U.S. Department of Energy
2597 B¾ Road
Grand Junction, CO 81503

June 16, 2006

Mr. Myron Fliegel
U. S. Nuclear Regulatory Commission
Mail Stop T7J8
Two White Flint North
11545 Rockville Pike
Rockville, MD 20852-2747

Subject: Transmittal of Calculation Sets of the Remedial Action Plan, Moab Uranium Mill Tailings Remedial Action (UMTRA) Project

Dear Mr. Fliegel:

Enclosed are four sets of the following calculation sets as listed, as well as new Table of Contents pages and tabs for insertion into the previously provided binders.

Attachment 1

- Volume Calculation for the Moab Tailings Pile

Attachment 3

- Hydrologic Characterization – Vertical Travel Time to Uppermost (Dakota) Aquifer Calculation

Attachment 4

- Geochemical Attenuation and Performance Assessment Modeling

Attachment 5

- Cone Penetration Tests
- Seismic Rippability Investigation

DOE looks forward to discussing the calculation sets during our upcoming June 20 and 21, 2006, meetings. If you have any questions, please call me at (970) 248-7612 or Joel Berwick of my staff at (970) 248-6020.

Sincerely,

Robert H. Beck
for

Donald R. Metzler
Moab Federal Project Director

cc w/o enclosure:
J. Berwick, EM-3.2 (e)
B. Birk, EM-3.2 (e)
J. Elmer, Stoller (e)
K. Karp, Stoller (e)
Project File MOA 2.12 (R. Burrows)

\DB\Moab\RAP\Addntl Calc Sets to NRC.doc

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Appendix A Freeze/Thaw Layer Design

Appendix B Radon Barrier Design Remedial Action Plan Calculation

Appendix C Slope Stability of Crescent Junction Disposal Cell

Appendix D Settlement, Cracking, and Liquefaction Analysis

Appendix E Site Drainage–Hydrology Parameters

Appendix F Crescent Junction Site Hydrology Report

Appendix G Diversion Channel Design, North Side Disposal Cell

Appendix H Erosional Protection of Disposal Cell Cover

Appendix I Volume Calculation for the Moab Tailings Pile

U.S. Department of Energy—Grand Junction, Colorado

Calculation Cover Sheet

Calc. No.: MOA-02-05-2006-5-02-00 Rev. 1 **Discipline:** Geotechnical **No. of Sheets:** 13

Project: Moab UMTRA Project

Site: Moab Disposal Site

Feature:
Volume Calculation for the Moab Tailings Pile

Sources of Data:

- Various site topography files, including pre-2000 data, 2003, and 2005 topography files.
- Boring logs and CPTs from SRK (2000) site investigation.
- Boring logs from Dames & Moore (1981) site investigation.
- Boring logs, test pit logs, CPT soundings, and laboratory test data from Golder (2005) field investigation.

Sources of Formulae and References:

ConeTec, Inc. (ConeTec) 2000. Cone Penetration Test Report, "Atlas Minerals Mill Tailings Impoundment," Moab, Utah, Vols I and II, Salt Lake City, Utah, May 12.

Dames & Moore (D&M). 1981. Report of Engineering Design Study, "Additions to Tailings Pond- Embankment System," Moab, Utah, for Atlas Minerals, Salt Lake City, Utah, May 26.

Steffen Robertson and Kirsten (SRK). 2000. "Dewatering Options for Placement of Cover, Moab Tailings Impoundment," prepared for Moab Mill Reclamation Trust, Lakewood, Colorado, June.

Preliminary Calc. ☒ **Final Calc.** ☐ **Supersedes Calc. No.** MOA-02-05-2006-5-02-00

Author:	Kimberly L. Morrison	6/5/06	**Checked by:**	Neal Kinsley for Greg Lord	6-14-06
	Name	Date		Name	Date
Approved by:	[signature]	6/5/06		John Eldner	6-14-06
	Name	Date		Name	Date
				Gregory M. Smith	6-14-06
				Name	Date
				Name	Date

Problem Statement:

Estimate the total volume of tailings and associated fill materials requiring removal and re-location from the Moab Tailings Impoundment, including an estimate of the various material types (i.e., cover fill, sands, transitional tailings and slimes).

Method of Solution:

Review site geotechnical data including boring logs, test pit logs, laboratory test results and cone penetration test (CPT) soundings conducted at the Site. Using AutoCAD and Land Development Desktop (LDD), develop cross-sections both laterally (northwest to southeast) and transversely (southwest to northeast) across the site in order to estimate the volumes. Where laboratory test data are available, use the data to divide the material into the following general classifications:

- Sand: <30 percent fines (minus 74 micron).
- Transitional tailings: >30 percent and < 70 percent fines.
- Slimes: >70 percent fines.

Assumptions:

- Relative percent fines can be estimated from the cone penetration soundings based on relative resistance, whereby higher resistances infer presence of sandy soils and lower resistance infer presence of fine-grained soils.
- The average end area method, wherein averaged cross-sectional areas from two adjacent sections multiplied by the distance between those two sections provides a reasonable estimate of the volume of material between the same sections.

Calculation:

Volumes were calculated using the average-end area method, whereby cross-sections were developed across the site and the material constituents of each cross-section were averaged with the same from the adjacent cross-section and multiplied by the distance between the sections.

Discussion:

- Based on the method discussed herein, results of the volume evaluation using lateral cross-sections (0 through 10) and transverse cross-sections (11 through 25) are summarized as follows, with volumes presented in cubic yards (cy):

Material Type	Lateral Cross-Sections	Transverse Cross-Sections
Cover Fill	452,800 cy	440,800 cy
Sand Tailings	2,860,100 cy	2,736,700 cy
Transitional Tailings	3,930,500 cy	3,903,100 cy
Slimes	3,116,100 cy	3,236,600 cy

- The total volume of tailings and cover soils was calculated to be 10.36 million cy and 10.32 million cy using the lateral and transverse cross-sections, respectively.
- See Tables 1 and 2 for summary of cross-sectional areas and volumes based on the lateral and transverse cross-sections, respectively.
- See Figures 1 through 8 for map and cross-sections.

Table 1. Area and Volume Summary

GOLDER ASSOCIATES INC

TABLE 1
AREA AND VOLUME SUMMARY
BASED ON LATERAL SECTIONS

Data from AutoCAD Sections 22-May-06 *0532269 DR 18May06.dwg*

Section	Cover Fill Area (ft^2)	Sand Tailings Area (ft^2)	Transitional Tailings Area (ft^2)	Slimes Tailings Area (ft^2)
0	0	33,613	0	0
1	2,427	60,649	44,207	3,213
2	4,657	35,088	72,000	30,949
3	6,963	20,934	73,724	51,085
4	8,843	29,590	43,767	71,139
5	9,724	28,294	70,101	52,258
6	12,217	39,020	34,538	68,572
7	8,570	21,813	64,582	58,960
8	7,366	25,373	63,253	60,320
9	361	58,795	64,448	24,171
10	0	61,556	0	0

Volumes Calculations

Section Increment	Cover Fill Volume (ft^3)	Sand Tailings Volume (ft^3)	Transitional Tailings Volume (ft^3)	Slimes Tailings Volume (ft^3)
Outside 0	0	2,100,813	0	0
0 to 1	242,700	9,426,200	4,420,700	321,300
1 to 2	708,400	9,573,700	11,620,700	3,416,200
2 to 3	1,162,000	5,602,200	14,572,400	8,203,400
3 to 4	1,580,600	5,052,400	11,749,100	12,222,400
4 to 5	1,856,700	5,788,400	11,386,800	12,339,700
5 to 6	2,194,100	6,731,400	10,463,900	12,083,000
6 to 7	2,078,700	6,083,300	9,912,000	12,753,200
7 to 8	1,593,600	4,718,600	12,783,500	11,928,000
8 to 9	772,700	8,416,800	12,770,100	8,449,100
9 to 10	36,100	12,035,100	6,444,800	2,417,100
Outside 10	0	1,692,790	0	0

Total (ft^3)	12,225,600	77,221,703	106,124,000	84,133,400	**279,704,703**
Total (yd^3)	452,800	2,860,063	3,930,519	3,116,052	**10,359,433**

Table 2. Area and Volume Summary Based on Transverse Sections

GOLDER ASSOCIATES INC

TABLE 2
AREA AND VOLUME SUMMARY
BASED ON TRANSVERSE SECTIONS

Data from AutoCAD Sections 1-Jun-06 *0532269A027*

Section	Cover Fill Area (ft^2)	Sand Tailings Area (ft^2)	Transitional Tailings Area (ft^2)	Slimes Tailings Area (ft^2)
11	0	27,774	5,649	0
12	3,430	16,667	31,875	567
13	2,897	16,159	48,193	9,117
14	5,356	21,704	38,804	29,743
15	6,681	17,276	25,998	51,026
16	8,435	17,476	20,190	58,429
17	7,138	23,344	24,057	56,265
18	4,848	18,228	23,136	70,274
19	4,790	17,565	46,072	56,152
20	5,212	25,587	50,827	52,443
21	6,864	24,841	71,631	42,733
22	2,238	31,676	100,069	10,192
23	1,624	60,991	41,118	0
24	0	44,823	0	0
25	0	12,373	0	0

Volumes Calculations

Section Increment	Cover Fill Volume (ft^3)	Sand Tailings Volume (ft^3)	Transitional Tailings Volume (ft^3)	Slimes Tailings Volume (ft^3)	
Outside 11	0	2,083,050	423,675	0	
11 to 12	343,000	4,444,100	3,752,400	56,700	
12 to 13	632,700	3,282,600	8,006,800	968,400	
13 to 14	825,300	3,786,300	8,699,700	3,886,000	
14 to 15	1,203,700	3,898,000	6,480,200	8,076,900	
15 to 16	1,511,600	3,475,200	4,618,800	10,945,500	
16 to 17	1,557,300	4,082,000	4,424,700	11,469,400	
17 to 18	1,198,600	4,157,200	4,719,300	12,653,900	
18 to 19	963,800	3,579,300	6,920,800	12,642,600	
19 to 20	1,000,200	4,315,200	9,689,900	10,859,500	
20 to 21	1,207,600	5,042,800	12,245,800	9,517,600	
21 to 22	910,200	5,651,700	17,170,000	5,292,500	
22 to 23	386,200	9,266,700	14,118,700	1,019,200	
23 to 24	162,400	10,581,400	4,111,800	0	
24 to 25	0	5,719,600	0	0	
Outside 25	0	525,853	0	0	
Total (ft^3)	11,902,600	73,891,003	105,382,575	87,388,200	**278,564,378**
Total (yd^3)	440,837	2,736,704	3,903,058	3,236,600	**10,317,199**

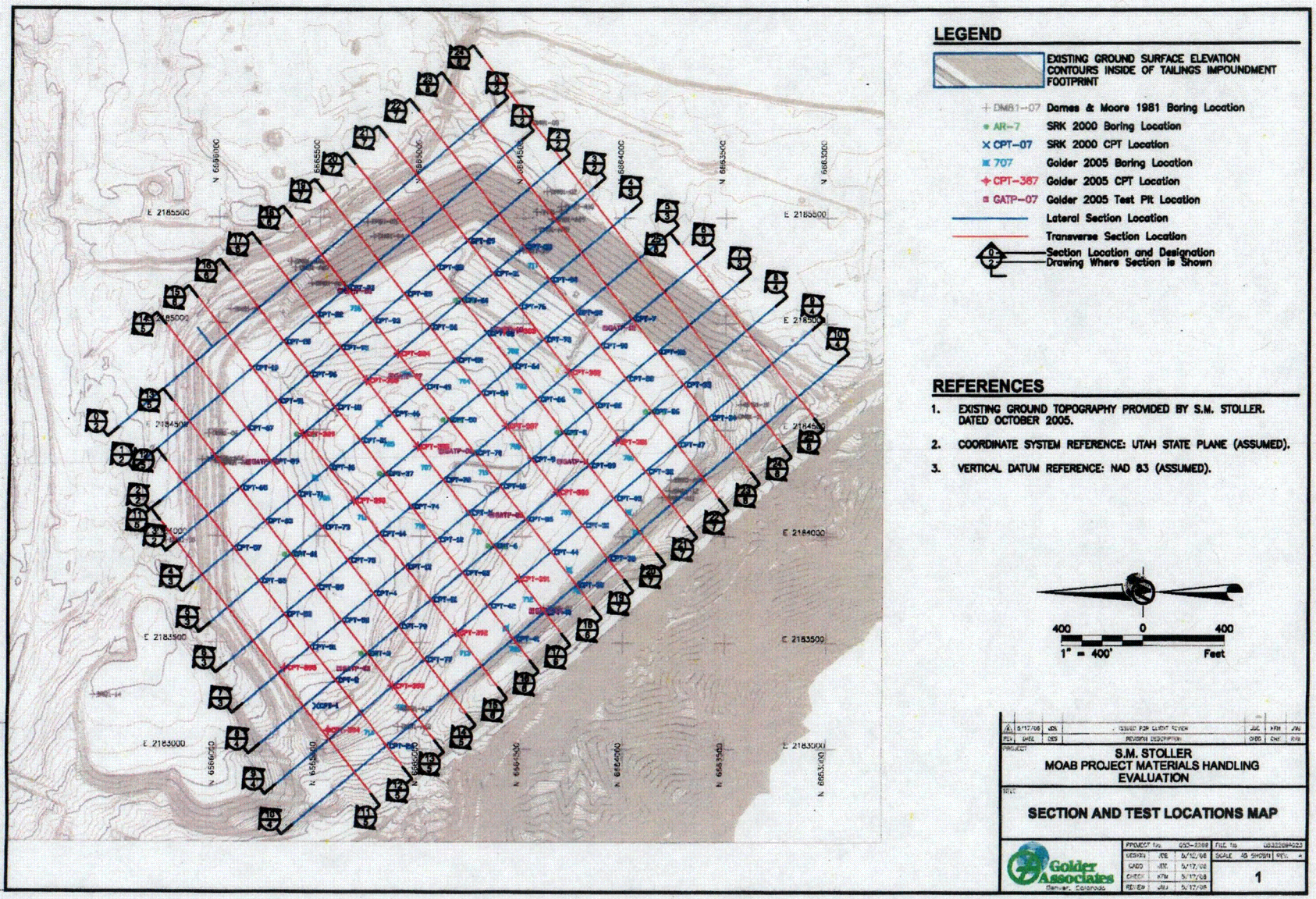

Figure 1. Section and Test Locations Map

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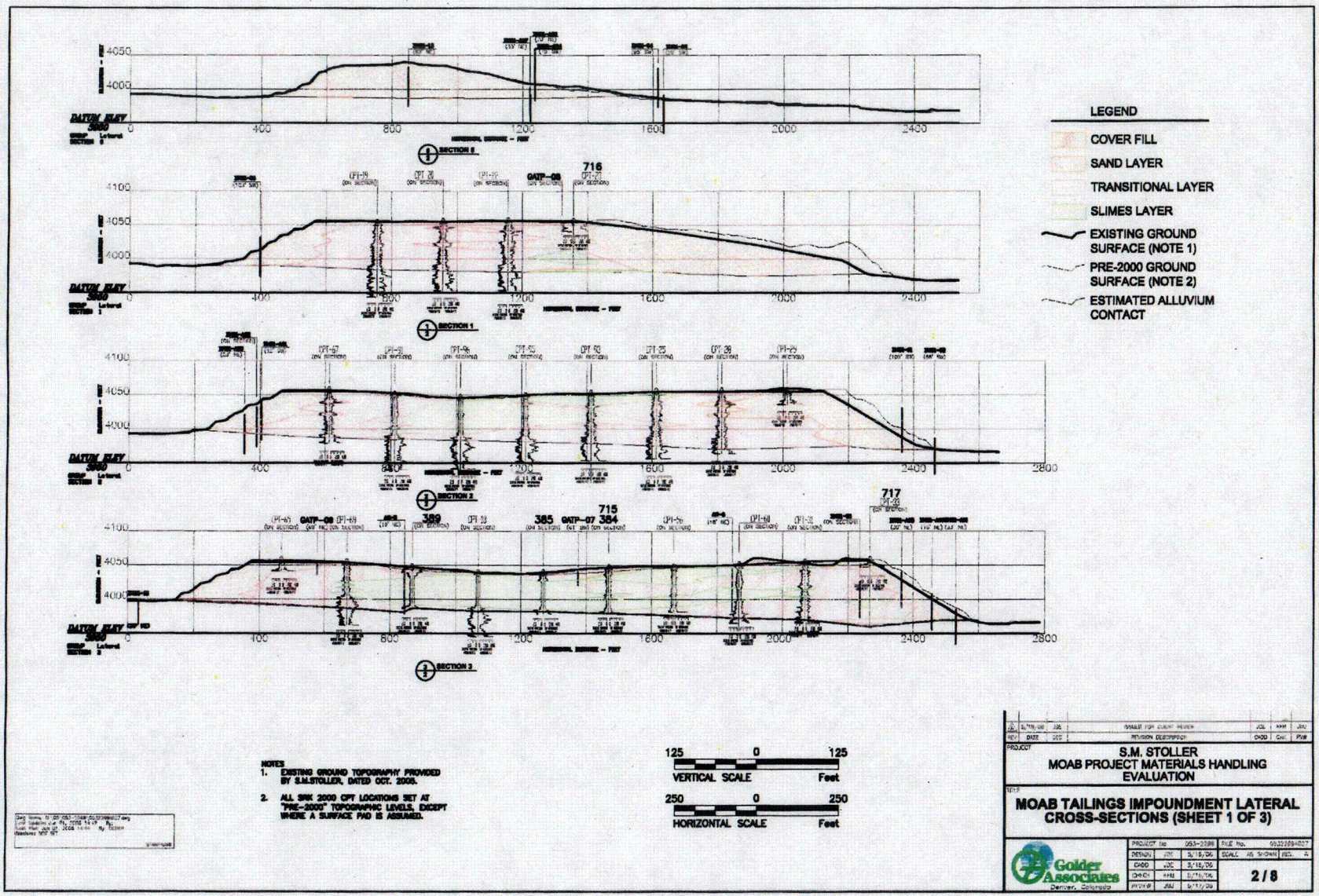

Figure 2. Moab Tailings Impoundment Lateral Cross-Section (Sheet 1 of 3)

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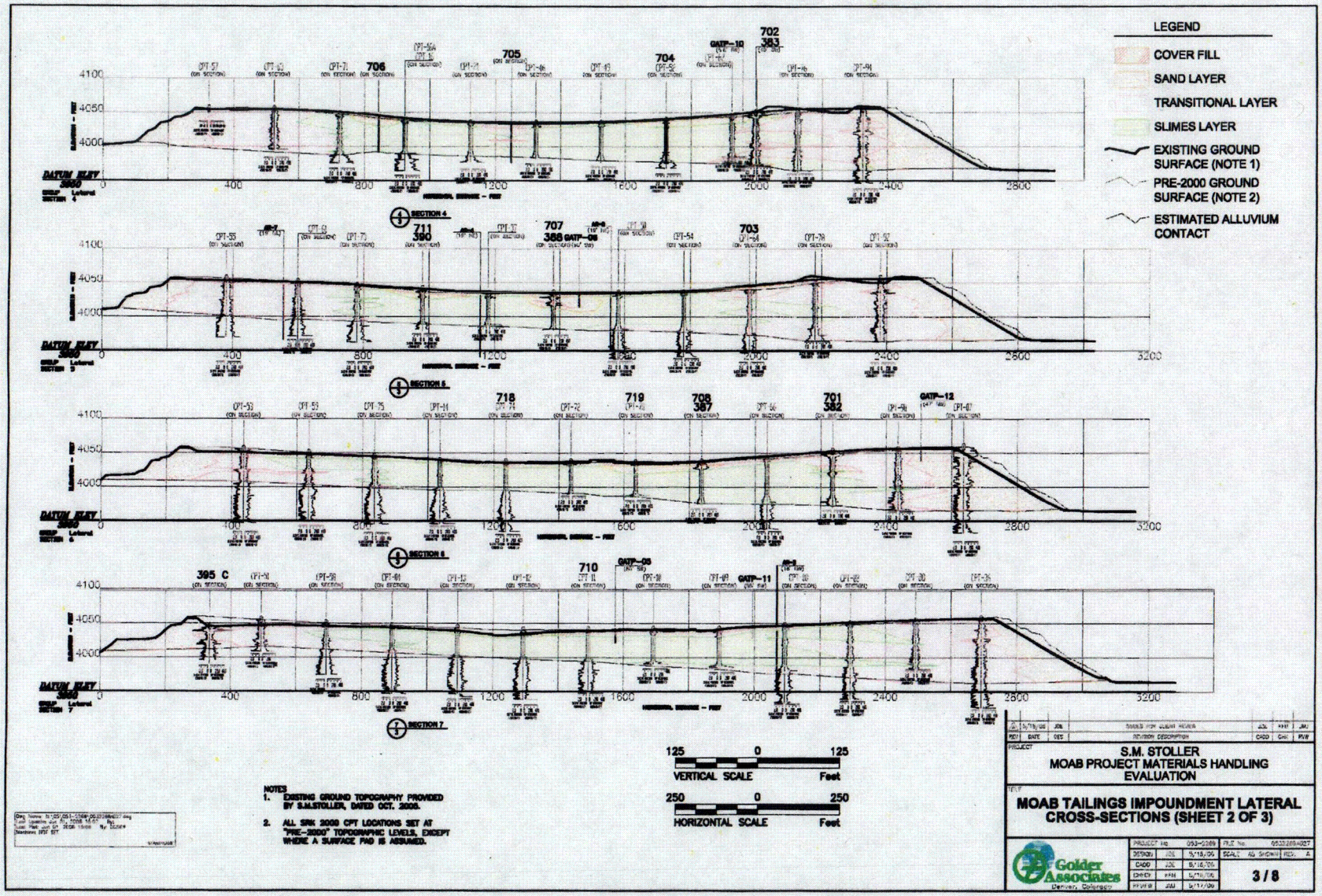

Figure 3. Moab Tailings Impoundment Lateral Cross-Section (Sheet 2 of 3)

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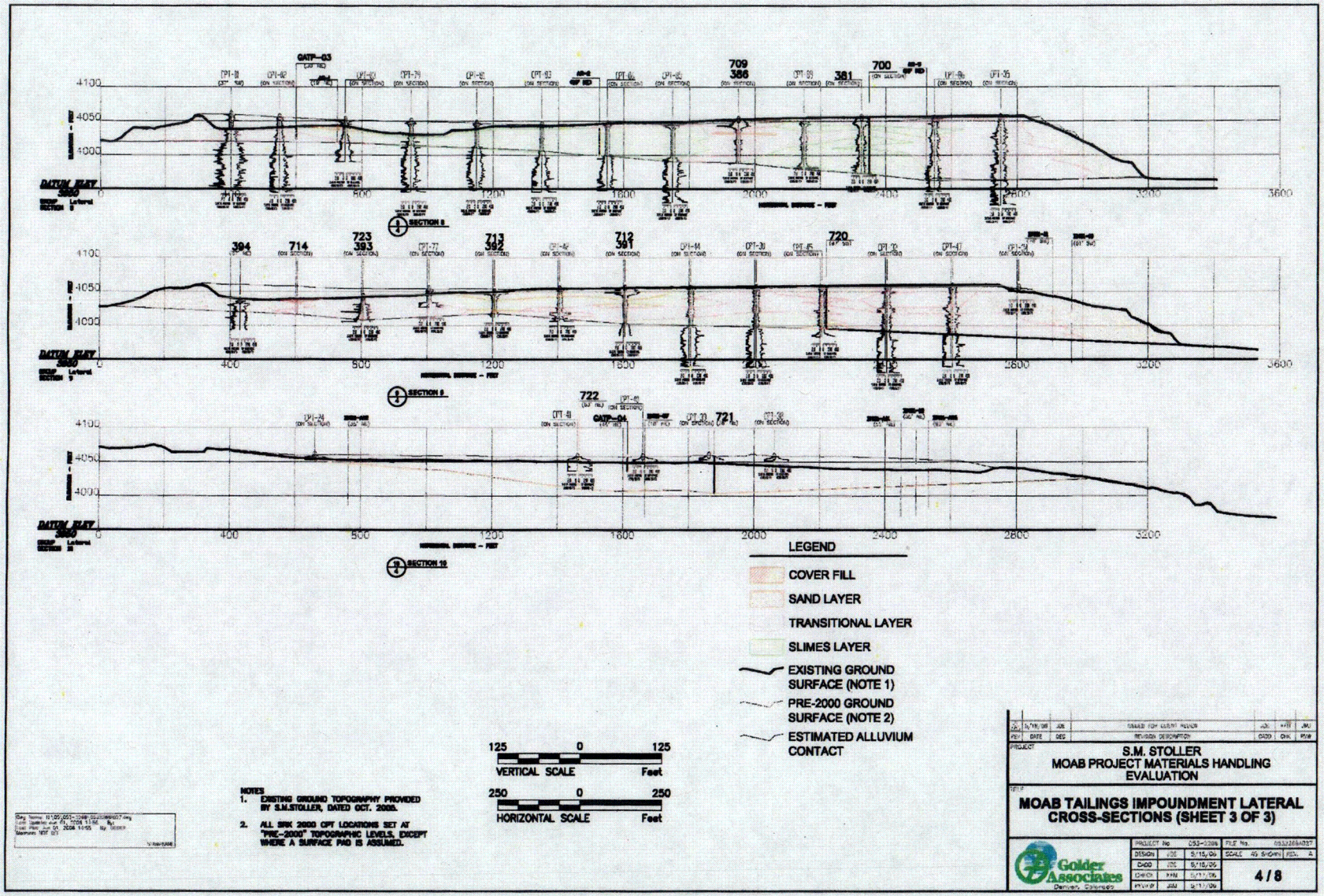

Figure 4. Moab Tailings Impoundment Lateral Cross-Sections (Sheet 3 of 3)

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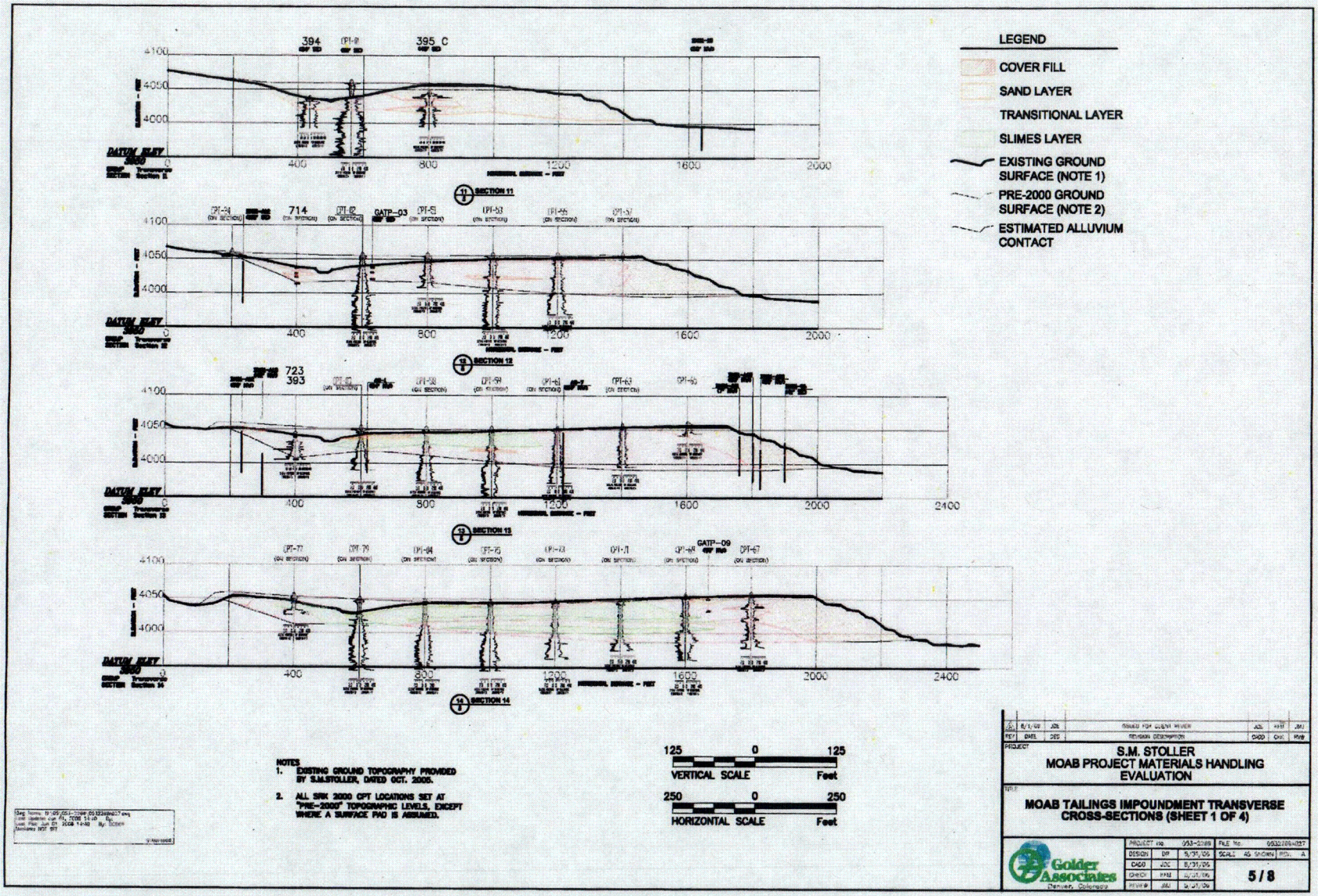

Figure 5. Moab Tailings Impoundment Transverse Cross Sections (Sheet 1 of 4)

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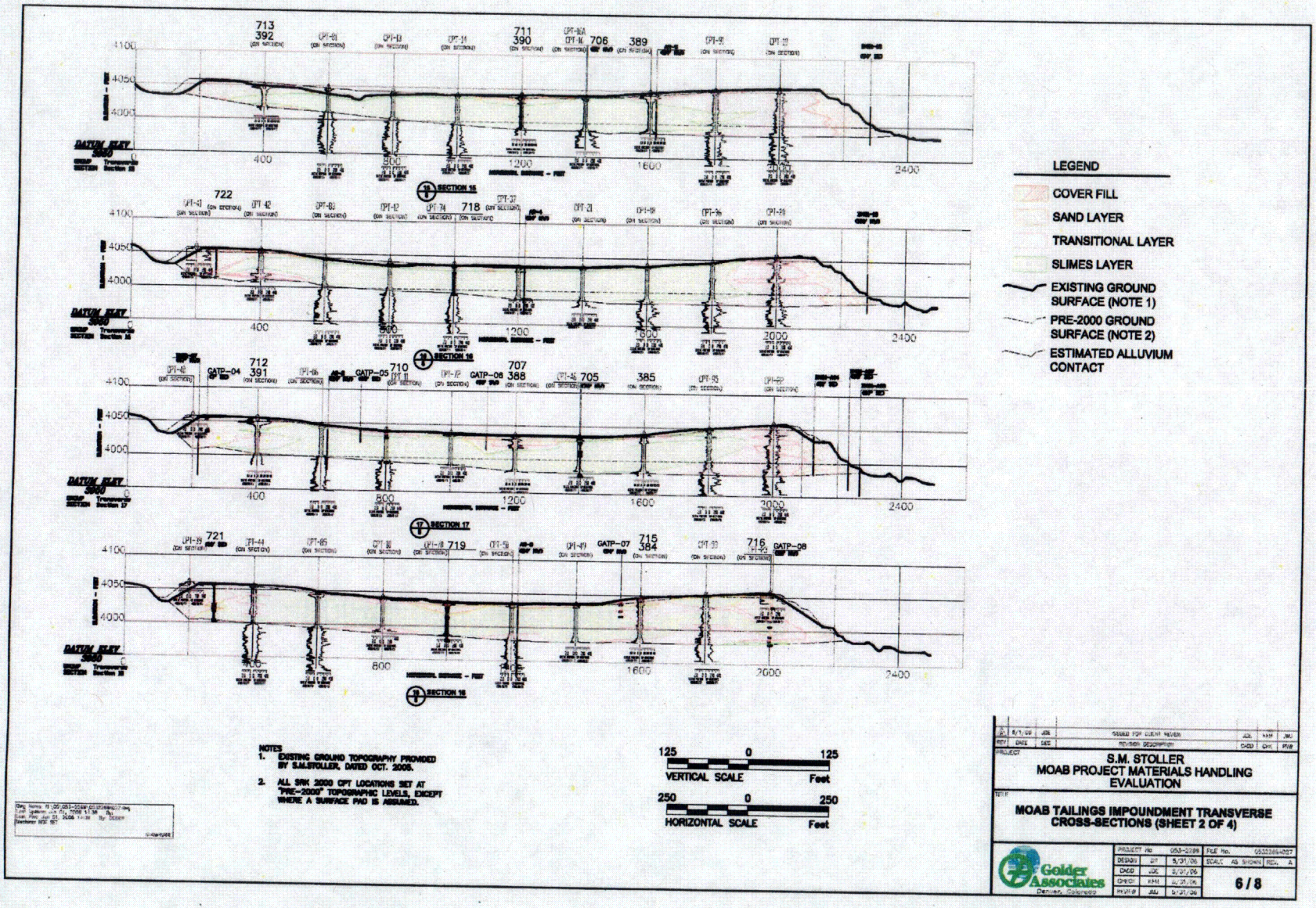

Figure 6. Moab Tailings Impoundment Transverse Cross Sections (Sheet 2 of 4)

C06

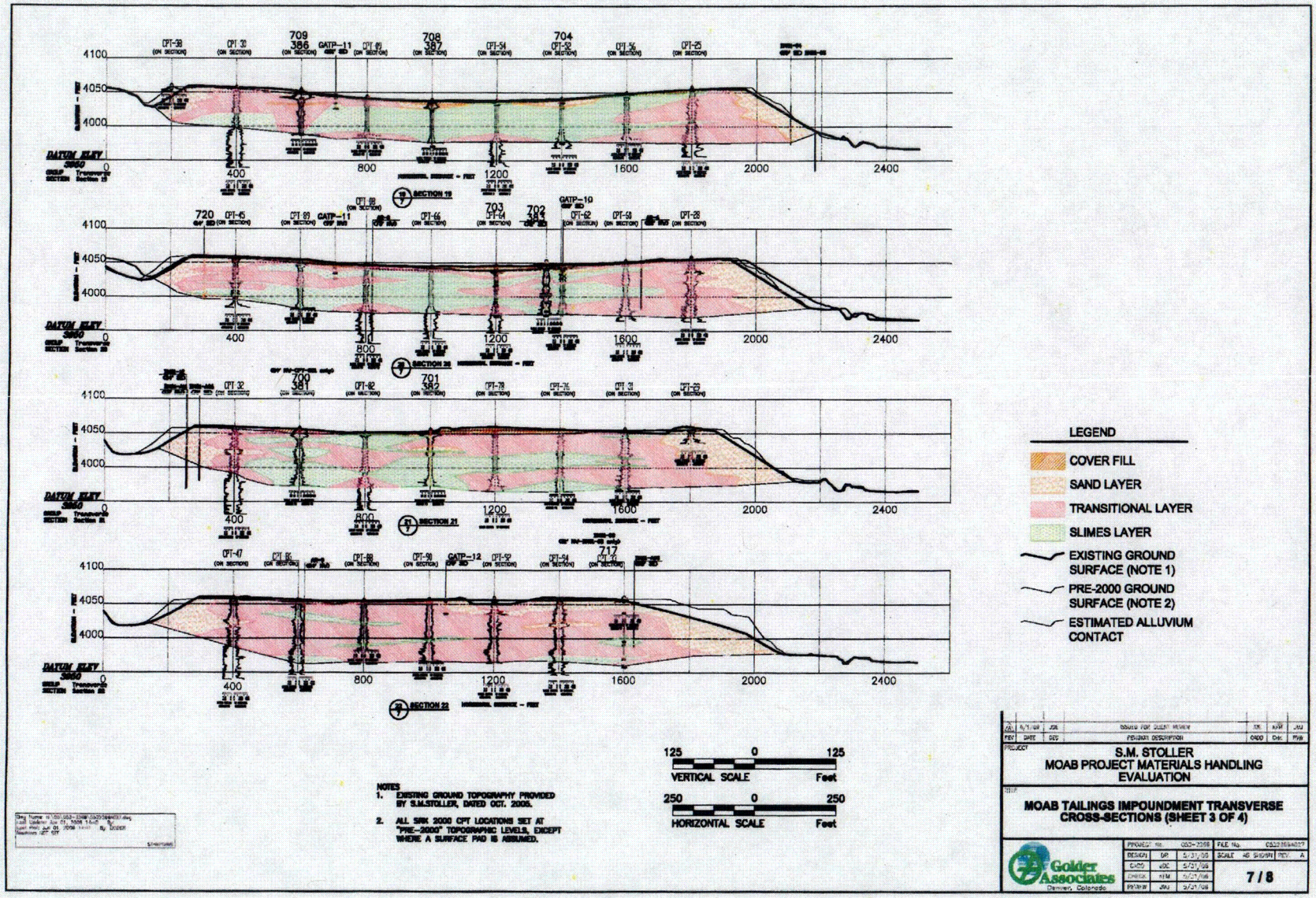

Figure 7. Moab Tailings Impoundment Transverse Cross Sections (Sheet 3 of 4)

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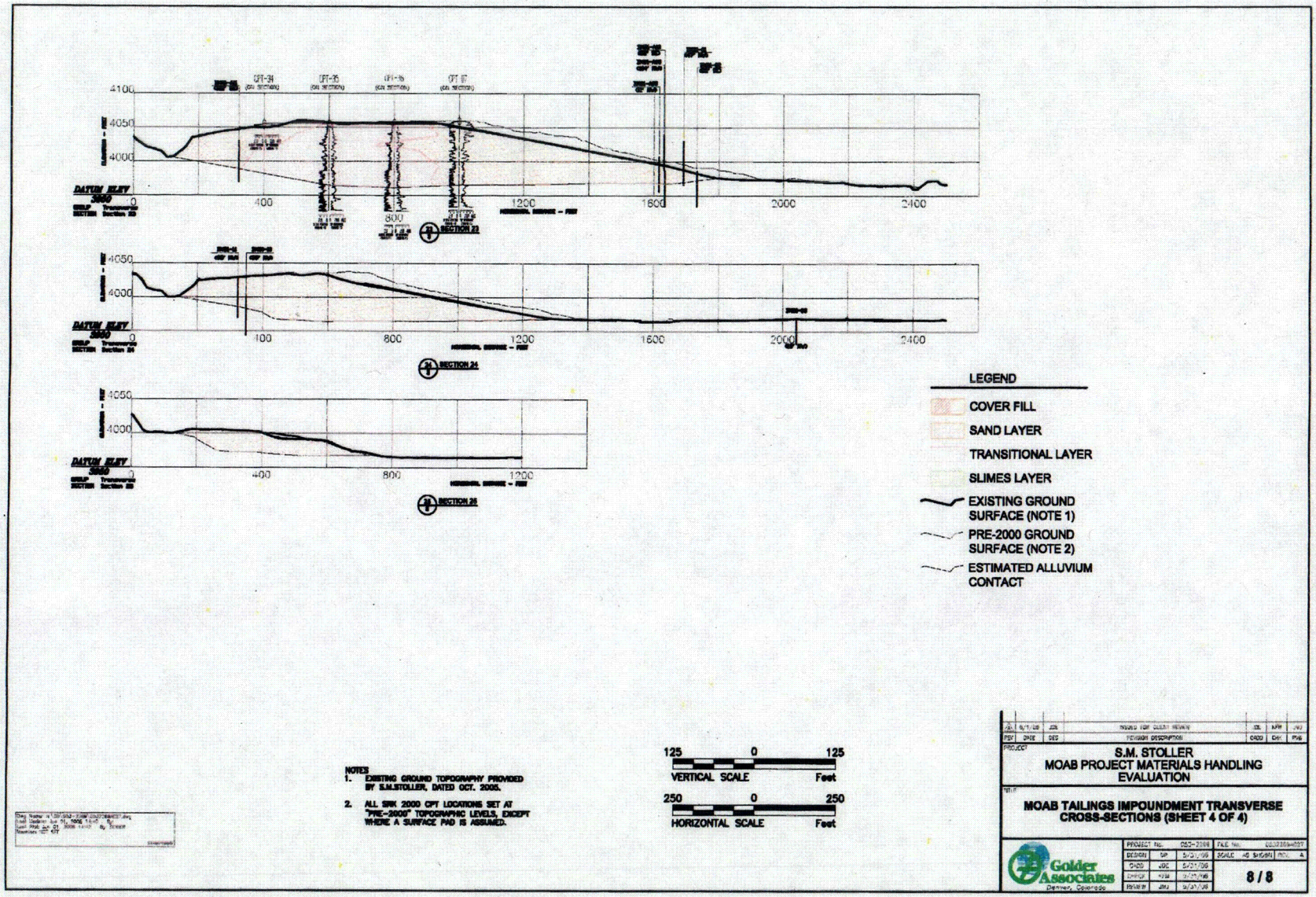

Figure 8. Moab Tailings Impoundment Transverse Cross Sections (Sheet 4 of 4)

C08

Conclusion and Recommendations:

- The total volume of tailings and cover soils requiring removal is approximately 10.3 to 10.4 million cy. This volume includes no allowance for excavation of contaminated alluvial soils at the base of the tailings pile.
- Volume estimates of the individual constituents were made by developing lateral and transverse cross-sections through the impoundment. The total volumes compare well for the two sets of calculations.

Computer Source:

Not applicable.

Contents

Appendix A Saturated Hydraulic Conductivity Determination of Weathered Mancos Shale

Appendix B Field Permeability "Bail" Testing

Appendix C Field Permeability "Packer" Testing

Appendix D Hydrologic Characterization – Ground Water Pumping Records

Appendix E Hydrologic Characterization – Vertical Travel Time to Uppermost (Dakota) Aquifer

U.S. Department of Energy—Grand Junction, Colorado

Calculation Cover Sheet

Calc. No.: MOA-02-05-2006-2-13-00 **Discipline: Hydrology** **No. of Sheets: 7**

Project: Moab UMTRA Project

Site: Crescent Junction Disposal Site

Feature:
Hydrologic Characterization – Vertical Travel Time to Uppermost (Dakota) Aquifer Calculation

Sources of Data:

- Published literature and maps within 30-mile radius of the Crescent Junction Disposal Site (see below).
- Water level elevation data for Mancos Shale from SEEPro database.

Sources of Formulae and References:

Bredehoeft, J. D., C.E. Neuzil, and P.C.D. Milly, 1983. *Regional Flow in the Dakota Aquifer: A Study of the Role of Confining Layers*, U.S. Geological Survey Water-Supply Paper 2237, 45 p.

DOE, 1991. *Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Site at Grand Junction, Colorado.* Appendix A to Attachment 3, Volumes 1 and 2. UMTRA-DOE/AL–050505.000.

Domenico, P.A., and F.W. Schwartz, 1990. *Physical and Chemical Hydrogeology*, John Wiley and Sons, New York, 824 p.

Freethey, G.W., and G.E. Cordy, 1991. *Geohydrology of Mesozoic Rocks in the Upper Colorado River Basin in Arizona, Colorado, New Mexico, Utah, and Wyoming, Excluding the San Juan Basin.* U. S. Geological Survey Professional Paper 1411-C, U.S. Government Printing Office, Washington, 117 p, 6 Plates.

Frenzel, P.F., and F.P. Lyford, 1982. *Estimates of Vertical Hydraulic Conductivity and Regional Ground-Water Flow Rates in Rocks of Jurassic and Cretaceous Age, San Juan Basin New Mexico and Colorado.* U.S. Geological Survey Water-Resources Investigations 82-4015.

Infill Companies, 2003. *Class V Landfill Application*, prepared for Green River Landfill, LLC, April.

Kimball, Briant, A., 2006. Personal Communication, U. S. Geological Survey, Salt Lake City office, April 11.

Nuclear Regulatory Commission (NRC), 1993. *Final Standard Review Plan for the Review and Remedial Action of Inactive Mill Tailings Sites under Title I of the Uranium Mill Railings Radiation Control Act, Revision 1*, 78 p., 4 Appendices.

Preliminary Calc. ☐ **Final Calc.** ☐ **Supersedes Calc. No.**

Author: [signature] 6-14-06
Name Date

Checked by: [signature] 6/14/06
Name Date

[signature] 6/14/06
Name Date

Dave Peterson 6/14/06
Name Date

[signature] 6/14/06
Name Date

Approved by: [signature] 6-14-06
Name Date

Problem Statement:

Preliminary site selection performed jointly by the U.S. Department of Energy (DOE) and the Contractor has identified a 2,300-acre withdrawal area in the Crescent Flat area just northeast of Crescent Junction, Utah, as a possible site for a final disposal cell for the Moab uranium mill tailings. The proposed disposal cell would cover approximately 300 acres. Based on the preliminary site-selection process, the suitability of the Crescent Junction Disposal Site is being evaluated from several technical aspects including geomorphic, geologic, hydrologic, seismic, geochemical, and geotechnical. The objective of this calculation set is to estimate the vertical travel time for ground water migrating from the Crescent Junction Disposal Site through the Mancos Shale confining unit to the Dakota aquifer.

Conclusions from these data will be incorporated into the Remedial Action Selection Report of the Remedial Action Plan (RAP) and Site Design for Stabilization of Moab Title I Uranium Mill Tailings at the Crescent Junction, Utah, Disposal Site.

Method of Solution:

The time required for ground water to migrate from the disposal site through the Mancos Shale to the Dakota aquifer is estimated in this calculation. Figure 1 presents a cross-sectional diagram showing the geologic profile that underlies the proposed Crescent Junction Disposal Cell. Each of the variables required to analytically assess vertical flow are shown in Figure 1. The average linear velocity, which stems from Darcy's Law, is used to estimate the downward rate of ground water movement. Key elements of the average linear velocity calculation are presented below:

$$V = q/n_e = (-K\, dh/dz)/n_e$$

where:

V = average linear velocity (L/T)
q = specific discharge (L^3/L^2T), or simply (L/T)
K = hydraulic conductivity (L/T)
dh/dz = vertical hydraulic gradient (L/L), or simply (dimensionless)
n_e = effective porosity (L^3/L^3), or simply (dimensionless)
where: L = length units and T = time units

Ground water levels were measured in coreholes 0201, 0202, 0203, 0204, 0205, 0208, and 0210 at the Crescent Junction Disposal Site. After the water-level data were gathered, they were entered into the SEEPro database and used to plot the ground water elevations presented in Figure 2. The measured ground water levels in the Mancos Shale, which are given the symbol h_1 in Figure 1, range in elevation from 4,650 to 4,920 feet (ft) above mean sea level. The hydraulic head value of 4,920 ft is used in the calculation because it yields the shortest travel time to the Dakota aquifer.

Ground water levels from the Dakota aquifer are presented in Figure 3, which was modified after Freethey and Cordy (1991). Potentiometric surface contours were extrapolated into the area of the site, which occupies the area 38.96° north by 109.80° west. As shown on Figure 3 the elevation of the potentiometric surface of the Dakota aquifer is approximately 4,700 ft above mean sea level. In Figure 1 the potentiometric surface of the Dakota aquifer is designated with the symbol h_2.

Geological data presented on page eight of Calc MOA-02-03-2006-1-01 in RAP Attachment 2 of this document shows that the vertical distance from the land surface to the top of the Dakota aquifer is approximately 2,400 ft. Because the minimum depth to water in the coreholes at the site is approximately 100 ft, the vertical flow path, which is designated by the letter ℓ, extends from the measured water surface in coreholes to the Dakota aquifer: a distance of approximately 2,300 ft. The time required for drainage to migrate from the bottom of the disposal cell to the first occurrence of ground water is neglected in this calculation.

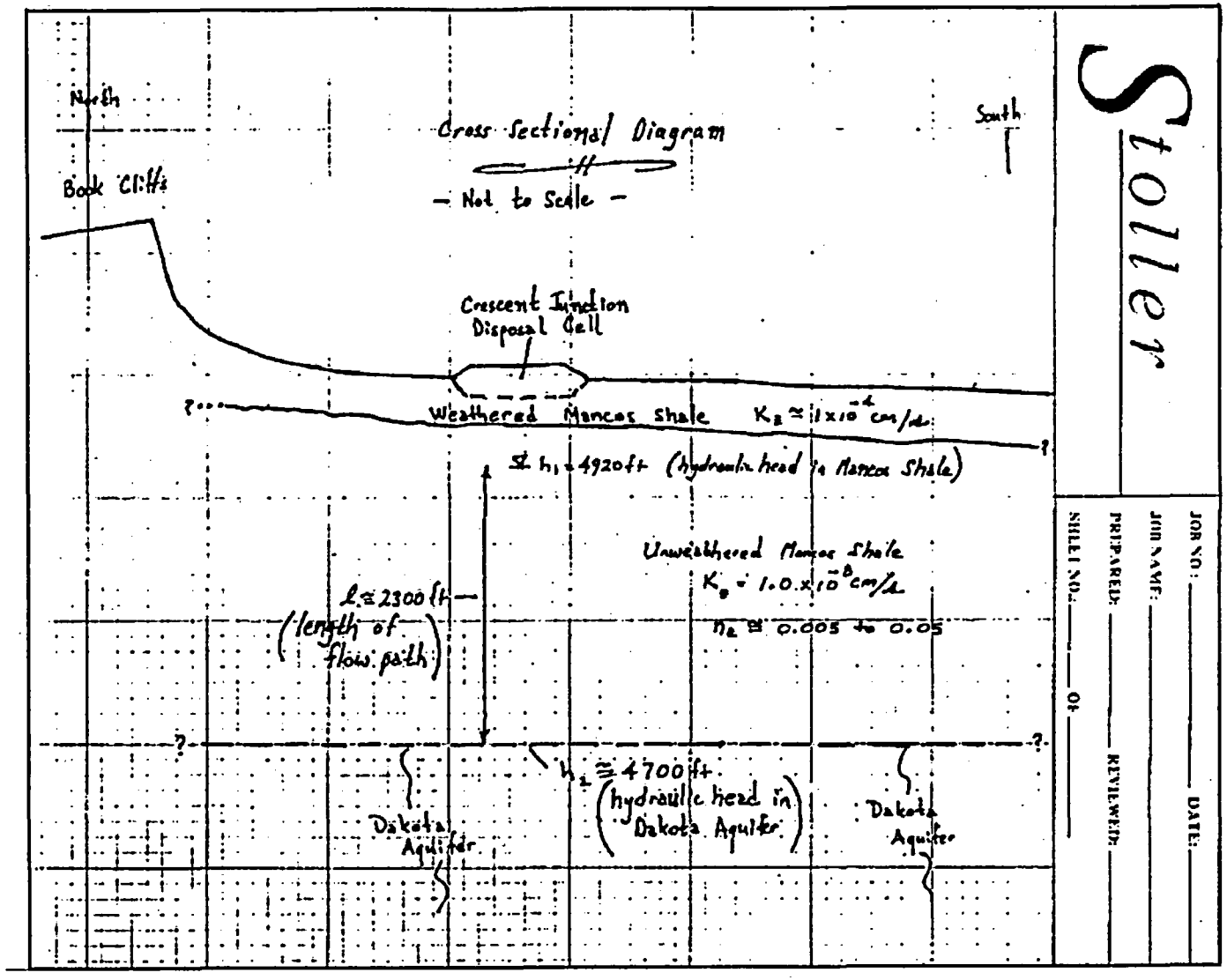

Figure 1. Schematic Cross Section through Crescent Junction, Utah, Disposal Cell

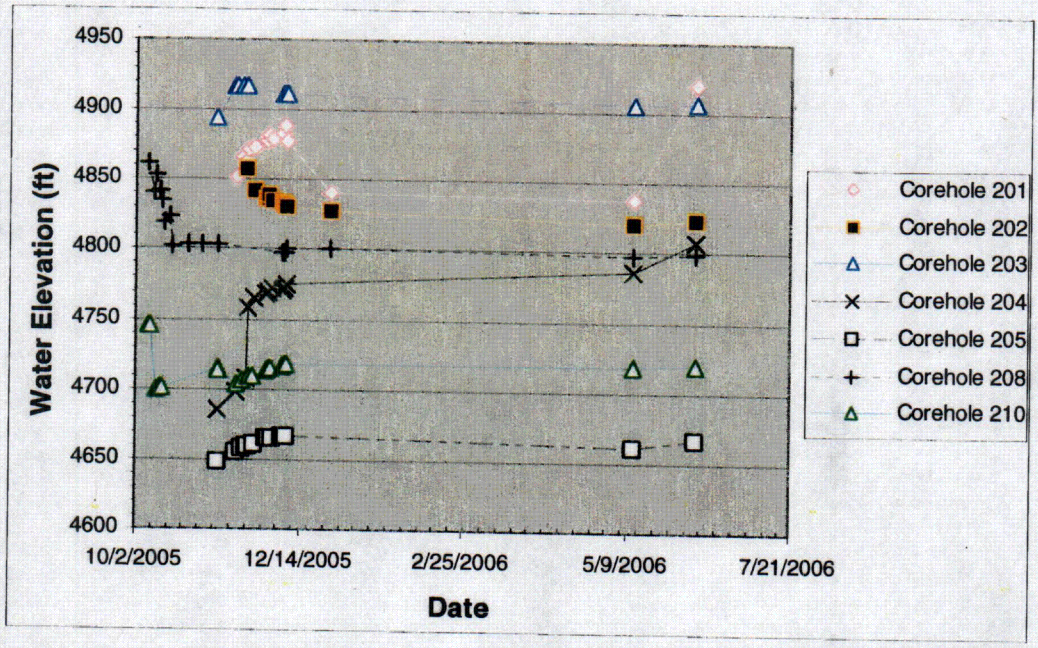

Figure 2. Ground Water Elevations Measured at Crescent Junction Disposal Site, Utah

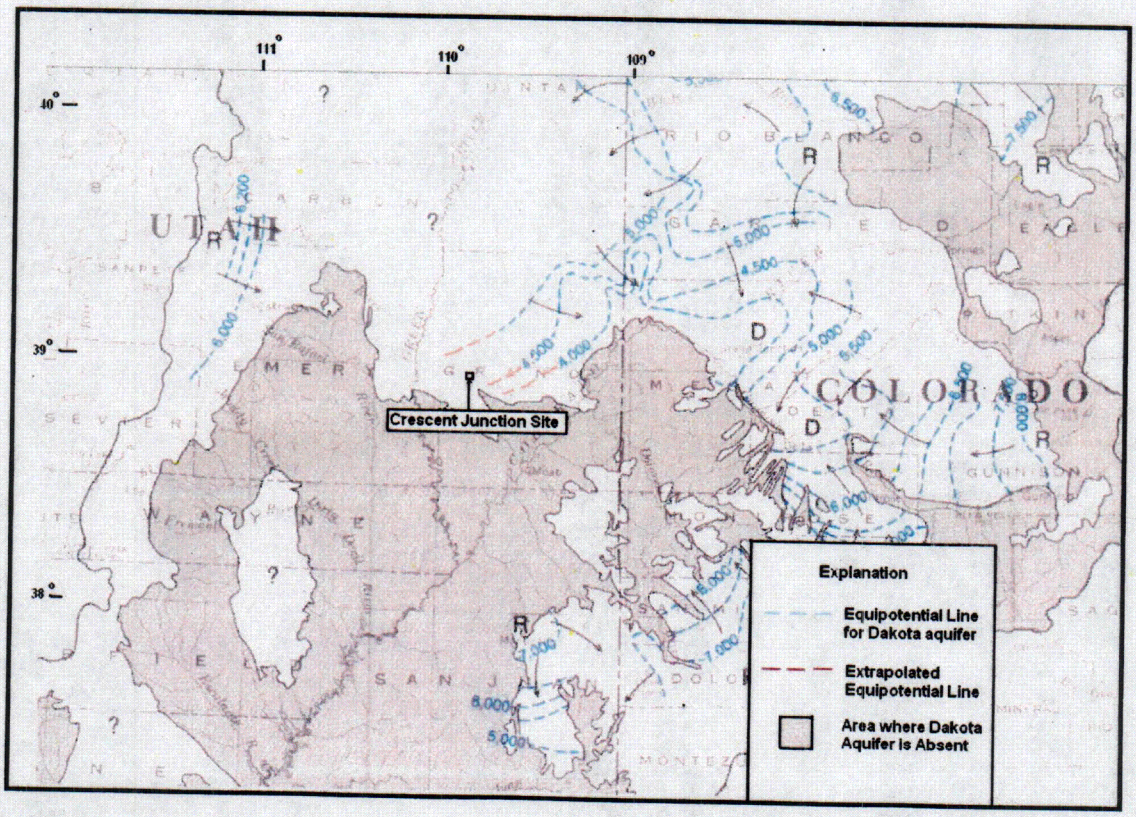

Figure 3. Map showing Generalized Potentiometric Surface and Extrapolated Potentiometric Surface into Crescent Junction Disposal Site (after Freethey and Cordy, 1991, Plate 5)

C09

Effective porosity of the Mancos Shale was not measured at the site during the investigation; consequently, it was estimated from literature values. The Nuclear Regulatory Commission (NRC) (1993, p. 46) suggests "an effective porosity of 10 percent is assumed conservative (represents the largest flow velocity), unless measured grain size and compaction information support a different value". Effective porosity values for shale are reported to range from 0.5 to 5 percent (Domenico and Schwartz 1990, p. 26). Because these latter values are more conservative than the 10 percent values suggested by NRC, the effective porosity in this calculation is given the range 0.5 to 5 percent.

Hydraulic conductivity measurements of discrete intervals in the unweathered Mancos Shale were made using dual-packer tests. Results from these tests are presented in Table 1. The hydraulic-conductivity data set is insufficient to ascertain its frequency distribution; however, the results are assumed to lie within a log normal distribution because randomly sampled hydraulic conductivity values typically fit a log normal distribution (Domenico and Schwartz 1990, p. 26). Also according to Domenico and Schwartz (1990, p. 66), the "average" value of hydraulic conductivity is represented by the geometric mean. The calculated geometric mean of the hydraulic conductivity data in Table 1 is 2.4×10^{-8}cm/s.

Table 1. Summary of Field-Permeability "Packer" Test Results for the Crescent Junction Site

Hole ID @ Depth Interval (ft)	Calculated Permeability[1] (cm/s)				
	Test 1	Test 2	Test 3	Test 4	Test 5
Dual-Packer Tests:					
0204 @ 80 to 92	J 1.3×10^{-8}	3.9×10^{-7}	J 9.6×10^{-9}	6.6×10^{-7}	J 1.3×10^{-8}
0204 @ 110 to 122	J 7.5×10^{-9}	9.1×10^{-8}	4.2×10^{-7}	J 9.1×10^{-8}	J 7.5×10^{-9}
0204 @ 283 to 295	J 8.9×10^{-9}	1.2×10^{-6}	2.6×10^{-6}	J 1.1×10^{-8}	J 1.2×10^{-8}
0208 @ 90 to 102	J 6.0×10^{-9}	J 7.7×10^{-9}	J 2.2×10^{-9}	J 7.7×10^{-9}	J 6.0×10^{-9}
0208 @ 121 to 133	J 8.0×10^{-9}	J 1.4×10^{-8}	7.5×10^{-7}	J 1.4×10^{-8}	J 8.0×10^{-9}
0208 @ 282 to 294	6.3×10^{-7}	6.0×10^{-7}	J 6.0×10^{-9}	J 5.7×10^{-9}	2.1×10^{-7}

[1]J flag indicates a *no-flow* packer test in which a maximum hydraulic conductivity is calculated, based on duration of test (see Packer-test Calculation [RAP Attachment 3] for details).

Assumptions:

- Literature sources are reliable and representative of consensus of opinion.
- Hydraulic conductivity is a log normally distributed function.
- The actual value of effective porosity is within the range 0.005 to 0.05.
- Extrapolated value of hydraulic head for Dakota aquifer is accurate.
- Hydraulic head measurements obtained from the Mancos Shale represent perched, connate ground water without any connection to the Dakota aquifer.

Calculation:

Calculate specific discharge using Darcy's Law and the input values described above.

Specific Discharge Calculation

Calculate specific discharge using hydraulic-head value of 4,920 ft in Mancos Shale:

$$q = -K\, dh/dz = -(2.4 \times 10^{-8}\ \text{cm/sec}) \times (4{,}920\ \text{ft} - 4{,}700\ \text{ft})/(2{,}300\ \text{ft})$$

$$q = -2.30 \times 10^{-9}\ \text{cm/sec (downward flow)}$$

Average Linear Velocity Calculation

Calculate average linear velocity using the downward specific discharge value and the values 0.005 and 0.05 for effective porosity:

Using $n_e = 0.005$:

$$V = q/n_e = (-2.30 \times 10^{-9}\ \text{cm/sec})/(0.005) = 4.59 \times 10^{-7}\ \text{cm/sec}$$

Using $n_e = 0.05$:

$$V = q/n_e = (-2.30 \times 10^{-9}\ \text{cm/sec})/(0.05) = 4.59 \times 10^{-8}\ \text{cm/sec}$$

Travel Time Calculation

Calculate travel time using the above-calculated velocities:

Distance = rate × time; therefore, Time (t) = (distance)/(rate)

Travel time calculated based on velocity from $n_e = 0.005$:

$$\text{Time} = (2{,}300\ \text{ft})/(4.59 \times 10^{-7}\ \text{cm/sec})\ \frac{(1.03 \times 10^{6}\ \text{ft/yr})}{(\text{cm/sec})} = 4{,}860\ \text{yr}$$

Travel time calculated based on velocity from $n_e = 0.05$:

$$\text{Time} = (2{,}300\ \text{ft})/(4.59 \times 10^{-8}\ \text{cm/sec})\ \frac{(1.03 \times 10^{6}\ \text{ft/yr})}{(\text{cm/sec})} = 48{,}600\ \text{yr}$$

Discussion:

The travel time developed in this calculation for ground water to migrate from the Disposal Site through the Mancos Shale to the Dakota aquifer ranges from 4,860 to 48, 600 years. An order-of-magnitude estimate seems appropriate for this calculation because uncertainties associated with three variables could have a strong effect on the outcome, namely: (1) the hydraulic gradient between the Mancos Shale and the Dakota aquifer, (2) the geometric mean hydraulic conductivity, and (3) the effective porosity. These variables are discussed briefly below.

(1) Hydraulic Gradient Between Mancos Shale and Dakota Aquifer

Ground water levels from the Dakota aquifer are presented in Figure 3, which was modified after Freethey and Cordy (1991). Potentiometric surface contours were extrapolated into the area of the site. As shown on Figure 3 the elevation of the potentiometric surface of the Dakota aquifer is approximately 4,700 ft above mean sea level. The maximum hydraulic head of 4,920 ft was measured at corehole 0201 (Figure 2) and the minimum hydraulic head of 4,648 ft was measured at corehole 0205. Because the elevation of the extrapolated potentiometric surface of the Dakota aquifer is within the range of the measured heads in the Mancos Shale, there is some basis to suspect that the Mancos heads are

expressing the potentiometric surface of the underlying Dakota aquifer. If this were the case, then the vertical hydraulic gradient across the Mancos Shale would be effectively zero, and no potential would exist for vertical flow between the unstressed Mancos Shale system and the Dakota aquifer. Therefore, the estimated vertical travel times of 4,860 to 48,600 years are conservative.

(2) Geometric Mean Hydraulic Conductivity

Site-specific packer tests in selected coreholes were used to arrive at a population of measured hydraulic conductivity values for the Mancos Shale. The sample population was then used to develop an estimate of the geometric-mean hydraulic conductivity for the layers comprising the Mancos Shale. Measured values of hydraulic conductivity in the Mancos Shale at the Crescent Junction Disposal Site are similar to the measured values of hydraulic conductivity in the Mancos Shale at the Grand Junction Disposal Site (DOE 1991, Calculations GRJ–08–89–14–01, Sheet 9; GRJ–12–89–12–06–00b, Sheet 52/58) and to those reported for the Mancos Shale near Green River Landfill site (Infill Companies, April 2003, pg. 17).

Vertical hydraulic conductivity values presented in Table 1 are strongly biased toward the high end of the potential range because 20 of the packer tests resulted in no-flow conditions. If more precise measurements were made of the hydraulic conductivity the true hydraulic conductivity values would lower the calculated geometric mean hydraulic conductivity. In more-precise studies made by the U.S. Geological Survey of the Mancos Shale and its equivalent the Pierre Shale, the vertical hydraulic conductivity ranged from 1.0×10^{-8} to 1.9×10^{-12} cm/s (Frenzel and Lyford, 1982, p. 17 and 30–31; Bredehoeft and others, 1983, p. 28–29). Based on these literature results, the true geometric mean hydraulic conductivity at the Crescent Junction Site could be 0.5 to 2 orders of magnitude lower than the one used in this calculation. Recomputing the travel time calculation with the lower mean hydraulic conductivities would yield a travel time ranging from 23,500 years to 11,750,000 years. Therefore, a hydraulic conductivity value of 2.3×10^{-8} cm/sec yields a conservative (minimum) range of travel times.

(3) Effective Porosity

Using the conservatively low literature-derived values of 0.005 to 0.05 for effective porosity also leads to a conservative approximation of travel time. Effective porosity values vary over a relatively limited range and consequently have less effect on potential error propagation. The minimum literature value for an effective porosity value of 0.005 would embody a reasonable measure of conservatism.

Conclusion and Recommendations:

Hydraulic head measurements obtained from the Mancos Shale represent perched, connate ground water without any connection to the Dakota aquifer. The absolute age of the connate ground water has not been determined for the Crescent Junction Site; however, Briant Kimball (personal communication, April 11, 2006) states, "any brine in Mancos would be older than the ages that could be determined by carbon-14". This would signify that the age of the brine is at a minimum Late Pleistocene, which provides a credible basis to the notion that the vertical travel times calculated herein are a conservative estimate.

With the vertical travel time between the Mancos Shale and the Dakota aquifer estimated to range from 4,860 to 48,600 years, the construction of the Crescent Junction Disposal Cell would pose no adverse impact on ground water resources in the area.

Computer Source:

Not applicable.

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