSM
Unconfined Compressive Strength

Client : GRI
Project : 5262
Location : N/A
Rock Type : Weathered
Rock Name : N/A
Characteristics : N/A
Core ID : B-3@8.0
File Name : B-3@8.0_UCS
Test Performed by : HH
Date Tested : 11/16/11
Data Reduced by : EAS
Date Reduced : 11/18/11

Core Length		Diameter		L/D	Failure Load	Failure Stress	UCS 2:1		Failure Mode
in	cm	in	cm	Ratio	lbs	psi	psi	MPa	
3.964	10.07	2.041	5.18	1.94	3,394	1,038	1,044	7.2	Structural

P-wave		S-wave		Dynamic E		Dynamic	Static E		Static	Density, ρ	
ft/sec	m/sec	ft/sec	m/sec	ksi	GPa	ν	ksi	GPa	ν	lb/ft³	g/cm³
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	118	1.88



APPENDIX B

Geotechnical Data Report by GeoDesign (March 7, 2011)

GEODESIGN INC

GEOTECHNICAL DATA REPORT

Proposed River Intake Pump Station

Gladstone, Oregon

For

Brown and Caldwell

March 7, 2011

GeoDesign Project: BrownCald-49-03

Engineers | Geologists | Environmental Consultants

GEODESIGN INC

March 7, 2011

Brown and Caldwell
6500 SW Macadam Avenue, Suite 200
Portland, OR 97239

Attention: Mr. Brett Teel

Geotechnical Data Report
Proposed River Intake Pump Station
Gladstone, Oregon
GeoDesign Project: BrownCald-49-03

GeoDesign, Inc. is pleased to submit our geotechnical data report for the proposed RIPS on the Clackamas River located in Gladstone, Oregon. Our services for this project were conducted in accordance with our proposal dated May 14, 2010. This report presents the results of our surface reconnaissance, subsurface exploration, and laboratory analyses.

We appreciate the opportunity to be of continued service to you. Please call if you have questions regarding this report.

Sincerely,

GeoDesign, Inc.

Brett A. Shipton, P.E., G.E.
Principal Engineer

cc: Mr. Nick Wobbrock, Brown and Caldwell (via email only)

ECM:BAS:kt
Attachments
Seven copies submitted
Document ID: BrownCald-49-03-030711-geor.doc

TABLE OF CONTENTS		PAGE NO.

1.0 INTRODUCTION

GeoDesign, Inc. is pleased to submit this geotechnical data report for the proposed RIPS on the Clackamas River. The proposed structure is located upstream of the existing intake structure, near the north bank of the Clackamas River, approximately 0.8 mile from the confluence with the Willamette River (Figure 1). Preliminary plans show an approximately 82-foot-high intake structure with a foundation footprint of approximately 30.5 feet by 45 feet (Figure 2). Preliminary plans show the proposed intake structure located approximately 10 feet east of the existing intake structure. The base of the proposed intake will be located in the Clackamas River at an elevation of 4.0 feet below MSL. The proposed intake structure will be accessed at the top of the slope by a bridge. The bridge will support foot and vehicle traffic as well as the raw water pipeline.

In addition, GeoDesign performed subsurface investigations at locations downstream of the intake structure. The purpose for this exploration was to collect information that can be used to evaluate the erosion potential of the downstream gravel bar. Erosion of the gravel bar would potentially result in lower elevation in the river around the intake structure.

2.0 PURPOSE AND SCOPE

The purpose of our services was to explore subsurface conditions at the site and develop a geotechnical engineering data report for the design team of the intake structure. Specifically, we performed the following tasks:

- Reviewed readily available geologic and geotechnical data relevant to the site.
- Coordinated and managed the field investigation, including utility locates, right-of-way permits, and scheduling of contractors and GeoDesign's staff.
- Performed the following explorations in the river and on the riverbank:
  - Drilled three borings in the proposed footprint of the RIPS to depths ranging between 31.5 and 42 feet BGS
  - Drilled two borings at the gravel bar on the north bank of the Clackamas River, downstream of the intake structure, to depths ranging between 13 and 15 feet BGS
  - Drilled one boring at the gravel bar on the south bank of the Clackamas River, downstream of the intake structure, to a depth of 42 feet BGS
  - Drilled one boring at the rock outcropping upstream of the existing pump station to a depth of 15.5 feet BGS
  - Drilled one boring to a depth determined by GeoDesign sufficient for a slope stability analysis
- Obtained undisturbed and disturbed soil samples for laboratory testing.
- Maintained a log of subsurface conditions observed in the exploratory borings.
- Completed a laboratory testing program on selected soil samples collected from the explorations. Specifically, we completed the following tests:
  - Moisture content determinations on 14 samples in general accordance with ASTM D 2216
  - Five fines determinations and one gradation in general accordance with ASTM D 1140 and ASTM D 422

    - Two Atterberg limits determinations in general accordance with ASTM D 4318
    - Ten unconfined compression tests in general accordance with ASTM D 7012
- Mapped the rock outcropping on the riverbank adjacent to the intake structure and created a profile of the slope.
- Prepared this geotechnical data report detailing our findings.

3.0 SITE CONDITIONS

3.1 SURFACE CONDITIONS

The proposed structure is located upstream of the existing intake structure near the north bank of the Clackamas River, approximately 0.9 mile from the confluence with the Willamette River, in Gladstone, Oregon. The location of the proposed intake structure is at the base of an approximately 3H:4V slope on basalt that is exposed in the riverbed. A paved parking area is located at the top of the bank (elevation of 55 feet above MSL), and the face of the slope is heavily vegetated with blackberries, ivy, and large deciduous trees growing out of the face of the slope. Basalt bedrock is exposed at an approximate elevation of 15 feet above MSL. The basalt slopes downward to the southwest at an approximate 2H:1V slope. The elevation of the rock at the proposed southwest corner of the intake structure is approximately 3 feet above MSL. The basalt bedrock in the northern approximate half of the proposed intake structure was exposed during our field explorations in August 2010 but is seasonally underwater.

A gravel bar is located in the river 40 feet down river, and most of the proposed intake structure is between the Clackamas River and the base of the riverbank. Gravel, cobbles, and boulders were observed at the surface, and basalt bedrock was exposed in locations along the southern edge of the gravel bar. The gravel bar was vegetated with willow trees and grass at the time of our exploration. The riverbank slopes steeply down to the river, and we understand the top of the riverbank had been re-graded in the vicinity of boring CR-6 to improve slope stability.

3.2 REGIONAL GEOLOGY AND FAULTING

The site is located at the southwestern margin of the Portland Basin physiographic province. The Portland Basin is bound by the Tualatin Mountains to the west and south and the Cascade Range to the east and north. The Portland Basin is described as a fault-bounded, pull-apart basin that was formed by two northwest trending fault zones (Pratt, et al., 2001). The Portland Hills Fault Zone trends along the west side of the basin and the Frontal Fault Zone trends along the east side of the basin near Lacamas Lake, east of Vancouver, Washington. The Portland Basin is underlain by volcanic bedrock and contains a thick sequence of sedimentary deposits that lap onto the uplifted bedrock highlands at the basin margins.

The bedrock unit underlying the project area is a sequence of basalt flows belonging to the Miocene age (20 million to 10 million years before present) CRBG. The CRBG is a widespread series of flood basalt flows that originated from southeastern Washington and northeastern Oregon and flowed westward down the ancient Columbia River Valley. The basalt flows generally followed and filled pre-existing topographic lowlands in western Oregon. Basalt thicknesses can range from tens of feet to several hundred feet.

Faulting and folding were contemporaneous with deposition of the CRBG flows, and this structural deformation continued into the Quaternary (2.6 million years to present). The CRBG mapped along the southern boundary of the Portland Basin shows an extensive history of faulting and tectonic displacement (Burns, et. al, 1997; Ma, et. al, 2009). A majority of the mapped faults in the project area show no documented evidence of displacement during the Quaternary and are considered to be inactive (Burns, et. al, 1997; Personius, S.F., 2002).

However, several of the faults in the area have evidence of displacement during the Pliocene to Pleistocene (5.3 million years to 10,000 years), and down-drop along these faults created lowlands now identified as the Portland Basin. As the floor of these basins down-dropped, they were filled with a thick sequence of alluvial and fluvial sediments. A coarse-grained facies of the Troutdale Formation consisting of a sequence of alluvial gravel, sand, and silt was deposited in the central part of the Portland Basin. A significant portion of the sand and gravel component of this facies was derived from sediment sources located in eastern Washington and Idaho and transported to the Portland Basin by the proto-Columbia River.

The Springwater Formation is a sequence of Pliocene to Pleistocene alluvial gravel, sand, and silt deposited in the eastern part of the Portland Basin. The Springwater Formation is similar in age and consolidation history to the Troutdale Formation; however, the Springwater Formation was deposited in major river drainages that originated in the Cascade Mountains and foothills. Hence, a significant portion of the sand and gravel component of this formation contains volcanic rock of the Cascade Mountains, which distinguishes it from the Troutdale Formation. Geologic mapping by Madin (1990) indicates the presence of Troutdale Formation in the site vicinity, while mapping by Ma (Ma, et al. 2009) indicates the unit belongs to the Springwater Formation. For the purposes of this report we have referred to the unit by the original classification as the Troutdale Formation.

During the late Pleistocene (15,500 to 13,000 years before present), a sequence of catastrophic floods inundated the Portland Basin. These floods originated from repeated collapses of a glacially dammed lake in western Montana, and water from these outbursts flowed down the Columbia River into the Portland Basin. These series of outburst floods are termed the Missoula Floods, and the upper water surface during these events reached as high as 400 feet, inundating much of the Portland Basin.

The Missoula Floods selectively eroded the pre-existing topography in the Portland Basin and subsequently deposited sediments as the flood waters receded. A variety of individual sedimentary facies are associated with the Missoula Floods, including coarse-grained deposits of gravel and sand associated with floodways and tributary channels and a fine-grained facies composed of silt and clay deposited in slack-water lakes.

3.3 RIPS GEOLOGY

The site of the proposed intake structure is located on the northern bank of the Clackamas River, approximately 0.8 mile east of the confluence with the Willamette River. The area of the intake structure is dominated by a prehistoric high river terrace that has been cut by the Clackamas River to form a very steep bank that slopes down to a modern river-cut terrace. The river-cut bank has exposed volcanic bedrock at the river level that is overlain by sedimentary deposits decreasing in relative age to the top of the bank.

The geologic profile located at the intake site consists of basalt flows of CRBG overlain by laminated sandy silt and clay of the Pliocene to Pleistocene age. The unit is mapped as Troutdale Formation by Madin (1990). The Troutdale Formation is overlain by interbedded sand and gravel layers of the Missoula Flood deposits. The flood deposits are capped by fill material and development features that include parking areas and roads.

The surface of the basalt at the base of the intake structure has been severely eroded by the river and exhibits a distinctive columnar jointing pattern. Typically, the vertical joints are open at the surface and filled with clay or hard, black secondary mineralization. A semi-continuous, healed fracture within the basalt is located approximately 100 feet east of the existing intake structure and trends roughly southwest to northeast. The mapped surface geologic units at the site and the approximate healed fracture are shown on Figure 3.

3.4 FAULTS

There are no mapped late Quaternary age faults (faults within known movement in the last 16,000 years) within the RIPS site boundaries. The nearest mapped fault is an unnamed fault mapped approximately 0.5 mile northeast of the proposed RIPS structure. There is no documented evidence of displacement of the unnamed fault during the Quaternary period (2.6 million years to present) and the fault is considered to be inactive (Burns, et. al, 1997). The nearest Quaternary age fault is the Oatfield Fault mapped approximately 0.6 mile northeast of the site (Burns, et. al, 1997; Personius, S.F., 2002). Exposure from a light rail tunnel excavation indicates that the Oatfield Fault offsets approximately 1 million year old Boring Lava. There is no evidence that the Oatfield Fault offsets Missoula Flood deposits.

3.5 SUBSURFACE CONDITIONS

We explored subsurface conditions at the site by drilling eight borings (CR-1 through CR-8) to depths ranging between 13 and 65 feet BGS. The approximate locations of the borings are shown on Figure 2. Descriptions of the field explorations, laboratory procedures, and logs of the explorations and laboratory testing results are provided in Appendix A. A description and results of unconfined compression strength testing performed by others are provided In Appendix B.

Subsurface conditions consist of fill, loose sand, dense gravel and cobbles, alluvium, and hard silt overlying bedrock. The following sections provide a more detailed description of subsurface conditions observed in the borings.

3.5.1 Fill

Three inches of asphalt underlain by 6 inches aggregate base was encountered in boring CR-8, located in the parking lot north of the intake structure. The pavement section is underlain by medium stiff clay to a depth of 4.5 feet BGS at the location of our exploration. Gravel and cobble fill soils were also encountered in CR-6 to a depth of 5 feet BGS. Laboratory testing performed on the samples of the clay fill indicate that the natural moisture content varied between approximately 21 and 23 percent at the time of our exploration. Laboratory testing performed on a sample of the clay fill indicates the clay fill had low to medium plasticity.

3.5.2 Silt, Sand, Gravel, and Cobble Alluvium

Alluvium was encountered at the slopes on the north and south riverbanks in borings CR-6 and CR-8. Alluvium was also encountered in borings CR-4 and CR-5 located on the gravel bar on the north side of the river. The alluvium consists primarily of gravel and cobbles with varying amounts of silt and sand. Boulders were encountered in the gravel and cobble matrix.

Interbedded layers of very loose to medium dense sand were encountered between gravel and cobble deposits in borings CR-4 and CR-8. The sand deposits encountered in CR-4 and CR-8 are 1.5 and 5.5 feet thick, respectively. Medium stiff to very stiff silt layers up to 5 feet thick were also encountered between sand and gravel layers in borings CR-6 and CR-8.

3.5.3 Fine-Grained Troutdale Formation

Silt was encountered between approximately 28 and 48 feet BGS (elevation of 27.8 to 48 feet above MSL). SPT blow count data indicated that the consistency of the silt is very stiff to hard. This unit was interpreted to be fine-grained Troutdale Formation soils. The silt has varying amounts of sand, and particle size analyses of the silt indicated the soil has between 92 and 57 percent fines. Laboratory testing indicates that the fine-grained soils have medium to high plasticity. The natural moisture content of the silt varied between approximately 35 and 51 percent at the time of our exploration.

3.5.4 Basalt

Basalt bedrock interpreted to belong to basalt flows of the Miocene age (20 million to 10 million years before present) CRBG were encountered in borings CR-1, CR-2, CR-3, CR-4, CR-7, and CR-8. The rock hardness rating of the basalt ranges from extremely soft (R0) to very hard (R5) and is related to the degree of weathering, discontinuities (fractures and joints), and vesicular content. The vesicular content of the basalt ranges from less than 5 percent to 40 percent based on visual estimates. Weathering of the rock mass occurred along discontinuities that included fractures and joints. The basalt generally ranges from intensely to slightly fractured with smooth planar joints that have secondary mineralization and clay infilling at the joints.

The degree of weathering ranges from decomposed to fresh. Weathering is commonly associated with the age of the rock unit and exposure to weathering agents, such as water. Extremely soft (R0) to soft (R2) basalt was encountered in the upper 8 to 10 feet of borings CR-1, CR-2, and CR-7 drilled within the footprint of the proposed intake structure. In our opinion, the deep weathering profile is the result of erosion and seasonal contact with water from the Clackamas River. An approximately 10-foot-thick zone of medium hard (R3) to very hard (R5) basalt was encountered beneath the upper weathered zone. A second approximately 6- to 10-foot-thick zone of intensely weathered basalt was encountered between depths of approximately 18 and 20 feet BGS. The second zone of weathered basalt was typically underlain by medium hard (R3) to hard (R4) basalt to the maximum depths explored in CR-1, CR-2, and CR-7.

Extremely soft (R0) to soft (R2) basalt with up to 2 feet of joint infilling was encountered CR-3. GeoDesign interprets boring CR-3 to be drilled through a joint in the columnar basalt formation.

3.5.5 Groundwater

The river level was within 1 foot of the ground surface elevation of boring CR-2 (elevation of 9.9 feet above MSL) at the time of exploration in August 2010. A review of aerial photographs and site visits performed in the winter of 2009/2010 indicate that the ground surface at the location of CR-1, CR-2, and CR-7 are seasonally underwater. Artesian pressures were observed during drilling of borings CR-1 and CR-2 with moderate to rapid groundwater seepage at the ground surface. The artesian pressures were observed while at depths between 27 and 40 feet BGS.

3.6 EXISTING SLOPE PROFILE

GeoDesign mapped the basalt outcropping in the vicinity of the proposed intake structure. Exposed basalt was typically observed from an elevation of 10 feet to approximately 12 to 15 feet above MSL. A map showing the area of exposed basalt and other geologic units is shown on Figure 3. The geologic units along the face of the slope were observed along Section A-A' on Figure 3 by repelling from the top of the slope and removing vegetation to observe and sample the soil of the slope face.

The basalt was overlain by the fine-grained Troutdale Formation between elevations of 12 and 38 feet above MSL. The Troutdale Formation is overlain by alluvial sand, gravel, and fill to the top of the bank at an elevation of approximately 56 feet above MSL at the top of the bank. The riverbank shows evidence of several landslides in the form of distinct steep concave upper slopes with disturbed soil lobe deposits at the toe of the slope. The landslide material appears to have originated near the top of the slope within the interbedded sand and gravel layers of the Missoula Flood deposits and slumped down to the toe. We observed abundant groundwater seepage located mid-slope near the contact between the Troutdale Formation and the overlying Missoula Flood deposits that likely acts to de-stabilize the steep face of the riverbank. The slump features have been subsequently modified by river erosion during seasonal high stands.

A slope profile based on the soils encountered in a boring at the top of the slope (CR-8) and the mapped geologic units at the slope face are presented on Figure 4. Because of limitations in the survey data along the steeper sections of the slope, the slope contours in our profile were approximate based on mapping that occurred as GeoDesign went down the face of the slope.

4.0 LIMITATIONS

We have prepared this data report for use by Brown and Caldwell, the City of Lake Oswego, and members of their design and construction teams for the proposed project. The data and report can be used for bidding or estimating purposes, but our report, conclusions, and interpretations should not be construed as warranty of the subsurface conditions and are not applicable to other sites.

Exploration observations indicate soil conditions only at specific locations and only to the depths penetrated. They do not necessarily reflect soil strata or water level variations that may exist between exploration locations. If subsurface conditions differing from those described are noted during the course of excavation and construction, re-evaluation will be necessary. The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. No warranty, express or implied, should be understood.

◆ ◆ ◆

We appreciate the opportunity to be of continued service to you. Please call if you have questions concerning this report or if we can provide additional services.

Sincerely,

GeoDesign, Inc.

Elliott C. Mecham, P.E.
Project Engineer

Brett A. Shipton, P.E., G.E.
Principal Engineer

REGISTERED PROFESSIONAL ENGINEER 66267 OREGON JULY 11, 2000 BRETT A SHIPTON

EXPIRES: 6·30·2012

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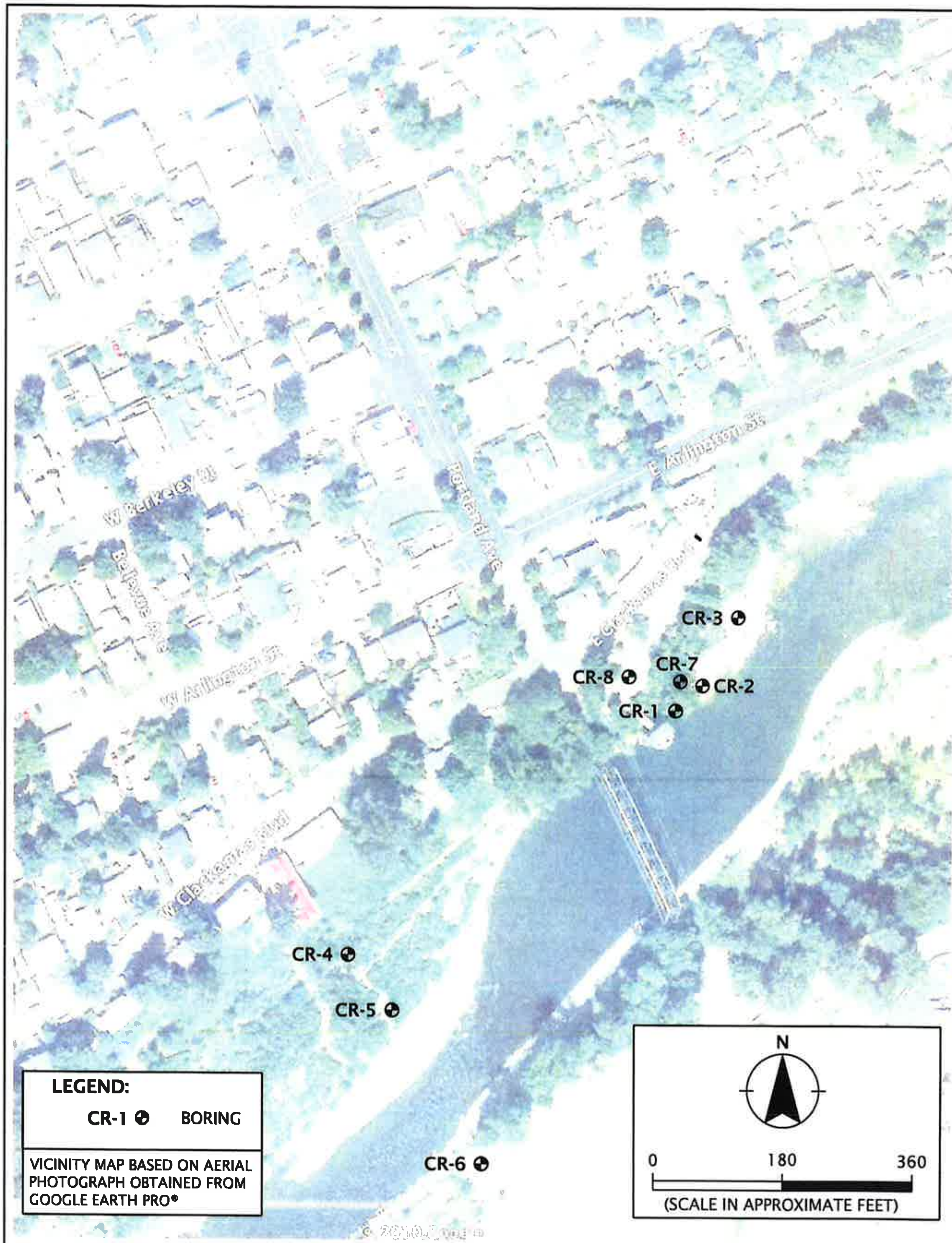
FIGURES



GEODESIGN INC 15575 SW Sequoia Parkway - Suite 100 Portland OR 97224 Off 503.968.8787 Fax 503.968.3068	BROWNCALD-49-03	VICINITY MAP	
	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE 1

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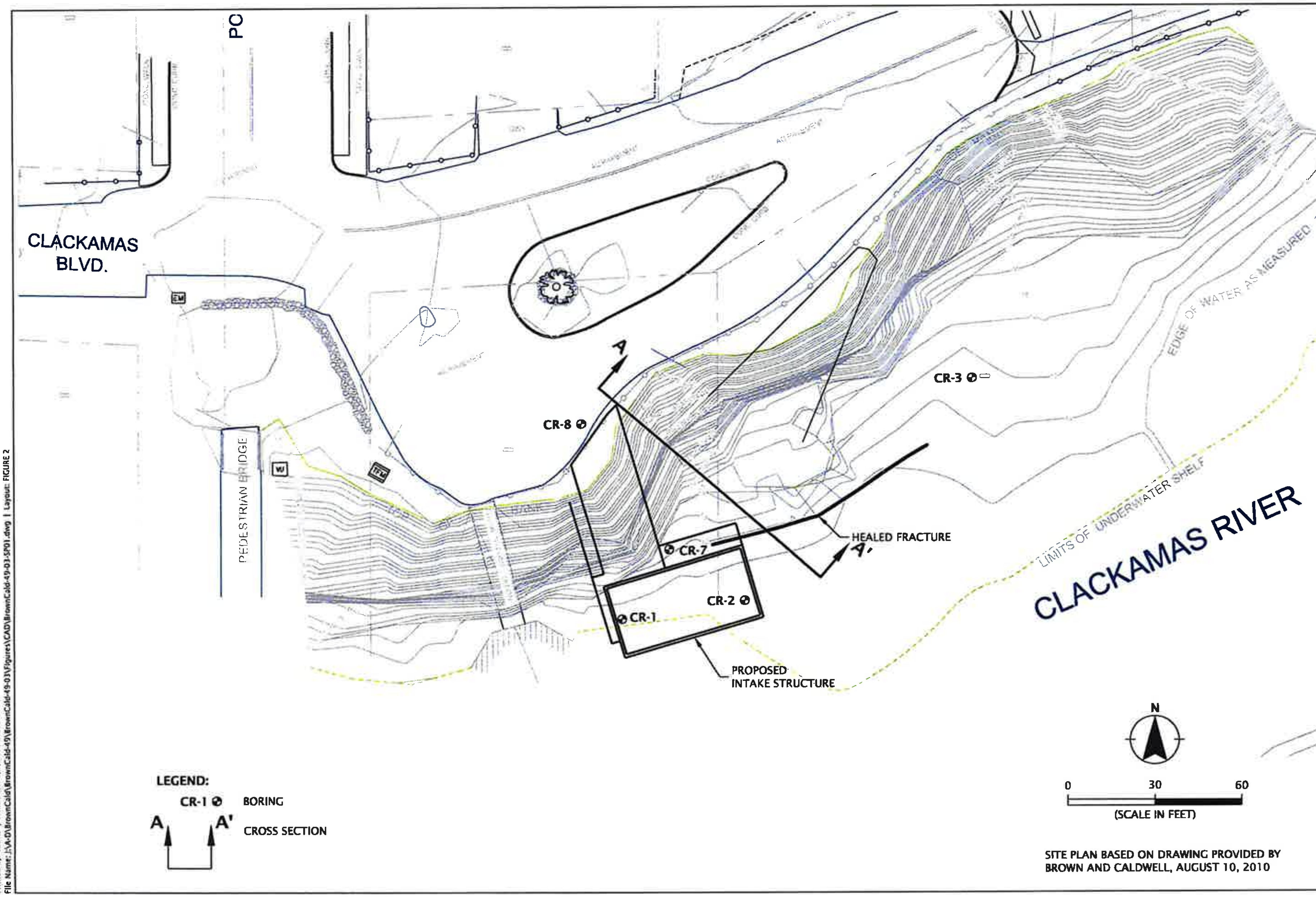
File Name: J:\A-D\BrownCald\BrownCald-49\BrownCald-49-03\Figures\CAD\BrownCald-49-03-VM01.dwg | Layout: FIGURE 1



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SITE PLAN

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE 2

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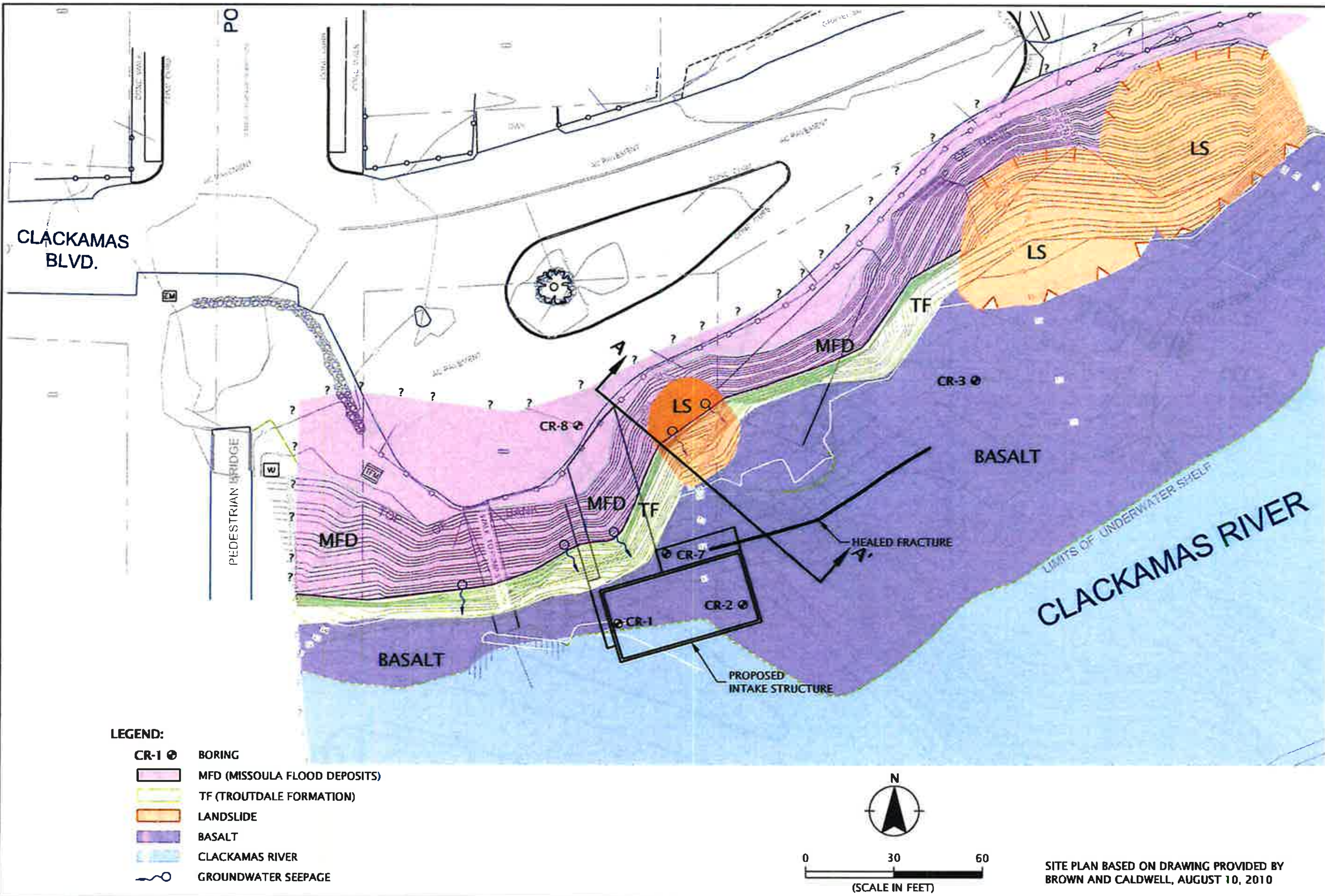

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GEOLOGY

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE 3

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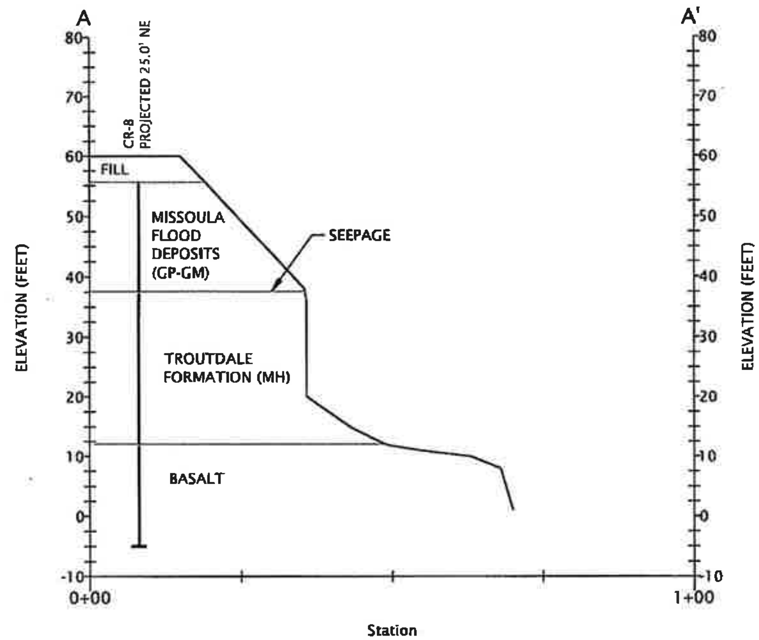

0 20 40

(SCALE IN FEET)

PROFILE BASED ON OBSERVATIONS AND FIELD MEASUREMENTS BY GEODESIGN STAFF

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CROSS SECTION A-A'

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE 4

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APPENDIX A

APPENDIX A

FIELD EXPLORATIONS

GENERAL

We explored subsurface conditions at the site by drilling eight borings (CR-1 through CR-8). Borings CR-1 through CR-7 were drilled to depths varying between approximately 13 and 42 feet BGS between July 20 and August 18, 2010. Borings CR-1 through CR-7 were drilled by PLI Systems of Hillsboro, Oregon, using hollow-stem auger drilling methods and HQ and NQ wire line coring techniques. Boring CR-8 was drilled to a depth of 65 feet BGS using mud-rotary methods by Western States Drilling of Aurora, Oregon. The approximately boring locations are shown on Figure 2. The boring locations of the explorations were surveyed in the field by Westlake Consultants.

SOIL AND ROCK SAMPLING

A member of our geological staff observed the explorations. We obtained disturbed soil samples and rock cores from the explorations for geotechnical laboratory testing. Classification and sampling intervals are shown in the exploration logs included in this appendix.

Soil samples were obtained from the borings using one of the following methods:

- SPTs were performed in sandy soils in general conformance with ASTM D 1586. The sampler was driven with a 140-pound hammer free-falling 30 inches. The number of blows required to drive the sampler 1 foot, or as otherwise indicated, into the soils is shown adjacent to the sample symbols on the exploration logs. Disturbed sand samples were obtained from the split barrel for subsequent classification and index testing.
- A Dames & Moore Type-U sampler was also used to collect samples. The sampler was driven using a 140-pound hammer falling 30 inches, just as with the SPT samples, and the penetration resistance was recorded for general correlation with previous subsurface information. Samples retained from the split barrel consist of up to six 1-inch-high by 2.48-inch-diameter brass rings.

An automatic trip hammer was used to drive the samples in boring CR-8; a cat head was used to lift the hammer in borings CR-1 through CR-7.

ROCK CORING

Rock was cored continuously using NQ and HQ wire line rock coring methods in general accordance with ASTM D 2113-99. The percentage of the core recovered and RQD are noted on the exploration logs. RQD is determined by summing the length of intact pieces of core longer than 4 inches and dividing by the length of the core advance.

SOIL AND ROCK CLASSIFICATION

The soil and rock samples were classified in the field in accordance with the "Exploration Key" (Table A-1), "Soil Classification System" (Table A-2), and "Rock Classification System" (Table A-3), which are included in this appendix. The exploration logs indicate the depths at which the soil and rock characteristics change, although the change actually could be gradual. If the change occurred between sample locations, the depth was interpreted. Classifications and sampling intervals are presented on the exploration logs included in this appendix. Photographs of the rock cores are also included in this appendix.

LABORATORY TESTING

CLASSIFICATION

The soil samples were classified in the laboratory to confirm field classifications. The laboratory classifications are presented on the exploration logs if those classifications differed from the field classifications.

MOISTURE CONTENT

We determined the natural moisture content of selected soil samples in general accordance with ASTM D 2216. The natural moisture content is a ratio of the weight of the water to dry soil in a test sample and is expressed as a percentage. The moisture content of samples tested are presented on the exploration logs included in this appendix.

ATTERBERG LIMITS

The plastic limit and liquid limit (Atterberg limits) of a selected soil sample was determined in accordance with ASTM D 4318. Atterberg limits include liquid limit, plastic limit, and plasticity index of soils. The index properties are used to classify soils and for correlation with other engineering properties of soils. The results of the tests are presented on Figure A-9 and on the boring logs.

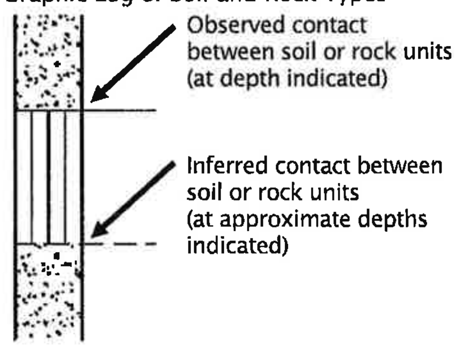
PARTICLE SIZE ANALYSIS

Particle size analyses was performed selected samples in general accordance with ASTM D 1140 and ASTM D 422. These tests are a quantitative determination of the soil particle size distribution expressed as a percentage of soil weight. The test results are presented on Figure A-10.

We also completed particle size analyses on selected samples in general accordance with ASTM D 1140. This test determines of the amount of material finer than a 75-µm (No. 200) sieve expressed as a percentage of the dry weight of soil. The test results are presented on the exploration logs in this appendix and on the laboratory summary on Figure A-11.

SYMBOL	SAMPLING DESCRIPTION
	Location of sample obtained in general accordance with ASTM D 1586 Standard Penetration Test with recovery
	Location of sample obtained using thin-wall Shelby tube or Geoprobe® sampler in general accordance with ASTM D 1587 with recovery
	Location of sample obtained using Dames & Moore sampler and 300-pound hammer or pushed with recovery
	Location of sample obtained using Dames & Moore or 3-inch-O.D. split-spoon sampler and 140-pound hammer or pushed with recovery
	Location of grab sample
	Rock coring interval
	Water level during drilling
	Water level taken on date shown

Graphic Log of Soil and Rock Types



GEOTECHNICAL TESTING EXPLANATIONS

ATT	Atterberg Limits	P	Pushed Sample
CBR	California Bearing Ratio	PP	Pocket Penetrometer
CON	Consolidation	P200	Percent Passing U.S. Standard No. 200 Sieve
DD	Dry Density	RES	Resilient Modulus
DS	Direct Shear	SIEV	Sieve Gradation
HYD	Hydrometer Gradation	TOR	Torvane
MC	Moisture Content	UC	Unconfined Compressive Strength
MD	Moisture-Density Relationship	VS	Vane Shear
OC	Organic Content	kPa	Kilopascal

ENVIRONMENTAL TESTING EXPLANATIONS

CA	Sample Submitted for Chemical Analysis	ND	Not Detected
P	Pushed Sample	NS	No Visible Sheen
PID	Photoionization Detector Headspace Analysis	SS	Slight Sheen
ppm	Parts per Million	MS	Moderate Sheen
		HS	Heavy Sheen

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EXPLORATION KEY

TABLE A-1

RELATIVE DENSITY - COARSE-GRAINED SOILS

Relative Density	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)
Very Loose	0 – 4	0 - 11	0 - 4
Loose	4 – 10	11 - 26	4 - 10
Medium Dense	10 – 30	26 - 74	10 - 30
Dense	30 – 50	74 - 120	30 - 47
Very Dense	More than 50	More than 120	More than 47

CONSISTENCY - FINE-GRAINED SOILS

Consistency	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)	Unconfined Compressive Strength (tsf)
Very Soft	Less than 2	Less than 3	Less than 2	Less than 0.25
Soft	2 - 4	3 - 6	2 - 5	0.25 - 0.50
Medium Stiff	4 - 8	6 – 12	5 - 9	0.50 - 1.0
Stiff	8 - 15	12 – 25	9 - 19	1.0 - 2.0
Very Stiff	15 - 30	25 – 65	19 – 31	2.0 - 4.0
Hard	More than 30	More than 65	More than 31	More than 4.0

PRIMARY SOIL DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOILS (more than 50% retained on No. 200 sieve)	GRAVEL (more than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVELS (< 5% fines)	GW or GP	GRAVEL
		GRAVEL WITH FINES (≥ 5% and ≤ 12% fines)	GW-GM or GP-GM	GRAVEL with silt
			GW-GC or GP-GC	GRAVEL with clay
		GRAVELS WITH FINES (> 12% fines)	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND (50% or more of coarse fraction passing No. 4 sieve)	CLEAN SANDS (<5% fines)	SW or SP	SAND
		SANDS WITH FINES (≥ 5% and ≤ 12% fines)	SW-SM or SP-SM	SAND with silt
			SW-SC or SP-SC	SAND with clay
		SANDS WITH FINES (> 12% fines)	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOILS (50% or more passing No. 200 sieve)	SILT AND CLAY	Liquid limit less than 50	ML	SILT
			CL	CLAY
			CL-ML	silty CLAY
			OL	ORGANIC SILT or ORGANIC CLAY
		Liquid limit 50 or greater	MH	SILT
			CH	CLAY
			OH	ORGANIC SILT or ORGANIC CLAY
HIGHLY ORGANIC SOILS			PT	PEAT

MOISTURE CLASSIFICATION

Term	Field Test
dry	very low moisture, dry to touch
moist	damp, without visible moisture
wet	visible free water, usually saturated

ADDITIONAL CONSTITUENTS

Secondary granular components or other materials such as organics, man-made debris, etc.

Percent	Silt and Clay In: Fine-Grained Soils	Silt and Clay In: Coarse-Grained Soils	Percent	Sand and Gravel In: Fine-Grained Soils	Sand and Gravel In: Coarse-Grained Soils
< 5	trace	trace	< 5	trace	trace
5 – 12	minor	with	5 – 15	minor	minor
> 12	some	silty/clayey	15 – 30	with	with
			> 30	sandy/gravelly	sandy/gravelly

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SOIL CLASSIFICATION SYSTEM

TABLE A-2

HARDNESS	DESCRIPTION
Extremely Soft (R0)	Indented by thumbnail
Very Soft (R1)	Can be peeled by pocket knife or scratched with finger nail
Soft (R2)	Can be peeled by a pocket knife with difficulty
Medium Hard (R3)	Can be scratched by knife or pick
Hard (R4)	Can be scratched with knife or pick only with difficulty
Very Hard (R5)	Cannot be scratched with knife or sharp pick

WEATHERING	DESCRIPTION
Decomposed	Rock mass is completely decomposed
Predominantly Decomposed	Rock mass is more than 50% decomposed
Moderately Weathered	Rock mass is decomposed locally
Slightly Weathered	Rock mass is generally fresh
Fresh	No discoloration in rock fabric

JOINT SPACING	DESCRIPTION
Very Close	Less than 2 inches
Close	2 inches to 1 foot
Moderate Close	1 foot to 3 feet
Wide	3 feet to 10 feet
Very Wide	Greater than 10 feet

FRACTURING	FRACTURE SPACING
Very Intensely Fractured	Chips and fragments with a few scattered short core lengths
Intensely Fractured	0.1 foot to 0.3 foot with scattered fragments intervals
Moderately Fractured	0.3 foot to 1 foot with most lengths 0.6 foot
Slightly Fractured	1 foot to 3 feet
Very Slightly Fractured	Greater than 3 feet
Unfractured	No fractures

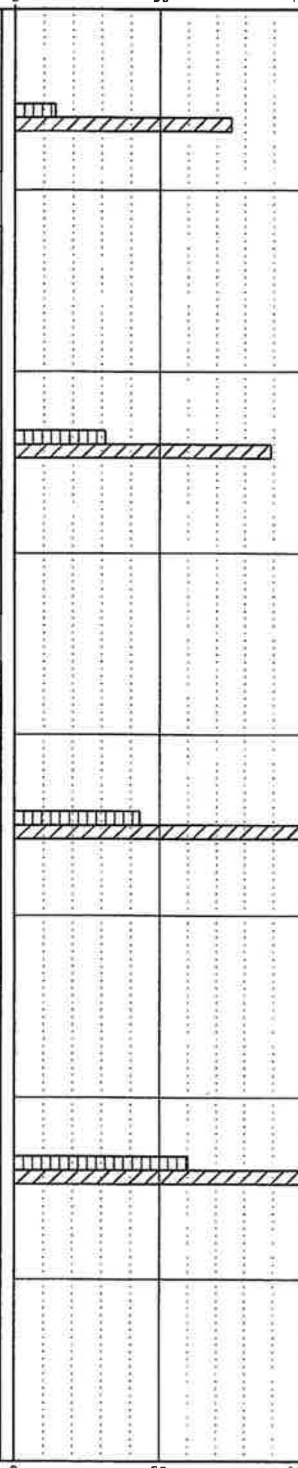
HEALING	DESCRIPTION
Not Healed	Discontinuity surface, fractured zone, sheared material or filling not re-cemented
Partly Healed	Less than 50% of fractured or sheared material
Moderately Healed	Greater than 50% of fractured or sheared material
Totally Healed	All fragments bonded

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	INSTALLATION AND COMMENTS
0.0	Extremely soft (R0), orange-brown BASALT; decomposed, jointed 20°, 50°, and 70°, moderately to intensely fractured, irregular, rough joint surfaces, with open joints oriented 20°, 50°,a nd 70° (Columbia River Basalt).	10.8	Water return: brown-orange at 0.0 feet
3.0	Extremely soft to very soft (R0-R1), orange-brown BASALT; decomposed, intensely fractured, oriented 30 - 50°.	7.8 / 3.0	
5.0	becomes orange-gray; decomposed to intensely weathered, moderately to intensely fractured, irregular, rough joint surfaces, open joints oriented 15°, 35°, and 75° with clay infilling at 5.0 feet		UC = 395 psi Water return: gray at 6.0 feet
9.0	Medium hard (R3), orange-gray BASALT; slightly to moderately weathered, intensely fractured, irregular, rough joint surfaces, oriented 10° - 20°, 50°, and 65 - 70°, with clay, and moderately healed with secondary mineralization, vesicular (<5%). becomes hard (R4), gray; fresh, moderately fractured at 11.0 feet	1.8 / 9.0	
13.5	Hard to very hard (R4-R5), gray BASALT; fresh, moderately to slightly fractured, rough joint surfaces, open, oriented 10° - 20°, 35°, and 60° - 90°, moderately healed, with quartz and iron oxide, vesicular (<5%).	-2.7 / 13.5	UC = 37,147 psi
19.5	Extremely soft to soft (R0-R2), green-	-8.7 / 19.5	

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0

GRAPHIC LOG | TESTING | SAMPLE

▲ BLOW COUNT
● MOISTURE CONTENT %
RQD% / CORE REC%



DRILLED BY: PLI Systems Inc. LOGGED BY: JGH COMPLETED: 08/09/10

BORING METHOD: NQ rock coring (see report text) BORING BIT DIAMETER: 2 1/2-inch

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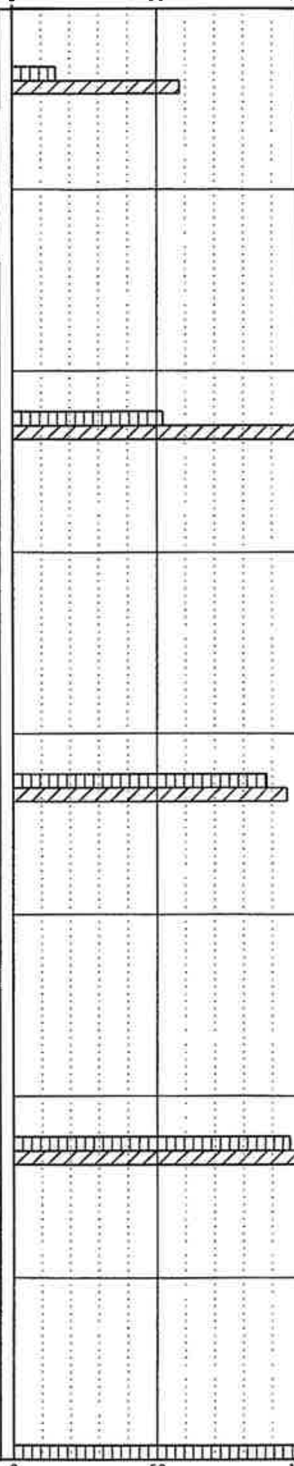
BROWNCALD-49-03	BORING CR-1	
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-1

BORING LOG BROWNCALD-49-03-CR1_8.GPJ GEODESIGN.GDT PRINT DATE: 3/7/11:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
20.0		dark gray BASALT; intensely weathered, intensely fractured to sheared, irregular, rough joint surfaces.					
22.5							
		Very soft to soft (R1-R2), green-gray BASALT; intensely weathered, 10° - 20°, 35°, and 65°, moderately to intensely fractured, smooth to rough joint surfaces, partly healed, open with orange clay, oriented 10° - 20°, 35°, and 65° - 90°, vesicular (30%).	-12.7 / 23.5				Water return: brown-red at 24.5 feet
25.0		becomes extremely soft (R0); with red clay infilled fractures at 25.0 feet becomes soft (R2) at 26.0 feet					UC = 1,056 psi Water return: gray at 27.0 feet
27.5							
		Medium hard to hard (R3-R4), gray BASALT; fresh to slightly weathered, slightly to moderately fractured, rough joint surfaces, moderately healed, open with quartz and white oxide filling, oriented 0° - 20°, 30°, and 70°.	-17.2 / 28.0				
30.0							
32.5							
		Medium hard to hard (R3-R4), gray BASALT; fresh to slightly weathered, slightly fractured, rough joint surfaces, moderately healed, open with quartz and iron oxide filling, oriented 30°, 50°, and 80°, vesicular (40%).	-22.7 / 33.5				
35.0							UC = 9,566 psi
37.5		fractures predominately oriented 15° - 70° at 38.0 feet					
40.0							



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BORING METHOD: NQ rock coring (see report text) BORING BIT DIAMETER: 2 1/2-inch

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BORING CR-1
(continued)

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-1

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 50 100)	INSTALLATION AND COMMENTS
40.0		(continued from previous page)					UC = 14,917 psi
		Exploration completed to a depth of 42.0 feet.	-31.2 42.0				After drilling, water flowing out of hole to the ground surface at approximately 2 gallons/minute.
42.5							
45.0							
47.5							
50.0							
52.5							
55.0							
57.5							
60.0							

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BORING METHOD: NQ rock coring (see report text) BORING BIT DIAMETER: 2 1/2-inch

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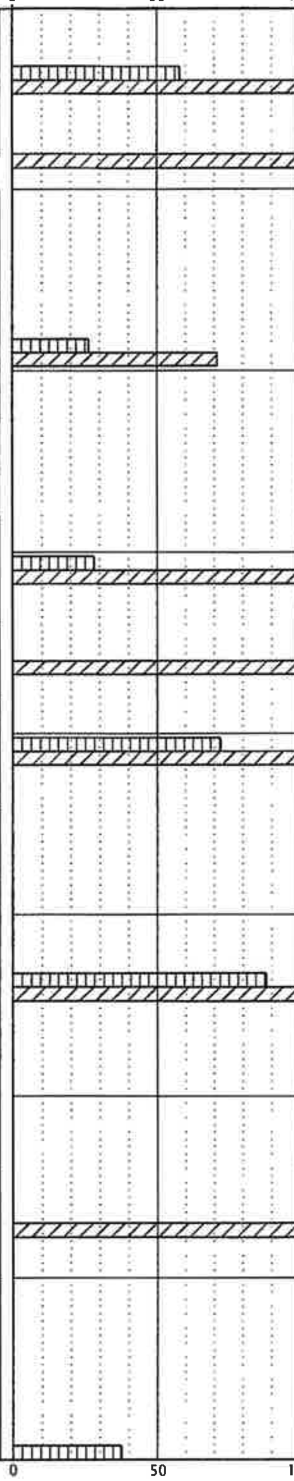
MARCH 2011

BORING CR-1
(continued)

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-1

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
0.0		Extremely soft (R0), brown-orange-gray BASALT; decomposed (Columbia River Basalt).	9.9				Water return: brown-orange at 0.0 feet
		Extremely soft (R0), brown-orange-gray BASALT; decomposed.	7.9 / 2.0				
2.5		Extremely soft (R0), gray-orange BASALT; decomposed, intensely fractured, rough joint surfaces, planar joints oriented 20° and 45°.	7.4 / 2.5				Stop Run 2 to contain cuttings at 2.5 feet. Water return: gray at 3.0 feet
5.0							
7.5		becomes very soft to soft (R1-R2), green-gray; intensely to moderately weathered, intensely fractured, open, with clay filling and slickensides, oriented 30° - 35° and 50° at 6.5 feet becomes medium hard (R3), gray; moderately weathered, moderately to intensely fractured at 7.5 feet becomes medium hard to hard (R3-R4) at 8.5 feet					
10.0		Medium hard to hard (R3-R4), gray BASALT; slightly weathered, moderately fractured, rough joint surfaces, open, oriented 50° and 60° - 70°.	0.4 / 9.5				
12.5		Hard to very hard (R4-R5), gray BASALT; fresh to slightly weathered, slightly fractured, smooth to rough joint surfaces, open with clay secondary mineral filling and slickensides, oriented 30° and 60° - 70°.	-1.1 / 11.0				
15.0		becomes intensely fractured at 15.0 feet					UC = 45,131 psi
17.5		Soft to medium hard (R2-R3), gray BASALT; moderately to intensely weathered, intensely fractured, rough joint surfaces, open with clay and secondary mineral filling, oriented 0° - 20° and 75° - 90°.	-6.1 / 16.0				
20.0		Very soft (R1), green-gray BASALT; intensely weathered, moderately to intensely fractured, smooth to rough joint surfaces, open with clay filling, oriented 15° and 60° - 70°, vesicular	-7.6 / 17.5				



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BORING METHOD: NQ rock coring (see report text) BORING BIT DIAMETER: 2 1/2-inch

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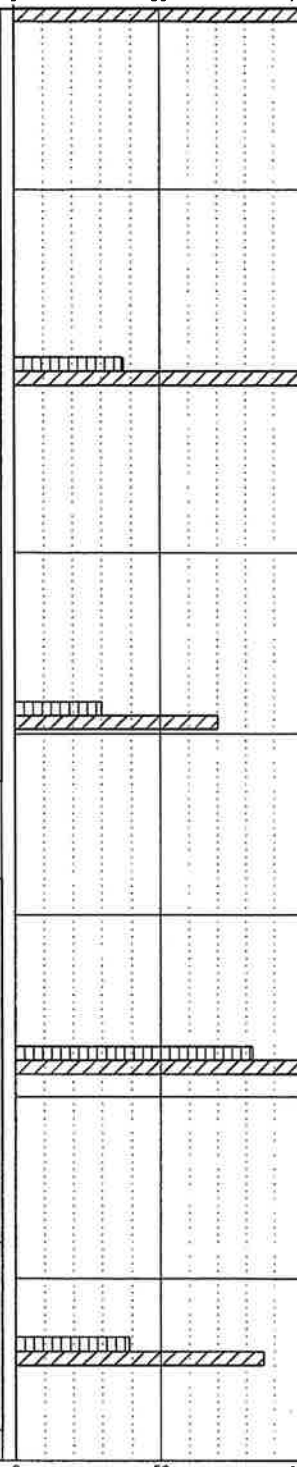
MARCH 2011

BORING CR-2

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-2

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
20.0		(20%). becomes red-gray at 19.0 feet (continued from previous page)					
		becomes extremely soft (R0), dark gray; very intensely fractured to sheared at 21.5 feet					
22.5		Very soft (R1), green-gray BASALT; intensely weathered, moderately to intensely fractured, irregular, rough joint surfaces, open, with clay filling, oriented 15° and 60° - 70°, vesicular (20%). becomes very soft to soft (R1-R2), gray to dark gray; partly healed at 23.5 feet	-12.6 / 22.5				
25.0							
27.5		Medium hard (R3), gray BASALT; slightly to moderately weathered, moderately to intensely fractured, partly healed, rough joint surfaces, open, with quartz and secondary mineralization, oriented 60° - 90°, vesicular (20 - 30%).	-17.6 / 27.5				Water flowing out of hole at surface after coring to 27.0 feet.
30.0							No HCL reaction Driller Comment: approximately 2 to 3 inches rapid fall during last 2.5 feet, coring "open joints"?
32.5		Medium hard to hard (R3-R4), gray BASALT; fresh, moderately fractured, rough joint surfaces, partly healed, open, with quartz, clay, and secondary mineralization, oriented 0° - 20° and 75° - 90°, vesicular (20 to 30%).	-22.1 / 32.0				
35.0							UC = 11,898 psi
37.5		Medium hard to hard (R3-R4), gray BASALT; fresh, moderately fractured, smooth to rough joint surfaces, moderately healed, open with clay and secondary mineralization, oriented 10°, 65° to 90°.	-27.1 / 37.0				
40.0							



DRILLED BY: PLI Systems Inc. LOGGED BY: JGH COMPLETED: 08/05/10

BORING METHOD: NQ rock coring (see report text) BORING BIT DIAMETER: 2 1/2-inch

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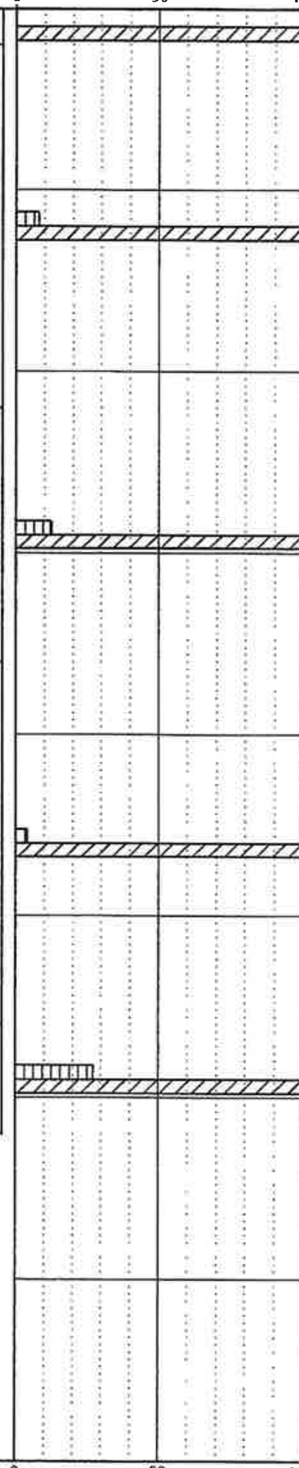
BROWNCALD-49-03	BORING CR-2 (continued)	
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-2

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 50 100)	INSTALLATION AND COMMENTS
40.0		Exploration completed to a depth of 40.0 feet.	-30.1 40.0				After drilling, water flowing out of hole at surface approximately 5 gallons/minute.
42.5							
45.0							
47.5							
50.0							
52.5							
55.0							
57.5							
60.0						0 50 100	

DRILLED BY: PLI Systems Inc. LOGGED BY: JGH COMPLETED: 08/05/10

BORING METHOD: NQ rock coring (see report text) BORING BIT DIAMETER: 2 1/2-inch

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
0.0			11.4				
		Very soft to soft (R1-R2), brown to gray BASALT/vertical joint infilling; very intensely fractured, rough joint surfaces, not healed.					Block off at 0.5 foot. Hole located between basalt columns within a vertical joint system.
2.5		Very soft (R1), dark gray, red/orange BASALT/vertical joint infilling; intensely weathered to decomposed, intensely fractured, irregular, rough joint surfaces, partly healed.	9.4 / 2.0				
5.0		Soft (R1-R2), dark gray BASALT/vertical joint infilling; intensely weathered, irregular, rough joint surfaces, jointed 20°, 45°, and 60° with slickensides - 30° rake, intensely fractured.	5.9 / 5.5				
7.5		Soft (R1-R2), dark gray BASALT/vertical joint infilling, intensely weathered, jointed 10° to 15°.	2.4 / 9.0				
10.0		Very stiff, red mottled gray CLAY; wet (decomposed basalt/joint infilling).	1.4 / 10.0				Water return: gray to red at 10.5 feet
12.5		Soft (R2), dark gray BASALT/vertical joint infilling; intensely weathered, very intensely fractured to intensely fractured, irregular, rough joint surfaces, partly to not healed, vesicles apparent at margins of basalt fragments.	-0.6 / 12.0				Water return: gray at 12.5 feet
15.0		Soft (R-2), dark gray BASALT/vertical joint infilling; intensely weathered, intensely fractured.	-2.6 / 14.0				
17.5		Exploration completed to a depth of 15.5 feet.	-4.1 / 15.5				
20.0							



DRILLED BY: PLI Systems Inc.   LOGGED BY: CLR   COMPLETED: 08/04/10

BORING METHOD: NQ rock coring (see report text)   BORING BIT DIAMETER: 2 1/2-inch

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BROWNCALD-49-03	BORING CR-3	
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-3

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	INSTALLATION AND COMMENTS
0.0	Very dense, dark gray COBBLES with gravel (GP), trace sand and silt; moist.	11.8	Intermittent drill chatter Heavy drill chatter at 2.5 feet.
5.5	Very loose, brown, silty SAND (SM); wet.	6.3 / 5.5	Smooth, soft drilling from 5.5 to 7.0 feet.
7.0	Medium dense, gray GRAVEL with cobbles and boulders (GP), minor sand and silt; moist to wet, rounded to subrounded.	4.8 / 7.0	
10.0	Medium hard to hard (R3-R4), gray BASALT, slightly weathered, moderately fractured, vesicles <5%, jointed 60° to 70°, moderately close spacing, moderately to intensely fractured.	1.8 / 10.0	Smooth, hard drilling from 10.0 to 15.0 feet
15.0	Exploration completed at a depth of 15.0 feet.	-3.2 / 15.0	

Legend: ▲ BLOW COUNT ● MOISTURE CONTENT % ▯ RQD% ▨ CORE REC% (scale 0 – 50 – 100)

Blow count: 3 (at approx. 5.5–6.0 feet)

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0

DRILLED BY: PLI Systems Inc. LOGGED BY: BBP COMPLETED: 08/12/10

BORING METHOD: hollow-stem auger and HQ rock coring (see report text) BORING BIT DIAMETER: 1 3/4-inch

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BROWNCALD-49-03

MARCH 2011

BORING CR-4

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-4

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
0.0		Very dense, gray-brown COBBLES and BOULDERS with gravel and fine to medium sand (GP-GM), minor silt; moist, rounded to subrounded gravel, cobbles, and boulders greater than 14 inches in diameter.	15.0				
2.5						56	
5.0						58	
7.5							
		boulder at 9.5 feet				50/1"	
10.0							
12.5							
		Exploration completed at a depth of 13.0 feet.	2.0 / 13.0				
15.0							
17.5							
20.0							

DRILLED BY: PLI Systems Inc. LOGGED BY: JGH COMPLETED: 08/10/10

BORING METHOD: solid-stem auger, HQ and NQ rock coring (see report text) BORING BIT DIAMETER: 4-inch

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BROWNCALD-49-03

MARCH 2011

BORING CR-5

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-5

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
0.0		Dense, brown, gravelly COBBLES (GP), trace sand and silt - FILL.	31.5				Bench height = 24.6 feet above water line; determined with clinometer. Hand dug first foot for sump.
2.5							Slight chatter at 3.5 feet.
5.0		Stiff, brown, fine, sandy SILT (ML), trace to minor clay, sparse to trace organics (roots); dry to moist.	26.5 / 5.0			▲ 12	
7.5							
10.0		Medium dense, gray, fine to coarse GRAVEL with cobbles (GW), minor sand, trace silt; moist. boulder at 11.0 feet	21.5 / 10.0			▲ 15	Driller Comment: boulder caught in casing at 11.0 feet. Drilling chatter at 11.0 feet. Begin coring attempt. Unable to proceed. Advance casing.
12.5							Hard, slow drilling from 14.0 to 15.0 feet.
15.0		grades to very dense, with sand, minor silt at 15.5 feet					
17.5							Casing at 17.3 feet. Smoother drilling. Slight chatter.
20.0							

DRILLED BY: PLI Systems Inc. LOGGED BY: BBP COMPLETED: 08/18/10

BORING METHOD: hollow-stem auger and HQ rock coring (see report text) BORING BIT DIAMETER: 1 3/4-inch

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BROWNCALD-49-03

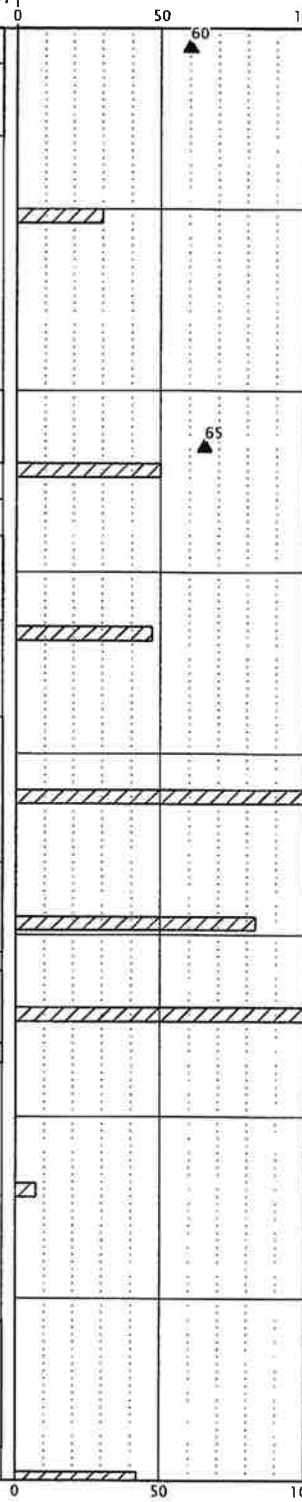
MARCH 2011

BORING CR-6

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-6

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
20.0		Very dense, brown-gray, fine to coarse GRAVEL with cobbles (GW), minor sand, trace silt; moist.	11.5 / 20.0			60	
22.5							
25.0						65	Core recovered at 25.0 feet. Ream casing and core back to bottom. Resume coring at 25.0 feet.
27.5							
30.0							
32.5		Medium dense, gray COBBLES with gravel (GP); moist.	-0.5 / 32.0				
		Medium dense, brown-gray, sandy GRAVEL to SAND with gravel with cobbles (GW/SP), minor silt; moist to wet.	-2.5 / 34.0				Drilling chatter at 33.5 feet.
35.0							
37.5							
40.0							



DRILLED BY: PLI Systems Inc. LOGGED BY: BBP COMPLETED: 08/18/10

BORING METHOD: hollow-stem auger and HQ rock coring (see report text) BORING BIT DIAMETER: 1 3/4-inch

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BROWNCALD-49-03

MARCH 2011

BORING CR-6
(continued)

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-6

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 50 100)	INSTALLATION AND COMMENTS
40.0		Stiff, gray CLAY (CH), trace rounded gravel; moist.	-8.5 / 40.0				
		Exploration completed to a depth of 42.0 feet.	-10.5 / 42.0				
42.5							
45.0							
47.5							
50.0							
52.5							
55.0							
57.5							
60.0						0 50 100	

DRILLED BY: PLI Systems Inc. LOGGED BY: BBP COMPLETED: 08/18/10

BORING METHOD: hollow-stem auger and HQ rock coring (see report text) BORING BIT DIAMETER: 1 3/4-inch

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BROWNCALD-49-03

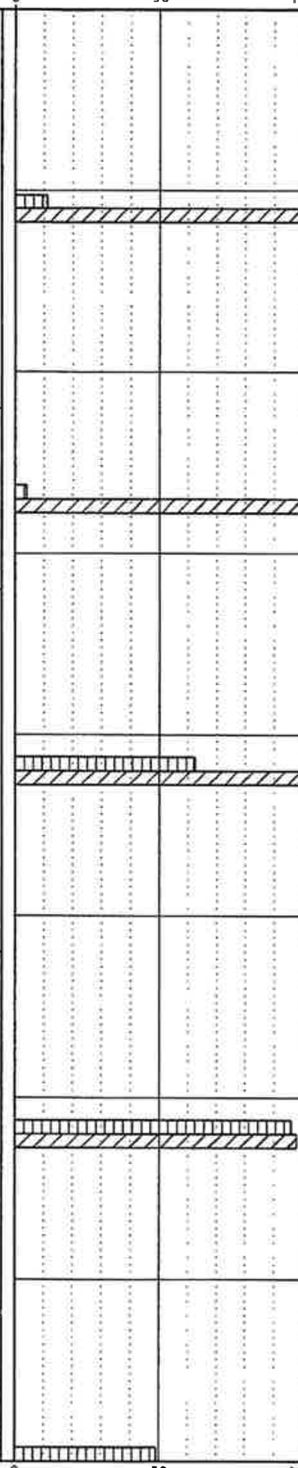
BORING CR-6
(continued)

MARCH 2011

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-6

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 – 50 – 100)	INSTALLATION AND COMMENTS
0.0		Very soft (R0-R1), gray-brown and red BASALT; intensely weathered to decomposed, intensely fractured, irregular, rough joint surfaces, partly healed, open with clay filling, oriented 15° and 30°. becomes extremely soft (R0) at 2.0 feet	11.9				
2.5							
5.0		becomes gray; intensely weathered at 4.5 feet					UC = 624 psi
		Very soft (R1), gray BASALT; intensely weathered, intensely fractured, irregular, rough joints surfaces, open with clay filling, oriented 20° and 60°. becomes soft (R2); moderately weathered, moderately fractured, moderately healed, vesicular (10%) at 7.0 feet	6.4 / 5.5				
7.5							
		Medium hard (R3), gray BASALT; slightly weathered, moderately fractured, irregular, rough joint surfaces, open with clay and iron oxide filling, oriented 10°, 25°, 60°, and 90°, vesicular (5%).	3.9 / 8.0				
10.0							
12.5							
		Hard to very hard (R4-R5), gray BASALT; slightly weathered to fresh, slightly fractured, irregular, rough joint surfaces, open with clay filling, oriented 35°, vesicular (5%).	-1.1 / 13.0				
15.0							UC = 32,864 psi
17.5							
		Medium hard to hard (R3-R4), gray BASALT; fresh to slightly weathered, moderately fractured, irregular, rough joint surfaces, partly healed, open with clay filling, oriented 20° and 60°.	-6.1 / 18.0				Water return: gray to dark red at 19.0 feet Water return: dark red to
20.0							



DRILLED BY: PLI Systems Inc. LOGGED BY: CLR COMPLETED: 08/06/10

BORING METHOD: NQ rock coring (see report text) BORING BIT DIAMETER: 2 1/2-inch

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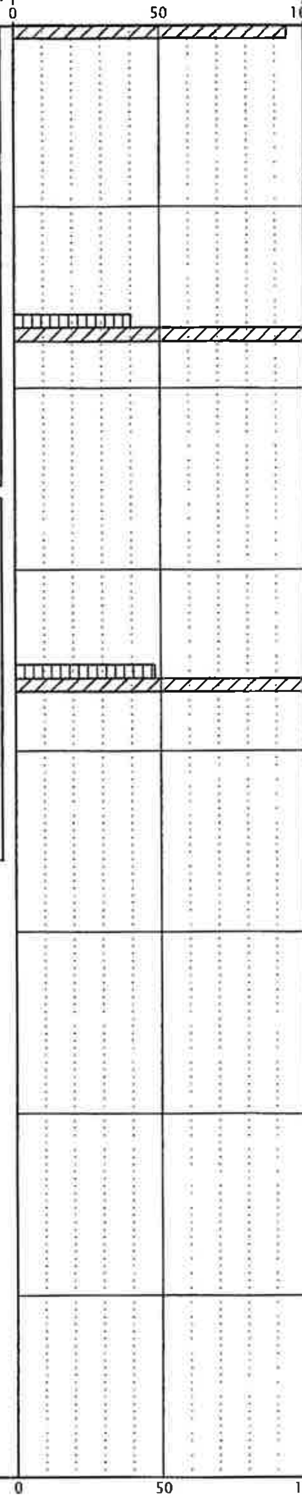
BROWNCALD-49-03	**BORING CR-7**		
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR		**FIGURE A-7**

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	INSTALLATION AND COMMENTS
20.0	becomes very soft to soft (R1-R2), dark gray; intensely weathered, very intensely to intensely fractured at 20.0 feet		green at 19.5 feet Water return: green to gray at 20.0 feet
22.5	Soft (R2), red-gray-black BASALT; intensely weathered, moderately to intensely fractured, irregular, rough joint surfaces, partly healed, open with clay, iron oxide, and secondary mineral filling, oriented 0° - 20° and 75° - 90°, vesicular (10 - 20%).	-10.1 / 22.0	
25.0	becomes extremely soft (R0), orange-gray; decomposed, intensely fractured at 24.0 feet becomes soft (R2), gray; intensely weathered at 25.6 feet		UC = 2,968 psi
27.5	Medium hard (R3), gray BASALT; slightly weathered, moderately fractured, irregular, rough joint surfaces, partly healed, open with quartz and secondary mineral filling, oriented 10°, 30°, and 60° - 90°, vesicular (25 to 30%).	-14.6 / 26.5	
30.0			
32.5	Exploration completed to a depth of 31.5 feet.	-19.6 / 31.5	
35.0			
37.5			
40.0			

Columns: GRAPHIC LOG, TESTING, SAMPLE

▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC%



DRILLED BY: PLI Systems Inc. LOGGED BY: CLR COMPLETED: 08/06/10

BORING METHOD: NQ rock coring (see report text) BORING BIT DIAMETER: 2 1/2-inch

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BROWNCALD-49-03

MARCH 2011

BORING CR-7
(continued)

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-7

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	BLOW COUNT	MOISTURE CONTENT %	INSTALLATION AND COMMENTS
0.0	ASPHALT CONCRETE (3 inches).	55.8				
	AGGREGATE BASE (6 inches).	55.5 / 0.3				
	Medium stiff, brown CLAY (CL), trace sand, gravel, and organics (rootlets); moist (disturbed structure) - **FILL.**	55.0 / 0.8	ATT	5		LL = 43% PL = 24%
2.5	minor sand at 2.5 feet			6		
5.0	Dense, brown-gray, fine to coarse GRAVEL and COBBLES with sand and silt (GP-GM), trace organics (rootlets); moist, subrounded to subangular and angular gravel (Missoula Flood Deposits).	51.3 / 4.5		119		
7.5	becomes very dense, without rootlets at 7.5 feet			121		Driller Comment: cobbles at 7.5 feet Heavy drilling chatter at 9.0 feet
10.0	becomes with sand at 10.0 feet		SIEV	123		
12.5	becomes medium dense, with orange mottles at 12.5 feet			71		
15.0	becomes very dense, with sand at 15.0 feet			81		
17.5	Loose, brown, fine to medium, silty SAND with fine to coarse gravel (SM); moist, subrounded (Missoula Flood Deposits).	38.8 / 17.0	P200	14		P200 = 17% Disturbed grab sample
20.0						

Legend: ▲ BLOW COUNT; ● MOISTURE CONTENT %; RQD%; CORE REC% (scale 0 – 50 – 100)

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: NAK COMPLETED: 07/20/10

BORING METHOD: mud rotary and HQ rock coring (see report text) BORING BIT DIAMETER: 4 7/8-inch

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BROWNCALD-49-03

MARCH 2011

BORING CR-8

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-8

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	BLOW COUNT / MOISTURE CONTENT %	INSTALLATION AND COMMENTS
20.0	Very stiff, brown, sandy SILT (ML); moist, low plasticity, fine sand (Missoula Flood Deposits).	35.8 / 20.0	P200	▲ 35	P200 = 53% Disturbed grab sample
22.5	Dense, brown-orange and gray, fine to coarse GRAVEL with silt and sand (GP-GM); moist to wet, subrounded to subangular (Missoula Flood Deposits).	33.3 / 22.5			
25.0			P200	▲ 32	P200 = 10%
28.0	Very stiff, brown-green with white stripes SILT (MH), minor sand; moist, medium to plasticity (Troutdale Formation).	27.8 / 28.0			
30.0			P200 ATT	▲ 35	P200 = 92% LL = 69% PL = 42%
35.0	becomes trace sand at 35.0 feet			▲ 53	
40.0					

Legend: ▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (scale 0 – 50 – 100)

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: NAK COMPLETED: 07/20/10

BORING METHOD: mud rotary and HQ rock coring (see report text) BORING BIT DIAMETER: 4 7/8-inch

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BROWNCALD-49-03

MARCH 2011

BORING CR-8
(continued)

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-8

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION / DEPTH	TESTING	BLOW COUNT / MOISTURE CONTENT % / RQD% / CORE REC% (0–50–100)	INSTALLATION AND COMMENTS
40.0	(continued from previous page)				
	becomes hard, brown-red to green, sandy; blocky at 41.0 feet		P200	▲ 66	P200 = 57%
42.5					
45.0				▲ 30-50/4"	
47.5					
	Very dense, gray-green to brown, clayey SAND (SC); moist (decomposed basalt rock).	7.8 / 48.0			
50.0	Very soft to soft (R1-R2), gray BASALT; intensely to moderately weathered, intensely fractured, random, irregular, rough joint surfaces, open, predominantly oriented 60° - 70°, vesicular (5 - 10%).	5.8 / 50.0		▲ 50/3"	
52.5	becomes medium hard to hard (R3-R4); moderately to slightly weathered, moderately to slightly fractured at 53.0 feet				
55.0	Medium hard to hard (R3-R4), gray BASALT; slightly weathered, slightly fractured, smooth to rough joint surfaces, open, oriented 10° - 15°), vesicular (5 - 10%).	0.8 / 55.0	UC		UC = 12,547 psi
57.5					
	becomes soft (R2); 80° to 90° planar joint, slightly open with oxide coating at 59.0 feet		UC		UC = 1,727 psi
60.0					

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: NAK COMPLETED: 07/20/10

BORING METHOD: mud rotary and HQ rock coring (see report text) BORING BIT DIAMETER: 4 7/8-inch

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BROWNCALD-49-03

MARCH 2011

BORING CR-8
(continued)

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-8

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	▲ BLOW COUNT ● MOISTURE CONTENT % RQD% CORE REC% (0 50 100)	INSTALLATION AND COMMENTS
60.0		Hard to very hard (R4-R5), gray BASALT; slightly weathered to fresh, unfractured, vesicular (<5%).	-4.2 60.0				
62.5				UC			UC = 20,381 psi
65.0		becomes jointed, moderately to intensely fractured, rough joint surfaces, open, predominantly oriented 0° - 20°, with planar open joint oriented 80° - 90°, discontinuities filled with clay at 63.6 feet	-9.2 65.0				
		Exploration completed at a depth of 65.0 feet.					
67.5							
70.0							
72.5							
75.0							
77.5							
80.0							

DRILLED BY: Western States Soil Conservation, Inc. LOGGED BY: NAK COMPLETED: 07/20/10

BORING METHOD: mud rotary and HQ rock coring (see report text) BORING BIT DIAMETER: 4 7/8-inch

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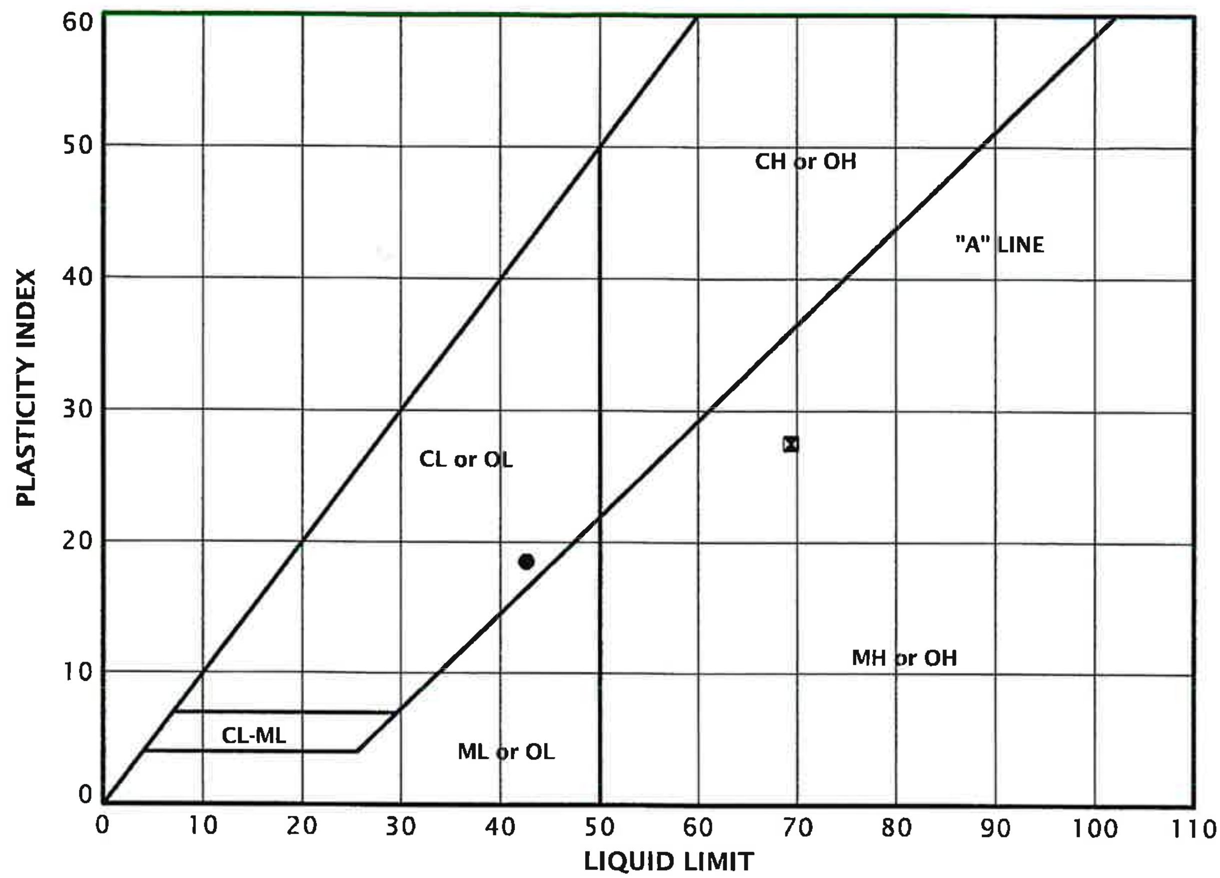
BROWNCALD-49-03

MARCH 2011

BORING CR-8
(continued)

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-8



KEY	EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	MOISTURE CONTENT (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
●	CR-8	1.0	21	43	24	19
⊠	CR-8	30.0	46	69	42	27

ATTERBERG_LIMITS 7 BROWNCALD-49-03-CR1_8.GPJ GEODESIGN.GDT PRINT DATE: 3/7/11:KT

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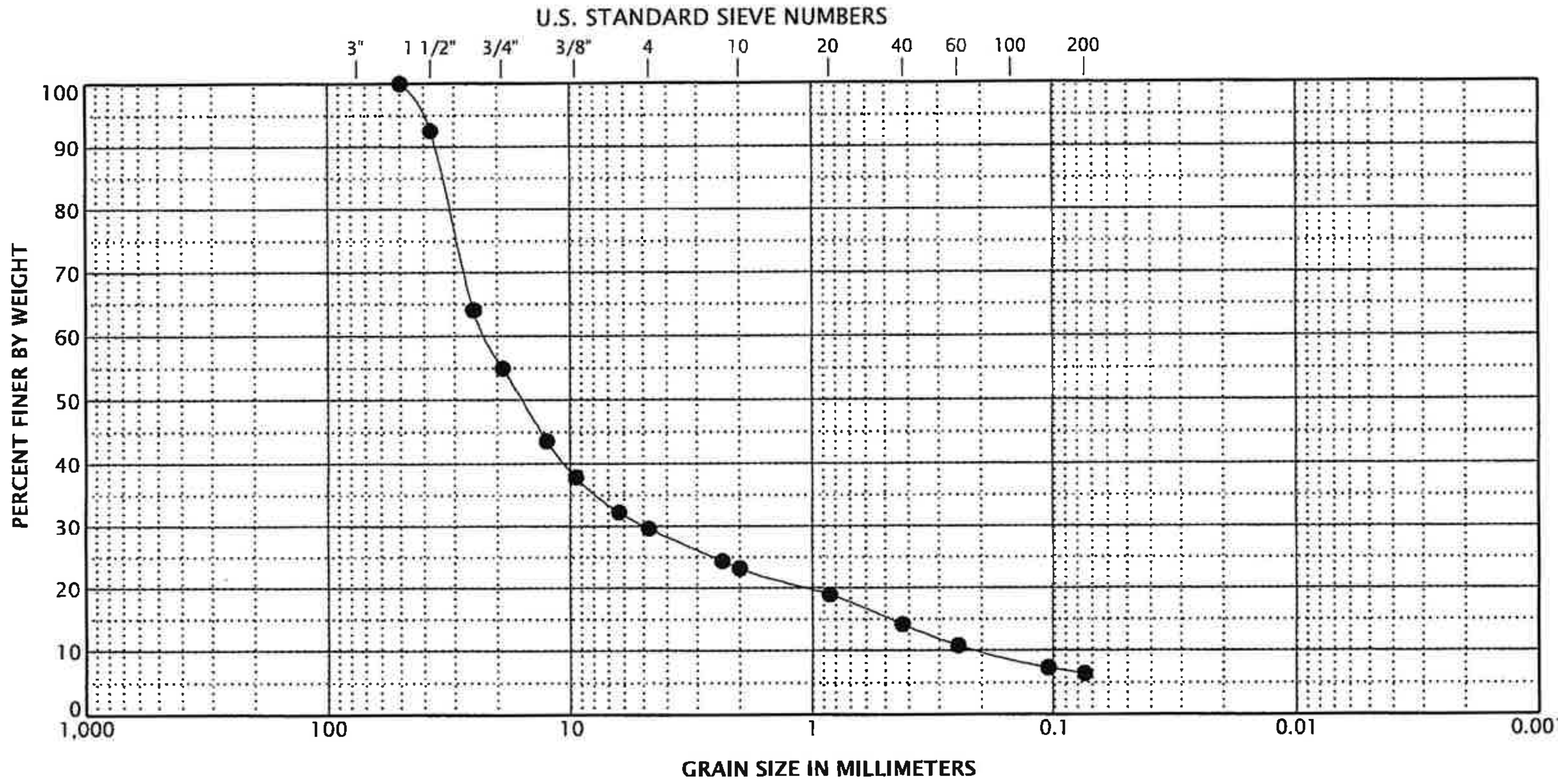
BROWNCALD-49-03	ATTERBERG LIMITS TEST RESULTS
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR — FIGURE A-9



BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY

KEY	EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	MOISTURE CONTENT (PERCENT)	D60	D50	D30	D10	D5	GRAVEL (PERCENT)	SAND (PERCENT)	SILT (PERCENT)	CLAY (PERCENT)
●	CR-8	10.0	8	22.12	15.83	4.95	0.21		70	23	6	

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BROWNCALD-49-03

MARCH 2011

GRAIN-SIZE TEST RESULTS

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-10

SAMPLE INFORMATION			MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT (PERCENT)	PLASTIC LIMIT (PERCENT)	PLASTICITY INDEX (PERCENT)
CR-8	1.0	54.8	21					43	24	19
CR-8	2.5	53.3	23							
CR-8	5.0	50.8	8							
CR-8	7.5	48.3	7							
CR-8	10.0	45.8	8		70	23	6			
CR-8	12.5	43.3	9							
CR-8	15.0	40.8	7							
CR-8	17.5	38.3	23				17			
CR-8	20.0	35.8	36				53			
CR-8	25.0	30.8	16				10			
CR-8	30.0	25.8	46				92	69	42	27
CR-8	35.0	20.8	51							
CR-8	40.0	15.8	35				57			
CR-8	45.0	10.8	42							

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SUMMARY OF LABORATORY DATA

PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION
GLADSTONE, OR

FIGURE A-11

BORING CR-1, CORE RUN 1, 0 TO 3.0 FEET

BORING CR-1, CORE RUN 2, 3.0 TO 9.0 FEET (1 OF 2)

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR — **FIGURE A-12**

BORING CR-1, CORE RUN 2, 3.0 TO 9.0 FEET (2 OF 2)

BORING CR-1, CORE RUN 3, 9.0 TO 13.5 FEET (1 OF 2)

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MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-13

BORING CR-1, CORE RUN 3, 9.0 TO 13.5 FEET (2 OF 2)

BORING CR-1, CORE RUN 4, 13.5 TO 18.5 FEET (1 OF 2)

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-14

BORING CR-1, CORE RUN 4, 13.5 TO 18.5 FEET (2 OF 2)

BORING CR-1, CORE RUN 5, 18.5 TO 21.5 FEET

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR — FIGURE A-15

BORING CR-1, CORE RUN 6, 23.5 TO 28.0 FEET (1 OF 2)

BORING CR-1, CORE RUN 6, 23.5 TO 28.0 FEET (2 OF 2)

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MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-16

BORING CR-1, CORE RUN 7, 28.0 TO 33.5 FEET (1 OF 2)

BORING CR-1, CORE RUN 7, 28.0 TO 33.5 FEET (2 OF 2)

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MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-17

BORING CR-1, CORE RUN 8, 33.5 TO 37.5 FEET

BORING CR-1, CORE RUN 9, 37.5 TO 42.0 FEET (2 OF 2)

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-18

BORING CR-2, CORE RUN 1, 0 TO 2.0 FEET

BORING CR-2, CORE RUN 2, 2.0 TO 2.5 FEET

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MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-19

BORING CR-2, CORE RUN 3, 2.5 TO 4.5 FEET

BORING CR-2, CORE RUN 4, 7.0 TO 8.5 FEET

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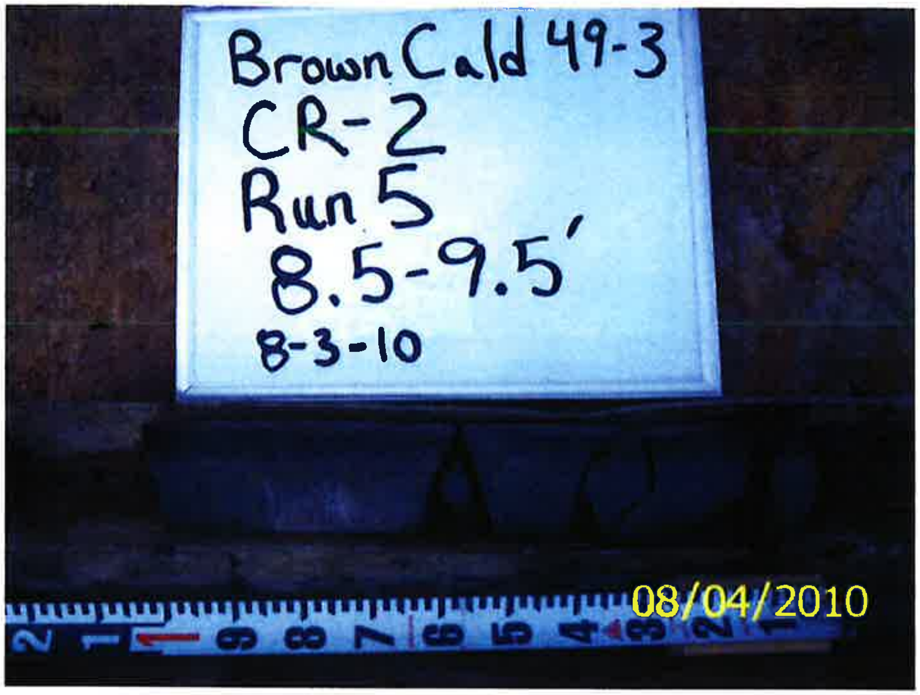
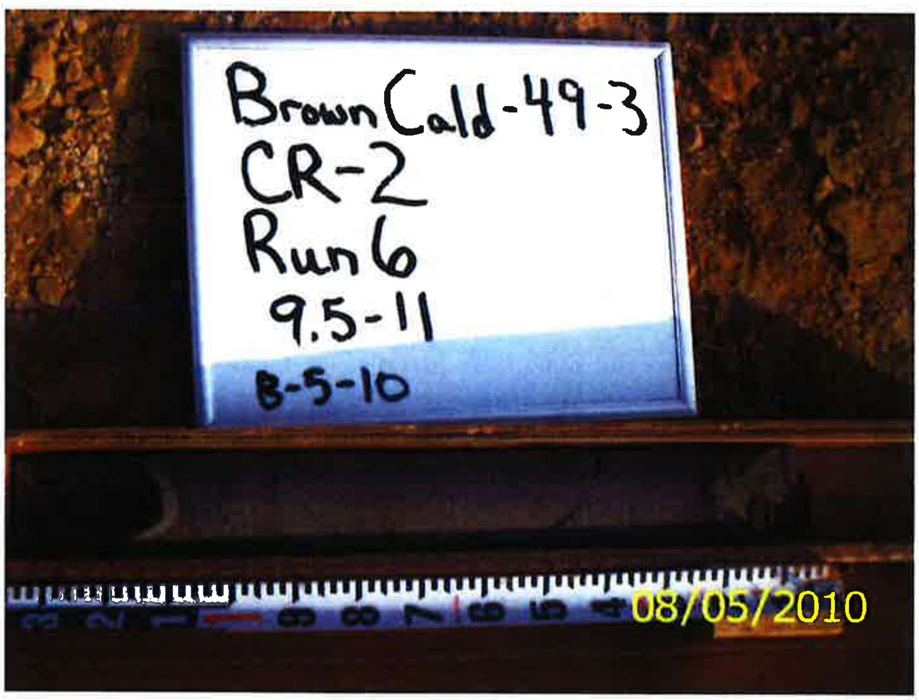
	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-20**



BORING CR-2, CORE RUN 5, 8.5 TO 9.5 FEET



BORING CR-2, CORE RUN 6, 9.5 TO 11.0 FEET

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-21**

BORING CR-2, CORE RUN 7, 11.0 TO 16.0 FEET

BORING CR-2, CORE RUN 8, 16.0 TO 17.5 FEET

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-22**

BORING CR-2, CORE RUN 9, 17.5 TO 22.5 FEET (1 OF 2)

BORING CR-2, CORE RUN 9, 17.5 TO 22.5 FEET (2 OF 2)

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MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-23**

BORING CR-2, CORE RUN 10, 22.5 TO 27.5 FEET (1 OF 2)

BORING CR-2, CORE RUN 10, 22.5 TO 27.5 FEET (2 OF 2)

BORING CR-2, CORE RUN 11, 27.5 TO 32.0 FEET

BORING CR-2, CORE RUN 12, 32.0 TO 37.0 FEET (1 OF 2)

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-25

BORING CR-2, CORE RUN 12, 32.0 TO 37.0 FEET (2 OF 2)

BORING CR-2, CORE RUN 13, 37.0 TO 40.0 FEET

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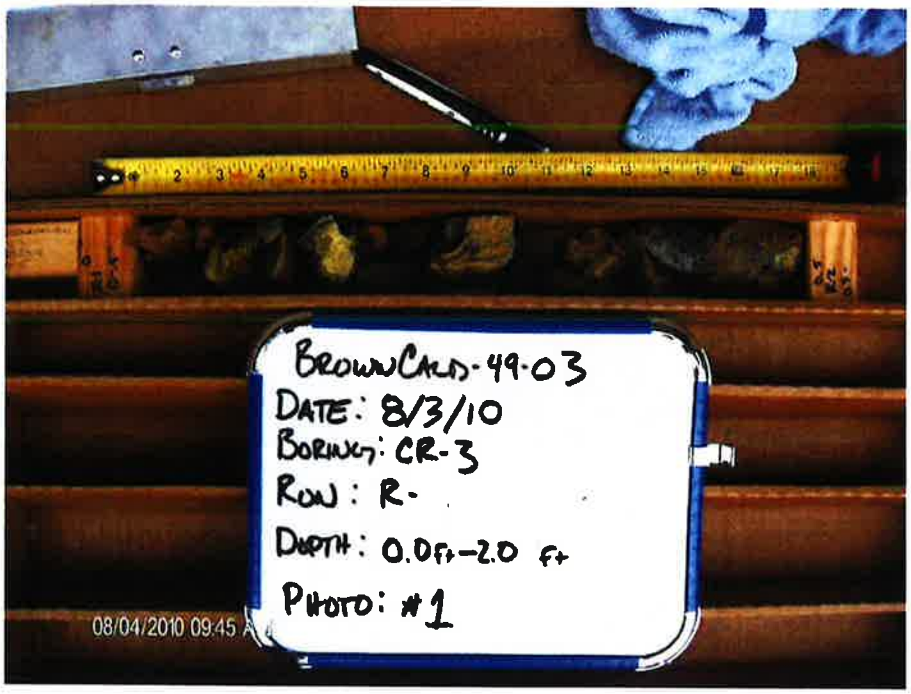
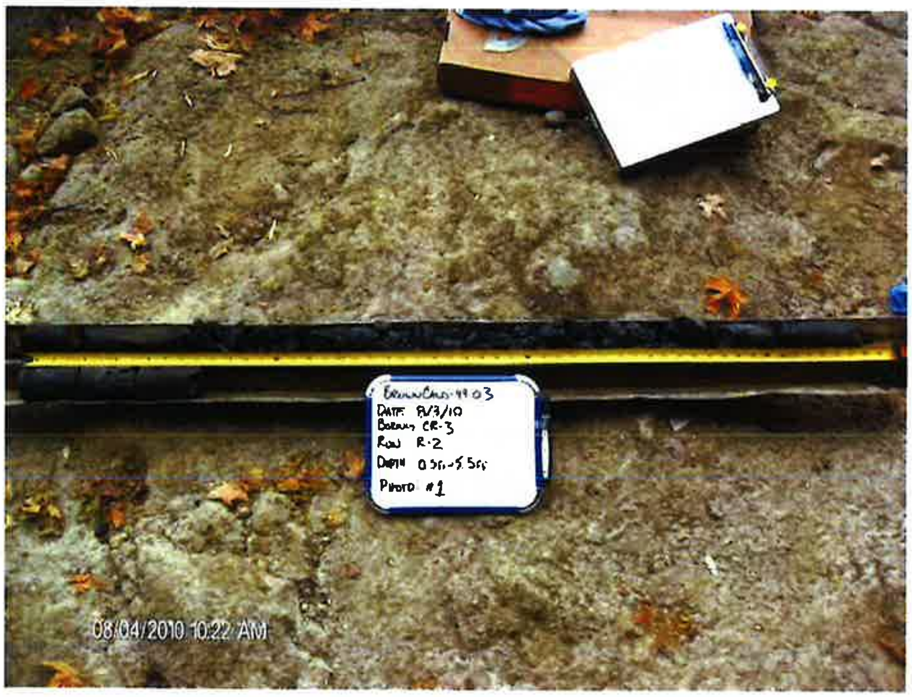
BROWNCALD-49-03	CORE PHOTOGRAPHS	
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-26



BORING CR-3, CORE RUN 1, 0 TO 0.5 FOOT



BORING CR-3, CORE RUN 2, 0.5 TO 5.5 FEET

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-27**

BORING CR-3, CORE RUN 3, 5.5 TO 9.25 FEET

BORING CR-3, CORE RUN 4, 9.25 TO 14.25 FEET

BORING CR-3, CORE RUN 5, 14.25 TO 15.5 FEET

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BROWNCALD-49-03	**CORE PHOTOGRAPHS**	
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-29**

BORING CR-4, CORE RUN 1, 0 TO 5.0 FEET

BORING CR-4, CORE RUN 2, 5.0 TO 10.0 FEET

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-30**

BORING CR-4, CORE RUN 3, 10.0 TO 15.0 FEET

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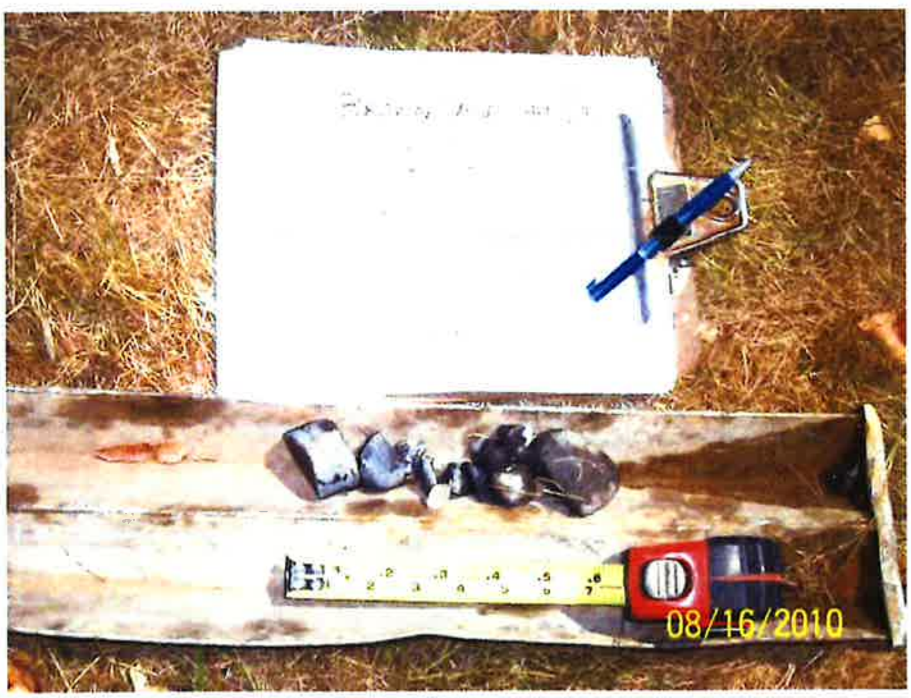
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-31

BORING CR-6, CORE RUN 2, 15.0 TO 16.5 FEET
[CORE RUN 1 – NO RECOVERY]



BORING CR-6, CORE RUN 3, 16.5 TO 17.3 FEET

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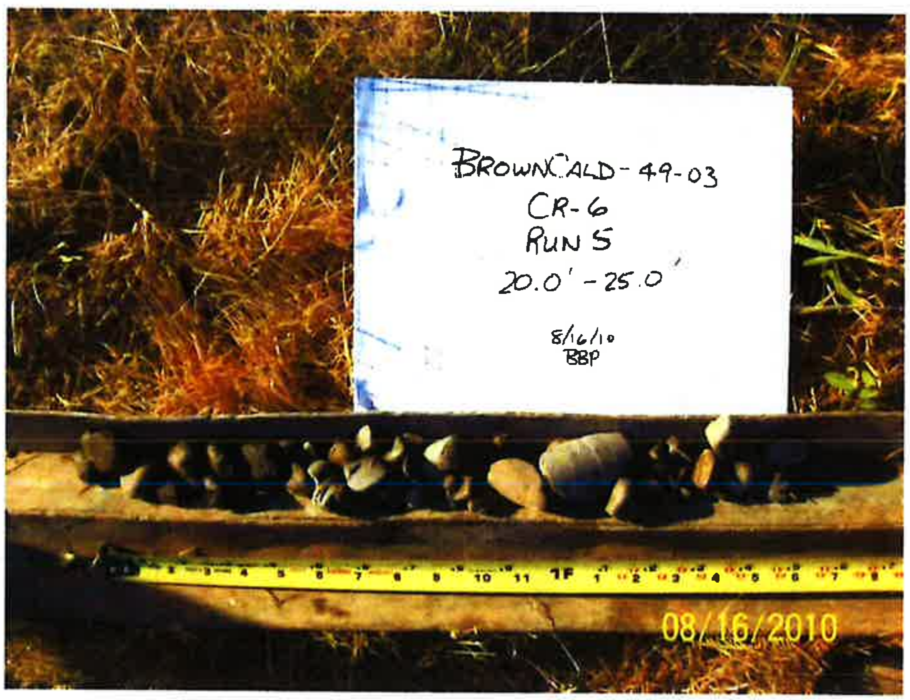
BROWNCALD-49-03	CORE PHOTOGRAPHS	
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-32

BORING CR-6, CORE RUN 4, 17.3 TO 20.0 FEET



BORING CR-6, CORE RUN 5, 20.0 TO 25.0 FEET

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-33**

BORING CR-6, CORE RUN 6, 25.0 TO 27.0 FEET

BORING CR-6, CORE RUN 7, 27.0 TO 29.5 FEET

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BROWNCALD-49-03	CORE PHOTOGRAPHS	
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-34

BORING CR-6, CORE RUN 8, 29.5 TO 31.5 FEET

BORING CR-6, CORE RUN 9, 31.5 TO 33.0 FEET

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-35

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BORING CR-6, CORE RUN 10, 33.0 TO 34.0 FEET

BORING CR-6, CORE RUN 11, 34.0 TO 37.8 FEET

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-36**

BORING CR-6, CORE RUN 12, 37.8 TO 42.0 FEET

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MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR		FIGURE A-37

BORING CR-7, CORE RUN 1, 0 TO 5.5 FEET

BORING CR-7, CORE RUN 2, 5.5 TO 8.0 FEET

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-38**

BORING CR-7, CORE RUN 3, 8.0 TO 13.25 FEET

BORING CR-7, CORE RUN 4, 13.25 TO 18.0 FEET

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MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-39**

BORING CR-7, CORE RUN 5, 18.0 TO 22.25 FEET

BORING CR-7, CORE RUN 6, 22.25 TO 26.5 FEET

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BROWNCALD-49-03	CORE PHOTOGRAPHS	
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-40

BORING CR-7, CORE RUN 7, 26.5 TO 31.5 FEET

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BROWNCALD-49-03	CORE PHOTOGRAPHS		
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-41	

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BORING CR-8, CORE RUN 1, 50.0 TO 55.0 FEET

BORING CR-8, CORE RUN 2, 55.0 TO 60.0 FEET

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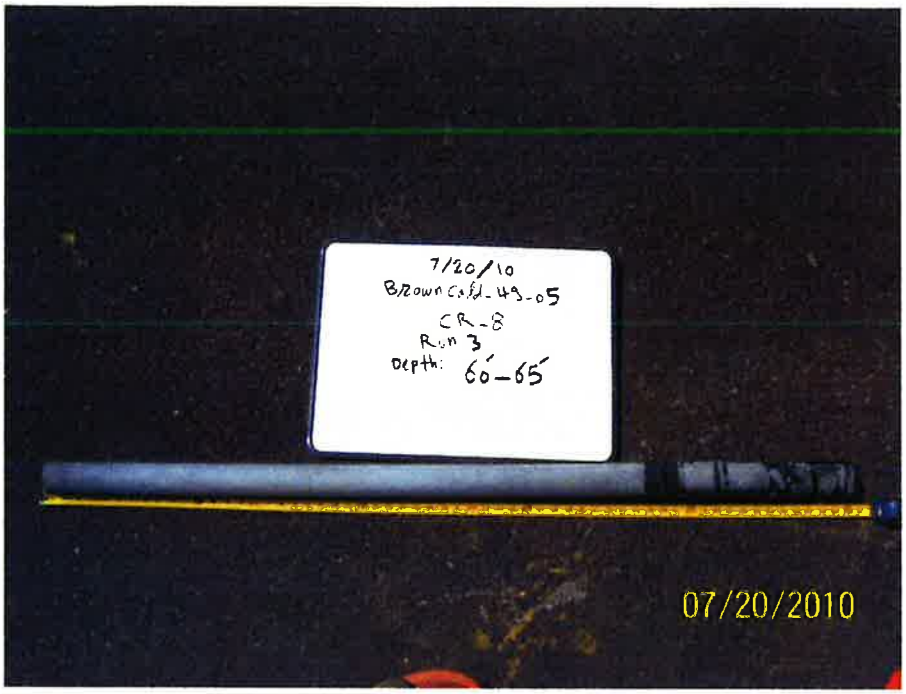
BROWNCALD-49-03	**CORE PHOTOGRAPHS**	
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-42**



BORING CR-8, CORE RUN 3, 60.0 TO 65.0 FEET

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MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-43

BORING CR-1, BOX 1, 0 TO 10.0 FEET

BORING CR-1, BOX 2, 10.0 TO 18.5 FEET

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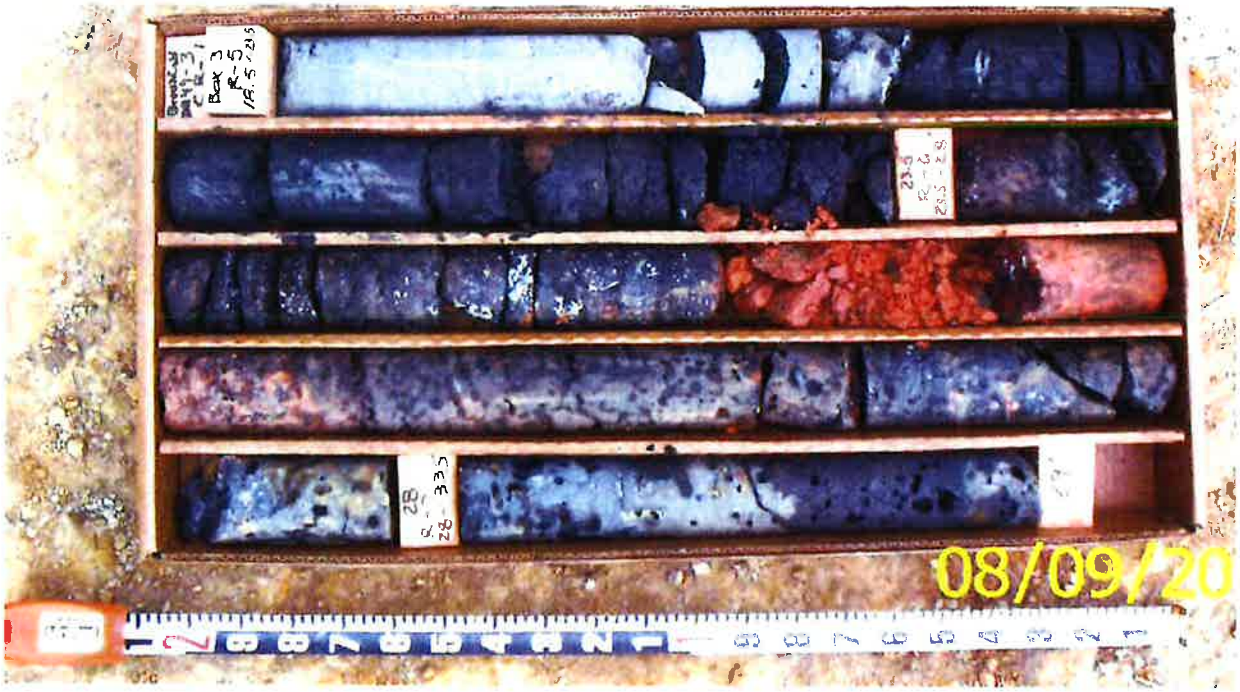
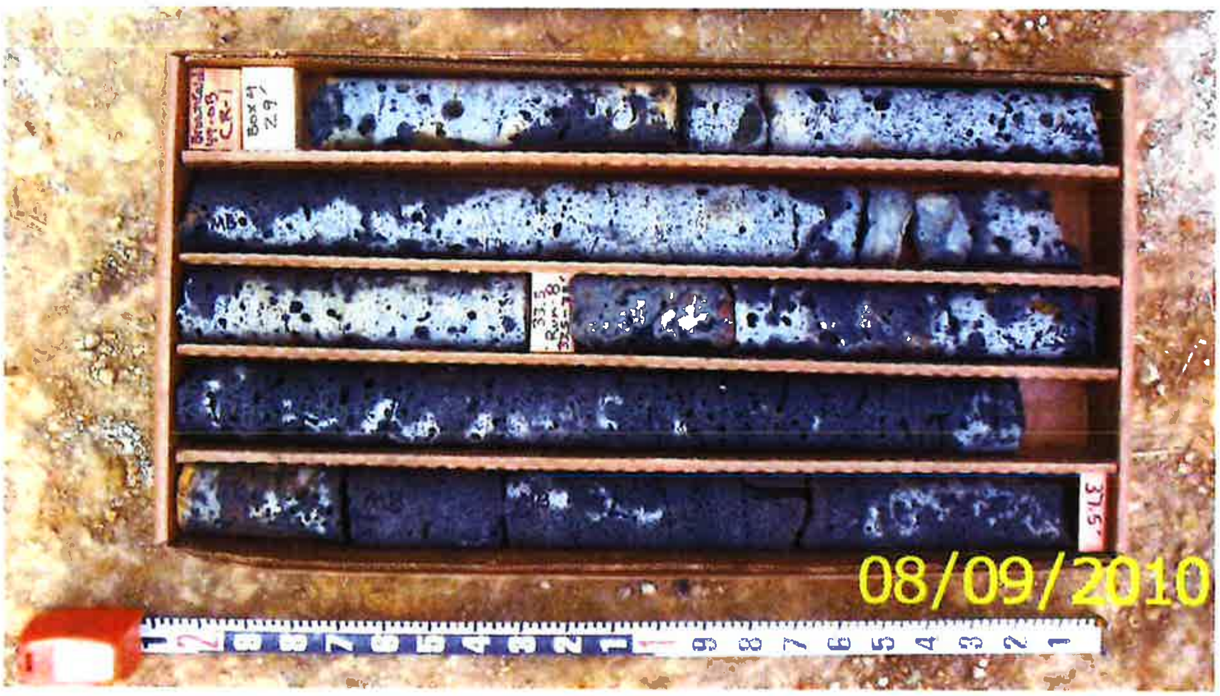
BROWNCALD-49-03	**CORE PHOTOGRAPHS**	
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-44**



BORING CR-1, BOX 3, 18.5 TO 29.0 FEET



BORING CR-1, BOX 4, 29.0 TO 37.5 FEET

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	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-45

BORING CR-1, BOX 5, 37.5 TO 42.0 FEET

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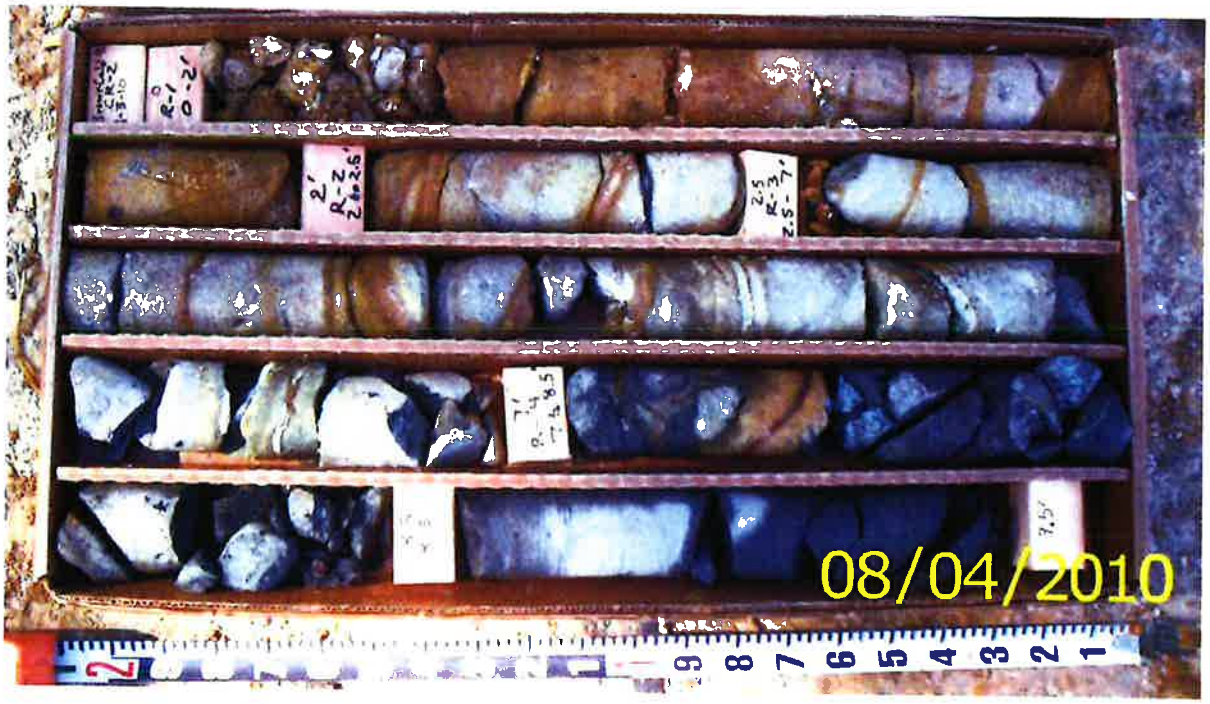
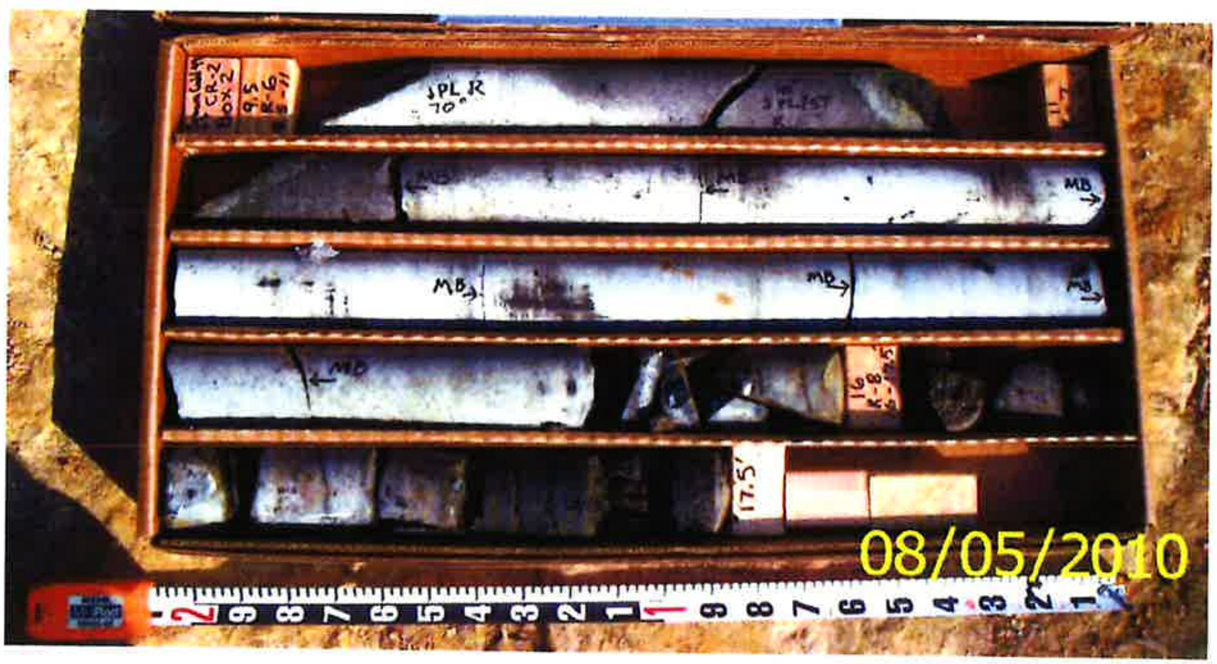
	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-46**



BORING CR-2, BOX 1, 0 TO 9.5 FEET



BORING CR-2, BOX 2, 9.5 TO 17.5 FEET

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MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-47

BORING CR-2, BOX 3, 17.5 TO 26.0 FEET

BORING CR-2, BOX 4, 26.0 TO 36.0 FEET

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MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-48

BORING CR-2, BOX 5, 36.0 TO 40.0 FEET

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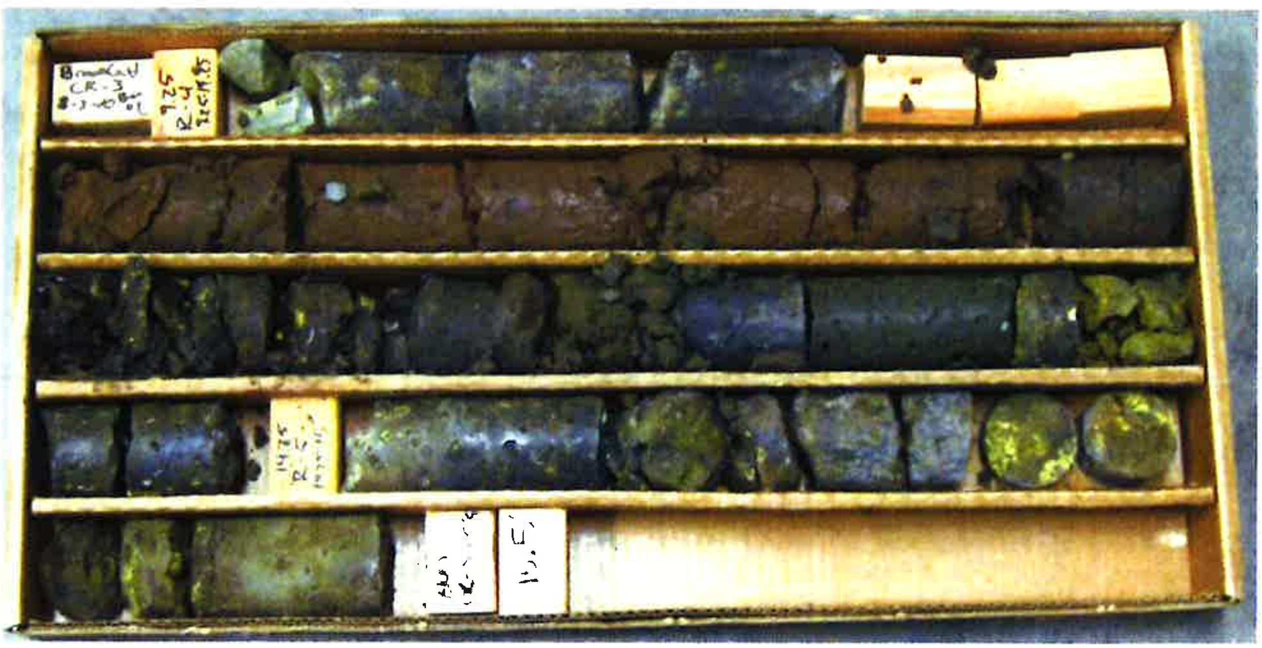
	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR — **FIGURE A-49**

BORING CR-3, BOX 1, 0 TO 9.25 FEET



BORING CR-3, BOX 2, 9.25 TO 15.5 FEET

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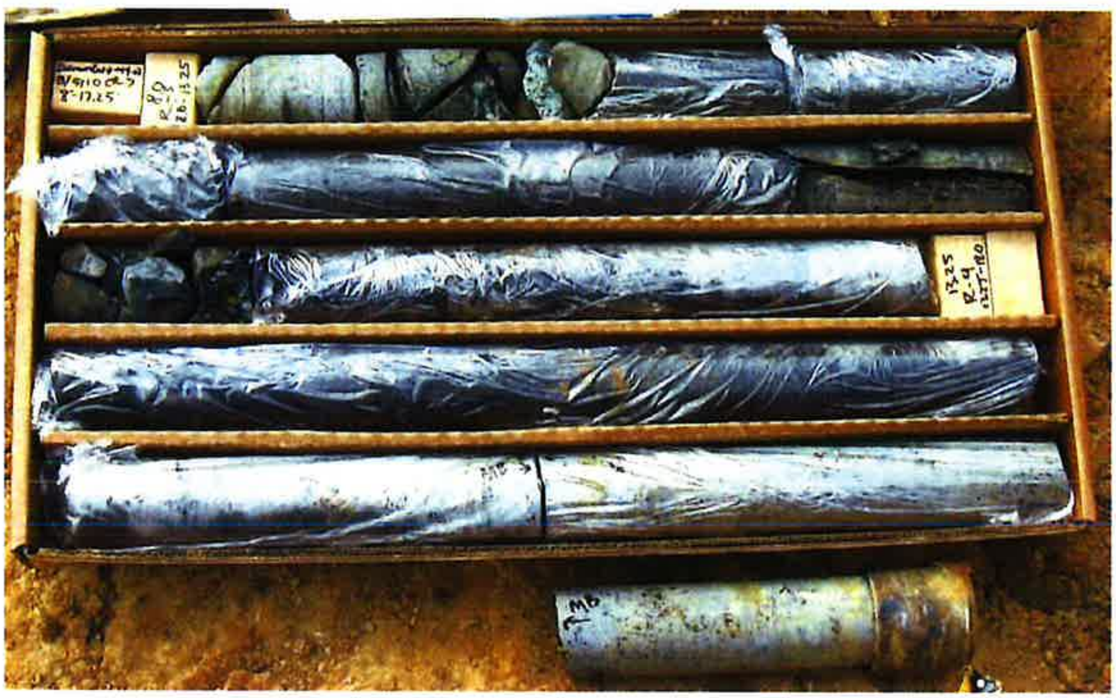
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-50**

BORING CR-7, BOX 1, 0 TO 8.0 FEET



BORING CR-7, BOX 2, 8.0 TO 17.25 FEET

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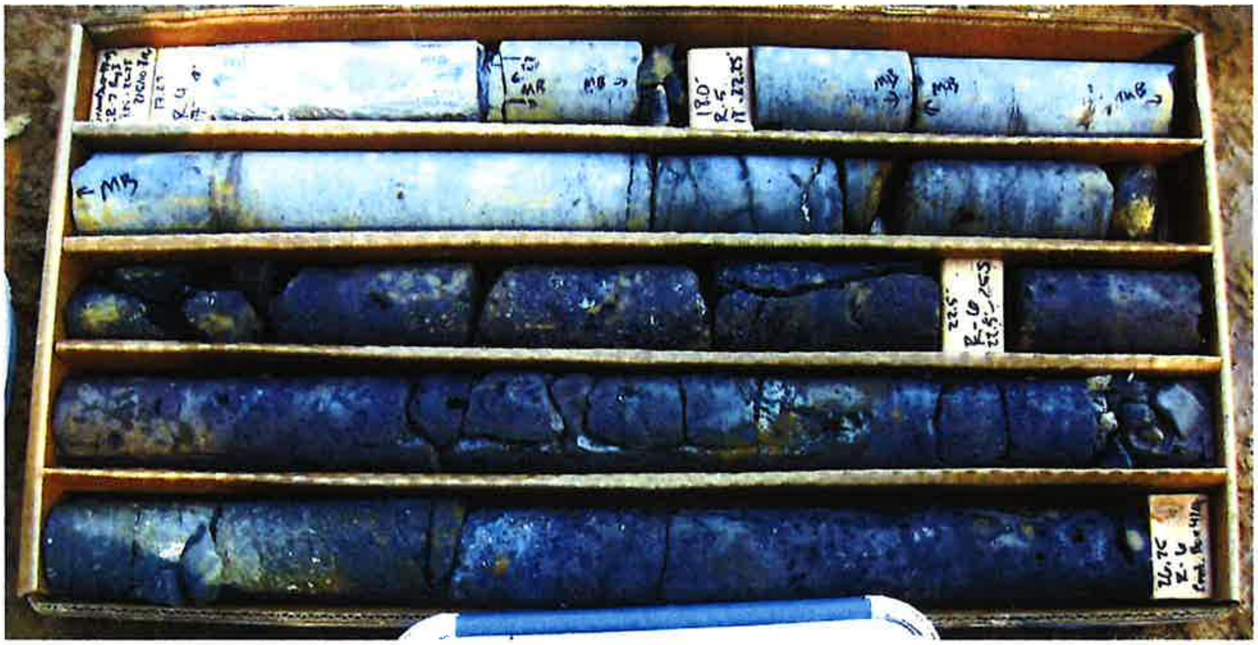
	MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-51



BORING CR-7, BOX 3, 17.25 TO 26.25 FEET

BORING CR-7, BOX 4, 26.25 TO 31.5 FEET

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MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	**FIGURE A-52**

BORING CR-8, BOX 1, 50.0 TO 58.5 FEET

BORING CR-8, BOX 2, 58.5 TO 65.0 FEET

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BROWNCALD-49-03	CORE PHOTOGRAPHS	
MARCH 2011	PROPOSED CLACKAMAS RIVER INTAKE PUMP STATION GLADSTONE, OR	FIGURE A-53

APPENDIX B

APPENDIX B

OUTSIDE LABORATORY TESTING

We submitted several bedrock samples to ACS Testing Inc. of Tigard, Oregon, and to Kleinfelder of Redmond, Washington, to conduct supplemental laboratory testing. The results of their testing are discussed below and included in this appendix.

UNCONFINED COMPRESSION STRENGTH

Unconfined compressive strength testing was completed on several samples from the extracted rock cores. The testing was completed in accordance with ASTM D 7012. The test results are included at the end of this appendix and summarized in Table B-1.

Table B-1. Unconfined Compressive Strength Test Results

Boring	Depth (feet BGS)	Rock Description	Unconfined Compressive Strength (psi)
CR-1	5.0	Extremely Soft Basalt (R0)	395
CR-1	13.5	Very Hard Basalt (R5)	37,147
CR-1	26.0	Soft Basalt (R2)	1,056
CR-1	34.8	Hard Basalt (R4)	9,566
CR-1	40.9	Hard Basalt (R4)	14,917
CR-2	15.0	Very Hard Basalt (R5)	45,131
CR-2	34.5	Hard Basalt (R4)	11,898
CR-7	18.5	Hard Basalt (R4)	9,971
CR-7	4.9	Extremely Soft Basalt (R0)	624
CR-7	15.2	Very Hard Basalt (R5)	32,864
CR-7	25.7	Soft Basalt (R2)	2,968
CR-8	57	Hard Basalt (R4)	12,547
CR-8	59	Soft Basalt (R2)	1,727
CR-8	60	Very Hard Basalt (R5)	20,381

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Unconfined Compressive Strength Test ASTM D7012-09 ε1

PROJECT:	Clackamas River	**LAB SAMPLE NO.:**	9778
PROJECT NO.:	113373	**SAMPLE NO.:**	CR-1 5.0'-5.9'
PROJECT LOCATION:	Gladstone, OR	**SAMPLE DESCRIP:**	Basalt
SAMPLED BY:	JGH	**DATE TESTED:**	9/27/2010
DATE SAMPLED:		**REPORTED BY:**	A.Stirbys

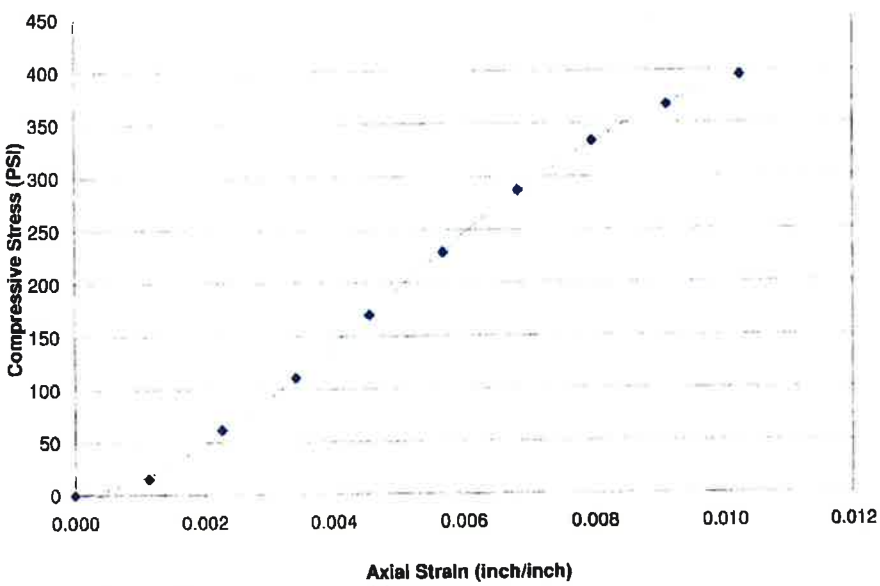
Tare Weight (grams)	0.00
Wet Specimen Weight + tare (g)	375.40
Dry Specimen Weight + tare (g)	375.40
Weight of Water (g)	0.00
Weight of Dry Specimen (g)	375.40
Weight of Wet Specimen (g)	375.40
Water Content (%)	0.0
Unit Weight Wet (pcf)	100.6
Unit Weight Dry (pcf)	100.6
Unit Weight of Water (pcf)	62.43

Diameter (in)		2.03
Area (in^2)		3.24
Height (in)		4.39
Volume (in^3)		14.21
Maximum Load, P (lbs)		1,280
Compressive Strength (PSI)		395
Specific Gravity		1.61
Sample Break Type	Intact	x
	Fracture	

Other Break Comments:

Axial Load (lbs)	Deflection (inch)	Axial Strain (inch/inch)	Compressive Stress (PSI)
0	0.000	0.00000	0
50	0.005	0.00114	15
200	0.010	0.00228	62
360	0.015	0.00342	111
550	0.020	0.00456	170
740	0.025	0.00569	229
930	0.030	0.00683	287
1,080	0.035	0.00797	334
1,190	0.040	0.00911	368
1,280	0.045	0.01025	395

Compressive Stress versus Axial Strain Plot



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Unconfined Compressive Strength Test ASTM D7012-09 $^{\varepsilon 1}$

PROJECT:	Clackamas River
PROJECT NO.:	113373
SAMPLE DESCRIP:	Basalt
SAMPLE NO.:	CR-1 5.0'-5.9'
LAB SAMPLE NO.:	9778
REPORTED BY:	A.Stirbys

PROJECT:	Clackamas River
PROJECT NO.:	113373
SAMPLE DESCRIP:	Basalt
SAMPLE NO.:	CR-1 5.0'-5.9'
LAB SAMPLE NO.:	9778
REPORTED BY:	A.Stirbys

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Data checked by: CL Date 6-Oct

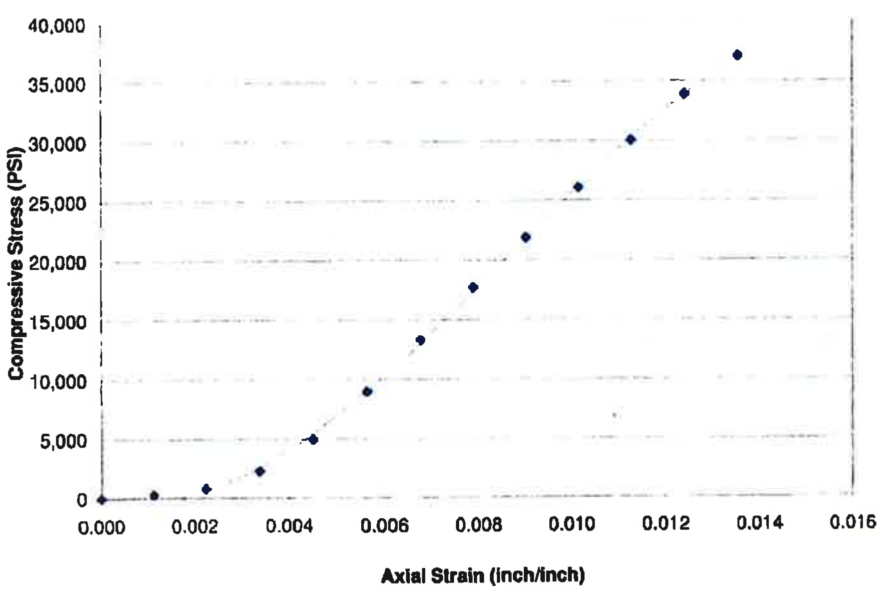
Unconfined Compressive Strength Test ASTM D7012-09 $^{\varepsilon 1}$

PROJECT:	Clackamas River	LAB SAMPLE NO.:	9770
PROJECT NO.:	113373	SAMPLE NO.:	CR-1 13.5'-14.5'
PROJECT LOCATION:	Gladstone, OR	SAMPLE DESCRIP:	Basalt
SAMPLED BY:	JGH	DATE TESTED:	9/27/2010
DATE SAMPLED:		REPORTED BY:	A.Stirbys

Tare Weight (grams)	0.00	Diameter (in)	2.04
Wet Specimen Weight + tare (g)	668.90	Area (in^2)	3.27
Dry Specimen Weight + tare (g)	668.90	Height (in)	4.43
Weight of Water (g)	0.00	Volume (in^3)	14.48
Weight of Dry Specimen (g)	668.90	Maximum Load, P (lbs)	121.416
Weight of Wet Specimen (g)	668.90		
Water Content (%)	0.0	Compressive Strength (PSI)	37.147
Unit Weight Wet (pcf)	176.0	Specific Gravity	2.82
Unit Weight Dry (pcf)	176.0	Sample Break Type: Intact	x
Unit Weight of Water (pcf)	62.43	Sample Break Type: Fracture	
Other Break Comments:			

Axial Load (lbs)	Deflection (inch)	Axial Strain (inch/inch)	Compressive Stress (PSI)
0	0.000	0.00000	0
1,030	0.005	0.00113	315
2,660	0.010	0.00226	814
7,464	0.015	0.00339	2,284
16,260	0.020	0.00451	4,975
29,455	0.025	0.00564	9,012
43,781	0.030	0.00677	13,395
58,006	0.035	0.00790	17,747
71,540	0.040	0.00903	21,888
85,300	0.045	0.01016	26,097
98,218	0.050	0.01129	30,050
110,880	0.055	0.01242	33,924
121,416	0.060	0.01354	37,147

Compressive Stress versus Axial Strain Plot



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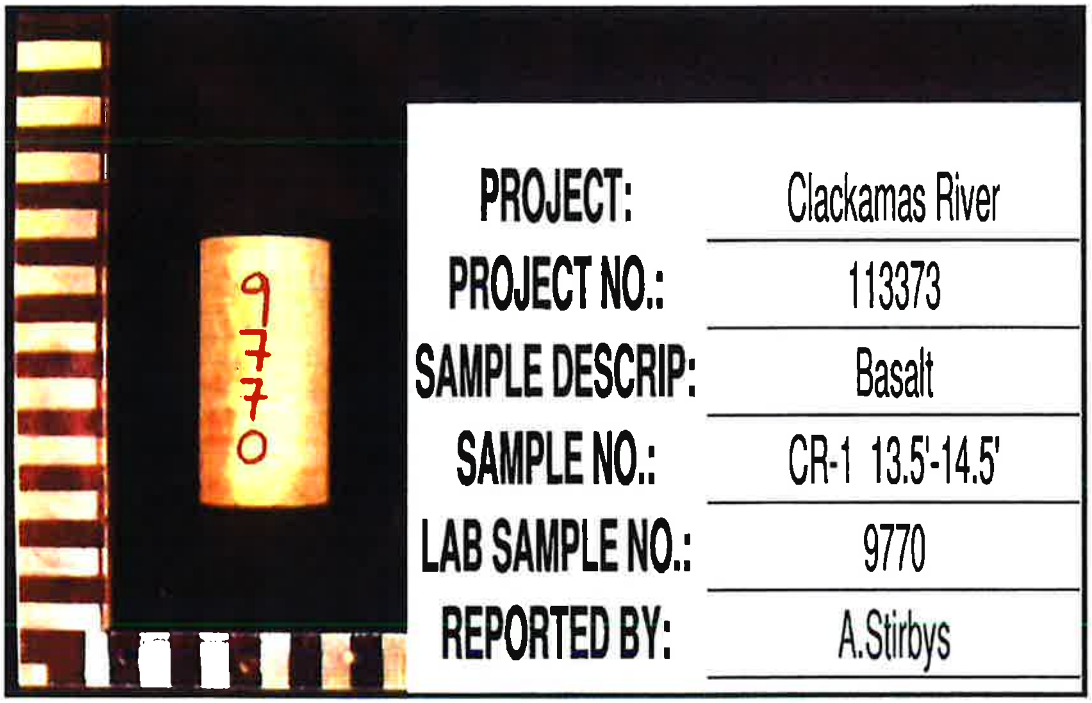
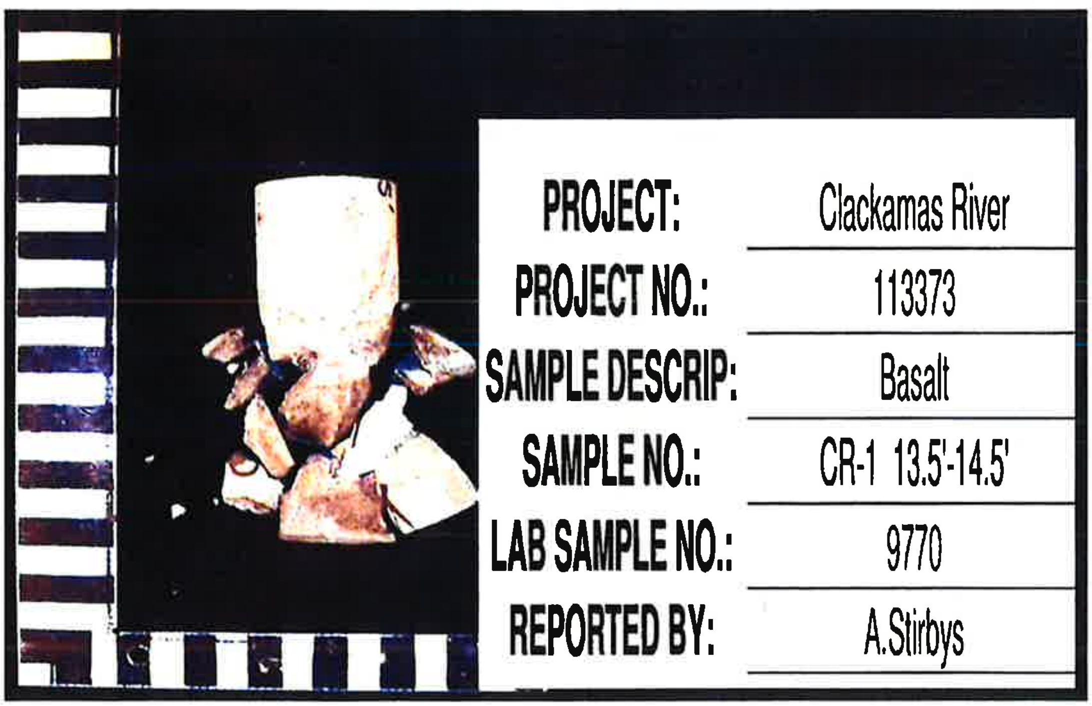
Unconfined Compressive Strength Test ASTM D7012-09 ε1





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Data checked by: CL Date 6-Oct

*Unconfined Compressive Strength Test ASTM D7012-09 ^ε1^*

PROJECT:	Clackamas River	**LAB SAMPLE NO.:**	9776
PROJECT NO.:	113373	**SAMPLE NO.:**	CR-1 26.0'-26.8'
PROJECT LOCATION:	Gladstone, OR	**SAMPLE DESCRIP:**	Basalt
SAMPLED BY:	JGH	**DATE TESTED:**	9/27/2010
DATE SAMPLED:		**REPORTED BY:**	A.Stirbys

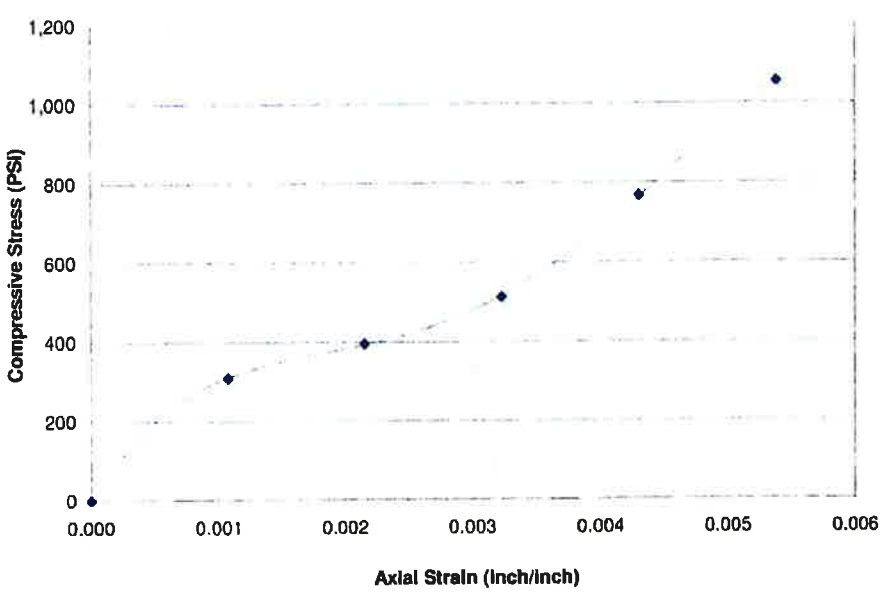
Tare Weight (grams)	0.00
Wet Specimen Weight + tare (g)	479.20
Dry Specimen Weight + tare (g)	479.20
Weight of Water (g)	0.00
Weight of Dry Specimen (g)	479.20
Weight of Wet Specimen (g)	479.20
Water Content (%)	0.0
Unit Weight Wet (pcf)	121.5
Unit Weight Dry (pcf)	121.5
Unit Weight of Water (pcf)	62.43

Diameter (in)	2.03
Area (in^2)	3.24
Height (in)	4.64
Volume (in^3)	15.02
Maximum Load, P (lbs)	3,418
Compressive Strength (PSI)	1,056
Specific Gravity	1.95
Sample Break Type: Intact	x
Sample Break Type: Fracture	

Other Break Comments:

Axial Load (lbs)	Deflection (inch)	Axial Strain (Inch/Inch)	Compressive Stress (PSI)
0	0.000	0.00000	0
1,005	0.005	0.00108	311
1,281	0.010	0.00216	396
1,658	0.015	0.00323	512
2,488	0.020	0.00431	769
3,418	0.025	0.00539	1,056

Compressive Stress versus Axial Strain Plot



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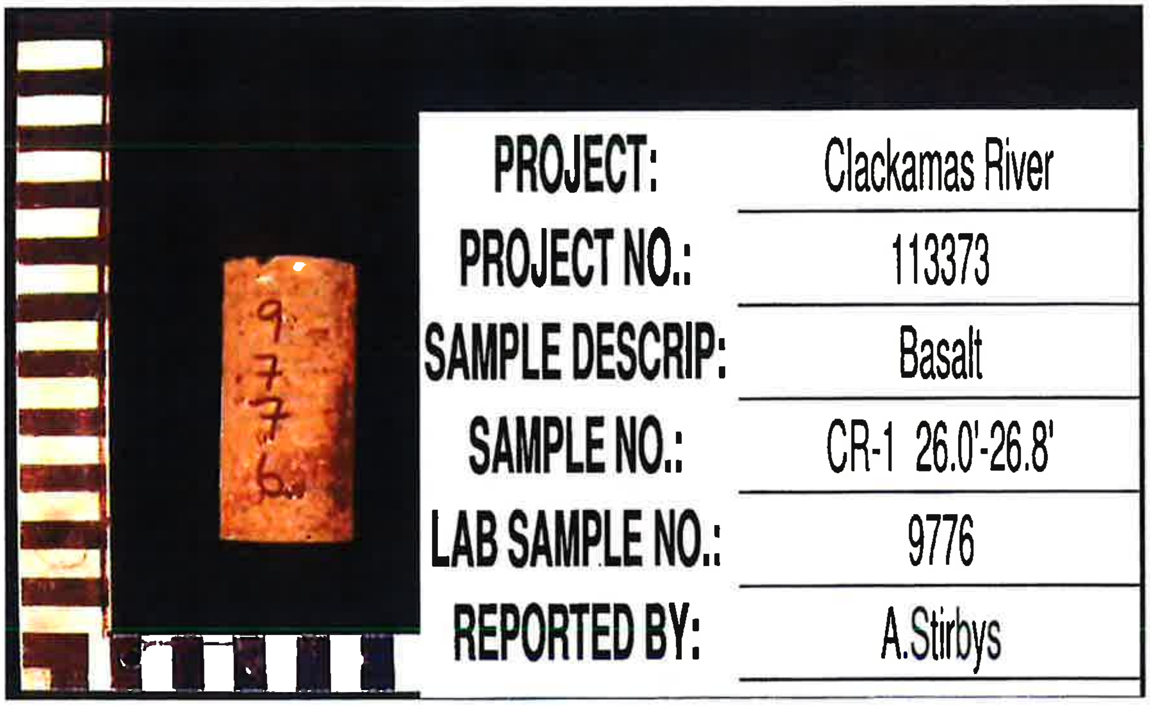
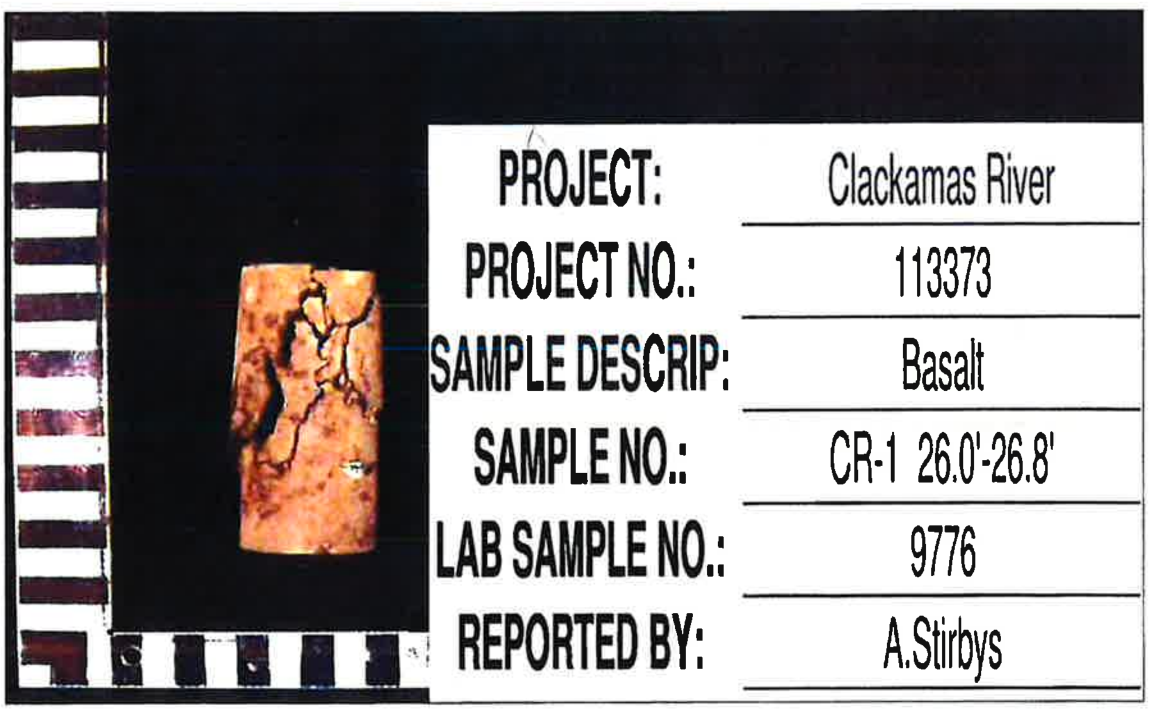
Unconfined Compressive Strength Test ASTM D7012-09 $^{\varepsilon 1}$





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Data checked by: CL Date

Unconfined Compressive Strength Test ASTM D7012-09 ε1

PROJECT:	Clackamas River	**LAB SAMPLE NO.:**	9773
PROJECT NO.:	113373	**SAMPLE NO.:**	CR-1 34.8'-35.6'
PROJECT LOCATION:	Gladstone, OR	**SAMPLE DESCRIP:**	Basalt
SAMPLED BY:	JGH	**DATE TESTED:**	9/27/2010
DATE SAMPLED:		**REPORTED BY:**	A.Stirbys

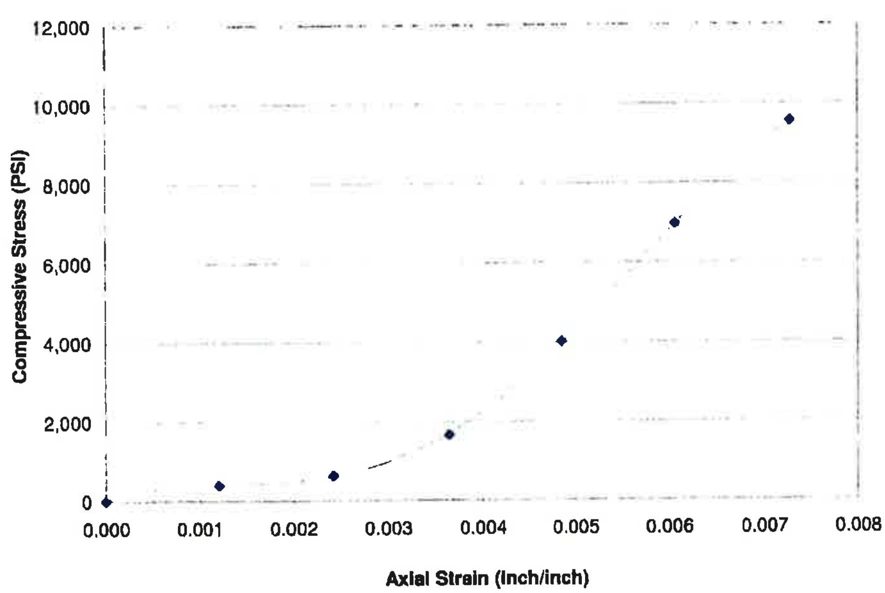
Tare Weight (grams)	0.00
Wet Specimen Weight + tare (g)	527.90
Dry Specimen Weight + tare (g)	527.90
Weight of Water (g)	0.00
Weight of Dry Specimen (g)	527.90
Weight of Wet Specimen (g)	527.90
Water Content (%)	0.0
Unit Weight Wet (pcf)	149.3
Unit Weight Dry (pcf)	149.3
Unit Weight of Water (pcf)	62.43

Diameter (in)		2.04
Area (in²)		3.27
Height (in)		4.12
Volume (in³)		13.47
Maximum Load, P (lbs)		31,265
Compressive Strength (PSI)		9,566
Specific Gravity		2.39
Sample Break Type	Intact	x
	Fracture	

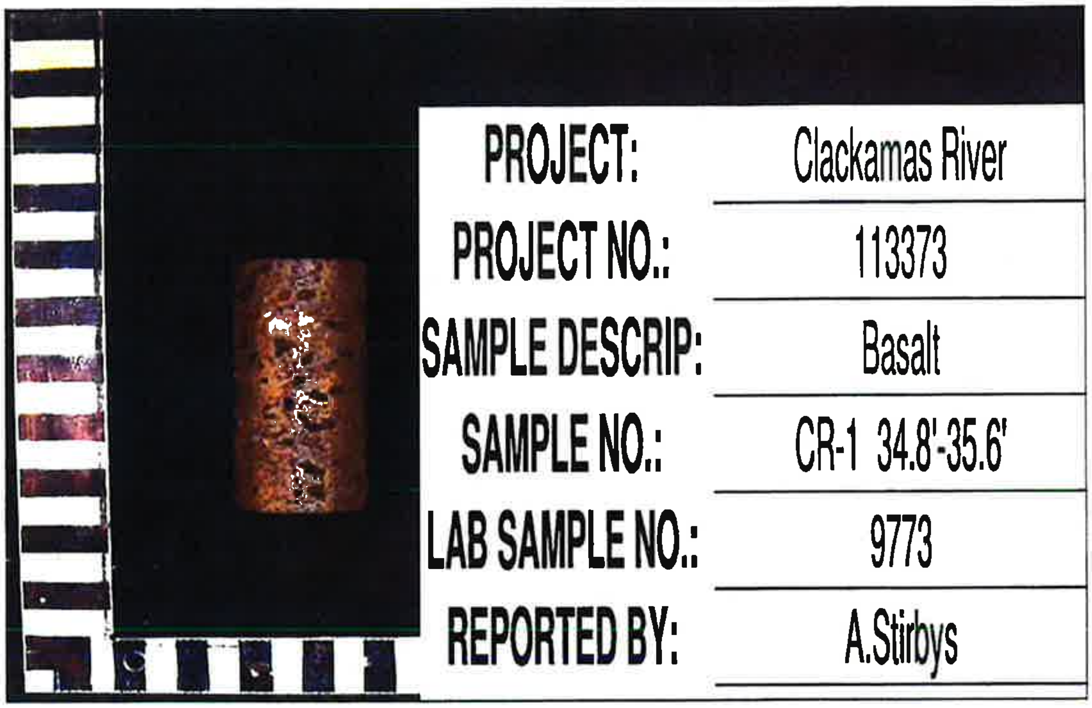
Other Break Comments:	

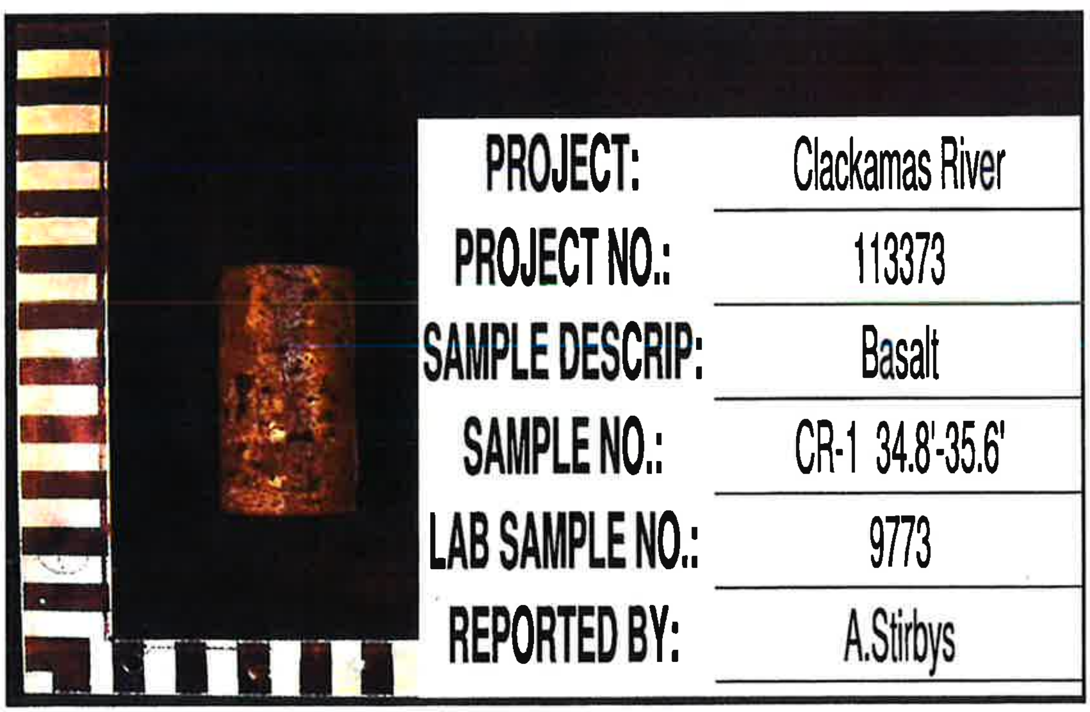
Axial Load (lbs)	Deflection (inch)	Axial Strain (inch/inch)	Compressive Stress (PSI)
0	0.000	0.00000	0
1,330	0.005	0.00121	407
2,086	0.010	0.00243	638
5,428	0.015	0.00364	1,661
13,144	0.020	0.00485	4,021
22,795	0.025	0.00607	6,974
31,265	0.030	0.00728	9,566

Compressive Stress versus Axial Strain Plot



Unconfined Compressive Strength Test ASTM D7012-09 $^{\varepsilon 1}$





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Data checked by: CL Date: 6 Oct

Unconfined Compressive Strength Test ASTM D7012-09 ε1

PROJECT:	Clackamas River	**LAB SAMPLE NO.:**	9772
PROJECT NO.:	113373	**SAMPLE NO.:**	CR-1 40.9'-41.6'
PROJECT LOCATION:	Gladstone, OR	**SAMPLE DESCRIP:**	Basalt
SAMPLED BY:	JGH	**DATE TESTED:**	9/27/2010
DATE SAMPLED:		**REPORTED BY:**	A.Stirbys

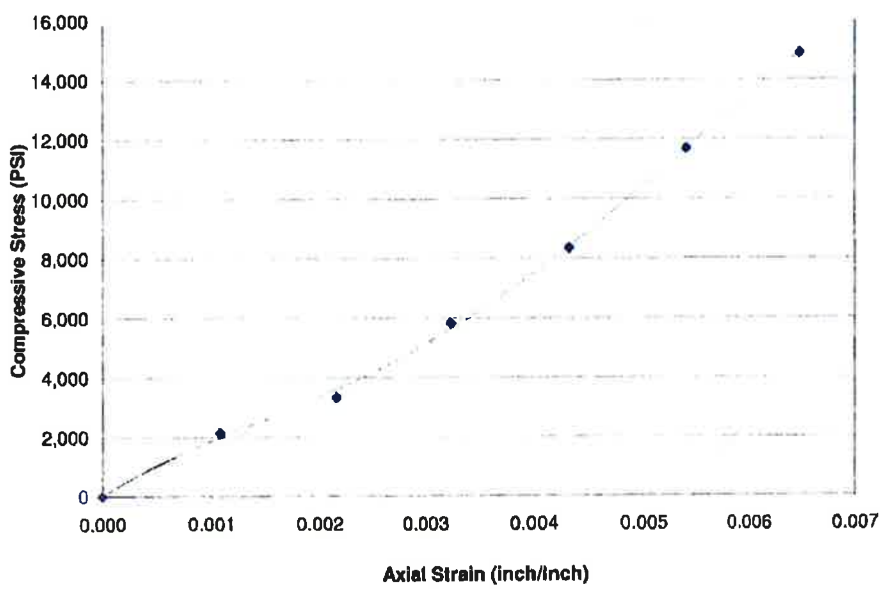
Tare Weight (grams)	0.00
Wet Specimen Weight + tare (g)	629.80
Dry Specimen Weight + tare (g)	629.80
Weight of Water (g)	0.00
Weight of Dry Specimen (g)	629.80
Weight of Wet Specimen (g)	629.80
Water Content (%)	0.0
Unit Weight Wet (pcf)	158.5
Unit Weight Dry (pcf)	158.5
Unit Weight of Water (pcf)	62.43

Diameter (in)		2.04
Area (in^2)		3.27
Height (in)		4.63
Volume (in^3)		15.13
Maximum Load, P (lbs)		48,757
Compressive Strength (PSI)		**14,917**
Specific Gravity		2.54
Sample Break Type	Intact	x
	Fracture	

Other Break Comments:

Axial Load (lbs)	Deflection (inch)	Axial Strain (inch/inch)	Compressive Stress (PSI)
0	0.000	0.00000	0
6,980	0.005	0.00108	2,136
10,980	0.010	0.00216	3,359
19,125	0.015	0.00324	5,851
27,268	0.020	0.00432	8,343
38,208	0.025	0.00540	11,690
48,757	0.030	0.00648	14,917

Compressive Stress versus Axial Strain Plot



Unconfined Compressive Strength Test ASTM D7012-09 ε1

PROJECT:	Clackamas River
PROJECT NO.:	113373
SAMPLE DESCRIP:	Basalt
SAMPLE NO.:	CR-1 40.9'-41.6'
LAB SAMPLE NO.:	9772
REPORTED BY:	A.Stirbys

PROJECT:	Clackamas River
PROJECT NO.:	113373
SAMPLE DESCRIP:	Basalt
SAMPLE NO.:	CR-1 40.9'-41.6'
LAB SAMPLE NO.:	9772
REPORTED BY:	A.Stirbys

KLEINFELDER

Data checked by CL Date 6-Oct

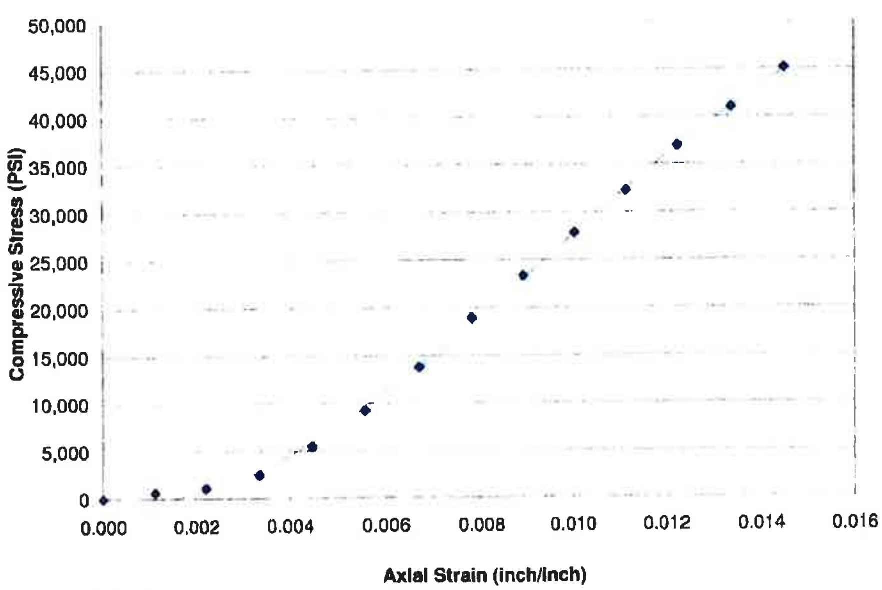
Unconfined Compressive Strength Test ASTM D7012-09 $^{\varepsilon 1}$

PROJECT:	Clackamas River	**LAB SAMPLE NO.:**	9771
PROJECT NO.:	113373	**SAMPLE NO.:**	CR-2 15.0'-15.5'
PROJECT LOCATION:	Gladstone, OR	**SAMPLE DESCRIP:**	Basalt
SAMPLED BY:	JGH	**DATE TESTED:**	9/27/2010
DATE SAMPLED:		**REPORTED BY:**	A.Stirbys

Tare Weight (grams)	0.00	Diameter (in)		2.05
Wet Specimen Weight + tare (g)	693.40	Area (in²)		3.30
Dry Specimen Weight + tare (g)	693.40	Height (in)		4.48
Weight of Water (g)	0.00	Volume (in³)		14.79
Weight of Dry Specimen (g)	693.40	Maximum Load, P (lbs)		148,961
Weight of Wet Specimen (g)	693.40			
Water Content (%)	0.0	**Compressive Strength (PSI)**		**45,131**
Unit Weight Wet (pcf)	178.6	Specific Gravity		2.86
Unit Weight Dry (pcf)	178.6	**Sample Break Type**	Intact	x
Unit Weight of Water (pcf)	62.43		Fracture	
Other Break Comments:				

Axial Load (lbs)	Deflection (inch)	Axial Strain (inch/inch)	Compressive Stress (PSI)
0	0.000	0.00000	0
2,160	0.005	0.00112	654
3,744	0.010	0.00223	1,134
8,142	0.015	0.00335	2,467
18,028	0.020	0.00446	5,462
30,536	0.025	0.00558	9,252
45,538	0.030	0.00670	13,797
62,479	0.035	0.00781	18,929
77,081	0.040	0.00893	23,353
91,861	0.045	0.01004	27,831
106,512	0.050	0.01116	32,270
121,900	0.055	0.01228	36,932
135,400	0.060	0.01339	41,022
148,961	0.065	0.01451	45,131

Compressive Stress versus Axial Strain Plot



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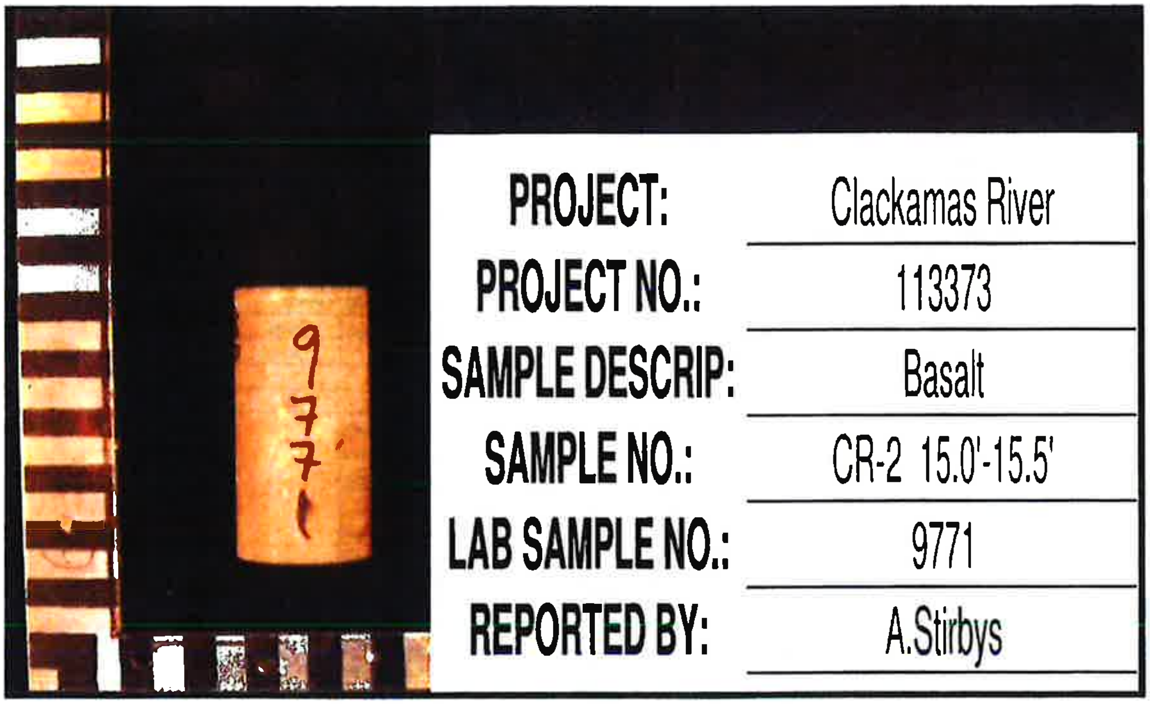
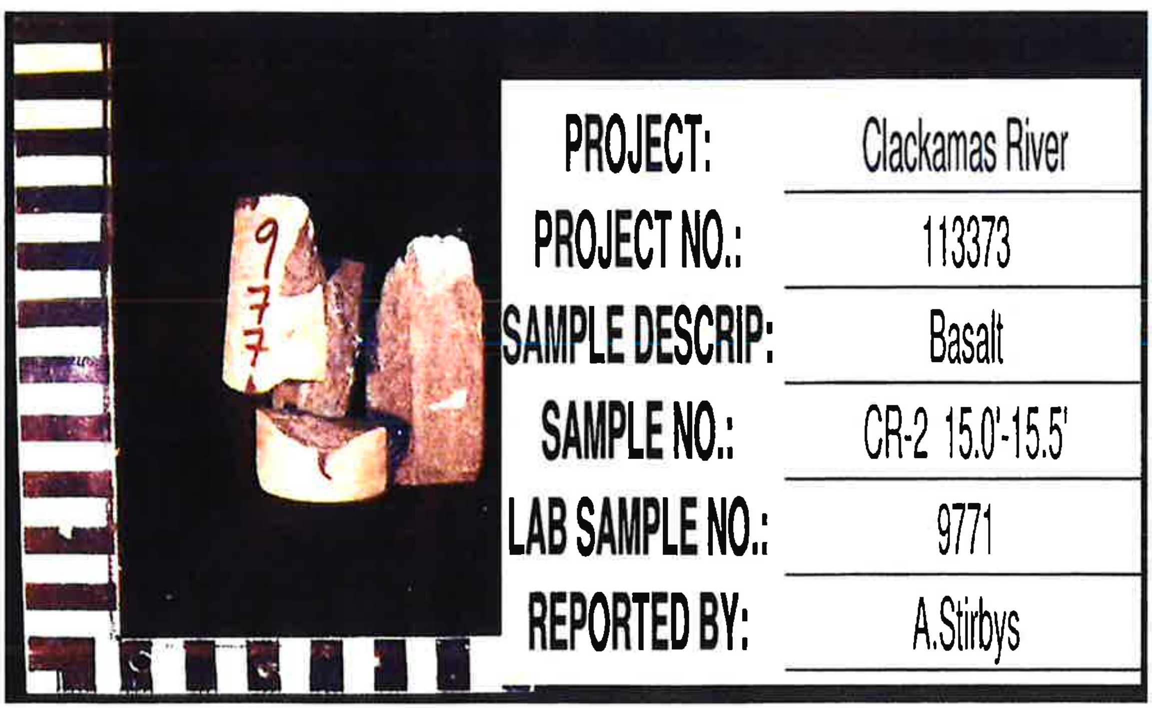
Unconfined Compressive Strength Test ASTM D7012-09 $^{\varepsilon 1}$





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Data checked by: CL Date: 6-Oct

Unconfined Compressive Strength Test ASTM D7012-09 ε1

PROJECT:	Clackamas River	**LAB SAMPLE NO.:**	9774
PROJECT NO.:	113373	**SAMPLE NO.:**	CR-2 34.5'-35.1'
PROJECT LOCATION:	Gladstone, OR	**SAMPLE DESCRIP:**	Basalt
SAMPLED BY:	JGH	**DATE TESTED:**	9/27/2010
DATE SAMPLED:		**REPORTED BY:**	A.Stirbys

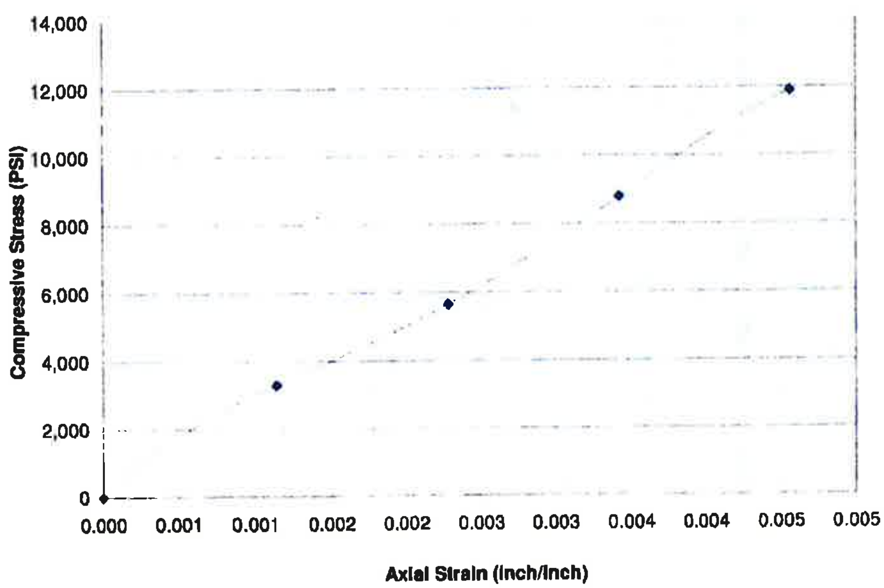
Tare Weight (grams)	0.00
Wet Specimen Weight + tare (g)	586.90
Dry Specimen Weight + tare (g)	586.90
Weight of Water (g)	0.00
Weight of Dry Specimen (g)	586.90
Weight of Wet Specimen (g)	586 90
Water Content (%)	0 0
Unit Weight Wet (pcf)	156.2
Unit Weight Dry (pcf)	156.2
Unit Weight of Water (pcf)	62.43

Diameter (in)		2.04
Area (in^2)		3.27
Height (in)		4.38
Volume (in^3)		14 32
Maximum Load, P (lbs)		38,889
Compressive Strength (PSI)		**11,898**
Specific Gravity		2 50
Sample Break Type	Intact	x
	Fracture	

Other Break Comments:

Axial Load (lbs)	Deflection (inch)	Axial Strain (inch/inch)	Compressive Stress (PSI)
0	0.000	0 00000	0
10,781	0.005	0 00114	3 298
18,457	0.010	0 00228	5,647
28,776	0.015	0.00342	8 804
38,889	0.020	0.00457	11,898

Compressive Stress versus Axial Strain Plot



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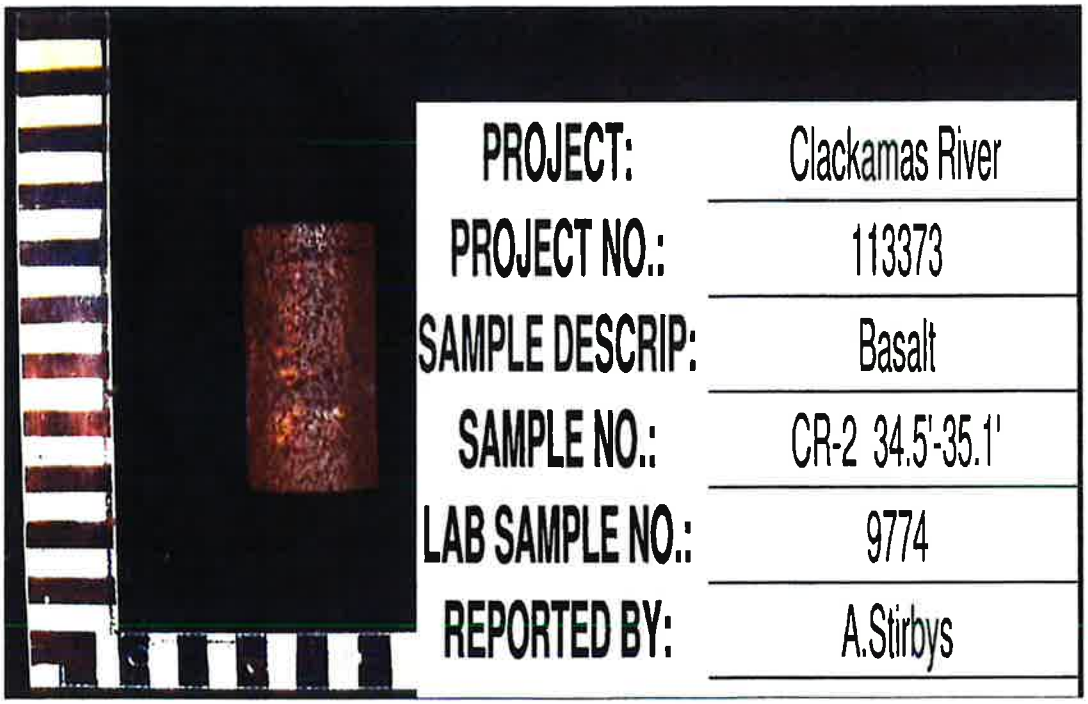
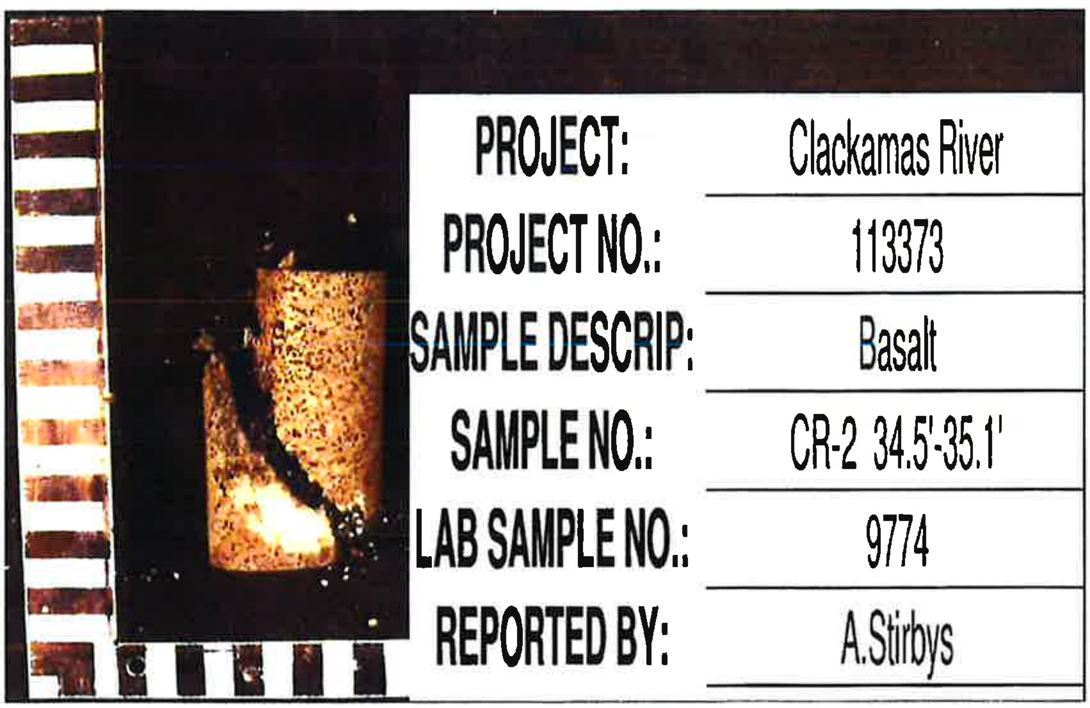
Unconfined Compressive Strength Test ASTM D7012-09 ε1





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Data checked by: CL Date: 6 (?)

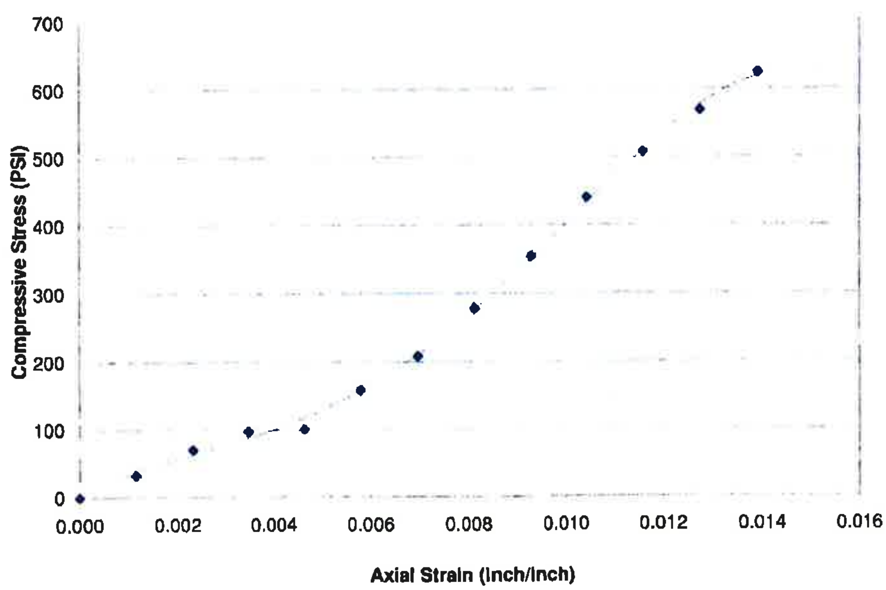
Unconfined Compressive Strength Test ASTM D7012-09 ε1

PROJECT:	Clackamas River	**LAB SAMPLE NO.:**	9777
PROJECT NO.:	113373	**SAMPLE NO.:**	CR-7 4.9'-5.5'
PROJECT LOCATION:	Gladstone, OR	**SAMPLE DESCRIP:**	Basalt
SAMPLED BY:	JGH	**DATE TESTED:**	9/27/2010
DATE SAMPLED:		**REPORTED BY:**	A.Stirbys

Tare Weight (grams)	0.00	Diameter (in)	2.04
Wet Specimen Weight + tare (g)	400.00	Area (in²)	3.27
Dry Specimen Weight + tare (g)	400.00	Height (in)	4.31
Weight of Water (g)	0.00	Volume (in³)	14.09
Weight of Dry Specimen (g)	400.00	Maximum Load, P (lbs)	2,040
Weight of Wet Specimen (g)	400.00		
Water Content (%)	0.0	**Compressive Strength (PSI)**	624
Unit Weight Wet (pcf)	108.2	Specific Gravity	1.73
Unit Weight Dry (pcf)	108.2	Sample Break Type: Intact	x
Unit Weight of Water (pcf)	62.43	Sample Break Type: Fracture	
Other Break Comments:			

Axial Load (lbs)	Deflection (inch)	Axial Strain (inch/inch)	Compressive Stress (PSI)
0	0.000	0.00000	0
110	0.005	0.00116	34
230	0.010	0.00232	70
320	0.015	0.00348	98
330	0.020	0.00464	101
520	0.025	0.00580	159
680	0.030	0.00696	208
910	0.035	0.00812	278
1,160	0.040	0.00928	355
1,440	0.045	0.01044	441
1,660	0.050	0.01160	508
1,860	0.055	0.01276	569
2,040	0.060	0.01392	624

Compressive Stress versus Axial Strain Plot



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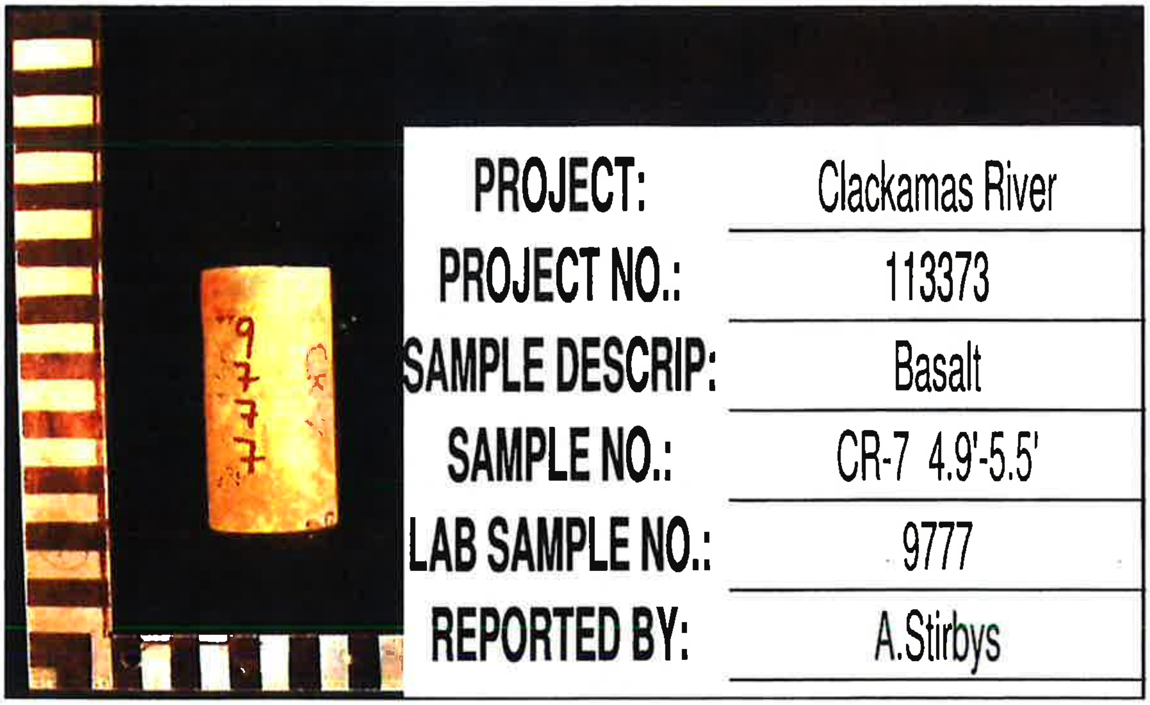
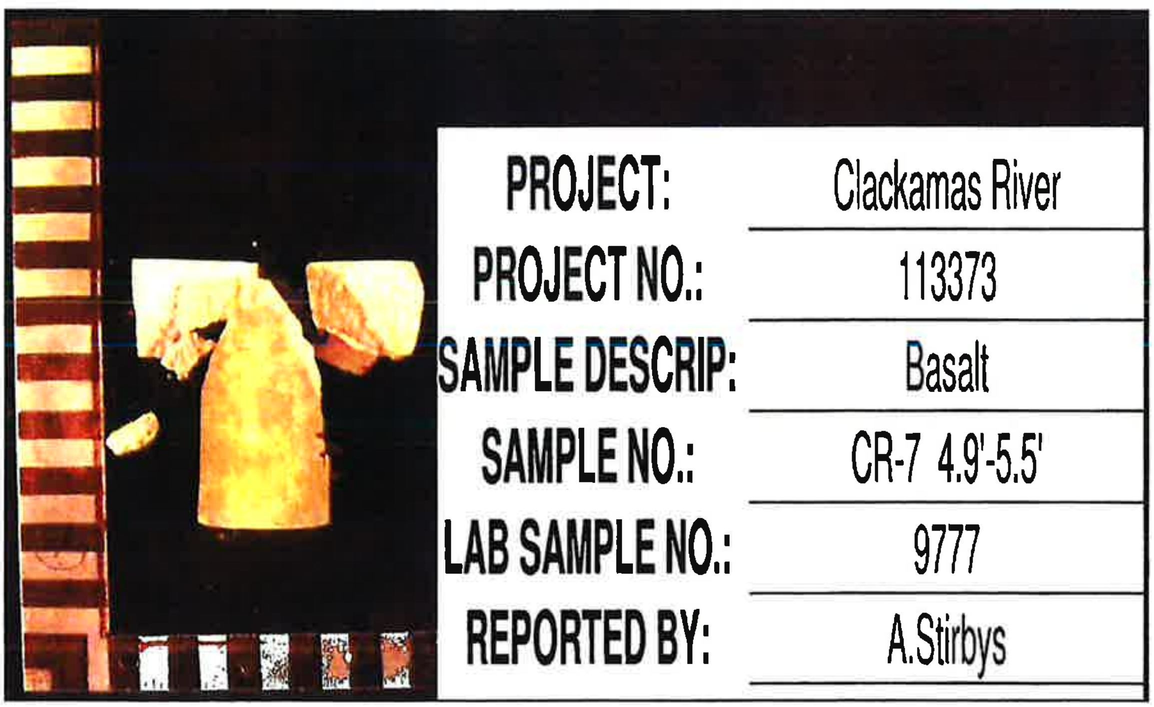
Unconfined Compressive Strength Test ASTM D7012-09 $^{\varepsilon 1}$





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Data checked by: CL Date: 6 Oct

Unconfined Compressive Strength Test ASTM D7012-09 ε1

PROJECT:	Clackamas River	**LAB SAMPLE NO.:**	9769
PROJECT NO.:	113373	**SAMPLE NO.:**	CR-7 15.2'-16.0'
PROJECT LOCATION:	Gladstone, OR	**SAMPLE DESCRIP:**	Basalt
SAMPLED BY:	JGH	**DATE TESTED:**	9/27/2010
DATE SAMPLED:		**REPORTED BY:**	A.Stirbys

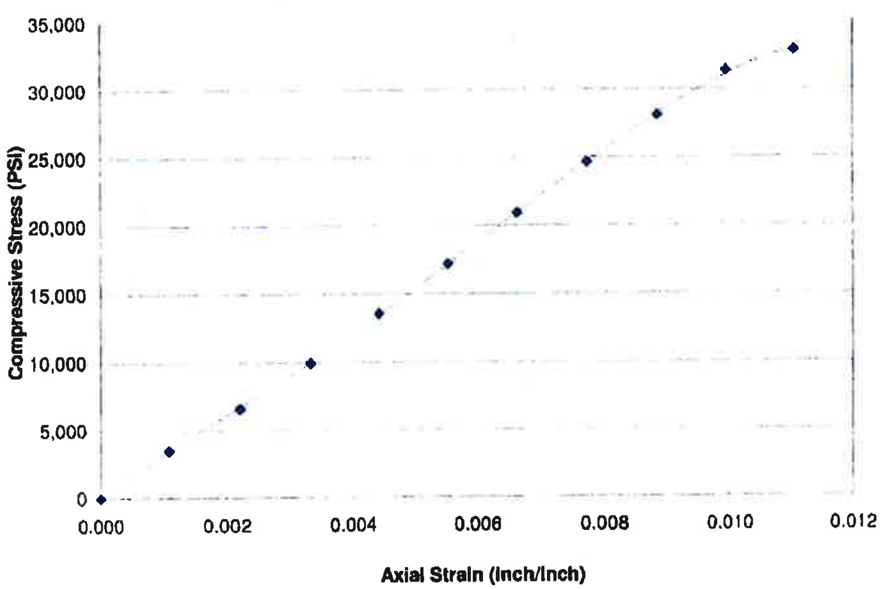
Tare Weight (grams)	0 00
Wet Specimen Weight + tare (g)	692.40
Dry Specimen Weight + tare (g)	692 40
Weight of Water (g)	0 00
Weight of Dry Specimen (g)	692.40
Weight of Wet Specimen (g)	692 40
Water Content (%)	0 0
Unit Weight Wet (pcf)	176 8
Unit Weight Dry (pcf)	176 8
Unit Weight of Water (pcf)	62 43

Diameter (in)		2.05
Area (in²)		3 30
Height (in)		4.52
Volume (in³)		14 92
Maximum Load, P (lbs)		108,472
Compressive Strength (PSI)		**32.864**
Specific Gravity		2 83
Sample Break Type	Intact	x
	Fracture	

Other Break Comments:

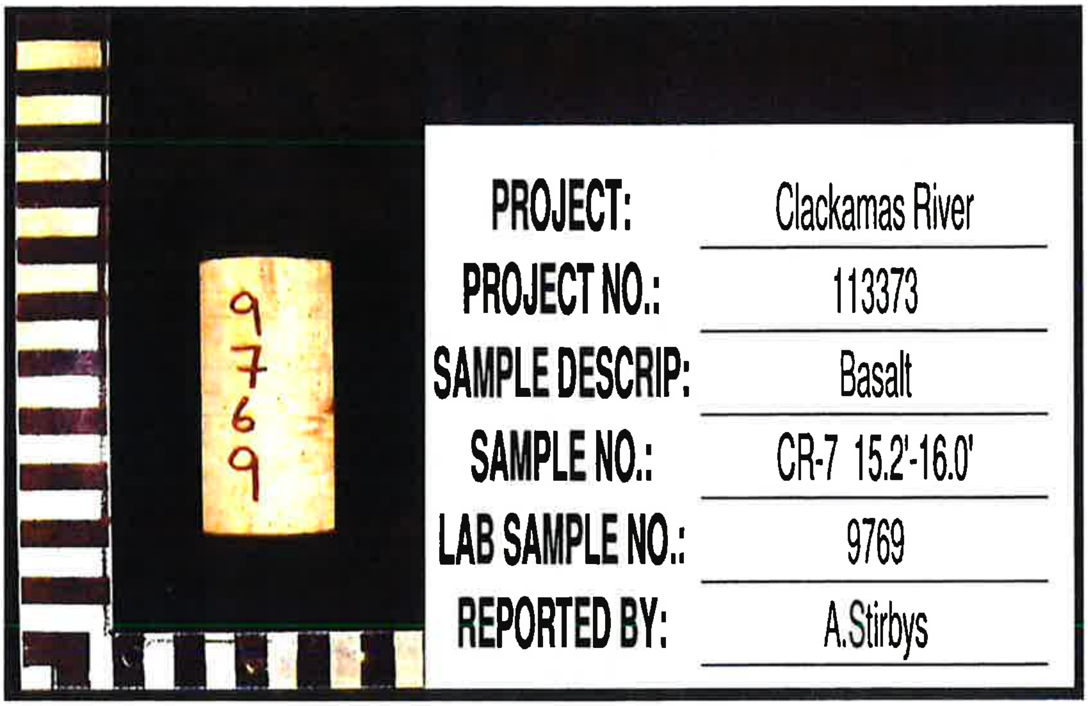
Axial Load (lbs)	Deflection (Inch)	Axial Strain (inch/inch)	Compressive Stress (PSI)
0	0 000	0.00000	0
11,586	0.005	0.00111	1.510
21.760	0.010	0.00221	6.593
32,800	0.015	0.00332	9 937
44.780	0.020	0 00442	13.567
56.754	0.025	0 00553	17.195
69.114	0.030	0.00664	20.940
81.379	0.035	0.00774	24.656
92.789	0.040	0 00885	28 11[illegible]
103.573	0.045	0.00996	31.380
108.472	0.050	0.01106	32.864

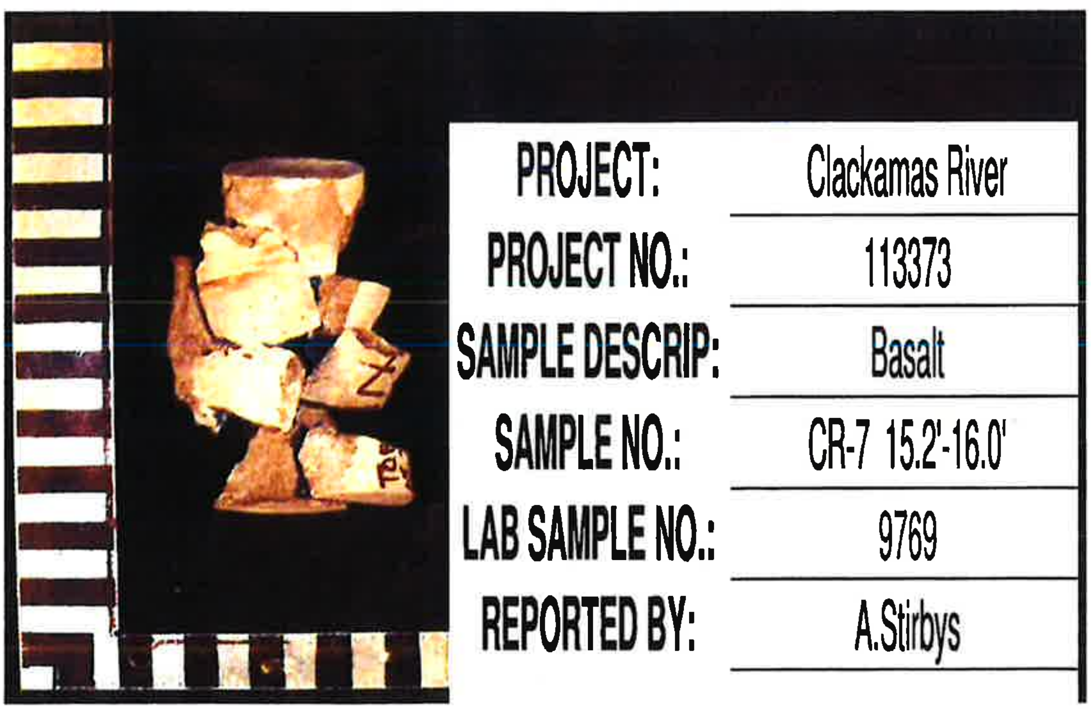
Compressive Stress versus Axial Strain Plot



KLEINFELDER

Unconfined Compressive Strength Test ASTM D7012-09 $^{\varepsilon 1}$





KLEINFELDER

Data checked by: CL Date 6 Oct

Unconfined Compressive Strength Test ASTM D7012-09 $^{\varepsilon 1}$

PROJECT:	Clackamas River	**LAB SAMPLE NO.:**	9775
PROJECT NO.:	113373	**SAMPLE NO.:**	CR-7 25.7'-26.8'
PROJECT LOCATION:	Gladstone, OR	**SAMPLE DESCRIP:**	Basalt
SAMPLED BY:	JGH	**DATE TESTED:**	9/27/2010
DATE SAMPLED:		**REPORTED BY:**	A.Stirbys

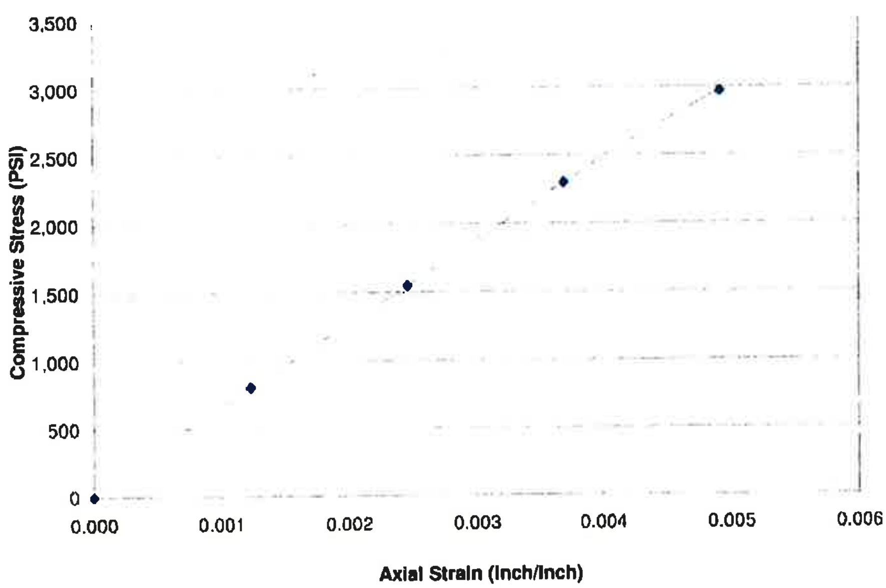
Tare Weight (grams)	0.00
Wet Specimen Weight + tare (g)	427.00
Dry Specimen Weight + tare (g)	427.00
Weight of Water (g)	0.00
Weight of Dry Specimen (g)	427.00
Weight of Wet Specimen (g)	427.00
Water Content (%)	0.0
Unit Weight Wet (pcf)	131.4
Unit Weight Dry (pcf)	131.4
Unit Weight of Water (pcf)	62.43

Diameter (in)		1.97
Area (in^2)		3.05
Height (in)		4.06
Volume (in^3)		12.38
Maximum Load, P (lbs)		9,047
Compressive Strength (PSI)		2,968
Specific Gravity		2.11
Sample Break Type	Intact	x
	Fracture	

Other Break Comments:

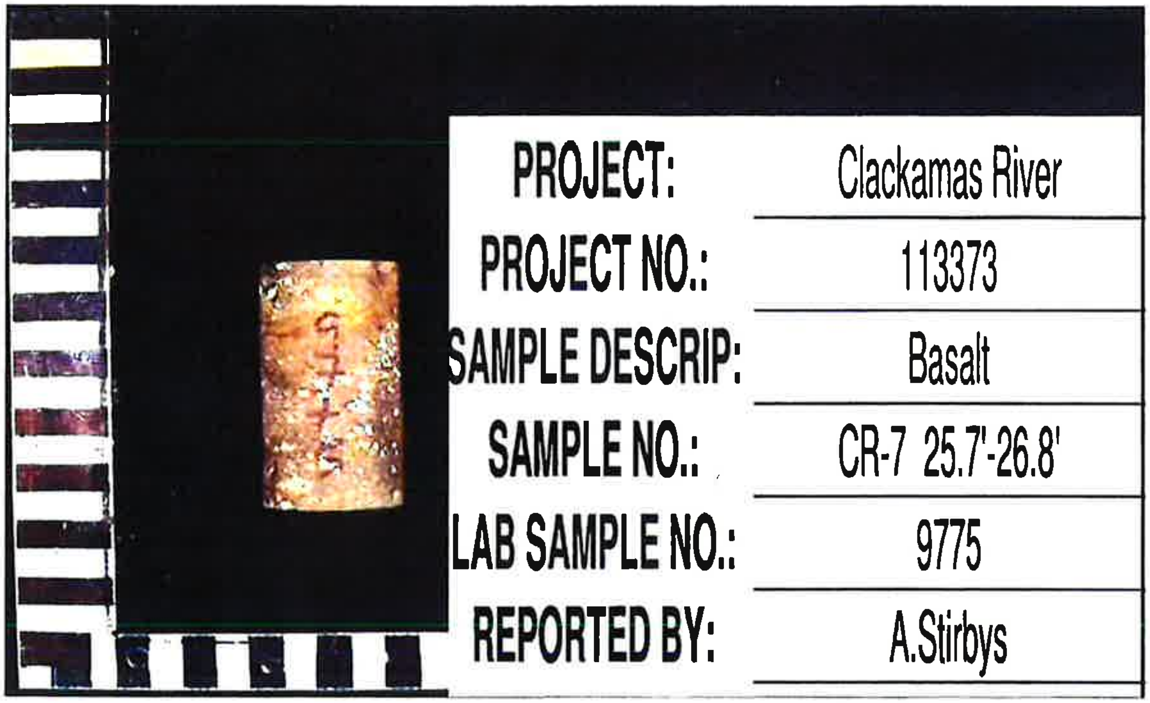
Axial Load (lbs)	Deflection (inch)	Axial Strain (inch/inch)	Compressive Stress (PSI)
0	0.000	0.00000	0
2,463	0.005	0.00123	808
4,724	0.010	0.00246	1,550
7,012	0.015	0.00369	2,300
9,047	0.020	0.00493	2,968

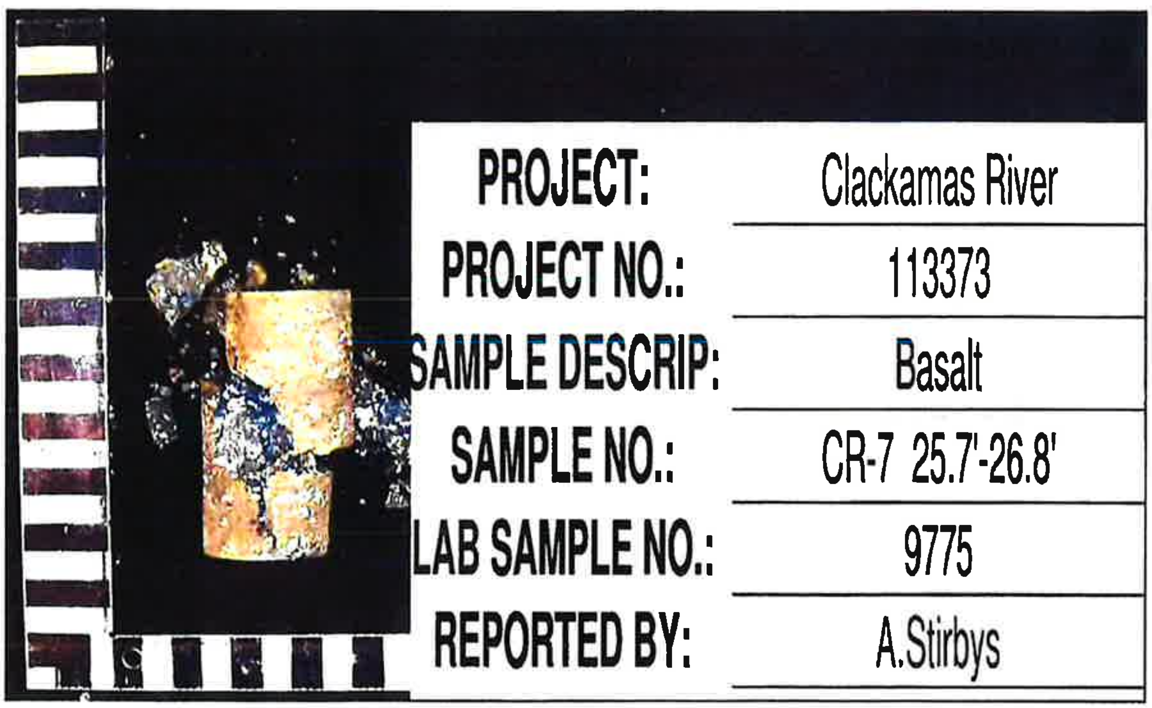
Compressive Stress versus Axial Strain Plot



KLEINFELDER

Unconfined Compressive Strength Test ASTM D7012-09 $^{\varepsilon 1}$





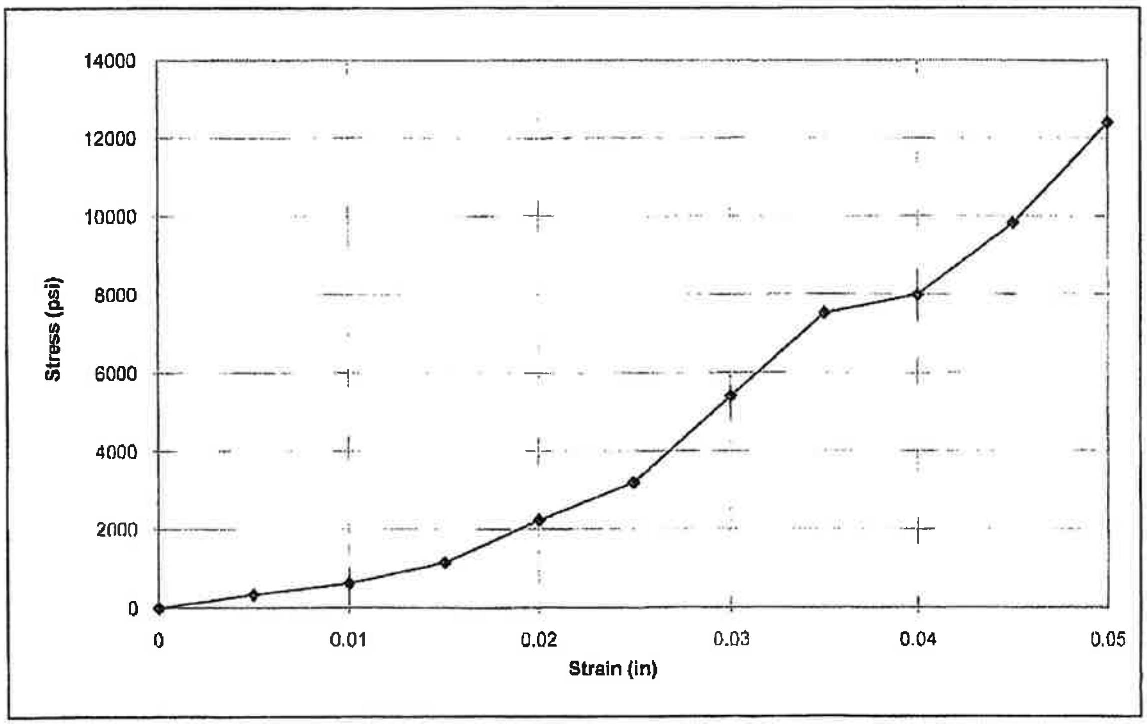
ACS Testing, Inc
7409 SW Tech Center Dr Ste 145
Tigard, OR 97223
PH: 503-443-3799 F: 503-620-2748

Geo Design
Attn: Jason Bryant
15575 SW Sequoia Parkway #100
Portland OR 97224

PROJECT:	CLACKAMAS RIVER INTAKE STRUCTURE	**JOB NO:**	10-2827-000
LOCATION:	CR-08 @ 55'-57'	**WORK ORDER NO:**	BrownCald-49-03
MATERIAL:	ROCK CORES	**LAB NO:**	5151-1
SAMPLE SOURCE:	Site	**DATE SAMPLED:**	NG
SAMPLE PREP:			

UNCONFINED COMPRESSION STRENGTH OF Rock Cores
APPLICABLE PORTIONS OF (ASTM D7012)

DIAMETER:	2.40 in	MAXIMUM STRESS:	12,547 psi
HEIGHT:	5.58 in	AT STRAIN:	0.99%
STRAIN RATE:	.005 inches/min.		
DRY DENSITY:	176.0 lb/cu.ft		
MOISTURE:	0.0%		



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DOUG ESQUIVEL, VP OPERATIONS

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Geo Design
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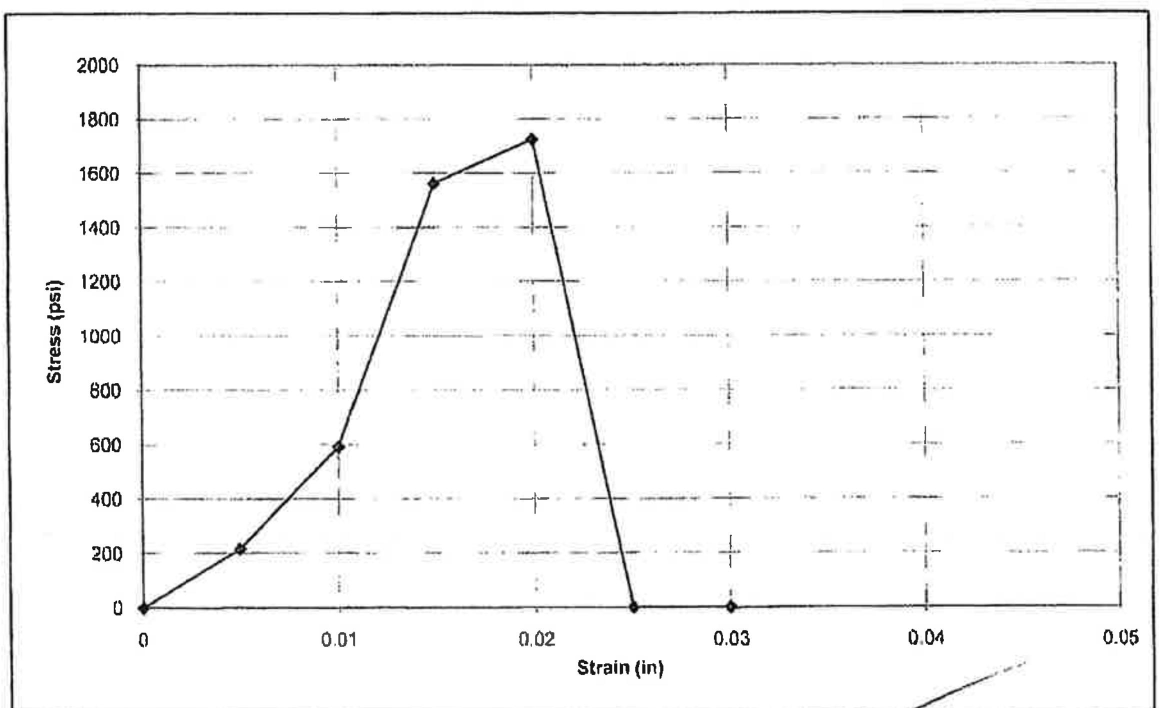
Portland OR 97224

PROJECT:	CLACKAMAS RIVER INTAKE STRUCTURE	**JOB NO:**	10-2827-000
LOCATION:	CR-08 @ 59'	**WORK ORDER NO:**	BrownCald-49-03
MATERIAL:	ROCK CORES	**LAB NO:**	5151-2
SAMPLE SOURCE:	Site	**DATE SAMPLED:**	NA
SAMPLE PREP:			

UNCONFINED COMPRESSION STRENGTH OF Rock Cores
APPLICABLE PORTIONS OF (ASTM D7012)

DIAMETER:	2.40 in	MAXIMUM STRESS:	1,727 psi
HEIGHT:	4.03 in	AT STRAIN:	0.50%
STRAIN RATE:	.005 inches/min		
DRY DENSITY:	169.4 lb/cu.ft		
MOISTURE:	0.0%		



Core shear break from fracture ran full length of core

REVIEWED BY ____________________
DOUG ESQUIVEL, VP OPERATIONS

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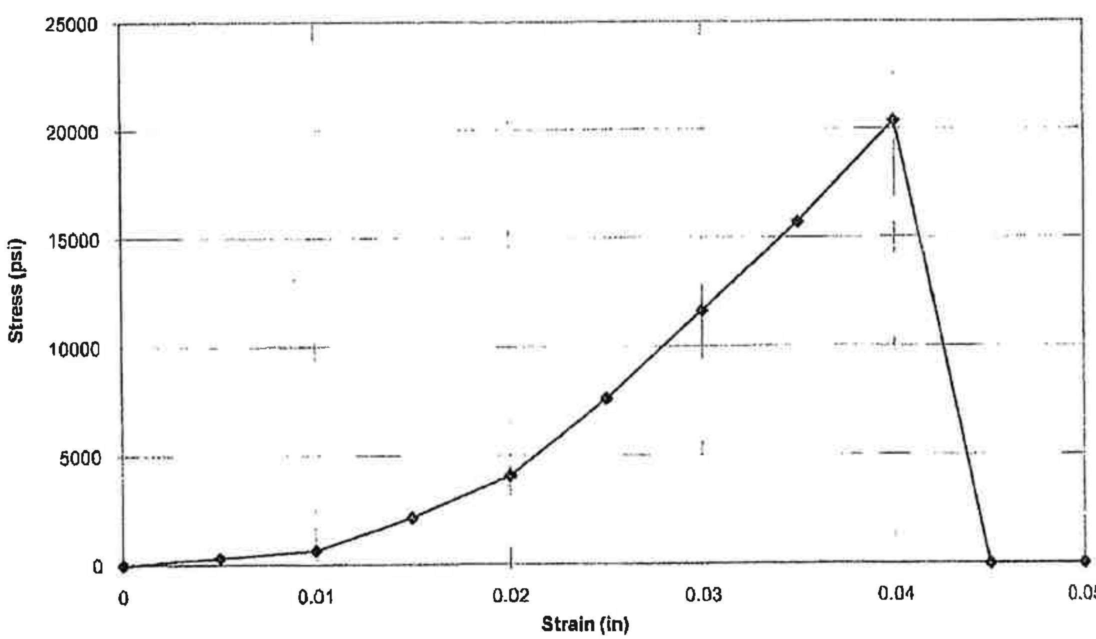
ACS Testing, Inc
7409 SW Tech Center Dr Ste 145
Tigard, OR 97223
PH: 503-443-3799 F: 503-620-2748

Geo Design
Attn: Jason Bryant
15575 SW Sequoia Parkway #100
Portland OR 97224

PROJECT:	CLACKAMAS RIVER INTAKE STRUCTURE	**JOB NO:**	10-2827-000
LOCATION:	CR-08 @ 60'-63.6'	**WORK ORDER NO:**	BrownCald-49-03
MATERIAL:	ROCK CORES	**LAB NO:**	5151-3
SAMPLE SOURCE:	Site	**DATE SAMPLED:**	NA
SAMPLE PREP:			

UNCONFINED COMPRESSION STRENGTH OF Rock Cores
APPLICABLE PORTIONS OF (ASTM D7012)

DIAMETER:	2.40 in	MAXIMUM STRESS:	20,381 psi
HEIGHT:	5.82 in	AT STRAIN:	0.69%
STRAIN RATE:	.005 inches/min.		
DRY DENSITY:	178 2 lb/cu.ft		
MOISTURE:	0.0%		



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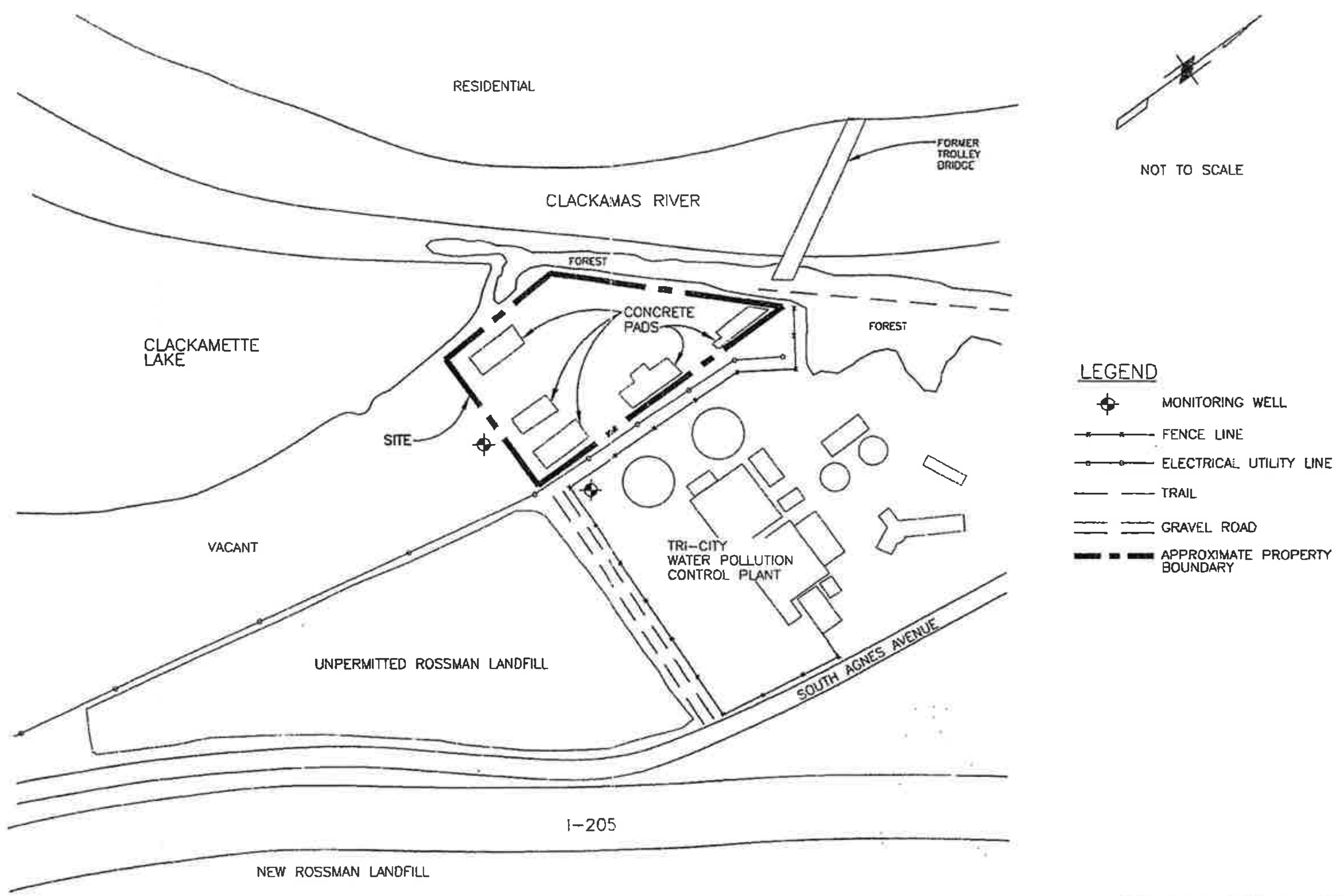
DOUG ESQUIVEL, VP OPERATIONS

DE/js

ACRONYMS

ACRONYMS

ASTM	American Society for Testing and Materials
BGS	below ground surface
CRBG	Columbia River Basalt Group
H:V	horizontal to vertical
MSL	mean sea level
psi	pounds per square inch
RIPS	River Intake Pump Station
RQD	rock quality designation
SPT	standard penetration test
µm	micrometer



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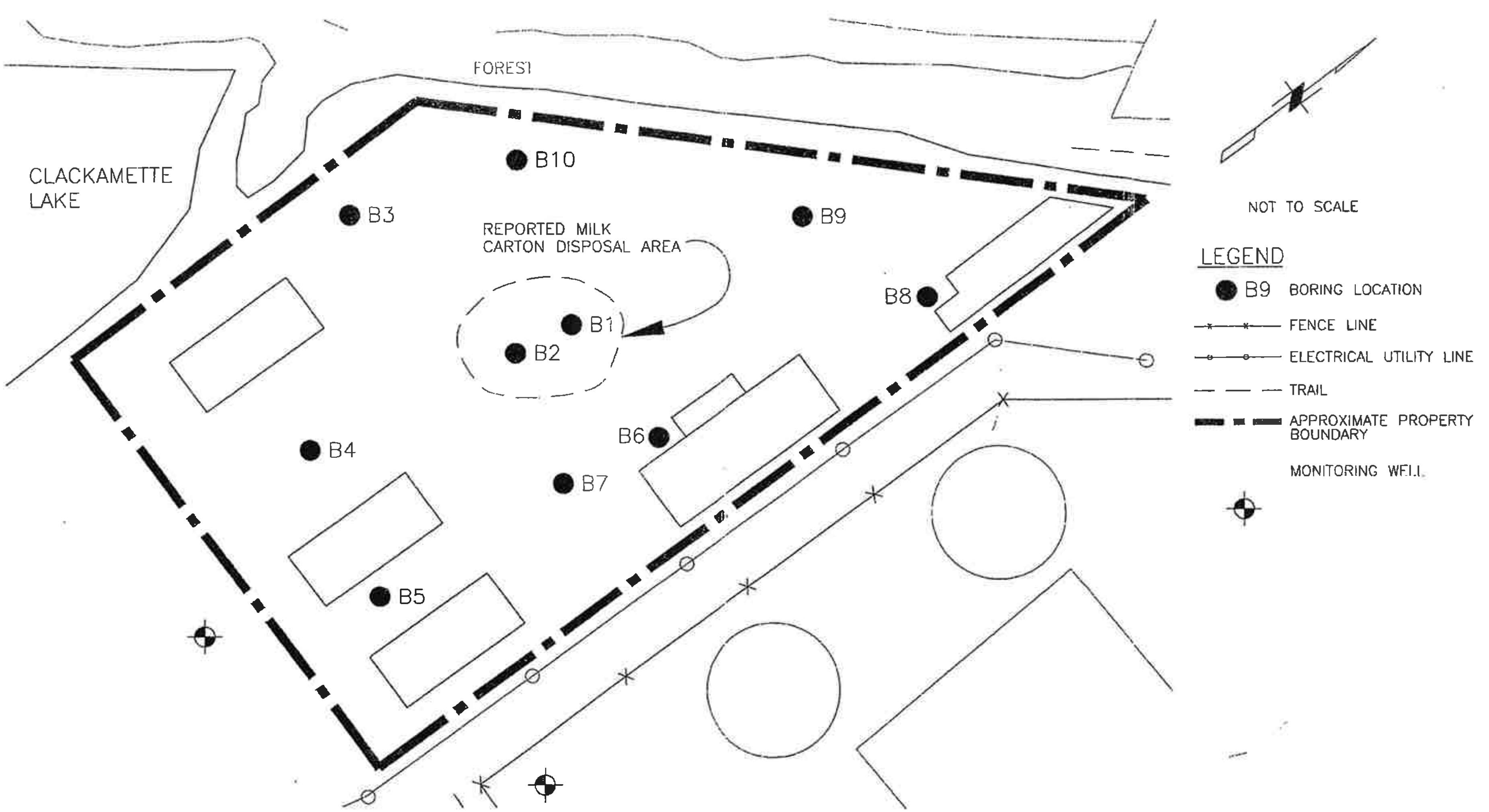
SITE MAP

Phase I & II ESA
Tax Lot 502
Oregon City, OR

JULY 2001
52-09970005.01 00001

FIGURE 2



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BORING LOCATION MAP

JULY 2001
52-09970005.01 00001

Phase I & II ESA
Tax Lot 502
Oregon City, OR

FIGURE 3

Date(s) Drilled	6/12/01	Logged By	CNM	Checked By	JOD
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	2" Macro Core Bit	Total Depth of Borehole	31.5 FT
Drill Rig Type	CME 75	Drilling Contractor	Geotech Exploration	Approximate Surface Elevation	N/A
Groundwater Level and Date Measured	27.0 feet bgs on 6/12/01	Sampling Method(s)	2" California Modified Split Spoon	Hammer Data	140 lb. Hammer
Borehole Backfill	1/4" Bentonite Chips	Location			

Elevation, feet	Depth, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Sampling Resistance, Blows/12 in.	SAMPLES: Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	0							DARK GRAY COBBLES, some sand, very dense, [dry].	
							GC	DARK REDDISH BROWN [2.5yr-3/4] CLAYEY GRAVEL, some sand, medium dense, [moist].	
	5		1	16	0%		CH	DARK REDDISH BROWN [2.5yr-3/4] CLAY WITH SAND, medium stiff to stiff, plastic, [moist].	PID=7.6
								Sand content increases with depth.	
	10		2	8	11.1%				PID=8.4
							GP	VERY DUSKY RED [2.5yr-2-5/2] POORLY GRADED GRAVEL, some cobbles, medium dense, [moist].	
	15		3	10	33.3%		ML	DARK GRAY [2.5yr-4/1] SILT, stiff, [moist].	PID=40.3, Note: Concrete in Sampler
								6" to 12" Thick alternating layers of Bluish Gray Silt, Poorly Graded Very Fine Sand and Clay.	
	20		4	9	66.6%				PID=40.7
	25		5	12	100%				PID=42.7
								▽ *Grades to Wet.*	
	30								

Project: Tri-City Service District
Project Location: Clackamas County
Project Number: 52-00082010.09

Log of Boring B-01-2001

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	30		6		11.1%		SP	BLACK [5yr-2-5/1] POORLY GRADED SAND WITH GRAVEL, dense, [wet].	PID=41.3
								Boring terminated at a depth of 31.5 feet below ground surface [bgs], on 6-12-01 and backfilled with bentonite chips upon completion.	
	35								
	40								
	45								
	50								
	55								
	60								
	65								

URS

Project: Tri-City Service District Project Location: Clackamas County Project Number: 52-00082010.09	**Log of Boring B-02-2001** Sheet 1 of 2

Date(s) Drilled	6/12/01	Logged By	CNM	Checked By	JOD
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type	2" Macro Core Bit	Total Depth of Borehole	31.5 FT
Drill Rig Type	CME 75	Drilling Contractor	Geotech Exploration	Approximate Surface Elevation	N/A
Groundwater Level and Date Measured	Not Encountered	Sampling Method(s)	2" California Modified Split Spoon	Hammer Data	140 lb. Hammer
Borehole Backfill	1/4" Bentonite Chips	Location			

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	0							DARK GRAY COBBLES, some sand, very dense, [dry].	
							GC	DARK REDDISH BROWN [2.5yr-3/4] CLAYEY GRAVEL, some sand, very dense, [moist].	
	5		1	81/11"	66.6%				PID=32.6, Note: Asphalt in Shoe of Sampler
							ML	BLUISH GRAY [Glet2-6/5PB] SILT, very stiff, [moist].	
	10		2	18	66.6%		SC	DARK GRAY [2.5y-4/1] CLAYEY SAND, trace gravel, medium dense, [moist].	PID=39.0
	15		3	12	0%		ML	DARK GRAY [2.5y-4/1] SILT, medium stiff to very stiff, [moist].	PID=N/A, Note: Concrete in Shoe of Sampler
								6" to 12" Thick alternating layers of Dark Gray to Black Silt, Poorly Graded Very fine Sand and Clay.	
	20		4	29	66.6%				PID=36.3
	25		5	14	100%				PID=6.3
	30								

Report: G32_PORT_ENV; File: TCSD.GPJ; 6/26/2001 B-02-2001

Project:	Tri-City Service District	**Log of Boring B-02-2001**
Project Location:	Clackamas County	Sheet 2 of 2
Project Number:	52-00082010.09	

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resistance, Blows/12 in.	SAMPLES Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	30		6	5	100%				PID=5.2
								Boring terminated at a depth of 31.5 feet below ground surface [bgs], on 6/12/01 and backfilled with bentonite chips upon completion.	
	35								
	40								
	45								
	50								
	55								
	60								
	65								

Project: Tri-City Service District Project Location: Clackamas County Project Number: 52-00082010.09	Log of Boring B-03-2001 Sheet 1 of 2

Date(s) Drilled	6/12/01	Logged By	CNM	Checked By	JOD
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type		Total Depth of Borehole	41.5 FT
Drill Rig Type	CME 75	Drilling Contractor	Geotech Exploration	Approximate Surface Elevation	N/A
Groundwater Level and Date Measured	Not Encountered	Sampling Method(s)	2" California Modified Split Spoon	Hammer Data	140 lb. Hammer
Borehole Backfill	1/4" Bentonite Chips	Location			

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	0							DARK GRAY COBBLES, [some sand], dense, [dry].	
							GC	DARK REDDISH BROWN [2.5yr-3/4] CLAYEY GRAVEL, some sand, medium dense, [moist].	Note: Wood Chips in Sampler
	5		1	21	44.4%				PID=3.8
							CH	DARK REDDISH BROWN [2.5yr-3/4] FAT CLAY, some sand, very stiff, [moist].	
	10		2	44	77.7%		ML	DARK GRAY [5y-4/1] SILT, some clay, soft to hard, [moist].	PID=6.1
								6" to 12' Thick alternating layers of Dark Gray to Black Silt, Poorly Graded Very Fine Sand and Clay	
	15		3	4	100%				PID=5.2
	20		4	4	100%				PID=4.3
	25		5	16	100%				PID=4.1, Note: Sticks and Twigs in Sample
	30								

Project: Tri-City Service District	Log of Boring B-03-2001
Project Location: Clackamas County	Sheet 2 of 2
Project Number: 52-00082010.09	

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	30		6	12	100%				PID=3.5
	35		7	9	100%				PID=6.7
	40		8	8	100%				PID=2.2
								Boring terminated at a depth of 41.5 feet below ground surface [bgs], on 6-12-01 and backfilled with bentonite chips upon completion.	
	45								
	50								
	55								
	60								
	65								

Report: OB2_PORT_ENV; File: TCSD.GPJ; 6/26/2001 B-03-2001

Project: Tri-City Service District Project Location: Clackamas County Project Number: 52-00082010.09	**Log of Boring B-04-2001** Sheet 1 of 2

Date(s) Drilled	6/12/01	Logged By	CNM	Checked By	JOD
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type		Total Depth of Borehole	41.5 FT
Drill Rig Type	CME 75	Drilling Contractor	Geotech Exploration	Approximate Surface Elevation	N/A
Groundwater Level and Date Measured	Not Encountered	Sampling Method(s)	2" California Modified Split Spoon	Hammer Data	140 lb. Hammer
Borehole Backfill	1/4" Bentonite Chips	Location			

Elevation, feet	Depth, feet	SAMPLES: Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	0							**DARK GRAY COBBLES**, some sand, dense, [dry].	
							SM	**DARK OLIVE GRAY [5y-3/2] SILTY SAND**, trace gravel, very dense, [moist].	
	5		1	50/5"	33.3%				PID=7.2
							CL-ML	**VERY DARK GRAYISH BROWN [10yr-3/2] SILTY CLAY WITH SAND**, trace gravel, medium stiff to hard, [moist].	
	10		2	26	55.5%				PID=3.7
								6" to 12" Thick alternating layers of Dark Gray to Black Silt, Poorly Graded Very Fine Sand and Clay.	
	15		3	5	100%				PID=2.8
	20		4	5	100%				PID=7.3
	25		5	54-8"	0%				PID=2.1, Note: Concrete in Sampler
	30								

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Project:	Tri-City Service District
Project Location:	Clackamas County
Project Number:	52-00082010.09

Log of Boring B-04-2001

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	30		6	27	100%				PID=2.2
							SP	VERY DARK BROWN [10yr-2/2] POORLY GRADED SAND, fine to medium grained, meduim dense to very dense, [moist].	
	35		7	29	100%				PID=2.8
								Grades with Gravels	
	40		8	50/3"	0%				PID=N/A
								Boring terminated at a depth of 41.5 feet below ground surface [bgs], on 6-12-01 and backfilled with bentonite chips upon completion.	
	45								
	50								
	55								
	60								
	65								

Project: Tri-City Service District Project Location: Clackamas County Project Number: 52-00082010.09	**Log of Boring B-05-2001** Sheet 1 of 2

Date(s) Drilled	6/12/01	Logged By	CNM	Checked By	JOD
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type		Total Depth of Borehole	41.5 FT
Drill Rig Type	CME 75	Drilling Contractor	Geotech Exploration	Approximate Surface Elevation	N/A
Groundwater Level and Date Measured	Not Encountered	Sampling Method(s)	2" California Modified Split Spoon	Hammer Data	140 lb. Hammer
Borehole Backfill	1/4" Bentonite Chips	Location			

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resistance, Blows/12 in.	SAMPLES Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	0							DARK GRAY COBBLES, some sand, dense, [dry].	
							SM	DARK OLIVE GRAY [5y-3/2] SILTY SAND WITH GRAVEL, very dense, [dry].	
	5		1	50/5.5"	11.1%				PID=2.7
							CH	VERY DARK GRAY [5y-3/1] FAT CLAY, some silt, stiff to hard, [moist].	
	10		2	10	66.6%				PID=2.3, Note: Asphalt in Sampler
								Alternating layers of Dark Grey to Black Silt, Poorly Graded Very Fine Sand and Clay.	
	15		3	50-2"	0%				PID=N/A, Note: Concrete in Shoe of Sampler
	20		4	50	5.5%				PID=N/A
	25		5	27	0%		SP	VERY DARK BROWN [7.5yr-2 5/2] POORLY GRADED SAND WITH GRAVEL, medium dense, [moist].	PID=N/A
	30								

Project: Tri-City Service District
Project Location: Clackamas County
Project Number: 52-00082010.09

Log of Boring B-05-2001

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	30		6	18	100%				PID=3.6
	35		7	30	100%				PID=1.7
							SM	VERY DARK BROWN [7.5yr-2 5/2] SILTY SAND WITH GRAVEL, very dense, [wet].	
	40		8	50/6"	66.6%				PID=1.6
								Boring terminated at a depth of 41.5 feet below ground surface [bgs], on 6-12-01 and backfilled with bentonite chips upon completion.	
	45								
	50								
	55								
	60								
	65								

Project: Tri-City Service District	Log of Boring B-06-2001
Project Location: Clackamas County	Sheet 1 of 2
Project Number: 52-00082010.09	

Date(s) Drilled	6/13/01	Logged By	CNM	Checked By	JOD
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type		Total Depth of Borehole	36.5 FT
Drill Rig Type	CME 75	Drilling Contractor	Geotech Exploration	Approximate Surface Elevation	N/A
Groundwater Level and Date Measured	26.0 feet bgs on 6/13/01	Sampling Method(s)	2" California Modified Split Spoon	Hammer Data	140 lb. Hammer
Borehole Backfill	1/4" Bentonite Chips	Location			

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	0							DARK GRAY COBBLES, some sand, very dense, [dry].	
							CH	VERY DARK BROWN [10yr-2] FAT CLAY, some sand, hard, [moist].	
	5		1	50/4"	33.3%		CH	VERY DARK GRAYISH BROWN [10yr-3/2] FAT CLAY with gray silt mottles, hard, [moist].	PID=3.0
	10		2	51	88.8%		SM	GRAY [10yr-5/1] SILTY SAND, fine grained sand with trace gravel, very dense, [moist]. *Grades with more Sand and Gravel.*	PID=4.8
	15		3	85	100%				PID=2.5
	20		4	2	100%		CH	DARK BROWN [10yr-3/3] FAT CLAY, very plastic, red streaks in sampler, very soft to soft, [moist].	PID=1.6
	25		5	6	100%		ML	VERY DARK GRAYISH BROWN [10yr-3/2] SILT, very soft to medium stiff, [wet]. ∇ *Alternating layers of Silt, Very Fine Sand and Clay.*	PID=1.1 Water Level at 26.0'
	30								

Report: G 32_PORT_ENV; File: TCSD.GPJ; 6/26/2001 B-06-2001

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Project: Tri-City Service District	Log of Boring B-06-2001
Project Location: Clackamas County	Sheet 2 of 2
Project Number: 52-00082010.09	

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	30		6	2	100%				PID=0.9
	35		7	3	100%				PID=1.2
								Boring terminated at a depth of 36.5 feet below ground surface [bgs], on 6-13-01 and backfilled with bentonite chips upon completion.	
	40								
	45								
	50								
	55								
	60								
	65								

Project: Tri-City Service District	# Log of Boring B-07-2001
Project Location: Clackamas County	
Project Number: 52-00082010.09	

Date(s) Drilled	6/13/01	Logged By	CNM	Checked By	JOD
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type		Total Depth of Borehole	31.5 FT
Drill Rig Type	CME 75	Drilling Contractor	Geotech Exploration	Approximate Surface Elevation	N/A
Groundwater Level and Date Measured	24.0 feet bgs on 6/13/01	Sampling Method(s)	2" California Modified Split Spoon	Hammer Data	140 lb. Hammer
Borehole Backfill	1/4" Bentonite Chips	Location			

Elevation, feet	Depth, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Sampling Resistance, Blows/12 in.	SAMPLES: Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	0							DARK GRAY COBBLES, some sand, very dense, [dry].	
							CH	VERY DARK BROWN [10yr-2/2] FAT CLAY WITH GRAVEL, some sand, hard, [moist].	
	5		1	66/11"	88.8%				PID=2.6
	10		2	22	33.3%		SC	VERY DARK BROWN [10yr-2/2] CLAYEY SAND WITH GRAVEL, medium dense to dense, [moist].	PID=6.0
	15		3	45	5.5%			*Clay content decreases.*	PID=N/A
							CH	DARK YELLOWISH BROWN [10yr-3/4] FAT CLAY, plastic, very soft, [wet].	
	20		4	0	100%				PID=1.2
									∇ Water Level at 24.0'
	25		5	4	100%		ML	VERY DARK GRAY [10yr-3/1] SILT, soft to medium stiff, [wet].	PID=2.5
								Alternating layers of Silt, Very Fine Sand and Clay.	
	30								

Project: Tri-City Service District Project Location: Clackamas County Project Number: 52-00082010.09	Log of Boring B-07-2001 Sheet 2 of 2

Elevation feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	30		6	5	100%				PID=0.7
								Boring terminated at a depth of 31.5 feet below ground surface [bgs], on 6-13-01 and backfilled with bentonite chips upon completion.	
	35								
	40								
	45								
	50								
	55								
	60								
	65								

Project: Tri-City Service District	Log of Boring B-08-2001
Project Location: Clackamas County	Sheet 1 of 1
Project Number: 52-00082010.09	

Date(s) Drilled	6/13/01	Logged By	CNM	Checked By	JOD
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type		Total Depth of Borehole	20.0 FT
Drill Rig Type	CME 75	Drilling Contractor	Geotech Exploration	Approximate Surface Elevation	N/A
Groundwater Level and Date Measured	14.0 feet bgs on 6/13/01	Sampling Method(s)	2" California Modified Split Spoon	Hammer Data	140 lb. Hammer
Borehole Backfill	1/4" Bentonite Chips	Location			

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	0							DARK GRAY COBBLES, some sand, very dense, [dry].	
							SM	DARK GRAY [10yr-4/1] SILTY SAND WITH GRAVEL, loose to very dense, [moist].	
	5		1	52	44.4%			*Grades with more Gravel.*	PID=0.0
	10		2	5	5.5%			*Grades to Wet with less Gravel.*	PID=0.0
								∇	
	15		3	40	0%				PID=N/A
	20							Boring terminated at a depth of 20.0 feet below ground surface [bgs], on 6-13-01 and backfilled with bentonite chips upon completion.	
	25								
	30								

Report: 10B2_PORT_ENV; File: TCSD.GPJ; 6/26/2001 B-08-2001

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Project: Tri-City Service District	Log of Boring B-09-2001
Project Location: Clackamas County	Sheet 1 of 2
Project Number: 52-00082010.09	

Date(s) Drilled	6/13/01	Logged By	CNM	Checked By	JOD
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type		Total Depth of Borehole	36.5 FT
Drill Rig Type	CME 75	Drilling Contractor	Geotech Exploration	Approximate Surface Elevation	N/A
Groundwater Level and Date Measured	Not Encountered	Sampling Method(s)	2" California Modified Split Spoon	Hammer Data	140 lb. Hammer
Borehole Backfill	1/4" Bentonite Chips	Location			

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	0							DARK GRAY COBBLES, some sand, dense, [moist].	
							CH	REDDISH BROWN [5yr-4/4] SANDY FAT CLAY, very stiff, [moist].	
	5		1	23	77.7%				PID=0.0
							CH	DARK RED [2.5yr-3/4] FAT CLAY, with dark mottles, ground organic materials and areas of light to medium cementation, medium stiff to very stiff, [moist].	
	10		2	7	44.4%				PID=0.0
	15		3	6	33.3%			*Grades to Wet.*	PID=0.0
							CH	ALTERNATING LAYERS OF VERY DARK GRAYISH BROWN [10yr-3/2] AND VERY DARK GRAY [10yr-3/1] FAT CLAY, very plastic, very soft to medium stiff, [wet].	
	20		4	2	100%				PID=0.0
								Dark Gray alternating layers of Silt, Very Fine Sand and Clay.	Water Level at 24.0'
	25		5	4	100%				PID=0.0
	30								

Project: Tri-City Service District	Log of Boring B-09-2001
Project Location: Clackamas County	Sheet 2 of 2
Project Number: 52-00082010.09	

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resistance, Blows/12 in.	SAMPLES Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	30		6	5	100%				PID=0.0
	35		7	4	100%				PID=0.0
								Borinr terminated at a depth of 36.5 feet below ground surface [bgs], on 6-13-01 and backfilled with bentonite chips upon completion.	
	40								
	45								
	50								
	55								
	60								
	65								

Project: Tri-City Service District Project Location: Clackamas County Project Number: 52-00082010.09	# Log of Boring B-10-2001 Sheet 1 of 2

(s) .ed	6/13/01	Logged By	CNM	Checked By	JOD
Drilling Method	Hollow Stem Auger	Drill Bit Size/Type		Total Depth of Borehole	40.0 FT
Drill Rig Type	CME 75	Drilling Contractor	Geotech Exploration	Approximate Surface Elevation	N/A
Groundwater Level and Date Measured	24.0 feet bgs on 6/13/01	Sampling Method(s)	2" California Modified Split Spoon	Hammer Data	140 lb. Hammer
Borehole Backfill	1/4" Bentonite Chips	Location			

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	0							DARK GRAY COBBLES, some sand, dense, [moist].	
							CH	REDDISH BROWN [5yr-4/4] SANDY FAT CLAY WITH GRAVEL, with mottles of gray and dark brown areas of cementation, stiff, [moist].	
	5		1	10	100%				PID=0.2, Note: Some Organic Materials
	10		2	13	5.5%		CH	ALTERNATING LAYERS OF BROWN AND GRAY FAT CLAY, very plastic, very soft to stiff, [moist].	PID=N/A
	15		3	3	100%			*Dark Gray alternating layers of Silt, Very fine Sand and Clay.*	PID=0.0
	20		4	2	100%			*Grades to wet.*	PID=0.0
								▽	Water Level at 24.0'
	25		5	7	100%				PID=0.0 Note: Wood Chips at 26.5'
	30								

Project: Tri-City Service District	Log of Boring B-10-2001
Project Location: Clackamas County	Sheet 2 of 2
Project Number: 52-00082010.09	

Elevation, feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, Blows/12 in.	Percent Recovery	Graphic Log	Lithologic Log (USCS Code)	MATERIAL DESCRIPTION	REMARKS
	30		6	5	100%				PID=0.0
	35		7	3	100%				PID=0.0
	40							Boring terminated at a depth of 40.0 feet below ground surface [bgs], on 6-13-01 and backfilled with bentonite chips upon completion.	
	45								
	50								
	55								
	60								
	65								

Report: C B2_PORT_ENV; File: TCSD.GPJ; 6/26/2001 B-10-2001

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APPENDIX B: FIELD EXPLORATIONS

Appendix B
Field Explorations

CONTENTS

Figures

B.1 GENERAL

Shannon & Wilson, Inc., explored the subsurface conditions at the project site with one (1) geotechnical boring and one (1) shallow infiltration test boring. The geotechnical boring was designated B-1 and extended to a depth of 71.5 feet below the ground surface (bgs). The infiltration test boring was designated I-1 and extended to a depth of 5 feet bgs. The infiltration test was performed within approximately 10 feet of the geotechnical boring. The approximate geotechnical boring location is shown on the Site and Exploration Plan, Figure 2. This appendix describes the techniques used to advance and sample the borings and presents logs of the materials encountered during drilling. Infiltration testing methods and logs are also presented.

B.2 DRILLING

Borings B-1 and I-1 were drilled on July 26, 2019, by Western States Soil Conservation, Inc., (Western States) of Hubbard, Oregon. Western States provided and operated a track-mounted CME-55 rotary drill rig to complete the borings. Mud-rotary drilling techniques were used to advance the geotechnical boring and hollow-stem auger drilling techniques were used to advance the infiltration test boring. A qualified Shannon & Wilson staff member was on site throughout the field exploration program to locate the borings, observe drilling, collect samples, and log the materials encountered.

B.3 SAMPLING

B.3.1 Disturbed Sampling

Disturbed samples were collected in the borings, typically at 2.5- to 5-foot depth intervals, using a standard 2-inch outside diameter (O.D.) split spoon sampler in conjunction with Standard Penetration Testing. In a Standard Penetration Test (SPT), ASTM D1586, the sampler is driven 18 inches into the soil using a 140-pound hammer dropped 30 inches. The number of blows required to drive the sampler the last 12 inches is defined as the standard penetration resistance, or "N-value". The SPT N-value provides a measure of in situ relative density of cohesionless soils (silt, sand, and gravel) and the consistency of cohesive soils (silt and clay). All disturbed samples were visually identified and described in the field, sealed to retain moisture, and returned to our laboratory for additional examination and testing.

SPT N-values can be significantly affected by several factors, including the efficiency of the hammer used. Automatic hammers generally have higher energy transfer efficiencies than cathead (manual) hammers. Western States provided an energy efficiency value for the automatic hammer used on site, which is presented on the Drill Logs. The drill rig operated by Western States used an automatic hammer with a calibrated energy efficiency of 85.8 percent when measured in December 2018. All N-values presented in this report are in blows per foot, as counted in the field. No corrections of any kind have been applied.

An SPT was considered to have met "refusal" where more than 50 blows were required to drive the sampler 6-inches or less. If refusal was encountered in the first 6-inch interval (for example, 50 for 1.5"), the count is reported as 50/1st 1.5". If refusal was encountered in the second 6-inch interval (for examples, 48, 50 for 1.5"), the count is reported as 50/1.5". If refusal was encountered in the last 6-inch interval (for example, 39, 48, 50 for 1.5"), the count is reported as 98/7.5".

B.3.2 Undisturbed Sampling

An undisturbed sample was collected in a 3-inch O.D. thin-wall Shelby tube which was hydraulically pushed into the undisturbed soil at the bottom of Boring B-1. The soils exposed at the ends of the tube were examined and described in the field. After examination, the ends of the tube were sealed to preserve the natural moisture of the sample. The sealed tube was stored in the upright position, and care was taken to avoid shock and vibration during their transport and storage in our laboratory.

B.4 MATERIAL DESCRIPTIONS

In the field, samples were described and identified visually in accordance with the ODOT Soil and Rock Classification Manual (1987). The ASTM International (ASTM) D2488 Visual-Manual method was also used as a guide in determining the key diagnostic properties of soils. Consistency, color, relative moisture, degree of plasticity, peculiar odors, and other distinguishing characteristics of the samples were noted. Once returned to our laboratory, the samples were re-examined, various standard laboratory tests were conducted, and the field descriptions and identifications were modified where necessary. Please refer to the ODOT Soil and Rock Classification Manual (1987) for definitions of descriptive terminology used in the Drill Logs.

B.5 DRILL LOGS

The summary log for Boring B-1 is presented in the Drill Logs, Figure B1. Material descriptions and interfaces on the logs are interpretive, and actual changes may be gradual. The left-hand portion of the Drill Log gives individual sample intervals, percent recovery, SPT data, and natural moisture content measurements. Material descriptions and geotechnical unit designations are shown in the center of the Drill Log, and the right-hand portion provides a graphic log, miscellaneous comments, and a graphic depicting hole backfill details.

B.6 BOREHOLE ABANDONMENT

The borings were backfilled with bentonite chips in accordance with Oregon Water Resource Department regulations.

B.7 IN-SITU INFILTRATION TESTING

One in situ infiltration test was completed using the Encased Falling Head Test method to support design of stormwater infiltration facilities within the project area. The infiltration test was performed in close proximity to the geotechnical boring location. The test was conducted in accordance with the Clackamas County Stormwater Standards. At the infiltration test location, a hole was drilled to the desired test depth of 5 feet using an 9-inch outside-diameter, 6-inch inside-diameter hollow stem auger. Twelve inches of water was then added to the bottom of the auger to presoak the soil. After the presoak period, water was again added to the hole to return the level to 12 inches over the test surface, and the drawdown was measured at 10-minute intervals for 1 hour. This process was repeated two more times for a total of three trials. At the beginning of each trial, the water level was returned to approximately 12 inches. Infiltration test results are presented in Figure B2.

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

DRILL LOG
OREGON DEPARTMENT OF TRANSPORTATION

		Hole No. **B-1**
Project **Trolley Trail Bridge: Gladstone to Oregon City Feasibility Study**	Purpose **Pedestrian Bridge**	E.A. No. **N/A**
Highway **N/A**	County **Clackamas**	Key No. **N/A**
Hole Location Northing: **~ 630,348** Easting: **~ 7,664,586**		Start Card No. **N/A**
Equipment **CME 55 Track Rig (Hammer Efficiency = 85.8%)**	Driller **Western States**	Bridge No. **N/A**
Project Geologist **Seth Sonnier, RG**	Recorder **Micah Hintz**	Ground Elev. **~ 47 ft.**
Start Date **July 26, 2019** End Date **July 26, 2019**	Total Depth **71.50 ft**	Tube Height **N/A**

Test Type
"A" - Auger Core
"GP" - GeoProbe®
"X" - Auger
"C" - Core, Barrel Type
"N" - Standard Penetration
"U" - Undisturbed Sample
"T" - Test Pit

Rock Abbreviations

Discontinuity	Shape	Surface Roughness
J - Joint	Pl - Planar	P - Polished
F - Fault	C - Curved	Sl - Slickensided
B - Bedding	U - Undulating	Sm - Smooth
Fo - Foliation	St - Stepped	R - Rough
S - Shear	Ir - Irregular	VR - Very Rough

Typical Drilling Abbreviations

Drilling Methods	Drilling Remarks
WL - Wire Line	LW - Lost Water
HS - Hollow Stem Auger	WR - Water Return
DF - Drill Fluid	WC - Water Color
SA - Solid Auger	DP - Down Pressure
CA - Casing Advancer	DR - Drill Rate
HA - Hand Auger	DA - Drill Action

Material Description — SOIL: Soil Name, USCS, Color, Plasticity, Moisture, Consistency/Relative Density, Texture, Cementation, Structure, Origin. ROCK: Rock Name, Color, Weathering, Hardness, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance	Rock: Discontinuity Data Or RQD%	Percent Natural Moisture	Material Description	Unit Description	Graphic Log	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
0							**0.00 - 7.50 Silty SAND; SM; Dark brown; Nonplastic fines; Moist; Very loose to loose; Fine sand; Trace organics; (Alluvium)**		Mud rotary drilling technique (5-inch hole)		
	N1	61	3-3-3		30	N- 1 (2.50-4.00) Silty SAND; SM; Dark brown; Nonplastic fines; Moist; Loose; Fine sand; Trace organics; (Alluvium)					
5	N2	11	1-2-1			N- 2 (5.00-6.50) Silty SAND; SM; Dark brown; Nonplastic fines; Moist; Very loose; Fine sand; Trace organics; (Alluvium)					
	N3	56	0-1-1		40	N- 3 (7.50-9.00) Sandy SILT; ML; Dark brown; Nonplastic to low plasticity; Moist; Very loose; Fine sand; Stratified with 2 to 4-inch interbeds of Silty SAND (SM); Micaceous; (Alluvium)	**7.50 - 9.50 Sandy SILT; ML; Dark brown; Nonplastic to low plasticity; Moist; Soft; Fine sand; Stratified with 2 to 4-inch interbeds of Silty SAND (SM); Micaceous; (Alluvium)**		N-3: 62.0% Fines		
10	N4	22	1-1-1		24	N- 4 (10.00-11.50) Silty SAND; SM; Dark brown; Low plasticity fines; Moist; Very loose; Fine sand; Micaceous; (Alluvium)					
	U1	100			25	U- 1 (12.50-14.50) Silty SAND; SM; Dark brown; Low plasticity fines; Moist; Fine sand; Micaceous; (Alluvium)	**9.50 - 14.50 Silty SAND; SM; Dark brown; Low plasticity fines; Moist; Very loose; Fine sand; Micaceous; (Alluvium)**		U-1: 35.0% Fines; Dry Density=69.2 pcf U-1: Dry density = 69.2 pcf		
15	N5	39	2-3-2		28	N- 5 (14.50-16.00) SAND with some silt; SP-SM; Dark brown; Nonplastic fines; Moist; Loose; Fine sand; Micaceous; (Alluvium)	**14.50 - 23.00 SAND with some silt; SP-SM; Dark brown; Nonplastic fines; Moist; Very loose to loose; Fine sand; Micaceous; (Alluvium)**		N-5: 24.8% Fines		
	N6	28	2-3-3		17	N- 6 (17.50-19.00) SAND with some silt; SP-SM; Dark brown; Nonplastic fines; Moist; Loose; Fine sand; Micaceous; (Alluvium)			N-6: 23.4% Fines		
20	N7	50	2-2-2		26	N- 7 (20.00-21.50) SAND with some silt; SP-SM; Dark brown; Nonplastic fines; Moist; Very loose to loose; Fine sand; Micaceous; (Alluvium)			N-7: 15.9% Fines		
25	N8	33	36-50/5"		8	N- 8 (25.00-25.90) Sandy GRAVEL with some silt; GP; Dark gray; Nonplastic fines; Moist; Very dense; Fine to coarse subangular gravel; Fine to coarse sand; (Gravel Alluvium)	**23.00 - 32.50 Sandy GRAVEL with some silt to GRAVEL with some sand and silt; GP/GP-GM; Dark gray; Nonplastic fines; Moist; Very dense; Fine to coarse subangular gravel; Fine to coarse sand; (Gravel Alluvium)**		Gravelly material inferred from drilling action encountered at approximately 23 feet. N-8: 60% gravels, 30% sands, 10% fines		
30	N9	17	50/1st 6"			N- 9 (30.00-30.50) GRAVEL with some sand and silt; GP-GM; Dark gray; Nonplastic fines; Moist; Very dense; Fine to coarse subangular gravel; Fine to coarse sand; (Gravel Alluvium)					
35							**32.50 - 52.00 GRAVEL with some**				

ODOT DRILL LOG - FOR SW REVIEW 101474-003.GPJ ODOT_MANWITHSWLAB.GDT 1/8/20

Depth (ft)	Test Type, No.	Percent Recovery	Soil: Driving Resistance / Rock: Discontinuity Data Or RQD%	Percent Natural Moisture	Material Description (SOIL: Soil Name, USCS, Color, Plasticity, Moisture, Consistency/Relative Density, Texture, Cementation, Structure, Origin. ROCK: Rock Name, Color, Weathering, Hardness, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.)	Unit Description	Drilling Methods, Size and Remarks	Water Level/ Date	Backfill/ Instrumentation
35	N10	67	39-36-30	8	N- 10 (35.00-36.50) GRAVEL with some sand and trace silt; GP; Dark brown with some dark gray and red-yellow gravel; Nonplastic fines; Moist; Very dense; Fine to coarse subangular to subrounded gravel; Fine to coarse sand; (Gravel Alluvium)	**sand and trace to some silt; GP/GP-GM; Dark gray; Nonplastic fines; Moist; Very dense; Fine to coarse subangular gravel; Fine to coarse sand; (Gravel Alluvium)**	N-10: 68% gravels, 26% sands, 6% fines		
40	N11	0	50/1st 6"		N- 11 (40.00-40.50) No recovery				
45	N12	17	37-25-23		N- 12 (45.00-46.50) GRAVEL with trace sand; GP; Dark gray; Moist; Dense; Fine to coarse subangular gravel; Fine to coarse sand; (Gravel Alluvium)				
50	N13	0	50/1st 3"		N- 13 (50.00-50.30) No recovery				
						52.00 - 57.50 Sandy SILT with trace to some gravel; ML; Olive-gray to olive-brown with blue-gray and yellow layers; Nonplastic to low plasticity; Moist; Hard; Fine to medium sand; Relict mudstone texture; Heavy iron staining; (Sandy River Mudstone)			
55	N14	100	12-25-24		N- 14 (55.00-56.50) Sandy SILT with trace to some gravel; ML; Olive-gray to olive-brown with blue-gray and yellow layers; Nonplastic to low plasticity; Moist; Hard; Fine to medium sand; Relict mudstone texture; Heavy iron staining; (Sandy River Mudstone)				
						57.50 - 62.50 Silty CLAY with some sand; CL; Olive-gray to olive-brown; Medium plasticity; Moist; Very Stiff; Fine sand; Relict mudstone texture; Heavy iron staining; (Sandy River Mudstone)			
60	N15	100	6-11-13		N- 15 (60.00-61.50) Silty CLAY with some sand; CL; Olive-gray to olive-brown; Medium plasticity; Moist; Very Stiff; Fine sand; Relict mudstone texture; Heavy iron staining; (Sandy River Mudstone)				
						62.50 - 71.50 Clayey SILT with some sand; MH; Gray to yellow-brown; High plasticity; Moist; Very Stiff; Fine sand; Relict mudstone texture; Heavy iron staining; (Sandy River Mudstone)			
65	N16	100	9-11-11	47	N- 16 (65.00-66.50) Clayey SILT with some sand; MH; Gray to yellow-brown; High plasticity; Moist; Very Stiff; Fine sand; Relict mudstone texture; Heavy iron staining; (Sandy River Mudstone)		Atterberg Limits N-16: LL=67, PL=33, PI=35		
70	N17	100	6-14-19		N- 17 (70.00-71.50) Clayey SILT with some sand; MH; Dark gray to olive-brown with blue-gray layers; High plasticity; Moist; Hard; Fine sand; Relict mudstone texture; Heavy iron staining; (Sandy River Mudstone)				
						71.50 End of hole			
75									
80									
85									
88									

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Project Name: Trolley Trail Bridge
Job #: 101474
Elevation: Approx. 408 ft.
Field Rep.: MXH

Location: Clackamas County, Oregon		**Date:** 7/26/2019	**Test Hole Number:** I-1
Depth to bottom of hole: 4.7 feet	**Dimension of hole:** 8" Hollow-Stem Auger		**Test method:** Encased Falling Head Test
Depth (feet):	**Soil Texture:**		
0.0 - 4.7	Silty SAND (SM)		
Presaturation Start Time:	7/26/2019 @ 0823		

Time:	Time Interval (minutes):	Measurement (inches):	Drop in water level (inches):	Infiltration rate (inches per hour):	Remarks:
11:50	-	4.15	-	0.0	
12:10	20	4.25	0.1	**3.6**	
12:10	-	4.15	-	0.0	
12:30	20	4.24	0.1	**3.2**	
12:30	-	4.15	-	0.0	
12:50	20	4.25	0.1	**3.6**	
12:50	-	4.15	-	0.0	
13:10	20	4.25	0.1	**3.6**	

APPENDIX C: LABORATORY TEST RESULTS

Appendix C

Laboratory Test Results

CONTENTS

Figures

APPENDIX C: LABORATORY TEST RESULTS

C.1 GENERAL

The soil and rock samples obtained during the field explorations were described and identified in the field in accordance with the ODOT Soil and Rock Classification Manual (1987). The samples were then reviewed in the laboratory. Physical characteristics of the samples were noted, and field descriptions and identifications were modified as necessary. During the course of the examination, some samples were selected for further testing. We refined our descriptions and identifications based on the results of the laboratory tests, in accordance with the ODOT Soil and Rock Classification Manual (1987).

The soil testing program included moisture content tests, unit weight tests, Atterberg limits tests, and particle-size analyses. Laboratory testing was performed by Shannon & Wilson, Inc. All test procedures were performed in accordance with applicable ASTM International standards. Test procedures are summarized in the following paragraphs.

C.2 MOISTURE (NATURAL WATER) CONTENT

Natural moisture content tests were performed, in accordance with ASTM D2216, on selected soil samples. The natural moisture content is a measure of the amount of moisture in the soil at the time of exploration. It is defined as the ratio of water weight to dry soil weight, expressed as a percentage. Results of all moisture content tests are presented on the Drill Logs in Appendix B. Results of the moisture content tests are also presented in this appendix.

C.3 UNIT WEIGHT

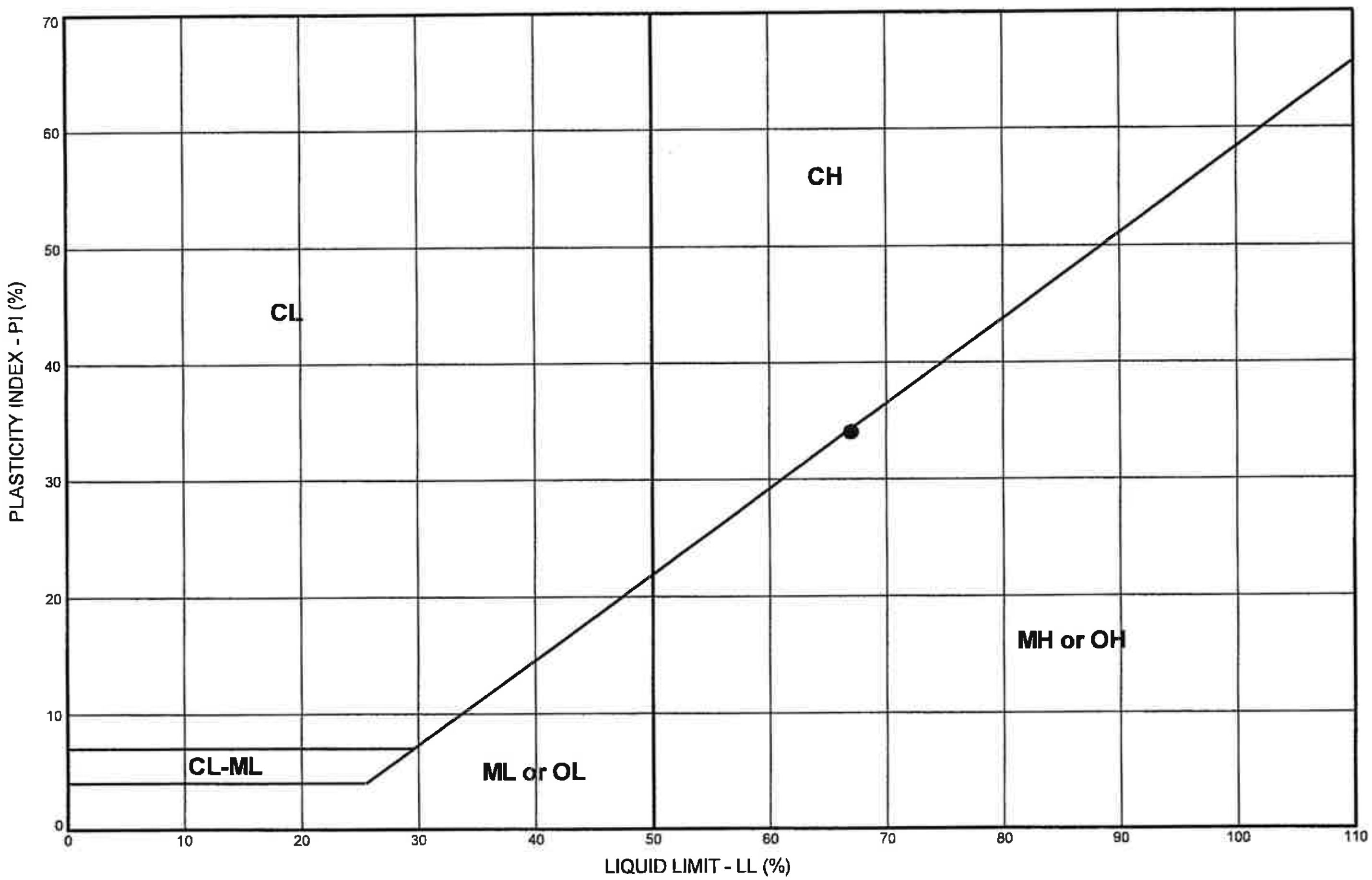
Unit weight of one undisturbed soil sample was determined in accordance with ASTM D7263. The test was conducted in conjunction with moisture content testing, described above in Section C.2. Wet and dry unit weights were calculated by measuring the dimensions of the cylindrical undisturbed sample, the sample weight, and moisture content. Unit weight is defined as the ratio of soil weight in pounds (wet and dry) to the in-place volume of the sample in cubic feet and is presented in pounds per cubic foot (pcf). Results of the unit weight test are presented on the Drill Logs in Appendix B.

C.4 ATTERBERG LIMITS

Atterberg limits were determined for one selected sample in accordance with ASTM D4318. This analysis yields index parameters of the soil that are useful in soil identification, as well as in engineering analyses. An Atterberg limits test determines a soil's liquid limit (LL) and plastic limit (PL). These are the maximum and minimum moisture contents at which the soil exhibits plastic behavior. A soil's plasticity index (PI) can be determined by subtracting PL from LL. Results of all Atterberg limits tests are presented on Figure C1, Atterberg Limits Results.

C.5 PARTICLE-SIZE ANALYSIS

Particle-size analyses were conducted on select samples, including one bulk streambed sediment sample collected from the Clackamas River and provided to Shannon & Wilson by West Consultants, Inc., in accordance with ASTM D6913. For all samples, a wet sieve analysis was performed to determine the percentage (by weight) of the sample passing the No. 200 (0.075 mm) sieve. For select samples the material retained on the No. 200 sieve was then shaken through a series of sieves to determine the distribution of the plus No. 200 fraction. Results of all particle-size analyses are presented on Figure C2, Grain Size Distribution.



NOTES

1) Atterberg limits tests were performed in general accordance with ASTM D4318 unless otherwise noted in the report.

2) Group Name and Group Symbol are in accordance with ASTM D2488 and are refined in accordance with ASTM D2487 where appropriate laboratory tests are performed.

3) Plasticity adjectives used in sample descriptions correspond to plasticity index as follows:
- Nonplastic (NP) (< 3%)
- Low Plasticity (3 to 15%)
- Medium Plasticity (15 to 30%)
- High Plasticity (> 30%)

BORING AND SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL[2]	GROUP NAME[2]	LL %	PL %	PI %[3]	NAT. W.C. %	FINES %
● B-1, N16	65.0	*MH*	*Clayey SILT with some sand*	67	33	34	47	

Trolley Trail Bridge:
Gladstone to Oregon City Feasibility Study
Clackamas County, Oregon

ATTERBERG LIMITS RESULTS

January 2020 101474-005

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

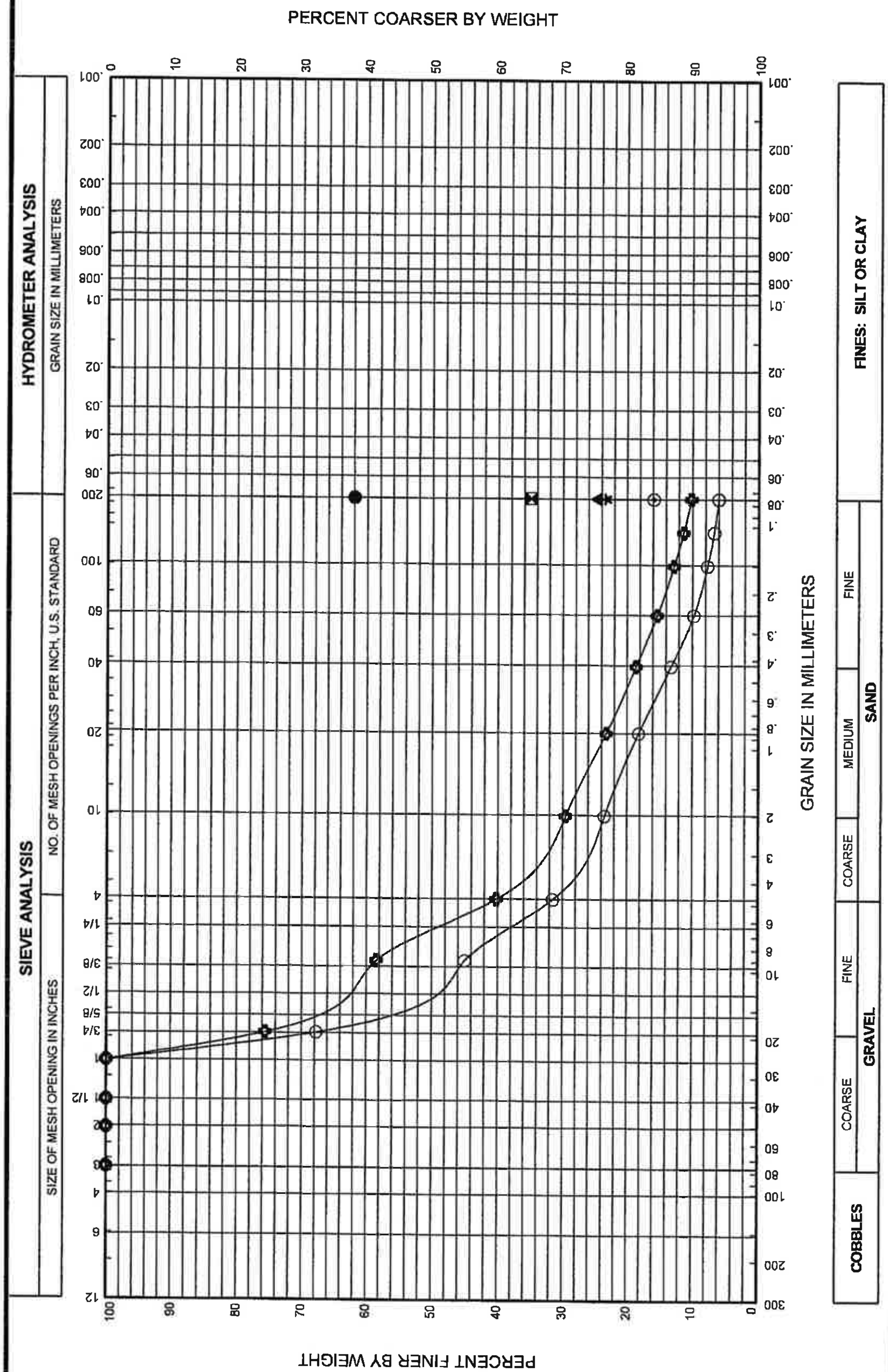
FIG. C1

FIG. C1

NOTES:

1) Sieve analyses were performed in general accordance with ASTM D6913, sieve with hydrometer analyses were performed in general accordance with ASTM D422, and amount finer than #200 sieve analyses were performed in general accordance with ASTM D1140 unless otherwise noted in the report.

2) Group Name and Group Symbol are in accordance with ASTM D2488 and are refined in accordance with ASTM D2487 where appropriate laboratory tests are performed.



BORING AND SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL[2]	GROUP NAME[2]	GRAVEL %	SAND %	FINES %	NAT. W.C. %	DRY DENSITY PCF
● B-1, N3	7.5	ML	*Sandy SILT*	-	-	62	16	
⊠ B-1, U1	12.5	SM	*Silty SAND*	-	-	35	25	
▲ B-1, N5	14.5	SP-SM	*SAND with some silt*	-	-	25	26	
★ B-1, N6	17.5	SP-SM	*SAND with some silt*	-	-	23	17	
⊙ B-1, N7	20.0	SP-SM	*SAND with some silt*	-	-	16	25	
✪ B-1, N8	25.0	GP-GM	*Sandy GRAVEL with some silt*	60	30	10	8	
○ B-1, N10	35.0	GP	*GRAVEL with some sand and trace silt*	68	26	6	8	

Trolley Trail Bridge:
Gladstone to Oregon City Feasibility Study
Clackamas County, Oregon

GRAIN SIZE DISTRIBUTION

January 2020 | 101474-005

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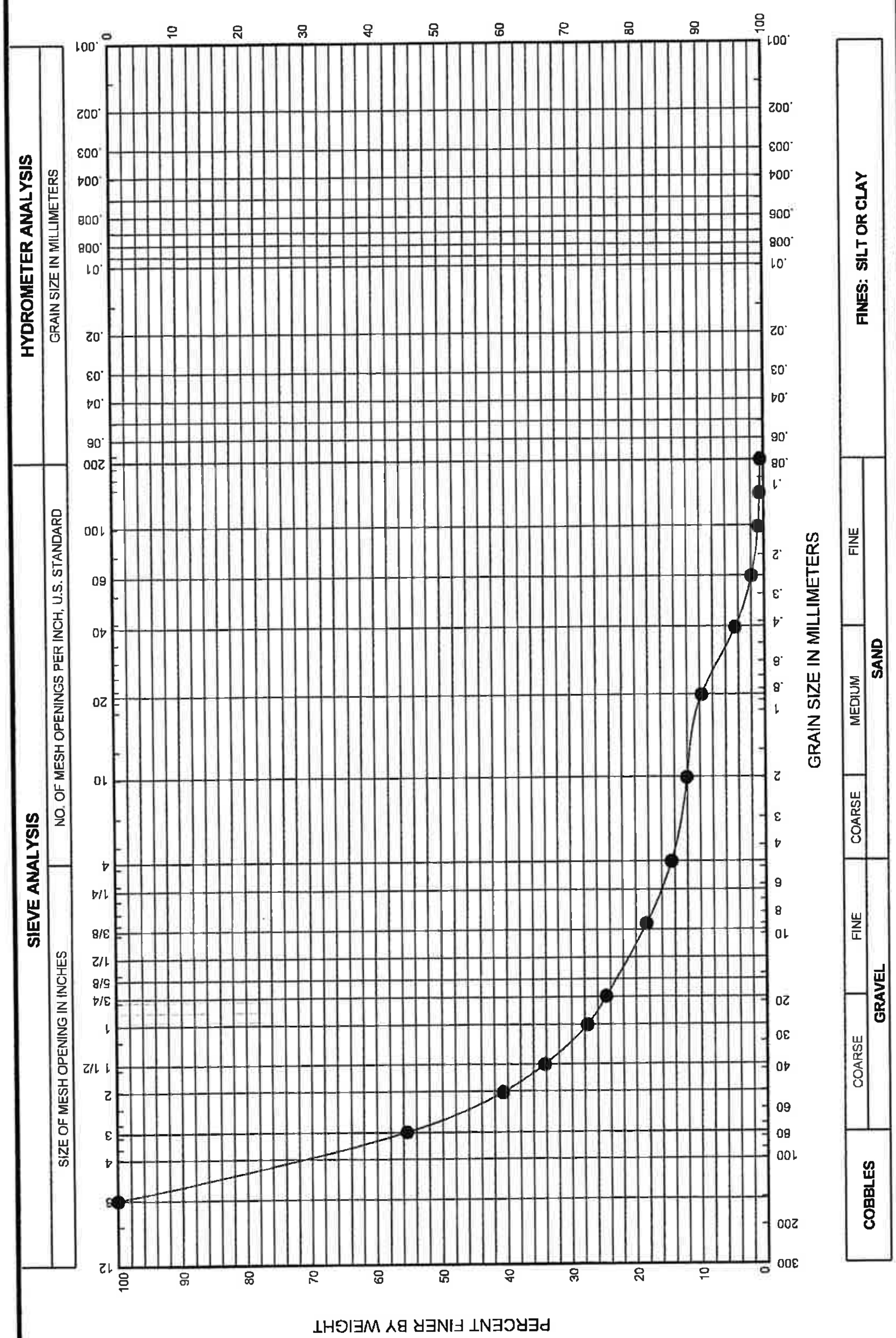
FIG. C2
Sheet 1 of 2

FIG. C2

NOTES:
1) Sieve analyses were performed in general accordance with ASTM D6913, sieve with hydrometer analyses were performed in general accordance with ASTM D422, and amount finer than #200 sieve analyses were performed in general accordance with ASTM D1140 unless otherwise noted in the report.
2) Group Name and Group Symbol are in accordance with ASTM D2488 and are refined in accordance with ASTM D2487 where appropriate laboratory tests are performed.



BORING AND SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL[2]	GROUP NAME[2]	GRAVEL %	SAND %	FINES %	NAT. W.C. %	DRY DENSITY PCF
● Stream Bed Sediment,	0.0	*GP*	*GRAVEL with trace sand*	41	14	0		

Trolley Trail Bridge:
Gladstone to Oregon City Feasibility Study
Clackamas County, Oregon

GRAIN SIZE DISTRIBUTION

January 2020

101474-005

SHANNON & WILSON, INC.
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FIG. C2
Sheet 2 of 2

FIG. C2

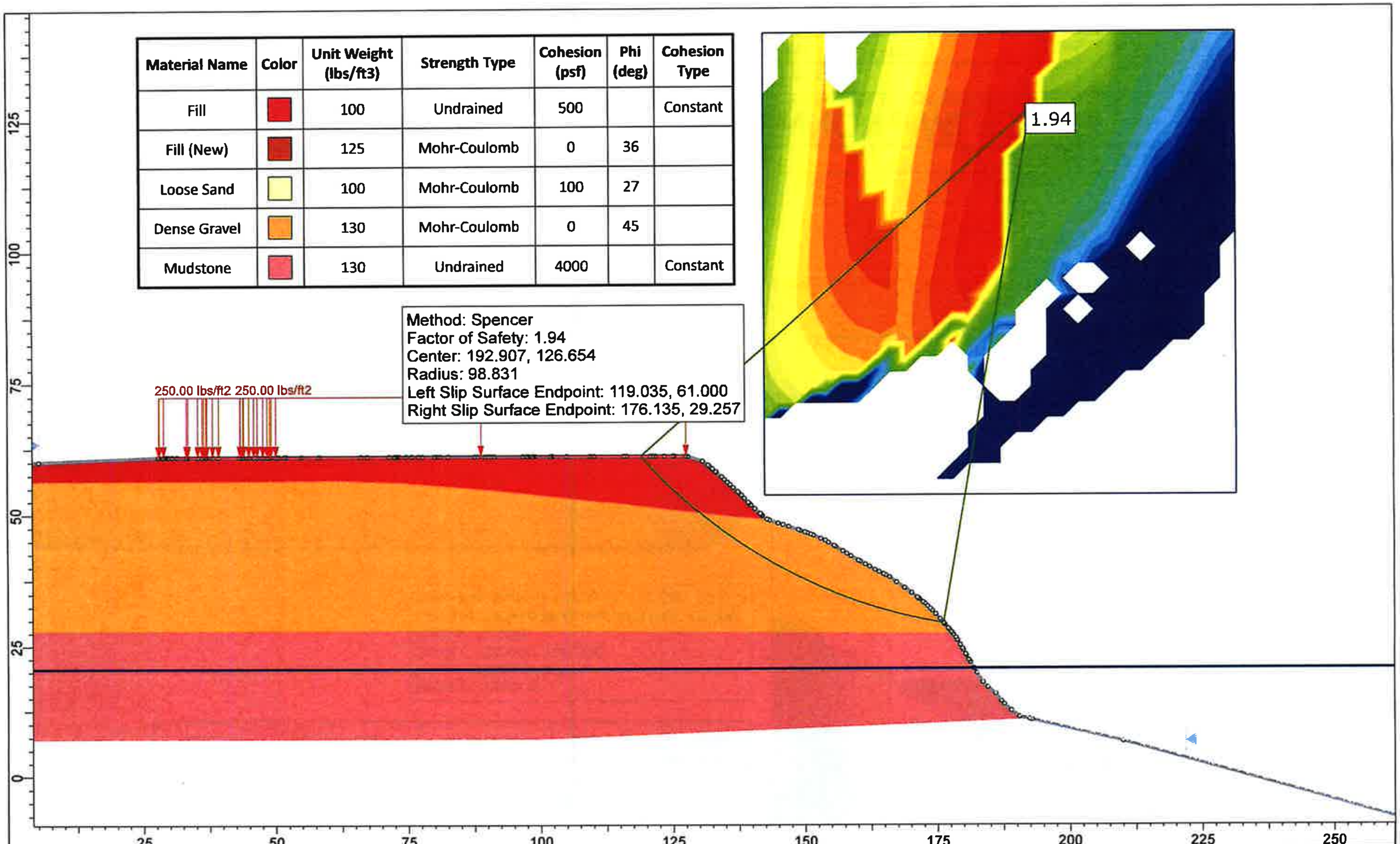
APPENDIX D: GLOBAL STABILITY ANALYSIS RESULTS

Appendix D

Global Stability Analysis Results

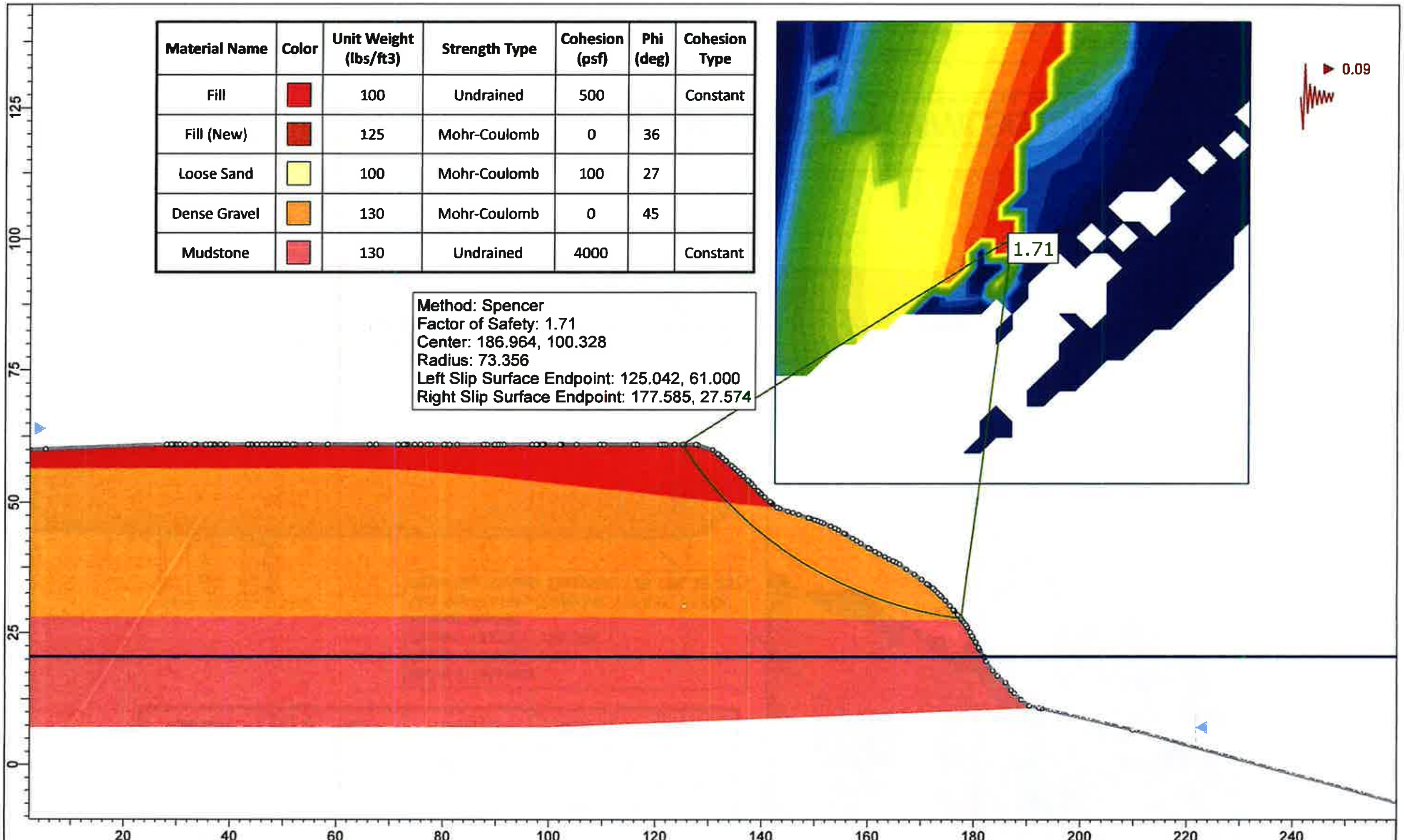
CONTENTS

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type
Fill		100	Undrained	500		Constant
Fill (New)		125	Mohr-Coulomb	0	36	
Loose Sand		100	Mohr-Coulomb	100	27	
Dense Gravel		130	Mohr-Coulomb	0	45	
Mudstone		130	Undrained	4000		Constant



Project: Trolley Trail Bridge	SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS			
	Analysis Description: North Abutment, Static Analysis			
	Drawn By: M. Hintz	Scale: 1:300	Company: Shannon & Wilson, Inc.	
FIG. D1	Date: 9/30/2019, 1:45:37 PM		File Name: 101474 Prelim Slope Stability.slmd	

SLIDEINTERPRET 8.027



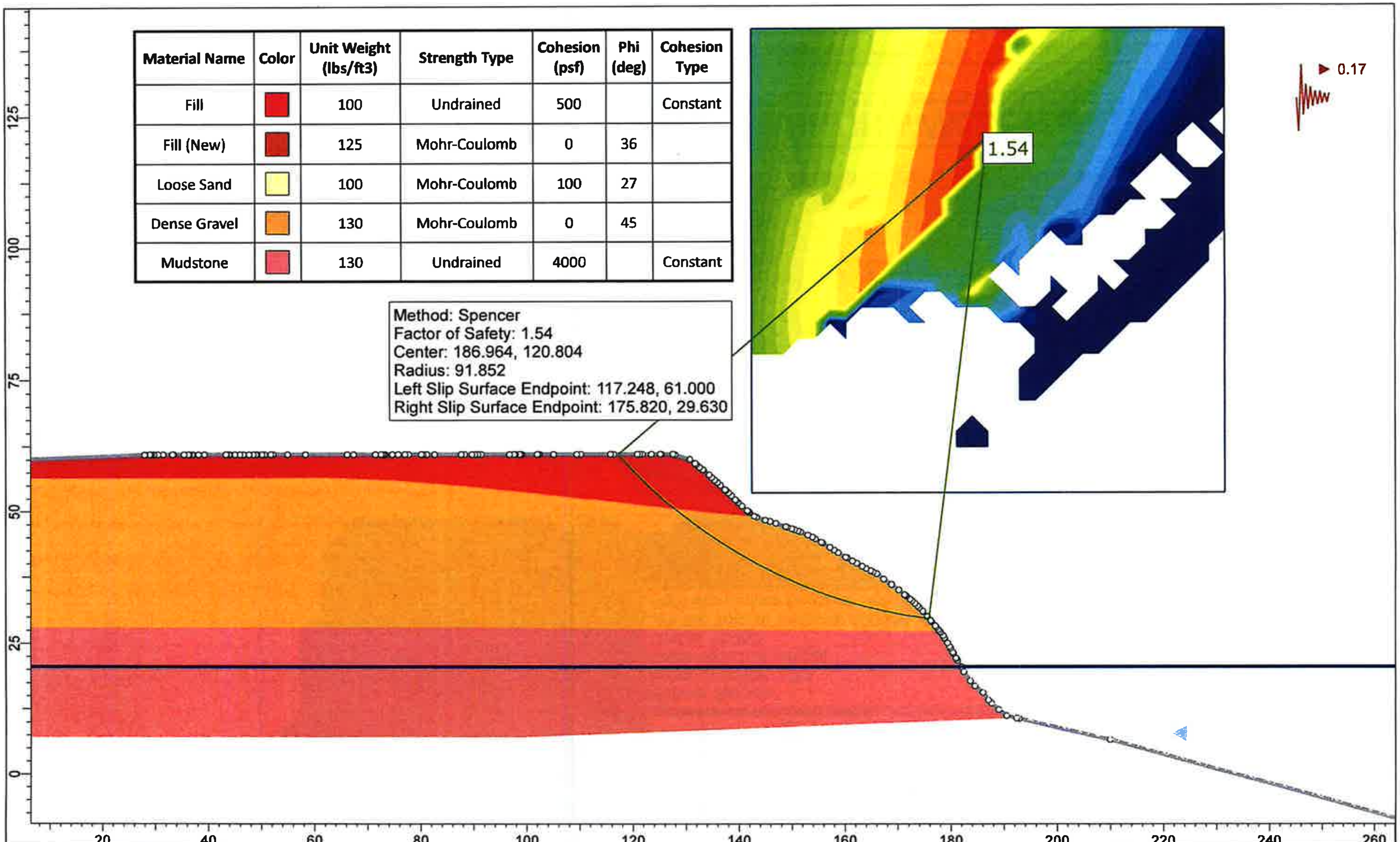
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type
Fill		100	Undrained	500		Constant
Fill (New)		125	Mohr-Coulomb	0	36	
Loose Sand		100	Mohr-Coulomb	100	27	
Dense Gravel		130	Mohr-Coulomb	0	45	
Mudstone		130	Undrained	4000		Constant

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Project	Trolley Trail Bridge
Analysis Description	North Abutment, Pseudostatic Analysis, CSZE event
Drawn By	M. Hintz
Scale	1:300
Company	Shannon & Wilson, Inc.
Date	9/30/2019, 1:45:37 PM
File Name	101474 Prelim Slope Stability.slmd

FIG. D2

SLIDEINTERPRET 8.027

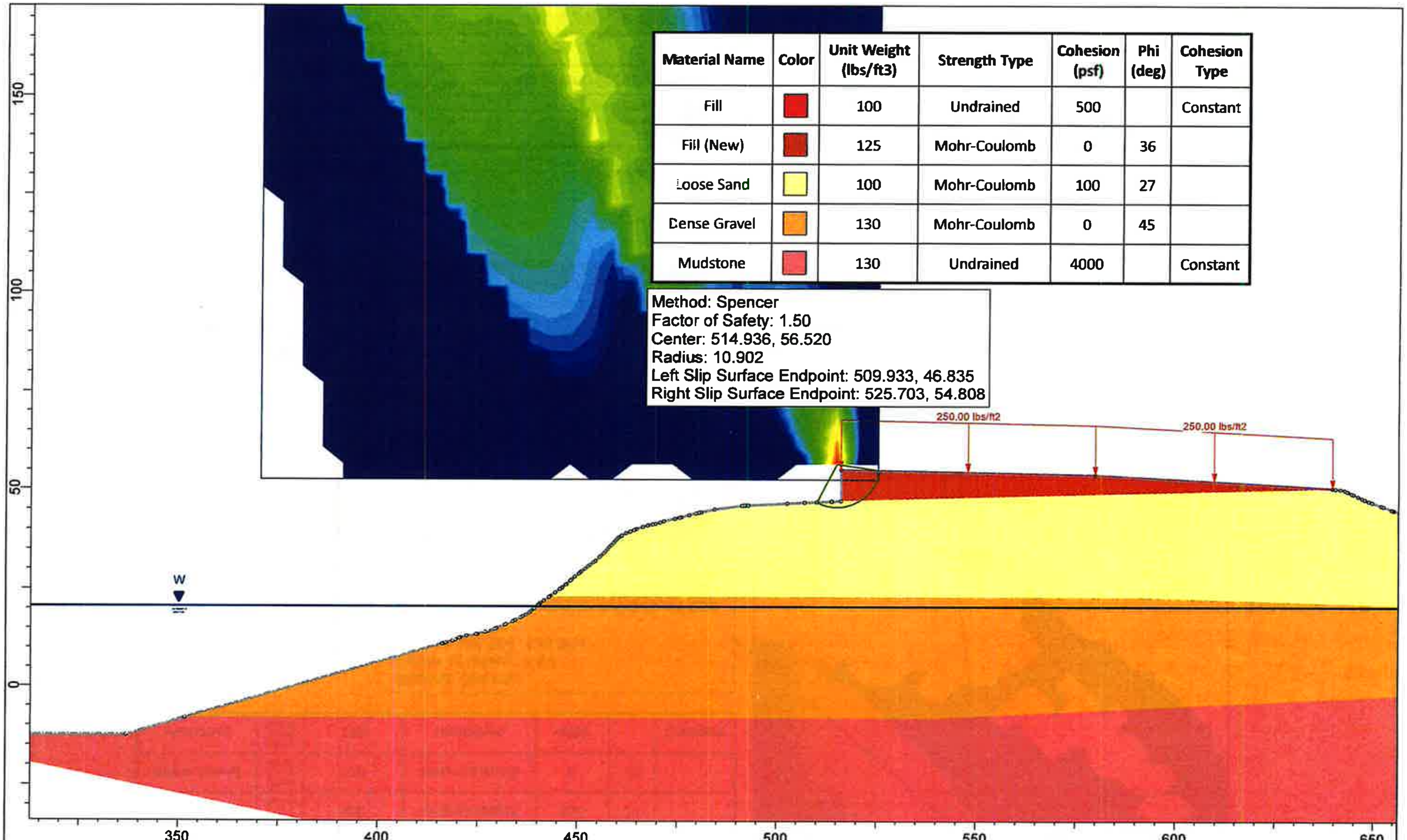


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type
Fill		100	Undrained	500		Constant
Fill (New)		125	Mohr-Coulomb	0	36	
Loose Sand		100	Mohr-Coulomb	100	27	
Dense Gravel		130	Mohr-Coulomb	0	45	
Mudstone		130	Undrained	4000		Constant

Project	Trolley Trail Bridge
	SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
Analysis Description	North Abutment, Pseudostatic Analysis, 1,000-year event
Drawn By	M. Hintz
Scale	1:300
Company	Shannon & Wilson, Inc.
Date	9/30/2019, 1:45:37 PM
File Name	101474 Prelim Slope Stability.slmd

FIG. D3

SLIDEINTERPRET 8.027



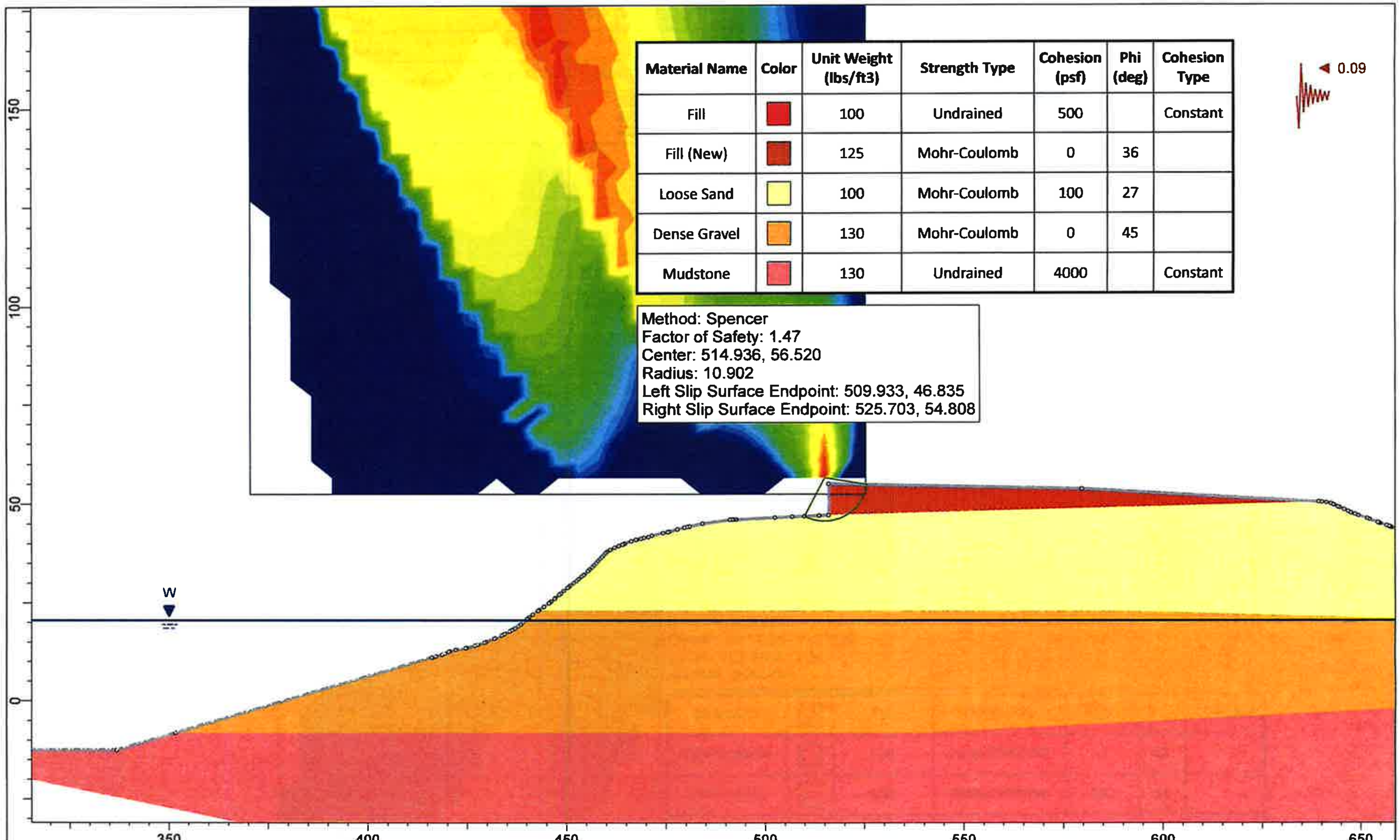
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type
Fill		100	Undrained	500		Constant
Fill (New)		125	Mohr-Coulomb	0	36	
Loose Sand		100	Mohr-Coulomb	100	27	
Dense Gravel		130	Mohr-Coulomb	0	45	
Mudstone		130	Undrained	4000		Constant

Method: Spencer
Factor of Safety: 1.50
Center: 514.936, 56.520
Radius: 10.902
Left Slip Surface Endpoint: 509.933, 46.835
Right Slip Surface Endpoint: 525.703, 54.808

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Project Trolley Trail Bridge	*Analysis Description* South Abutment, Static Analysis		
	Drawn By M. Hintz	*Scale* 1:400	*Company* Shannon & Wilson, Inc.
FIG. D4	*Date* 9/30/2019, 1:45:37 PM		*File Name* 101474 Prelim Slope Stability.slmd

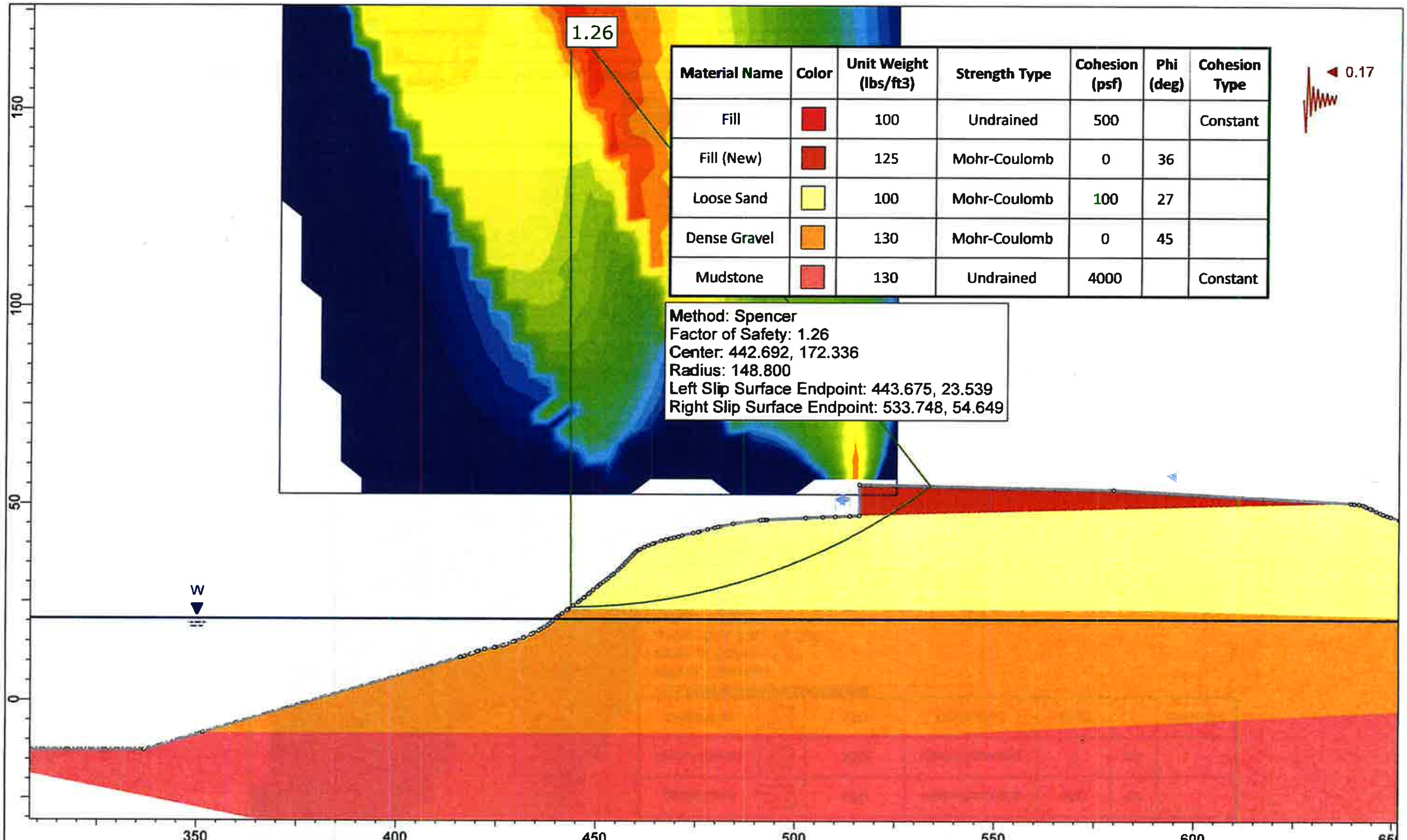
SLIDEINTERPRET 8.027



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type
Fill		100	Undrained	500		Constant
Fill (New)		125	Mohr-Coulomb	0	36	
Loose Sand		100	Mohr-Coulomb	100	27	
Dense Gravel		130	Mohr-Coulomb	0	45	
Mudstone		130	Undrained	4000		Constant

Project: Trolley Trail Bridge	SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
	Analysis Description: South Abutment, Pseudostatic Analysis, CSZE event
	Drawn By: M. Hintz / Scale: 1:400 / Company: Shannon & Wilson, Inc.
FIG. D5	Date: 9/30/2019, 1:45:37 PM / File Name: 101474 Prelim Slope Stability.slmd

SLIDEINTERPRET 8.027



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type
Fill		100	Undrained	500		Constant
Fill (New)		125	Mohr-Coulomb	0	36	
Loose Sand		100	Mohr-Coulomb	100	27	
Dense Gravel		130	Mohr-Coulomb	0	45	
Mudstone		130	Undrained	4000		Constant

Project	SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS			
Trolley Trail Bridge	Analysis Description: South Abutment, Pseudostatic Analysis, 1,000-year event			
	Drawn By: M. Hintz	Scale: 1:400	Company: Shannon & Wilson, Inc.	
FIG. D6	Date: 9/30/2019, 1:45:37 PM		File Name: 101474 Prelim Slope Stability.slmd	

SLIDEINTERPRET 8.027

IMPORTANT INFORMATION

Important Information

About Your Geotechnical/Environmental Report

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors that were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

IMPORTANT INFORMATION

IMPORTANT INFORMATION

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland

DAVID EVANS AND ASSOCIATES INC

Appendix F: Hydraulics Report

REGISTERED PROFESSIONAL ENGINEER
77018PE
OREGON
JANUARY 9, 2007
HANS RAYMOND HADLEY
EXPIRES: 6/30/2021

Bridge Hydraulic Design and Scour Assessment
Detailed Report

for

Trolley Trail (Clackamas River) Bridge
City of Gladstone, Clackamas County, Oregon

Prepared for:

David Evans & Associates, Inc.
530 Center Street, Suite 605
Salem, OR 97301
(503) 361-8635

Prepared by:

WEST Consultants, Inc.
2601 25th St. SE, Suite 450
Salem, OR 97302
(503) 485-5490

January 7, 2020

TABLE OF CONTENTS

INTRODUCTION

The City of Gladstone plans to build a new pedestrian bridge over the Clackamas River at the location of the former Gladstone Trolley Bridge. The former steel truss bridge had to be demolished in March 2014 after a significant flood in the Clackamas River undermined the pier foundation on the Oregon City side of the river, causing the bridge to lean. A bridge had been in this location since 1892 and was replaced in 1908 by the bridge that remained in this location until 2014. Scour mitigation repair work had been completed in the early 2000's but concerns of additional undermining were raised in 2013. A bridge location map is shown in **Figure 1** (all figures are provided in **Appendix A**). This report summarizes the hydraulic designs and scour assessments conducted for the proposed bridge alternatives.

Five proposed bridge design alternatives were provided by David Evans & Associates (DEA). All five alternatives follow the same general horizontal path alignment which is generally the same as the former railroad bridge. The bridge foundations have not be designed but would be expected to consist of drilled shafts or driven steel piles. The abutments for all alternatives will be aligned with the flow of the river. The minimum low chord elevation for all options is 51.4 feet at the south abutment. All elevations in this report are referenced to the North American Vertical Datum of 1988 (NGVD 88), unless stated otherwise. **Table 1** summarizes the length, width, number of spans and bridge type for each alternative.

Table 1. Bridge Alternatives

Alternative No.	Length (ft)	Width (ft)	Number of Spans	Bridge Type
1	365	19	1	Steel Truss (tall)
2	365	19	3	Prestressed Concrete Girder
3	365	19	3	Steel Girder
4	365	19	1	Steel Arch
5	365	19	3	Steel Truss (short)

For hydraulic design purposes, Alternatives 1 and 4 are considered to be the same bridge and are referred to as Alternatives 1/4. Alternatives 2, 3, and 5 are also considered to be the same design hydraulically and are referred to as Alternatives 2/3/5. Preliminary plans for Alternatives 1 through 5 are provided in **Figure 2** through **Figure 6**, respectively.

RESEARCH

The contributing drainage area for the Clackamas River at the bridge site is 942 square miles. The watershed varies in elevation from about -4 feet just upstream of the bridge site to approximately 7,215 feet at the summit of Olallie Butte located near the southeast corner of the watershed. The mean annual precipitation over the watershed is approximately 73 inches (USDA, 1998). The nearest USGS stream gage (No. 14211010 Clackamas River near Oregon City, OR) is located approximately 4,500 ft upstream of the project site and has annual peak flow data from water years 2002 to 2017. A historic UGSG gage (No. 14211000 Clackamas River near Clackamas, OR) was located approximately 4 miles upstream of the project site and has annual peak flow data for water years 1912, and 1963 to 1983.

A Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) is available for Clackamas County, Oregon (FEMA, 2008) which includes the Clackamas River. The portion of the Clackamas River at the project site was studied by detailed methods. Peak flows and regulatory floodplain and floodway elevations are available for the bridge site. The effective model for the Clackamas River obtained from FEMA included only the output information and no input geometry.

Bridge plans were not available for the former railroad bridge. Information needed for incorporating the bridge into the hydraulic model was obtained from historic descriptions and photographs available from the Clackamas County Historical Society (CCHS, 2019). The superstructure consisted of a 260-ft long central steel truss span and two jump spans (of unknown length) located at each end of the bridge. The piers were located at each end of the central span and consisted of 3'-10" diameter circular steel tubes connected by a partial height concrete web wall and steel cross bracing. The piers were founded on 9 ft wide octagonal shaped concrete footings connected by a 2 ft wide web wall. The high and low chord of the bridge was obtain from the flood profiles provided in the FEMA (2008) study. The south pier is no longer present at the site; however, the concrete footing for the north pier is still present and was included in the survey for the bridge site. The jump spans were assumed to be 30 feet in total length supported by 1 ft diameter piers at 10 ft spacing. This assumption is based on a historic photograph of the bridge (**Figure 7**) obtained from CCHS website.

The City of Lake Oswego constructed a new raw water intake tower along the right bank of the

Clackamas River approximately 150 feet upstream of the proposed location for the Trolley Trail Bridge. The intake was completed in 2015 and replaced the previous intake that was built in 1968. The failure of the south pier of the railroad bridge in 2014 was thought by some to have been caused by the construction of the new raw water intake. It is possible that the coffer dam that was used during construction of the intake increased the hydraulic forces on the south pier of the railroad bridge, exacerbating the ongoing undermining of the pier. However, in its current configuration, the raw water intake tower is not expected to detrimentally impact the hydraulic conditions at the proposed bridge site.

REGULATORY STANDARDS

The proposed bridge structure will be located within a regulatory (FEMA) floodplain and floodway. FEMA and county regulations require that any proposed development within the floodway not result in any increase in the 100-year base flood elevation. It is understood that the proposed bridge will also need to comply with Oregon Department of Transportation (ODOT) guidelines (ODOT, 2014). For a bridge located in a regulatory floodplain, a minimum of 1 foot of clearance above the 100-year base flood is desired. For bridges that are subject to large woody debris, a minimum of 3 feet of clearance is desired. According to the ODOT Hydraulic Manual (2014), because the bridge is located in a regulatory FEMA floodplain, the design flood for the proposed bridge crossing over the Clackamas River is the 1-percent annual chance (100-year recurrence interval) event.

SITE INVESTIGATION

A site investigation of the bridge was conducted by Hans Hadley, P.E., WEST Consultants, Inc., on June 11, 2019. A subsequent visit was made on September 27, 2019 to collect a bed material sample. A survey of the area and existing bridge was made by DEA. Seven cross sections were surveyed: two sections downstream of the bridge, one each at the upstream and downstream face of the bridge, and three sections upstream of the bridge. Nine additional cross sections were available from a previous survey conducted by WEST Consultants, Inc. (WEST) and KPFF Consulting Engineers for the Clackamette Park Boat Ramp Project located approximately 1,200 ft downstream of the project site. The cross sections were incorporated into the study to account for backwater associated with the Willamette River and the Highway 99E bridge. A plan view showing the location of the cross sections is shown in **Figure 8**. A photographic log of the project area is presented in **Appendix B.**

Observations made during the site investigation are summarized as follows:

1) Lateral Channel Stability

The channel banks along the north side of the Clackamas River appear to be moderately stable and generally well vegetated; however, some erosion was noted along the bank toes. A siltstone bedrock outcropping was observed beneath the pier foundation for the former railroad bridge and showed signs of minor erosion.

The channel banks along the south side of the Clackamas River appear to be less stable. This area is a point bar feature composed of erodible alluvial material that is susceptible to channel migration. The bank material at the proposed bridge site is composed of sand-, gravel, and cobble-sized material and is considered to be erodible under high flow conditions. A photograph of the former south bridge pier (**Figure 9**) from August 2013 indicates that significant erosion of the bank material had occurred at this location.

2) Aggradation/Degradation

No signs of long-term channel aggradation or degradation were observed. However, the bridge site is subject to episodic deposition and erosion during large flood events.

3) Manning's *n*

The Manning's n value for the main channel of the Clackamas River is estimated to be 0.045. The overbank area Manning's n values were estimated to range between 0.07 and 0.12. These values were selected based upon the investigator's judgment and experience.

4) Riprap

Broken concrete rubble was observed along the south bank near the former railroad bridge pier location. A riprap and root wad revetment was observed along the left bank approximately 500 feet downstream of the proposed bridge site.

5) Bed Material

The stream bed and bank material of the Clackamas River is generally comprised of sand-, gravel, and cobble-sized material. One shovel sample of sub-armor bed material was obtain from the exposed bar located upstream of the bridge site. A grain-size distribution (**Figure 10**) was developed for the sample by Shannon and Wilson. The D_{50} of the sample material is 68 mm. The maximum particle size is 150 mm.

Siltstone bedrock was also observed along the right bank at the bridge site and upstream at the site of the raw water intake tower.

6) Evidence of Scour

Other than the observed concrete rubble bank protection and historic pictures of the partially undermined south pier, no other evidence of channel scour was observed.

7) Pier Alignment

The existing north pier foundation is aligned with the flow of the river. No other piers were present at the time of the site visit.

8) Hydraulic Controls

The Willamette River is located approximately 4,300 feet downstream of the project site. It is tidally influenced at the confluence with the Clackamas River. The Highway 99E Bridge is located approximately 2,800 feet downstream of the bridge site. This bridge creates a backwater influence at the project site during high flow conditions.

9) High Water Marks

No high water marks were observed near the bridge.

10) Debris

Large woody debris was not observed at the project site. However, large debris is transported by the Clackamas River and has been observed downstream in Clackamette Park. Additionally, information from the Clackamas County Historical Society indicates that "drift of logs, timber and trees is quite considerable" (CCHS, 2014)

11) Bed Forms

No dune bed forms were observed. Pools and riffles are present along the project reach.

HYDROLOGY

The available 15 year record of discharges for USGS gage No. 14211010 Clackamas River near Oregon City, OR is insufficient for conducting a reliable flood frequency analysis. Discharges for the 10-, 50-, 100-, and 500-year flood events were obtained from the effective hydraulic model that was used for the detailed FEMA study (FEMA, 2008). The FEMA discharges were developed using data from the discontinued USGS gage No. 14211000 Clackamas River near Clackamas, OR. The FEMA discharges were used for the hydraulic model and are shown in **Table 1**. The 2-year discharge was estimated by extrapolating the FEMA discharge on Log-Probability graph paper.

Table 2. Peak Discharges for Bridge Site (from FEMA, 2008).

Recurrence Interval (years)	Discharge (cfs)
2	38,000[1]
10	65,000
50	95,000
100	110,000
500	145,000

1. Extrapolated using Log-Probability graph paper

HYDRAULICS

The U.S. Army Corps of Engineers River Analysis System standard-step backwater computer program (HEC-RAS Version 5.0.7) was used to compute the bridge hydraulics (U.S. Army Corps of Engineers, 2019). The cross sections extracted from the survey data were used to develop the hydraulic models of the bridge reach. The cross sections were selected to adequately model flow contraction and expansion through the bridge opening. Channel and overbank resistance values were selected based upon the investigator's experience and judgment. Two downstream boundary conditions were evaluated with the hydraulic model, a with-backwater condition and a without-backwater condition. The with-backwater condition accounts for backwater from the Willamette River and was used to evaluate freeboard for the bridge. The without-backwater condition produces higher velocities and was used to evaluate scour conditions for the proposed bridge. The with-backwater downstream boundary water surface elevations were obtained from the effective FEMA flood profiles. The without-backwater boundary condition was set to a normal depth slope of 0.000535. The selected normal depth slope results in a water surface elevation of 44.5 feet at FEMA cross section A, which is the same as the published "without floodway" base flood elevation for this cross section.

As previously stated, Alternative 1 is essentially the same design hydraulically as Alternative 4. Similarly, Alternatives 2, 3, and 5 are essentially the same design hydraulically. Therefore, a single hydraulic model was developed to represent Alternatives 1 and 4 (referred to as Alternatives 1/4) and a single hydraulic model was developed to represent Alternatives 2, 3, and 5 (referred to as Alternatives 2/3/5). Hydraulic models were also developed for natural (no bridge or roadway) and existing conditions. For purposes of the no-rise analysis, existing conditions includes the steel truss railroad bridge the formerly occupied the project site, since this bridge was in place when the FEMA study was conducted.

Neither the 100-year base (design) flood nor the 500-year check flood will overtop the superstructure for any of the proposed alternatives. However, the bottom chord of the superstructure is submerged approximately 4.5 feet below the 500-year check flood elevation at the south abutment. The 100-year flood is 3.2 and 3.1 feet below the low chord of the bridge for Alternatives 1/4 and 2/3/5, respectively for the with-backwater conditions. Water surface profiles for the existing and proposed conditions alternatives are shown in **Figure 11** through **Figure 13**. Water surface elevations at the downstream bridge face for existing conditions and each alternative are shown in **Figure 14** through **Figure 16**. Summary tables of HEC-RAS output for the bridge design are presented in **Appendix C**.

A hydraulic data sheet for the proposed bridge alternatives for the with-backwater conditions is provided in **Table 3**. As seen in the table, Alternatives 1/4 and 2/3/5 will not cause an increase in backwater for the 100-year base flood compared to the existing condition. Backwater is reduced by 0.07 feet for Alternatives 1/4 and is the same as existing for Alternatives 2/3/5. A hydraulic data sheet for the proposed bridge alternatives for the without-backwater conditions is provided in **Table 4**.

Table 3. Hydraulic Data Sheet for the Proposed Bridge Alternatives (with-backwater).

	Existing (w/RR trestle)		Alternatives 1/4		Alternatives 2/3/5	
	Design (Base) Flood	Check Flood	Design (Base) Flood	Check Flood	Design (Base) Flood	Check Flood
Recurrence Interval (yrs)	100	500	100	500	100	500
Discharge (ft^3/s)	110,000	145,000	110,000	145,000	110,000	145,000
Approach Section H.W. Elevation with Natural Channel[1] (ft)	48.35	56.09	48.35	56.09	48.35	56.09
Approach Section H.W. Elevation with Bridge (ft)	48.56	56.41	48.46	56.38	48.56	56.50
Backwater (ft)	0.21	0.32	0.11	0.29	0.21	0.41
H.W. Elevation at Upstream Face of Bridge[2] (ft)	48.45	56.12	48.35	56.12	48.45	56.24
H.W. Elevation at Downstream Face of Bridge[3] (ft)	48.34	55.98	48.34	55.98	48.34	55.98
Waterway Area at Downstream Face of Bridge[4] (ft^2)	10,707	13,052	11,152	13,335	10,818	12,958
Average Cross Section Velocity at Downstream Face of Bridge (ft/s)	10.3	11.1	9.9	10.9	10.2	11.2

[1] Approach section located at River Station 4036. [2] Located at upstream face of bridge opening.
[3] Located at downstream face of bridge opening. [4] Area normal to channel centerline.

Table 4. Hydraulic Data Sheet for the Proposed Bridge Alternatives (without-backwater).

	Existing (w/RR trestle)		Alternatives 1/4		Alternatives 2/3/5	
	Design (Base) Flood	Check Flood	Design (Base) Flood	Check Flood	Design (Base) Flood	Check Flood
Recurrence Interval (yrs)	100	500	100	500	100	500
Discharge (ft^3/s)	110,000	145,000	110,000	145,000	110,000	145,000
Approach Section H.W. Elevation with Natural Channel[1] (ft)	41.46	45.15	41.46	45.15	41.46	45.15
Approach Section H.W. Elevation with Bridge (ft)	41.74	45.62	41.58	45.36	41.78	45.65
Backwater (ft)	0.28	0.47	0.12	0.21	0.32	0.50
H.W. Elevation at Upstream Face of Bridge[2] (ft)	41.59	45.27	41.45	45.08	41.65	45.36
H.W. Elevation at Downstream Face of Bridge[3] (ft)	41.41	45.03	41.41	45.03	41.41	45.03
Waterway Area at Downstream Face of Bridge[4] (ft^2)	8,593	9,675	8,876	10,038	8,588	9,710
Average Cross Section Velocity at Downstream Face of Bridge (ft/s)	12.8	15.0	12.4	14.5	12.8	14.9

[1] Approach section located at River Station 4036. [2] Located at upstream face of bridge opening.
[3] Located at downstream face of bridge opening. [4] Area normal to channel centerline.

SEDIMENT TRANSPORT

Sediment transport conditions within the project reach were evaluated using the Sediment Transport Capacity module in the HEC-RAS model. The Meyer-Peter and Muller (MPM) sediment transport formula was selected since it was developed using larger sediment sizes similar to those observed at the project site. The grain size distribution for the sediment sample taken from upstream of the bridge site was used for the analysis. Sediment transport capacity was computed for the 2-year flow at each cross section in the hydraulic model. **Table 5** summarizes the calculate sediment transport capacity for natural conditions, Alternatives 1/4, and Alternatives 2/3/5. As seen in the table, the sediment transport capacity is not significantly altered by the proposed bridge alternatives compared to natural (no bridge) conditions. Also, the transport capacities computed for the cross sections bounding the bridge site are less than the capacities of the upstream cross sections. This suggests that the bridge site would not be expected to experience significant long-term degradation based on the current geomorphic conditions at the project site. However, it should be noted that future large flood events could alter the morphology of the channel from its current condition, which could intern alter the sediment transport conditions in the project reach.

Table 5. Sediment Transport Capacity Calculated for the 2-year Peak Discharge

Cross Section	Natural Conditions (tons/day)	Alternative 1/4 (tons/day)	Alternative 2/3/5 (tons/day)
4884	11,270	11,250	11,150
4404	6,355	6,341	6,276
4036	6,743	6,730	6,670
3812	5,059	5,051	5,011
Bridge			
3790	5,410	5,402	5,402
3487	8,067	8,067	8,067
3174	5,502	5,502	5,502

SCOUR CALCULATIONS

Contraction Scour

Contraction scour was evaluated for the 500-year discharge for the without-backwater condition. To determine if live-bed or clear-water contraction scour would occur for this flow, Laursen's equation (FHWA, 2012) was used:

$$V_c = 11.17(y_1)^{\frac{1}{6}}(D_{50})^{\frac{1}{3}}$$

where y_1 is the depth of the approach channel section (XS 4036); D_{50} is the median diameter of the bed material, observed as approximately 0.22 feet (68 mm); and V_c, the critical velocity for incipient motion of bed material in the approach section, is calculated to be 12.2 ft/s. Since the approach section velocity of 16.8 ft/s is greater than the respective critical velocity, Laursen's live-bed scour equation (FHWA, 2012) was used to compute the contraction scour:

$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{\frac{6}{7}}\left(\frac{W_1}{W_2}\right)^{k_1}$$

where y_2 is the calculated average observed depth in the contracted section (XS 3812); Q_1 and Q_2 are the flows in the upstream section that is transporting sediment, and in the contracted section; W_1 is the top width of the upstream main channel; W_2 is the top width in the contracted section; and k_1 is an exponent, 0.64, based on the ratio of the bed shear velocity at the approach section to the settling velocity of the bed material. The contraction scour, $y_s = y_2 - y_0$, was computed to be 1.2 feet and 2.3 feet for Alternatives 1/4 and Alternatives 2/3/5, respectively. Parameters used for computing contraction scour are summarized in **Table 6**.

Table 6. Summary of Contraction Scour Parameters

Alternative	Y_1 (ft)	Vc (ft/sec)	Y_2 (ft)	Y_0 (ft)	Q_1 (cfs)	Q_2 (cfs)	W_1 (ft)	W_2 (ft)	Ys (ft)
1/4	34.4	12.2	37.9	36.7	133,049	143,370	265	251.8	1.2
2/3/5	34.7	12.2	38.9	36.7	132,890	142,723	265	243.8	2.3

Pier Scour

Alternatives 2/3/5 will have two interior bents each consisting of a single 4-foot diameter circular pier. A pier scour depth of 13.5 feet was estimated using the Colorado State University (CSU) equation (FHWA, 2012):

$$y_s = 2.0\, K_1 K_2 K_3 \left(\frac{a}{y_1}\right)^{0.65} Fr_1^{0.43} y_1$$

where K_1 is correction factor for pier nose shape, 1.0 for circular cylinders; K_2 is a correction factor for angle of attack of flow, 1.0 for piers aligned with flow; K_3 is a correction factor for the bed condition, 1.1 for plane bed condition; y_1 is the flow depth immediately upstream of the bridge, 42.6 feet; Fr_1 is the Froude number immediately upstream of the bridge, which is computed to be 0.39 ($Fr_1 = V_1/(gy_1)^{0.5}$); and V_1 is the velocity immediately upstream of the bridge pier, 14.5 ft/s. It is assumed that the channel thalweg could migrate to either pier location. Therefore, the maximum depth and maximum velocity for the upstream face cross section were used to estimate pier scour.

Aggradation/Degradation

Historic data was not available from which to determine the change in channel bed elevation over time. Signs of long-term degradation were not observed during the site reconnaissance. However, approximately 200 feet upstream of the bridge, the channel thalweg is approximately 7 feet lower than the thalweg at the bridge site. Due to the close proximity and similar hydraulic conditions, it is assumed that the channel could degrade to a similar depth at the bridge site. Long-term degradation was assumed to be 7 feet.

Total Scour

The total scour is equal to the addition of the contraction scour, pier scour, and long term degradation. Results of the scour evaluation are summarized in **Table 7**. Scour elevations at the downstream bridge face for the proposed bridge Alternatives 1/4 and Alternatives 2/3/5 are shown in **Figure 17** and **Figure 18**, respectively.

Table 7. Summary of Scour for the Proposed Bridge.

Alternative	Return Period	Contraction Scour (ft)	Long-term Degradation (ft)	Pier Scour (ft)	Total Scour (ft)	Thalweg Elevation (ft)	Total Scour Elevation
1/4	500 years	1.2	7.0	n/a	8.2	2.7	-5.5
2/3/5	500 years	2.3	7.0	13.5	22.8	2.7	-20.1

ABUTMENT PROTECTION

Due to a history of channel migration along the south bank, abutment protection is recommended for the south abutment. The north abutment will be located landward of the bridge pier footing for the former railroad bridge which is founded on siltstone bedrock that is moderately resistant to erosion. The stability of the north bank should be evaluated by a geotechnical engineer to determine if additional erosion protection is needed for this location.

Abutment riprap protection was designed assuming ODOT and HEC-11 criteria. According to the ODOT Hydraulics Manual (2014), the abutment protection is to be sized for the 100-year discharge and checked against the 500-year discharge to ensure the riprap will remain in place during a larger flood. Riprap size was computed using the following ODOT equation:

$$D_{50} = \frac{0.001CV_a^3}{d_{avg}^{0.5}K_1^{1.5}}$$

where D_{50} is the median riprap particle size in feet, C is a correction factor (a stability factor of SF = 1.7 was selected to account for potential turbulent mixing flow at the bridge abutment and impacts from debris, resulting in a C of 1.69 ($C=(SF/1.2)^{1.5}$); V_a is the average velocity in the main channel, d_{avg} is the average flow depth in the main channel, and:

$$K_1 = \left(1 - \frac{(\sin\theta)^2}{(\sin\emptyset)^2}\right)^{0.5} = 0.53$$

where θ is the bank angle with the horizontal, 33.69 degrees; and ϕ is the riprap angle of repose, 41 degrees. The riprap is expected to have a side slope of 1.5H on 1V.

Using the above equations, the D_{50} calculated for each of the alternatives for the 100-year event corresponded to ODOT Class 2000 English riprap size. The check flood event (500-year recurrence interval) indicates that the stability factor (SF) for Class 2000 riprap is greater than 1.0 for the proposed bridge alternatives. Parameters and results of the riprap sizing calculation for each proposed bridge alternative are summarized in **Table 8**.

Table 8. Summary of ODOT Riprap Sizing for Each Proposed Bridge Alternative.

Alternative	C	V_a (ft/s)	D_{avg} (ft)	θ	ϕ	K_1	D_{50} (in)	ODOT Riprap Class
1/4	1.69	13.1	32.5	33.69°	41°	0.53	21	2000
2/3/5	1.69	13.5	32.4	33.69°	41°	0.53	23	2000

Riprap gradation requirements for Class 2000 riprap are shown in **Table 9**. The minimum recommended blanket thickness (T) for Class 2000 riprap is 4.0 ft. **Figure 19** shows the ODOT typical riprap blanket section that is recommended for use with Class 2000 riprap.

Table 9. Class 2000 Riprap Gradation.

Percent by Weight	Class 2000 Stone Weight (lb)
20	2000 – 1400
30	1400 – 700
40	700 – 40
10 - 0	40 – 0

SUMMARY

Hydraulic and scour evaluations for the proposed bridge alternatives over the Clackamas River were conducted. Neither the 100-year base (design) flood nor the 500-year check flood will overtop the superstructure for any of the proposed alternatives. However, the bottom chord of the superstructure would be submerged approximately 4.5 below the 500-year check flood elevation at the south abutment. The 100-year flood is 3.2 and 3.1 feet below the low chord of the bridge for Alternatives 1/4 and 2/3/5, respectively for the with-backwater conditions. Alternatives 1/4 and 2/3/5 will not result in an increase in the FEMA 100-year base flood elevations. A FEMA No-Rise Certification is provided in **Figure 20**.

The sediment transport capacity of the Clackamas River is not significantly altered by the proposed bridge alternatives compared to natural (no bridge) conditions. Also, the transport capacities computed for the cross sections bounding the bridge site are less than the capacities of the upstream cross sections. This suggests that the bridge site would not be expected to experience significant long-term degradation based on the current geomorphic conditions at the project site. However, it should be noted that future large flood events could alter the morphology of the channel from its current condition, which could intern alter the sediment transport conditions for the project reach.

Scour calculations were conducted for 500-year recurrence interval flood. The total scour, shown in **Table 7**, is 8.2 feet for Alternatives 1/4 and 22.8 feet for Alternatives 2/3/5 resulting in total scour elevations of -5.5 feet for Alternatives 1/4 and -20.1 feet for Alternatives 2/3/5.

Abutment protection is considered necessary for the south abutment. Using ODOT criteria for riprap revetment, a D_{50} of 21 inches and 23 inches was calculated for Alternatives 1/4 and 2/3/5, respectively. This corresponds to ODOT Class 2000 English riprap. The stability of the north bank should be evaluated by a geotechnical engineer to determine if additional erosion protection is needed for this location.

REFERENCES

Clackamas County Historical Society (CCHS), https://clackamascountyhistoricalsociety.wordpress.com/2014/03/12/the-gladstone-trolley-bridge-1908-2014/, accessed October 2019.

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Federal Highway Administration (FHWA), Evaluating Scour at Bridges, FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18, Fifth Edition, Washington, D.C., April 2012.

National Resource Conservation Service, U.S. Department of Agriculture, Annual Precipitation Map of Oregon, April 1998.

Oregon Department of Transportation (ODOT) Highway Division, Hydraulics Manual, ODOT, Salem, Oregon, April 2014.

U.S. Army Corps of Engineers, HEC-RAS River Analysis System Computer Program, Version 5.0.7, March 2019.

APPENDIX A

FIGURES

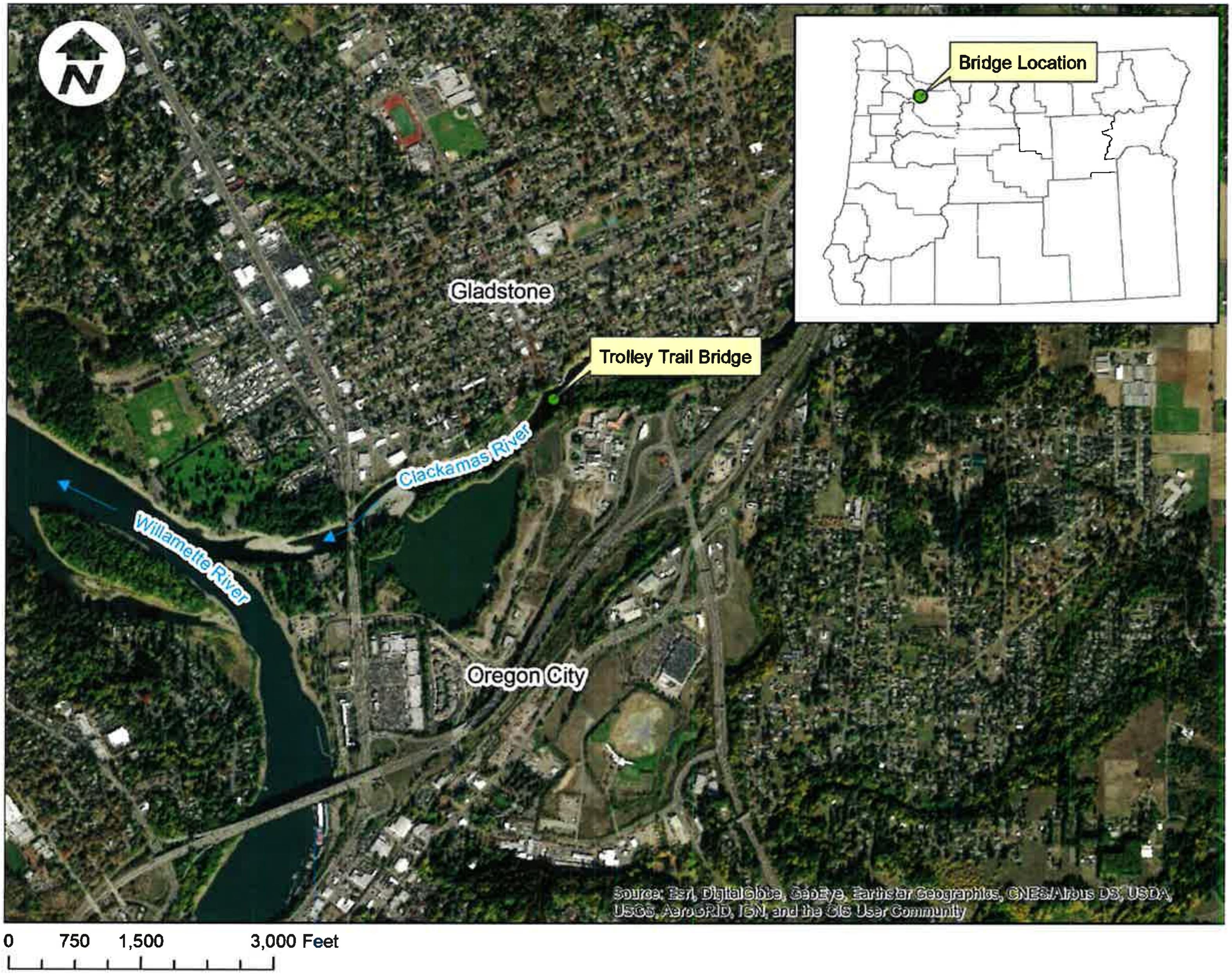


Figure 1. Bridge Location Map

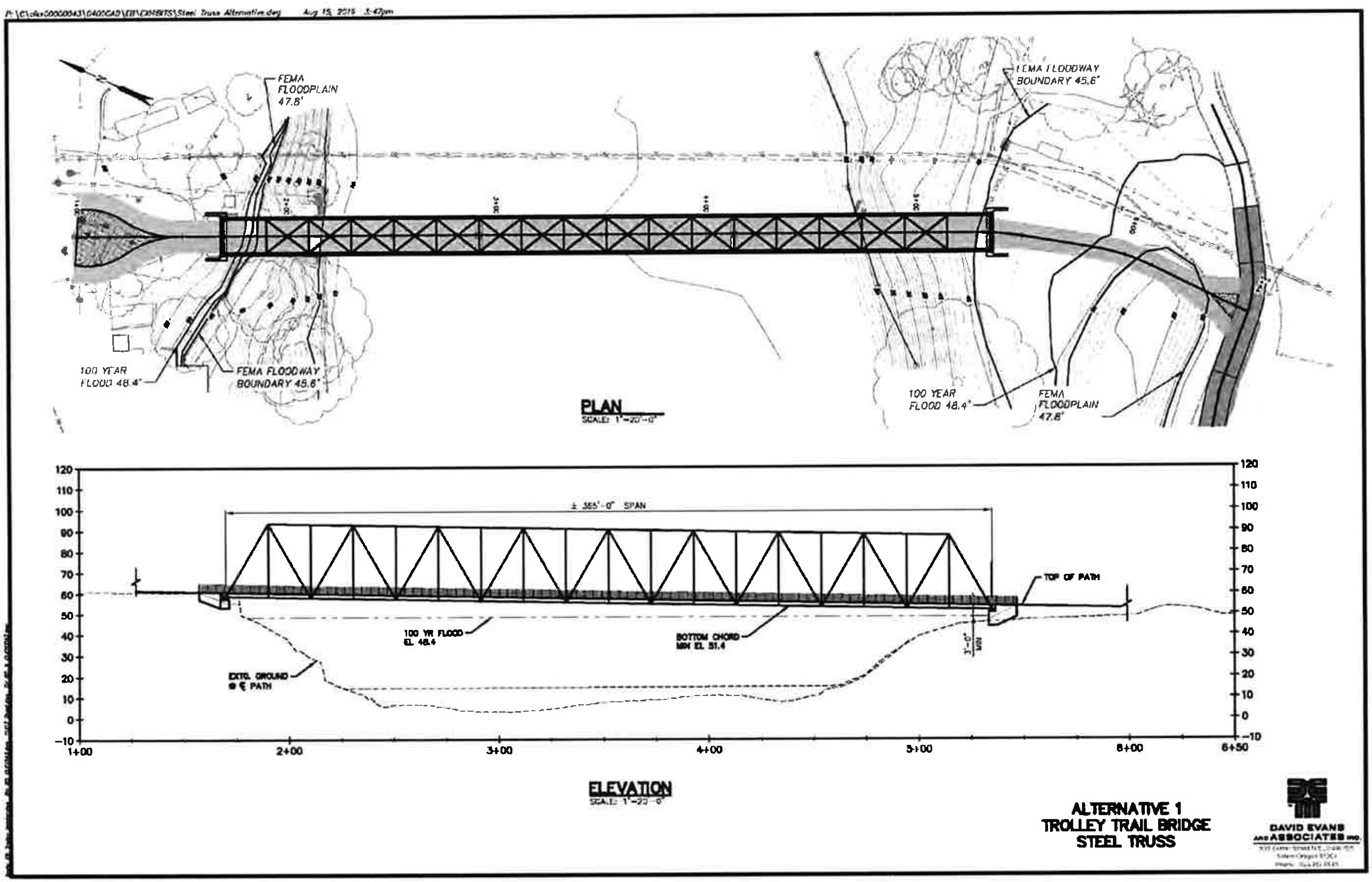


Figure 2. Preliminary Design Plans for Alternative 1

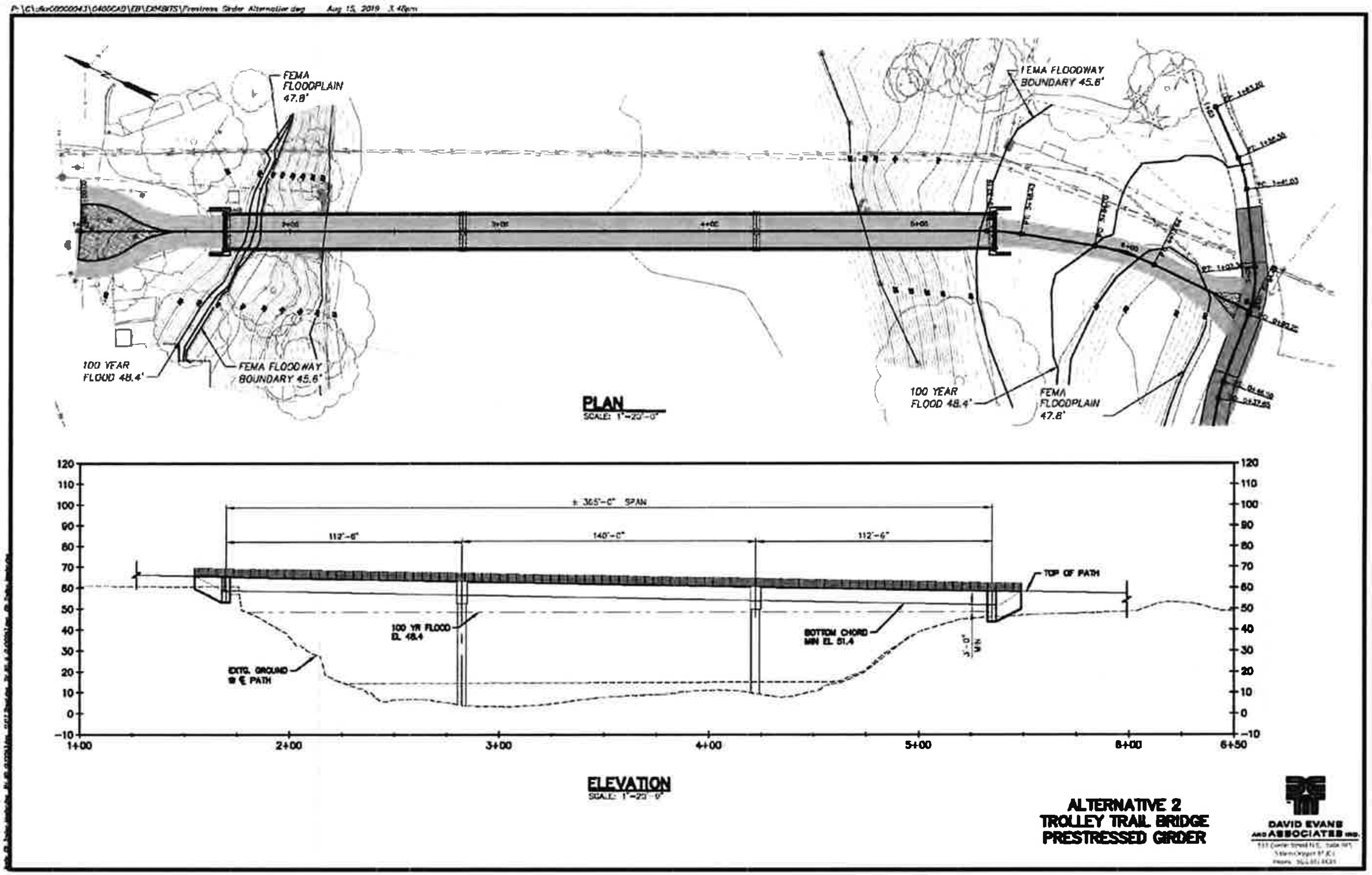


Figure 3. Preliminary Design Plans for Alternative 2

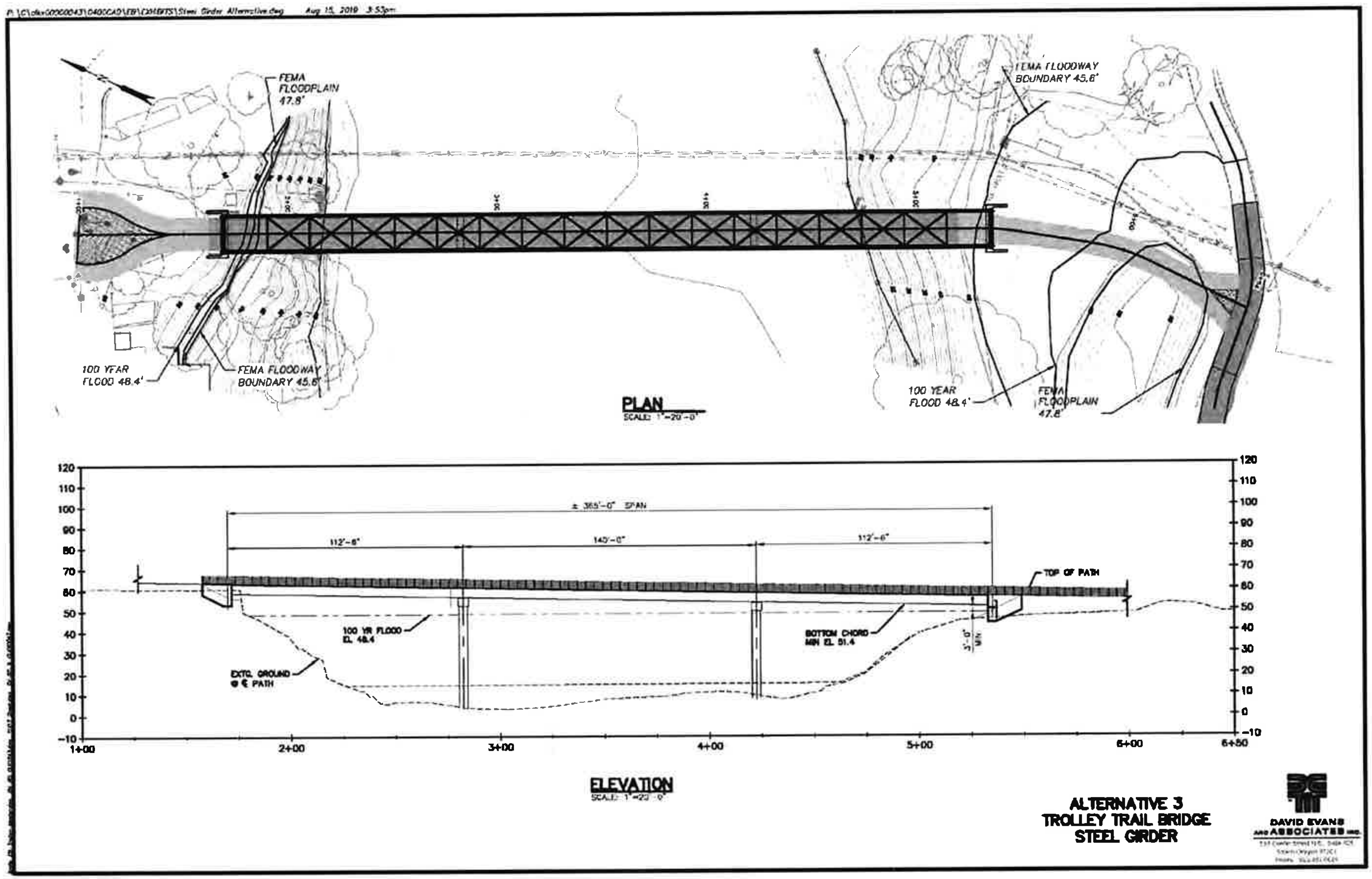


Figure 4. Preliminary Design Plans for Alternative 3

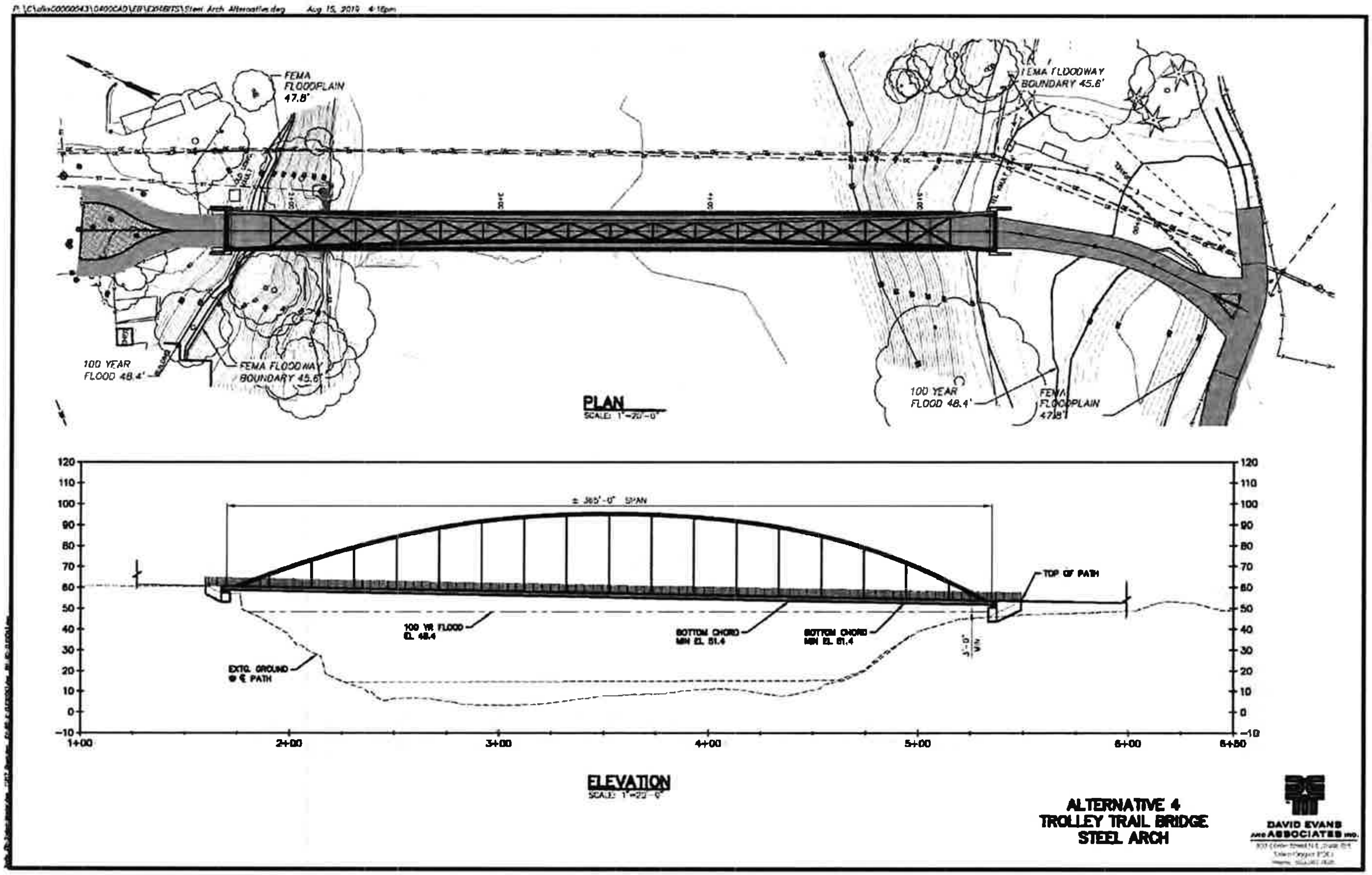


Figure 5. Preliminary Design Plans for Alternative 4

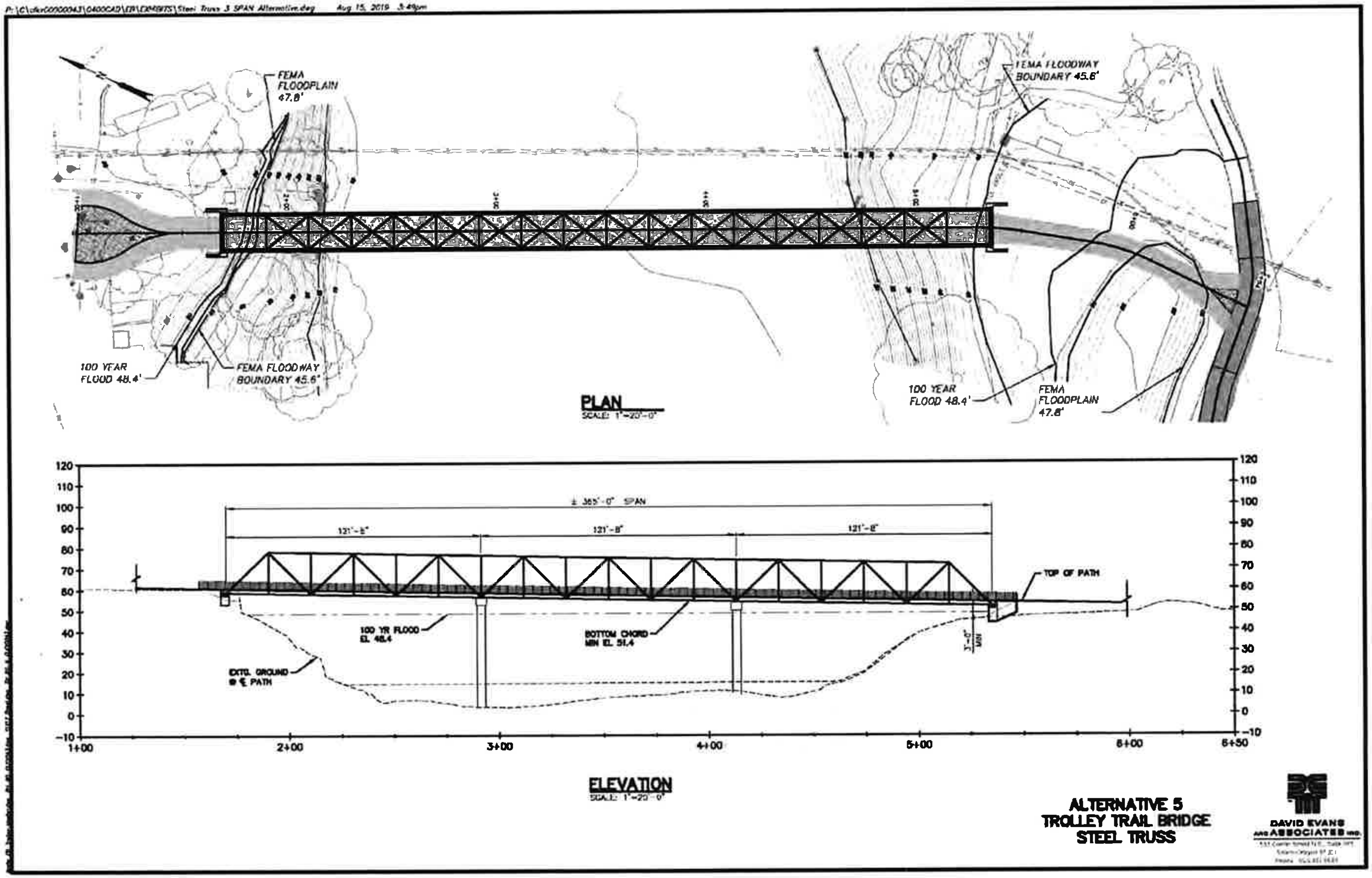


Figure 6. Preliminary Design Plans for Alternative 5

Figure 7. Photograph of Historic Railroad Bridge

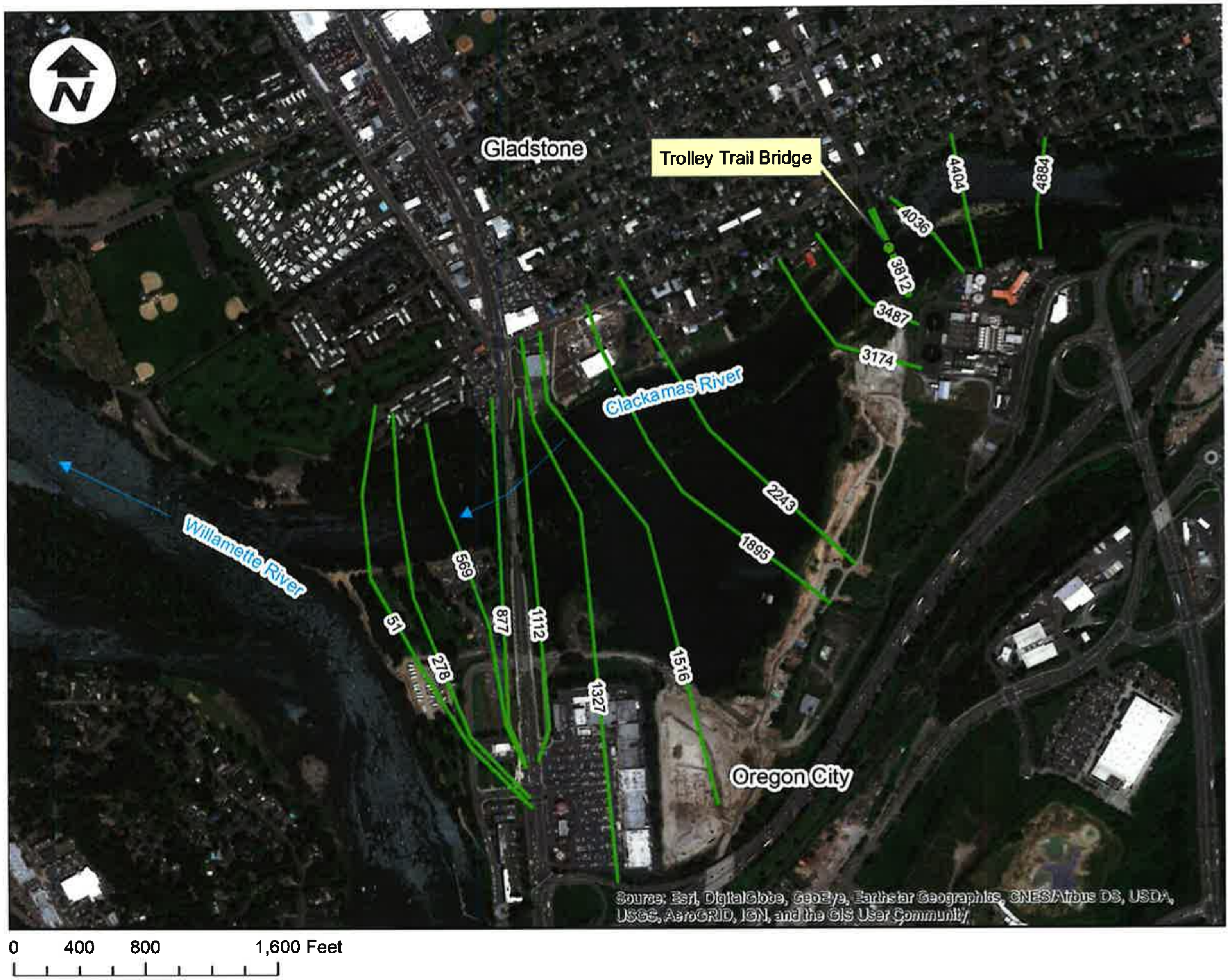


Figure 8. Cross Section Layout Map

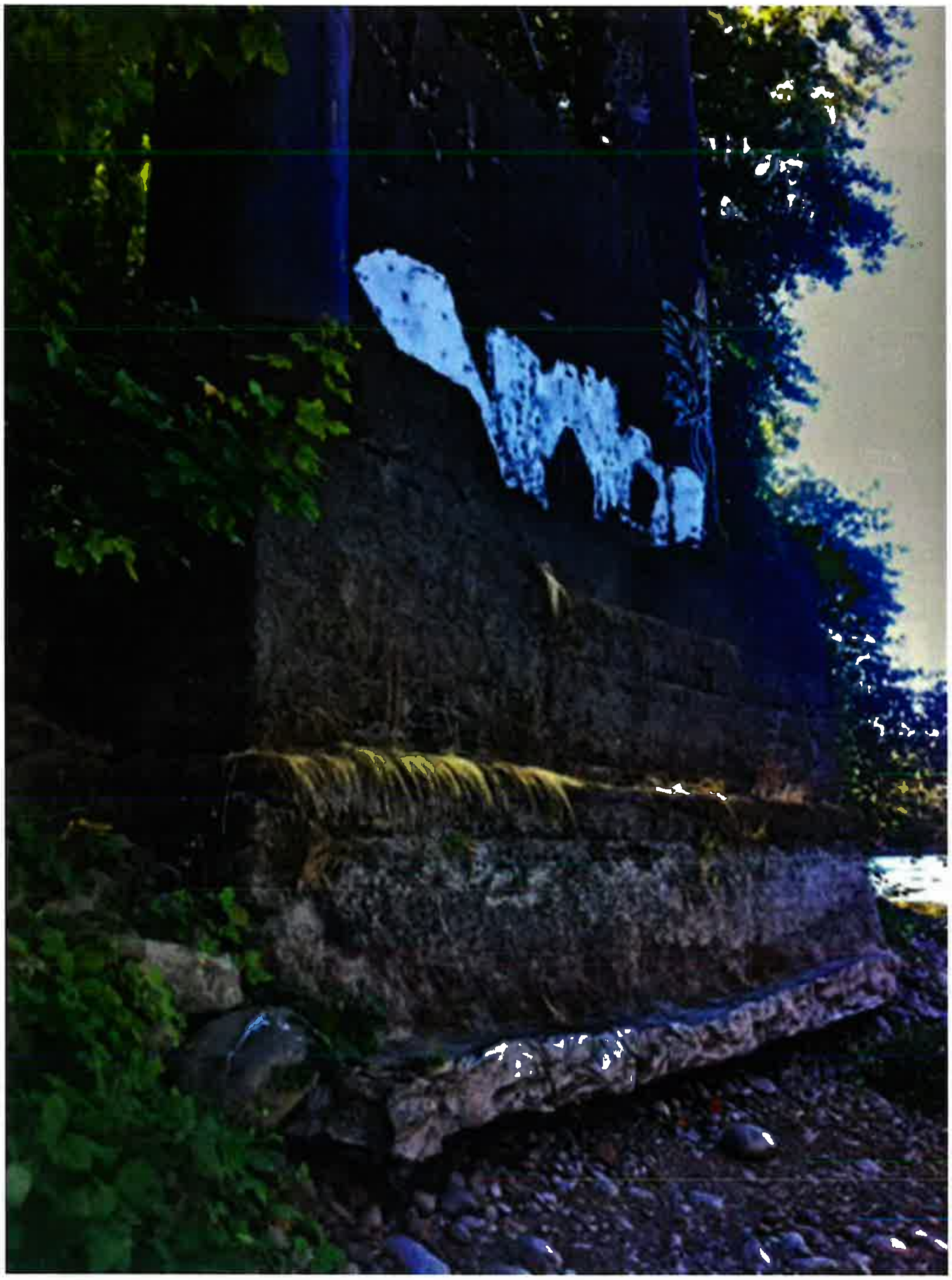
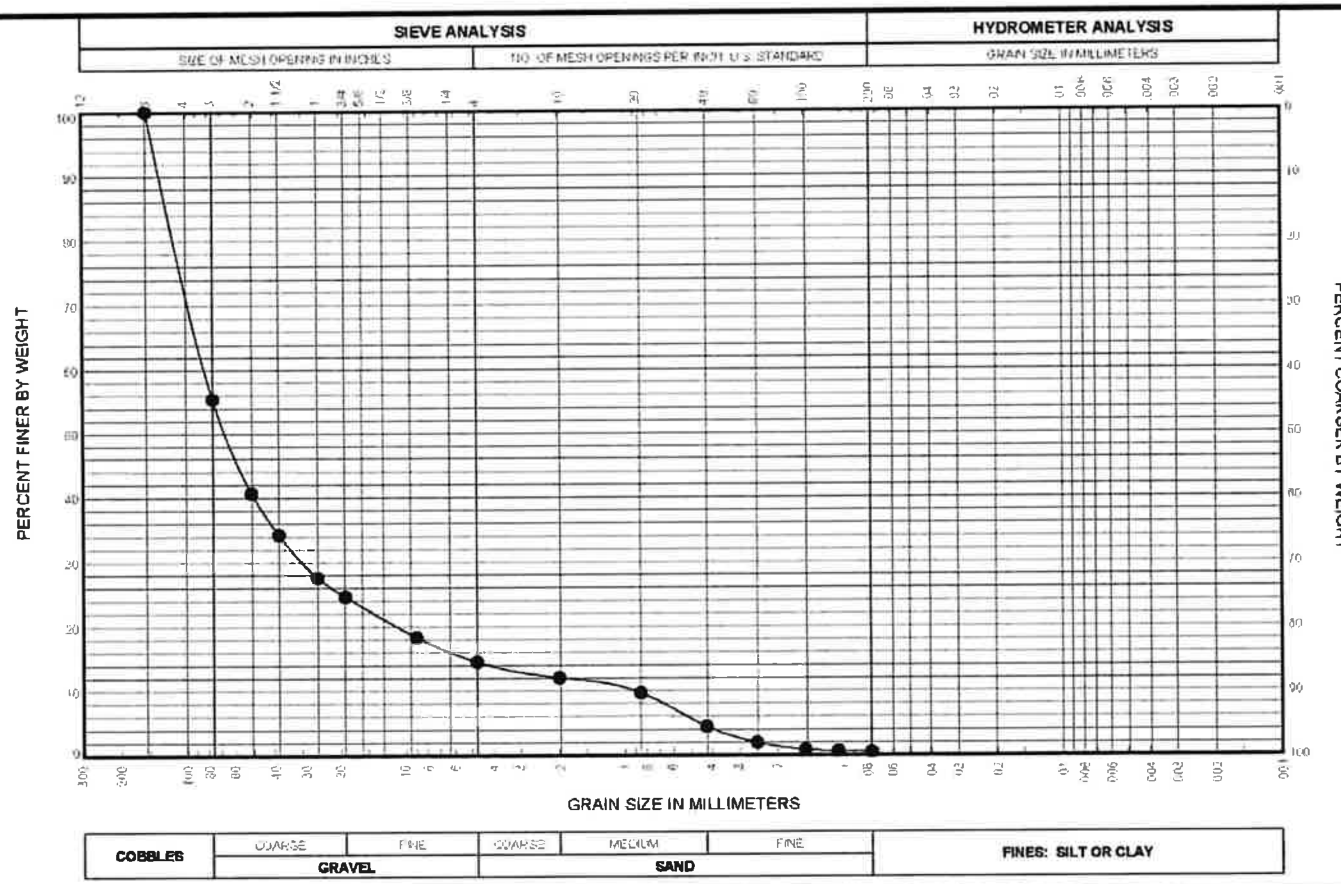


Figure 9. Photograph of Historic Railroad Bridge South Bridge Pier (prior to demolition)

NOTES:
1) Sieve analyses were performed in general accordance with ASTM D6913, sieve with hydrometer analyses were performed in general accordance with ASTM D422, and amount finer than #200 sieve analyses were performed in general accordance with ASTM D1140 unless otherwise noted in the report.
2) Group Name and Group Symbol are in accordance with ASTM D2488 and are refined in accordance with ASTM D2487 where appropriate laboratory tests are performed.



BORING AND SAMPLE NO.	DEPTH (feet)	GROUP SYMBOL[2]	GROUP NAME[2]	Cc	Cu	GRAVEL %	SAND %	FINES %	NAT W.C. %	DRY DENSITY PCF
● Trolley Trail Bridge,	0.0			11.2	86.9	41.0	14.0	0.5		

Trolley Trail Bridge:
Gladstone to Oregon City Feasibility Study
Clackamas County, Oregon

GRAIN SIZE DISTRIBUTION

October 2019 101474

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG.

FIG.

Figure 10. Sediment Sample Grain Size Distribution

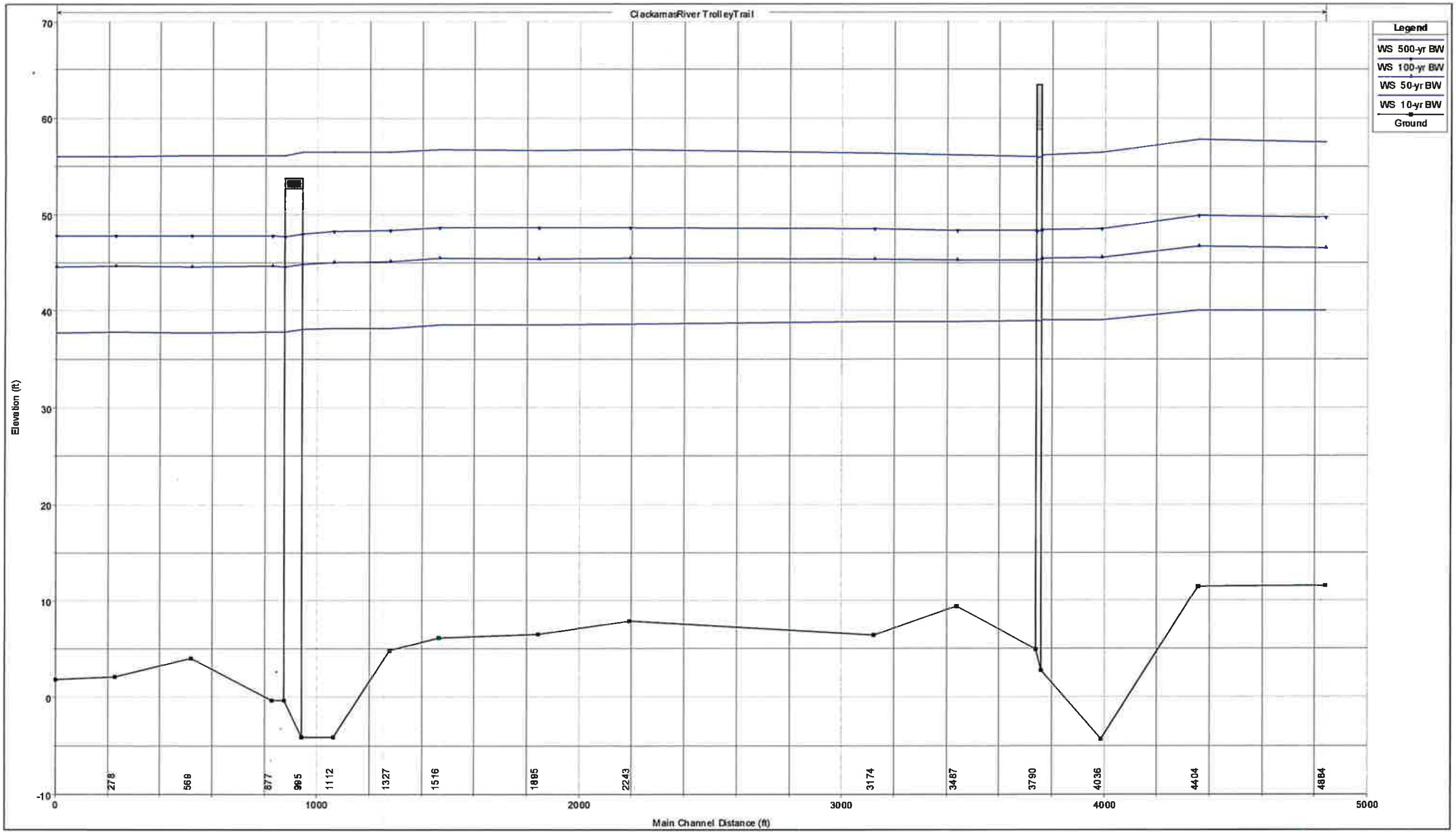


Figure 11. Water Surface Profiles for Existing Conditions

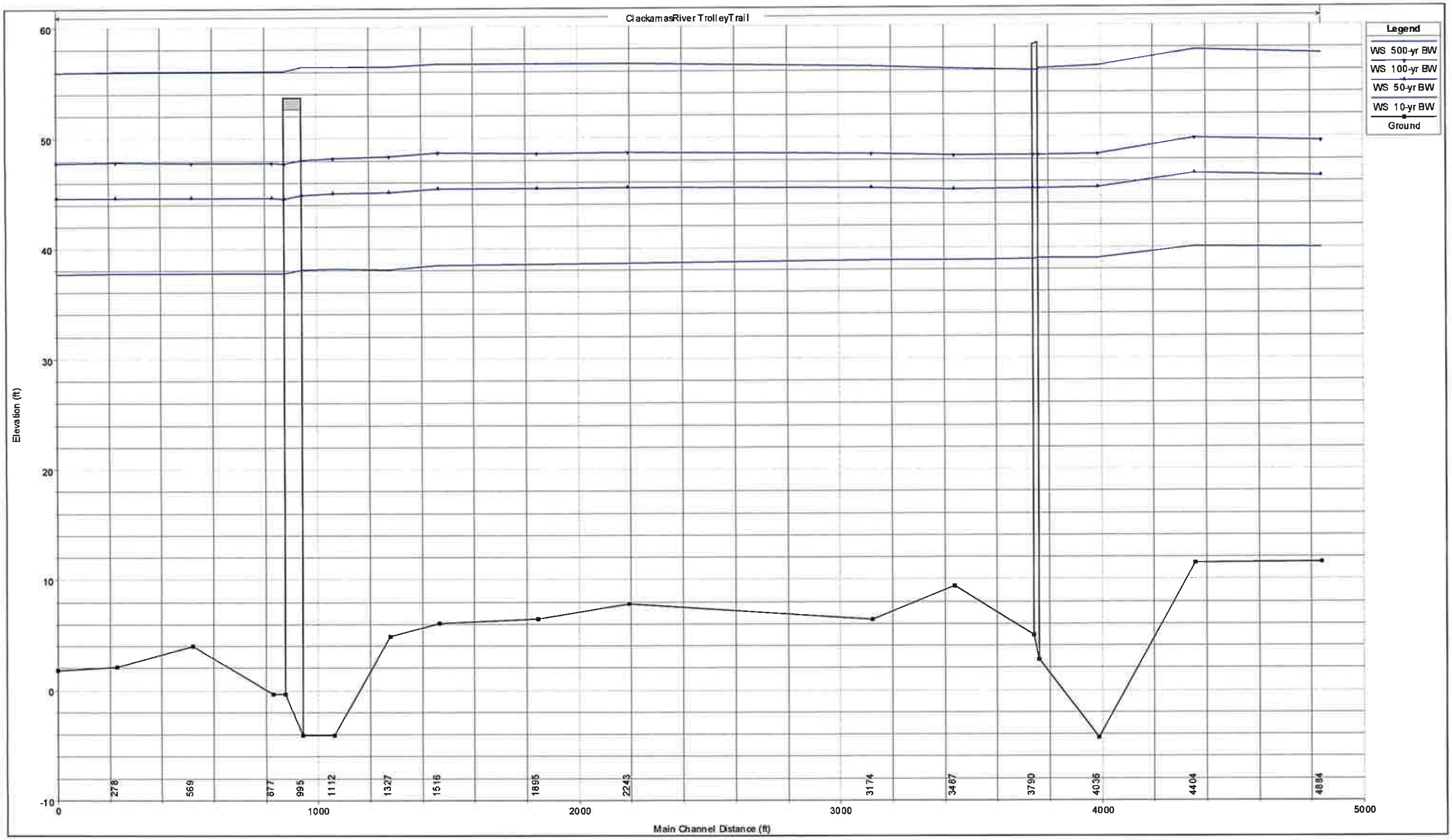


Figure 12. Water Surface Profiles for Alternatives 1/4

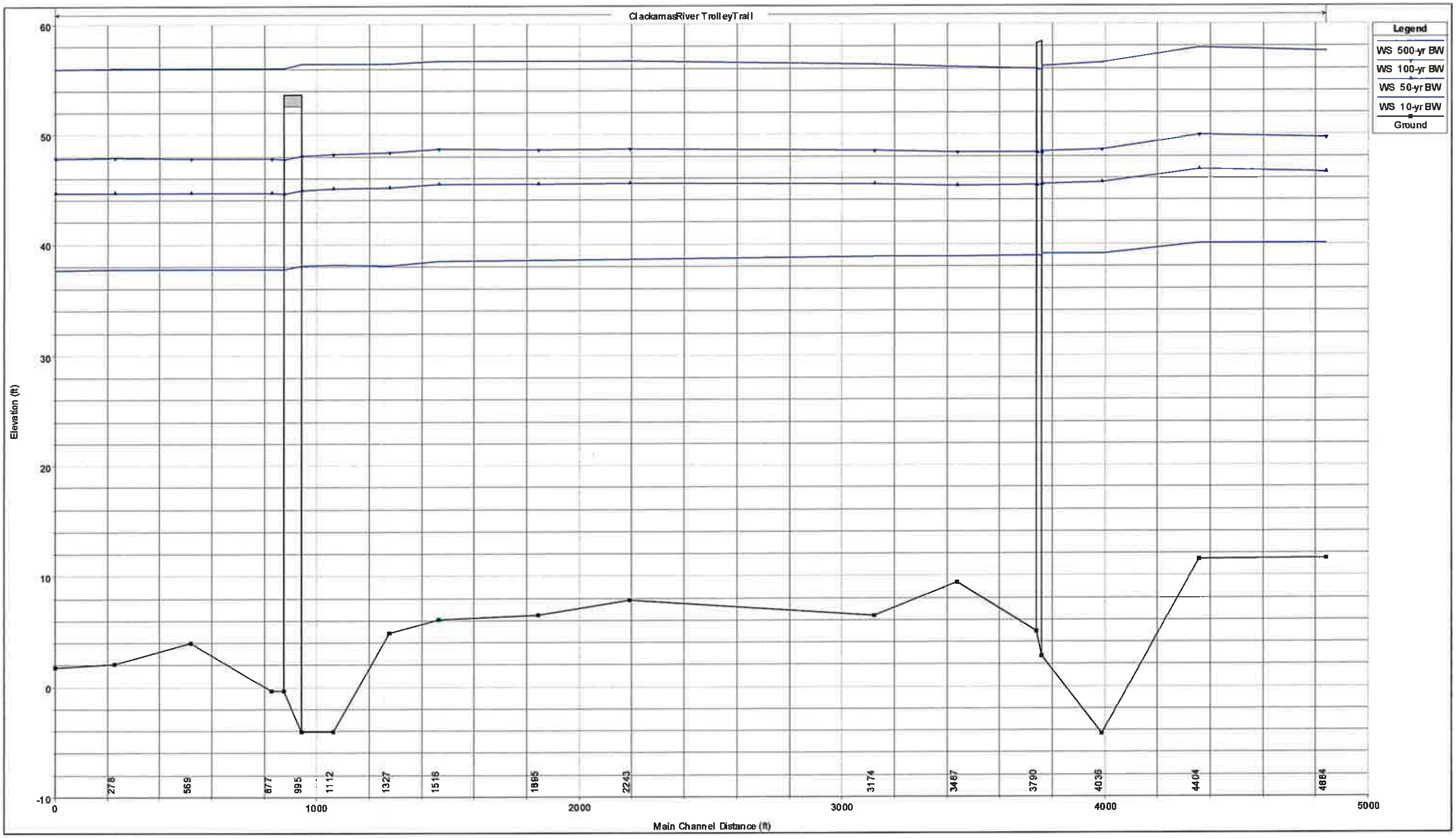


Figure 13. Water Surface Profiles for Alternatives 2/3/5

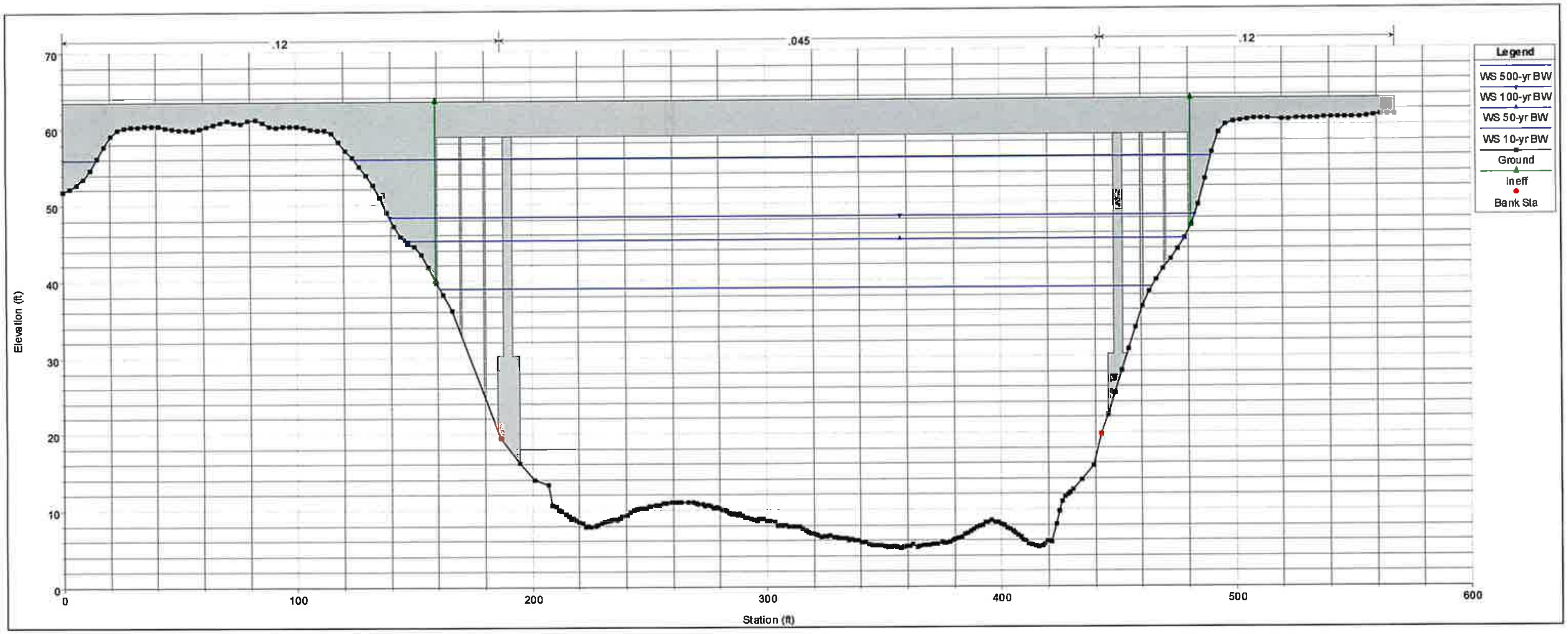


Figure 14. Downstream Bridge Cross Section for Existing Conditions (includes historic railroad bridge)

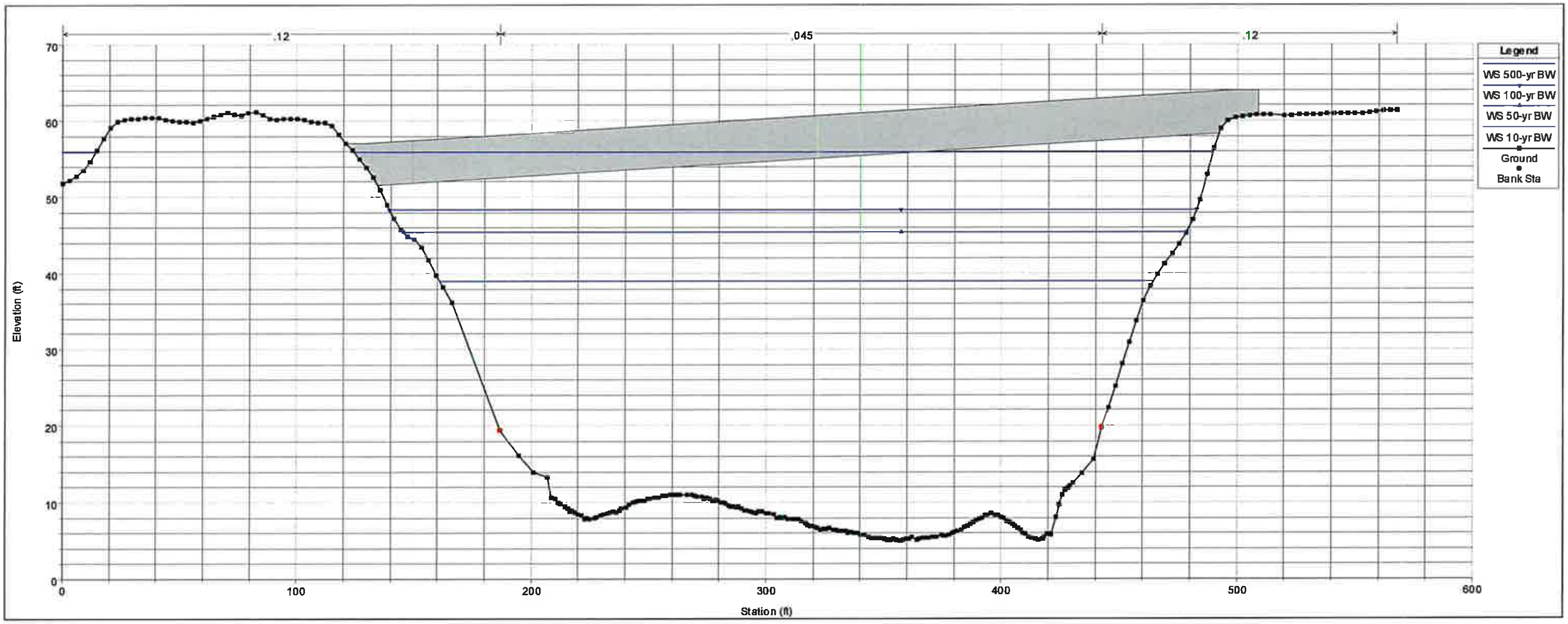


Figure 15. Downstream Bridge Cross Section for Alternatives 1/4

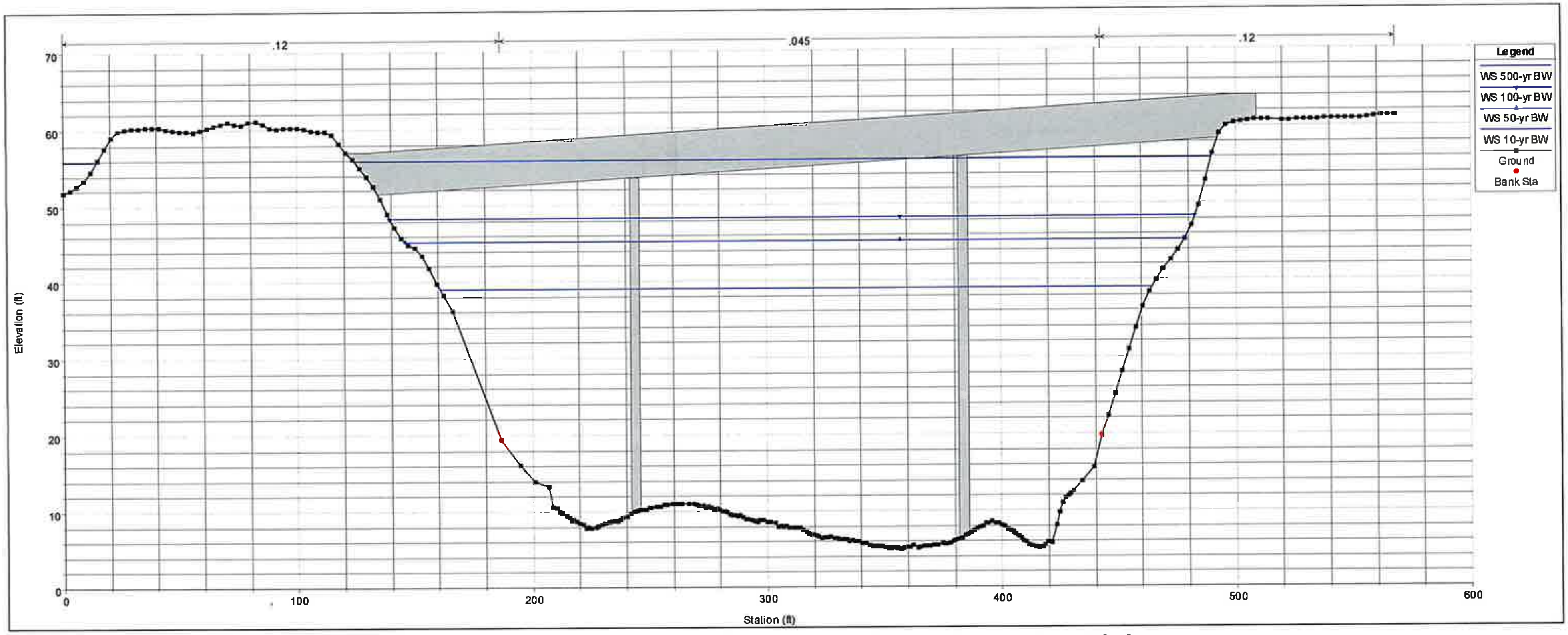


Figure 16. Downstream Bridge Cross Section for Alternatives 2/3/5

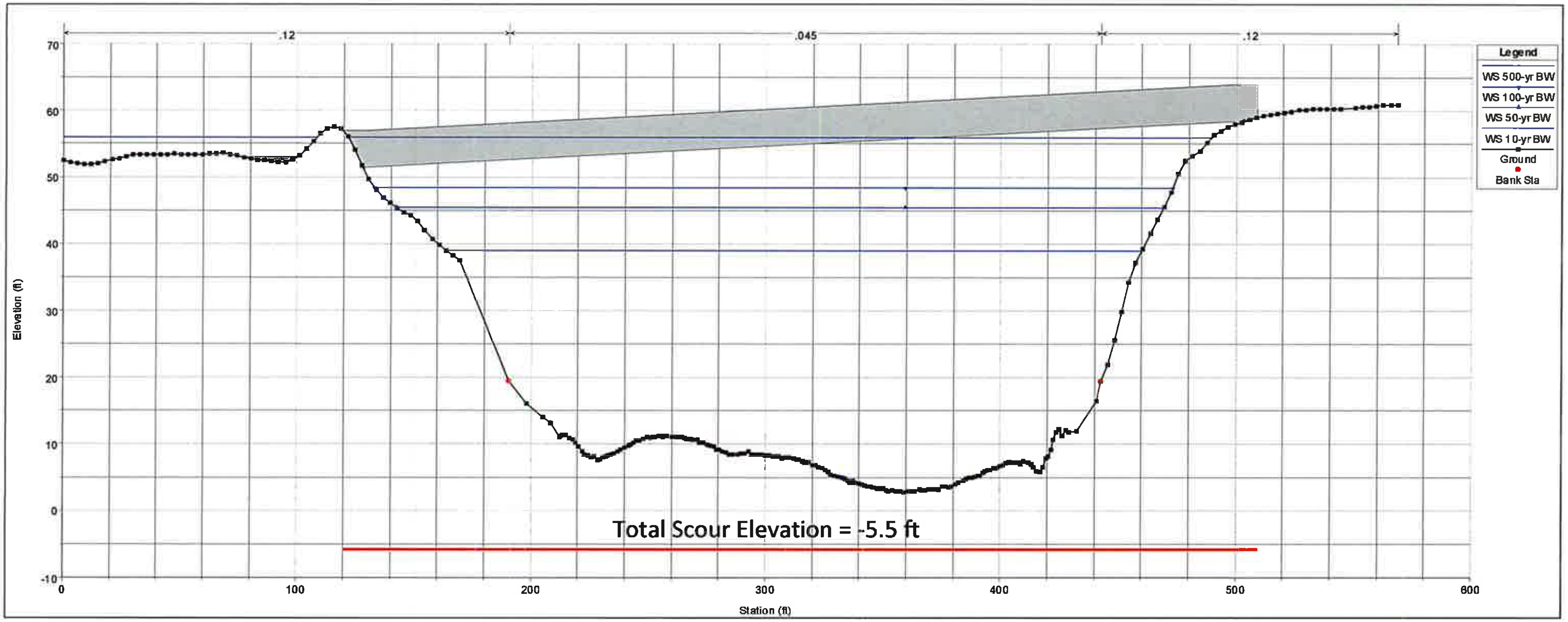


Figure 17. Scour Elevation for Alternatives 1/4 at Upstream Face

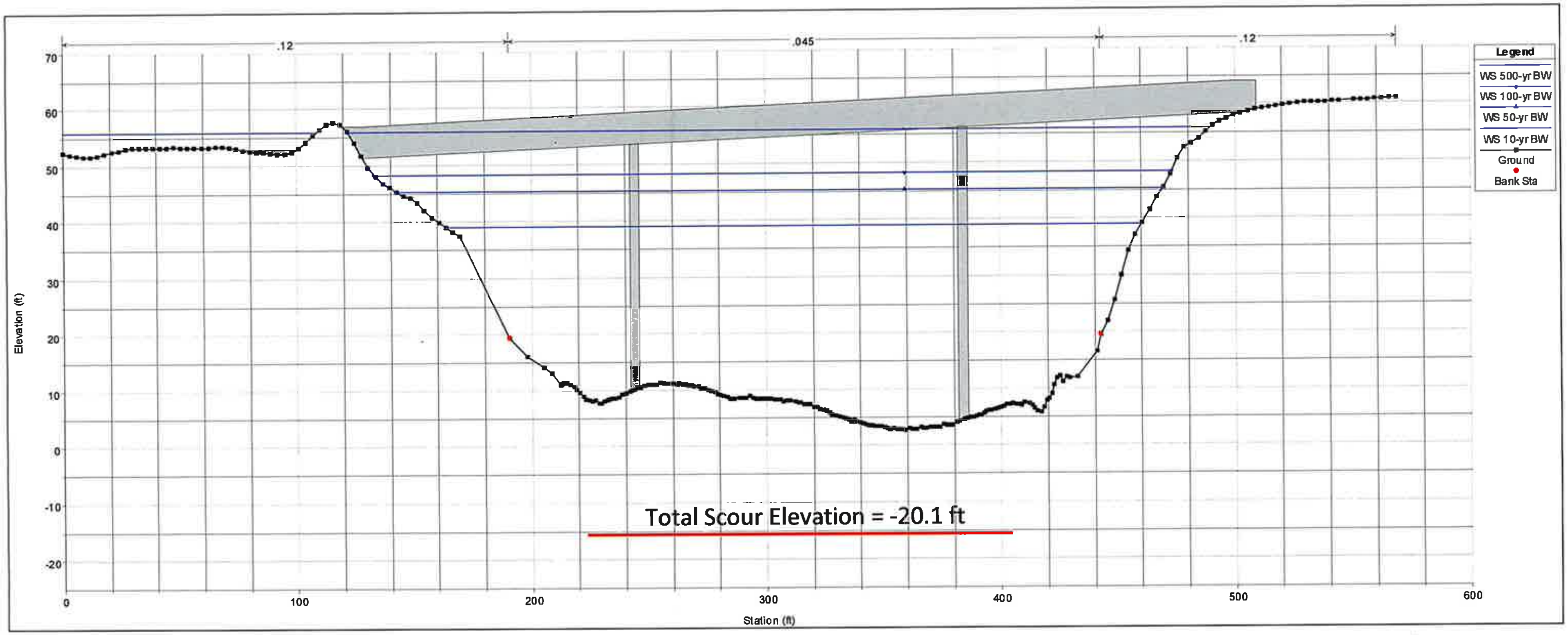


Figure 18. Scour Elevation for Alternative 2/3/5 at Upstream Face

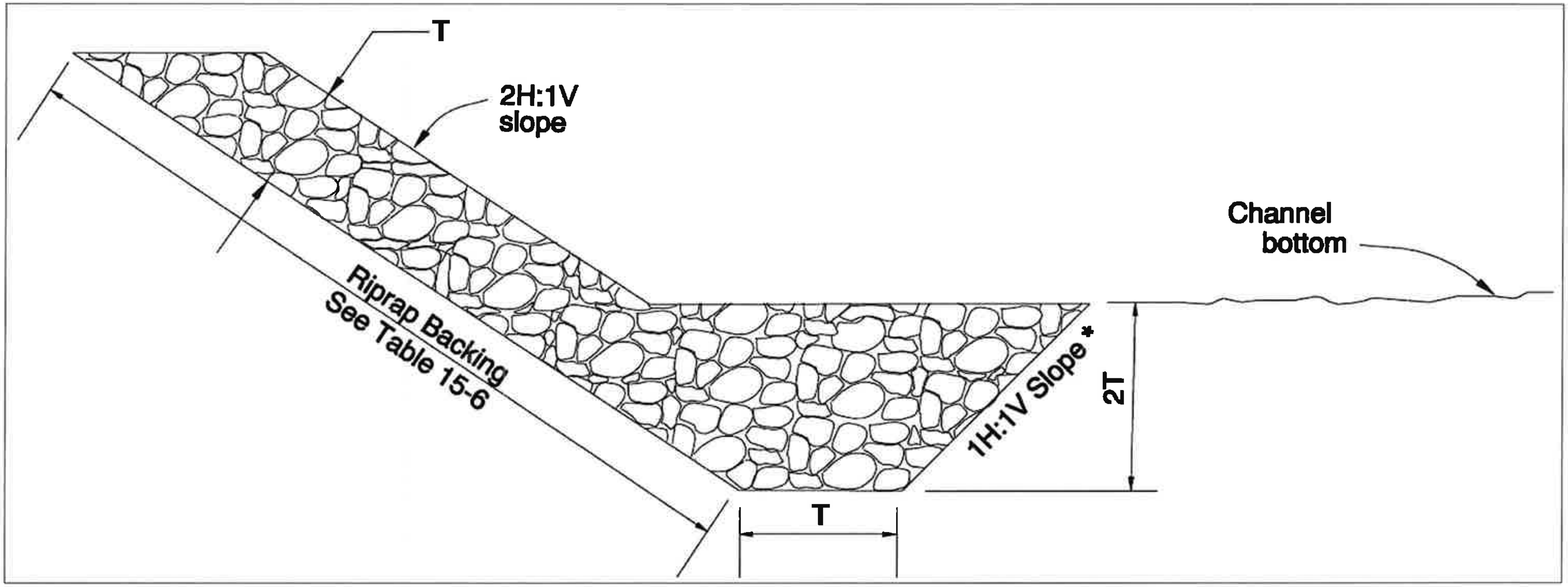


Figure 19. ODOT Typical Riprap Blanket Section (T = 4 foot for Class 2000 Riprap)

Figure 20. FEMA No-Rise Certification

CERTIFICATION OF A "NO-RISE" DETERMINATION FOR A PROPOSED FLOODWAY DEVELOPMENT

City of Gladstone & Oregon City

Community Name

Trolley Trail Bridge Replacement (Alternatives 1,2,3,4,&5)

Development Name

Clackamas River

Trolley Trail Bridge

Lot/Property Designation

City of Gladstone

Property Owner

I hereby certify that the proposed replacement bridge project for Trolley Trail Bridge over the Clackamas River will result in no loss of conveyance and no increase in backwater (as seen in Table 3), during the occurrence of the 1-percent-annual-chance exceedance (100-year flood) discharge.

I further certify that the data submitted herewith in support of this request are accurate to the best of my knowledge, that the analyses have been performed correctly and in accordance with sound engineering practice.

01/07/2020

Date

Engineers Stamp

APPENDIX B

PHOTOGRAPHIC LOG

Photo 1 – Looking upstream from water intake

Photo 2 – Looking d/s toward water intake

Photo 3 – Looking d/s along right bank u/s from bridge location

Photo 4 – Looking sout1west toward left abutment location

Photo 5 – North bridge pier foundation

Photo 6 – Bed material on north gravel bar d/s from bridge

Photo 7 – Rock and root wad revetment d/s from bridge site on left bank

Photo 8 – Looking u/s from bridge site toward water intake

Photo 9 – Concrete rubble on left bank near former bridge pier location

Photo 10 – North bridge pier foundation

Photo 11 – Armor layer at sediment sample location

Photo 12 – Sediment sample location with armor layer removed

APPENDIX C

HEC-RAS OUTPUT

Natural Condition Profiles

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Vel Total	Flow Area	Top W Chnl	Top Width	Hydr Depth C	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)	
TrolleyTrail	51	100-yr	110000	1.81	38.83	23.13	39.47	0.000535	7.59	4.5	24447.41	309.53	1793.07	31.64	0.24
TrolleyTrail	51	500-yr	145000	1.81	42.95	26.92	43.67	0.000535	8.24	4.72	30727.1	309.53	2222.92	35.76	0.24
TrolleyTrail	51	100-yr BW	110000	1.81	47.8	23.13	48.05	0.000168	5.02	2.87	38340.84	309.53	2355.45	40.61	0.14
TrolleyTrail	51	500-yr BW	145000	1.81	56	26.92	56.16	0.000097	4.31	2.34	61908.71	309.53	2769.16	48.81	0.11
TrolleyTrail	51	2-yr	38000	1.81	27.34	14.96	27.8	0.000535	5.62	4.29	8857.21	309.53	1295.16	20.15	0.22
TrolleyTrail	278	100-yr	110000	2.14	38.98	23.84	39.59	0.000536	7.57	4.3	25589.02	300.73	1686.85	31.5	0.24
TrolleyTrail	278	500-yr	145000	2.14	43.15	29.6	43.79	0.000505	7.98	4.52	32087.85	300.73	1998.37	35.67	0.24
TrolleyTrail	278	100-yr BW	110000	2.14	47.86	23.84	48.09	0.000161	4.9	2.79	39456.71	300.73	2173.05	40.38	0.14
TrolleyTrail	278	500-yr BW	145000	2.14	56.01	29.6	56.19	0.00011	4.58	2.44	59473.56	300.73	2544.24	48.52	0.12
TrolleyTrail	278	2-yr	38000	2.14	27.43	15.41	27.95	0.000607	5.94	4.49	8462.6	300.73	1368.49	19.95	0.23
TrolleyTrail	569	100-yr	110000	3.99	38.89	24.39	39.91	0.000808	9.1	5.55	19837.04	308.05	1823.05	30.37	0.29
TrolleyTrail	569	500-yr	145000	3.99	42.99	27.57	44.13	0.000806	9.89	5.91	24519.08	308.05	1862.5	34.47	0.3
TrolleyTrail	569	100-yr BW	110000	3.99	47.78	24.39	48.21	0.000265	6.19	3.66	30025.21	308.05	1917.48	39.26	0.17
TrolleyTrail	569	500-yr BW	145000	3.99	56.02	27.57	56.24	0.000132	4.96	2.61	55629.87	308.05	2174.16	47.5	0.13
TrolleyTrail	569	2-yr	38000	3.99	27.64	16.42	28.13	0.000618	5.85	4.34	8755.13	308.05	702.03	19.12	0.24
TrolleyTrail	877	100-yr	110000	-0.31	38.99	22.58	40.34	0.000887	9.99	6.83	16103.58	283.12	1734.82	33.43	0.3
TrolleyTrail	877	500-yr	145000	-0.31	43.05	25.86	44.61	0.000929	11.02	7.26	19972.58	283.12	1786.79	37.5	0.32
TrolleyTrail	877	100-yr BW	110000	-0.31	47.79	22.58	48.38	0.000317	6.97	4.49	24517.93	283.12	1824.47	42.24	0.19
TrolleyTrail	877	500-yr BW	145000	-0.31	56.04	25.86	56.3	0.000146	5.31	2.85	50867.8	283.12	2223.64	50.49	0.13
TrolleyTrail	877	2-yr	38000	-0.31	27.82	13.32	28.3	0.000487	5.69	4.91	7745.06	283.12	444.94	22.27	0.21
TrolleyTrail	995		Bridge												
TrolleyTrail	1112	100-yr	110000	-4.09	40.01	18.88	40.82	0.000486	7.57	5.72	19223.04	377.5	1713.27	34.85	0.23
TrolleyTrail	1112	500-yr	145000	-4.09	44.28	21.88	45.25	0.000521	8.47	6.09	23802.39	377.5	1780.31	39.12	0.24
TrolleyTrail	1112	100-yr BW	110000	-4.09	48.24	18.88	48.65	0.0002	5.6	3.92	28069.24	377.5	1828.48	43.07	0.15
TrolleyTrail	1112	500-yr BW	145000	-4.09	56.4	21.88	56.8	0.000127	5.01	2.81	51589.51	377.5	2041.88	51.24	0.12
TrolleyTrail	1112	2-yr	38000	-4.09	28.2	10.66	28.49	0.000275	4.32	4.2	9036.91	377.5	459.02	23.04	0.16
TrolleyTrail	1327	100-yr	110000	4.87	39.97	25.65	41.05	0.000925	8.89	6.49	16938.95	391.89	1565.16	27.57	0.3
TrolleyTrail	1327	500-yr	145000	4.87	44.41	28.46	45.4	0.00077	8.96	6.04	23995.57	391.89	1598.4	32.01	0.28
TrolleyTrail	1327	100-yr BW	110000	4.87	48.35	25.65	48.7	0.000252	5.54	3.63	30341.02	391.89	1725	35.95	0.16
TrolleyTrail	1327	500-yr BW	145000	4.87	56.44	28.46	56.71	0.000162	5.08	3.18	45588.31	391.89	3159.22	44.05	0.14
TrolleyTrail	1327	2-yr	38000	4.87	28.09	18.49	28.68	0.000902	6.16	6.16	6169.58	384.74	625.96	16.04	0.27
TrolleyTrail	1516	100-yr	110000	6.09	40.87	26.37	41.24	0.000389	5.75	4.07	27035.69	440.51	2507.3	26.71	0.2
TrolleyTrail	1516	500-yr	145000	6.09	45.26	28.98	45.56	0.000277	5.37	3.9	37215.83	440.51	2569.72	31.09	0.17
TrolleyTrail	1516	100-yr BW	110000	6.09	48.65	26.37	48.76	0.00009	3.28	2.44	45097.87	440.51	2734.09	34.48	0.1
TrolleyTrail	1516	500-yr BW	145000	6.09	56.66	28.98	56.75	0.000052	2.87	2.17	66776.05	440.51	3065.97	42.5	0.08
TrolleyTrail	1516	2-yr	38000	6.09	28.28	19.77	28.86	0.00097	6.08	6.08	6254.36	429.86	1840.25	14.55	0.28
TrolleyTrail	1895	100-yr	110000	6.47	40.89	26.31	41.47	0.000565	7.01	5.25	20946.19	392.94	1733.51	27.65	0.24
TrolleyTrail	1895	500-yr	145000	6.47	45.24	29.21	45.74	0.000435	6.78	4.99	29061.52	392.94	1936.33	32	0.21
TrolleyTrail	1895	100-yr BW	110000	6.47	48.63	26.31	48.82	0.000145	4.18	3.08	35675.45	392.94	1969.52	35.39	0.12
TrolleyTrail	1895	500-yr BW	145000	6.47	56.65	29.21	56.79	0.000087	3.72	2.73	53196.39	392.94	2387.83	43.41	0.1
TrolleyTrail	1895	2-yr	38000	6.47	28.62	18.91	29.23	0.000927	6.26	6.26	6072.92	380.74	1392.94	15.95	0.28
TrolleyTrail	2243	100-yr	110000	7.8	41.07	27.78	41.69	0.00064	7.15	5.55	19832.02	414.48	1592.96	25.94	0.25
TrolleyTrail	2243	500-yr	145000	7.8	45.37	30.6	45.92	0.000496	6.96	5.35	27112.48	414.48	1715.47	30.24	0.22
TrolleyTrail	2243	100-yr BW	110000	7.8	48.67	27.78	48.88	0.000168	4.34	3.35	32806	414.48	1731.29	33.54	0.13
TrolleyTrail	2243	500-yr BW	145000	7.8	56.66	30.6	56.83	0.000102	3.91	2.98	48715.18	414.48	2410.51	41.53	0.11
TrolleyTrail	2243	2-yr	38000	7.8	28.93	19.08	29.61	0.001176	6.6	6.6	5758.35	399.96	1326.27	14.4	0.31
TrolleyTrail	3174	100-yr	110000	6.36	41.35		42.65	0.001058	9.21	8.76	12552.61	458.7	544.7	25.59	0.32
TrolleyTrail	3174	500-yr	145000	6.36	45.25		46.93	0.001134	10.48	9.85	14715.93	458.7	564	29.49	0.34
TrolleyTrail	3174	100-yr BW	110000	6.36	48.52		49.29	0.000456	7.13	6.63	16587.72	458.7	582.15	32.76	0.22
TrolleyTrail	3174	500-yr BW	145000	6.36	56.35		57.2	0.000382	7.53	6.39	22689.29	458.7	1076.25	40.58	0.21
TrolleyTrail	3174	2-yr	38000	6.36	30.07		30.58	0.000902	5.77	5.68	6689.78	458.7	499.67	14.3	0.27
TrolleyTrail	3487	100-yr	110000	9.4	41.19		43.3	0.001636	11.73	10.96	10033.35	350.8	424.04	26.28	0.4
TrolleyTrail	3487	500-yr	145000	9.4	44.92		47.7	0.001813	13.5	12.46	11635.47	350.8	435.09	30.01	0.43
TrolleyTrail	3487	100-yr BW	110000	9.4	48.34		49.62	0.000724	9.16	8.32	13213.47	350.8	488.87	33.43	0.28
TrolleyTrail	3487	500-yr BW	145000	9.4	56.12		57.51	0.000605	9.64	7.94	18270.8	350.8	778.52	41.21	0.26
TrolleyTrail	3487	2-yr	38000	9.4	30.22		30.98	0.00121	7.04	6.83	5561.14	350.8	390.36	15.3	0.32
TrolleyTrail	3790	100-yr	110000	4.96	41.29		43.96	0.00162	13.16	12.45	8837.34	255.6	312.42	32.38	0.41
TrolleyTrail	3790	500-yr	145000	4.96	44.83		48.56	0.001982	15.6	14.55	9966.68	255.6	329.25	35.92	0.46
TrolleyTrail	3790	100-yr BW	110000	4.96	48.23		50.01	0.000838	10.77	9.9	11115.29	255.6	342.94	39.32	0.3
TrolleyTrail	3790	500-yr BW	145000	4.96	55.83		57.93	0.000794	11.79	10.48	13835.53	255.6	379.38	46.91	0.3
TrolleyTrail	3790	2-yr	38000	4.96	30.54		31.27	0.000752	6.85	6.7	5668.61	255.6	280.83	21.63	0.26
TrolleyTrail	3812	100-yr	110000	2.74	41.33		43.99	0.001585	13.14	12.48	8811.6	251.81	307.01	32.97	0.4
TrolleyTrail	3812	500-yr	145000	2.74	44.87		48.61	0.001951	15.6	14.61	9921.45	251.81	323.73	36.5	0.46
TrolleyTrail	3812	100-yr BW	110000	2.74	48.24		50.03	0.000831	10.8	9.96	11044.32	251.81	339.66	39.88	0.3
TrolleyTrail	3812	500-yr BW	145000	2.74	55.83		57.96	0.000791	11.83	10.33	14032.08	251.81	475.19	47.47	0.3
TrolleyTrail	3812	2-yr	38000	2.74	30.58		31.29	0.000713	6.77	6.64	5723.56	251.81	274.21	22.21	0.25
TrolleyTrail	4036	100-yr	110000	-4.3	41.46	30.78	44.56	0.0023	14.59	11.65	9443.28	265	463.8	30.47	0.47
TrolleyTrail	4036	500-yr	145000	-4.3	45.15	34.68	49.23	0.002642	16.88	13.12	11049.82	265	475.99	34.16	0.51
TrolleyTrail	4036	100-yr BW	110000	-4.3	48.35	30.78	50.3	0.00112	11.66	8.76	12552.51	265	536.9	37.36	0.34
TrolleyTrail	4036	500-yr BW	145000	-4.3	56.09	34.68	58.16	0.000963	12.26	8.7	16672.65	265	575.95	45.1	0.32
TrolleyTrail	4036	2-yr	38000	-4.3	30.55	19.08	31.61	0.001347	8.31	7.63	4978.97	265	408.13	19.56	0.33
TrolleyTrail	4404	100-yr	110000	11.45	43.86		45.26	0.001032	9.95	7.56	14545.98	342.1	640.44	29.01	0.33
TrolleyTrail	4404	500-yr	145000	11.45	48.25		50.03	0.001105	11.31	8.31	17449.46	342.1	706.77	33.39	0.35
TrolleyTrail	4404	100-yr BW	110000	11.45	49.74		50.66	0.000543	8.16	5.94	18511.3	342.1	713.59	34.88	0.24
TrolleyTrail	4404	500-yr BW	145000	11.45	57.52		58.49	0.000452	8.52	6.02	24089.21	342.1	721.06	42.66	0.23
TrolleyTrail	4404	2-yr	38000	11.45	31.43		32.05	0.000913	6.45	5.46	6958.15	342.1	583.22	16.58	0.28
TrolleyTrail	4884	100-yr	110000	11.52	43.63		46.31	0.002024	13.89	10.29	10687.36	241.6	478.93	29.09	0.45
TrolleyTrail	4884	500-yr	145000	11.52	47.8		51.25	0.002203	15.84	11.33	12795.16	241.6	527.04	33.26	0.48
TrolleyTrail	4884	100-yr BW	110000	11.52	49.51		51.26	0.001055	11.34	8.03	13701.8	241.6	532.11	34.97	0.34
TrolleyTrail	4884	500-yr BW	145000	11.52	57.19		59.05	0.000885	11.85	8.14	17821.03	241.6	540.58	42.65	0.32
TrolleyTrail	4884	2-yr	38000	11.52	31.65		32.77	0.001612	8.7	7.17	5303.4	241.6	417.94	17.11	0.37

Natural Condition Approach Section

Plan: Natural ClackamasRiver TrolleyTrail RS: 4036 Profile: 100-yr

E.G. Elev (ft)	44.56	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.1	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	41.46	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	30.78	Flow Area (sq ft)	2259.26	7038.95	145.07
E.G. Slope (ft/ft)	0.0023	Area (sq ft)	2259.26	8048.51	145.07
Q Total (cfs)	110000	Flow (cfs)	7004.07	102710.1	285.8
Top Width (ft)	463.8	Top Width (ft)	187.08	265	11.72
Vel Total (ft/s)	11.65	Avg. Vel. (ft/s)	3.1	14.59	1.97
Max Chl Dpth (ft)	45.76	Hydr. Depth (ft)	12.08	30.47	12.38
Conv. Total (cfs)	2293905	Conv. (cfs)	146060.6	2141884	5960
Length Wtd. (ft)	230.13	Wetted Per. (ft)	189.38	251.62	24.01
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	1.71	4.02	0.87
Alpha	1.47	Stream Power (lb/ft s)	5.31	58.6	1.71
Frctn Loss (ft)	0.44	Cum Volume (acre-ft)	1323.39	957.96	118.78
C & E Loss (ft)	0.13	Cum SA (acres)	77.81	33.91	9.35

Plan: Natural ClackamasRiver TrolleyTrail RS: 4036 Profile: 100-yr BW

E.G. Elev (ft)	50.3	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.94	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	48.35	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	30.78	Flow Area (sq ft)	3683.4	8631.04	238.08
E.G. Slope (ft/ft)	0.00112	Area (sq ft)	3683.4	9874.93	238.08
Q Total (cfs)	110000	Flow (cfs)	8942.58	100680.4	376.97
Top Width (ft)	536.9	Top Width (ft)	256.42	265	15.48
Vel Total (ft/s)	8.76	Avg. Vel. (ft/s)	2.43	11.66	1.58
Max Chl Dpth (ft)	52.65	Hydr. Depth (ft)	14.36	37.36	15.38
Conv. Total (cfs)	3287270	Conv. (cfs)	267242.5	3008762	11265.6
Length Wtd. (ft)	230.76	Wetted Per. (ft)	259.71	251.62	31.87
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	0.99	2.4	0.52
Alpha	1.63	Stream Power (lb/ft s)	2.41	27.97	0.83
Frctn Loss (ft)	0.22	Cum Volume (acre-ft)	2010.63	1222.01	209.91
C & E Loss (ft)	0.05	Cum SA (acres)	88.26	33.92	12.59

Plan: Natural ClackamasRiver TrolleyTrail RS: 4036 Profile: 500-yr

E.G. Elev (ft)	49.23	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.08	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	45.15	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	34.68	Flow Area (sq ft)	2968.03	7890.14	191.66
E.G. Slope (ft/ft)	0.002642	Area (sq ft)	2968.03	9024.99	191.66
Q Total (cfs)	145000	Flow (cfs)	11395.46	133166.3	438.22
Top Width (ft)	475.99	Top Width (ft)	197.39	265	13.61
Vel Total (ft/s)	13.12	Avg. Vel. (ft/s)	3.84	16.88	2.29
Max Chl Dpth (ft)	49.45	Hydr. Depth (ft)	15.04	34.16	14.08
Conv. Total (cfs)	2820966	Conv. (cfs)	221698	2590742	8525.6
Length Wtd. (ft)	230.64	Wetted Per. (ft)	200.33	251.62	28.15
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	2.44	5.17	1.12
Alpha	1.53	Stream Power (lb/ft s)	9.38	87.29	2.57
Frctn Loss (ft)	0.52	Cum Volume (acre-ft)	1674.99	1097.34	159.99
C & E Loss (ft)	0.1	Cum SA (acres)	84.88	33.92	10.73

Plan: Natural ClackamasRiver TrolleyTrail RS: 4036 Profile: 500-yr BW

E.G. Elev (ft)	58.16	Element	Left OB	Channel	Right OB
Vel Head (ft)	2.07	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	56.09	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	34.68	Flow Area (sq ft)	5856.46	10418.03	398.16
E.G. Slope (ft/ft)	0.00096	Area (sq ft)	5856.46	11924.94	398.16
Q Total (cfs)	145000	Flow (cfs)	16604.1	127772.1	623.83
Top Width (ft)	575.95	Top Width (ft)	281.5	265	29.45
Vel Total (ft/s)	8.7	Avg. Vel. (ft/s)	2.84	12.26	1.57
Max Chl Dpth (ft)	60.39	Hydr. Depth (ft)	20.8	45.1	13.52
Conv. Total (cfs)	4672229	Conv. (cfs)	535021.8	4117106	20101.2
Length Wtd. (ft)	232.01	Wetted Per. (ft)	292.25	251.62	48.37
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	1.2	2.49	0.5
Alpha	1.76	Stream Power (lb/ft s)	3.42	30.53	0.78
Frctn Loss (ft)	0.2	Cum Volume (acre-ft)	2836.79	1488.4	376
C & E Loss (ft)	0	Cum SA (acres)	112.17	32.78	30.98

Existing Condition (with former railroad bridge)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Vel Total	Flow Area	Top W Chnl	Top Width	Hydr Depth C	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)	
TrolleyTrail	51	100-yr	110000	1.81	38.83	23.13	39.47	0.000535	7.59	4.5	24447.41	309.53	1793.07	31.64	0.24
TrolleyTrail	51	500-yr	145000	1.81	42.95	26.92	43.67	0.000535	8.24	4.72	30727.1	309.53	2222.92	35.76	0.24
TrolleyTrail	51	100-yr BW	110000	1.81	47.8	23.13	48.05	0.000168	5.02	2.87	38340.84	309.53	2355.45	40.61	0.14
TrolleyTrail	51	500-yr BW	145000	1.81	56	26.92	56.16	0.000097	4.31	2.34	61908.71	309.53	2769.16	48.81	0.11
TrolleyTrail	51	2-yr	38000	1.81	27.34	14.96	27.8	0.000535	5.62	4.29	8857.21	309.53	1295.16	20.15	0.22
TrolleyTrail	278	100-yr	110000	2.14	38.98	23.84	39.59	0.000536	7.57	4.3	25589.02	300.73	1686.85	31.5	0.24
TrolleyTrail	278	500-yr	145000	2.14	43.15	29.6	43.79	0.000505	7.98	4.52	32087.85	300.73	1998.37	35.67	0.24
TrolleyTrail	278	100-yr BW	110000	2.14	47.86	23.84	48.09	0.000161	4.9	2.79	39456.71	300.73	2173.05	40.38	0.14
TrolleyTrail	278	500-yr BW	145000	2.14	56.01	29.6	56.19	0.00011	4.58	2.44	59473.56	300.73	2544.24	48.52	0.12
TrolleyTrail	278	2-yr	38000	2.14	27.43	15.41	27.95	0.000607	5.94	4.49	8462.6	300.73	1368.49	19.95	0.23
TrolleyTrail	569	100-yr	110000	3.99	38.89	24.39	39.91	0.000808	9.1	5.55	19837.04	308.05	1823.05	30.37	0.29
TrolleyTrail	569	500-yr	145000	3.99	42.99	27.57	44.13	0.000806	9.89	5.91	24519.08	308.05	1862.5	34.47	0.3
TrolleyTrail	569	100-yr BW	110000	3.99	47.78	24.39	48.21	0.000265	6.19	3.66	30025.21	308.05	1917.48	39.26	0.17
TrolleyTrail	569	500-yr BW	145000	3.99	56.02	27.57	56.24	0.000132	4.96	2.61	55629.87	308.05	2174.16	47.5	0.13
TrolleyTrail	569	2-yr	38000	3.99	27.64	16.42	28.13	0.000618	5.85	4.34	8755.13	308.05	702.03	19.12	0.24
TrolleyTrail	877	100-yr	110000	-0.31	38.99	22.58	40.34	0.000887	9.99	6.83	16103.58	283.12	1734.82	33.43	0.3
TrolleyTrail	877	500-yr	145000	-0.31	43.05	25.86	44.61	0.000929	11.02	7.26	19972.58	283.12	1786.79	37.5	0.32
TrolleyTrail	877	100-yr BW	110000	-0.31	47.79	22.58	48.38	0.000317	6.97	4.49	24517.93	283.12	1824.47	42.24	0.19
TrolleyTrail	877	500-yr BW	145000	-0.31	56.04	25.86	56.3	0.000146	5.31	2.85	50867.8	283.12	2223.64	50.49	0.13
TrolleyTrail	877	2-yr	38000	-0.31	27.82	13.32	28.3	0.000487	5.69	4.91	7745.06	283.12	444.94	22.27	0.21
TrolleyTrail	995		Bridge												
TrolleyTrail	1112	100-yr	110000	-4.09	40.01	18.88	40.82	0.000486	7.57	5.72	19223.04	377.5	1713.27	34.85	0.23
TrolleyTrail	1112	500-yr	145000	-4.09	44.28	21.88	45.25	0.000521	8.47	6.09	23802.39	377.5	1780.31	39.12	0.24
TrolleyTrail	1112	100-yr BW	110000	-4.09	48.24	18.88	48.65	0.0002	5.6	3.92	28069.24	377.5	1828.48	43.07	0.15
TrolleyTrail	1112	500-yr BW	145000	-4.09	56.4	21.88	56.8	0.000127	5.01	2.81	51589.51	377.5	2041.88	51.24	0.12
TrolleyTrail	1112	2-yr	38000	-4.09	28.2	10.66	28.49	0.000275	4.32	4.2	9036.91	377.5	459.02	23.04	0.16
TrolleyTrail	1327	100-yr	110000	4.87	39.97	25.65	41.05	0.000925	8.89	6.49	16938.95	391.89	1565.16	27.57	0.3
TrolleyTrail	1327	500-yr	145000	4.87	44.41	28.46	45.4	0.00077	8.96	6.04	23995.57	391.89	1598.4	32.01	0.28
TrolleyTrail	1327	100-yr BW	110000	4.87	48.35	25.65	48.7	0.000252	5.54	3.63	30341.02	391.89	1725	35.95	0.16
TrolleyTrail	1327	500-yr BW	145000	4.87	56.44	28.46	56.71	0.000162	5.08	3.18	45588.31	391.89	3159.22	44.05	0.14
TrolleyTrail	1327	2-yr	38000	4.87	28.09	18.49	28.68	0.000902	6.16	6.16	6169.58	384.74	625.96	16.04	0.27
TrolleyTrail	1516	100-yr	110000	6.09	40.87	26.37	41.24	0.000389	5.75	4.07	27035.69	440.51	2507.3	26.71	0.2
TrolleyTrail	1516	500-yr	145000	6.09	45.26	28.98	45.56	0.000277	5.37	3.9	37215.83	440.51	2569.72	31.09	0.17
TrolleyTrail	1516	100-yr BW	110000	6.09	48.65	26.37	48.76	0.00009	3.28	2.44	45097.87	440.51	2734.09	34.48	0.1
TrolleyTrail	1516	500-yr BW	145000	6.09	56.66	28.98	56.75	0.000052	2.87	2.17	66776.05	440.51	3065.97	42.5	0.08
TrolleyTrail	1516	2-yr	38000	6.09	28.28	19.77	28.86	0.00097	6.08	6.08	6254.36	429.86	1840.25	14.55	0.28
TrolleyTrail	1895	100-yr	110000	6.47	40.89	26.31	41.47	0.000565	7.01	5.25	20946.19	392.94	1733.51	27.65	0.24
TrolleyTrail	1895	500-yr	145000	6.47	45.24	29.21	45.74	0.000435	6.78	4.99	29061.52	392.94	1936.33	32	0.21
TrolleyTrail	1895	100-yr BW	110000	6.47	48.63	26.31	48.82	0.000145	4.18	3.08	35675.45	392.94	1969.52	35.39	0.12
TrolleyTrail	1895	500-yr BW	145000	6.47	56.65	29.21	56.79	0.000087	3.72	2.73	53196.39	392.94	2387.83	43.41	0.1
TrolleyTrail	1895	2-yr	38000	6.47	28.62	18.91	29.23	0.000927	6.26	6.26	6072.92	380.74	1392.94	15.95	0.28
TrolleyTrail	2243	100-yr	110000	7.8	41.07	27.78	41.69	0.00064	7.15	5.55	19832.02	414.48	1592.96	25.94	0.25
TrolleyTrail	2243	500-yr	145000	7.8	45.37	30.6	45.92	0.000496	6.96	5.35	27112.48	414.48	1715.47	30.24	0.22
TrolleyTrail	2243	100-yr BW	110000	7.8	48.67	27.78	48.88	0.000168	4.34	3.35	32806	414.48	1731.29	33.54	0.13
TrolleyTrail	2243	500-yr BW	145000	7.8	56.66	30.6	56.83	0.000102	3.91	2.98	48715.18	414.48	2410.51	41.53	0.11
TrolleyTrail	2243	2-yr	38000	7.8	28.93	19.08	29.61	0.001176	6.6	6.6	5758.35	399.96	1326.27	14.4	0.31
TrolleyTrail	3174	100-yr	110000	6.36	41.35		42.65	0.001058	9.21	8.76	12552.61	458.7	544.7	25.59	0.32
TrolleyTrail	3174	500-yr	145000	6.36	45.25		46.93	0.001134	10.48	9.85	14715.93	458.7	564	29.49	0.34
TrolleyTrail	3174	100-yr BW	110000	6.36	48.52		49.29	0.000456	7.13	6.63	16587.72	458.7	582.15	32.76	0.22
TrolleyTrail	3174	500-yr BW	145000	6.36	56.35		57.2	0.000382	7.53	6.39	22689.29	458.7	1076.25	40.58	0.21
TrolleyTrail	3174	2-yr	38000	6.36	30.07		30.58	0.000902	5.77	5.68	6689.78	458.7	499.67	14.3	0.27
TrolleyTrail	3487	100-yr	110000	9.4	41.19		43.3	0.001636	11.73	10.96	10033.35	350.8	424.04	26.28	0.4
TrolleyTrail	3487	500-yr	145000	9.4	44.92		47.7	0.001813	13.5	12.46	11635.47	350.8	435.09	30.01	0.43
TrolleyTrail	3487	100-yr BW	110000	9.4	48.34		49.62	0.000724	9.16	8.32	13213.47	350.8	488.87	33.43	0.28
TrolleyTrail	3487	500-yr BW	145000	9.4	56.12		57.51	0.000605	9.64	7.94	18270.8	350.8	778.52	41.21	0.26
TrolleyTrail	3487	2-yr	38000	9.4	30.22		30.98	0.00121	7.04	6.83	5561.14	350.8	390.36	15.3	0.32
TrolleyTrail	3790	100-yr	110000	4.96	41.41	26.87	44.06	0.001599	13.1	12.4	8873.27	255.6	312.87	32.5	0.41
TrolleyTrail	3790	500-yr	145000	4.96	45.04	30.5	48.72	0.001939	15.49	14.48	10014.56	255.6	330.9	36.13	0.45
TrolleyTrail	3790	100-yr BW	110000	4.96	48.34	26.87	50.1	0.000828	10.73	9.93	11073.63	255.6	343.24	39.43	0.3
TrolleyTrail	3790	500-yr BW	145000	4.96	55.98	30.5	58.07	0.000785	11.75	10.71	13533.18	255.6	380.18	47.07	0.3
TrolleyTrail	3790	2-yr	38000	4.96	30.55	17.65	31.28	0.000751	6.85	6.7	5671.07	255.6	280.85	21.64	0.26
TrolleyTrail	3801		Bridge												
TrolleyTrail	3812	100-yr	110000	2.74	41.61	26.5	44.23	0.001539	13.02	12.37	8895.29	251.81	308.08	33.25	0.4
TrolleyTrail	3812	500-yr	145000	2.74	45.34	30.17	48.97	0.001864	15.38	14.44	10040.76	251.81	326.7	36.98	0.45
TrolleyTrail	3812	100-yr BW	110000	2.74	48.45	26.5	50.22	0.000815	10.73	9.99	11011.85	251.81	340.28	40.09	0.3
TrolleyTrail	3812	500-yr BW	145000	2.74	56.12	30.17	58.24	0.000779	11.79	10.77	13459.37	251.81	477.29	47.76	0.3
TrolleyTrail	3812	2-yr	38000	2.74	30.62	17.18	31.33	0.000709	6.76	6.63	5734.86	251.81	274.29	22.25	0.25
TrolleyTrail	4036	100-yr	110000	-4.3	41.74	30.78	44.77	0.002224	14.44	11.5	9564.14	265	464.65	30.75	0.46
TrolleyTrail	4036	500-yr	145000	-4.3	45.62	34.68	49.57	0.002515	16.62	12.88	11257.45	265	477.61	34.63	0.5
TrolleyTrail	4036	100-yr BW	110000	-4.3	48.56	30.78	50.48	0.001098	11.6	8.69	12657.38	265	551.6	37.57	0.33
TrolleyTrail	4036	500-yr BW	145000	-4.3	56.41	34.68	58.44	0.000938	12.16	8.61	16844.03	265	576.68	45.42	0.32
TrolleyTrail	4036	2-yr	38000	-4.3	30.59	19.08	31.65	0.001337	8.29	7.61	4994.49	265	408.31	19.6	0.33
TrolleyTrail	4404	100-yr	110000	11.45	44.08		45.45	0.001005	9.87	7.49	14685.08	342.1	641.2	29.22	0.32
TrolleyTrail	4404	500-yr	145000	11.45	48.59		50.34	0.001066	11.19	8.2	17693.37	342.1	712.49	33.74	0.34
TrolleyTrail	4404	100-yr BW	110000	11.45	49.93		50.84	0.000532	8.11	5.9	18645.46	342.1	713.77	35.07	0.24
TrolleyTrail	4404	500-yr BW	145000	11.45	57.8		58.76	0.000441	8.45	5.97	24295.51	342.1	721.34	42.95	0.23
TrolleyTrail	4404	2-yr	38000	11.45	31.47		32.09	0.000906	6.43	5.44	6979.32	342.1	583.35	16.61	0.28
TrolleyTrail	4884	100-yr	110000	11.52	43.84		46.48	0.001971	13.77	10.19	10790.47	241.6	479.77	29.3	0.45
TrolleyTrail	4884	500-yr	145000	11.52	48.15		51.51	0.002123	15.66	11.17	12979.64	241.6	529.87	33.61	0.48
TrolleyTrail	4884	100-yr BW	110000	11.52	49.7		51.43	0.001034	11.26	7.97	13802.43	241.6	532.32	35.16	0.33
TrolleyTrail	4884	500-yr BW	145000	11.52	57.48		59.31	0.000864	11.76	8.07	17977.51	241.6	540.9	42.94	0.32
TrolleyTrail	4884	2-yr	38000	11.52	31.69		32.8	0.001601	8.68	7.15	5317.35	241.6	418.16	17.15	0.37

Existing Condition (with former railroad bridge) Approach Section

Plan: RRtrestle ClackamasRiver TrolleyTrail RS: 4036 Profile: 100-yr

E.G. Elev (ft)	44.77	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.03	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	41.74	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	30.78	Flow Area (sq ft)	2311.92	7103.84	148.38
E.G. Slope (ft/ft)	0.002224	Area (sq ft)	2311.92	8122.96	148.38
Q Total (cfs)	110000	Flow (cfs)	7138.5	102572.1	289.42
Top Width (ft)	464.65	Top Width (ft)	187.81	265	11.84
Vel Total (ft/s)	11.5	Avg. Vel. (ft/s)	3.09	14.44	1.95
Max Chl Dpth (ft)	46.04	Hydr. Depth (ft)	12.31	30.75	12.54
Conv. Total (cfs)	2332394	Conv. (cfs)	151361.7	2174896	6136.7
Length Wtd. (ft)	230.18	Wetted Per. (ft)	190.16	251.62	24.31
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	1.69	3.92	0.85
Alpha	1.47	Stream Power (lb/ft s)	5.21	56.6	1.65
Frctn Loss (ft)	0.42	Cum Volume (acre-ft)	1323.59	958.41	118.78
C & E Loss (ft)	0.13	Cum SA (acres)	77.81	33.91	9.35

Plan: RRtrestle ClackamasRiver TrolleyTrail RS: 4036 Profile: 100-yr BW

E.G. Elev (ft)	50.48	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.92	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	48.56	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	30.78	Flow Area (sq ft)	3737.43	8678.66	241.29
E.G. Slope (ft/ft)	0.0011	Area (sq ft)	3737.43	9929.57	241.29
Q Total (cfs)	110000	Flow (cfs)	8989.6	100630.7	379.71
Top Width (ft)	551.6	Top Width (ft)	270.96	265	15.64
Vel Total (ft/s)	8.69	Avg. Vel. (ft/s)	2.41	11.6	1.57
Max Chl Dpth (ft)	52.86	Hydr. Depth (ft)	13.79	37.57	15.43
Conv. Total (cfs)	3319197	Conv. (cfs)	271256.8	3036483	11457.5
Length Wtd. (ft)	230.8	Wetted Per. (ft)	274.25	251.62	32.13
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	0.93	2.36	0.51
Alpha	1.63	Stream Power (lb/ft s)	2.25	27.42	0.81
Frctn Loss (ft)	0.22	Cum Volume (acre-ft)	2010.81	1222.34	209.9
C & E Loss (ft)	0.05	Cum SA (acres)	88.3	33.92	12.59

Plan: RRtrestle ClackamasRiver TrolleyTrail RS: 4036 Profile: 500-yr

E.G. Elev (ft)	49.57	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.95	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	45.62	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	34.68	Flow Area (sq ft)	3060.9	7998.46	198.09
E.G. Slope (ft/ft)	0.002515	Area (sq ft)	3060.9	9149.25	198.09
Q Total (cfs)	145000	Flow (cfs)	11647.45	132906.4	446.16
Top Width (ft)	477.61	Top Width (ft)	198.75	265	13.86
Vel Total (ft/s)	12.88	Avg. Vel. (ft/s)	3.81	16.62	2.25
Max Chl Dpth (ft)	49.92	Hydr. Depth (ft)	15.4	34.63	14.3
Conv. Total (cfs)	2891451	Conv. (cfs)	232262.2	2650291	8897
Length Wtd. (ft)	230.72	Wetted Per. (ft)	201.78	251.62	28.68
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	2.38	4.99	1.08
Alpha	1.53	Stream Power (lb/ft s)	9.06	82.93	2.44
Frctn Loss (ft)	0.5	Cum Volume (acre-ft)	1675.38	1098.14	160.02
C & E Loss (ft)	0.1	Cum SA (acres)	84.89	33.92	10.73

Plan: RRtrestle ClackamasRiver TrolleyTrail RS: 4036 Profile: 500-yr BW

E.G. Elev (ft)	58.44	Element	Left OB	Channel	Right OB
Vel Head (ft)	2.04	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	56.41	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	34.68	Flow Area (sq ft)	5945.42	10491.03	407.58
E.G. Slope (ft/ft)	0.00094	Area (sq ft)	5945.42	12008.69	407.58
Q Total (cfs)	145000	Flow (cfs)	16791.55	127575.2	633.28
Top Width (ft)	576.68	Top Width (ft)	281.5	265	30.18
Vel Total (ft/s)	8.61	Avg. Vel. (ft/s)	2.82	12.16	1.55
Max Chl Dpth (ft)	60.71	Hydr. Depth (ft)	21.12	45.42	13.51
Conv. Total (cfs)	4734219	Conv. (cfs)	548240.6	4165302	20676.5
Length Wtd. (ft)	231.93	Wetted Per. (ft)	292.56	251.62	49.15
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	1.19	2.44	0.49
Alpha	1.77	Stream Power (lb/ft s)	3.36	29.69	0.75
Frctn Loss (ft)	0.2	Cum Volume (acre-ft)	2837.05	1488.89	375.99
C & E Loss (ft)	0.01	Cum SA (acres)	112.13	32.77	30.98

Alternatives 1/4 Profiles

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Vel Total	Flow Area	Top W Chnl	Top Width	Hydr Depth C	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)	
TrolleyTrail	51	100-yr	110000	1.81	38.83	23.13	39.47	0.000535	7.59	4.5	24447.41	309.53	1793.07	31.64	0.24
TrolleyTrail	51	500-yr	145000	1.81	42.95	26.92	43.67	0.000535	8.24	4.72	30727.1	309.53	2222.92	35.76	0.24
TrolleyTrail	51	100-yr BW	110000	1.81	47.8	23.13	48.05	0.000168	5.02	2.87	38340.84	309.53	2355.45	40.61	0.14
TrolleyTrail	51	500-yr BW	145000	1.81	56	26.92	56.16	0.000097	4.31	2.34	61908.71	309.53	2769.16	48.81	0.11
TrolleyTrail	51	2-yr	38000	1.81	27.34	14.96	27.8	0.000535	5.62	4.29	8857.21	309.53	1295.16	20.15	0.22
TrolleyTrail	278	100-yr	110000	2.14	38.98	23.84	39.59	0.000536	7.57	4.3	25589.02	300.73	1686.85	31.5	0.24
TrolleyTrail	278	500-yr	145000	2.14	43.15	29.6	43.79	0.000505	7.98	4.52	32087.85	300.73	1998.37	35.67	0.24
TrolleyTrail	278	100-yr BW	110000	2.14	47.86	23.84	48.09	0.000161	4.9	2.79	39456.71	300.73	2173.05	40.38	0.14
TrolleyTrail	278	500-yr BW	145000	2.14	56.01	29.6	56.19	0.00011	4.58	2.44	59473.56	300.73	2544.24	48.52	0.12
TrolleyTrail	278	2-yr	38000	2.14	27.43	15.41	27.95	0.000607	5.94	4.49	8462.6	300.73	1368.49	19.95	0.23
TrolleyTrail	569	100-yr	110000	3.99	38.89	24.39	39.91	0.000808	9.1	5.55	19837.04	308.05	1823.05	30.37	0.29
TrolleyTrail	569	500-yr	145000	3.99	42.99	27.57	44.13	0.000806	9.89	5.91	24519.08	308.05	1862.5	34.47	0.3
TrolleyTrail	569	100-yr BW	110000	3.99	47.78	24.39	48.21	0.000265	6.19	3.66	30025.21	308.05	1917.48	39.26	0.17
TrolleyTrail	569	500-yr BW	145000	3.99	56.02	27.57	56.24	0.000132	4.96	2.61	55629.87	308.05	2174.16	47.5	0.13
TrolleyTrail	569	2-yr	38000	3.99	27.64	16.42	28.13	0.000618	5.85	4.34	8755.13	308.05	702.03	19.12	0.24
TrolleyTrail	877	100-yr	110000	-0.31	38.99	22.58	40.34	0.000887	9.99	6.83	16103.58	283.12	1734.82	33.43	0.3
TrolleyTrail	877	500-yr	145000	-0.31	43.05	25.86	44.61	0.000929	11.02	7.26	19972.58	283.12	1786.79	37.5	0.32
TrolleyTrail	877	100-yr BW	110000	-0.31	47.79	22.58	48.38	0.000317	6.97	4.49	24517.93	283.12	1824.47	42.24	0.19
TrolleyTrail	877	500-yr BW	145000	-0.31	56.04	25.86	56.3	0.000146	5.31	2.85	50867.8	283.12	2223.64	50.49	0.13
TrolleyTrail	877	2-yr	38000	-0.31	27.82	13.32	28.3	0.000487	5.69	4.91	7745.06	283.12	444.94	22.27	0.21
TrolleyTrail	995		Bridge												
TrolleyTrail	1112	100-yr	110000	-4.09	40.01	18.88	40.82	0.000486	7.57	5.72	19223.04	377.5	1713.27	34.85	0.23
TrolleyTrail	1112	500-yr	145000	-4.09	44.28	21.88	45.25	0.000521	8.47	6.09	23802.39	377.5	1780.31	39.12	0.24
TrolleyTrail	1112	100-yr BW	110000	-4.09	48.24	18.88	48.65	0.0002	5.6	3.92	28069.24	377.5	1828.48	43.07	0.15
TrolleyTrail	1112	500-yr BW	145000	-4.09	56.4	21.88	56.8	0.000127	5.01	2.81	51589.51	377.5	2041.88	51.24	0.12
TrolleyTrail	1112	2-yr	38000	-4.09	28.2	10.66	28.49	0.000275	4.32	4.2	9036.91	377.5	459.02	23.04	0.16
TrolleyTrail	1327	100-yr	110000	4.87	39.97	25.65	41.05	0.000925	8.89	6.49	16938.95	391.89	1565.16	27.57	0.3
TrolleyTrail	1327	500-yr	145000	4.87	44.41	28.46	45.4	0.00077	8.96	6.04	23995.57	391.89	1598.4	32.01	0.28
TrolleyTrail	1327	100-yr BW	110000	4.87	48.35	25.65	48.7	0.000252	5.54	3.63	30341.02	391.89	1725	35.95	0.16
TrolleyTrail	1327	500-yr BW	145000	4.87	56.44	28.46	56.71	0.000162	5.08	3.18	45588.31	391.89	3159.22	44.05	0.14
TrolleyTrail	1327	2-yr	38000	4.87	28.09	18.49	28.68	0.000902	6.16	6.16	6169.58	384.74	625.96	16.04	0.27
TrolleyTrail	1516	100-yr	110000	6.09	40.87	26.37	41.24	0.000389	5.75	4.07	27035.69	440.51	2507.3	26.71	0.2
TrolleyTrail	1516	500-yr	145000	6.09	45.26	28.98	45.56	0.000277	5.37	3.9	37215.83	440.51	2569.72	31.09	0.17
TrolleyTrail	1516	100-yr BW	110000	6.09	48.65	26.37	48.76	0.00009	3.28	2.44	45097.87	440.51	2734.09	34.48	0.1
TrolleyTrail	1516	500-yr BW	145000	6.09	56.66	28.98	56.75	0.000052	2.87	2.17	66776.05	440.51	3065.97	42.5	0.08
TrolleyTrail	1516	2-yr	38000	6.09	28.28	19.77	28.86	0.00097	6.08	6.08	6254.36	429.86	1840.25	14.55	0.28
TrolleyTrail	1895	100-yr	110000	6.47	40.89	26.31	41.47	0.000565	7.01	5.25	20946.19	392.94	1733.51	27.65	0.24
TrolleyTrail	1895	500-yr	145000	6.47	45.24	29.21	45.74	0.000435	6.78	4.99	29061.52	392.94	1936.33	32	0.21
TrolleyTrail	1895	100-yr BW	110000	6.47	48.63	26.31	48.82	0.000145	4.18	3.08	35675.45	392.94	1969.52	35.39	0.12
TrolleyTrail	1895	500-yr BW	145000	6.47	56.65	29.21	56.79	0.000087	3.72	2.73	53196.39	392.94	2387.83	43.41	0.1
TrolleyTrail	1895	2-yr	38000	6.47	28.62	18.91	29.23	0.000927	6.26	6.26	6072.92	380.74	1392.94	15.95	0.28
TrolleyTrail	2243	100-yr	110000	7.8	41.07	27.78	41.69	0.00064	7.15	5.55	19832.02	414.48	1592.96	25.94	0.25
TrolleyTrail	2243	500-yr	145000	7.8	45.37	30.6	45.92	0.000496	6.96	5.35	27112.48	414.48	1715.47	30.24	0.22
TrolleyTrail	2243	100-yr BW	110000	7.8	48.67	27.78	48.88	0.000168	4.34	3.35	32806	414.48	1731.29	33.54	0.13
TrolleyTrail	2243	500-yr BW	145000	7.8	56.66	30.6	56.83	0.000102	3.91	2.98	48715.18	414.48	2410.51	41.53	0.11
TrolleyTrail	2243	2-yr	38000	7.8	28.93	19.08	29.61	0.001176	6.6	6.6	5758.35	399.96	1326.27	14.4	0.31
TrolleyTrail	3174	100-yr	110000	6.36	41.35		42.65	0.001058	9.21	8.76	12552.61	458.7	544.7	25.59	0.32
TrolleyTrail	3174	500-yr	145000	6.36	45.25		46.93	0.001134	10.48	9.85	14715.93	458.7	564	29.49	0.34
TrolleyTrail	3174	100-yr BW	110000	6.36	48.52		49.29	0.000456	7.13	6.63	16587.72	458.7	582.15	32.76	0.22
TrolleyTrail	3174	500-yr BW	145000	6.36	56.35		57.2	0.000382	7.53	6.39	22689.29	458.7	1076.25	40.58	0.21
TrolleyTrail	3174	2-yr	38000	6.36	30.07		30.58	0.000902	5.77	5.68	6689.78	458.7	499.67	14.3	0.27
TrolleyTrail	3487	100-yr	110000	9.4	41.19		43.3	0.001636	11.73	10.96	10033.35	350.8	424.04	26.28	0.4
TrolleyTrail	3487	500-yr	145000	9.4	44.92		47.7	0.001813	13.5	12.46	11635.47	350.8	435.09	30.01	0.43
TrolleyTrail	3487	100-yr BW	110000	9.4	48.34		49.62	0.000724	9.16	8.32	13213.47	350.8	488.87	33.43	0.28
TrolleyTrail	3487	500-yr BW	145000	9.4	56.12		57.51	0.000605	9.64	7.94	18270.8	350.8	778.52	41.21	0.26
TrolleyTrail	3487	2-yr	38000	9.4	30.22		30.98	0.00121	7.04	6.83	5561.14	350.8	390.36	15.3	0.32
TrolleyTrail	3790	100-yr	110000	4.96	41.41		44.06	0.0016	13.11	12.39	8874.65	255.6	312.87	32.5	0.41
TrolleyTrail	3790	500-yr	145000	4.96	45.03		48.72	0.001944	15.5	14.45	10035.55	255.6	330.87	36.12	0.45
TrolleyTrail	3790	100-yr BW	110000	4.96	48.34		50.1	0.00083	10.74	9.86	11150.95	255.6	343.23	39.43	0.3
TrolleyTrail	3790	500-yr BW	145000	4.96	55.98		58.07	0.000785	11.75	10.44	13892.81	255.6	380.18	47.07	0.3
TrolleyTrail	3790	2-yr	38000	4.96	30.55		31.28	0.000751	6.85	6.7	5671.07	255.6	280.85	21.64	0.26
TrolleyTrail	3801		Bridge												
TrolleyTrail	3812	100-yr	110000	2.74	41.45	26.49	44.09	0.001566	13.09	12.43	8847.87	251.81	307.46	33.09	0.4
TrolleyTrail	3812	500-yr	145000	2.74	45.08	30.16	48.77	0.001914	15.51	14.52	9989.48	251.81	325.06	36.71	0.45
TrolleyTrail	3812	100-yr BW	110000	2.74	48.35	26.49	50.12	0.000823	10.77	9.93	11080.28	251.81	339.97	39.98	0.3
TrolleyTrail	3812	500-yr BW	145000	2.74	56.12	30.16	58.21	0.000774	11.76	10.23	14167.76	251.81	477.27	47.75	0.3
TrolleyTrail	3812	2-yr	38000	2.74	30.59	17.18	31.3	0.000712	6.77	6.64	5726.61	251.81	274.23	22.22	0.25
TrolleyTrail	4036	100-yr	110000	-4.3	41.58	30.78	44.65	0.002267	14.53	11.59	9494.52	265	464.16	30.59	0.46
TrolleyTrail	4036	500-yr	145000	-4.3	45.36	34.68	49.38	0.002584	16.76	13.01	11142.77	265	476.69	34.37	0.5
TrolleyTrail	4036	100-yr BW	110000	-4.3	48.46	30.78	50.39	0.001109	11.63	8.73	12605.72	265	542.58	37.47	0.33
TrolleyTrail	4036	500-yr BW	145000	-4.3	56.38	34.68	58.42	0.00094	12.17	8.62	16827.73	265	576.61	45.39	0.32
TrolleyTrail	4036	2-yr	38000	-4.3	30.56	19.08	31.62	0.001345	8.31	7.63	4983.15	265	408.18	19.57	0.33
TrolleyTrail	4404	100-yr	110000	11.45	43.96		45.34	0.001021	9.92	7.53	14604.78	342.1	640.76	29.1	0.32
TrolleyTrail	4404	500-yr	145000	11.45	48.4		50.17	0.001088	11.26	8.26	17557.6	342.1	710.07	33.55	0.34
TrolleyTrail	4404	100-yr BW	110000	11.45	49.84		50.75	0.000537	8.13	5.92	18579.66	342.1	713.68	34.98	0.24
TrolleyTrail	4404	500-yr BW	145000	11.45	57.78		58.74	0.000442	8.46	5.97	24275.86	342.1	721.31	42.92	0.23
TrolleyTrail	4404	2-yr	38000	11.45	31.44		32.06	0.000911	6.44	5.46	6963.86	342.1	583.26	16.59	0.28
TrolleyTrail	4884	100-yr	110000	11.52	43.72		46.38	0.002001	13.84	10.25	10730.92	241.6	479.29	29.18	0.45
TrolleyTrail	4884	500-yr	145000	11.52	47.95		51.37	0.002167	15.76	11.26	12877.49	241.6	528.25	33.41	0.48
TrolleyTrail	4884	100-yr BW	110000	11.52	49.6		51.34	0.001045	11.3	8	13753.08	241.6	532.22	35.06	0.34
TrolleyTrail	4884	500-yr BW	145000	11.52	57.45		59.28	0.000866	11.77	8.07	17962.61	241.6	540.87	42.91	0.32
TrolleyTrail	4884	2-yr	38000	11.52	31.66		32.78	0.001609	8.7	7.16	5307.16	241.6	418	17.12	0.37

Alternatives 1/4 Approach Section

Plan: Alt 1&4 ClackamasRiver TrolleyTrail RS: 4036 Profile: 100-yr

E.G. Elev (ft)	44.65	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.07	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	41.58	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	30.78	Flow Area (sq ft)	2281.57	7066.48	146.47
E.G. Slope (ft/ft)	0.002267	Area (sq ft)	2281.57	8080.09	146.47
Q Total (cfs)	110000	Flow (cfs)	7061.28	102651.4	287.34
Top Width (ft)	464.16	Top Width (ft)	187.39	265	11.77
Vel Total (ft/s)	11.59	Avg. Vel. (ft/s)	3.09	14.53	1.96
Max Chl Dpth (ft)	45.88	Hydr. Depth (ft)	12.18	30.59	12.44
Conv. Total (cfs)	2310198	Conv. (cfs)	148299.5	2155864	6034.6
Length Wtd. (ft)	230.15	Wetted Per. (ft)	189.71	251.62	24.13
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	1.7	3.97	0.86
Alpha	1.47	Stream Power (lb/ft s)	5.27	57.74	1.69
Frctn Loss (ft)	0.43	Cum Volume (acre-ft)	1323.5	958.24	118.81
C & E Loss (ft)	0.13	Cum SA (acres)	77.81	33.91	9.35

Plan: Alt 1&4 ClackamasRiver TrolleyTrail RS: 4036 Profile: 100-yr BW

E.G. Elev (ft)	50.39	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.93	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	48.46	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	30.78	Flow Area (sq ft)	3710.59	8655.42	239.72
E.G. Slope (ft/ft)	0.00111	Area (sq ft)	3710.59	9902.9	239.72
Q Total (cfs)	110000	Flow (cfs)	8972.58	100649.1	378.35
Top Width (ft)	542.58	Top Width (ft)	262.02	265	15.56
Vel Total (ft/s)	8.73	Avg. Vel. (ft/s)	2.42	11.63	1.58
Max Chl Dpth (ft)	52.76	Hydr. Depth (ft)	14.16	37.47	15.4
Conv. Total (cfs)	3303790	Conv. (cfs)	269486.7	3022940	11363.4
Length Wtd. (ft)	230.77	Wetted Per. (ft)	265.31	251.62	32
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	0.97	2.38	0.52
Alpha	1.63	Stream Power (lb/ft s)	2.34	27.68	0.82
Frctn Loss (ft)	0.22	Cum Volume (acre-ft)	2010.79	1222.26	209.94
C & E Loss (ft)	0.05	Cum SA (acres)	88.29	33.92	12.6

Plan: Alt 1&4 ClackamasRiver TrolleyTrail RS: 4036 Profile: 500-yr

E.G. Elev (ft)	49.38	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.02	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	45.36	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	34.68	Flow Area (sq ft)	3009.56	7938.68	194.53
E.G. Slope (ft/ft)	0.002584	Area (sq ft)	3009.56	9080.67	194.53
Q Total (cfs)	145000	Flow (cfs)	11509.78	133048.5	441.78
Top Width (ft)	476.69	Top Width (ft)	197.97	265	13.72
Vel Total (ft/s)	13.01	Avg. Vel. (ft/s)	3.82	16.76	2.27
Max Chl Dpth (ft)	49.66	Hydr. Depth (ft)	15.2	34.37	14.18
Conv. Total (cfs)	2852474	Conv. (cfs)	226423	2617360	8690.7
Length Wtd. (ft)	230.66	Wetted Per. (ft)	200.96	251.62	28.38
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	2.42	5.09	1.11
Alpha	1.53	Stream Power (lb/ft s)	9.24	85.3	2.51
Frctn Loss (ft)	0.51	Cum Volume (acre-ft)	1675.21	1097.84	160.04
C & E Loss (ft)	0.1	Cum SA (acres)	84.89	33.92	10.74

Plan: Alt 1&4 ClackamasRiver TrolleyTrail RS: 4036 Profile: 500-yr BW

E.G. Elev (ft)	58.42	Element	Left OB	Channel	Right OB
Vel Head (ft)	2.04	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	56.38	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	34.68	Flow Area (sq ft)	5936.96	10484.09	406.68
E.G. Slope (ft/ft)	0.00094	Area (sq ft)	5936.96	12000.73	406.68
Q Total (cfs)	145000	Flow (cfs)	16773.84	127593.8	632.37
Top Width (ft)	576.61	Top Width (ft)	281.5	265	30.11
Vel Total (ft/s)	8.62	Avg. Vel. (ft/s)	2.83	12.17	1.55
Max Chl Dpth (ft)	60.68	Hydr. Depth (ft)	21.09	45.39	13.51
Conv. Total (cfs)	4728312	Conv. (cfs)	546978.8	4160712	20621.1
Length Wtd. (ft)	232.06	Wetted Per. (ft)	292.53	251.62	49.08
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	1.19	2.45	0.49
Alpha	1.77	Stream Power (lb/ft s)	3.37	29.77	0.76
Frctn Loss (ft)	0.2	Cum Volume (acre-ft)	2837.19	1488.79	376.08
C & E Loss (ft)	0.01	Cum SA (acres)	112.15	32.69	30.99

Alternatives 2/3/5 Profile

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Vel Total	Flow Area	Top W Chnl	Top Width	Hydr Depth C	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(ft/s)	(sq ft)	(ft)	(ft)	(ft)	
TrolleyTrail	51	100-yr	110000	1.81	38.83	23.13	39.47	0.000535	7.59	4.5	24447.41	309.53	1793.07	31.64	0.24
TrolleyTrail	51	500-yr	145000	1.81	42.95	26.92	43.67	0.000535	8.24	4.72	30727.1	309.53	2222.92	35.76	0.24
TrolleyTrail	51	100-yr BW	110000	1.81	47.8	23.13	48.05	0.000168	5.02	2.87	38340.84	309.53	2355.45	40.61	0.14
TrolleyTrail	51	500-yr BW	145000	1.81	56	26.92	56.16	0.000097	4.31	2.34	61908.71	309.53	2769.16	48.81	0.11
TrolleyTrail	51	2-yr	38000	1.81	27.34	14.96	27.8	0.000535	5.62	4.29	8857.21	309.53	1295.16	20.15	0.22
TrolleyTrail	278	100-yr	110000	2.14	38.98	23.84	39.59	0.000536	7.57	4.3	25589.02	300.73	1686.85	31.5	0.24
TrolleyTrail	278	500-yr	145000	2.14	43.15	29.6	43.79	0.000505	7.98	4.52	32087.85	300.73	1998.37	35.67	0.24
TrolleyTrail	278	100-yr BW	110000	2.14	47.86	23.84	48.09	0.000161	4.9	2.79	39456.71	300.73	2173.05	40.38	0.14
TrolleyTrail	278	500-yr BW	145000	2.14	56.01	29.6	56.19	0.00011	4.58	2.44	59473.56	300.73	2544.24	48.52	0.12
TrolleyTrail	278	2-yr	38000	2.14	27.43	15.41	27.95	0.000607	5.94	4.49	8462.6	300.73	1368.49	19.95	0.23
TrolleyTrail	569	100-yr	110000	3.99	38.89	24.39	39.91	0.000808	9.1	5.55	19837.04	308.05	1823.05	30.37	0.29
TrolleyTrail	569	500-yr	145000	3.99	42.99	27.57	44.13	0.000806	9.89	5.91	24519.08	308.05	1862.5	34.47	0.3
TrolleyTrail	569	100-yr BW	110000	3.99	47.78	24.39	48.21	0.000265	6.19	3.66	30025.21	308.05	1917.48	39.26	0.17
TrolleyTrail	569	500-yr BW	145000	3.99	56.02	27.57	56.24	0.000132	4.96	2.61	55629.87	308.05	2174.16	47.5	0.13
TrolleyTrail	569	2-yr	38000	3.99	27.64	16.42	28.13	0.000618	5.85	4.34	8755.13	308.05	702.03	19.12	0.24
TrolleyTrail	877	100-yr	110000	-0.31	38.99	22.58	40.34	0.000887	9.99	6.83	16103.58	283.12	1734.82	33.43	0.3
TrolleyTrail	877	500-yr	145000	-0.31	43.05	25.86	44.61	0.000929	11.02	7.26	19972.58	283.12	1786.79	37.5	0.32
TrolleyTrail	877	100-yr BW	110000	-0.31	47.79	22.58	48.38	0.000317	6.97	4.49	24517.93	283.12	1824.47	42.24	0.19
TrolleyTrail	877	500-yr BW	145000	-0.31	56.04	25.86	56.3	0.000146	5.31	2.85	50867.8	283.12	2223.64	50.49	0.13
TrolleyTrail	877	2-yr	38000	-0.31	27.82	13.32	28.3	0.000487	5.69	4.91	7745.06	283.12	444.94	22.27	0.21
TrolleyTrail	995		Bridge												
TrolleyTrail	1112	100-yr	110000	-4.09	40.01	18.88	40.82	0.000486	7.57	5.72	19223.04	377.5	1713.27	34.85	0.23
TrolleyTrail	1112	500-yr	145000	-4.09	44.28	21.88	45.25	0.000521	8.47	6.09	23802.39	377.5	1780.31	39.12	0.24
TrolleyTrail	1112	100-yr BW	110000	-4.09	48.24	18.88	48.65	0.0002	5.6	3.92	28069.25	377.5	1828.48	43.07	0.15
TrolleyTrail	1112	500-yr BW	145000	-4.09	56.4	21.88	56.8	0.000127	5.01	2.81	51589.51	377.5	2041.88	51.24	0.12
TrolleyTrail	1112	2-yr	38000	-4.09	28.2	10.66	28.49	0.000275	4.32	4.2	9036.91	377.5	459.02	23.04	0.16
TrolleyTrail	1327	100-yr	110000	4.87	39.97	25.65	41.05	0.000925	8.89	6.49	16938.95	391.89	1565.16	27.57	0.3
TrolleyTrail	1327	500-yr	145000	4.87	44.41	28.46	45.4	0.00077	8.96	6.04	23995.57	391.89	1598.4	32.01	0.28
TrolleyTrail	1327	100-yr BW	110000	4.87	48.35	25.65	48.7	0.000252	5.54	3.63	30341.02	391.89	1725	35.95	0.16
TrolleyTrail	1327	500-yr BW	145000	4.87	56.44	28.46	56.71	0.000162	5.08	3.18	45588.31	391.89	3159.22	44.05	0.14
TrolleyTrail	1327	2-yr	38000	4.87	28.09	18.49	28.68	0.000902	6.16	6.16	6169.58	384.74	625.96	16.04	0.27
TrolleyTrail	1516	100-yr	110000	6.09	40.87	26.37	41.24	0.000389	5.75	4.07	27035.69	440.51	2507.3	26.71	0.2
TrolleyTrail	1516	500-yr	145000	6.09	45.26	28.98	45.56	0.000277	5.37	3.9	37215.83	440.51	2569.72	31.09	0.17
TrolleyTrail	1516	100-yr BW	110000	6.09	48.65	26.37	48.76	0.00009	3.28	2.44	45097.87	440.51	2734.09	34.48	0.1
TrolleyTrail	1516	500-yr BW	145000	6.09	56.66	28.98	56.75	0.000052	2.87	2.17	66776.05	440.51	3065.97	42.5	0.08
TrolleyTrail	1516	2-yr	38000	6.09	28.28	19.77	28.86	0.00097	6.08	6.08	6254.36	429.86	1840.25	14.55	0.28
TrolleyTrail	1895	100-yr	110000	6.47	40.89	26.31	41.47	0.000565	7.01	5.25	20946.19	392.94	1733.51	27.65	0.24
TrolleyTrail	1895	500-yr	145000	6.47	45.24	29.21	45.74	0.000435	6.78	4.99	29061.52	392.94	1936.33	32	0.21
TrolleyTrail	1895	100-yr BW	110000	6.47	48.63	26.31	48.82	0.000145	4.18	3.08	35675.45	392.94	1969.52	35.39	0.12
TrolleyTrail	1895	500-yr BW	145000	6.47	56.65	29.21	56.79	0.000087	3.72	2.73	53196.39	392.94	2387.83	43.41	0.1
TrolleyTrail	1895	2-yr	38000	6.47	28.62	18.91	29.23	0.000927	6.26	6.26	6072.92	380.74	1392.94	15.95	0.28
TrolleyTrail	2243	100-yr	110000	7.8	41.07	27.78	41.69	0.00064	7.15	5.55	19832.02	414.48	1592.96	25.94	0.25
TrolleyTrail	2243	500-yr	145000	7.8	45.37	30.6	45.92	0.000496	6.96	5.35	27112.48	414.48	1715.47	30.24	0.22
TrolleyTrail	2243	100-yr BW	110000	7.8	48.67	27.78	48.88	0.000168	4.34	3.35	32806	414.48	1731.29	33.54	0.13
TrolleyTrail	2243	500-yr BW	145000	7.8	56.66	30.6	56.83	0.000102	3.91	2.98	48715.18	414.48	2410.51	41.53	0.11
TrolleyTrail	2243	2-yr	38000	7.8	28.93	19.08	29.61	0.001176	6.6	6.6	5758.35	399.96	1326.27	14.4	0.31
TrolleyTrail	3174	100-yr	110000	6.36	41.35		42.65	0.001058	9.21	8.76	12552.61	458.7	544.7	25.59	0.32
TrolleyTrail	3174	500-yr	145000	6.36	45.25		46.93	0.001134	10.48	9.85	14715.93	458.7	564	29.49	0.34
TrolleyTrail	3174	100-yr BW	110000	6.36	48.52		49.29	0.000456	7.13	6.63	16587.72	458.7	582.15	32.76	0.22
TrolleyTrail	3174	500-yr BW	145000	6.36	56.35		57.2	0.000382	7.53	6.39	22689.29	458.7	1076.25	40.58	0.21
TrolleyTrail	3174	2-yr	38000	6.36	30.07		30.58	0.000902	5.77	5.68	6689.78	458.7	499.67	14.3	0.27
TrolleyTrail	3487	100-yr	110000	9.4	41.19		43.3	0.001636	11.73	10.96	10033.35	350.8	424.04	26.28	0.4
TrolleyTrail	3487	500-yr	145000	9.4	44.92		47.7	0.001813	13.5	12.46	11635.47	350.8	435.09	30.01	0.43
TrolleyTrail	3487	100-yr BW	110000	9.4	48.34		49.62	0.000724	9.16	8.32	13213.47	350.8	488.87	33.43	0.28
TrolleyTrail	3487	500-yr BW	145000	9.4	56.12		57.51	0.000605	9.64	7.94	18270.8	350.8	778.52	41.21	0.26
TrolleyTrail	3487	2-yr	38000	9.4	30.22		30.98	0.00121	7.04	6.83	5561.14	350.8	390.36	15.3	0.32
TrolleyTrail	3790	100-yr	110000	4.96	41.41		44.06	0.0016	13.11	12.39	8874.65	255.6	312.87	32.5	0.41
TrolleyTrail	3790	500-yr	145000	4.96	45.03		48.72	0.001944	15.5	14.45	10035.55	255.6	330.87	36.12	0.45
TrolleyTrail	3790	100-yr BW	110000	4.96	48.34		50.1	0.00083	10.74	9.86	11150.95	255.6	343.23	39.43	0.3
TrolleyTrail	3790	500-yr BW	145000	4.96	55.98		58.07	0.000785	11.75	10.44	13892.81	255.6	380.18	47.07	0.3
TrolleyTrail	3790	2-yr	38000	4.96	30.55		31.28	0.000751	6.85	6.7	5671.07	255.6	280.85	21.64	0.26
TrolleyTrail	3801		Bridge												
TrolleyTrail	3812	100-yr	110000	2.74	41.65	26.49	44.26	0.001534	13.01	12.35	8910.08	251.81	308.24	33.29	0.4
TrolleyTrail	3812	500-yr	145000	2.74	45.36	30.16	49	0.001864	15.38	14.38	10083.47	251.81	326.82	37	0.45
TrolleyTrail	3812	100-yr BW	110000	2.74	48.45	26.49	50.22	0.000816	10.74	9.9	11114.64	251.81	340.27	40.08	0.3
TrolleyTrail	3812	500-yr BW	145000	2.74	56.24	30.16	58.32	0.000767	11.72	10.19	14224.88	251.81	478.23	47.87	0.3
TrolleyTrail	3812	2-yr	38000	2.74	30.64	17.18	31.35	0.000707	6.75	6.62	5741	251.81	274.33	22.28	0.25
TrolleyTrail	4036	100-yr	110000	-4.3	41.78	30.78	44.81	0.002213	14.42	11.48	9582.29	265	464.77	30.79	0.46
TrolleyTrail	4036	500-yr	145000	-4.3	45.65	34.68	49.59	0.002507	16.6	12.87	11270.68	265	477.72	34.66	0.5
TrolleyTrail	4036	100-yr BW	110000	-4.3	48.56	30.78	50.48	0.001098	11.6	8.69	12657.39	265	551.6	37.57	0.33
TrolleyTrail	4036	500-yr BW	145000	-4.3	56.5	34.68	58.52	0.000931	12.13	8.58	16893.39	265	576.89	45.51	0.32
TrolleyTrail	4036	2-yr	38000	-4.3	30.61	19.08	31.67	0.001332	8.28	7.6	5002.92	265	408.41	19.62	0.33
TrolleyTrail	4404	100-yr	110000	11.45	44.11		45.48	0.001001	9.86	7.48	14706.1	342.1	641.31	29.26	0.32
TrolleyTrail	4404	500-yr	145000	11.45	48.62		50.36	0.001064	11.18	8.19	17709.38	342.1	712.51	33.76	0.34
TrolleyTrail	4404	100-yr BW	110000	11.45	49.93		50.84	0.000532	8.11	5.9	18645.48	342.1	713.77	35.07	0.24
TrolleyTrail	4404	500-yr BW	145000	11.45	57.89		58.84	0.000438	8.43	5.95	24354.99	342.1	721.42	43.03	0.23
TrolleyTrail	4404	2-yr	38000	11.45	31.49		32.11	0.000902	6.42	5.44	6990.84	342.1	583.43	16.63	0.28
TrolleyTrail	4884	100-yr	110000	11.52	43.88		46.5	0.001963	13.75	10.18	10806.06	241.6	479.89	29.34	0.45
TrolleyTrail	4884	500-yr	145000	11.52	48.17		51.53	0.002117	15.65	11.16	12991.56	241.6	530.06	33.63	0.48
TrolleyTrail	4884	100-yr BW	110000	11.52	49.7		51.43	0.001034	11.26	7.97	13802.45	241.6	532.32	35.16	0.33
TrolleyTrail	4884	500-yr BW	145000	11.52	57.56		59.38	0.000857	11.73	8.05	18022.63	241.6	540.99	43.02	0.32
TrolleyTrail	4884	2-yr	38000	11.52	31.71		32.81	0.001595	8.67	7.14	5324.94	241.6	418.28	17.17	0.37

Alternatives 2/3/5 Approach Section

Plan: Alt235 ClackamasRiver TrolleyTrail RS: 4036 Profile: 100-yr

E.G. Elev (ft)	44.81	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.02	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	41.78	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	30.78	Flow Area (sq ft)	2319.83	7113.57	148.88
E.G. Slope (ft/ft)	0.002213	Area (sq ft)	2319.83	8134.12	148.88
Q Total (cfs)	110000	Flow (cfs)	7158.53	102551.5	289.96
Top Width (ft)	464.77	Top Width (ft)	187.92	265	11.85
Vel Total (ft/s)	11.48	Avg. Vel. (ft/s)	3.09	14.42	1.95
Max Chl Dpth (ft)	46.08	Hydr. Depth (ft)	12.34	30.79	12.56
Conv. Total (cfs)	2338191	Conv. (cfs)	152163.8	2179863	6163.4
Length Wtd. (ft)	230.18	Wetted Per. (ft)	190.28	251.62	24.35
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	1.68	3.91	0.84
Alpha	1.48	Stream Power (lb/ft s)	5.2	56.31	1.65
Frctn Loss (ft)	0.42	Cum Volume (acre-ft)	1323.65	958.38	118.82
C & E Loss (ft)	0.12	Cum SA (acres)	77.82	33.91	9.35

Plan: Alt235 ClackamasRiver TrolleyTrail RS: 4036 Profile: 100-yr BW

E.G. Elev (ft)	50.48	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.92	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	48.56	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	30.78	Flow Area (sq ft)	3737.43	8678.67	241.29
E.G. Slope (ft/ft)	0.0011	Area (sq ft)	3737.43	9929.58	241.29
Q Total (cfs)	110000	Flow (cfs)	8989.6	100630.7	379.71
Top Width (ft)	551.6	Top Width (ft)	270.96	265	15.64
Vel Total (ft/s)	8.69	Avg. Vel. (ft/s)	2.41	11.6	1.57
Max Chl Dpth (ft)	52.86	Hydr. Depth (ft)	13.79	37.57	15.43
Conv. Total (cfs)	3319202	Conv. (cfs)	271257.3	3036488	11457.5
Length Wtd. (ft)	230.78	Wetted Per. (ft)	274.26	251.62	32.13
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	0.93	2.36	0.51
Alpha	1.63	Stream Power (lb/ft s)	2.25	27.42	0.81
Frctn Loss (ft)	0.22	Cum Volume (acre-ft)	2010.9	1222.24	209.95
C & E Loss (ft)	0.05	Cum SA (acres)	88.32	33.92	12.6

Plan: Alt235 ClackamasRiver TrolleyTrail RS: 4036 Profile: 500-yr

E.G. Elev (ft)	49.59	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.94	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	45.65	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	34.68	Flow Area (sq ft)	3066.82	8005.35	198.51
E.G. Slope (ft/ft)	0.002507	Area (sq ft)	3066.82	9157.15	198.51
Q Total (cfs)	145000	Flow (cfs)	11663.23	132890.1	446.67
Top Width (ft)	477.72	Top Width (ft)	198.84	265	13.87
Vel Total (ft/s)	12.87	Avg. Vel. (ft/s)	3.8	16.6	2.25
Max Chl Dpth (ft)	49.95	Hydr. Depth (ft)	15.42	34.66	14.31
Conv. Total (cfs)	2895956	Conv. (cfs)	232939.3	2654096	8921
Length Wtd. (ft)	230.7	Wetted Per. (ft)	201.87	251.62	28.71
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	2.38	4.98	1.08
Alpha	1.53	Stream Power (lb/ft s)	9.04	82.66	2.43
Frctn Loss (ft)	0.5	Cum Volume (acre-ft)	1675.45	1098.08	160.07
C & E Loss (ft)	0.09	Cum SA (acres)	84.9	33.91	10.74

Plan: Alt235 ClackamasRiver TrolleyTrail RS: 4036 Profile: 500-yr BW

E.G. Elev (ft)	58.52	Element	Left OB	Channel	Right OB
Vel Head (ft)	2.03	Wt. n-Val.	0.12	0.045	0.12
W.S. Elev (ft)	56.5	Reach Len. (ft)	291.78	228.05	192.93
Crit W.S. (ft)	34.68	Flow Area (sq ft)	5971.02	10512.03	410.34
E.G. Slope (ft/ft)	0.00093	Area (sq ft)	5971.02	12032.79	410.34
Q Total (cfs)	145000	Flow (cfs)	16845.01	127519	636.04
Top Width (ft)	576.89	Top Width (ft)	281.5	265	30.39
Vel Total (ft/s)	8.58	Avg. Vel. (ft/s)	2.82	12.13	1.55
Max Chl Dpth (ft)	60.8	Hydr. Depth (ft)	21.21	45.51	13.5
Conv. Total (cfs)	4752120	Conv. (cfs)	552065.5	4179210	20845.2
Length Wtd. (ft)	232.08	Wetted Per. (ft)	292.66	251.62	49.38
Min Ch El (ft)	-4.3	Shear (lb/sq ft)	1.19	2.43	0.48
Alpha	1.77	Stream Power (lb/ft s)	3.35	29.46	0.75
Frctn Loss (ft)	0.2	Cum Volume (acre-ft)	2837.38	1488.77	376.1
C & E Loss (ft)	0.01	Cum SA (acres)	112.15	32.69	30.99

DAVID EVANS AND ASSOCIATES INC

Appendix G: Stormwater Report

DAVID EVANS AND ASSOCIATES INC.

MEMORANDUM

DATE: October 14, 2019

TO: Doug Johnson
David Evans and Associates, Inc.
530 Center Street, Suite 605
Salem, Oregon 97301

FROM: Atalia Raskin, PE Water Resource Engineer

SUBJECT: Trolley Trail Bridge – Stormwater Management Concept Design

PROJECT: CLKX0043
Trolley Trail Bridge

CC: Andy Kutansky

Introduction

City of Gladstone obtained Surface Transportation Program funds through the Regional Flexible Funds Allocation to study the feasibility of rebuilding an abandoned trolley bridge crossing the Clackamas River that collapsed in 2014 as an extension of the Trolley Trail, a shared-use path for bicycles and pedestrians. Clackamas County is helping the City of Gladstone implement the project through the County's Oregon Department of Transportation (ODOT) certification. The study will evaluate bridge and trail alternatives for connections to Gladstone and Oregon City trails.

This memo is intended to provide design details on the stormwater management plan for the two bridge alternatives. The alignment alternatives studied are:

Alternative 1 – Single span steel truss
Alternative 3 – 3-span steel girder

There is no difference in the stormwater design between alternatives from a stormwater management perspective. The proposed bridge crosses the Clackamas River at approximately 4,500 feet upstream of the Willamette River and is located adjacent to the Clackamas River's 100-year floodplain.

Methodology

The project is located in both the City of Gladstone and the City of Oregon City and is administered through the County's ODOT certification. The ODOT 2014 *Hydraulics Manual* and Federal Aid Highway Program Programmatic Biological Opinion (FAHP) were reviewed for stormwater management criteria. Projects discharging directly into the Clackamas River are exempt from flow control requirements by both the ODOT *Hydraulic Manual* and FAHP. Additionally, FAHP does not require water quality for bicycle and pedestrian bridges not associated with a highway.

Stormwater runoff from the bridge flows to the Oregon City side of the bridge. Therefore, stormwater management will follow The City of Oregon City's *Stormwater and Grading Design Standards* dated February 2015 and updated in 2019.

DATE: October 14, 2019

TO: Doug Johnson

FROM: Atalia Raskin, PE Water Resource Engineer

SUBJECT: Trolley Trail Bridge – Stormwater Management Concept Design

The Oregon City standards apply to projects adding over 5,000 square-feet of new or replaced impervious surface area. The project is proposing to add 10,218 square-feet (0.23 acres) of impervious area. Bicycles and foot traffic will use the path with the occasional use by a service vehicle. Section 1.2.2 Exemptions, of the standards lists a set of criteria for projects that are exempt from following the standards. Item E. Pedestrian and bicycle improvements are a noted exception, as long as the following conditions are met:

- No other impervious area is proposed, and;
- Stormwater runoff is directed to adjacent vegetated areas.

Additionally, projects are exempt from the flow control requirement when they are located within the 100-year floodplain or up to 10 feet above the design flood elevation. The project area is within the 100-year floodplain of the Clackamas River. Therefore, no treatment or flow control standards are required for this project.

Dispersion Rain Garden

A small rain garden is proposed to provide stormwater flow dissipation. The rain garden was sized using the Water Environment Service's BMP Sizing Tool, approved for rain garden sizing by the City of Oregon City. Rain gardens are landscaped reservoirs that collect and treat stormwater runoff through vegetation and soil media. Additionally, for the Trolley Trail, the rain garden will provide a location for infiltration and dissipation of stormwater runoff into the vegetated corridor. The rain garden will be placed near the bridge to allow for stormwater runoff from the bridge to be directed to the rain garden. Alternatively, an inlet and pipe can be used to send stormwater to the facility if necessary. A design summary follows:

Site Characteristics:

- Soil Group: Camas Gravelly Sandy Loam, Newberg Fine Sandy Loam, Water
- Hydrologic Soil Group: Group A
- Contributing Area: 10,218 sq.-ft
- Facility Infiltration Rate: A1 (=> 2.00 in/hr)

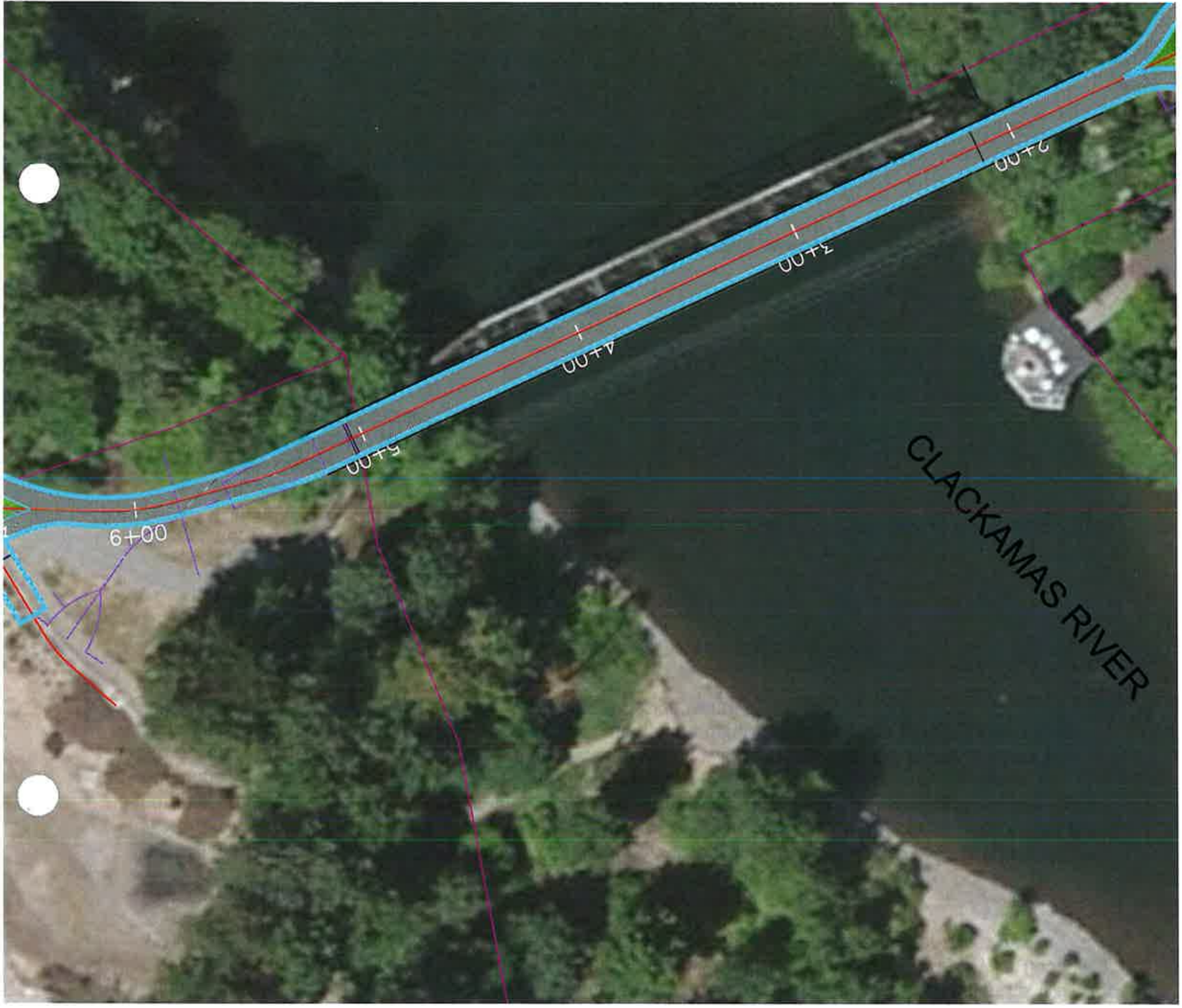
Stormwater Facility Characteristics:

- Minimum Size: 153.27 sq.-ft
- Proposed Size: 154 sq.-ft
- Water Depth: 12 inches
- Soil Media Depth: 18 inches
- Gravel Depth: 12 inches

Attachments:

Exhibit 1: Trolley Trail Bridge Basin Delineation
WES SMP Sizing Tool Report – Rain Garden Infiltration

File Path: P:\W\WPWX00000174\0600INFO\0670Reports\Hydraulic Report\2019-08-06_WashCo Culverts_Detention Memo.docx



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WES BMP Sizing Software Version 1.6.0.2, May 2018

WES BMP Sizing Report

Project Information

Project Name	Trolley Trail Bridge
Project Type	PublicFacilities
Location	Portland Ave
Stormwater Management Area	10218
Project Applicant	Clackamas County
Jurisdiction	OutofDistrict

Drainage Management Area

Name	Area (sq-ft)	Pre-Project Cover	Post-Project Cover	DMA Soil Type	BMP
Trolley Trail	10,218	Forested	ConventionalConcrete	B	BMP

LID Facility Sizing Details

LID ID	Design Criteria	BMP Type	Facility Soil Type	Minimum Area (sq-ft)	Planned Areas (sq-ft)	Orifice Diameter (in)
BMP	WaterQuality	Rain Garden - Infiltration	A1	153.3	154.0	0.0

Pond Sizing Details

1. FCWQT = Flow control and water quality treatment, WQT = Water quality treatment only
2. Depth is measured from the bottom of the facility and includes the three feet of media (drain rock, separation layer and growing media).
3. Maximum volume of the facility. Includes the volume occupied by the media at the bottom of the facility.
4. Maximum water storage volume of the facility. Includes water storage in the three feet of soil media assuming a 40 percent porosity.