APPENDIX A
FIELD INVESTIGATIONS

TABLE A-1

SUMMARY OF EXPLORATORY BORINGS AT ELKHEAD DAM

Number	Study	Purpose	Location
AH-1 — AH-3	ECI, 1973	Dam	Floodplain, within dam embankment limits
AH-4 — AH-6	ECI, 1973	Borrow	NE of dam, Borrow Area 5
AH-7 — AH-12	ECI, 1972	Dam	Along alternate dam axis
AH-13 — AH-15	ECI, 1972	Borrow	NW of dam, Borrow Area 1
AH-16 — AH-20	ECI, 1972	Borrow	NE of dam, under reservoir
DDH-1	ECI, 1973	Dam	Left abutment
DDH-2	ECI, 1973	Dam	Floodplain, within dam embankment limits
MKE-1, MKE-2	MKE, 1985	Dam	Proposed auxiliary spillway, RCC study
WC-1	WCC, 1993	Dam	Right abutment, proposed raise
WC-2, WC-3	WCC, 1993	Dam	Existing embankment
WC-4, WC-5	WCC, 1993	Dam	Floodplain, along crest of proposed raise
WC-6	WCC, 1993	Dam	Proposed power plant
WC-7	WCC, 1993	Dam	Left abutment, proposed raise
WC-8	WCC, 1993	Dam	Proposed spillway
WC-9, WC-10	WCC, 1993	Dam	Proposed emergency spillway
WC-11	WCC, 1993	Dam	Proposed spillway channel

TABLE A-2

SUMMARY OF TEST PITS AT ELKHEAD DAM

Number	Study	Notes
TP-1 — TP-26	ECI, 1973	Original dam study
TP-27 — TP-49	WCC, 1993	Proposed raise
MKTP1 — MKTP7	MKE, 1985	RCC spillway study

TABLE A-3

PIEZOMETER SUMMARY

Drill Hole	Ground Surface Elevation	Bottom of Slotted Interval	Slotted Interval	Date Completed	Water Surface Elevations		
					7/2/93	8/3/93	9/23/93
WC-1	6385.2	77.75′	50′	6/22/93	--	--	6358.6
WC-2	6375.9	69.9′	60′	6/30/93	6346.9	--	6337.6
WC-3	6375.8	94.6′	77′	7/2/93	--	--	6353.8
WC-4	6332.0	37.3′	28.9′	6/24/93	--	6324.3	6324.3
WC-7	6392.2	77.2′	40′	6/20/93	--	6355.1	6355.2

TABLE A-4

SURVEYED LOCATIONS OF TEST HOLES

Test Hole	Northing	Easting	Elevation
WC-1	49584.739	50871.202	6385.184
WC-2	49667.279	51000.797	6375.897
WC-3	49919.895	51439.781	6375.757
WC-4	49855.173	51662.362	6332.050
WC-5	49638.610	51431.028	6306.210
WC-6	49470.671	51745.622	6300.190
WC-7	49873.212	52188.851	6392.209
WC-8	49726.849	52032.735	6352.803
WC-9	50273.120	50250.896	6418.495
WC-10	50314.702	50477.281	6402.299
WC-11	50317.208	49362.855	6357.149

Notes:

1. Survey done by EPP & Associates, Craig, Colorado.
2. Elevations are to natural ground surface.
3. Test hole WC-9A not surveyed.
4. Surveyors were unsure of identities of WC-9 and WC-10.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-1

FEATURE: ELKHEAD RESERVOIR
LOCATION: DAM CREST
BEGUN: 6-21-93 FINISHED: 6-22-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 79.7
DEPTH TO BEDROCK: 5.0

STATE: COLORADO
GROUND ELEVATION: 6385.18
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOW
REVIEWED BY:

NOTES

ALL MEASUREMENTS ARE FROM GROUND LEVEL AND ARE THE SAME AS THOSE USED BY THE DRILLER.

ALL MEASUREMENTS ARE IN FEET EXCEPT WHERE NOTED DIFFERENTLY.

DRILLED BY:
REGIONAL DRILL CREW; L. WASHBURN, DRILLER, L. ZOLEMAN, J.VANAUSDAL, DRILLER HELPERS.

PURPOSE:
SUBSURFACE INVESTIGATION, APPROXIMATELY 150 FT. UPSTREAM OF THE NEW DAM CREST ALONG THE RIGHT ABUTMENT.

DRILL EQUIPMENT:
GUS PECH #1 TRUCK MOUNTED ROTARY DRILL RIG.

DRILL METHOD:
0.0-10.0 - PENETRATION TESTS TAKEN AT 5.0 FT. INCREMENTS FOLLOWED BY A 4-INCH DIAMETER HOLLOW-STEM AUGER THROUGH ALL OVERBURDEN MATERIALS. THE PROCEDURE FOLLOWED WAS TO DRIVE A CALIFORNIA SAMPLER 1.0 FT. COUNTING THE NUMBER OF BLOWS AND MEASURING THE DISTANCE TRAVELED BY EACH TO THE BOTTOM OF THE SAMPLE INTERVAL. THE AUGER WAS THEN ADVANCED TO THE TOP OF THE NEXT ASSIGNED SAMPLE INTERVAL.

10.0-20.0 - AUGERED WITH 4 IN. DIAMETER HOLLOW-STEM AUGER. DISCONTINUED CALIF. SAMPLES DUE TO REFUSAL AT 10.6 FT.

20.0-79.7 - CORED WITH A HQ3 SYSTEM, USING A DIAMOND BIT AND A TRIPLE TUBE CORE BARREL.

CASING RECORD:
0.0-20.0 - 4 INCH DIA (TEMPORARY)
20.0-79.7 HQ3 DIA (TEMPORARY)

DRILLING MEDIUM:
0.0-20.0 NONE
20.0-79.7 RESERVOIR WATER

DRILL FLUID LOSSES:

INTERVAL (FT.)	LOSS (PCT.)
20.0-30.0	15

DEPTH	FLD CLASS/LITH	ELEVATION	% CORE RECOVERY	RQD	FRAC DENSITY	SPT 0	SPT 50
	FILL		100			23	
	(CL) -5.0						50
10							50
20							
			100	91	1		
30							
			100	87	4		
40	clyst. ss						
			79	71	1		
			100	100	1		
50			100	100	1		
60			98	98	0		
70			96	96	0		
	-79.7		BOTTOM OF HOLE				
80							

CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 1.0: ROAD BASE:

1.0 - 5.0: QUATERNARY RESIDUAL SOIL (Qrs):

1.0 - 5.0: LEAN CLAY:
ABOUT 90% FINES WITH MEDIUM PLASTICITY. SLOW TO NO DILATANCY MEDIUM TO HIGH TOUGHNESS, MEDIUM TO HIGH DRY STRENGTH; ABOUT 10% PREDOMINANTLY FINE TO VERY FINE SAND; MAXIMUM SIZE, FINE SAND; FIRM, DRY TO MOIST; BROWN TO GRAY TO DARK GRAY; EASY T AUGER; STRONG REACTION WITH HCl. (CL)

5.0 - 79.7: TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl):

5.0 - 79.7: INTERBEDDED CLAYSTONE AND SANDSTONE:
CONSISTS OF APPROXIMATELY 39% CLAYSTONE AND 61% SANDSTONE.

CLAYSTONE IS OCCASIONALLY SANDY, LIGHT GRAY TO DARK GRAY, GENERALLY LAMINATED TO VERY THINLY BEDDED (LESS THAN 3/8 IN. TO 0.1 FT.); SLIGHTLY WEATHERED TO FRESH (W2). SOME Fe STAINING OCCURS IN MINOR AMOUNTS ON SOME NATURAL JOINTS AND FRACTURES, SEE AS NOTED BELOW; SOFT TO MODERATELY SOFT (H5-H8) AND BREAKS WITH LIGHT TO HEAVY HAND PRESSURE; NO REACTI WITH HCL.

SANDSTONE IS OCCASIONALLY CLAYEY; LIGHT GRAY TO DARK GRAY; SOME BROWN OXIDIZED AREAS; FINE GRAINED TO VERY FINE GRAINED POORLY TO WELL CEMENTED; GENERALLY THINLY TO THICKLY BEDDED (0.1 FT. TO 3.0 FT.); SLIGHTLY TO FRESH WEATHERED (W2), Fe STAINING OCCURS IN MINOR AMOUNTS OF ROCK AND ON SOME NATURAL JOINTS AND FRACTURES, SEE AS NOTED BELOW; SOFT TO HARD (H3-H5) AND BREAKS WITH LIGHT HAND PRESSURE TO HEAVY HAMMER BLOW; NO REACTION WITH HCL THROUGH POORLY CEMENTED AREAS AND MODERATE TO STRONG REACTION THROUGH WELL CEMENTED AREAS.

THE OVERALL INTERVAL HAS PREDOMINANTLY PLANAR BEDDING 70 TO 90 DEGREES FROM CORE AXIS. SOME UNDULATION OF BEDS; CONTAINS A SMALL COAL BED FROM 57.0 TO 58.7 FT. AND SOME MINOR COAL AND CLAY SEAMS TO 1/16 IN. THICK; PREDOMINATELY VERY SLIGHTL FRACTURED TO UNFRACTURED (FD0 -FD1), WITH THE EXCEPTION OF MODERATELY TO SLIGHTLY FRACTURED (FD4) FROM 30.0 TO 40.0 FT.

8 JOINTS AT 10 TO 30 DEGREES; TIGHT TO OPEN; SLIGHTLY TO MODERATELY ROUGH; SIGHTLY WEATHERED TO FRESH; SPACED 0.1 5.6 FT. APART FROM 28.5 TO 47.8 FT.

5.0 - 5.7 LAB TEST DATA - WATER CONTENT = 12%

10.0 - 10.6 LAB TEST DATA - 99% FINES, 1% SAND, LL = 38, PI = 15, WATER CONTENT = 12% (CL)

21.5 - LAB TEST DATA - 87% FINES, 13% SAND, LL = NP, PI = NP, WATER CONTENT = 5%, SPECIFIC GRAVITY =2.63. (ML)

32.0 - LAB TEST DATA - 67% SAND, 33% FINES, WATER CONTENT = 6%, SPECIFIC GRAVITY =2.51.

62. 0 - LAB TEST DATA - 97% FINES, 3% SAND, LL = 39, PI = 17

COMMENTS:

ALL MEASUREMENTS ARE DEPTHS SUBTRACTED FROM GROUND SURFACE. ELEVATIONS WERE NOT AVAILABLE AT THIS TIME.

SAMPLES FROM CALIFORNIA SAMPLER AND DRILL CORE WERE SELECTED AND LABORATORY TESTED AS DIRECTED BY WOODWARD-CLYDE CONSULTANTS.

DIFFERENCES BETWEEN FIELD AND LAB CLASSIFICATION OF SOILS ARE A RESULT OF FURTHER WORKING (BREAKING DOWN) OF MATERIAL DURING GRADATION TESTING, RESULTING IN AN INCREASE IN PERCENTAGE OF FINES AND A DECREASE IN PERCENTAGE OF COARSE PARTICLES.

CENTER COLUMN DATA IS NOT SHOWN IN INTERVALS OF LESS THAN 1.0 FT.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-1

FEATURE: ELKHEAD RESERVOIR
LOCATION: DAM CREST
BEGUN: 6-21-93 FINISHED: 6-22-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 79.7
DEPTH TO BEDROCK: 5.0

STATE: COLORADO
GROUND ELEVATION: 6385.18
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DON
REVIEWED BY:

NOTES

30.0-40.0 15
40.0-47.6 25
47.6-50.0 25
50.0-60.0 25
60.0-70.0 15
70.0-79.7 15

TESTING AND SAMPLING:
SOIL SAMPLES WERE TAKEN FROM THE FOLLOWING INTERVALS.
0.0-1.0
5.0-5.7
10.0-10.6
SELECTED SAMPLES WERE LABORATORY TESTED FOR NATURAL MOISTURES, DENSITIES, GRADATION, HYDROMETER, AND ATTERBERG LIMITS. RESULTS ARE SHOWN IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN.

CORE RECOVERY:

INTERVAL (FT.)	RECOVERY (%)
5.0-5.6	100
10.0-10.5	100

ALL OTHER CORE RECOVERY IS REPORTED IN THE CORE RECOVERY COLUMN.

HOLE COMPLETION:
HQ3 DIAMETER CASING WAS REMOVED. INSTALLED ONE 1/2 INCH DIAMETER RISER. PIEZOMETER WAS INSTALLED TO 77.25 FT. THE BOTTOM 50.0 FT. SLOTTED WITH A 2.0 FT. BLANK FROM 79.25 TO 77.25 FT. A BENTONITE PLUG WAS INSTALLED FROM 24.8 TO 21.4 FT. CEMENT GROUT WAS INSTALLED FROM 21.4 FT. TO THE SURFACE. THE REMAINDER OF THE HOLE WAS BACKFILLED WITH 10-20 SILICA SAND.

A FLUSH FITTING BOLT DOWN STEEL CAP WAS EMBEDDED IN CEMENT WITH NO STICK UP ABOVE GROUND LEVEL.

CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)

WATER CONTENT = 10%, SPECIFIC GRAVITY =2.67. (CL)

STRATIGRAPHY:

0.0 - 1.0 ROAD BASE
1.0 - 5.0 QUATERNARY RESIDUAL SOIL (Qrs)
5.0 - 79.7 TERTIARY FORT UNION / CRETACEOUS LANCE FORMATIONS (Tf/Kl) - UNDIFFERENTIATED

COMMENTS:
THICKNESS. THE DATA FOR THESE INTERVALS CAN BE FOUND IN EITHER THE "NOTES" OR "CLASSIFICATION AND PHYSICAL CONDITION" COLUMNS.

DATA PRESENTED IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN, AND CENTER COLUMN ARE BASED ON BUREAU OF RECLAMATION ENGINEERING GEOLOGY MANUAL.

ALL ANGLES MEASURED FROM THE CORE AXIS AT ZERO DEGREES.

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

FEATURE: ELKHEAD RESERVOIR
LOCATION: DAM CREST
BEGUN: 6-29-93 FINISHED: 6-30-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 71.9
DEPTH TO BEDROCK: 70.7

STATE: COLORADO
GROUND ELEVATION: 6375.90
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOM
REVIEWED BY:

NOTES

ALL MEASUREMENTS ARE FROM GROUND LEVEL AND ARE THE SAME AS THOSE USED BY THE DRILLER.

ALL MEASUREMENTS ARE IN FEET EXCEPT WHERE NOTED DIFFERENTLY.

DRILLED BY:
REGIONAL DRILL CREW: L. WASHBURN, DRILLER, L. ZOLEMAN, J.VANAUSDAL, DRILLER HELPERS.

PURPOSE:
SUBSURFACE INVESTIGATION, DAM CREST ALONG THE RIGHT ABUTMENT.

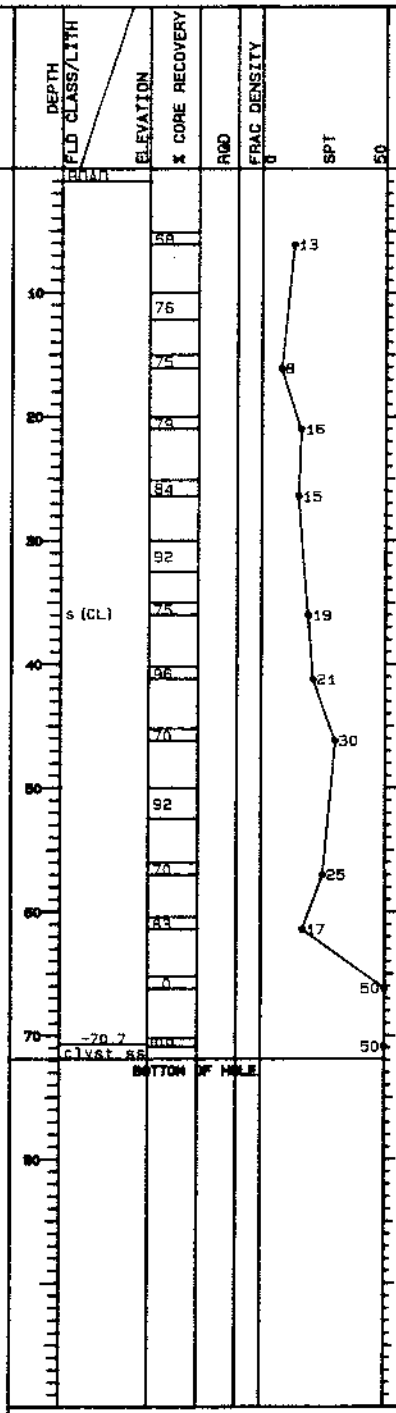
DRILL EQUIPMENT:
GUS PECH #1 TRUCK MOUNTED ROTARY DRILL RIG.

DRILL METHOD:
0.0 - 71.9 - PENETRATION TESTS TAKEN AT 5.0 FT. INCREMENTS FOLLOWED BY A 4-INCH DIAMETER HOLLOW-STEM AUGER THROUGH ALL OVERBURDEN MATERIALS. THE PROCEDURE FOLLOWED WAS TO DRIVE A CALIF. SAMPLER 1.0 FT. COUNTING THE NUMBER OF BLOWS AND MEASURING THE DISTANCE TRAVELED BY EACH TO THE BOTTOM OF THE SAMPLE INTERVAL. THE AUGER WAS THEN ADVANCED TO THE TOP OF THE NEXT ASSIGNED SAMPLED INTERVAL. A 3" SHELBY TUBE PENETRATION TEST WAS PERFORMED AT 10.0, 30.0, AND 50.0 FT.

CASING RECORD:
0.0-71.9 - 4 INCH DIA (TEMPORARY)

DRILLING MEDIUM:
0.0-71.9 NONE

TESTING AND SAMPLING:
SOIL SAMPLES WERE TAKEN FROM THE FOLLOWING INTERVALS.
5.1 - 6.1
10.0-12.2
15.0-16.1
20.0-21.0
25.1-26.4
30.0-32.5
35.0-36.0
40.2-41.2
45.2-46.2
50.0-52.5
56.0-57.0
60.4-61.4
65.2-66.2
70.2-70.9



CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 1.0: **ROAD BASE:**

1.0 - 70.7: **DAM EMBANKMENT:**

1.0 - 70.7: **SANDY LEAN CLAY:**
ABOUT 80% FINES WITH MEDIUM PLASTICITY, SLOW TO NO DILATANCY, MEDIUM TO HIGH TOUGHNESS, MEDIUM TO HIGH DRY STRENGTH; ABOUT 20% PREDOMINANTLY FINE TO VERY FINE SAND; MAXIMUM SIZE, FINE SAND; FIRM; DRY TO WET; BROWN TO GRAY TO DARK GRAY; EASY TO AUGER, SANDY IN SOME AREAS; STRONG REACTION WITH HCl. s (CL)

5.1-6.1 LAB TEST DATA - IN-PLACE DRY UNIT WEIGHT = 111.9 PCF., WATER CONTENT = 12%.

15.0-16.1 LAB TEST DATA - 76% SAND, 24% FINES. LL = NP, PI = NP, WATER CONTENT = 19%. (SM)

20.0-21.0 LAB TEST DATA - 58% FINES, 42% SAND, LL = 30, PI = 13, WATER CONTENT = 17%. IN-PLACE DRY UNIT WEIGHT = 109.9 PCF. s (CL)

25.1-26.4 LAB TEST DATA - WATER CONTENT = 17%

35.0-36.0 LAB TEST DATA - WATER CONTENT = 22%

40.2-41.2 LAB TEST DATA - 95% FINES, 5% SAND, LL = 34, PI = 14, WATER CONTENT = 18%. (CL)

45.2-46.2 LAB TEST DATA - IN-PLACE DRY UNIT WEIGHT = 105.4 PCF., WATER CONTENT = 18%.

56.0-57.0 LAB TEST DATA - 82% FINES, 12% SAND, LL = NA, PI = NA, WATER CONTENT = 18%, IN-PLACE DRY UNIT WEIGHT = 108.9 PCF.

60.4-61.4 LAB TEST DATA - 93% FINES, 7% SAND, LL = 24, PI = 69, WATER CONTENT = 16%. (CL)

70.7 - 71.9: **TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED:**

70.7 - 71.9: **CRUSHED CLAYSTONE AND SANDSTONE:**
RETRIEVED AS CLAY AND SAND SIZED FRAGMENTS FROM POWER AUGER HOLE, DRY TO MOIST, TAN, SOME IRON STAINING OF SAND SIZE FRAGMENTS, WEAK TO STRONG REACTION WITH HCl, MODERATELY HARD TO HARD TO AUGER.

70.2-70.9 LAB TEST DATA - 98% FINES, 2% SAND, LL = 41, PI = 17, WATER CONTENT = 16%, IN-PLACE DRY UNIT WEIGHT = 114.9 PCF. (CL)

STRATIGRAPHY:

0.0 - 1.0 ROAD BASE
1.0 - 70.9 DAM EMBANKMENT
70.9 - 71.9 TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED

COMMENTS:

ALL MEASUREMENTS ARE DEPTHS SUBTRACTED FROM GROUND SURFACE. ELEVATIONS WERE NOT AVAILABLE AT THIS TIME.

SAMPLES FROM CALIFORNIA SAMPLER AND DRILL CORE WERE SELECTED AND LABORATORY TESTED AS DIRECTED BY WOODWARD-CLYDE CONSULTANTS.

DIFFERENCES BETWEEN FIELD AND LAB CLASSIFICATION OF SOILS ARE A RESULT OF FURTHER WORKING (BREAKING DOWN) OF MATERIAL DURING GRADATION TESTING, RESULTING IN AN INCREASE IN PERCENTAGE OF FINES AND A DECREASE IN PERCENTAGE OF COARSE PARTICLES.

CENTER COLUMN DATA IS NOT SHOWN IN INTERVALS OF LESS THAN 1.0 FT.

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

FEATURE: ELKHEAD RESERVOIR
LOCATION: DAN CREEK
BEGUN: 6-29-93 FINISHED: 6-30-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 71.9
DEPTH TO BEDROCK: 70.7

STATE: COLORADO
GROUND ELEVATION: 6375.90
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: X. DOW
REVIEWED BY:

NOTES

SELECTED SAMPLES WERE LABORATORY TESTED FOR NATURAL MOISTURES, DENSITIES, GRADATION, HYDROMETER, AND ATTERBERG LIMITS. RESULTS ARE SHOWN IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN.

HOLE COMPLETION:
INSTALLED ONE 1/2 INCH PVC DIAMETER RISER. THE PIEZOMETER WAS INSTALLED TO 71.9 FT. WITH 2.0 FT. UNSLOTTED PIECE ON THE BOTTOM FROM 71.9 TO 69.9 FT. THEN 60.0 FT. OF SLOTTED FROM 69.9 TO 9.9 FT. 10.0 FT. OF UNSLOTTED PVC WAS INSTALLED TO THE SURFACE. 10-20 SILICA SAND WAS PLACED TO 8.2 FT. A BENTONITE PLUG WAS INSTALLED FROM 8.2 TO 4.5 FT. THE REMAINDER OF THE HOLE WAS BACKFILLED WITH CEMENT GROUT.

A FLUSH FITTING BOLT DOWN STEEL CAP WAS EMBEDDED IN CEMENT WITH NO STICK UP ABOVE GROUND LEVEL.

COMMENTS:
THICKNESS. THE DATA FOR THESE INTERVALS CAN BE FOUND IN EITHER THE "NOTES" OR "CLASSIFICATION AND PHYSICAL CONDITION" COLUMNS.

DATA PRESENTED IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN, AND CENTER COLUMN ARE BASED ON BUREAU OF RECLAMATION ENGINEERING GEOLOGY MANUAL.

ALL ANGLES MEASURED FROM THE CORE AXIS AT ZERO DEGREES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-3

FEATURE: ELKHEAD RESERVOIR
LOCATION: DAM CREST
BEGUN: 7-1-93 FINISHED: 7-2-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 29.2 (-29.20) 7-2-93

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 97.6
DEPTH TO BEDROCK: 88.3

STATE: COLORADO
GROUND ELEVATION: 6375.76
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOM
REVIEWED BY:

NOTES

ALL MEASUREMENTS ARE FROM GROUND LEVEL AND ARE THE SAME AS THOSE USED BY THE DRILLER.

ALL MEASUREMENTS ARE IN FEET EXCEPT WHERE NOTED DIFFERENTLY.

DRILLED BY:
REGIONAL DRILL CREW: L. ZOLEMAN DRILLER, J.VANAUSDAL, G. LARSEN, DRILLER HELPERS.

PURPOSE:
SUBSURFACE INVESTIGATION, DAM CREST, APPROX. CENTER OF EMBANKMENT.

DRILL EQUIPMENT:
GUS PECH #1 TRUCK MOUNTED ROTARY DRILL RIG.

DRILL METHOD:
0.0 - 88.3- PENETRATION TESTS TAKEN AT 5.0 FT. INCREMENTS FOLLOWED BY A 4-INCH DIAMETER HOLLOW-STEM AUGER USING A WIRELINE SYSTEM TO RETRIEVE ALL OVERBURDEN SAMPLES. THE PROCEDURE FOLLOWED WAS TO DRIVE A CALIF. SAMPLER 1.0 FT. COUNTING THE NUMBER OF BLOWS AND MEASURING THE DISTANCE TRAVELED BY EACH TO THE BOTTOM OF THE SAMPLE INTERVAL. THE AUGER WAS THEN ADVANCED TO THE TOP OF THE NEXT ASSIGNED SAMPLED INTERVAL. A 3" SHELBY TUBE PENETRATION TEST WAS PERFORMED AT APPROX. 10.0, 30.0, AND 50.0 FT.

88.3 - 97.6 - CORED WITH A HQ WIRELINE SYSTEM, USING A DIAMOND BIT AND A TRIPLE TUBE CORE BARREL.

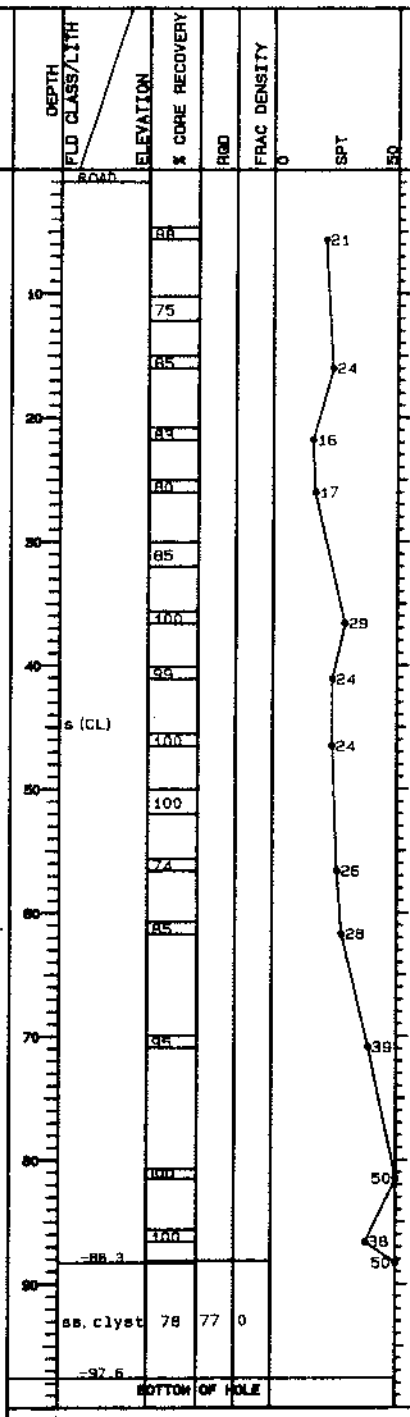
CASING RECORD:
0.0-88.3 - 4 INCH DIA (TEMPORARY)
88.3-97.6 HQWL DIA (TEMPORARY)

DRILLING MEDIUM:
0.0-88.3 NONE
88.3-97.6 RESERVOIR WATER

DRILL FLUID LOSSES:

INTERVAL (FT.)	LOSS (PCT.)
88.3-97.6	100

TESTING AND SAMPLING:
SOIL SAMPLES WERE TAKEN FROM THE FOLLOWING



CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 1.0: **ROAD BASE:**

1.0 - 88.3: **DAM EMBANKMENT:**

1.0 - 88.3: **SANDY LEAN CLAY:**
ABOUT 60-70% FINES WITH MEDIUM PLASTICITY, SLOW TO NO DILATANCY, MEDIUM TO HIGH TOUGHNESS, MEDIUM TO HIGH DRY STRENGTH; ABOUT 30-40% PREDOMINANTLY FINE TO VERY FINE SAND; MAXIMUM SIZE, FINE SAND; FIRM; DRY TO WET; BROWN TO GRAY TO DARK GRAY; EASY TO AUGER; SANDY IN SOME AREAS; STRONG REACTION WITH HCl. s (CL)

4.6 - 5.6 - LAB TEST DATA - WATER CONTENT = 8%.

15.0-16.0 - LAB TEST DATA - 59% SAND, 41% FINES, LL = 23, PI = 4, WATER CONTENT = 15.7%. (ML)

20.8-21.8 - LAB TEST DATA - IN-PLACE DRY UNIT WEIGHT = 101.6 PCF., WATER CONTENT = 21%

25.0-26.0 - LAB TEST DATA - WATER CONTENT = 20%.

35.6-36.6 - LAB TEST DATA - 54% SAND, 46% FINES, LL = 27, PI = 11, WATER CONTENT = 15%., IN-PLACE DRY UNIT WEIGHT = 114.4 PCF (SC-CL)

40.1-41.1 - LAB TEST DATA - WATER CONTENT = 18%.

45.5-46.5 - LAB TEST DATA - WATER CONTENT = 20%.

55.5-56.5 - LAB TEST DATA - 71% FINES, 29% SAND, LL = 36, PI = 17, WATER CONTENT = 19.4%. (CL)

60.7-61.7 - LAB TEST DATA - WATER CONTENT = 17%

69.9-70.9 - LAB TEST DATA - 60% SAND, 40% FINES, LL = 31, PI = 15, WATER CONTENT = 18%. (SC)

80.7-81.5 - LAB TEST DATA - WATER CONTENT = 14%

85.5-86.5 - LAB TEST DATA - 76% FINES, 24% SAND, LL = 30, PI = 14, WATER CONTENT = 19%. (CL)

88.3 - 97.6: **TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED:**

88.3 - 97.6: **SANDSTONE AND CLAYSTONE:**
CONSISTS OF APPROXIMATELY 58% SANDSTONE AND 42% CLAYSTONE.

SANDSTONE IS OCCASIONALLY CLAYEY AND CARBONACEOUS WITH A COAL INTERBED FROM 93.5 TO 93.9 FT.; LIGHT GRAY TO BLACK; FINE GRAINED; POORLY CEMENTED; GENERALLY THINLY TO THICKLY BEDDED (0.2 TO 1.1 FT.); FRESH (W1); SOFT TO MODERATELY SOFT (H5-H6) AND BREAKS WITH LIGHT TO MODERATE HAND PRESSURE TO LIGHT HAMMER BLOW; WEAK TO NO REACTION WITH HCl.

CLAYSTONE IS OCCASIONALLY SANDY, LIGHT GRAY TO BLACK, GENERALLY LAMINATED TO VERY THINLY BEDDED (LESS THAN 3/8 IN. TO 0.1 FT.); FRESH (W1); SOFT TO MODERATELY SOFT (H5-H6)

COMMENTS:

ALL MEASUREMENTS ARE DEPTHS SUBTRACTED FROM GROUND SURFACE. ELEVATIONS WERE NOT AVAILABLE AT THIS TIME.

SAMPLES FROM THE CALIFORNIA SAMPLER AND DRILL CORE WERE SELECTED AND LABORATORY TESTED AS DIRECTED BY WOODWARD-CLYDE CONSULTANTS.

DIFFERENCES BETWEEN FIELD AND LAB CLASSIFICATION OF SOILS ARE A RESULT OF FURTHER WORKING (BREAKING DOWN) OF MATERIAL DURING GRADATION TESTING, RESULTING IN AN INCREASE IN PERCENTAGE OF FINES, AND A DECREASE IN PERCENTAGE OF COARSE PARTICLES.

CENTER COLUMN DATA IS NOT SHOWN IN INTERVALS OF LESS THAN 1.0 FT.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-3

FEATURE: ELKHEAD RESERVOIR
LOCATION: DAM CREST
BEGUN: 7-1-93 FINISHED: 7-2-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 29.2 (-29.20) 7-2-93

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 97.6
DEPTH TO BEDROCK: 88.3

STATE: COLORADO
GROUND ELEVATION: 6375.76
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOW
REVIEWED BY:

NOTES	CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)

INTERVALS.
4.6 - 5.6
10.2-12.2
15.0-16.0
20.8-21.8
25.0-26.0
30.0-32.0
35.6-36.6
40.1-41.1
45.5-46.5
50.0-52.0
55.6-56.6
60.7-61.7
69.9-70.9
80.7-81.5
85.6-86.6
88.1-88.3
88.3-88.5

SELECTED SAMPLES WERE LABORATORY TESTED FOR NATURAL MOISTURES, DENSITIES, GRADATION, HYDROMETER, AND ATTERBERG LIMITS. RESULTS ARE SHOWN IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN.

SHELBY TUBE SAMPLES WERE TAKEN BY WOODWARD-CLYDE CONSULTANTS FOR TESTING.

CORE RECOVERY:

INTERVAL (FT.)	RECOVERY (%)
88.1-88.3	0

ALL OTHER CORE RECOVERY IS REPORTED IN THE CORE RECOVERY COLUMN.

HOLE COMPLETION:
HQ WIRELINE DIAMETER CASING WAS REMOVED. INSTALLED ONE 1/2 INCH DIAMETER RISER. THE PIEZOMETER WAS INSTALLED TO 96.7 FT. WITH THE BOTTOM 2.1 FT. UNSLOTTED. SLOTTED PVC WAS THEN INSTALLED FROM 94.6 TO 17.6 FT. 10-20 SILICA SAND WAS PLACED TO 35.0 FT. AND THEN PEA GRAVEL TO 12.0 FT. A BENTONITE PLUG WAS INSTALLED FROM 12.0 TO 7.0 FT. THE REMAINDER OF THE HOLE WAS BACKFILLED WITH CEMENT GROUT.

A FLUSH FITTING BOLT DOWN STEEL CAP WAS EMBEDDED IN CEMENT WITH NO STICK UP ABOVE GROUND LEVEL.

WATER LEVEL DATA:

BEGINNING OF DATE 1993	SHIFT HOLE DEPTH	WATER
7-2-93	88.1	29.2

AND BREAKS WITH LIGHT TO HEAVY HAND PRESSURE; NONE REACTION WITH HCl.

THE OVERALL INTERVAL HAS PREDOMINANTLY PLANAR BEDDING 70 TO 90 DEGREES FROM CORE AXIS, SOME UNDULATION OF BEDS; CONTAINS A SMALL COAL BED FROM 93.5 TO 93.9 FT.; UNFRACTURED (FDO).

88.3-88.5 - LAB TEST DATA - 83% SAND, 17% FINES, WATER CONTENT = 11%, SPECIFIC GRAVITY = 2.60

STRATIGRAPHY:

0.0 - 1.0	ROAD BASE
1.0 - 88.3	DAM EMBANKMENT
88.3 - 97.6	TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED

COMMENTS:
THICKNESS. THE DATA FOR THESE INTERVALS CAN BE FOUND IN EITHER THE "NOTES" OR "CLASSIFICATION AND PHYSICAL CONDITION" COLUMNS.

DATA PRESENTED IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN, AND CENTER COLUMN ARE BASED ON THE BUREAU OF RECLAMATION ENGINEERING GEOLOGY MANUAL.

ALL ANGLES MEASURED FROM THE CORE AXIS AT ZERO DEGREES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-4

FEATURE: ELKHEAD RESERVOIR
LOCATION: DOWNSTREAM FACE
BEGUN: 6-23-93 FINISHED: 6-24-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 40.0
DEPTH TO BEDROCK: 8.6

STATE: COLORADO
GROUND ELEVATION: 6332.05
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DBW
REVIEWED BY:

NOTES

ALL MEASUREMENTS ARE FROM GROUND LEVEL AND ARE THE SAME AS THOSE USED BY THE DRILLER.

ALL MEASUREMENTS ARE IN FEET EXCEPT WHERE NOTED DIFFERENTLY.

DRILLED BY:
REGIONAL DRILL CREW; L. WASHBURN, DRILLER; L. ZOLEMAN, J. VANALUSDAL, DRILLER HELPERS.

PURPOSE:
SUBSURFACE INVESTIGATION. DOWNSTREAM FACE, NEAR EXITING SPILLWAY.

DRILL EQUIPMENT:
GUS PECH #1 TRUCK MOUNTED ROTARY DRILL RIG.

DRILL METHOD:
0.0 - 8.6 - PENETRATION TESTS TAKEN AT 5.0 FT. INCREMENTS FOLLOWED BY A 4-INCH DIAMETER HOLLOW-STEM AUGER. THE PROCEDURE FOLLOWED WAS TO DRIVE A CALIFORNIA SAMPLER 1.0 FT. COUNTING THE NUMBER OF BLOWS AND MEASURING THE DISTANCE TRAVELED BY EACH TO THE BOTTOM OF THE SAMPLED INTERVAL. THE AUGER WAS THEN ADVANCED TO THE TOP OF THE NEXT ASSIGNED SAMPLE INTERVAL.

8.6 - 40.0 - CORED WITH A HQ3 SYSTEM. USING BOTH A DIAMOND AND A POPCORN BIT AND TRIPLE TUBE CORE BARREL.

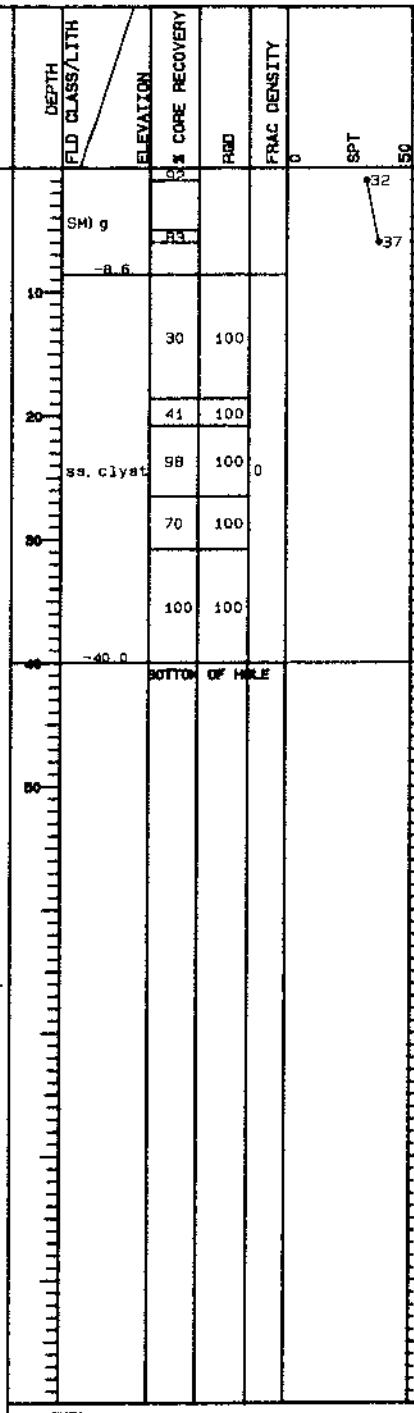
CASING RECORD:
0.0-8.6 - 4 INCH DIA (TEMPORARY)
8.6-40.0 HQ3 DIA (TEMPORARY)

DRILLING MEDIUM:
0.0-8.6 NONE
8.6-40.0 RESERVOIR WATER

DRILL FLUID LOSSES:

INTERVAL (FT.)	LOSS (PCT.)
8.6-26.5	10
26.5-30.8	5
30.8-40.0	5

TESTING AND SAMPLING:
SOIL SAMPLES WERE TAKEN FROM THE FOLLOWING INTERVALS.
0.0-1.0
5.0-6.0



CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 8.6: QUATERNARY ALLUVIUM (Qal):

0.0 - 8.6: SILTY SAND WITH GRAVEL:
ABOUT 60% PREDOMINANTLY FINE TO COARSE SAND; ABOUT 25% FINES WITH MEDIUM TO LOW PLASTICITY, SLOW TO NO DILATANCY. MEDIUM TO HIGH TOUGHNESS, MEDIUM TO HIGH DRY STRENGTH; ABOUT 15% COARSE TO FINE, HARD, SUBROUNDED TO ROUNDED GRAVEL, MAXI SIZE. COARSE GRAVEL; DRY; TAN; STRONG REACTION WITH HCl. (SM

0.0 - 1.0 - LAB TEST DATA - 52% SAND, 48% FINES, LL = 20, PI = 4, WATER CONTENT = 9%. (SC/SM)

5.0 - 6.0 - LAB TEST DATA - 74% SAND, 26% FINES, LL = 23, PI = 3, WATER CONTENT = 7%. (SM)

8.6 - 40.0: TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED:

8.6 - 40.0: SANDSTONE AND CLAYSTONE:
CONSISTS OF APPROXIMATELY 77% SANDSTONE AND 23% CLAYSTONE.

SANDSTONE IS OCCASIONALLY CLAYEY AND CARBONACEOUS; LIGHT GRA TO BLACK TO TAN; FINE TO VERY FINE GRAINED; GENERALLY LAMINAT TO THICKLY BEDDED (LESS THAN 3/8 IN. TO 1.0 FT.); WELL CEMENTED AREAS ARE FRESH TO SLIGHTLY WEATHERED (W2); HARD (H3 AND HAD A STRONG REACTION WITH HCl; POORLY CEMENTED AREAS AF FRESH TO MODERATELY WEATHERED (W1-W4), MODERATELY SOFT TO HAF (H3-H5), AND HAD NO TO WEAK REACTION WITH HCl.

CLAYSTONE IS OCCASIONALLY SANDY AND CARBONACEOUS; GRAY TO BLACK; GENERALLY LAMINATED TO VERY THINLY BEDDED (LESS THAN 3 IN. TO 0.1 FT.); FRESH (W1); SOFT TO MODERATELY SOFT (H4-H5) AND BREAKS WITH LIGHT TO MODERATE HAND PRESSURE TO LIGHT HAMM BLOW; NO TO STRONG REACTION WITH HCl.

THE OVERALL INTERVAL HAS PREDOMINANTLY PLANAR BEDDING 78 TO 9 DEGREES FROM THE CORE AXIS; CONTAINS SMALL COAL SEAMS TO 1/4 IN. THICK, AND A COAL INTERBED FROM 38.4 TO 38.7 FT.; UNFRACTURED (FD0).

STRATIGRAPHY:

0.0 - 8.6 QUATERNARY ALLUVIUM (Qal)
8.6 - 40.0 TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED.

COMMENTS:

ALL MEASUREMENTS ARE DEPTHS SUBTRACTED FROM GROUND SURFACE. ELEVATIONS WERE NOT AVAILABLE AT THIS TIME.

SAMPLES FROM CALIFORNIA SAMPLER AND DRILL CORE WERE SELECTED AND LABORATORY TESTED AS DIRECTED BY WOODWARD-CLYDE CONSULTANTS.

DIFFERENCES BETWEEN FIELD AND LAB CLASSIFICATION OF SOILS ARE A RESULT OF FURTHER WORKING (BREAKING DOWN) OF MATERIAL DURING GRADATION TESTING, RESULTING IN AN INCREASE IN PERCENTAGE OF FINES, AND A DECREASE IN PERCENTAGE OF COARSE PARTICLES.

CENTER COLUMN DATA IS NOT SHOWN IN INTERVALS OF LESS THAN 1.0 FT.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-4

FEATURE: ELKHEAD RESERVOIR
LOCATION: DOWNSTREAM FACE
BEGUN: 5-23-83 FINISHED: 5-24-83
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 40.0
DEPTH TO BEDROCK: 6.8

STATE: COLORADO
GROUND ELEVATION: 6332.05
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOW
REVIEWED BY:

NOTES

SELECTED SAMPLES WERE LABORATORY TESTED FOR NATURAL MOISTURES, DENSITIES, GRADATION, HYDROMETER, AND ATTERBERG LIMITS. RESULTS ARE SHOWN IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN.

HOLE COMPLETION:
HQ3 DIAMETER CASING WAS REMOVED. INSTALLED ONE 1/2 INCH DIAMETER RISER. PIEZOMETER WAS INSTALLED TO 39.3 FT. WITH THE BOTTOM 2.0 FT. UNSLOTTED. SLOTTED PVC WAS INSTALLED FROM 37.3 TO 8.4 FT. THEN UNSLOTTED TO SURFACE. 10-20 SILICA SAND WAS PLACED TO 6.8 FT. A BENTONITE PLUG WAS INSTALLED FROM 6.8 TO 4.4 FT. THE REMAINDER OF THE HOLE WAS BACKFILLED WITH CEMENT GROUT.

A STEEL STANDPIPE WITH LOCKING CAP WAS INBEDDED IN CEMENT WITH A 2.0 FT. STICK UP ABOVE GROUND LEVEL.

COMMENTS:
THICKNESS. THE DATA FOR THESE INTERVALS CAN BE FOUND IN EITHER THE "NOTES" OR "CLASSIFICATION AND PHYSICAL CONDITION" COLUMNS.

DATA PRESENTED IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN, AND CENTER COLUMN ARE BASED ON BUREAU OF RECLAMATION ENGINEERING GEOLOGY MANUAL.

ALL ANGLES MEASURED FROM THE CORE AXIS AT ZERO DEGREES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-5

FEATURE: ELKHEAD RESERVOIR
LOCATION: DOWNSTREAM FACE
BEGUN: 6-24-93 FINISHED: 6-24-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 40.4
DEPTH TO BEDROCK: 18.2

STATE: COLORADO
GROUND ELEVATION: 6306.21
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOM
REVIEWED BY:

NOTES

ALL MEASUREMENTS ARE FROM GROUND LEVEL AND ARE THE SAME AS THOSE USED BY THE DRILLER.

ALL MEASUREMENTS ARE IN FEET EXCEPT WHERE NOTED DIFFERENTLY.

DRILLED BY:
REGIONAL DRILL CREW: L. WASHBURN, DRILLER, L. ZOLEMAN, J. VANAUSDAL, DRILLER HELPERS.

PURPOSE:
SUBSURFACE INVESTIGATION, DAM TOE.

DRILL EQUIPMENT:
GUS PECH #1 TRUCK MOUNTED ROTARY DRILL RIG.

DRILL METHOD:
0.0 - 15.9- PENETRATION TESTS TAKEN AT 5.0 FT. INCREMENTS FOLLOWED BY A 4-INCH DIAMETER HOLLOW-STEM AUGER. THE PROCEDURE FOLLOWED WAS TO DRIVE A CALIFORNIA SAMPLER 1.0 FT. COUNTING THE NUMBER OF BLOWS AND MEASURING THE DISTANCE TRAVELED BY EACH TO THE BOTTOM OF THE SAMPLE INTERVAL. THE AUGER WAS THEN ADVANCED TO THE TOP OF THE NEXT ASSIGNED SAMPLE INTERVAL.

15.9 - 40.4 - CORED WITH A HQ3 SYSTEM, USING A DIAMOND BIT AND TRIPLE TUBE CORE BARREL.

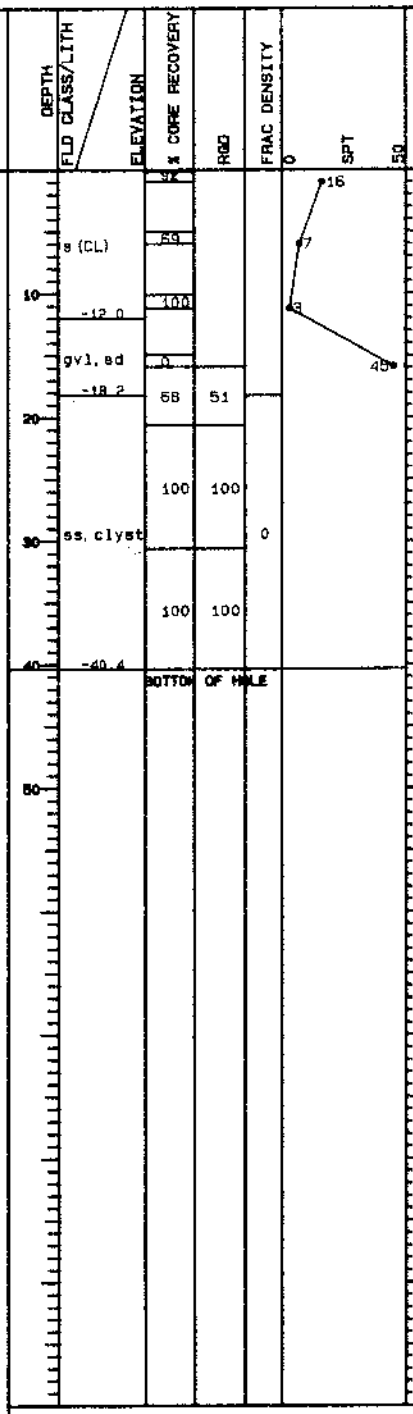
CASING RECORD:
0.0-15.9 - 4 INCH DIA (TEMPORARY)
15.9-40.4 HQ3 DIA (TEMPORARY)

DRILLING MEDIUM:
0.0-15.9 NONE
15.9-40.4 RESERVOIR WATER

DRILL FLUID LOSSES:

INTERVAL (FT.)	LOSS (PCT.)
15.9-20.6	0
20.6-30.6	?
30.6-40.4	?

TESTING AND SAMPLING:
SOIL SAMPLES WERE TAKEN FROM THE FOLLOWING INTERVALS.
0.2-1.0
5.0-6.0
10.1-11.2
30.0
SELECTED SAMPLES WERE



CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 18.2 QUATERNARY ALLUVIUM (Qal):

0.0 - 12.0: SANDY LEAN CLAY:
ABOUT 60-70% FINES WITH MEDIUM PLASTICITY, SLOW TO NO DILATANCY, MEDIUM TO HIGH TOUGHNESS, MEDIUM TO HIGH DRY STRENGTH; ABOUT 30-40% PREDOMINANTLY FINE TO VERY FINE SAND; MAXIMUM SIZE, FINE SAND; BROWN TO DARK BROWN; DRY TO WET; CONTAINS SOME ROOTS; Fe STAINING ON SOME FRAGMENTS; EASY TO AUGER; NONE TO WEAK REACTION WITH HCl. s (CL)

0.2 - 1.0 - LAB TEST DATA - WATER CONTENT = 13%, IN-PLACE DRY UNIT WEIGHT = 101.9 PCF.

5.0 - 6.0 - LAB TEST DATA - 67% FINES, 33% SAND, LL = 35, PI = 13, WATER CONTENT = 31%. (CL)

10.0 -11.2 - LAB TEST DATA - WATER CONTENT = 33%, IN-PLACE DR UNIT WEIGHT = 88.6 PCF.

12.0 - 18.2: GRAVEL AND SAND:
POOR RECOVERY. RECOVERED AS AUGER CUTTINGS AND IN DRILL CORE AS HARD, SUBROUNDED TO ROUNDED, GRAVEL AND SAND, WITH A TRACE OF FINES; MAXIMUM SIZE, 2.0 IN.

18.2 - 40.4: TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED:

18.2 - 40.4: SANDSTONE AND CLAYSTONE:
CONSISTS OF APPROXIMATELY 65% CLAYSTONE AND 35% SANDSTONE.

CLAYSTONE IS OCCASIONALLY SANDY AND CARBONACEOUS; LIGHT GRAY TO BLACK; LAMINATED TO VERY THINLY BEDDED (LESS THAN 3/8 IN. 0.1 FT.); SOFT TO MODERATELY SOFT (H5-H6); FRESH (W1); NONE T WEAK REACTION WITH HCl.

SANDSTONE IS OCCASIONALLY CLAYEY AND CARBONACEOUS; LIGHT GRAY TO BLACK; FINE TO VERY FINE GRAINED; LAMINATED TO THICKLY BEDDED (LESS THAN 3/8 IN. TO 3.0 FT.); FRESH (W1); WELL CEMENTED AREAS ARE HARD (H3), AND HAD A STRONG REACTION WITH HCl; POORLY CEMENTED AREAS ARE SOFT TO MODERATELY SOFT (H5-H6 AND HAD A NONE TO STRONG REACTION WITH HCl.

THE OVERALL INTERVAL HAS PREDOMINANTLY PLANAR BEDDING 70 TO 9 DEGREES FROM THE CORE AXIS; SOME UNDULATIONS OF BEDS; CONTAIN SMALL COAL SEAMS TO 1/16 IN. THICK AND COAL INTERBEDS FROM 20.1 TO 20.6 FT. AND 23.2 TO 23.3 FT.; UNFRACTURED (FD0).

30.0 LAB TEST DATA - 99% FINES, 1% SAND, LL = 47, PI = 24, WATER CONTENT = 11%. SPECIFIC GRAVITY = 2.68.

STRATIGRAPHY:

0.0 - 18.2 QUATERNARY ALLUVIUM (Qal)
18.2 - 40.4 TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED

COMMENTS:

ALL MEASUREMENTS ARE DEPTHS SUBTRACTED FROM GROUND SURFACE. ELEVATIONS WERE NOT AVAILABLE AT THIS TIME.

SAMPLES FROM CALIFORNIA SAMPLER AND DRILL CORE WERE SELECTED AND LABORATORY TESTED AS DIRECTED BY WOODWARD-CLYDE CONSULTANTS.

DIFFERENCES BETWEEN FIELD AND LAB CLASSIFICATION OF SOILS ARE A RESULT OF FURTHER WORKING (BREAKING DOWN) OF MATERIAL DURING GRADATION TESTING, RESULTING IN AN INCREASE IN PERCENTAGE OF FINES, AND A DECREASE IN PERCENTAGE OF COARSE PARTICLES.

CENTER COLUMN DATA IS NOT SHOWN IN INTERVALS OF LESS THAN 1.0 FT.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-5

FEATURE: ELKHEAD RESERVOIR
LOCATION: DOWNSTREAM FACE
BEGUN: 6-24-93 FINISHED: 6-24-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 40.4
DEPTH TO BEDROCK: 16.2

STATE: COLORADO
GROUND ELEVATION: 6306.21
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOW
REVIEWED BY:

NOTES

LABORATORY TESTED FOR NATURAL MOISTURES, DENSITIES, GRADATION, HYDROMETER, AND ATTERBERG LIMITS. RESULTS ARE SHOWN IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN.

CORE RECOVERY:

INTERVAL (FT.)	RECOVERY (%)
15.9-20.6	68
20.6-30.6	100
30.6-40.4	100

HOLE COMPLETION:
HQ3 DIAMETER CASING WAS REMOVED. THE HOLE WAS BACKFILLED WITH CEMENT GROUT.

COMMENTS:
THICKNESS. THE DATA FOR THESE INTERVALS CAN BE FOUND IN EITHER THE "NOTES" OR "CLASSIFICATION AND PHYSICAL CONDITION" COLUMNS.

DATA PRESENTED IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN, AND CENTER COLUMN ARE BASED ON BUREAU OF RECLAMATION ENGINEERING GEOLOGY MANUAL.

ALL ANGLES MEASURED FROM THE CORE AXIS AT ZERO DEGREES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-6

FEATURE: ELKHEAD RESERVOIR
LOCATION: DAM TOE
BEGUN: 8-21-93 FINISHED: 8-21-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 30.0
DEPTH TO BEDROCK: 8.6

STATE: COLORADO
GROUND ELEVATION: 6800 19
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DON
REVIEWED BY:

NOTES

ALL MEASUREMENTS ARE FROM GROUND LEVEL AND ARE THE SAME AS THOSE USED BY THE DRILLER.

ALL MEASUREMENTS ARE IN FEET EXCEPT WHERE NOTED DIFFERENTLY.

DRILLED BY:
REGIONAL DRILL CREW: L. WASHBURN, DRILLER, L. ZOLEMAN, J. VANAUSDAL, DRILLER HELPERS.

PURPOSE:
SUBSURFACE INVESTIGATION, DAM TOE.

DRILL EQUIPMENT:
GUS PECH #1 TRUCK MOUNTED ROTARY DRILL RIG.

DRILL METHOD:
0.0 - 15.5- PENETRATION TESTS TAKEN AT 5.0 FT. INCREMENTS FOLLOWED BY A 4-INCH DIAMETER HOLLOW STEM-AUGER. THE PROCEDURE FOLLOWED WAS TO DRIVE A CALIFORNIA SAMPLER 1.0 FT. COUNTING THE NUMBER OF BLOWS AND MEASURING THE DISTANCE TRAVELED BY EACH TO THE BOTTOM OF THE SAMPLED INTERVAL. THE AUGER WAS THEN ADVANCED TO THE TOP OF THE NEXT ASSIGNED SAMPLE INTERVAL.

15.5 - 30.0 - CORED WITH A HQ3 SYSTEM, USING A DIAMOND BIT AND TRIPLE TUBE CORE BARREL.

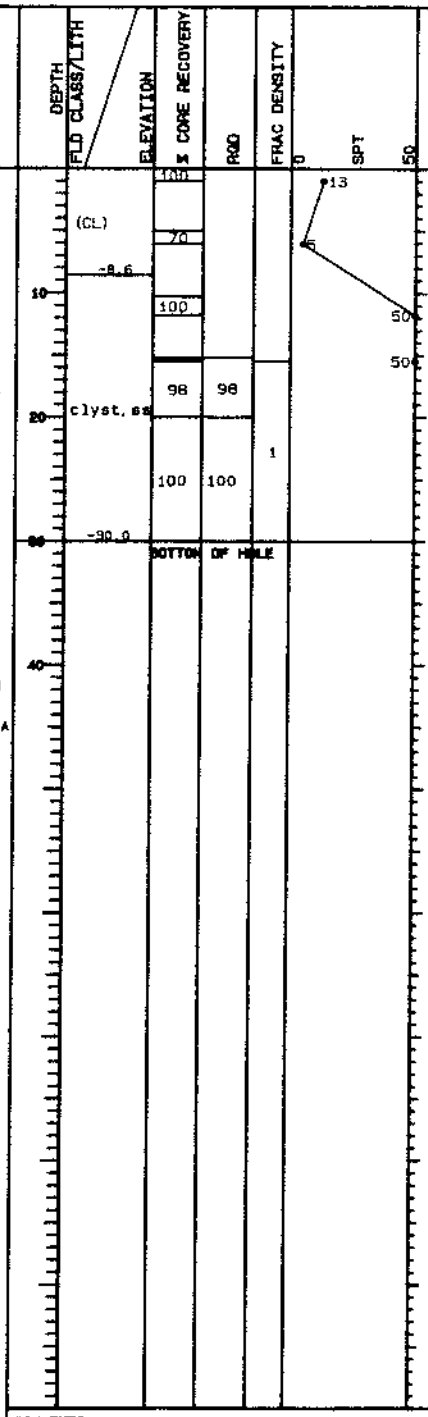
CASING RECORD:
0.0-15.5 - 4 INCH DIA (TEMPORARY)
15.5-30.0 - HQ3 DIA (TEMPORARY)

DRILLING MEDIUM:
0.0-15.5 NONE
15.5-30.0 RESERVOIR WATER

DRILL FLUID LOSSES:

INTERVAL (FT.)	LOSS (PCT.)
15.2-20.0	10
20.0-30.0	10

TESTING AND SAMPLING:
SOIL SAMPLES WERE TAKEN FROM THE FOLLOWING INTERVALS.
0.0- 1.0
5.0- 6.1
10.3-11.8
15.2-15.5
22.0
30.0



CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 8.6: QUATERNARY ALLUVIUM (Qal):

0.0 - 8.6: LEAN CLAY:
ABOUT 90% FINES WITH MEDIUM TO HIGH PLASTICITY, SLOW TO NO DILATANCY, HIGH TOUGHNESS, MEDIUM TO HIGH DRY STRENGTH; ABOU 10% PREDOMINANTLY FINE TO VERY FINE SAND; MAXIMUM SIZE, FINE SAND; MOIST TO WET; DARK BROWN; ROOTS AND OTHER ORGANIC MATERIAL THROUGHOUT; EASY TO AUGER; NO REACTION WITH HCl. (C

0.0 - 1.0 - LAB TEST DATA - 82% FINES, 18% SAND, LL = 41, PI = 19, WATER CONTENT = 21%. (CL)

5.0 - 6.1 - LAB TEST DATA - 90% FINES, 10% SAND, LL = 27, PI = 12. (CL)

8.6 - 30.0: TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED:

8.6 - 15.5: CRUMBED CLAYSTONE AND SANDSTONE:

RETRIEVED AS CLAY AND SAND SIZED FRAGMENTS FROM POWER AUGER HOLE; DRY TO MOIST; GRAY; FRESH; EASY TO HARD TO AUGER; CONTAINS COAL FRAGMENTS; WEAK TO STRONG REACTION WITH HCl. MATERIAL IDENTIFIED AS "SANDY CLAY (CL)"- ABOUT 80-90% FINES WITH LOW TO MEDIUM PLASTICITY, LOW TO MEDIUM DRY STRENGTH, SL TO RAPID DILATANCY, LOW TO MEDIUM TOUGHNESS; ABOUT 10-20% FI SAND.

15.5 - 30.0: SANDSTONE AND CLAYSTONE:
CONSISTS OF APPROXIMATELY 98% SANDSTONE AND 2% CLAYSTONE. SANDSTONE IS OCCASIONALLY CLAYEY AND CARBONACEOUS; LIGHT GR TO BLACK; GENERALLY LAMINATED TO VERY THICKLY BEDDED (LESS THAN 3/8 IN. TO 8.0 FT.); FINE TO VERY FINE GRAINED; FRESH (W1); WELL CEMENTED AREAS ARE HARD (H3), AND HAD A STRONG REACTION WITH HCl; POORLY CEMENTED AREAS ARE SOFT TO MODERATELY SOFT (H5-H8) AND HAD NONE TO STRONG REACTION WIT HCl; CONTAINS SOME PYRITE.

CLAYSTONE IS OCCASIONALLY SANDY AND CARBONACEOUS; LIGHT GRA TO DARK GRAY; GENERALLY LAMINATED TO VERY THINLY BEDDED (LE THAN 3/8 IN. TO 0.1 FT.); FRESH (W1); SOFT TO MODERATELY SO (H5-H6); NONE TO WEAK REACTION WITH HCl.

THE OVERALL INTERVAL HAS PREDOMINANTLY PLANAR BEDDING AT 60 TO 90 DEGREES FROM CORE AXIS; SOME UNDULATION OF BEDS; CONTAINS SMALL COAL SEAMS TO 1/16 IN. THICK; VERY SLIGHTLY FRACTURED (FD1) BY ONE HEALED FRACTURE ZONE AS FOLLOWS;

1 FRACTURED ZONE; TIGHT; HEALED; CONTAINS ANGULAR MEDIU SIZE GRAVEL FRAGMENTS OF CLAYSTONE IN A SANDY MATRIX; ALSO CONTAINS COAL AND PYRITE FRAGMENTS; LOCATED AT DEPTH FROM 17.3 TO 17.8 FT.

10.3 - 11.1 LAB TEST DATA - 78% FINES, 22% SAND, LL = 28, PI = 6, WATER CONTENT = 12%. (CL-ML)

COMMENTS:

ALL MEASUREMENTS ARE DEPTHS SUBTRACTED FROM GROUND SURFACE. ELEVATIONS WERE NOT AVAILABLE AT THIS TIME.

SAMPLES TAKEN BY THE CALIFORNIA SAMPLER AND FROM DRILL CORE WERE SELECTED AND LABORATORY TESTED AS DIRECTED BY WOODWARD-CLYDE CONSULTANTS.

DIFFERENCES BETWEEN FIELD AND LAB CLASSIFICATION OF SOILS ARE A RESULT OF FURTHER WORKING (BREAKING DOWN) OF MATERIAL DURING GRADATION TESTING, RESULTING IN AN INCREASE IN PERCENTAGE OF FINES AND A DECREASE IN PERCENTAGE OF COARSE PARTICLES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-6

FEATURE: ELKHEAD RESERVOIR
LOCATION: DAM TOE
BEGUN: 8-21-93 FINISHED: 8-21-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 30.0
DEPTH TO BEDROCK: 8.6

STATE: COLORADO
GROUND ELEVATION: 6300.19
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOW
REVIEWED BY:

NOTES

SELECTED SAMPLES WERE LABORATORY TESTED FOR NATURAL MOISTURES, DENSITIES, GRADATION, HYDROMETER, AND ATTERBERG LIMITS. RESULTS ARE SHOWN IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN.

CORE RECOVERY:

INTERVAL (FT.)	RECOVERY (%)
15.2-15.5	100

ALL OTHER CORE RECOVERY IS REPORTED IN THE CORE RECOVERY COLUMN.

HOLE COMPLETION:
HQ3 DIAMETER CASING WAS REMOVED. THE HOLE WAS BACKFILLED WITH CEMENT GROUT.

CLASSIFICATION AND PHYSICAL CONDITION (CONTINUED)

15.2 - 15.5 LAB TEST DATA - WATER CONTENT = 14%.

22.0 - LAB TEST DATA - 78% SAND, 22% FINES, WATER CONTENT = 9%, SPECIFIC GRAVITY = 2.63.

30.0 - LAB TEST DATA - 85% SAND, 15% FINES, WATER CONTENT = 6%, SPECIFIC GRAVITY = 2.67.

STRATIGRAPHY:

0.0 - 8.6 QUATERNARY ALLUVIUM (Qal)
8.6 - 30.0 TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED

COMMENTS:
CENTER COLUMN DATA IS NOT SHOWN IN INTERVALS OF LESS THAN 1.0 FT. THICKNESS. THE DATA FOR THESE INTERVALS CAN BE FOUND IN EITHER THE "NOTES" OR "CLASSIFICATION AND PHYSICAL CONDITION" COLUMNS.

DATA PRESENTED IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN, AND CENTER COLUMN ARE BASED ON BUREAU OF RECLAMATION ENGINEERING GEOLOGY MANUAL.

ALL ANGLES MEASURED FROM THE CORE AXIS AT ZERO DEGREES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-7

FEATURE: ELKHEAD RESERVOIR
LOCATION: LEFT ABUTMENT
BEGUN: 6-17-83 FINISHED: 6-20-83
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 82.8
DEPTH TO BEDROCK: 8.0

STATE: COLORADO
GROUND ELEVATION: 6392.21
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DON
REVIEWED BY:

NOTES

ALL MEASUREMENTS ARE FROM GROUND LEVEL AND ARE THE SAME AS THOSE USED BY THE DRILLER.

ALL MEASUREMENTS ARE IN FEET EXCEPT WHERE NOTED DIFFERENTLY.

DRILLED BY:
REGIONAL DRILL CREW; L. WASHBURN, DRILLER, L. ZOLEMAN, J.VANAUSDAL, DRILLER HELPERS.

PURPOSE:
SUBSURFACE INVESTIGATION, LEFT ABUTMENT

DRILL EQUIPMENT:
GUS PECH #1 TRUCK MOUNTED ROTARY DRILL RIG.

DRILL METHOD:
0.0-20.3 - PENETRATION TESTS TAKEN AT 5.0 FT. INCREMENTS FOLLOWED BY A 4-INCH DIAMETER HOLLOW-STEM AUGER THROUGH ALL OVERBURDEN MATERIALS. THE PROCEDURE FOLLOWED WAS TO DRIVE A CALIFORNIA SAMPLER 1.0 FT. COUNTING THE NUMBER OF BLOWS AND MEASURING THE DISTANCE TRAVELED BY EACH TO THE BOTTOM OF THE SAMPLED INTERVAL. THE AUGER THEN WAS ADVANCED TO THE TOP OF THE NEXT ASSIGNED SAMPLE INTERVAL.

20.3 -63.0 AUGER CONTINUED TO BE ADVANCED UNTIL REFUSAL. CUTTING SAMPLES WERE TAKEN.

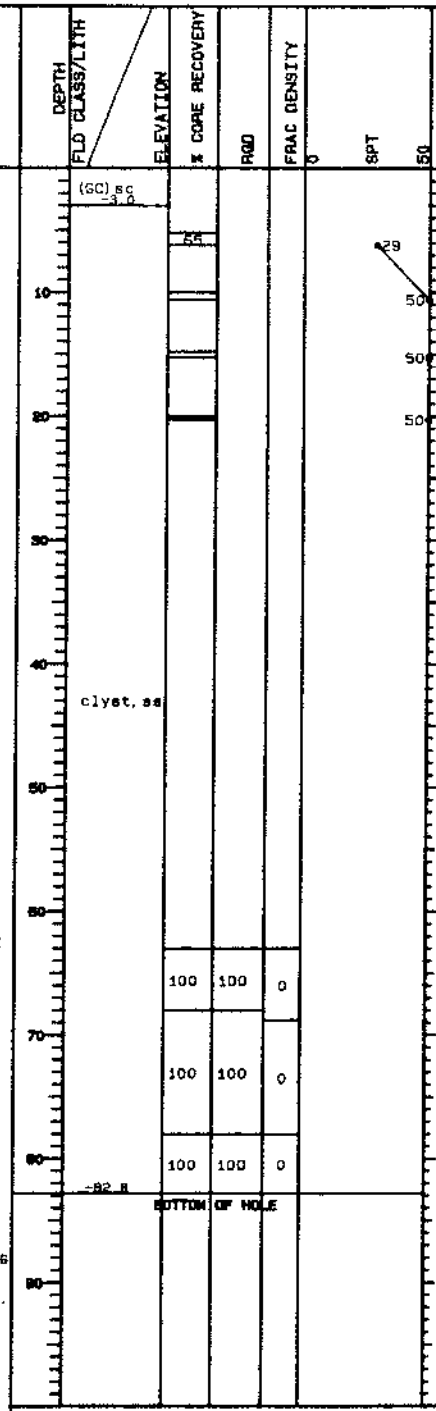
63.0 - 82.8 CORED WITH A HQ3 SYSTEM, USING A DIAMOND BIT AND A TRIPLE TUBE CORE BARREL.

CASING RECORD:
0.0-63.0 - 4 INCH DIA (TEMPORARY)
63.0-82.8 HQ3 DIA (TEMPORARY)

DRILLING MEDIUM:
0.0-63.0 NONE
63.0-82.8 RESERVOIR WATER

DRILL FLUID LOSSES:

INTERVAL (FT.)	LOSS (PCT.)
63.0-68.0	10
68.0-78.0	10
78.0-82.8	10



CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 3.0: QUATERNARY TERRACE DEPOSIT (Qt):

0.0 - 3.0: CLAYEY GRAVEL WITH SAND AND COBBLES:
ABOUT 50% FINE TO COARSE, HARD, SUBROUNDED TO ROUNDED GRAVE ABOUT 30% FINES WITH MEDIUM PLASTICITY, SLOW TO NO DILATANCY, MEDIUM TO HIGH TOUGHNESS, MEDIUM TO HIGH DRY STRENGTH; ABOUT 20% PREDOMINANTLY FINE TO VERY FINE SAND; TRACE OF HARD, SUBROUNDED TO ROUNDED COBBLES; MAXIMUM SIZE IN.; DRY; BROWN TO GRAY; HARD TO AUGER; STRONG REACTION WIT HCl. (GC) sc

3.0 - 82.8: TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED:

3.0 - 63.0: CRUSHED CLAYSTONE AND SANDSTONE:
RETRIEVED AS CLAY AND SAND SIZED FRAGMENTS FROM POWER AUGER HOLE; DRY TO MOIST; TAN; GRAY TO BLACK; EASY TO MODERATELY

TO AUGER; CONTAINS COAL FRAGMENTS; SOME IRON STAINING OF SAND SIZE FRAGMENTS; WEAK TO STRONG REACTION WITH HCl. MATERIAL IDENTIFIED AS 'SANDY CLAY (CL)'- ABOUT 80-90% FINES WITH MEDIUM TO HIGH PLASTICITY, MEDIUM TO HIGH DRY STRENGTH,

DILATANCY, MEDIUM TO HIGH TOUGHNESS; ABOUT 10-20% FINE SAND.

5.2 - 6.2 LAB TEST DATA - 98% FINES, 2% SAND, LL = 36, PI = 20, WATER CONTENT = 22%. (CL)

10.0 - 10.6 LAB TEST DATA - 69% FINES, 31% SAND, LL = 39, PI = 17, WATER CONTENT = 15%. (CL)

63.0 - 82.8: CLAYSTONE AND SANDSTONE:
CONSISTS OF APPROXIMATELY 62% SANDSTONE AND 38% CLAYSTONE.

SANDSTONE IS OCCASIONALLY CLAYEY AND CARBONACEOUS; LIGHT GR TO BLACK; FINE GRAINED TO VERY FINE GRAINED; POORLY TO WELL CEMENTED; GENERALLY LAMINATED TO THICKLY BEDDED (LESS THAN 3/8 IN. TO 3.0 FT.); FRESH (W2); SOFT THROUGH POORLY CEMENT AREAS (H6) AND BREAKS WITH LIGHT HAND PRESSURE; HARD THROUG WELL CEMENTED AREAS (H3) AND BREAKS WITH HEAVY HAMMER BLOW; NONE TO STRONG REACTION WITH HCl.

CLAYSTONE IS OCCASIONALLY SANDY AND CARBONACEOUS; LIGHT GRA TO BLACK; GENERALLY LAMINATED TO VERY THINLY BEDDED (LESS THAN 3/8 IN. TO 0.1 FT.); SLIGHTLY WEATHERED TO FRESH (W2); SOFT TO MODERATELY SOFT (H5-H6). BREAKS WITH LIGHT TO MODERATE HAND PRESSURE; NO REACTION WITH HCl.

THE OVERALL INTERVAL HAS PREDOMINANTLY PLANAR BEDDING 70 TO

DEGREES FROM CORE AXIS; CONTAINS SMALL COAL SEAMS TO 1/4 IN THICK; SOME UNDULATION OF BEDS; UNFRACTURED (FD0).

STRATIGRAPHY:

0.0 - 3.0 QUATERNARY TERRACE DEPOSIT (QT)
3.0 - 82.8 TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED

COMMENTS:

ALL MEASUREMENTS ARE DEPTHS SUBTRACTED FROM GROUND SURFACE. ELEVATIONS WERE NOT AVAILABLE AT THIS TIME.

SAMPLES TAKEN BY THE CALIFORNIA SAMPLER AND FROM DRILL CORE WERE SELECTED AND LABORATORY TESTED AS DIRECTED BY WOODWARD-CLYDE CONSULTANTS.

DIFFERENCES BETWEEN FIELD AND LAB CLASSIFICATION OF SOILS ARE A RESULT OF FURTHER WORKING (BREAKING DOWN) OF MATERIAL DURING GRADATION TESTING, RESULTING IN AN INCREASE IN PERCENTAGE OF FINES AND A DECREASE IN PERCENTAGE OF COARSE PARTICLES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-7

FEATURE: ELKHEAD RESERVOIR
LOCATION: LEFT ABUTMENT
BEGUN: 6-17-93 FINISHED: 6-20-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 82.8
DEPTH TO BEDROCK: 6.0

STATE: COLORADO
GROUND ELEVATION: 6392.21
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOM
REVIEWED BY:

NOTES

TESTING AND SAMPLING:
SOIL SAMPLES WERE TAKEN FROM THE FOLLOWING INTERVALS.
5.2-6.2
10.0-10.5
14.8-15.3
20.0-20.3
SELECTED SAMPLES WERE LABORATORY TESTED FOR NATURAL MOISTURES, DENSITIES, GRADATION, HYDROMETER, AND ATTERBERG LIMITS. RESULTS ARE SHOWN IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN.

CORE RECOVERY:

INTERVAL (FT.)	RECOVERY (%)
10.0-10.5	100
14.8-15.3	100
20.0-20.3	100

ALL OTHER CORE RECOVERY IS REPORTED IN THE CORE RECOVERY COLUMN.

HOLE COMPLETION:
HQ3 DIAMETER CASING WAS REMOVED. INSTALLED ONE 1 1/2 INCH DIAMETER RISER. PIEZOMETER WAS INSTALLED TO 79.2 FT. WITH THE BOTTOM 2.0 FT. UNSLOTTED. SLOTTED PVC WAS INSTALLED FROM 77.2 TO 37.2 FT. A BENTONITE PLUG WAS INSTALLED FROM 34.0 TO 30.0 FT. CEMENT GROUT WAS INSTALLED FROM 30.0 FT. THE REMAINDER OF THE HOLE WAS BACKFILLED WITH 10-20 SILICA SAND.

A STEEL STANDPIPE WITH LOCKING CAP WAS IMBEDDED IN CEMENT WITH A 2.0 FT. STICK UP ABOVE GROUND LEVEL.

COMMENTS:
CENTER COLUMN DATA IS NOT SHOWN IN INTERVALS OF LESS THAN 1.0 FT. THICKNESS. THE DATA FOR THESE INTERVALS CAN BE FOUND IN EITHER THE "NOTES" OR "CLASSIFICATION AND PHYSICAL CONDITION" COLUMNS.

DATA PRESENTED IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN AND CENTER COLUMN ARE BASED ON BUREAU OF RECLAMATION ENGINEERING GEOLOGY MANUAL.

ALL ANGLES MEASURED FROM THE CORE AXIS AT ZERO DEGREES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-8

SHEET 1 OF

FEATURE: ELKHEAD RESERVOIR
LOCATION: LEFT ABUTMENT SPILLWAY
BEGUN: 6-20-83 FINISHED: 6-20-83
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 40.0
DEPTH TO BEDROCK: 1.0

STATE: COLORADO
GROUND ELEVATION: 6359.810
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOW
REVIEWED BY:

NOTES

ALL MEASUREMENTS ARE FROM GROUND LEVEL AND ARE THE SAME AS THOSE USED BY THE DRILLER.

ALL MEASUREMENTS ARE IN FEET EXCEPT WHERE NOTED DIFFERENTLY.

DRILLED BY:
REGIONAL DRILL CREW: L. WASHBURN, DRILLER, L. ZOLMAN, J.VANAUSDAL, DRILLER HELPERS.

PURPOSE:
SUBSURFACE INVESTIGATION, LEFT ABUTMENT SPILLWAY.

DRILL EQUIPMENT:
GUS PECH #1 TRUCK MOUNTED ROTARY DRILL RIG.

DRILL METHOD:
0.0-1.0 - PENETRATION TESTS TAKEN AT 5.0 FT. INCREMENTS FOLLOWED BY A 4-INCH DIAMETER HOLLOW-STEM AUGER THROUGH ALL OVERBURDEN MATERIALS. THE PROCEDURE FOLLOWED WAS TO DRIVE A CALIFORNIA SAMPLER 1.0 FT. COUNTING THE NUMBER OF BLOWS AND MEASURING THE DISTANCE TRAVELED BY EACH TO THE BOTTOM OF THE SAMPLED INTERVAL. THE AUGER WAS THEN ADVANCED TO THE TOP OF THE NEXT ASSIGNED SAMPLE INTERVAL.

1.0 - 40.0 CORED WITH A HQ3 SYSTEM, USING A DIAMOND BIT AND A TRIPLE TUBE CORE BARREL.

CASING RECORD:
0.0-40.0 HQ3 DIA (TEMPORARY)

DRILLING MEDIUM:
0.0-40.0 RESERVOIR WATER

DRILL FLUID LOSSES:

INTERVAL (FT.)	LOSS (PCT.)
0.0-40.0	0

TESTING AND SAMPLING:
SOIL SAMPLES WERE TAKEN FROM THE FOLLOWING INTERVALS.
0.0 -1.0
THE SAMPLE WAS LABORATORY TESTED FOR NATURAL MOISTURE, DENSITY, GRADATION, HYDROMETER, AND ATTERBERG LIMITS. RESULTS ARE SHOWN IN

DEPTH	FLD CLASS/LITH	ELEVATION	% CORE RECOVERY	RQD	FRAC DENSITY
	s (CL)		100	100	
			100	88	2
10			98	98	0
20	ss, clyst		100	100	0
			100	100	0
30			92	92	0
40		~40.0	100	100	0
			BOTTOM OF HOLE		
50					

SPT 0 — 50

CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 1.0: QUATERNARY SLOPEWASH/ALLUVIUM (Qsw/Qal) - TRANSPORTED SOIL:

0.0 - 1.0: SANDY LEAN CLAY:
ABOUT 70% FINES WITH MEDIUM PLASTICITY, SLOW TO NO DILATANCY MEDIUM TO HIGH TOUGHNESS, MEDIUM TO HIGH DRY STRENGTH; ABOUT 20% PREDOMINANTLY FINE TO VERY FINE SAND; ABOUT 10% HARD, SUBROUNDED TO ROUNDED GRAVEL; MAXIMUM SIZE 3 IN.; DRY, TAN; STRONG REACTION WITH HCl. s (CL)

0.0 - 1.0 LAB TEST DATA - 56% FINES, 32% SAND, 12% GRAVEL, LL = 27, PI = 12, s (CL)

1.0 - 40.0: TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED:

1.0 - 40.0: SANDSTONE AND CLAYSTONE:
CONSISTS OF APPROXIMATELY 80% SANDSTONE AND 20% CLAYSTONE.

SANDSTONE IS OCCASIONALLY CLAYEY AND CARBONACEOUS, FINE GRAI TO VERY FINE GRAINED, POORLY TO WELL CEMENTED; LIGHT GRAY TO BLACK; TAN; GENERALLY LAMINATED TO VERY THICKLY BEDDED (LESS THAN 3/8 IN. TO 3.8 FT.); MODERATELY TO SLIGHTLY WEATHERED T FRESH (W2), SOFT THROUGH POORLY CEMENTED AREAS (H6) AND BREA WITH LIGHT HAND PRESSURE; HARD THROUGH WELL CEMENTED AREAS (H3) AND BREAKS WITH HEAVY HAMMER BLOW; NONE TO STRONG REACT WITH HCl.

CLAYSTONE IS OCCASIONALLY SANDY AND CARBONACEOUS; LIGHT GRAY BLACK; GENERALLY LAMINATED TO THINLY BEDDED (LESS THAN 3/8 I TO 0.1 FT.); SLIGHTLY WEATHERED TO FRESH (W2); SOFT TO MODERATELY SOFT (H5-H6) AND BREAKS WITH LIGHT TO MODERATE HA PRESSURE; NO REACTION WITH HCl.

THE OVERALL INTERVAL HAS PREDOMINANTLY PLANAR BEDDING 60 TO DEGREES FROM CORE AXIS; CONTAINS SMALL COAL SEAMS TO 1/4 IN.; SOME UNDULATION OF BEDS; VERY SLIGHTLY FRACTURED (FD1) TO 8.3 FT., THEN UNFRACTURED (FD0). JOINT SUMMARY AS FOLLOWS:

1 JOINT AT 30 DEGREES; TIGHT TO OPEN; MODERATELY ROUGH; Fe STAINED FROM 1.8 TO 2.6 FT.

1 JOINT AT 86 DEGREES; TIGHT; MODERATELY ROUGH; Fe STAINI AT 2.1 FT.

STRATIGRAPHY:

0.0 - 1.0 QUATERNARY SLOPEWASH / ALLUVIUM (Qsw/Qal) - TRANSPORTED SOIL
1.0 - 40.0 TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED

COMMENTS:

ALL MEASUREMENTS ARE DEPTHS SUBTRACTED FROM GROUND SURFACE. ELEVATIONS WERE NOT AVAILABLE AT THIS TIME.

SAMPLES TAKEN BY THE CALIFORNIA SAMPLER AND FROM DRILL CORE WERE SELECTED AND LABORATORY TESTED AS DIRECTED BY WOODWARD-CLYDE CONSULTANTS.

DIFFERENCES BETWEEN FIELD AND LAB CLASSIFICATION OF SOILS ARE A RESULT OF FURTHER WORKING (BREAKING DOWN) OF MATERIAL DURING GRADATION TESTING, RESULTING IN AN INCREASE IN PERCENTAGE OF FINES AND A DECREASE IN PERCENTAGE OF COARSE PARTICLES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-9A

FEATURE: ELKHEAD RESERVOIR
LOCATION: CREST OF EMERGENCY SPILLWAY
BEGUN: 7-2-83 FINISHED: 7-2-83
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 21.0
DEPTH TO BEDROCK: 10.7

STATE: COLORADO
GROUND ELEVATION: 6478.50
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOW
REVIEWED BY:

COMMENTS:

CENTER COLUMN DATA IS NOT SHOWN IN INTERVALS OF LESS THAN 1.0 FT. THICKNESS. THE DATA FOR THESE INTERVALS CAN BE FOUND IN EITHER THE "NOTES" OR "CLASSIFICATION AND PHYSICAL CONDITION" COLUMNS.

DATA PRESENTED IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN, AND CENTER COLUMN ARE BASED ON BUREAU OF RECLAMATION ENGINEERING GEOLOGY MANUAL.

ALL ANGLES MEASURED FROM THE CORE AXIS AT ZERO DEGREES.

ABBREVIATIONS:

HQ = 2.5 IN. CORE DIA., 3.78 IN. HOLE DIA.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-9

SHEET 1 OF

FEATURE: ELKHEAD RESERVOIR
LOCATION: CREST OF EMERGENCY SPILLWAY
BEGUN: 6-16-93 FINISHED: 6-16-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 15.3
DEPTH TO BEDROCK: 10.8

STATE: COLORADO
GROUND ELEVATION: 6418.50
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOM
REVIEWED BY:

NOTES

ALL MEASUREMENTS ARE FROM GROUND LEVEL AND ARE THE SAME AS THOSE USED BY THE DRILLER.

ALL MEASUREMENTS ARE IN FEET EXCEPT WHERE NOTED DIFFERENTLY.

DRILLED BY:
REGIONAL DRILL CREW: L. WASHBURN, DRILLER. L. ZOLMAN, J.VANAUSDAL, DRILLER HELPERS.

PURPOSE:
SUBSURFACE INVESTIGATION, CREST EMERGENCY SPILLWAY.

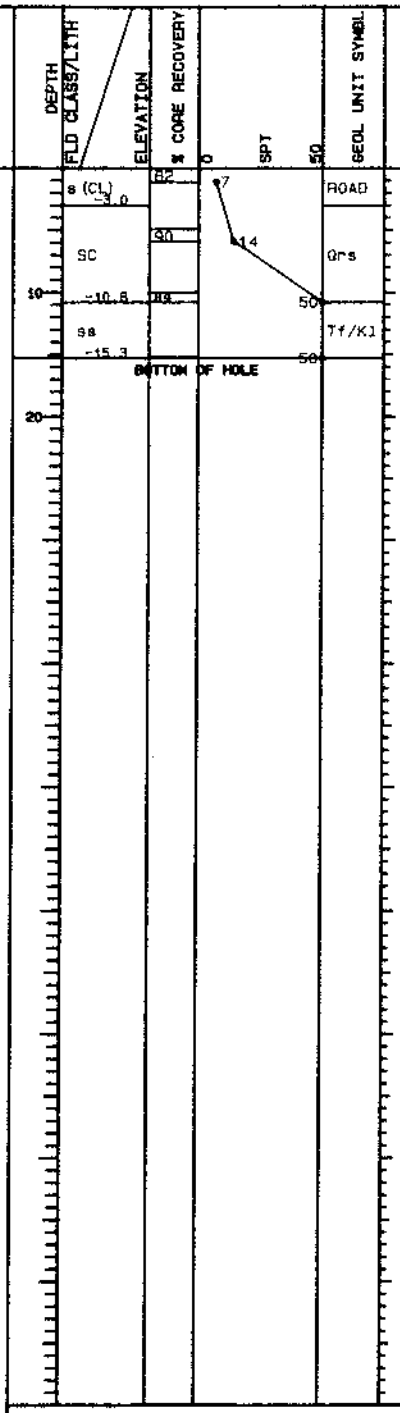
DRILL EQUIPMENT:
GUS PECH #1 TRUCK MOUNTED ROTARY DRILL RIG.

DRILL METHOD:
0.0-15.3 - PENETRATION TESTS TAKEN AT 5.0 FT. INCREMENTS FOLLOWED BY A 4-INCH DIAMETER HOLLOW-STEM AUGER THROUGH ALL OVERBURDEN MATERIALS. THE PROCEDURE FOLLOWED WAS TO DRIVE A CALIFORNIA SAMPLER 1.0 FT. COUNTING THE NUMBER OF BLOWS AND MEASURING THE DISTANCE TRAVELED BY EACH TO THE BOTTOM OF THE SAMPLE INTERVAL. THE AUGER WAS THEN ADVANCED TO THE TOP OF THE NEXT ASSIGNED SAMPLED INTERVAL.

CASING RECORD:
0.0-15.3 4 IN. DIA (TEMPORARY)

DRILLING MEDIUM:
0.0-15.3 NONE

TESTING AND SAMPLING:
SOIL SAMPLES WERE TAKEN FROM THE FOLLOWING INTERVALS.
0.0- 1.1
4.9- 5.9
10.0-10.8
15.2-15.3
SELECTED SAMPLES WERE LABORATORY TESTED FOR NATURAL MOISTURES, DENSITIES, GRADATION, HYDROMETER, AND ATTERBERG LIMITS. RESULTS ARE SHOWN IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN.



CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 3.0: ROAD BASE:

0.0 - 3.0: SANDY LEAN CLAY:
ABOUT 60% FINES WITH LOW TO MEDIUM PLASTICITY, SLOW DILATANCY, LOW TO MEDIUM TOUGHNESS; ABOUT 40% PREDOMINANTLY VERY FINE TO FINE SAND; MAXIMUM SIZE, FINE SAND; DENSE; MOIST; DARK BROWN; CONTAINS ROOTS; EASY TO AUGER; NO REACTION WITH HCL. s (CL)

0.0 - 1.1 LAB TEST DATA - 50% FINES, 50% SAND, LL = 30, PI = 18, WATER CONTENT = 12%. (SC/CL)

3.0 - 10.8: QUATERNARY RESIDUAL SOIL (Qrs):

3.0 - 10.8: CLAYEY SAND:
ABOUT 60-70% PREDOMINANTLY VERY FINE SAND; ABOUT 30-40% FINES WITH LOW TO MEDIUM PLASTICITY, SLOW DILATANCY, LOW TO MEDIUM TOUGHNESS; LOOSE TO DENSE; MOIST; LIGHT BROWN TO TAN; CONTAINS ROOTS; EASY TO HARD TO AUGER; NONE TO STRONG REACTION WITH HCL (SC)

4.9 - 5.9 LAB TEST DATA - 59% SAND, 41% FINES, LL = NA, PI = NA.

10.0 - 10.8 LAB TEST DATA - WATER CONTENT = 17%, IN-PLACE DRY UNIT WEIGHT = 112.6 PCF.

10.8 - 15.3: TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED:

10.8 - 15.3: CRUSHED SANDSTONE:
POOR RECOVERY, RETRIEVED AS SANDSTONE FRAGMENTS FROM POWER AUGER HOLE; MOIST; LIGHT BROWN; FINE TO VERY FINE GRAINED; IRON OXIDE STAINING; STRONG REACTION WITH HCL.

STRATIGRAPHY:

0.0 - 3.0	ROAD BASE
3.0 - 10.8	QUATERNARY RESIDUAL SOIL (Qrs)
10.8 - 15.3	TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED.

COMMENTS:

ALL MEASUREMENTS ARE DEPTHS SUBTRACTED FROM GROUND SURFACE. ELEVATIONS WERE NOT AVAILABLE AT THIS TIME.

SAMPLES TAKEN BY THE CALIFORNIA SAMPLER AND FROM DRILL CORE WERE SELECTED AND LABORATORY TESTED AS DIRECTED BY WOODWARD-CLYDE CONSULTANTS.

DIFFERENCES BETWEEN FIELD AND LAB CLASSIFICATION OF SOILS ARE A RESULT OF FURTHER WORKING (BREAKING DOWN) OF MATERIAL DURING GRADATION TESTING, RESULTING IN AN INCREASE IN PERCENTAGE OF FINES AND A DECREASE IN PERCENTAGE OF COARSE PARTICLES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-9

FEATURE: ELKHEAD RESERVOIR
LOCATION: CREST OF EMERGENCY SPILLWAY
BEGUN: 8-18-93 FINISHED: 8-18-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 15.3
DEPTH TO BEDROCK: 10.8

STATE: COLORADO
GROUND ELEVATION: 6478.50
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DON
REVIEWED BY:

NOTES

CORE RECOVERY:

INTERVAL (FT.)	RECOVERY (%)
15.2-15.3	0

ALL OTHER CORE RECOVERY IS REPORTED IN THE CORE RECOVERY COLUMN.

HOLE COMPLETION:
4 IN. DIAMETER CASING WAS REMOVED. HOLE WAS BACKFILLED TO SURFACE WITH CEMENT GROUT.

COMMENTS:
CENTER COLUMN DATA IS NOT SHOWN IN INTERVALS OF LESS THAN 1.0 FT. THICKNESS. THE DATA FOR THESE INTERVALS CAN BE FOUND IN EITHER THE "NOTES" OR "CLASSIFICATION AND PHYSICAL CONDITION" COLUMNS.

DATA PRESENTED IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN, AND CENTER COLUMN ARE BASED ON BUREAU OF RECLAMATION ENGINEERING GEOLOGY MANUAL.

ALL ANGLES MEASURED FROM THE CORE AXIS AT ZERO DEGREES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-9A

FEATURE: ELKHEAD RESERVOIR
LOCATION: CREST OF EMERGENCY SPILLWAY
BEGUN: 7-2-93 FINISHED: 7-2-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 21.0
DEPTH TO BEDROCK: 10.7

STATE: COLORADO
GROUND ELEVATION: 6418.50
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DBM
REVIEWED BY:

NOTES

ALL MEASUREMENTS ARE FROM GROUND LEVEL AND ARE THE SAME AS THOSE USED BY THE DRILLER.

ALL MEASUREMENTS ARE IN FEET EXCEPT WHERE NOTED DIFFERENTLY.

DRILLED BY:
REGIONAL DRILL CREW; L. ZOLMAN DRILLER, J.VANAUSDAL, G. LARSEN, DRILLER HELPER.

PURPOSE:
SUBSURFACE INVESTIGATION, CREST EMERGENCY SPILLWAY

DRILL EQUIPMENT:
GUS PECH #1 TRUCK MOUNTED ROTARY DRILL RIG.

DRILL METHOD:
0.0-21.0 - CORED WITH HQ WIRE LINE SYSTEM.

CASING RECORD:
0.0-21.0 HQ IN. DIA (TEMPORARY)

DRILLING MEDIUM:
0.0-21.0 RESERVOIR WATER

CORE RECOVERY:

INTERVAL (FT.)	RECOVERY (%)
0.0 - 11.0	3
11.0- 21.0	93

HOLE COMPLETION:
HQ DIAMETER
CASING WAS REMOVED. HOLE WAS BACKFILLED TO SURFACE WITH PEA GRAVEL.

DEPTH	FLD CLASS/LITH	ELEVATION	% CORE RECOVERY	RQD	FRAC DENSITY	WEATHERING	GEOL UNIT SYMBOL
			3	3			
10	-10.7						
	85		93	86	3 / 7 / 3	4	Tf/Kl
20	-21.0						
	BOTTOM OF HOLE						
30							

CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 10.7: **NO RECOVERY:**
SEE ADJACENT DRILL HOLE DH-WC-9 FOR DETAILED DESCRIPTION OF REACH.

10.7 - 21.0: **TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED**

10.7 - 21.0: **SANDSTONE:**
OCCASIONALLY CLAYEY AND CARBONACEOUS; TAN, LIGHT GRAY TO BLACK; PREDOMINANTLY FINE GRAINED. POORLY TO WELL CEMENTED; GENERALLY LAMINATED TO THICKLY BEDDED (LESS THAN 3/8 IN. TO 2.4 FT.). PREDOMINANTLY PLANAR BEDDING AT 70 TO 90 DEGRE FROM CORE AXIS; MODERATELY TO SLIGHTLY WEATHERED (W4). SOME IRON OXIDE STAINING; MODERATELY HARD TO HARD (H3-H4); WEAK STRONG REACTION WITH HCl; SLIGHTLY FRACTURED (FD3) FROM 10. TO 13.8 FT. AND 15.0 TO 20.1 FT., INTENSELY FRACTURED FROM 13.8 TO 15.0 FT. (FD7) WITH DISCONTINUITIES PRESENT AT ANGL FROM THE CORE AXIS AS FOLLOWS;

6 BEDDING JOINTS AT 84 TO 90 DEGREES; TIGHT (OO), PLANAR, MODERATE TO SLIGHTLY ROUGH (R3-R4), FRESH TO A TRACE OF OXIDATION ON SOME SURFACES (W2). SPACED 0.2 TO 2.4 FT. APART (SP3-SP5).

11.0 - 11.4 LAB TEST DATA - 65% FINES, 35% SAND, LL = NP, PI = NP, WATER CONTENT = 77%, SPECIFIC GRAVITY = 2.50. (ML)

20.6 - 21.0 LAB TEST DATA - WATER CONTENT = 1%, SPECIFIC GRAVITY = 2.53.

STRATIGRAPHY:

0.0 - 10.7 NO RECOVERY
10.7 - 21.0 TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED

COMMENTS:

ALL MEASUREMENTS ARE DEPTHS SUBTRACTED FROM GROUND SURFACE. ELEVATIONS WERE NOT AVAILABLE AT THIS TIME.

SAMPLES TAKEN BY THE CALIFORNIA SAMPLER AND FROM DRILL CORE WERE SELECTED AND LABORATORY TESTED AS DIRECTED BY WOODWARD-CLYDE CONSULTANTS.

DIFFERENCES BETWEEN FIELD AND LAB CLASSIFICATION OF SOILS ARE A RESULT OF FURTHER WORKING (BREAKING DOWN) OF MATERIAL DURING GRADATION TESTING, RESULTING IN AN INCREASE IN PERCENTAGE OF FINES AND A DECREASE IN PERCENTAGE OF COARSE PARTICLES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-9A

FEATURE: ELKHEAD RESERVOIR
LOCATION: CREST OF EMERGENCY SPILLWAY
BEGUN: 7-2-83 FINISHED: 7-2-83
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 21.0
DEPTH TO BEDROCK: 10.7

STATE: COLORADO
GROUND ELEVATION: 6478.50
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOW
REVIEWED BY:

COMMENTS:

CENTER COLUMN DATA IS NOT SHOWN IN INTERVALS OF LESS THAN 1.0 FT. THICKNESS. THE DATA FOR THESE INTERVALS CAN BE FOUND IN EITHER THE "NOTES" OR "CLASSIFICATION AND PHYSICAL CONDITION" COLUMNS.

DATA PRESENTED IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN, AND CENTER COLUMN ARE BASED ON BUREAU OF RECLAMATION ENGINEERING GEOLOGY MANUAL.

ALL ANGLES MEASURED FROM THE CORE AXIS AT ZERO DEGREES.

ABBREVIATIONS:

HQ = 2.5 IN. CORE DIA., 3.78 IN. HOLE DIA.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-10

FEATURE: ELKHEAD RESERVOIR
LOCATION: CREST OF EMERGENCY SPILLWAY
BEGUN: 6-17-83 FINISHED: 6-17-83
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 5.3
DEPTH TO BEDROCK: 3.0

STATE: COLORADO
GROUND ELEVATION: 6402.30
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOW
REVIEWED BY:

NOTES

ALL MEASUREMENTS ARE FROM GROUND LEVEL AND ARE THE SAME AS THOSE USED BY THE DRILLER.

ALL MEASUREMENTS ARE IN FEET EXCEPT WHERE NOTED DIFFERENTLY.

DRILLED BY:
REGIONAL DRILL CREW: L. WASHBURN, DRILLER, L. ZOLMAN, J.VANAUSDAL, DRILLER HELPERS.

PURPOSE:
SUBSURFACE INVESTIGATION, CREST EMERGENCY SPILLWAY

DRILL EQUIPMENT:
GUS PECH #1 TRUCK MOUNTED ROTARY DRILL RIG.

DRILL METHOD:
0.0-5.3 - PENETRATION TESTS TAKEN AT 5.0 FT. INCREMENTS FOLLOWED BY A 4 INCH DIAMETER HOLLOW-STEM AUGER THROUGH ALL OVERBURDEN MATERIALS. THE PROCEDURE FOLLOWED WAS TO DRIVE A CALIF. SAMPLER 1.0 FT.COUNTING THE NUMBER OF BLOWS AND MEASURING THE DISTANCE TRAVELED BY EACH TO THE BOTTOM OF THE SAMPLED INTERVAL. THE AUGER WAS THEN ADVANCED TO THE TOP OF THE NEXT ASSIGNED SAMPLE INTERVAL.

CASING RECORD:
0.0-5.3 4 IN. DIA (TEMPORARY)

DRILLING MEDIUM:
0.0-5.3 NONE

TESTING AND SAMPLING:
SOIL SAMPLES WERE TAKEN FROM THE FOLLOWING INTERVALS.
0.0-1.1
5.2-5.3
SELECTED SAMPLES WERE LABORATORY TESTED FOR NATURAL MOISTURES, DENSITIES, GRADATION, HYDROMETER, AND ATTERBERG LIMITS. RESULTS ARE SHOWN IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN.

CORE RECOVERY:

INTERVAL (FT.)	RECOVERY (%)
5.2- 5.3	0

ALL OTHER CORE RECOVERY

DEPTH	FLD CLASS/LITH	ELEVATION	% CORE RECOVERY	WEATHERING	SPT 0 50	GEOL UNIT SYMBOL
	s (CL) -3.0		88		23	Qrs
	ss -5.3			4	50	Tf/Kl
			BOTTOM OF HOLE			
10						

CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 3.0: QUATERNARY RESIDUAL SOIL (Qrs):

0.0 - 3.0: CLAYEY SAND:
ABOUT 60-70% PREDOMINANTLY VERY FINE TO FINE SAND; ABOUT 30- FINES WITH NO TO LOW PLASTICITY, SLOW DILATANCY, LOW TOUGHNE MAXIMUM SIZE FINE SAND; DENSE; MOIST; BROWN TO DARK BROWN; ROOTS; NO REACTION WITH HCl; EASY TO AUGER. (SC)

0.0 -1.1 LAB TEST DATA - 56% SAND, 44% FINES, LL = 32, PI = 13. (SC)

3.0 TO 5.3: TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED:

3.0 - 5.3: SANDSTONE:
POOR RECOVERY, RETRIEVED AS AUGER CUTTINGS WHICH CONSISTED O PREDOMINANTLY FINE GRAINED SAND; SOFT TO MODERATELY HARD (H4 -H5); MODERATELY WEATHERED (W4), IRON OXIDE STAINED; LIGHT BROWN; MOIST; REFUSAL OF AUGER AT 5.3 FT.; WEAK TO STRONG REACTION WITH HCL.

STRATIGRAPHY:

0.0 - 3.0 QUATERNARY RESIDUAL SOIL (Qrs)
3.0 - 5.3 TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED.

COMMENTS:

ALL MEASUREMENTS ARE DEPTHS SUBTRACTED FROM GROUND SURFACE. ELEVATIONS WERE NOT AVAILABLE AT THIS TIME.

SAMPLES TAKEN BY THE CALIFORNIA SAMPLER AND FROM DRILL CORE WERE SELECTED AND LABORATORY TESTED AS DIRECTED BY WOODWARD-CLYDE CONSULTANTS.

DIFFERENCES BETWEEN FIELD AND LAB CLASSIFICATION OF SOILS ARE A RESULT OF FURTHER WORKING (BREAKING DOWN) OF MATERIAL DURING GRADATION TESTING, RESULTING IN AN INCREASE IN PERCENTAGE OF FINES AND A DECREASE IN PERCENTAGE OF COARSE PARTICLES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-10

FEATURE: ELKHEAD RESERVOIR
LOCATION: CREST OF EMERGENCY SPILLWAY
BEGUN: 8-17-83 FINISHED: 8-17-83
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 5.3
DEPTH TO BEDROCK: 3.0

STATE: COLORADO
GROUND ELEVATION: 6402.30
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOM
REVIEWED BY:

NOTES	
IS REPORTED IN THE CORE RECOVERY COLUMN. **HOLE COMPLETION:** 4 IN. DIAMETER CASING WAS REMOVED. HOLE WAS BACKFILLED TO SURFACE WITH DRILL CUTTINGS.	

COMMENTS:

CENTER COLUMN DATA IS NOT SHOWN IN INTERVALS OF LESS THAN 1.0 FT. THICKNESS. THE DATA FOR THESE INTERVALS CAN BE FOUND IN EITHER THE "NOTES" OR "CLASSIFICATION AND PHYSICAL CONDITION" COLUMNS.

DATA PRESENTED IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN, AND CENTER COLUMN ARE BASED ON BUREAU OF RECLAMATION ENGINEERING GEOLOGY MANUAL.

ALL ANGLES MEASURED FROM THE CORE AXIS AT ZERO DEGREES.

ABBREVIATIONS:

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-11

FEATURE: ELKHEAD RESERVOIR
LOCATION: CREST OF EMERGENCY SPILLWAY
BEGUN: 6-17-93 FINISHED: 6-17-93
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 16.1
DEPTH TO BEDROCK: 14.0

STATE: COLORADO
GROUND ELEVATION: 6357.15
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOW
REVIEWED BY:

NOTES

ALL MEASUREMENTS ARE FROM GROUND LEVEL AND ARE THE SAME AS THOSE USED BY THE DRILLER.

ALL MEASUREMENTS ARE IN FEET EXCEPT WHERE NOTED DIFFERENTLY.

DRILLED BY:
REGIONAL DRILL
CREW: L. WASHBURN, DRILLER, L. ZOLMAN, J.VANAUSDAL, DRILLER HELPERS.

PURPOSE:
SUBSURFACE INVESTIGATION, CREST EMERGENCY SPILLWAY

DRILL EQUIPMENT:
GUS PECH #1 TRUCK MOUNTED ROTARY DRILL RIG.

DRILL METHOD:
0.0-16.1 - PENETRATION TESTS TAKEN AT 5.0 FT. INCREMENTS FOLLOWED BY A 4 INCH DIAMETER HOLLOW - STEM AUGER THROUGH ALL OVERBURDEN MATERIALS. THE PROCEDURE FOLLOWED WAS TO DRIVE A CALIF. SAMPLER 1.0 FT. COUNTING THE NUMBER OF BLOWS AND MEASURING THE DISTANCE TRAVELED BY EACH TO THE BOTTOM OF THE SAMPLED INTERVAL. THE AUGER WAS THEN ADVANCED TO THE TOP OF THE NEXT ASSIGNED SAMPLE INTERVAL.

CASING RECORD:
0.0-16.1 4 IN. DIA (TEMPORARY)

DRILLING MEDIUM:
0.0-16.1 NONE

TESTING AND SAMPLING:
SOIL SAMPLES WERE TAKEN FROM THE FOLLOWING INTERVALS.
0.0 - 1.2
5.1 - 6.0
10.0-11.0
15.4-16.1
SELECTED SAMPLES WERE LABORATORY TESTED FOR NATURAL MOISTURES, DENSITIES, GRADATION, HYDROMETER, AND ATTERBERG LIMITS. RESULTS ARE SHOWN IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN.

DEPTH	FLD CLASS/LITH	ELEVATION	% CORE RECOVERY	WEATHERING	SPT	GEOL UNIT SYMBOL
			R2		16	
			R3		14	Qrs
10	s (CL)				16	
		14.0				
	clyst. ss		100	4	50	Tf/Kl
			BOTTOM OF HOLE			
20						

CLASSIFICATION AND PHYSICAL CONDITION

0.0 - 14.0: QUATERNARY RESIDUAL SOIL (Qrs):

0.0 - 14.0: SANDY LEAN CLAY:
ABOUT 60-70% FINES WITH MEDIUM PLASTICITY, SLOW DILATANCY, TO MEDIUM TOUGHNESS; ABOUT 30-40% PREDOMINANTLY VERY FINE TO FINE SAND; MAXIMUM SIZE, FINE SAND; ROOTS; DENSE; MOIST TO BROWN TO DARK BROWN; ALKALI STRINGERS; STRONG REACTION WITH HCl; EASY TO AUGER.

0.0 - 1.2 LAB TEST DATA - 58% FINES, 40% SAND, 2% GRAVEL, LL = 32, PI = 15, WATER CONTENT = 10%. s(CL)

5.1 - 6.0 LAB TEST DATA - 80% FINES, 20% SAND, LL = 41, PI = 23, WATER CONTENT = 23%, IN-PLACE DRY UNIT WEIGHT = 112.9 PCF. (CL)s

14.0 - 16.1: TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED:

14.0 - 16.1: CRUSHED CLAYSTONE AND SANDSTONE (L1):
RETRIEVED AS CLAY AND SAND SIZED FRAGMENTS FROM POWER AUGER HOLE; FINE TO VERY FINE SAND; LIGHT BROWN TO TAN; INTENSELY WEATHERED (W5), IRON STAINING OF FRAGMENTS; WEAK TO STRONG REACTION WITH HCl; EASY TO MODERATELY HARD TO AUGER, REFUSAL AT 16.1. MATERIAL WAS FIELD IDENTIFIED AS "CLAY (CL)"- AB 55% FINES WITH MEDIUM TO HIGH PLASTICITY, MEDIUM TO HIGH DRY STRENGTH, NONE TO SLOW DILATANCY, MEDIUM TO HIGH TOUGHNESS ABOUT 5% FINE SAND.

15.4-16.0 LAB TEST DATA - WATER CONTENT = 18%, IN-PLACE DRY UNIT WEIGHT = 112.2 PCF.

STRATIGRAPHY:

0.0 - 14.0 QUATERNARY RESIDUAL SOIL (Qrs)
14.0 - 16.1 TERTIARY FORT UNION / CRETACEOUS LANCE FORMATION (Tf/Kl) - UNDIFFERENTIATED.

COMMENTS:

ALL MEASUREMENTS ARE DEPTHS SUBTRACTED FROM GROUND SURFACE. ELEVATIONS WERE NOT AVAILABLE AT THIS TIME.

SAMPLES TAKEN BY THE CALIFORNIA SAMPLER AND FROM DRILL CORE WERE SELECTED AND LABORATORY TESTED AS DIRECTED BY WOODWARD-CLYDE CONSULTANTS.

DIFFERENCES BETWEEN FIELD AND LAB CLASSIFICATION OF SOILS ARE A RESULT OF FURTHER WORKING (BREAKING DOWN) OF MATERIAL DURING GRADATION TESTING, RESULTING IN AN INCREASE IN PERCENTAGE OF FINES AND A DECREASE IN PERCENTAGE OF COARSE PARTICLES.

GEOLOGIC LOG OF DRILL HOLE NO. DH-WC-11

FEATURE: ELKHEAD RESERVOIR
LOCATION: CREST OF EMERGENCY SPILLWAY
BEGUN: 8-17-83 FINISHED: 8-17-83
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:

PROJECT: TECHNICAL ASSISTANCE TO STATES
COORDINATES: N E
TOTAL DEPTH: 18.1
DEPTH TO BEDROCK: 14.0

STATE: COLORADO
GROUND ELEVATION: 6357.15
ANGLE FROM HORIZONTAL: 90 AZIMUTH:
HOLE LOGGED BY: K. DOW
REVIEWED BY:

NOTES

HOLE COMPLETION:
4 IN. DIAMETER CASING WAS REMOVED. HOLE WAS BACKFILLED TO SURFACE WITH CEMENT GROUT.

COMMENTS:
CENTER COLUMN DATA IS NOT SHOWN IN INTERVALS OF LESS THAN 1.0 FT. THICKNESS. THE DATA FOR THESE INTERVALS CAN BE FOUND IN EITHER THE "NOTES" OR "CLASSIFICATION AND PHYSICAL CONDITION" COLUMNS.

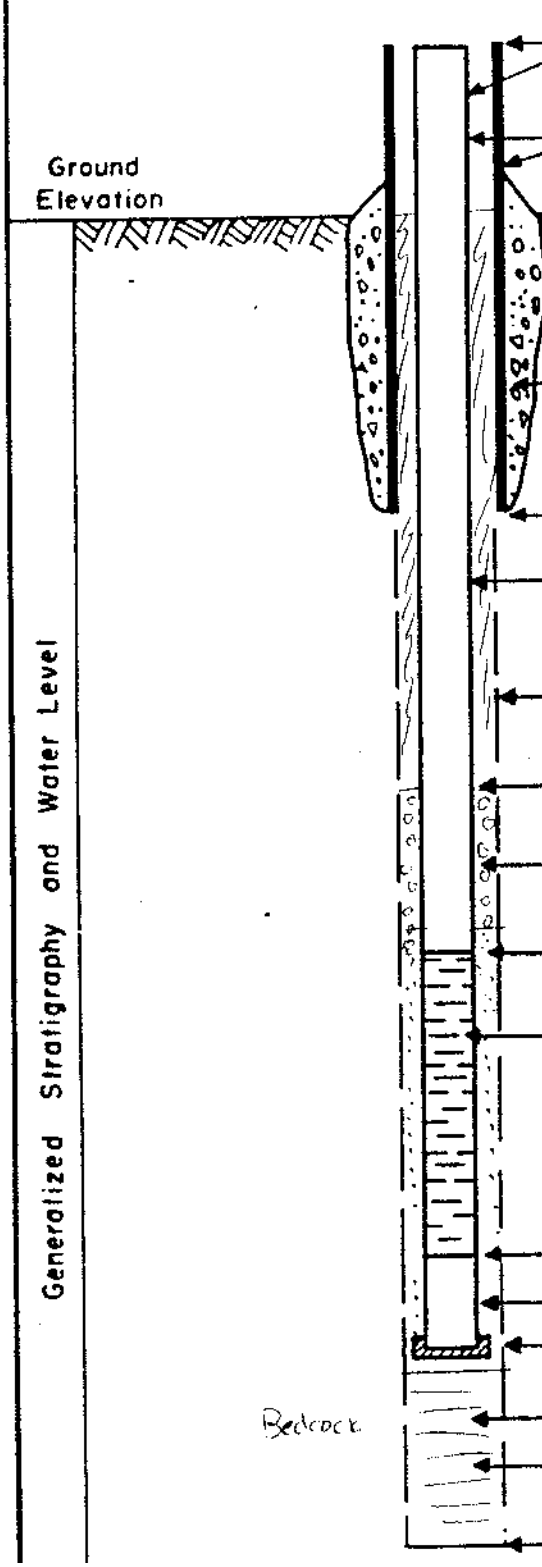
DATA PRESENTED IN THE CLASSIFICATION AND PHYSICAL CONDITION COLUMN, AND CENTER COLUMN ARE BASED ON BUREAU OF RECLAMATION ENGINEERING GEOLOGY MANUAL.

ALL ANGLES MEASURED FROM THE CORE AXIS AT ZERO DEGREES.

GROUND WATER OBSERVATION WELL REPORT

PROJECT Elkhead Dam Enlargement
LOCATION Moffat County, Colorado
Date Completed June 22, 1993 Original Depth 79.7'
Inspected By K. Dow Date 6/22/93
Checked By Jessica Marshall Date 10/18/93

Page 1 of 1
Well No. WC-1
Aquifer
Depth Interval 50'



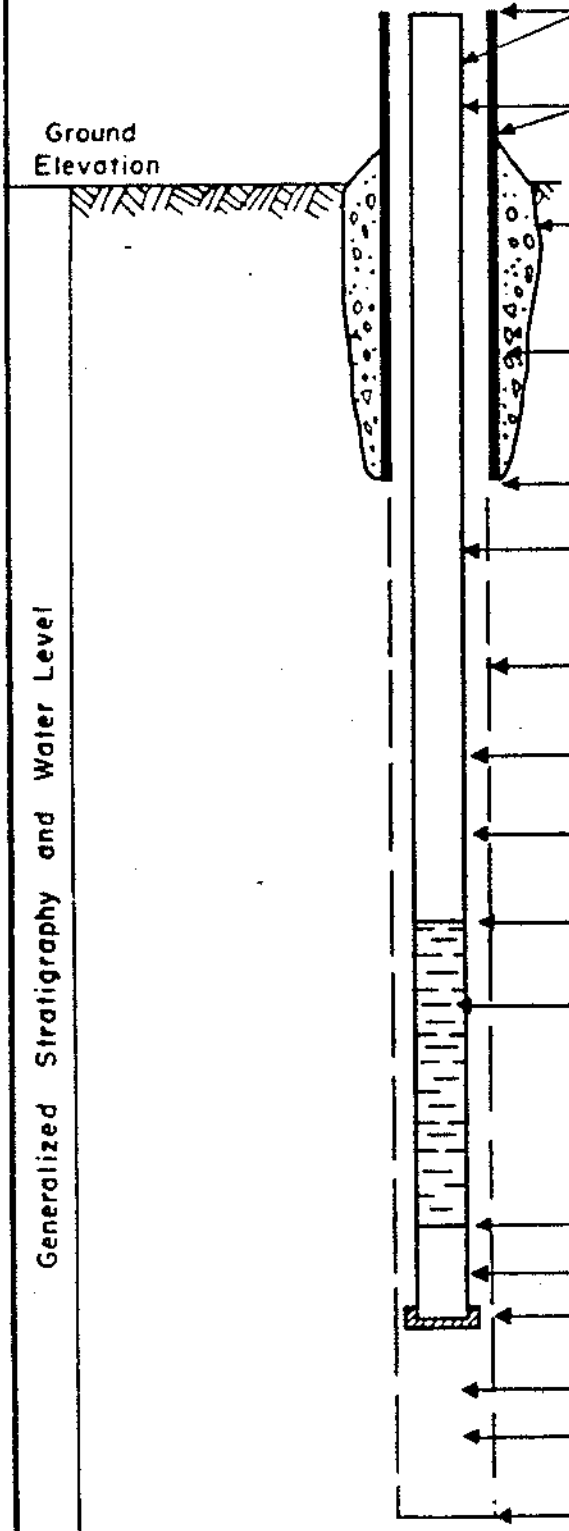
Elevation of top of surface casing / riser pipe.	6385.18
Height of top of surface casing / riser pipe above ground surface.	2" below surface
Depth of surface seal below ground surface	21.4'
Type of surface seal: Cement grout to 2" below surface	
I.D. of surface casing.	
Type of surface casing:	
Depth of surface casing below ground	1.2 ft
I.D. of riser pipe.	
Type of riser pipe: 1½" PVC	
Diameter of borehole	
Depth of borehole	
Type of backfill: Cement bentonite grout	
Elev./depth top of seal.	21.40
Type of seal: bentonite chips	
Elev./depth bottom of seal.	24.80
Type of sand pack. 10-20 silica sand	
Depth of top of sand pack.	24.80'
Elev./depth top of screened section.	27.25'
Type of screened section: slotted PVC 1½"	
Describe openings 0.020 slotted	
I.D. of screened section.	
Elev./depth bottom of screened section.	77.25'
Length of blank section.	2.01 ft
Elev./depth bottom of plugged blank section.	79.25 ft
Elev./depth bottom of sand column.	
Type of backfill below observation pipe. none	
Elev./depth of hole.	79.7

WOODWARD-CLYDE CONSULTANT

GROUND WATER OBSERVATION WELL REPORT

PROJECT Elkhead Dam Enlargement
LOCATION Moffat County - Colorado
Date Completed June 30, 1993 Original Depth 71.90'
Inspected By K Dow Date 6/30/93
Checked By Jessica Marshall Date 10/18/93

Page 1 of 1
Well No. WC-2
Aquifer
Depth Interval 60' slott



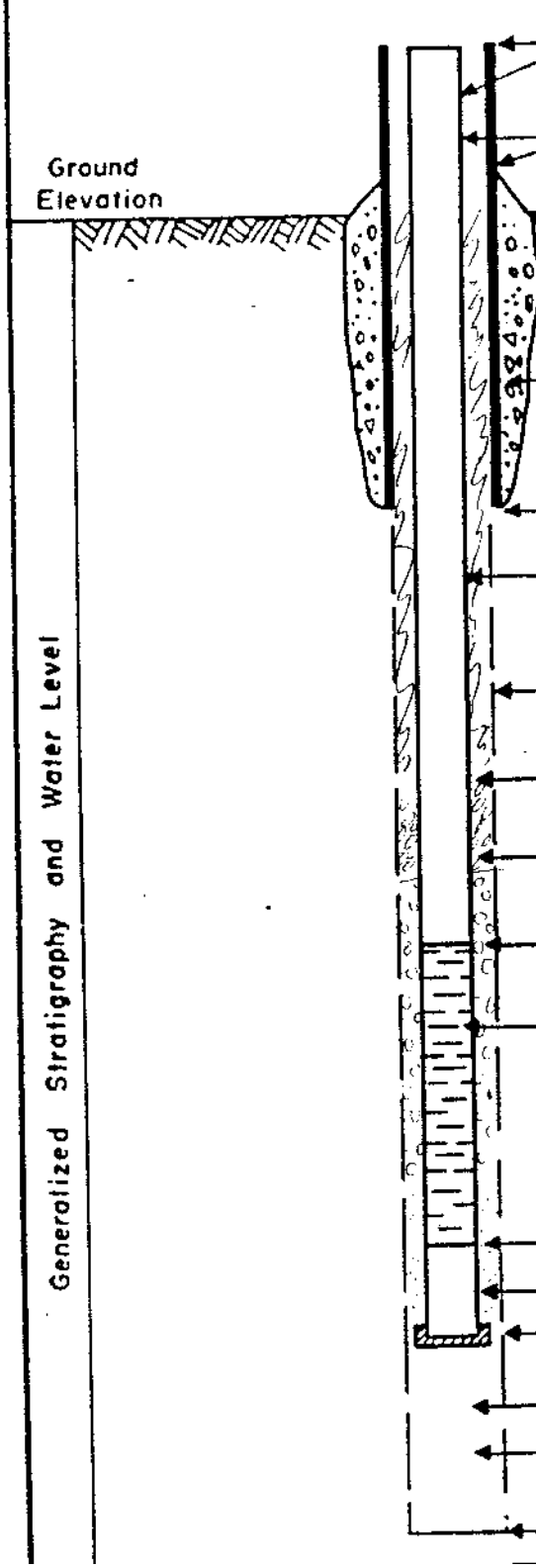
Elevation of top of surface casing / riser pipe.	6375.9 flush
Height of top of surface casing / riser pipe above ground surface.	flush
Depth of surface seal below ground surface	4.50
Type of surface seal: cement grout	to surface
I.D. of surface casing.	
Type of surface casing: 6"	
Depth of surface casing below ground	1.0
I.D. of riser pipe.	
Type of riser pipe: 1 1/2" PVC	
Diameter of borehole	
Depth of borehole	
Type of backfill: cement bentonite grout	
Elev./depth top of seal.	4.50
Type of seal: bentonite pellet	
Elev./depth bottom of seal.	8.20
Type of sand pack. 10-20 silica sand	
Depth of top of sand pack.	8.20
Elev./depth top of screened section.	9.90
Type of screened section: 1 1/2" PVC	
Describe openings. 0.020 slotted	
I.D. of screened section.	
Elev./depth bottom of screened section.	69.90
Length of blank section.	2.0
Elev./depth bottom of plugged blank section.	71.90
Elev./depth bottom of sand column.	
Type of backfill below observation pipe.	
Elev./depth of hole.	71.90

WOODWARD-CLYDE CONSULTAN

GROUND WATER OBSERVATION WELL REPORT

PROJECT Elkhead Dam Enlargement
LOCATION Moffat County, Colorado
Date Completed 7/2/93 Original Depth 97.6'
Inspected By K Dow Date 7/2/93
Checked By Jessica Marshall Date 10/18/93

Page 1 of 1
Well No. WC-3
Aquifer
Depth Interval 77' slotted



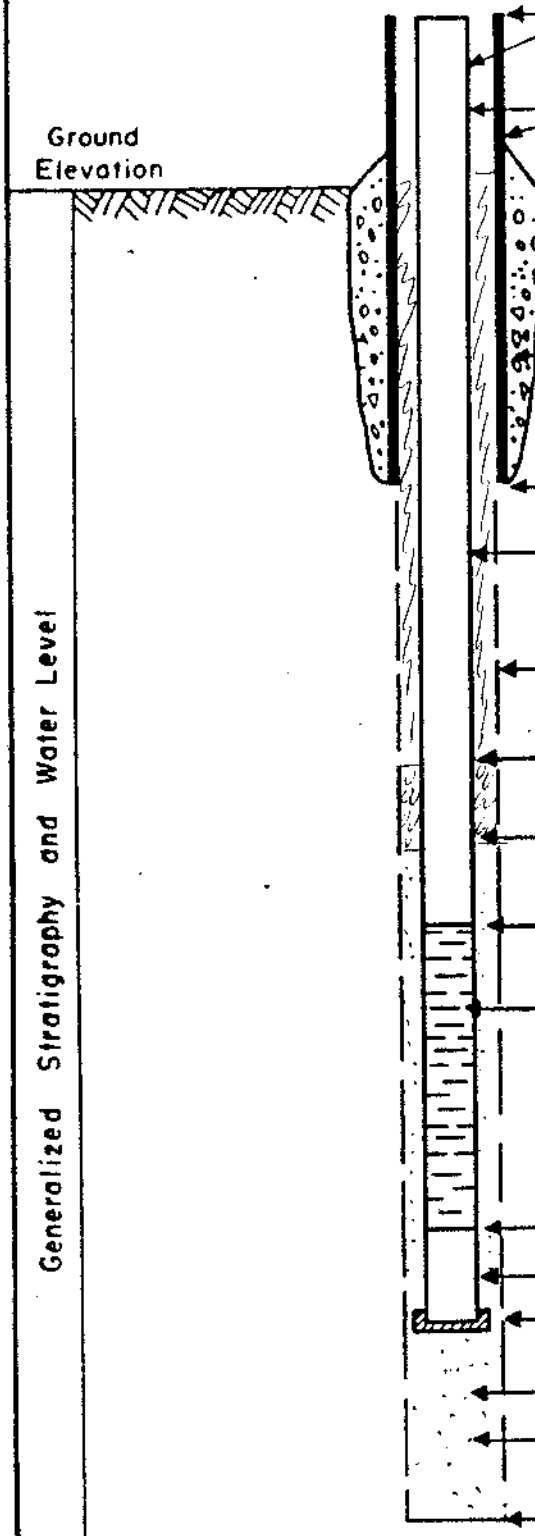
Elevation of top of surface casing / riser pipe.	6375.76
Height of top of surface casing / riser pipe above ground surface.	Ground level
Depth of surface seal below ground surface	0 to 7'
Type of surface seal: cement grout	
I.D. of surface casing.	
Type of surface casing:	
Depth of surface casing below ground	
I.D. of riser pipe.	
Type of riser pipe: 1 1/2" PVC	
Diameter of borehole	
Depth of borehole	
Type of backfill: Cement bentonite grout	
Elev./depth top of seal.	7.0'
Type of seal: bentonite pellets	
Elev./depth bottom of seal.	12.0'
Type of sand pack. Pea gravel to 12' 10 20 silica sand to 25'	
Depth of top of sand pack.	12.0'
Elev./depth top of screened section.	17.6
Type of screened section: 1 1/2" PVC	
Describe openings 0.020 slotted	
I.D. of screened section.	
Elev./depth bottom of screened section.	94.6
Length of blank section.	2.06
Elev./depth bottom of plugged blank section.	96.7
Elev./depth bottom of sand column.	
Type of backfill below observation pipe.	
Elev./depth of hole.	97.6'

WOODWARD-CLYDE CONSULTANT

GROUND WATER OBSERVATION WELL REPORT

PROJECT Ellwood Dam Enlargement
LOCATION Moffat County, Colorado
Date Completed June 24, 1993 Original Depth 40'
Inspected By K Dow Date 6/24/93
Checked By Jessica Marshall Date 10/18/93

Page 1 of 1
Well No. WC-4
Aquifer
Depth Interval 28.4' slo



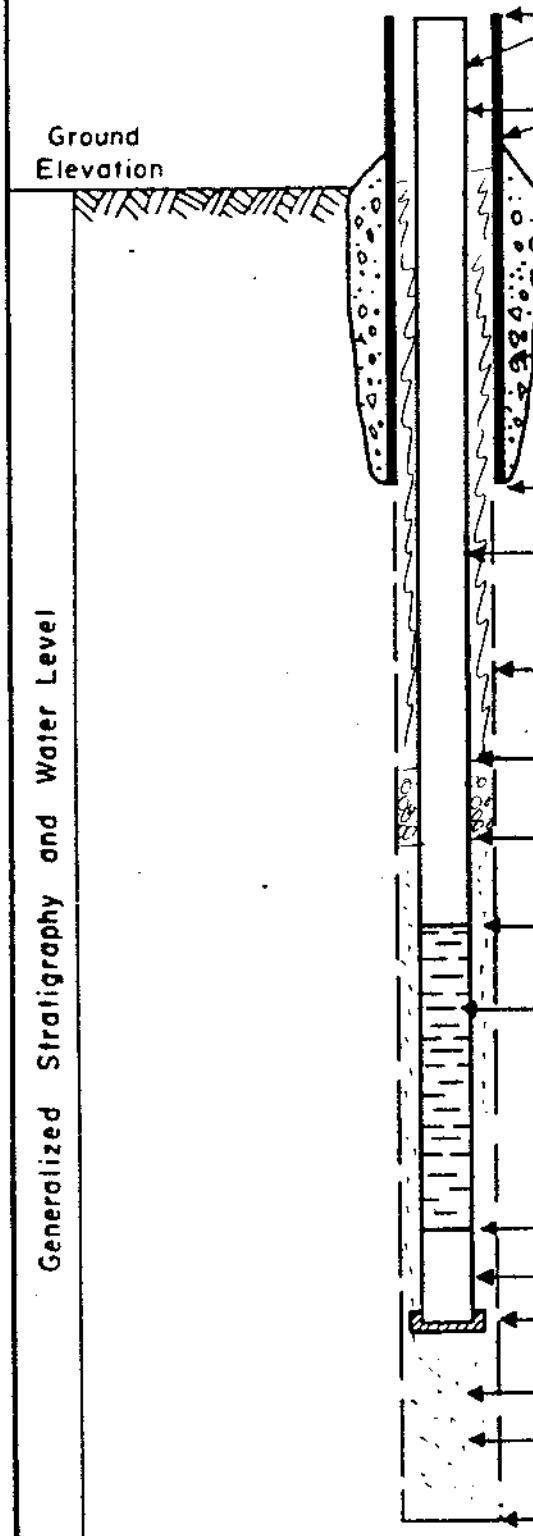
Elevation of top of surface casing / riser pipe.	6333.80
Height of top of surface casing / riser pipe above ground surface	2.0
Depth of surface seal below ground surface	4.35
Type of surface seal: cement grout	
I.D. of surface casing.	
Type of surface casing: steel standpipe	
Depth of surface casing below ground	2.0
I.D. of riser pipe.	
Type of riser pipe: 1½" PVC (solid)	
Diameter of borehole	
Depth of borehole	
Type of backfill: cement bentonite grout	
Elev./depth top of seal.	4.35'
Type of seal: bentonite pellets	
Elev./depth bottom of seal.	6.35'
Type of sand pack: 10-20 silica sand	
Depth of top of sand pack.	6.35
Elev./depth top of screened section.	8.35
Type of screened section: slotted PVC 1½"	
Describe openings 0.020 slotted	
I.D. of screened section.	
Elev./depth bottom of screened section.	37.26
Length of blank section.	2.0
Elev./depth bottom of plugged blank section.	39.26
Elev./depth bottom of sand column.	
Type of backfill below observation pipe: silica sand	
Elev./depth of hole.	40.0

WOODWARD-CLYDE CONSULTANT

GROUND WATER OBSERVATION WELL REPORT

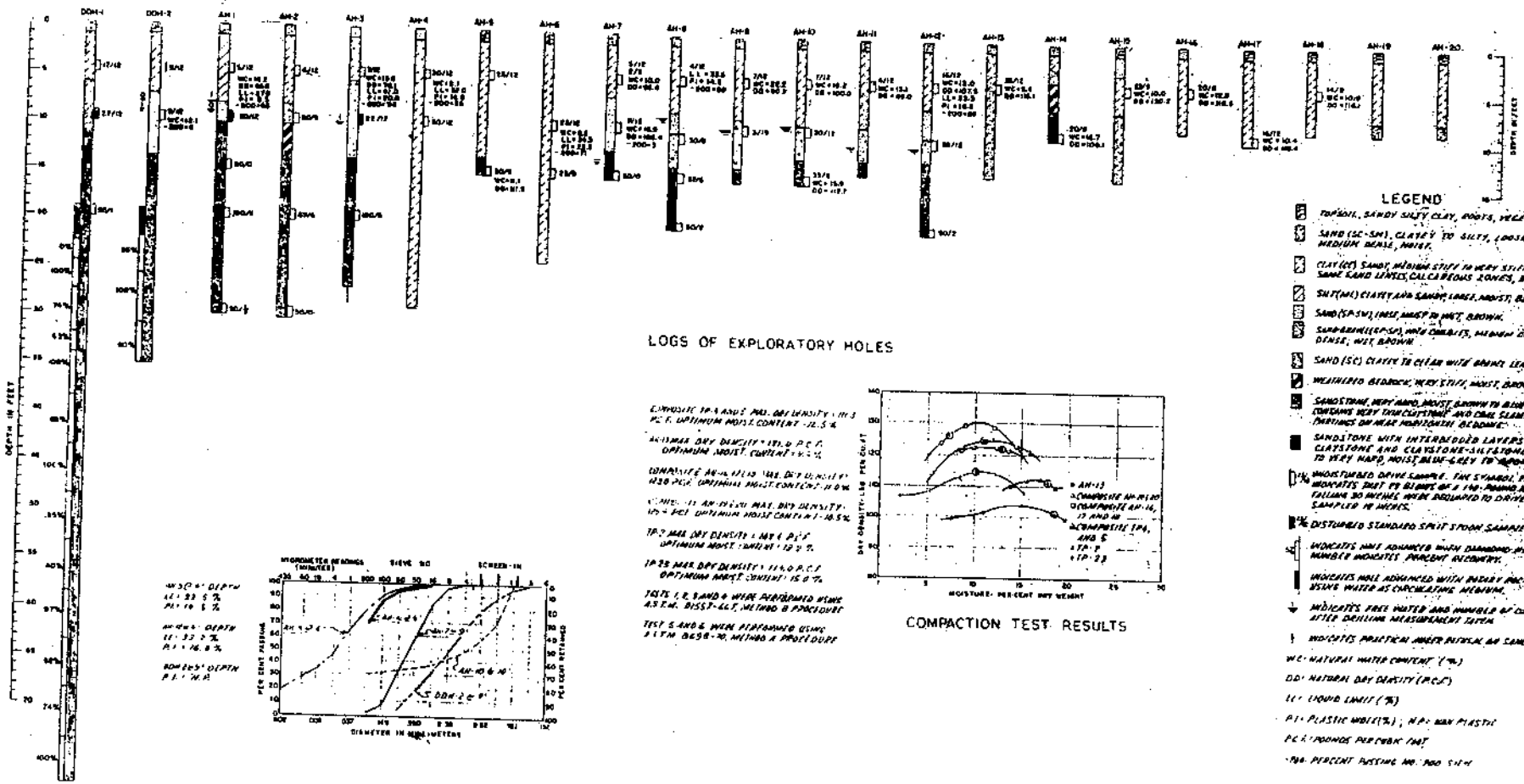
PROJECT Elkhead Dam Enlargement
LOCATION Moffat County, Colorado
Date Completed June 20, 1993 Original Depth 82.8
Inspected By K Dow Date 6/20/93
Checked By Jessica Marshall Date 10/18/93

Page 1 of 1
Well No. WC-7
Aquifer
Depth Interval 40' slotted



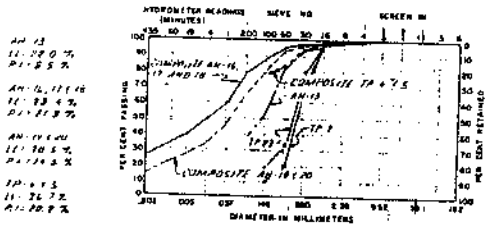
Elevation of top of surface casing / riser pipe.	6394.08
Height of top of surface casing / riser pipe above ground surface.	2.0'
Depth of surface seal below ground surface	30.0'
Type of surface seal: Cement grout	
I.D. of surface casing.	
Type of surface casing: 4" steel standpipe	
Depth of surface casing below ground	2.0
I.D. of riser pipe.	
Type of riser pipe: 1½ in PVC	
Diameter of borehole	
Depth of borehole	
Type of backfill: Cement-bentonite grout	
Elev./depth top of seal.	30.0
Type of seal: bentonite pellets	
Elev./depth bottom of seal.	34.0
Type of sand pack. 10-20 silica sand	
Depth of top of sand pack.	34.0
Elev./depth top of screened section.	37.2
Type of screened section: Slotted PVC	
Describe openings 0.020 slotted	
I.D. of screened section.	
Elev./depth bottom of screened section.	77.2
Length of blank section.	2.0
Elev./depth bottom of plugged blank section.	79.2
Elev./depth bottom of sand column.	
Type of backfill below observation pipe. 10-20 silica sand	
Elev./depth of hole.	82.8

WOODWARD-CLYDE CONSULTANT



LOGS OF EXPLORATORY HOLES

COMPACTION TEST RESULTS



GRADATION TEST RESULTS

COMPOSITE TP-4 AND 5 MAX. DRY DENSITY = 111.3 P.C.F. OPTIMUM MOIST. CONTENT = 12.5 %

AH-13 MAX. DRY DENSITY = 121.0 P.C.F. OPTIMUM MOIST. CONTENT = 9.5 %

COMPOSITE AH-11 & 20 MAX. DRY DENSITY = 120.0 P.C.F. OPTIMUM MOIST. CONTENT = 11.0 %

COMPOSITE AH-16, 17 AND 18 MAX. DRY DENSITY = 114.0 P.C.F. OPTIMUM MOIST. CONTENT = 10.5 %

TP-7 MAX. DRY DENSITY = 114.6 P.C.F. OPTIMUM MOIST. CONTENT = 12.2 %

TP-23 MAX. DRY DENSITY = 114.0 P.C.F. OPTIMUM MOIST. CONTENT = 15.0 %

TESTS 1, 2, 3 AND 4 WERE PERFORMED USING A.S.T.M. D1557-64T, METHOD B PROCEDURE

TEST 5 AND 6 WERE PERFORMED USING A.S.T.M. D698-70, METHOD A PROCEDURE

LEGEND

- TOPSOIL, SANDY SILTY CLAY, ROOTS, VEGETATION
- SAND (SC-SM), CLAYEY TO SILTY, LOOSE TO MEDIUM DENSE, MOIST.
- CLAY (CL) SANDY, MEDIUM STIFF TO VERY STIFF, MOIST, SOME SAND LENSES, CALCAREOUS ZONES, BROWN.
- SILT (ML) CLAYEY AND SANDY, LOOSE, MOIST, BROWN.
- SAND (SP-SM), LOOSE, MOIST TO WET, BROWN.
- SAND-GRAVEL (SP-SP), WITH COBBLES, MEDIUM DENSE TO DENSE, WET, BROWN
- SAND (SC) CLAYEY TO CLEAN WITH GRAVEL LENSES.
- WEATHERED BEDROCK, VERY STIFF, MOIST, BROWN.
- SANDSTONE, VERY HARD, MOIST, BROWN TO BLUE-GREY, CONTAINS VERY THIN CLAYSTONE AND COAL SEAMS. PARTINGS ON NEAR HORIZONTAL BEDDING.
- SANDSTONE WITH INTERBEDDED LAYERS OF CLAYSTONE AND CLAYSTONE-SILTSTONE, HARD TO VERY HARD, MOIST, BLUE-GREY TO BROWN.
- % UNDISTURBED DRIVE SAMPLE. THE SYMBOL FRONT INDICATES THAT 19 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 18 INCHES.
- % DISTURBED STANDARD SPLIT SPOON SAMPLE.
- INDICATES HOLE ADVANCED WITH DIAMOND-MACHINE NUMBER INDICATES PERCENT RECOVERY.
- INDICATES HOLE ADVANCED WITH ROTARY ROCK BIT USING WATER AS CIRCULATING MEDIUM.
- INDICATES FREE WATER AND NUMBER OF DAYS AFTER DRILLING MEASUREMENT TAKEN
- INDICATES PRACTICAL WATER PERCHED ON SANDSTONE

WC: NATURAL WATER CONTENT (%)

DD: NATURAL DRY DENSITY (P.C.F.)

LL: LIQUID LIMIT (%)

PI: PLASTIC INDEX (%) ; N.P.: NON PLASTIC

P.C.F.: POUNDS PER CUBIC FOOT

-#40: PERCENT PASSING NO. 40 SIEVE

NOTES

1. FOR REFERENCE DRAWINGS, SEE DWG. 1141-D-1.
2. FOR LOCATION OF EXPLORATORY DRILLING, BORROW AREAS AND GENERAL NOTES, SEE DWG. 1141-D-2.

33

REVISION NO.	DESCRIPTION	APPROVED	APPROVED

COLORADO DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WILDLIFE
ELKHEAD CREEK PROJECT

ELKHEAD LAKE DAM
EXPLORATION AND CONSTRUCTION MATERIALS
SHEET 2 OF 2

CONSULTANT: ENGINEERING CONSULTANTS, INC.

DESIGNED: S.P.
DRAWN: S.P.
CHECKED: Lyle Reed Lang

DIVISION OF WILDLIFE
DATE:

DWG. NO. 1141-D-3 | SHEET 3 OF 15 SHEETS

C-1339.A

BOREHOLE LOG

PROJECT ELKHEAD LAKE DAM
LOCATION AUXILIARY SPILLWAY
COORDINATES N ℄ STA. 0-20
E

ELEVATION ± 6377
INCLINATION VERTICAL
DIRECTION
LOGGED BY WAM

DRILLED BY BOYLES BROS
RIG MOBIL DRILL B-56
START 9·6·85
FINISH 9·6·85

Bore hole No 1

Sheet 1 of

DRILLING					GEOMECHANICAL			GEOLOGICAL		TESTING
CASING / BIT	RECOVERY (%)	RQD (%)	DEPTH / ELEV. (ft.)	Water Level / DATE	Weathering (DEG WEATH SW W F MW D)	Jointing (JOINTS/FT 0 1 2 3 4)	DISCONTINUITIES TYPE / DIP	COLUMN	DESCRIPTION	SAMPLING / LABORATORY / STANDARD PENETRATION / WATER PRESSURE
NC ϕ DIAMOND	60 20 / 80 40	60 20 / 80 40	1.0						ROAD SHOULDER 3/4" ϕ MINUS CRUSHED GRAVEL	
			10			NA			TRANSPORTED SOIL; SILTY SANDY CLAYEY, TAN STIFF LOW PLASTICITY (CL) STRINGER OF WHITE SILT, GIVE MOTTLED APPEARANCE. BELOW 12.0 SANDIER LOGGED FROM CUTTINGS AND 4.5' OF SAMPLE RECOVERED TO 20.0	
			18.8							
			20 / 21.4						ALLUVIAL GRAVEL; OLD RIVER TERRACE, COMPOSED OF WELL ROUNDED, HARD COBBLES OF BASALT AND ANGULAR FRAGMENTS OF DARK, HARD SANDSTONE.	
						BROKEN & DISTROYED	CJ — OX CJ — OX		BEDROCK; FORMATION SANDSTONE, WEAKLY CEMENTED MEDIUM GRAINED, YELLOW-BUFF BROKEN EASILY WITH FINGERS WHEN WET. INCIPIENT CLOSED JOINTS IN BEDDING PLANE ± 5° CORE PARTS ALONG BEDDING PLANES ABOVE 30.0	
			28.0				OJ — OX 5°			
			29.5 / 30						CLAYSTONE; BROWN-GRAY HIGHLY WEATHERED	
			35.0				OJ 1" OJ OX 5°		SANDSTONE, GRAY WEAKLY CEMENTED, THIN DARK, WAVY CROSSED INTERBEDS	
			40							
			50							

BOTTOM OF HOLE 35.0'

Bore hole No. 1 (0-20 ft)

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON-KNUDSEN COMPANY

BOREHOLE LOG

PROJECT ELKHEAD LAKE DAM
LOCATION AUXILIARY SPILLWAY
COORDINATES N ℄ STA. 0-220
E

ELEVATION ± 6394
INCLINATION VERTICAL
DIRECTION
LOGGED BY W.A.M.

DRILLED BY BOYLES BROS.
RIG MOBIL DRILL B-56
START 9·6·85
FINISH 9·6·85

Bore hol
0-2
Sheet

DRILLING						GEOMECHANICAL				GEOLOGICAL		TESTING
CASING	BIT	RECOVERY (%)	RQD (%)	DEPTH ELEV. (ft.)	Water Level DATE	Weathering DEG. WEATH SW W F MW D	Jointing JOINTS/FT 0 1 2 3 4	DISCONTINUITIES TYPE	DIP	COLUMN	DESCRIPTION	SAMPLING LABORATORY STANDARD PENETRAT WATER PRESSURE
4" I.D.	TRICONE			1.0							TOP SOIL;	
				5.0			NA				TRANSPORTED SOIL; SANDY CLAY YELLOW-TAN, LOW PLASTICITY (CL)	
				10 10.3							ALLUVIAL GRAVEL, OLD RIVER TERRACE, ROUNDED COBBLES OF BASALT (BLACK) GRANITE AND QUARTZITE (WHITE TO PINK) AND SANDSTONE (GRAY TO GREEN) (GP)	
NC ϕ - DIAMOND							BROKEN DISTURBED				BEDROCK; FORMATION: CLAYSTONE YELLOWISH GRAY HIGH ORGANIC CONTENT (CARBONIZED INCLUSIONS), CORE PARTS EASILY ALONG UNDULATING WAXY PLANES PARALLEL TO BEDDING	
				20 20.3 21.1				OX OX OX JOINTING UNCLEAR	50 100		COAL, PEAT, BLACK FRIABLE	
				29.0							SANDSTONE; MEDIUM TO FINE GRAINED, GRAY TO 22.5' BELOW OXIDIZED YELLOW BUFF, WEAKLY CEMENTED, CRUMBLES WITH FINGERS WHEN WET, BEDDING PLANES WELL DEFINED BY THIN COAL SEAMS (CIMM) WHICH PART EASILY	
				30		BOTTOM OF HOLE 29.0'						
				40								
				50								

Bore hole No
2

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON-KNUDSEN COMPANY

EXPLANATION
FOR TEST-PIT SYMBOLS

SOIL

- TOPSOIL
- CLAY
- SILT
- SAND
- GRAVEL

ROCK

- SANDSTONE
- CLAYSTONE/MUDSTONE
- INTERBEDDED SANDSTONE AND CLAYSTONE/MUDSTONE
- BEDROCK CONTACT

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

SHEET 1 OF 1
HOLE NO. TP-WC-27

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: ORIGINAL BORROW AREA
COORDINATES: N E
APPROXIMATE DIMENSIONS: 14.0' X 4.0' X 7.5'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACK
LOGGED BY: K. WESTON, B. HOPKINS
DATE(S) LOGGED: 06-30-93

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS (BY VO 3-5 in	5- in
TOPSOIL No sack sample. 1.0 ft.	**0.0 to 1.0 ft. - TOPSOIL:** Dark brown, dry to moist, roots and vegetation; would be classed as a "LEAN CLAY WITH SAND (CL)s".		
SANDSTONE SP-SM (Lab. Class.) One sack sample. 3.0 ft.	**1.0 to 3.0 ft. - SANDSTONE:** Highly weathered; yellow brown; fine to medium grained; subrounded; dry to moist; weakly to moderately cemented - pieces break with moderate hand pressure; weak reaction with HCl. **LAB TEST DATA:** 95% sand, 5% fines, LL=39, PI=NP, field moisture=6%. Laboratory Classification is POORLY GRADED SAND WITH SILT. **GEOLOGIC INTERPRETATION:** Tertiary Fort Union/Cretaceous Lance formations (Tf/Kl) - undifferentiated.		
CLAYSTONE SC (Lab. Class.) One sack sample. 7.5 ft.	**3.0 to 7.5 ft. - CLAYSTONE:** Highly weathered; dark brown to dark gray; moist; retrieved in small blocky fragments that break with moderate hand pressure; weak reaction with HCl. **LAB TEST DATA:** 77% sand, 23% fines, LL=39, PI=17, field moisture=17%. Max. dry unit wt., opt.: 104.4 lb/ft3, 23.2%. Laboratory Classification is CLAYEY SAND. **GEOLOGIC INTERPRETATION:** Tertiary Fort Union/Cretaceous Lance formations (Tf/Kl) - undifferentiated.		

REMARKS: Terminated digging at 7.5 ft. due to bedrock.
Digging was easy to moderately difficult.
Hand-drive samples in California liners were not taken.
Ground cover: Grass and sagebrush.

1/ Report to nearest 0.1 foot

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-27

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: ORIGINAL BORROW AREA
COORDINATES:
APPROXIMATE DIMENSIONS: 14' X 4' X 7.5'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 30, 1993

DEPTH (ft.)	GRAPHIC LOG OF TEST PIT
0	TOPSOIL - Dark brown; (CL)s; dry to moist; roots and vegetation.
	1.0' TOP OF BEDROCK
2	SANDSTONE - Highly weathered; yellow brown; fine to medium grained; subrounded; dry to moist; weakly to moderately cemented - pieces break with moderate hand pressure; weak reaction with HCl.
	3.0'
4	
6	CLAYSTONE - Highly weathered; dark brown to dark gra moist; retrieved in small blocky fragments that break with moderate hand pressure; weak reaction with HCl.
	7.5'
8	

50 lb. SACK SAMPLES

1.0' to 3.0'
3.0' to 7.5'

REMARKS: Terminated digging at 7.5 ft. due to bedrock.
Digging was easy to moderately difficult.
Hand-drive samples in California liners were not taken.
Ground cover: grass and sagebrush.

1/ Report to nearest 0.1 foot.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 1 OF 1 HOLE NO. TP-WC-28

FEATURE: BORROW AREA INVESTIGATION
PROJECT: ELKHEAD DAM ENLARGEMENT
AREA DESIGNATION: ORIGINAL BORROW AREA
GROUND ELEVATION:
COORDINATES: N E
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
APPROXIMATE DIMENSIONS: 14.0' X 3.0' X 3.3'
LOGGED BY: K. WESTON, B. HOPKINS
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE(S) LOGGED: 06-28-93
DATE:

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLUME) 3-5 in	5-12 in	PL
CLAYSTONE SC-CL (Lab. Class.) One sack sample. 3.3 ft.	**0.0 to 7.5 ft. - CLAYSTONE:** Highly weathered; brown; dry to moist; retrieved in small blocky fragments that break with moderate hand pressure; weak reaction with HCl 0.0' to 1.3', no HCl reaction 1.3' to 3.3'; iron stains 0.0' to 1.3'. **LAB TEST DATA:** 54% fines, 46% sand, LL=42, PI=20, field moisture=16%. Max. dry unit wt., opt.: 99.4 lb/ft3, 17.1%. Laboratory Classification is SANDY LEAN CLAY. **GEOLOGIC INTERPRETATION:** Tertiary Fort Union/Cretaceous Lance formations (Tf/Kl) - undifferentiated.			

REMARKS: Terminated digging at 3.3 ft. due to bedrock.
Digging was easy to moderately difficult.
Hand-drive samples in California liners were not taken.
Ground cover: Grass and sagebrush.

7-1336-A (1-86)
Bureau of Reclamation

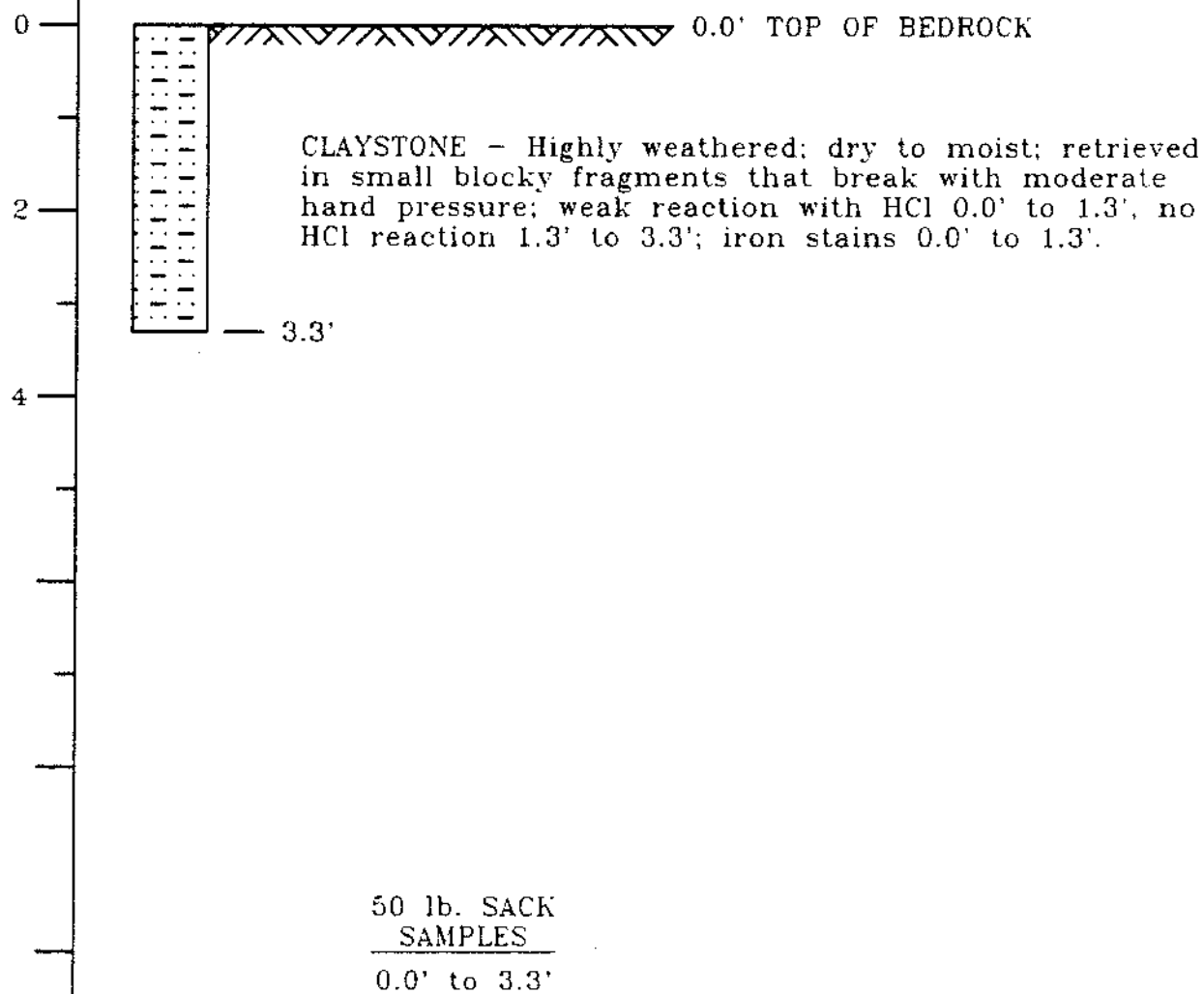
LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-28

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: ORIGINAL BORROW AREA
COORDINATES:
APPROXIMATE DIMENSIONS: 14' X 3' X 3.3'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACK
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 28, 1993

DEPTH (ft.)	GRAPHIC LOG OF TEST PIT



REMARKS: Terminated digging at 3.3 ft. due to bedrock.
Digging was easy to moderately difficult.
Hand-drive samples in California liners were not taken.
Ground cover: grass and sagebrush.

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

SHEET 1 OF 1
HOLE NO. TP-WC-29

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: ORIGINAL BORROW AREA
COORDINATES: N E
APPROXIMATE DIMENSIONS: 17.0' X 5.0' X 5.8'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHO
LOGGED BY: K. WESTON, B. HOPKINS
DATE(S) LOGGED: 06-28-93

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOL 3-5 in	5-12 in
TOPSOIL No sack sample. 1.0 ft.	**0.0 to 1.0 ft. - TOPSOIL:** Dark brown, dry to moist, roots and vegetation; would be classed as a "LEAN CLAY (CL)".		
(CL)s (visual) s(CL) (Lab. Class.) One sack sample. 2.0 ft.	**1.0 to 2.0 ft. - LEAN CLAY WITH SAND (CL)s:** About 75% fines with slow dilatancy, medium toughness, medium plasticity; about 25% predominantly fine sand; maximum size fine sand; no reaction with HCl. **IN-PLACE CONDITION:** Soft; homogeneous; brown; field moisture=11%. **LAB TEST DATA:** 57% fines, 43% sand, LL=30, PI=13. Max. dry unit wt., opt.; 107.4 lb/ft3, 16.8%. Laboratory Classification is SANDY LEAN CLAY. **GEOLOGIC INTERPRETATION:** Quaternary Residual soil (Grs).		
SANDSTONE SP-SM (Lab. Class.) One sack sample. 5.8 ft.	**2.0 to 5.8 ft. - SANDSTONE:** Highly weathered; buff colored; fine to medium grained; moist; poorly cemented; strong reaction with HCl; difficult to dig. **LAB TEST DATA:** 90% sand, 10% fines, LL=39, PI=NP, field moisture=10%. Laboratory Classification is POORLY GRADED SAND WITH SILT. **GEOLOGIC INTERPRETATION:** Tertiary Fort Union/Cretaceous Lance formations (Tf/Kl) - undifferentiated.		

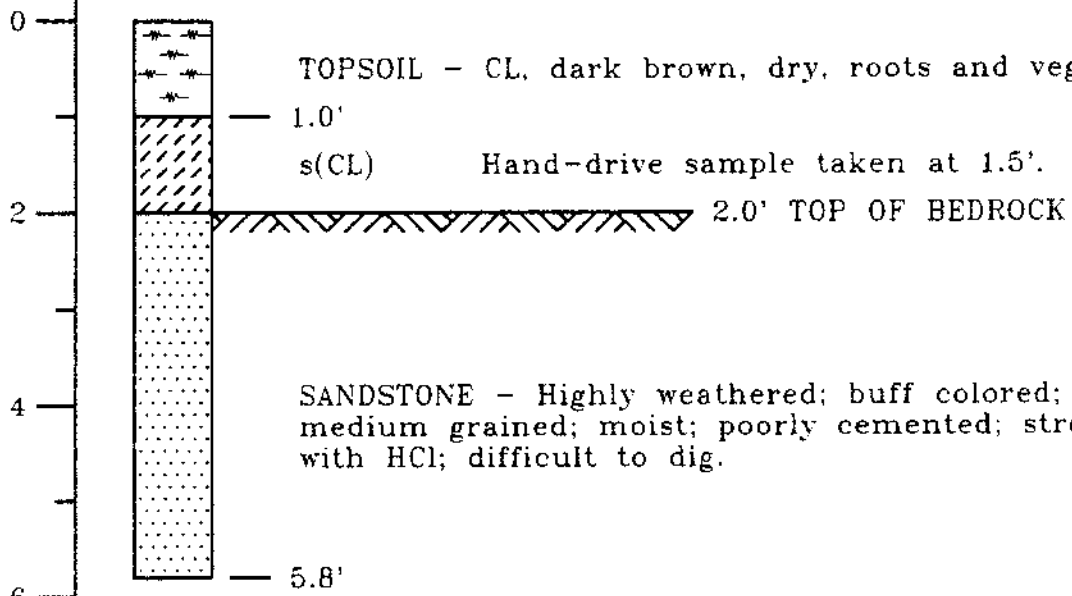
REMARKS: Terminated digging at 5.8 ft. due to bedrock.
Digging was difficult - near refusal at 5.8 ft.
Hand-drive sample in California liner was taken at a depth of 1.5 ft. but a reliable in-place unit weight could not be determined due to inadequate sample.
Ground cover: Grass and sagebrush.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	HOLE NO. TP-WC-29

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: ORIGINAL BORROW AREA
COORDINATES:
APPROXIMATE DIMENSIONS: 17' X 5' X 5.8'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOI
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 28, 1993

DEPTH (ft.)	GRAPHIC LOG OF TEST PIT



50 lb. SACK SAMPLES

1.0' to 2.0'
2.0' to 5.8'

REMARKS: Terminated digging at 5.8 ft. due to bedrock.
Digging was difficult - near refusal at 5.8 ft.
Hand-drive sample in California liner was taken at 1.5 ft.
Ground cover: grass and sagebrush.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 1 OF 2 HOLE NO. TP-WC-30

FEATURE: BORROW AREA INVESTIGATION
PROJECT: ELKHEAD DAM ENLARGEMENT
AREA DESIGNATION: ORIGINAL BORROW AREA
GROUND ELEVATION:
COORDINATES: N E
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
APPROXIMATE DIMENSIONS: 16.5' X 5.5' X 7.0'
LOGGED BY: K. WESTON, B. HOPKINS
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE(S) LOGGED: 06-28-93
DATE:

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 i (BY VOLUME 3-5 in	5-12 in	PL
TOPSOIL No sack sample. 1.0 ft.	**0.0 to 1.0 ft. - TOPSOIL:** Dark brown, dry to moist, roots and vegetation; would be classed as a "SANDY LEAN CLAY s(CL)".			
SM (visual) SM (Lab. Class.) One sack sample. 1.5 ft.	**1.0 to 1.5 ft. - SILTY SAND (SM):** About 80% predominantly fine sand; about 20% fines with low dry strength, rapid dilatancy, medium toughness, low plasticity; maximum size fine sand; no reaction with HCl. **IN-PLACE CONDITION:** Homogeneous; brown; field moisture=14%. **LAB TEST DATA:** 70% sand, 30% fines, LL=39, PI=NP. Laboratory Classification is SILTY SAND. **GEOLOGIC INTERPRETATION:** Quaternary Residual soil (Qrs).			
SP (visual) SM (Lab. Class.) One sack sample. 2.0 ft.	**1.5 to 2.0 ft. - POORLY GRADED SAND (SP):** About 100% predominantly medium grained, rounded to subrounded sand; trace of hard, rounded gravel; trace of fines; maximum size 2-inches; weak reaction with HCl. **IN-PLACE CONDITION:** Homogeneous; tan; abundant sandstone and claystone fragments, field moisture=11%. **LAB TEST DATA:** 80% sand, 20% fines, LL=36, PI=NP. Laboratory Classification is SILTY SAND. **GEOLOGIC INTERPRETATION:** Quaternary Residual soil (Qrs).			
(SC)g (visual) SM (Lab. Class.)	**2.0 to 3.6 ft. - CLAYEY SAND WITH GRAVEL (SC)g:** About 70% predominantly medium grained, rounded to subrounded sand; about 25% fines with low dry strength, rapid dilatancy, low toughness, low plasticity; about 5% hard, rounded to subrounded, fine to coarse gravel; maximum size coarse gravel; no reaction with HCl.			

REMARKS: Terminated digging at 7.0 ft. due to bedrock.
Digging was moderately difficult.
Hand-drive sample in California liner was taken at a depth of 3.0 ft., but a reliable in-place unit weight could not be determined due to inadequate sample.
Ground cover: Grass and sagebrush.

7-1935-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 2 OF 2 HOLE NO. TP-WC-30

FEATURE: BORROW AREA INVESTIGATION
PROJECT: ELKHEAD DAM ENLARGEMENT
AREA DESIGNATION: ORIGINAL BORROW AREA
GROUND ELEVATION:
COORDINATES: N E
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
APPROXIMATE DIMENSIONS: 16.5' X 5.5' X 7.0'
LOGGED BY: K. WESTON, B. HOPKINS
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE(S) LOGGED: 06-28-93
DATE:

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLUME) 3-5 in	5-12 in	PL
One sack sample. 3.6 ft.	**IN-PLACE CONDITION:** Homogeneous; dark brown; field moisture=15%. **LAB-TEST DATA:** 66% sand, 22% fines, 12% gravel, LL=37, PI=NP. Laboratory Classification is SILTY SAND. **GEOLOGIC INTERPRETATION:** Quaternary Residual soil (Qrs).			
SANDSTONE & CLAYSTONE SM (Lab. Class.) One sack sample. 7.0 ft.	**3.6 to 7.0 ft. - SANDSTONE AND CLAYSTONE:** Highly weathered; claystone is brown to dark brown; sandstone is tan and fine to medium grained; moderately hard to dig; retrieved pieces up to 1 ft. maximum dimension; moist; no reaction with HCl. **LAB-TEST DATA:** 74% sand, 26% fines, LL=39, PI=NP, field moisture=13%. Laboratory Classification is SILTY SAND. **GEOLOGIC INTERPRETATION:** Tertiary Fort Union/Cretaceous Lance formations (Tf/Kl) - undifferentiated.			

REMARKS:

7-1336-A (1-86)
Bureau of Reclamation

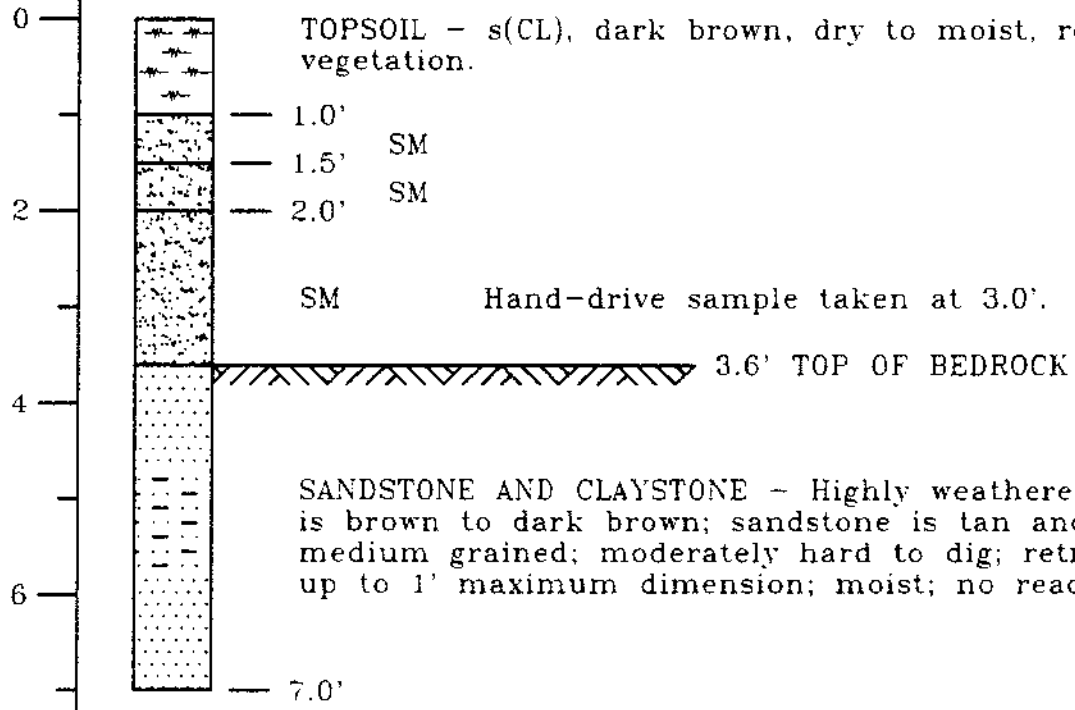
LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-30

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: ORIGINAL BORROW AREA
COORDINATES:
APPROXIMATE DIMENSIONS: 16.5' X 5.5' X 7.0'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHC
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 28, 1993

DEPTH (ft.)	GRAPHIC LOG OF TEST PIT



50 lb. SACK SAMPLES

1.0' to 1.5'
1.5' to 2.0'
2.0' to 3.6'
3.6' to 7.0'

REMARKS: Terminated digging at 7.0 ft. due to bedrock.
Digging was moderately difficult.
Hand-drive sample in California liner was taken at 3.0 ft.
Ground cover: grass and sagebrush.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 1 OF 1 HOLE NO. TP-WC-31

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: ORIGINAL BORROW AREA
COORDINATES: N E
APPROXIMATE DIMENSIONS: 14.0' X 2.0' X 5.5'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: 06-28-93

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLU 3-5 in	5-12 in
(CL)s (Visual) SC-CL (Lab. Class.) One sack sample. 2.0 ft.	**0.0 to 2.0 ft. - LEAN CLAY WITH SAND (CL)s:** About 75% fines with high dry strength, slow dilatancy, medium toughness, medium plasticity; about 25% predominantly fine grained sand; maximum size coarse sand; weak reaction with HCl. **IN-PLACE CONDITION:** Brown; sticks and abundant organic material; cans and other debris; field moisture=16%. **LAB-TEST DATA:** 50% fines, 50% sand, LL=30, PI=13. Max. dry unit wt., opt.; 105.2 lb/ft3, 15.9%. Laboratory Classification is LEAN CLAYEY SAND. **GEOLOGIC INTERPRETATION:** Fill Material.		
SANDSTONE & CLAYSTONE SM-ML (Lab. Class.) One sack sample. 5.5 ft.	**2.0 to 5.5 ft. - SANDSTONE AND CLAYSTONE:** Highly weathered; claystone is gray; sandstone is brown to orange brown and predominantly fine grained; iron stains throughout; weakly cemented - retrieved chunks up to 4-inches thick which could be broken with moderate hand pressure; strong reaction with HCl; moist; difficult to dig at 5.5 ft. **LAB TEST DATA:** 51% fines, 49% sand, LL=30, PI=NP, field moisture =12%. Laboratory Classification is SANDY SILT **GEOLOGIC INTERPRETATION:** Tertiary Fort Union/Cretaceous Lance formations (Tf/Kl) - undifferentiated.		

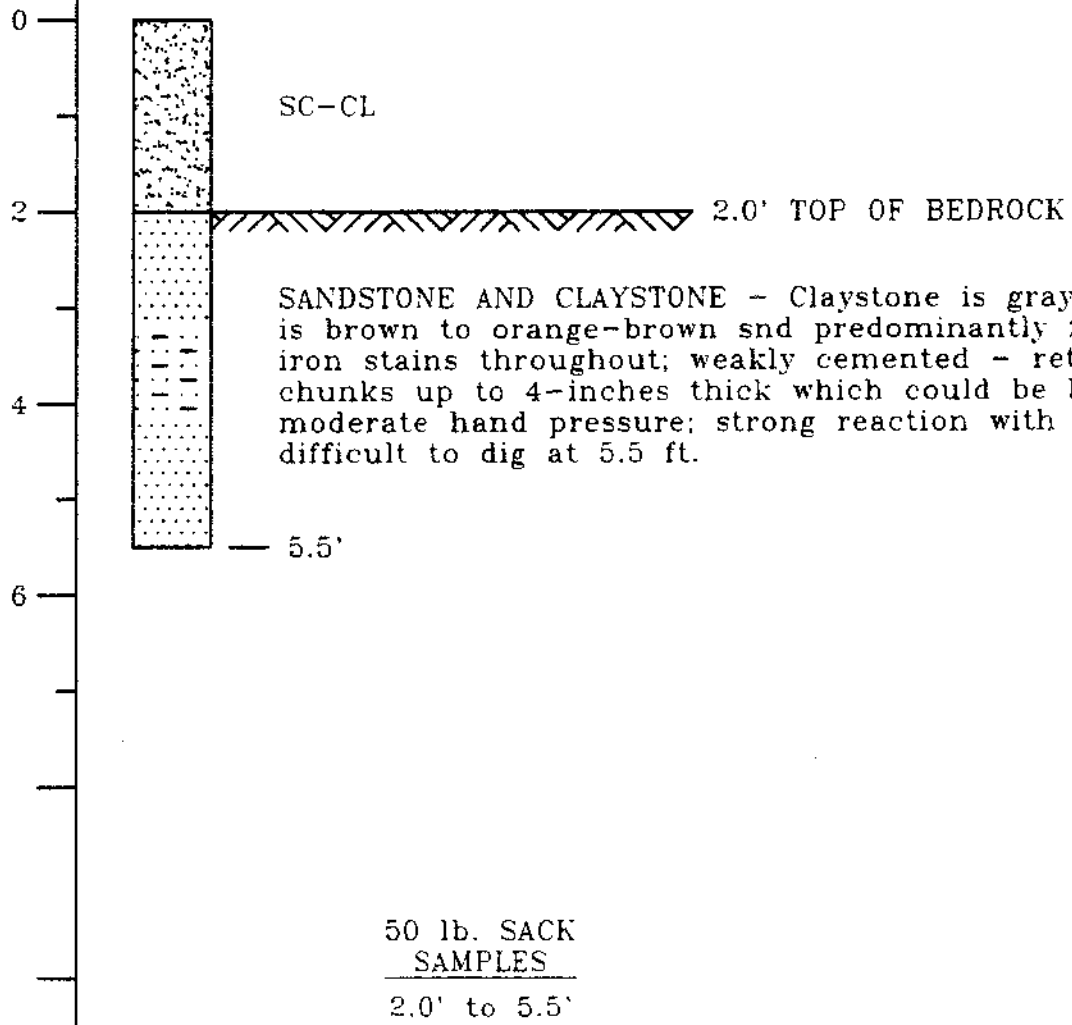
REMARKS: Terminated digging at 5.5 ft. due to bedrock.
Digging was moderately difficult.
Hand-drive samples in California liners were not taken.
Ground cover: Grass and sagebrush.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	HOLE NO. TP-WC-31

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: ORIGINAL BORROW AREA
COORDINATES:
APPROXIMATE DIMENSIONS: 14.0' X 2.0' X 5.5'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 28, 1993

DEPTH (ft.)	GRAPHIC LOG OF TEST PIT



REMARKS: Terminated digging at 5.5 ft. due to bedrock.
Digging was moderately difficult.
Hand-drive samples in California liners were not taken.
Ground cover: grass and sagebrush.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 1 OF 1 HOLE NO. TP-WC-32

FEATURE: BORROW AREA INVESTIGATION
PROJECT: ELKHEAD DAM ENLARGEMENT
AREA DESIGNATION: NORTH OF BOAT RAMP AREA
GROUND ELEVATION:
COORDINATES: N E
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
APPROXIMATE DIMENSIONS: 17.0' X 4.0' X 10.7'
LOGGED BY: K. WESTON, B. HOPKINS
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE(S) LOGGED: 06-28-93
DATE:

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLUME 3-5 in	5-12 in	PL
TOPSOIL No sack sample. 1.0 ft.	**0.0 to 1.0 ft. - TOPSOIL:** Dark brown, dry to moist, roots and vegetation; would be classed as a "LEAN CLAY (CL)".			
CL (visual) s (CL) (Lab. Class.) One sack sample. 4.0 ft.	**1.0 to 4.0 ft. - LEAN CLAY (CL):** About 100% fines with high dry strength, no dilatancy, high toughness, medium plasticity; maximum size fine sand; no reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; brown; field moisture 8%. **LAB TEST DATA:** 66% fines, 34% sand; LL=23, PI=8. Max. dru unit wt., opt.; 112.4 lb/ft3, 13.3%. Laboratory Classification is SANDY LEAN CLAY. **GEOLOGIC INTERPRETATION:** Quaternary Residual Soil (Qrs)?			
ML (visual) SC-CL (Lab. Class.) One sack sample. 10.7 ft.	**4.0 to 10.7 ft. - SILT (ML):** About 100% fines with medium dry strength, rapid dilatancy, medium toughness, no plasticity; maximum size fine sand; no reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; tan; field moisture 10%. **LAB TEST DATA:** 55% fines; 45% sand, LL=28, PI=12. Max. dry unit wt., opt.; 111.8 lb/ft3, 14.4%. Laboratory Classification is SANDY LEAN CLAY. **GEOLOGIC INTERPRETATION:** Quaternary Residual Soil (Qrs)?			

REMARKS: Digging was moderately difficult.
Hand-drive samples in California liners were taken at a depths of 2.5 and 7.0 ft., but a reliable in-place unit weight could not be determined due to inadequate sample. Samples were difficult to take.
Ground cover: Grass and sagebrush.

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

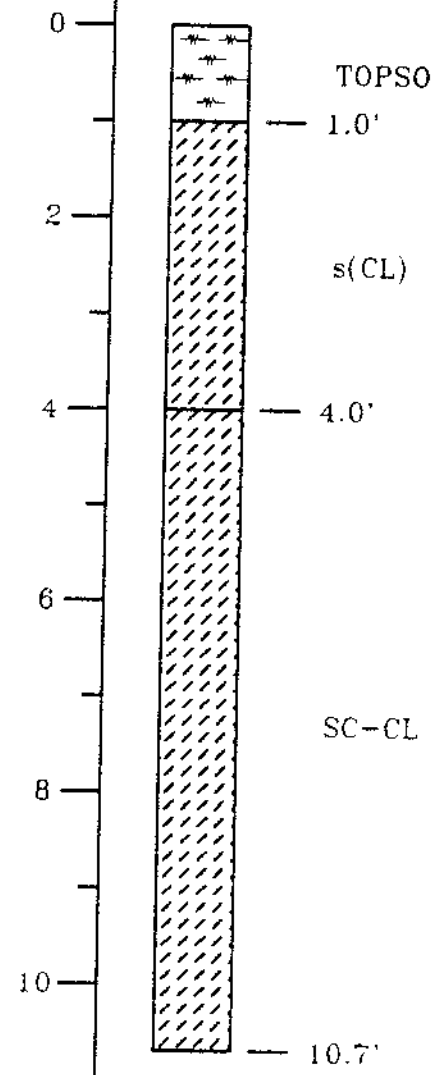
HOLE NO. TP-WC-32

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: NORTH OF BOAT RAMP AREA
COORDINATES:
APPROXIMATE DIMENSIONS: 17.0' X 4.0' X 10.7'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BA
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 28, 1993

DEPTH (ft.)

GRAPHIC LOG OF TEST PIT



TOPSOIL - CL, dark brown, dry to moist, vegetation.

s(CL) Hand-drive sample taken at 2.5'.

SC-CL Hand-drive sample taken at 7.0'.

50 lb. SACK SAMPLES
1.0' to 4.0'
4.0' to 10.7'

REMARKS:

Digging was easy to moderately difficult.
Hand-drive samples in California liners were taken at depths of 2.5 and 7.0 ft. Samples were difficult to take.
Ground cover: grass and sagebrush.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 1 OF 2 HOLE NO. TP-WC-33

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: NORTH OF BOAT RAMP AREA
COORDINATES: N E
APPROXIMATE DIMENSIONS: 17.0' X 4.5' X 9.4'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
LOGGED BY: K. WESTON, B. HOPKINS
DATE(S) LOGGED: 06-28-93

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLUM 3-5 in	5-12 in	P
TOPSOIL No sack sample. 1.0 ft.	**0.0 to 1.0 ft. - TOPSOIL:** Dark brown, dry to moist, roots and vegetation; would be classed as a "LEAN CLAY (CL)".			
CL (visual) s (CL) (Lab. Class.) One sack sample. 2.8 ft.	**1.0 to 2.8 ft. - LEAN CLAY (CL):** About 100% fines with high dry strength, slow dilatancy, medium toughness, medium plasticity; maximum size fine sand; no reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; reddish brown; field moisture=11%. **LAB TEST DATA:** 63% fines, 37% sand, LL=33, PI=18. Max. dry unit wt., opt.; 108.9 lb/ft3, 15.2%. Laboratory Classification is SANDY LEAN CLAY. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported soil.			
ML (visual) SC-CL (Lab. Class.) One sack sample. 4.2 ft.	**2.8 to 4.2 ft. - SILT (ML):** About 100% fines with medium dry strength, rapid dilatancy, medium toughness, no plasticity; maximum size fine sand; no reaction to HCl. **IN-PLACE CONDITION:** Firm; homogeneous; tan; field moisture=13%. **LAB TEST DATA:** 53% sand, 47% fines, LL=26, PI=9. Max. dry unit wt., opt.; 113.9 lb/ft3, 14.3%. Laboratory Classification is LEAN CLAYEY SAND. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported soil.			
(GP)s (visual) (GP)s (Lab. Class.)	**4.2 to 5.2 ft. - POORLY GRADED GRAVEL WITH SAND (GP)s:** About 75% predominantly coarse, hard, rounded to subrounded gravel; about 25% predominantly medium grained, rounded to subrounded sand; maximum size 3-inches; no reaction with HCl. **IN-PLACE CONDITION:** Homogeneous; brown; gravels composed primarily of igneous rock; field moisture=3%.			

REMARKS: Terminated digging at 9.4 ft. due to caving hole.
Digging was easy to moderately difficult.
Hand-drive sample in California liner was taken at a depth of 2.0 ft., but a reliable in-place unit weight could not be determined due to inadequate sample.
Ground cover: Grass and sagebrush.

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-33

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: NORTH OF BOAT RAMP AREA
COORDINATES: N E
APPROXIMATE DIMENSIONS: 17.0' X 4.5' X 9.4'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHO
LOGGED BY: K. WESTON, B. HOPKINS
DATE(S) LOGGED: 06-28-93

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLU 3-5 in	5-12 in
One sack sample. 5.2 ft.	**LAB-TEST DATA:** 58% gravel, 37% sand, 5% fines, LL=28, PI=NP. Laboratory Classification is POORLY GRADED GRAVEL WITH SAND. **GEOLOGIC INTERPRETATION:** Quaternary Terrace Deposit (Qt).		
(SP)g SM (Lab. Class.) One sack sample. 7.3 ft.	**5.2 to 7.3 ft. - POORLY GRADED SAND WITH GRAVEL (SP)g:** About 75% predominantly fine grained, rounded to subrounded sand; about 25% fine to coarse, hard, rounded to subrounded gravel; maximum size coarse gravel; no reaction with HCl. **IN-PLACE CONDITION:** Homogeneous; brown; field moisture=8%. **LAB-TEST DATA:** 86% sand, 14% fines, LL=24, PI=NP. Laboratory Classification is SILTY SAND. **GEOLOGIC INTERPRETATION:** Quaternary Terrace Deposit (Qt).		
(GP)s (visual) (GW-GM)s (Lab. Class.) One sack sample. 9.4 ft.	**7.3 to 9.4 ft. - POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)s:** About 75% predominantly coarse, hard, rounded to subrounded gravel; about 25% predominantly medium grained, rounded to subrounded sand; no reaction with HCl. **TOTAL SAMPLE (BY VOLUME):** About 5% 3- to 5-inch hard, rounded to subrounded cobbles; remainder minus 3 inch; maximum size 4.5-inches. **IN-PLACE CONDITION:** Homogeneous; brown; gravel and cobbles composed primarily of igneous rock, field moisture=4%. **LAB-TEST DATA:** 64% gravel, 30% sand, 6% fines, LL=25, PI=NP. Laboratory Classification (minus 3-inch) is WELL GRADED GRAVEL WITH SILT AND SAND. **GEOLOGIC INTERPRETATION:** Quaternary Terrace Deposit (Qt).	5	

REMARKS:

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

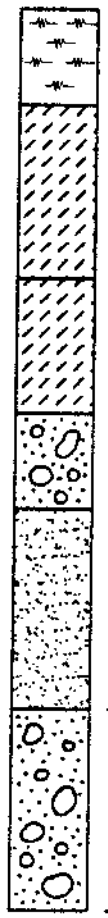
HOLE NO. TP-WC-33

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: NORTH OF BOAT RAMP AREA
COORDINATES:
APPROXIMATE DIMENSIONS: 17.0' X 4.5' X 9.4'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACI
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 28, 1993

DEPTH (ft.)

GRAPHIC LOG OF TEST PIT



0

TOPSOIL - CL, dark brown, dry to moist, vegetation.

1.0'

2

s(CL)

Hand-drive sample taken at 2.0'.

2.8'

SC-CL

4

4.2'

(GP)s

5.2'

6

SM

7.3'

8

(GW-GM)s

9.4'

10

50 lb. SACK SAMPLES

1.0' to 2.8'
2.8' to 4.2'
4.2' to 5.2'
5.2' to 7.3'
7.3' to 9.4'

REMARKS: Terminated digging at 9.4 ft. due to caving hole.
Hand-drive sample in California liner taken at a depth of 2.0 ft.
Digging was easy to moderately difficult.
Ground cover: grass and sagebrush.

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-34

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: NORTH OF BOAT RAMP AREA
COORDINATES: N E
APPROXIMATE DIMENSIONS: 17.0' X 4.0' X 12.5'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHO
LOGGED BY: K. WESTON, B. HOPKINS
DATE(S) LOGGED: 06-30-93

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLU 3-5 in	5-12 in
TOPSOIL No sack sample. 1.0 ft.	**0.0 to 1.0 ft. - TOPSOIL:** Dark brown, dry to moist, roots and vegetation; would be classed as a "LEAN CLAY (CL)".		
CL (visual) s (CL) (Lab. Class.) One sack sample. 2.0 ft.	**1.0 to 2.0 ft. - LEAN CLAY (CL):** About 100% fines with high dry strength, slow dilatancy, medium toughness, medium plasticity; maximum size fine sand; no reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; reddish brown; field moisture=12%. **LAB TEST DATA:** 68% fines, 32% sand, LL=37, PI=21. Max. dry unit wt., opt.; 105.8 lb/ft3, 16.2%. Laboratory Classification is SANDY LEAN CLAY. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported soil.		
CL-ML (visual) One sack sample. 9.5 ft.	**2.0 to 9.5 ft. - SILTY CLAY (CL-ML):** About 100% fines with medium dry strength, slow dilatancy, medium toughness, low plasticity; maximum size fine sand; strong reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; tan; field moisture 13%. **LAB TEST DATA:** In-place dry unit weight = 90.9 lb/ft3 at 11.3% moisture content. No other lab data - sample taken to Denver by Woodward-Clyde Consultants. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported soil.		
SC-SM (visual) (CL) s (Lab. Class.) One sack sample.	**9.5 to 12.5 ft. - SILTY CLAYEY SAND (SC-SM):** About 65% predominantly fine grained, subangular sand; about 35% fines with medium dry strength, rapid dilatancy, medium toughness, low plasticity; maximum size fine sand; weak reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; tan; field moisture=18%.		

REMARKS: Encountered wet silty sand at 12.5 ft. and discontinued digging.
Digging was moderately difficult.
Hand-drive samples in California liners were taken at depths of 3.0 and 7.0 ft., but a reliable in-place unit weight could not be determined at 7.0 ft. due to inadequate sample.
Ground cover: Grass and sagebrush.

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-34

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: NORTH OF BOAT RAMP AREA
COORDINATES: N E
APPROXIMATE DIMENSIONS: 17.0' X 4.0' X 12.5'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACK
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: 06-30-93

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLU (BY V 3-5 in	5- i
12.5 ft.	**LAB-TEST DATA:** 80% fines, 20% sand, LL=37, PI=21. Max. dry unit wt., opt.: 103.7 lb/ft3, 18.3%. Laboratory Classification is LEAN CLAY WITH SAND. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported soil.		

REMARKS:

7-1336-A (1-66)
Bureau of Reclamation

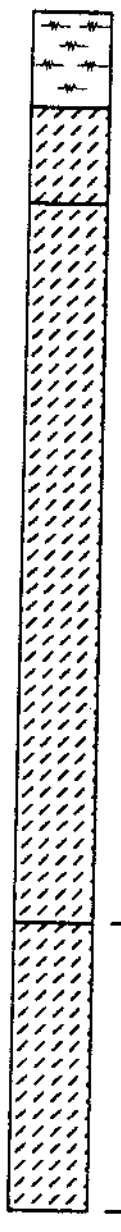
LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-34

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: NORTH OF BOAT RAMP AREA
COORDINATES:
APPROXIMATE DIMENSIONS: 17.0' X 4.0' X 12.5'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKI
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 30, 1993

DEPTH (ft.)	GRAPHIC LOG OF TEST PIT



0

TOPSOIL - CL, dark brown, dry to moist, vegetation.

1.0'

s(CL)

2

2.0'

Hand-drive sample taken at 3.0'.

4

6

CL-ML (Field Classification)

Hand-drive sample taken at 7.0'.

8

9.5'

10

50 lb. SACK SAMPLES

1.0' to 2.0'
2.0' to 9.5'
9.5' to 12.5'

(CL)s

12

Encountered wet SM at 12.5 ft. and discontinued digging.

12.5'

REMARKS: Digging was easy to moderately difficult.
Hand-drive samples in California liners were taken at depths of 3.0 and 7.0 ft.
Ground cover: grass and sagebrush.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 1 OF 2 HOLE NO. TP-WC-35

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: NORTH OF BOAT RAMP AREA
COORDINATES: N E
APPROXIMATE DIMENSIONS: 18.0' X 4.5' X 10.0'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKH
LOGGED BY: K. WESTON, B. HOPKINS
DATE(S) LOGGED: 06-30-93

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS (BY VOL 3-5 in	5-1 in
TOPSOIL No sack sample. 1.0 ft.	**0.0 to 1.0 ft. - TOPSOIL:** Dark brown, dry to moist, roots and vegetation; would be classed as a "LEAN CLAY (CL)".		
CL (visual) (CL)s (Lab. Class.) One sack sample. 4.2 ft.	**1.0 to 4.2 ft. - LEAN CLAY (CL):** About 100% fines with high dry strength, slow dilatancy, high toughness, high plasticity; maximum size fine sand; no reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; reddish brown; field moisture=13%. **LAB TEST DATA:** 80% fines, 20% sand, LL=36, PI=18. Max. dry unit wt., opt.: 101.1 lb/ft3, 21.3%. Laboratory Classification is LEAN CLAY WITH SAND. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported soil.		
CL-ML (visual) CL (Lab. Class.) One sack sample. 7.5 ft.	**4.2 to 7.5 ft. - SILTY CLAY (CL-ML):** About 100% fines with medium dry strength, rapid dilatancy, low toughness, no plasticity; maximum size fine sand; strong reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; tan; field moisture=19%. **LAB TEST DATA:** 89% fines, 11% sand, LL=34, PI=15. Max. dry unit wt., opt.: 105.7 lb/ft3, 17.3%. Laboratory Classification is LEAN CLAY. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported soil.		
SM (visual) SM (Lab. Class.)	**7.5 to 10.0 ft. - SILTY SAND (SM):** About 85% predominantly fine to medium grained sand; about 15% fines with low dry strength, rapid dilatancy, low toughness, no plasticity; maximum size coarse sand; no reaction with HCl. **IN-PLACE CONDITION:** Homogeneous; tan; field moisture=17%.		

REMARKS: Digging was easy to moderately difficult.
Hand-drive samples in California liners were taken at depths of 3.0 and 7.0 ft., but a reliable in-place unit weight could not be determined due to inadequate sample.
Ground cover: Grass and sagebrush.

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-35

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: NORTH OF BOAT RAMP AREA
COORDINATES: N E
APPROXIMATE DIMENSIONS: 18.0' X 4.5' X 10.0'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: 06-30-93

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLU 3-5 in	5-12 in
One sack sample. 10.0 ft.	**LAB-TEST DATA:** 76% sand, 24% fines, LL=24, PI=NP. Laboratory Classification is SILTY SAND. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported soil.		

REMARKS:

7-1336-A (1-86)
Bureau of Reclamation

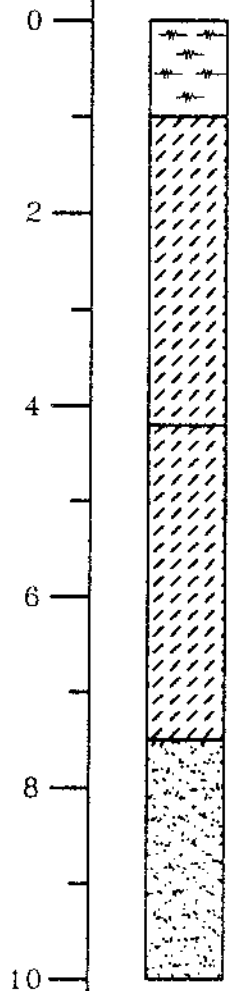
LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-35

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: NORTH OF BOAT RAMP AREA
COORDINATES:
APPROXIMATE DIMENSIONS: 18.0' X 4.5' X 10.0'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHO
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 30, 1993

DEPTH (ft.)	GRAPHIC LOG OF TEST PIT



TOPSOIL - CL, dark brown, dry to moist, vegetation.

(CL)s

Hand-drive sample taken at 3.0'.

CL

Hand-drive sample taken at 7.0'.

SM

50 lb. SACK SAMPLES

1.0' to 4.2'
4.2' to 7.5'
7.5' to 10.0'

REMARKS: Digging was easy to moderately difficult.
Hand-drive samples in California liners were taken at depths of 3.0 and 7.0 ft.
Ground cover: grass and sagebrush.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 1 OF 1 HOLE NO. TP-WC-36

FEATURE: BORROW AREA INVESTIGATION
PROJECT: ELKHEAD DAM ENLARGEMENT
AREA DESIGNATION: CAMPGROUND NEAR LEFT ABUTMENT
GROUND ELEVATION:
COORDINATES: N E
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
APPROXIMATE DIMENSIONS: 19.0' X 5.0' X 10.3'
LOGGED BY: K. WESTON, B. HOPKINS
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE(S) LOGGED: 06-29-93
DATE:

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLUM 3-5 in	5-12 in	P
TOPSOIL No sack sample. 1.5 ft.	**0.0 to 1.5 ft. - TOPSOIL:** Dark brown, dry to moist, roots and vegetation; would be classed as a "LEAN CLAY (CL)".			
CL (visual) (CL) s (Lab. Class.) One sack sample. 3.0 ft.	**1.5 to 3.0 ft. - LEAN CLAY (CL):** About 100% fines with high dry strength, slow dilatancy, medium toughness, medium plasticity; maximum size fine sand; no reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; reddish brown; field moisture=10%. **LAB TEST DATA:** 80% fines, 20% sand, LL=30, PI=12. Max. dry unit wt., opt.: 108.1 lb/ft3, 14.8%. Laboratory Classification is LEAN CLAY WITH SAND. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported Soil.			
CL-ML (visual) CL (Lab. Class.) One sack sample. 10.3 ft.	**3.0 to 10.3 ft. - SILTY CLAY (CL-ML):** About 100% fines with medium dry strength, rapid dilatancy, low toughness, no plasticity; maximum size fine sand; strong reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; tan; field moisture=16%. **LAB TEST DATA:** 88% fines, 12% sand, LL=32, PI=13. Max. dry unit wt., opt.: 106.4 lb/ft3, 15.1%. Laboratory Classification is LEAN CLAY. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported soil.			

REMARKS: Digging was easy to moderately difficult.
Hand-drive samples in California liners were taken at depths of 3.0 and 7.0 ft., but a reliable in-place unit weight could not be determined due to inadequate sample.
Ground cover: Grass and sagebrush.

7-1336-A (1-86)
Bureau of Reclamation

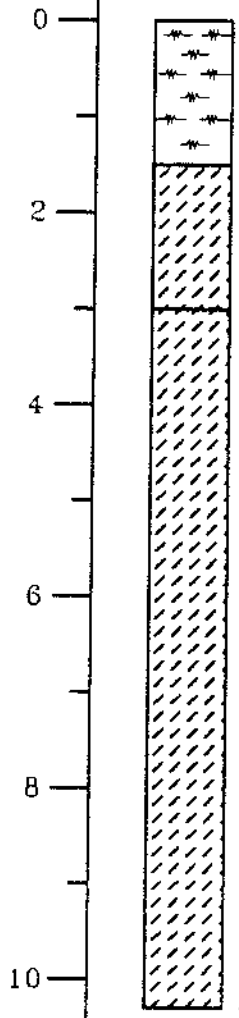
LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-36

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: CAMPGROUND NEAR LEFT ABUT.
COORDINATES:
APPROXIMATE DIMENSIONS: 19.0' X 5.0' X 10.3'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHO
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 29, 1993

DEPTH (ft.)	GRAPHIC LOG OF TEST PIT



TOPSOIL - CL, dark brown, dry to moist, vegetation.

(CL)s

Hand-drive sample taken at 3.0'.

CL

Hand-drive sample taken at 7.0'.

50 lb. SACK SAMPLES
1.5' to 3.0'
3.0' to 10.3'

REMARKS: Digging was easy to moderately difficult.
Hand-drive samples in California liners were taken at depths of 3.0 and 7.0 ft.
Ground cover: grass and sagebrush.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 1 OF 1 HOLE NO. TP-WC-37

FEATURE: BORROW AREA INVESTIGATION
PROJECT: ELKHEAD DAM ENLARGEMENT
AREA DESIGNATION: CAMPGROUND NEAR LEFT ABUTMENT
GROUND ELEVATION:
COORDINATES: N E
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
APPROXIMATE DIMENSIONS: 18.0' X 4.5' X 9.2'
LOGGED BY: K. WESTON, B. HOPKINS
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE(S) LOGGED: 06-29-93
DATE:

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLUM 3-5 in	5-12 in	P
TOPSOIL No sack sample. 1.5 ft.	**0.0 to 1.5 ft. - TOPSOIL:** Light brown, dry, white mottled appearance, calcareous, roots and vegetation; would be classed as a "SILT (ML)".			
ML (visual) SM (lab. Class.) One sack sample. 5.5 ft.	**1.5 to 5.5 ft. - SILT (ML):** About 100% fines with medium dry strength, rapid dilatancy, low toughness, no plasticity; maximum size fine sand; strong reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; tan; field moisture=8%. **LAB TEST DATA:** 67% sand, 33% fines, LL=24, PI=NP. Laboratory Classification is SILTY SAND. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported soil.			
(GP)s (visual) (GW-GM)s (Lab. Class.) One sack sample. 9.2 ft.	**5.5 to 9.2 ft. - POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)s:** About 60% fine to coarse, hard, rounded to subrounded gravel; about 40% predominantly medium grained, rounded sand; no reaction with HCl. **TOTAL SAMPLE (BY VOLUME):** About 5% 3- to 5-inch hard, rounded to subrounded cobbles; remainder minus 3 inch; maximum size 5-inches. **IN-PLACE CONDITION:** Homogeneous, brown; gravels composed of igneous rock including basalt; field moisture=4%. **LAB TEST DATA:** 64% gravel, 30% sand, 6% fines, LL=21, PI=NP. Laboratory Classification (minus 3-inch) is WELL GRADED GRAVEL WITH SILT AND SAND. **GEOLOGIC INTERPRETATION:** Quaternary Terrace Deposit (Qt).	5		

REMARKS:
Digging was easy to moderately difficult.
Hand-drive sample in California liner was taken at a depth of 2.5 ft., but a reliable in-place unit weight could not be determined due to inadequate sample.
Could not dig past a depth of 9.2 ft. (bedrock?).
Ground cover: Grass and sagebrush.

7-1336-A (1-66)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

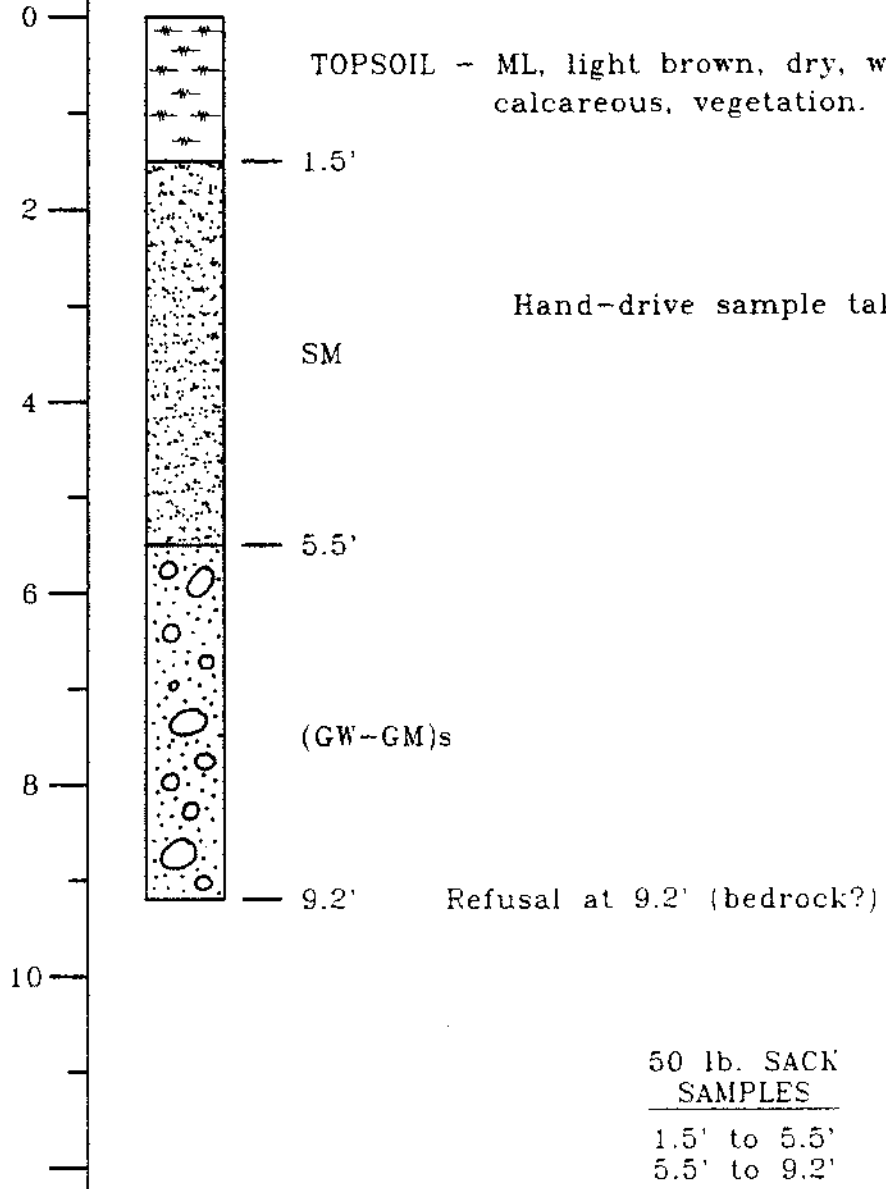
HOLE NO. TP-WC-37

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: CAMPGROUND NEAR LEFT ABUT.
COORDINATES:
APPROXIMATE DIMENSIONS: 18.0' X 4.5' X 9.2'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKH
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 29, 1993

DEPTH (ft.)

GRAPHIC LOG OF TEST PIT



REMARKS: Digging was easy to moderately difficult.
Hand-drive sample in California liner was taken at a depth of 2.5 ft.
Could not dig past a depth of 9.2 ft.
Ground cover: grass and sagebrush.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 1 OF 1 HOLE NO. TP-WC-38

FEATURE: BORROW AREA INVESTIGATION
PROJECT: ELKHEAD DAM ENLARGEMENT
AREA DESIGNATION: CAMPGROUND NEAR LEFT ABUTMENT
GROUND ELEVATION:
COORDINATES: N E
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
APPROXIMATE DIMENSIONS: 18.0' X 5.0' X 10.4'
LOGGED BY: K. WESTON, B. HOPKINS
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE(S) LOGGED: 06-29-93
DATE:

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLUM 3-5 in	5-12 in	P
TOPSOIL No sack sample. 1.0 ft.	**0.0 to 1.0 ft. - TOPSOIL:** Dark brown, dry to moist, roots and vegetation; would be classed as a "LEAN CLAY (CL)".			
CL (visual) CL (lab. Class.) One sack sample. 2.5 ft.	**1.0 to 2.5 ft. - LEAN CLAY (CL):** About 100% fines with high dry strength, slow dilatancy, medium toughness, medium plasticity; maximum size fine sand; no reaction with HCl. **IN-PLACE CONDITION:** Soft; homogeneous; reddish brown; field moisture=9%. **LAB TEST DATA:** 91% fines, 9% sand, LL=35, PI=16. Max. dry unit wt., opt.: 102.0 lb/ft3, 19.0%. Laboratory Classification is LEAN CLAY. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported soil.			
CL-ML (visual) CL (Lab. Class.) One sack sample. 10.4 ft.	**2.5 to 10.4 ft. - SILTY CLAY (CL-ML):** About 100% fines with medium dry strength, slow dilatancy, medium toughness, low plasticity; maximum size fine sand; strong reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; tan; from 9.5 to 10.4 ft. somewhat cemented, drier, very calcareous, and difficult to dig; field moisture 15%. **LAB TEST DATA:** 92% fines, 8% sand, LL=33, PI=14. Max. dry unit wt., opt.: 104.0 lb/ft3, 17.7%. Laboratory Classification is LEAN CLAY. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported soil.			

REMARKS: Digging was easy to difficult.
Hand-drive samples in California liners were taken at depths of 2.0 and 7.0 ft., but reliable in-place unit weights could not be determined due to inadequate samples.
Ground cover: Grass and sagebrush.

7-1336-A (1-86)
Bureau of Reclamation

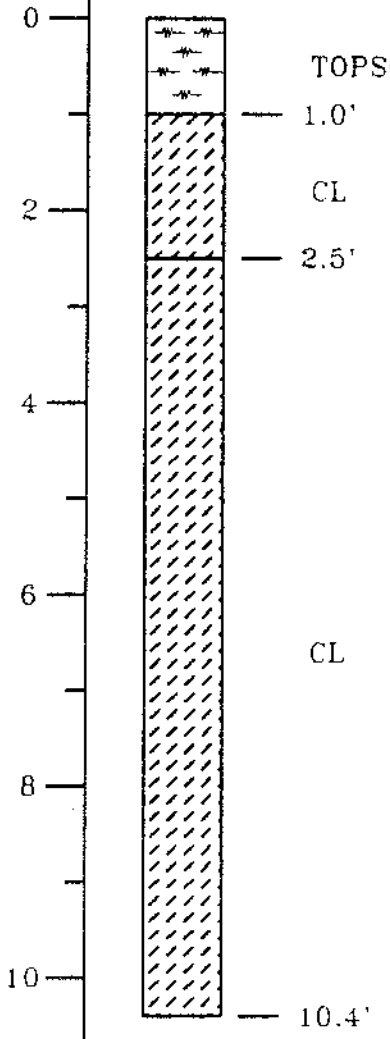
LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-38

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: CAMPGROUND NEAR LEFT ABUT.
COORDINATES:
APPROXIMATE DIMENSIONS: 18.0' X 5.0' X 10.4'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKH
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 29, 1993

DEPTH (ft.)	GRAPHIC LOG OF TEST PIT



TOPSOIL - CL, dark brown, dry to moist, vegetation.

Hand-drive sample taken at 2.0'.

Hand-drive sample taken at 7.0'.

From 9.5' to 10.4' somewhat cemented, drier, very calcareous, difficult to dig.

50 lb. SACK SAMPLES

1.0' to 2.5'
2.5' to 10.4'

REMARKS: Digging was easy to difficult.
Hand-drive samples in California liners were taken at depths of 2.0 and 7.0 ft.
Ground cover: grass and sagebrush.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 1 OF 2 HOLE NO. TP-WC-39

FEATURE: BORROW AREA INVESTIGATION
PROJECT: ELKHEAD DAM ENLARGEMENT
AREA DESIGNATION: DRAW EAST SIDE OF RESERVOIR
GROUND ELEVATION:
COORDINATES: N E
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
APPROXIMATE DIMENSIONS: 15.0' X 2.5' X 6.5'
LOGGED BY: K. WESTON, B. HOPKINS
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE(S) LOGGED: 06-29-93
DATE:

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 i (BY VOLUME 3-5 in	5-12 in	PL
TOPSOIL No sack sample. 1.0 ft.	**0.0 to 1.0 ft. - TOPSOIL:** Dark brown, dry to moist, roots and vegetation; some gravel; would be classed as a "LEAN CLAY WITH GRAVEL (CL)g".			
(GM-GC)s (visual) (GC)s (Lab. Class.) One sack sample. 2.0 ft.	**1.0 to 2.0 ft. - SILTY CLAYEY GRAVEL WITH SAND AND COBBLES (GM-GC)s:** About 50% predominantly coarse, hard, subangular to angular gravel; about 30% fines with low dry strength, rapid dilatancy, medium toughness, low plasticity; about 20% predominantly medium grained, subrounded to subangular sand; strong reaction with HCl. **TOTAL SAMPLE (BY VOLUME):** About 10% 3- to 5-inch hard, subrounded to subangular cobbles; trace of 5- to 12-inch hard, subrounded to subangular cobbles; remainder minus 3 inch; maximum dimension 9-inches. **IN-PLACE CONDITION:** Tan; sands and gravels are flat and elongated, and are composed of sandstone and metaquartzite(?); field moisture=10%. **LAB TEST DATA:** 50% gravel, 31% fines, 19% sand, LL=32, PI=10. Laboratory Classification (minus 3-inch) is CLAYEY GRAVEL WITH SAND. **GEOLOGIC INTERPRETATION:** Quaternary Slope Wash/Alluvium (Qsw/Qal) - Transported soil.	10		
ML (visual) s(ML) (Lab. Class.) One sack sample. 3.5 ft.	**2.0 to 3.5 ft. - SILT (ML):** About 100% fines with medium dry strength, rapid dilatancy, low toughness, no plasticity; maximum size fine sand; strong reaction with HCl. **IN-PLACE CONDITION:** Soft; homogeneous; tan; field moisture=11%. **LAB TEST DATA:** 61% fines, 39% sand, LL=21, PI=NP. Laboratory Classification is SANDY SILT. **GEOLOGIC INTERPRETATION:** Quaternary Residual Soil (Qrs).			
SANDSTONE	**3.5 to 6.5 ft. - SANDSTONE:** Highly weathered; brown to yellow-brown; fine grained; moist; poorly			

REMARKS: Terminated digging at 6.5 ft. due to bedrock.
Digging was moderately difficult to difficult.
Hand-drive sample in California liner was taken at a depth of 3.0 ft., but a reliable in-place unit weight could not be determined due to inadequate sample.
Ground cover: Grass and sagebrush.

7-1335-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 2 OF 2 HOLE NO. TP-WC-39

FEATURE: BORROW AREA INVESTIGATION
PROJECT: ELKHEAD DAM ENLARGEMENT
AREA DESIGNATION: DRAW EAST SIDE OF RESERVOIR
GROUND ELEVATION:
COORDINATES: N E
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
APPROXIMATE DIMENSIONS: 15.0' X 2.5' X 6.5'
LOGGED BY: K. WESTON, B. HOPKINS
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE(S) LOGGED: 06-29-93
DATE:

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLUM 3-5 in	5-12 in	P
s (ML) (Lab. Class.) One sack sample. 6.5 ft.	cemented; strong reaction with HCl; digs with moderate to difficult effort; retrieved in flat chunks 2 to 3 inches thick that break easily with moderate hand pressure; would be classed as a "POORLY GRADED SAND (SP)". **LAB TEST DATA:** 61% fines, 39% sand, LL=21, PI=NP, field moisture=11%. Laboratory Classification is SANDY SILT. **GEOLOGIC INTERPRETATION:** Tertiary Fort Union/Cretaceous Lance formations (Tf/Kl) - undifferentiated.			

REMARKS:

7-1336-A (1-86)
Bureau of Reclamation

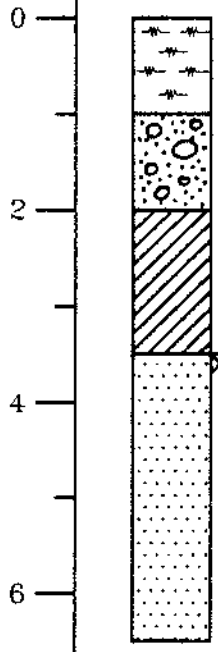
LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-39

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: DRAW EAST SIDE OF RESERVOIR
COORDINATES:
APPROXIMATE DIMENSIONS: 15.0' X 2.5' X 6.5'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 29, 1993

DEPTH (ft.)	GRAPHIC LOG OF TEST PIT



TOPSOIL - (CL)g, dark brown, dry to moist, roots, some gravel.

Hand-drive sample taken at 3.0'.

3.5' TOP OF BEDROCK

SANDSTONE - Highly weathered; brown to yellow brown; fine grained; poorly cemented; moist; strong HCl reaction; digs with moderate to difficult effort; retrieved in flat chunks 2 to 3 inches thick that break easily with moderate hand pressure.

50 lb. SACK SAMPLES
1.0' to 2.0'
2.0' to 3.5'
3.5' to 6.5'

REMARKS: Terminated digging at 6.5 ft. due to bedrock.
Digging was moderately difficult to difficult.
Hand-drive sample in California liner was taken at 3.0 ft.
Ground cover: grass and sagebrush.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 1 OF 1 HOLE NO. TP-WC-40

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: DRAW EAST SIDE OF RESERVOIR
COORDINATES: N E
APPROXIMATE DIMENSIONS: 15.0' X 4.5' X 15.0'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
LOGGED BY: K. WESTON, B. HOPKINS
DATE(S) LOGGED: 06-30-93

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLUM 3-5 in	5-12 in	P
TOPSOIL No sack sample. 1.0 ft.	**0.0 to 1.0 ft. - TOPSOIL:** Dark brown, dry, roots and vegetation; would be classed as a "LEAN CLAY (CL)".			
CL (visual) (CL)s (Lab. Class.) One sack sample. 5.0 ft.	**1.0 to 5.0 ft. - LEAN CLAY (CL):** About 100% fines with high dry strength, slow dilatancy, high toughness, medium plasticity; maximum size fine sand; weak reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; brown; field moisture=11%. **LAB TEST DATA:** 79% fines, 21% sand, LL=33, PI=14. Max. dry unit wt., opt.: 102.5 lb/ft3, 19.5%. Laboratory Classification is LEAN CLAY WITH SAND. **GEOLOGIC INTERPRETATION:** Quaternary Residual Soil (Qrs).			
CL (visual) s (CL) (Lab. Class.) One sack sample. 15.0 ft.	**5.0 to 15.0 ft. - LEAN CLAY (CL):** About 100% fines with high dry strength, slow dilatancy, high toughness, medium plasticity; maximum size fine sand; strong reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; tan; field moisture=9%. **LAB TEST DATA:** 69% fines, 31% sand, LL=27, PI=12. Laboratory Classification is SANDY LEAN CLAY. **GEOLOGIC INTERPRETATION:** Quaternary Residual soil (Qrs).			

REMARKS: Digging was easy to moderately difficult.
Hand-drive samples in California liners were taken at a depths of 3.0 and 7.0 ft., but reliable in-place unit weights could not be determined due to inadequate samples. Samples were difficult to take.
Ground cover: Grass and sagebrush.

7-1336-A (1-86)
Bureau of Reclamation

LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-40

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: DRAW EAST SIDE OF RESERVOIR
COORDINATES:
APPROXIMATE DIMENSIONS: 15.0' X 4.5' X 15.0'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHO
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 30, 1993

DEPTH (ft.)	GRAPHIC LOG OF TEST PIT
	TOPSOIL - CL, dark brown, dry, roots.
	1.0'
2	
	(CL)s Hand-drive sample taken at 3.0'.
4	
6	
8	
	Hand-drive sample taken at 7.0'.
10	s(CL)
	50 lb. SACK SAMPLES 1.0' to 5.0' 5.0' to 10.0'
12	
14	
	Reached limit of backhoe at 15.0 ft.

REMARKS: Digging was easy to moderately difficult.
Hand-drive samples in California liners were taken at depths of 3.0 and 7.0 ft.
Ground cover: grass and sagebrush

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 1 OF 1 HOLE NO. TP-WC-41

FEATURE: BORROW AREA INVESTIGATION
PROJECT: ELKHEAD DAM ENLARGEMENT
AREA DESIGNATION: DRAW EAST SIDE OF RESERVOIR
GROUND ELEVATION:
COORDINATES: N E
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
APPROXIMATE DIMENSIONS: 17.0' X 5.0' X 10.0'
LOGGED BY: K. WESTON, B. HOPKINS
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE(S) LOGGED: 06-29-93
DATE:

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLUM 3-5 in	5-12 in	F
TOPSOIL No sack sample. 0.7 ft.	**0.0 to 0.7 ft. - TOPSOIL:** Dark brown, dry to moist, roots and vegetation; would be classed as a " LEAN CLAY (CL) ".			
CL (visual) CL (Lab. Class.) One sack sample. 7.8 ft.	**0.7 to 7.8 ft. - LEAN CLAY (CL):** About 100% fines with high dry strength, slow dilatancy, high toughness, high plasticity; maximum size fine sand; no reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; brown; field moisture=13%. **LAB TEST DATA:** 94% fines, 6% sand, LL=33, PI=14. Max. dry unit wt., opt.: 103.3 lb/ft3, 18.5%. Laboratory Classification is LEAN CLAY. **GEOLOGIC INTERPRETATION:** Quaternary Residual soil (Qrs).			
SANDSTONE & CLAYSTONE CL (Lab. Class.) One sack sample. 10.0 ft.	**7.8 to 10.0 ft. - SANDSTONE AND CLAYSTONE:** Highly weathered; brown to yellow-brown; sandstone is predominantly fine grained; weakly cemented - pieces break with moderate finger pressure; moist; strong reaction with HCl. **LAB TEST DATA:** 88% fines, 12% sand, LL=33, PI=14, field moisture=10%. Max. dry unit wt., opt.: 107.1 lb/ft3, 16.6%. Laboratory Classification is LEAN CLAY. **GEOLOGIC INTERPRETATION:** Tertiary Fort Union/Cretaceous Lance formations (Tf/Kl) - undifferentiated.			

REMARKS: Terminated digging at 10.0 ft. due to bedrock.
Digging was moderately difficult to difficult.
Hand-drive samples in California liners were taken at depths of 3.0 and 7.0 ft., but reliable in-place unit weights could not be determined due to inadequate samples. Samples were difficult to obtain.
Ground cover: Grass and sagebrush.

7-1336-A (1-86)
Bureau of Reclamation

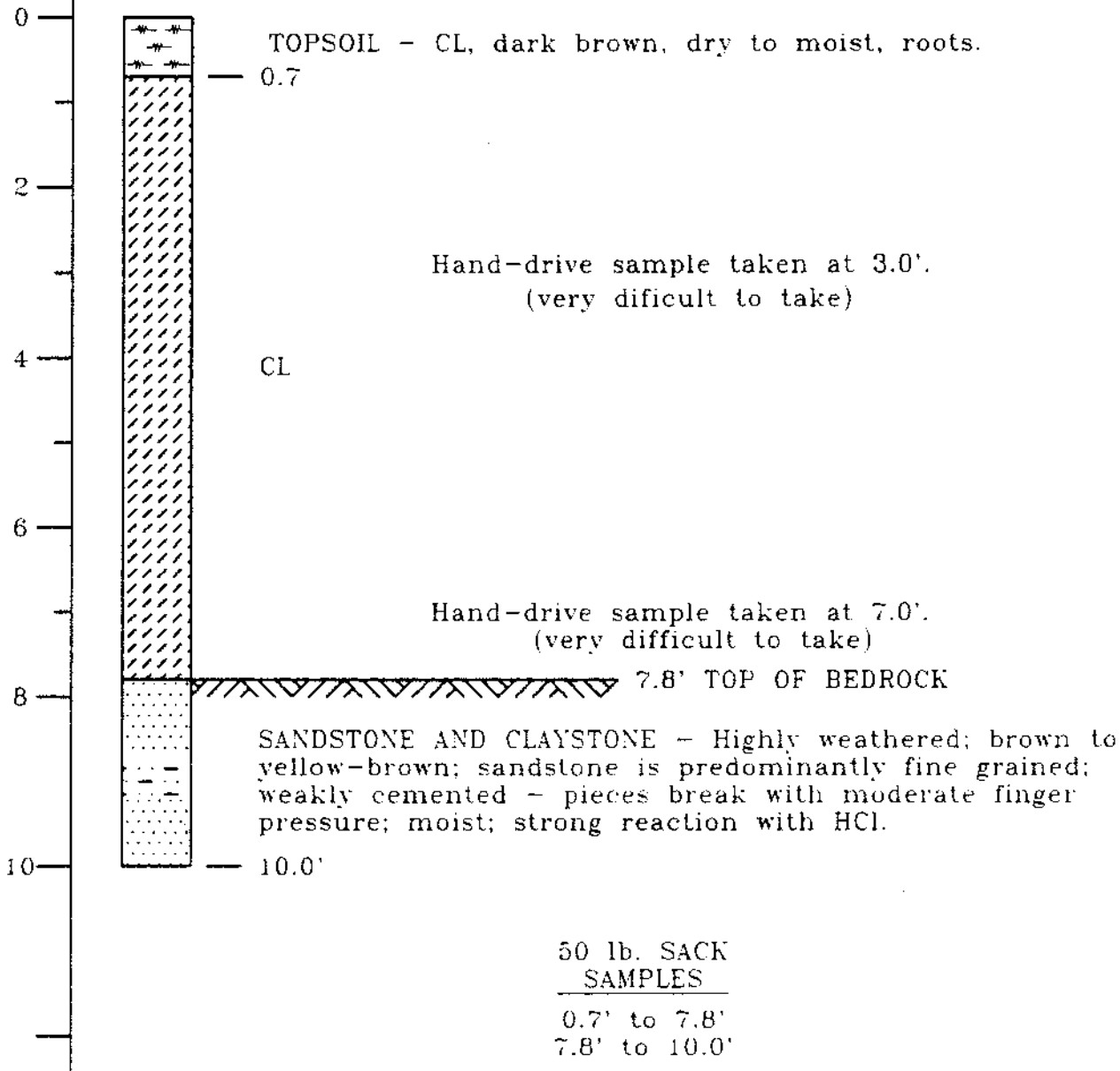
LOG OF TEST PIT OR AUGER HOLE

HOLE NO. TP-WC-41

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: DRAW EAST SIDE OF RESERVOIR
COORDINATES:
APPROXIMATE DIMENSIONS: 17.0' X 5.0' X 10.0
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHO
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 29, 1993

DEPTH (ft.)	GRAPHIC LOG OF TEST PIT



REMARKS: Terminated digging at 10.0 ft. due to bedrock.
Digging was moderately difficult to difficult.
Hand-drive samples in California liners taken at 3.0 and 7.0 ft.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	SHEET 1 OF 1 HOLE NO. TP-WC-42

FEATURE: BORROW AREA INVESTIGATION
PROJECT: ELKHEAD DAM ENLARGEMENT
AREA DESIGNATION: DRAW EAST SIDE OF RESERVOIR
GROUND ELEVATION:
COORDINATES: N E
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHOE
APPROXIMATE DIMENSIONS: 16.0' X 4.5' X 10.0'
LOGGED BY: K. WESTON, B. HOPKINS
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE(S) LOGGED: 06-29-93
DATE:

CLASSIFICATION GROUP SYMBOL (describe sample taken)	CLASSIFICATION AND DESCRIPTION OF MATERIAL SEE USBR 5000, 5005	% PLUS 3 (BY VOLUM 3-5 in	5-12 in	P
TOPSOIL No sack sample. 1.0 ft.	**0.0 to 1.0 ft. - TOPSOIL:** Dark brown, dry, roots and vegetation; would be classed as a "LEAN CLAY (CL)".			
CL (visual) s (CL) (Lab. Class.) One sack sample. 5.0 ft.	**1.0 to 5.0 ft. - LEAN CLAY (CL):** About 100% fines with high dry strength, slow dilatancy, medium toughness, medium plasticity; maximum size fine sand; weak reaction with HCl. **IN-PLACE CONDITION:** Soft; homogeneous; brown; field moisture=16%. **LAB TEST DATA:** 66% fines, 34% sand, LL=29, PI=17. Max. dry unit wt., opt.: 106.1 lb/ft3, 17.8%. Laboratory Classification is SANDY LEAN CLAY. **GEOLOGIC INTERPRETATION:** Quaternary Residual Soil (Qrs).			
CL (visual) One sack sample. 10.0 ft.	**5.0 to 10.0 ft. - CLAY (CL):** About 100% fines with high dry strength, slow dilatancy, medium toughness, medium plasticity; maximum size fine sand; weak reaction with HCl. **IN-PLACE CONDITION:** Firm; homogeneous; brown; field moisture=13%. **LAB TEST DATA:** No lab data - sample taken to Denver by Woodward-Clyde Consultants. **GEOLOGIC INTERPRETATION:** Quaternary Residual soil (Qrs).			

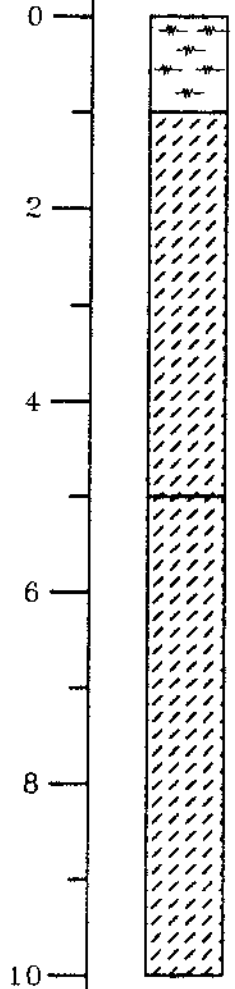
REMARKS: Digging was easy to moderately difficult.
Hand-drive samples in California liners were taken at a depths of 3.0 and 7.0 ft., but reliable in-place unit weights could not be determined due to inadequate samples. Samples were difficult to take.
Ground cover: Grass and sagebrush.

7-1336-A (1-86) Bureau of Reclamation	LOG OF TEST PIT OR AUGER HOLE	HOLE NO. TP-WC-42

FEATURE: BORROW AREA INVESTIGATION
AREA DESIGNATION: DRAW EAST SIDE OF RESERVOIR
COORDINATES:
APPROXIMATE DIMENSIONS: 16.0' X 4.5' X 10.0'
DEPTH WATER ENCOUNTERED 1/: NOT ENCOUNTERED
DATE:

PROJECT: ELKHEAD DAM ENLARGEMENT
GROUND ELEVATION:
METHOD OF EXPLORATION: JOHN DEERE 710C BACKHO
LOGGED BY: K. WESTON, B. HOPKINS
DATE (S) LOGGED: JUNE 29, 1993

DEPTH (ft.)	GRAPHIC LOG OF TEST PIT



REMARKS: Digging was easy to moderately difficult.
Hand-drive samples in California liners were taken at depths of 3.0 and 7.0 ft.
Ground cover: grass and sagebrush

Muller Engineering Company, Inc.
DESIGN NOTES AND COMPUTATIONS

Subject: ELKHEAD DAM TEST PITS Sheet No. 1 Of ___

Prepared By: JHK Checked By: _____ Date: 9/28/93 Project No.: 9315.01

SEE TEST PIT LOCATION MAPS ATTACHED:
DIRT SAMPLES TYPICALLY MARKED: TP-__ TOP OR BOT
TOP IS SAMPLE FROM 0'-5'. BOT IS SAMPLE FROM 5'-10'.

TP-43	0'-.5'	TOPSOIL,
	.5'-3'	CLAYEY, DRY,
	3'-4'	ROCKY, CLAYEY, DRY
	4'-10'	CLAYEY, MOIST
TP-44	0'-.5'	TOPSOIL
	.5'-3'	CLAYEY, DRY
	3'-4'	ROCKY, CLAYEY, DRY
	4'-10'	CLAYEY, MOIST
TP-45	0'-2'	TOPSOIL, CLAYEY
	2'-4'	SANDY, LOOSE TO MEDIUM DENSE
	4'-7'	SANDY TO SANDSTONE
TP-46	0'-.5'	TOPSOIL
	.5'-4'	SANDY, DRY, CHUNKY
	4'-10'	SANDY, MOIST
TP-47	0'-.5'	TOPSOIL
	.5'-5'	SANDY
	5'-10'	SANDY AND CLAYEY
TP-48	0'-.5'	TOPSOIL
BAGS MARKED	.5'-4'	CLAYEY, DRY, CHUNKY, WHITE VEINS OF MATERIAL
Δ1 TOP	4'-9'	CLAYEY, MOIST
Δ1 BOT	9'-10'	CLAY, MOIST TO WET
Δ1 10'+		
TP-49	0'-.5'	TOPSOIL
BAGS MARKED	.5'-5'	CLAY, MOIST
Δ2 TOP	5'-10'	CLAY, LIGHTER, MOIST
Δ2 BOT	10'+	MORE MOISTURE

THE CAMERA I TOOK TO THE SITE DIED, SO I USED A VIDEO CAMERA AND I WILL MAKE YOU A COPY AND SEND IT TO YOU.

Morrison-Knudsen Test Pits for RCC Study

ELKHEAD CREEK DAM
MATERIALS INVESTIGATION
TEST PIT LOG

TEST PIT #1

0-5.0	Topsoil, silty clay, organic, wet (saturated below 3.0) (OL)
5.0-10.0	Gravelly sand, tr. silt, poorly graded (coarse) max. size 3", angular, saturated (SP)

TEST PIT #2

0-6.0	Topsoil, silty clay, organic, wet (saturated below 4.0) (OL)
6.0-10.0	Gravelly sand, tr. silt, poorly graded, max, size 5", angular, saturated (SP)

TEST PIT #3

0-2.0	Topsoil, clayey sand, organic, moist (OL)
2.0-3.0	Sand, poorly graded, angular, moist (SP)
3.0	Weathered sandstone

TEST PIT #4

0-1.5	Topsoil, silty clay, organic, moist (OL)
1.5-8.0	Sandy clay, tr. gravel, medium plasticity, moist, brown

TEST PIT #5

0-2.0	Sand, well-graded, angular, moist
2.0	Sandstone, dense

TEST PIT #6

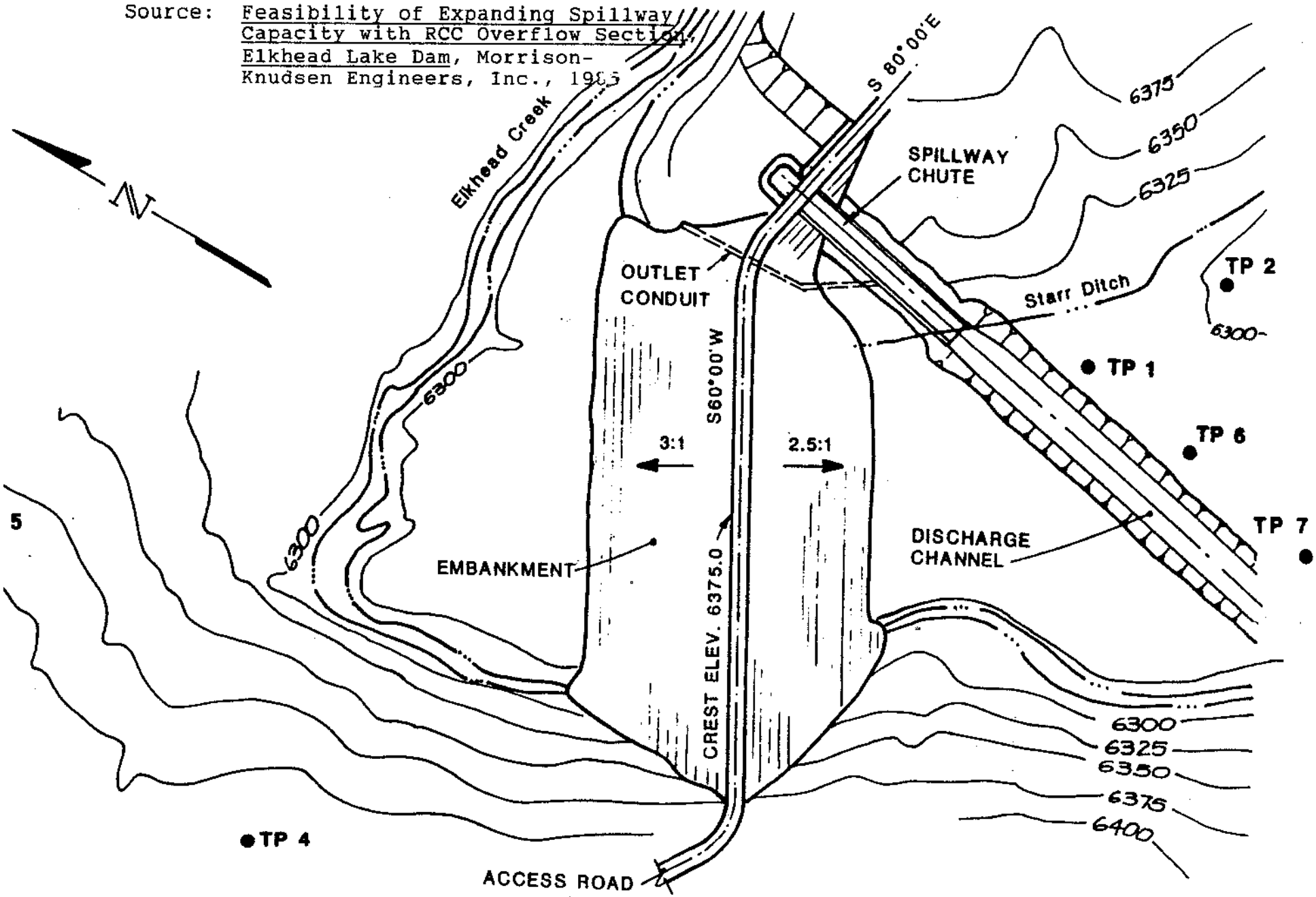
0-4.0	Topsoil, silty clay, organic, wet (saturated below 3.5) (OL)
4.0-14.0	Sandy, silty clay, tr. gravel, low plasticity, saturated, brown

TEST PIT #7

0-5.0	Topsoil, silty clay, organic, wet (saturated below 4.0)
5.0-12.0	Sandy, silty, clay, tr. gravel, low plasticity, saturated, brown

Source: Feasibility of Expanding Spillway Capacity with RCC Overflow Section, Elkhead Lake Dam
Morrison-Knudsen Engineers, Inc., July 1985

Source: Feasibility of Expanding Spillway Capacity with RCC Overflow Section, Elkhead Lake Dam, Morrison-Knudsen Engineers, Inc., 1985



Morrison-Knudsen
RCC Test Pits