Bergen Ditch and Reservoir Company
Loan Feasibility Study

Prepared for:

Colorado Water Conservation Board
Water Project Loan Program
August 2012

Project:

Rehabilitation of Bergen Reservoir No. 2
and Minor Improvements to Other Bergen Facilities
Located near C-470 and Belleview
Jefferson County, Colorado

FEASIBILITY STUDY APPROVAL
Pursuant to Colorado Revised Statutes 37-60-121 &122, and in accordance with policies adopted by the Board, the CWCB staff has determined this Feasibility Study meets all applicable requirements for approval.

Signed — Date: 11-13-2012

Prepared by:

Robert Easton, Manager
Bergen Ditch and Reservoir Company

James Ferentchak, P.E.
W. W. Wheeler and Associates
Water Resources Engineers

COLORADO WATER CONSERVATION BOARD
WATER PROJECT LOAN APPLICATION

Instructions: This application should be typed or printed neatly with black ink. Attach additional sheets as necessary to fully answer any question or to provide additional information that would be helpful in the evaluation of this application. When finished, please sign and return this application to:

THE COLORADO WATER CONSERVATION BOARD
Finance Section
1580 Logan St., Suite 600
Denver, CO 80203
Attn: Anna Mauss, P.E.
Phone: (303) 866-3441 x3224 Fax (303) 894-2578
Email:

Part A. - Description of the Applicant (Generally, the applicant is also the prospective owner and sponsor of the proposed project)

1. Name of applicant Bergen Ditch and Reservoir Company

   Mailing Address 9329 Lark Sparrow Trail
   Highlands Ranch, CO 80126

   Business Phone (303-470-0774 Fax (____)

   Federal ID Number_____ email reaston829@comcast.net

2. Person to contact regarding this application:

   Name Robert Easton

   Position/Title Manager

   Address 9329 Lark Sparrow Trail, Highlands Ranch, CO 80126

   Business Phone (303-470-0774 Cell (____)

   Email reaston829@comcast.net

3. Type of organization (Ditch Co., Irrigation District, Municipality, etc.): Ditch Company

   Date of Annual Meeting First Tuesday in January

   Is the organization incorporated in the State of Colorado? YES ☑ NO ☐ (If YES, please include a copy of the articles of incorporation, and the bylaws)

4. Please provide a brief description of the owner's existing water supply facilities and describe any existing operational or maintenance problems. Attach a map of the service area

System of ditches and reservoirs diverting and storing water from Turkey Creek in Jefferson County. Facilities include diverson structure, several miles of open and piped ditches and three large storage reservoirs. Reservoirs are located in the vicinity of Bowles ave, Belleview, and C-470 in east/central Jefferson County. Area map and facilities map included in attached feasibility analysis.

For existing facilities indicate:

Number of shareholders 17 or Number of customers served _____

Current Assessment per share $ 450/yr Number of shares 403.5

Number of acres irrigated approximately 140 Water Right: various CFS.

Average water diverted per year: 700-800/yr acre-feet.

Part B. - Description of the Project

1. Name of the Project Replacement of outlet works and rehabilitation of Bergen Reservoir #2

2. Purpose of this loan application. Check one.

- [ ] New project
- [x] Rehabilitation or replacement of existing facility
- [ ] Enlargement of existing facility
- [ ] Emergency Repair
- [ ] Other (describe) _____

3. If the project is for rehabilitation of an existing reservoir, is the reservoir currently under a storage restriction order from the State Engineer? YES [ ] NO [x]

4. General location of the project. (Please include county, and approximate distance and direction from nearest town, as well as legal description, if known.

Belleview and C-470 in south Jefferson County. Located on the border between Town of Morrison (north) and City of Lakewood (east). See map and further location information in attached feasibility analysis.

5. Please provide a brief narrative description of the proposed project including purpose, need, facilities, type of water uses to be served and service area. Attach separate sheet, if needed.

Bergen Reservoir #2 was built in the late 1800's. Recent year SEO inspections have resulted in directives to replace the antiquated dam outlet works, reinforce the dam and replace the toe drains. This project will complete all of those items thereby meeting SEO requirements and decreasing liability exposure, while preserving storage capability for water users. See additional information in Feasibility Analysis

6. Will the acquisition of additional water rights be necessary? YES [ ] NO [x]

If YES, please explain. _____

7. Please list the names, addresses and phone numbers of the Applicants' engineer(s) and attorney(s).

NAME	ADDRESS and PHONE
Jim Ferentchak	WW Wheeler and Associates 3700 S. Inca Englewood, CO 80110
	303-761-4130
Julia Robinson	75 Manhattan Dr. Suite 201 Boulder, CO 80303 303-442-6036

8. List any feasibility studies or other investigations that have been completed or are now in progress for the proposed project. If so, submit one copy of the study with this application
   BasePoint Design Report (attached)
   Kumar Report/Feasibility Study (attached)

9. Estimated cost of the project. Please include estimated engineering costs, and estimated construction costs, if known.

Estimated Engineering Costs:$	$129,105	
Estimated Construction Costs:	$1,904,296	
Estimated Other Costs:	$161,381 (construction mgmt)	(land, water rights purchase,etc.)
Estimated Total Costs:	$2,194,780	

10. Loan amount and terms you are requesting.

Requested Loan Amount:	$2,000,000	(Usually 90 % of est. Total Costs)
Term (length) of loan:	30 years	(Usually 10, 20, or 30 years)
Interest Rate:	3.15 %	(Please call for our current rates)

Part C. - Project Sponsor Financial Information

Because the CWCB's Fund is a revolving fund, it is important that the project sponsor have the financial capacity to repay any loans made by the CWCB. The following information is needed to assist the CWCB in a preliminary assessment of the applicant's financial capacity. The project sponsor will submit the three most recent annual financial statements.

1. List any existing long-term liability (multi-year) or indebtedness that exceeds one thousand dollars. For example, bank loans, government agency loans, bond issues, accounts payable, etc. Include names and addresses of lenders, amounts, due dates and maturity dates.

Lender Name & Address	Remaining Amount	Annual Payment	Maturity Date
none			

2. Are any of the above liabilities now in default, or been in default at any time in the past? YES ☐ NO ☑. If YES, please give detailed explanation.

3. Please provide a brief narrative description of sources of funding, in addition to the CWCB, which have been explored for this project (Examples would be Banks, USDA Rural Development, NRCS, Colorado Water Resources and Power Development Authority, Colorado Division of Local Government, etc.). Bank Funding, GOCO/Lottery Funds, Division of Local Government

4. What collateral will you be offering for this loan? Possibilities include a pledge of revenues, the project itself, real estate, water rights. Pledge of revenues from annual assessments

The above statements are true, to the best of my knowledge:

Signature of Applicant Robert A. Easton

Printed Name Robert A. Easton

Title Manager

Date 8/23/2012

Bergen Ditch and Reservoir Company
Contact List --Updated January 2012

Name and Address	Phone	E-mail
Stanton La Breche (President) c/o Jefferson County Open Space 700 Jefferson County Parkway, Suite 100 Golden, CO 80401	303-271-5925	slabrech@jeffco.us
Steve Persichetti (Vice President) P O Box 279 Morrison, CO 80465	303-859-4546	crashsplash@hotmail.com
Colin Insley, (Secretary/Treasurer) c/o Foothills Park and Recreation District 6612 S. Ward Street Littleton, CO 80127	303-409-2304 303-409-2140 (fax) 303-598-5367 (cell)	insley@fhprd.org
Robert Easton, (Manager) 9329 Lark Sparrow Trail Highlands Ranch, CO 80126	303-470-0774	reaston829@comcast.net
Scott Sauvageau Reservoir Management Company 12299 Mead Way, Unit "C" Littleton, CO 80125-1712	303-683-0521 (office) 303-520-0876 (cell) 303-683-0572 (fax)	scott.sauvageau@gmail.com
Julia Robinson (Attorney) 4430 Arapahoe Ave. Suite 155 Boulder, CO 80303 Tracey Giddens, Legal Asst/Office Manager	303-442-6036 303-440-7972 (fax)	julia@jorpc.com tgiddens@jorpc
Jim Ferentchak W. W. Wheeler & Associates 3700 S. Inca St. Englewood, CO 80110	303-761-4130 303-761-2802 (fax)	jim.ferentchak@wwwheeler.com

BERGEN DITCH AND RESERVOIR COMPANY
LIST OF STOCKHOLDERS
10/14/12
TOTAL SHARES = 403.50

Cert. No.	Date	No. of Shares	Name	Address	Phone
*519	03/21/90	1.00	BAUMAN, Jared L. (Jared's Nursery)	10500 W. Bowles Ave. Littleton, CO 80127	303-979-6022
*528	04/26/94	78.50	FOOTHILLS PARK &	6612 S. Ward Street	303-409-2100
*532		1.00	RECREATION DISTRICT	Littleton, CO 80127	
542	04/23/97	11.00		Attn: Colin Insley, Secretary	
546	08/28/01	2.50			
*549	11/03/03	2.00			
548	11/19/04	1.00			
	05/09/05	96.00			
*418	09/23/77	1.00	Coors, Andrew	15100 W. Belleview Ave.	
*520	02/08/91	4.00		Morrison, CO 80465	
*527	12/14/93	3.00			
*529	03/07/95	2.00			
		10.00			
554	10/14/11	15.00	Greenshire LLC	c/o Michael SaBell, Manager 1180 S. Union Blvd. Lakewood, CO 80228	303-994-5629
463	01/05/82	2.00	INDIAN HILLS WATER DISTRICT	Attn: Diane Hunter P. O. Box 710 Indian Hills, CO 80454	303-697-8810
*525	07/28/93	14.00	JEFFERSON COUNTY	700 Jefferson County Pkwy	303-271-5980
*526	07/28/93	130.00		Suite 100, Golden, CO 80401 Attn: Stanton La Breche	
			JEFFERSON COUNTY		
427	03/08/78	100.00	(Leased to FHPRD)	Foothills Park & Recreation	
		244.00		(address shown above)	

Note: The 100 shares owned by Jefferson County (represented by Certificate No. 427) have been leased to Foothills under a lease dated March 23, 1981, for a term of 100 years. A copy of that lease is attached to the minutes of the Company's annual meeting of December 2, 1981. Under that lease, Foothills has the authority to vote those shares and to pay the assessment. A copy of any notices sent to Foothills as lessee of the shares should also be sent to Jefferson County.

*437	04/20/79	5.00	KEN-CARYL WEST RANCH	One West Ranch Trail	303-697-8461
*438	04/20/79	4.00	WATER DISTRICT	Morrison, CO 80465	
*439	04/20/79	3.50		Attn: Kelly Reiman	Kelly Wk.
		12.50			303-741-1111

Cert. No.	Date	No. of Shares	Name	Address	Phone
465	02/16/82	1.00	KEYES, Paul L. & Sally R., in Joint Tenancy	5941 Gulf of Mexico Drive Longboat Key, FL 34228	941-383-7371
*552	06/23/09	0.50	LIM, Edwin S. and MARSHALL, Linda C, JTWROS	13900 W. Belleview Ave. Morrison, CO 80465	
*545	02/21/03	0.50	NILES, Richard G. & Susan in Joint Tenancy	13800 W. Belleview Ave. Morrison, CO 80465-1500	303-422-2899
536	12/15/97	1.00	PERSICHETTI, Steve	P.O. Box 279 Morrison, CO 80465	303-986-7282
537	12/15/97	1.00	RANGEL, Cruz	840 W. 11th Ave. Denver, CO 80204	303-623-7875
*535	10/13/97	7.5	RICKARD, Jr., Marion Jack	14 Morgan Oak Street Cape Girardeau, MO 63703	573-576-7614
*394 *403 *434 *484	07/20/72 02/26/75 01/05/79 10/12/83	2.00 2.00 1.00 1.00 6.00	SEBALD, J. Albert & Constance D., in Joint Tenancy	5423A Coyote Canyon Way Morrison, CO 80465	303-697-4180 Work: 303-861-5300
*553	03/01/2010	1.00	SEBALD, Dwight L. & Linda H., JTWROS	14130 W. Belleview Ave. Morrison, CO 80465	
550	06/23/09	1.00	SMITH, Norman E.	2346 W. Main St. Littleton, CO 80120	Work: 303-798-2200
551	06/23/09	1.00	SMITH, Norman G.and SMITH, Calvin G., JTWROS	PO Box 18400 Denver, CO 80218 ***(Note: still no letter to confirm who will keep original)***	Home-Calvin: 303-322-6681 Cell-Calvin: 626-485-3645

Cert No.	Date	No. of Shares	Name	Address	Phone
539	11/2/00	0.50	STAFFORD, Gerald R	16079 W. Belleview Ave. Morrison, CO 80465	303-697-4911
467	06/18/82	2.00	D.F. WINGERT & CO. 5353 W. Dartmouth, #502 Denver, CO 80227	c/o Dwayne Wingert 14724 W. Belleview Ave. Morrison, CO 80465	303-697-4396 Work: 303-980-6815

TOTAL SHARES 403.50

* The certificate numbers with an asterisk before them do not include the ownership of any interest in the Bergen Reservoir Nos. 4, 5 and 6 water rights.

Bergen Ditch and Reservoir Company
Board of Directors

Stanton La Breche – President

Steve Persichetti – Vice-President

Colin Insley – Secretary/Treasurer

Staff and Consultants

Robert Easton, Manager

Reservoir Management Services, Scott Savageau

Engineering Services:
W. W. Wheeler and Associates, James Ferentchak, P.E.
Kumar and Associates, Greg Monley, P.E.

Legal Counsel, Julia O. Robinson

BERGEN DITCH AND RESERVOIR COMPANY
9329 Lark Sparrow Trail, Highlands Ranch, CO 80126 303-470-0774

August 23, 2012

Colorado Water Conservation Board, Finance Section
Water Project Loan Program
1580 Logan St, Suite 600
Denver, CO 80203

Attn: Anna Mauss, P.E.

Dear Ms. Mauss,

In recent years inspections performed by the State Engineer's Office (SEO) have indicated a need for improvements and rehabilitation of Bergen Reservoir No. 2 Dam owned by the Bergen Ditch and Reservoir Company (Bergen). Bergen has completed several studies and sub-surface investigations regarding Bergen No. 2 and in October of 2011 we received a comprehensive report from our geotechnical consultants, Kumar and Associates, recommending several reservoir improvements to address SEO concerns.

The Bergen Board of Directors met on December 7, 2011 and by unanimous vote approved application to CWCB for a loan to finance the needed improvements and further authorized me, as Manager for Bergen, to prepare the required application and Loan Feasibility Study.

Enclosed please find our Loan Feasibility Study, a completed application form and supporting documents requesting $2,000,000 to complete the rehabilitation of Bergen Reservoir No. 2 and perform improvements on other Bergen facilities. Our submittal follows the guidelines you have published on your website, and we trust you will find our application and other documents are in order. We appreciate the assistance provided by Anna Mauss of your staff and we are prepared to answer any questions or provide additional information as needed.

We would appreciate review and approval of our loan request within your next available funding cycle, and we look forward to working with you on this project.

Sincerely,

Robert A. Easton

Robert A. Easton, Manager
Bergen Ditch and Reservoir Company

c: Bergen Board of Directors
Jim Ferentchak, W. W. Wheeler and Assoc.
Julia Robinson, Attorney for Bergen

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Loan Feasibility Study
Rehabilitation of Bergen Reservoir No. 2

Introduction and Background

The Bergen Ditch and Reservoir Company (Bergen) diverts water from Turkey Creek in central Jefferson County to provide irrigation for agricultural use and irrigation at public recreation facilities. Bergen is requesting $2,000,000 in funding from the Colorado Water Conservation Board (CWCB) Loan Program for the needed rehabilitation of Bergen Reservoir No. 2 Dam.

The proposed project would replace the outlet works structures and rebuild the existing embankment dam located near C-470 and Belleview in Jefferson County. This reservoir holds approximately 40 percent of current Bergen storage capacity and is critical to the current and future operation of the Company.

As a part of the project funding request, Bergen is also proposing to perform minor repairs to its main diversion structure on Turkey Creek, minor repairs to the middle dike separating Bergen No. 1 Reservoir from Bergen No. 2 Reservoir, and installing a sand separator structure, if sufficient funds are available following the No.2 Dam reconstruction work.

Purpose

This project is necessary because recent Colorado State Engineer's Office (SEO) reports have identified a need for rehabilitation of the Bergen No.2 Dam, with comments indicating seepage, slope stability and safety concerns that will likely result in storage restrictions being imposed if improvements are not made. A subsequent feasibility study by Kumar and Associates indicates a need to correct problems with erosion, seepage, slope stability and the outlet works. The subject reservoir, Bergen No. 2 was constructed in 1876, and after over 130 years is in need of significant rehabilitation. The project is important to Bergen to reduce potential liability, maximize the safety and storage capacity of our reservoirs, and to continue to provide required long-term irrigation water service to our shareholders.

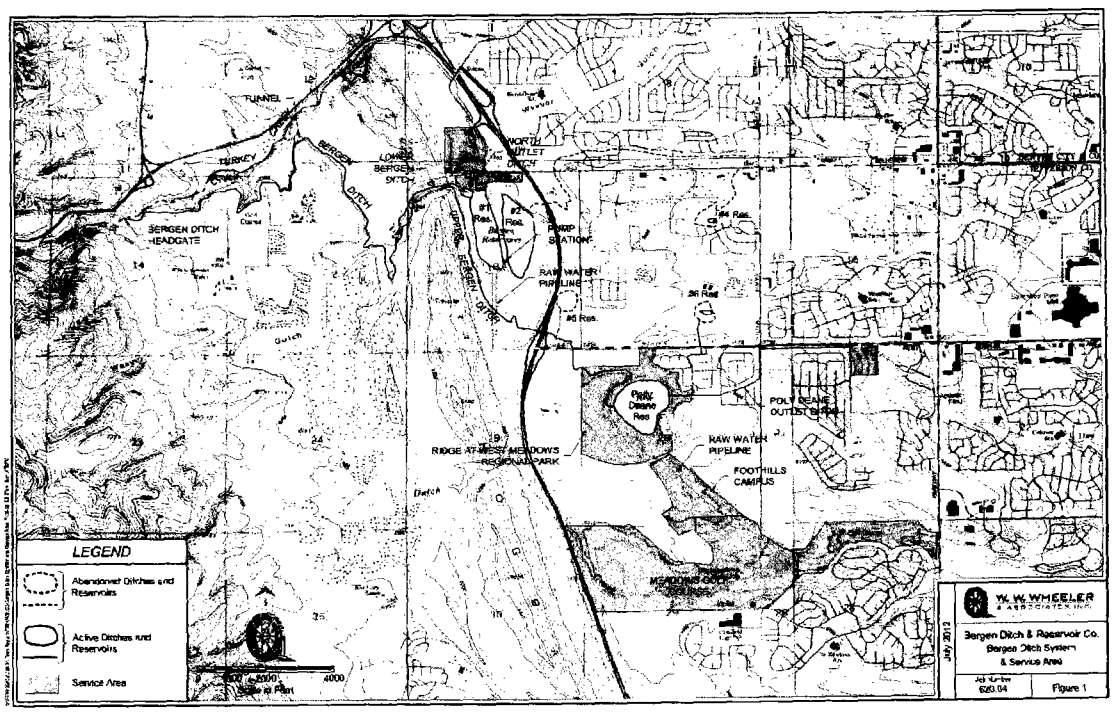
Study Area Description

The proposed project is located in central Jefferson County, near C-470 and West Belleview Avenue. Bergen, through its existing direct flow and storage rights, diverts water from Turkey Creek, a tributary of Bear Creek, by use of a head gate located near the mouth of Turkey Creek Canyon. Water is transported by a ditch system to

three main storage reservoirs east and south of the diversion point. The upper Bergen Ditch transports water to Polly Deane Reservoir (a.k.a. Hine Lake and Deane Reservoir) located at Ward Road and Coal Mine Ave.; and the lower Bergen Ditch transports water to Bergen Reservoirs No. 1 and No. 2, located east of the Hogback and just south of Belleview Ave. The easternmost of these 2 reservoirs, Bergen No. 2, is the subject of this project and loan application. Refer to Figure No. 1 for a map of the Bergen facilities locations.

The Bergen system has historically provided irrigation water to a number of agricultural users in the general service area bounded by the foothills on the west, Bear Creek on the North, Dutch Creek on the South and Wadsworth Blvd. on the east, all in central Jefferson County, (refer to the Bergen Ditch System and Service Area map, Figure No. 1). Due to the urbanization of this area since the 1960s there is little agricultural land remaining and the primary use of the water is now by public agencies for park and golf course turf irrigation, along with a number of smaller shareholders using water for landscape improvements on local residential and commercial developed properties.

Figure No. 1



The basic function of current facilities is to divert water from Turkey Creek, deliver the water through a series of open and piped ditches to storage reservoirs (Bergen No. 1, Bergen No. 2, and Polly Deane Reservoirs) and then deliver water from those

storage reservoirs to users through pumps, ditches and underground piping systems maintained by users.

General Socio-economic data for Jefferson County:
Population: 537,000
Median Age: 39 years old
Median Household Size: 2.5 persons
Median Home Value: $262,700
Median Household Income: $66,000

Bergen Reservoir No. 2 was originally constructed in about 1874, and the original dam crest was raised 10 feet in 1915. This dam has a long history of slumping of the embankment slopes (both upstream and downstream), and seepage problems. Specifically, cracking of the upstream slope had been reported east of the outlet works. The embankment and drains were repaired in 1925, 1943, 1947-1949. There have been no major structural modifications since 1949 until the overflow spillway was rebuilt in 1999 in order to meet SEO guidelines. In about 2007 the No. 2 Dam's outlet operator was damaged and failed, and was repaired in early 2009; the repair did not include replacement of the valve or any piping. A slope stability analysis of the dam embankment was conducted in 1984 and again in 1998. Ongoing SEO inspection reports have identified issues regarding seepage, stability, slope erosion, and poorly functioning outlet works. SEO has verbally recommended Bergen consider rehabilitation of the dam or face possible storage restrictions. The 2011 SEO inspection report for Bergen No. 2 Dam is attached in Appendix A.

Previous Studies

Attached to this application are two recently completed studies; the first identifying critical capital repairs needed within the entire Bergen system and establishing Bergen No. 2 rehabilitation as a priority, and the second further identifying specific solutions to repairs needed for Bergen Reservoir No. 2. Those two studies are:

1. Dam Safety Review – March 2008 Report, completed by BasePoint Design. This report recommends attention to several unsatisfactory items regarding the entire Bergen system and certain priority items specific to Bergen No. 2 including seepage, stability, upstream slope erosion protection, and replacement of outlet works. This report is included in Appendix B.
2. Geotechnical Engineering Study and Feasibility Level Design Proposed Modifications to Bergen Dam No. 2 – October 2011 Report, completed by Kumar and Associates. This report provides specific design recommendations, preliminary design drawings and cost estimates for various

modifications to the Bergen No. 2 Dam, and a supplemental report prepared by W. W. Wheeler and Associates provides preliminary design work and cost estimates for the replacement of the reservoir outlet works. This report and supplement are included in Appendix C. This study, recommended improvements, and cost estimate are submitted in support of the selected alternative for this project.

3. Cost estimates provided within these studies have since been updated, and the current cost estimate for proposed improvements is contained in this application in Table No. 5.

Project Sponsor - Applicant Agency

The Bergen Ditch and Reservoir Company is a Mutual Ditch Company formed under Colorado Statutes in 1874 for the purpose of using acquired direct flow and storage rights to provide irrigation water for agricultural use in a portion of central Jefferson County, Colorado. The Articles of Incorporation are attached in Appendix D. The company currently operates and maintains a system of diversion structures, ditches, dams and reservoirs providing water to 15 different shareholders owning the 403.5 shares of common stock in the company.

The company is controlled by a Board of Directors elected by shareholders at an annual meeting. Daily operations and water delivery are handled through an annual maintenance contract with Reservoir Management Company, and management/financial issues are handled by a part time ditch company manager. Powers of the Board and staff are defined in the Bergen By-Laws (attached in Appendix E) and Board authority includes the authority to enter into contracts for reservoir improvements and expansion.

Up until the 1960s the primary use of Bergen water was for agricultural purposes on lands within the study area described above. The vast majority of these lands were developed into residential subdivisions in the 1970's and 1980's, and multiple stock transactions transferred the majority of company ownership to Jefferson County (244 shares) and Foothills Park and Recreation District (Foothills) (96 shares). This combined ownership of 84 percent of available water is used to irrigate a large regional park and an 18-hole golf course located near Ward Road and Simms Street, both of which are owned by Foothills. Current acreage of irrigated turf is approximately 140 acres with a potential for future golf/park expansion of an additional 140 acres. Bergen Reservoir No. 2 provides approximately 726AF of storage for irrigation of these sites. The reservoir also provides surface acreage for recreation (boating and water skiing) which is leased to a private club for recreation purposes and provides income to Bergen.

Current annual shareholder assessments are $450 per share generating approximately $181,000 in revenue. The By-Laws allow the Board to set annual assessments at the level necessary to offset operating and capital costs. For additional income, the company also leases recreation rights to two reservoirs (Bergen Reservoirs No. 1 and No. 2), generating another $30,000 per year in revenue which helps to offset approximately 14 percent of Bergen's annual operating costs. Copies of three prior years of financial statements (2009 thru 2011) and the current operating budget are included in Appendix F.

Water Rights and Water Demands

Bergen water rights include both direct flow and storage rights. The Bergen rights are listed in Table No. 1. Because the direct flow rights are relatively junior in priority, Bergen can only divert direct flow during relatively infrequent periods of high stream flows. Bergen storage rights are very senior; however, stream flows in the summer, fall, and winter are typically too small to be diverted through the Bergen system. Therefore, Bergen typically diverts as much water as possible during the brief spring runoff period in order to fill reservoirs. The relative seniority of Bergen water rights and other downstream storage rights are listed in Table No. 2.

Current capacities of the three main reservoirs are: Bergen No. 1: 390 AF; Bergen No. 2: 726 AF; and Deane Reservoir: 516 AF. Three smaller reservoirs (Bergen Nos. 4, 5 and 6) have been essentially obliterated in recent years, and their water either transferred to Foothills in Case No. 82CW476, retained by stockholders, or otherwise sold out of the system. Original decreed capacity of entire system was 2,146 AF, and the current estimated operational capacity is 1,828 AF, including 196 acre-feet of storage on the Meadows Golf Course serving as alternate points of storage for the Bergen rights under the decree in Case No. 82CW476. The subject project to rehabilitate Bergen Dam No. 2 will preserve storage capacity for approximately 40 percent of the storage system. This project, coupled with improvements completed at Deane Reservoir approximately 25 years ago and the Meadows golf storage, will provide upgraded storage for 79 percent of the water supply.

Table No. 1

Bergen Ditch and Reservoir Company
List of Water Rights

Name	Source	Decreed Amount	Adjudication Date	Appropriation Date	Case No.	Administration No.	Current Amount	
Direct Flow								
Bergen Ditch	Turkey Ck	12.00 cfs	2/4/1884	5/1/1874	6832	8887.00000	NA	
Bergen Ditch	Turkey Ck	26.89 cfs[1]	2/4/1884	9/6/1878	6832, 67566	10476.00000	NA	
Bergen Ditch	Turkey Ck	4.01 cfs[1]	2/4/1884	9/6/1878	6832, 67566	10476.00000	NA	
Bergen Ditch	Turkey Ck	128.0 cfs	9/24/1935	10/24/1885	91471	13081.00000	NA	
Bergen Ditch	Weaver Ck	105.0 cfs	9/24/1935	10/24/1885	91471	13081.00000	NA	
Storage								
Bergen No. 1 Res.	Turkey Ck	375 AF[2,4]	2/4/1884	5/1/1874	6832	8887.00000	375 AF	
Bergen No. 2 Res.	Turkey Ck	574 AF[2,4]	2/4/1884	5/1/1874	6832	8887.00000	574 AF	
Deane Res.	Turkey Ck	518 AF[1,2,3]	2/4/1884	9/6/1878	6832, 67566	10476.00000	516 AF	
Deane Res. 1st Enl.	Turkey Ck		2/4/1884	9/25/1881	6832, 67566	11591.00000		
Bergen No. 1 Res. Enl.	Turkey Ck	212 AF	9/24/1935	3/1/1884	91471	12479.00000	15 AF	
Bergen No. 2 Res. Enl.	Turkey Ck	316 AF	9/24/1935	3/1/1884	91471	12479.00000	152 AF	
Bergen No. 4 Res.	Turkey Ck	61 AF	9/24/1935	3/1/1884	91471	12479.00000	0 AF	Delivery System Abandoned
Bergen No. 5 Res.	Turkey Ck	66 AF	9/24/1935	3/1/1884	91471	12479.00000	0 AF	Greatly Reduced Size
Bergen No. 6 Res.	Turkey Ck	24 AF	9/24/1935	12/18/1888	91471	14232.00000	0 AF	Eliminated

[1] Transferred from Independent Highline Ditch in Case No. 67566 dated 6/1/1950.

[2] The storage volume is not quantified by decree.

[3] 518 acre-feet is the amount shown in the State Engineer's tabulation.

[4] Quantified in the 1935 Decree.

Table No. 2

Senior Reservoir Water Rights Downstream on Turkey Creek, Bear Creek and South Platte River Relative Priority to Bergen Storage Decrees

Reservoir Rights	Priority	Administration No.	Appropriation Date	Decree Amount	Other Amount
Bergen No. 1 Reservoir	2	8887.00000	5/1/1874 O	12.00 cfs	375 af
Bergen No. 2 Reservoir					574 af
Polly Deane Reservoir	5	10476.00000	9/6/1878 O	26.68 cfs	518 af
Polly Deane Res, 1st Enl	8	11591.00000	9/25/1881 O	4.01 cfs	
Bergen No. 1 Res, 1st Enl	17	12479.00000	3/1/1884 S	212 af	
Bergen No. 2 Res, 1st Enl	18	12479.00000	3/1/1884 S	316 af	
Bergen No. 4 Res.	19	12479.00000	3/1/1884 S	61 af	
Bergen No. 5 Res.	20	12479.00000	3/1/1884 S	66 af	
Barr Lake (So. Platte River) *		13108.00000	11/20/1885 S	11,081 af	
Bergen No. 6 Res.	28	14232.00000	12/18/1888 S	24 af	
Lower Latham Res & Enl (S Platte R) *		17706.18437	6/23/1898 S	5,755 af	
Jackson Lake (So. Platte River) *		19918.18765	5/18/1901 S	30,992 af	
So. Platte River Large Reservoirs *			After 1901 S	200,000+af	

* Non-Bergen Rights

Demand for Water

For the period 1935 thru 2011, the average water delivered to storage annually in Bergen system was approximately 808 AF, the average water delivered each year was 628 AF and the average yield per share was 1.56 AF. This data is summarized in Table No. 3. During that time period there were 3 years (in the mid-fifties) when water delivered was less than 50 af. The highest annual yield in recent years was 3.13 AF/share in 1966.

Monthly summaries of reservoir storage volumes for Bergen No. 1 and No. 2 Reservoirs, and Poly Deane Reservoir are included in Appendix G. Monthly summaries of headgate diversions are also included in Appendix G.

Table No. 3

Summary of the Historic Operation of Bergen Reservoirs

Water Year	Water Stored (Ac-Ft)	Deliverable Yield (Ac-Ft)	Deliverable Yield (AF/Share)	Carryover Storage (Ac-Ft)	Notes
1935	680	763	1.89	115	[1]
1936	571	422	1.05	315	[1]
1937	855	925	2.29	185	[1]
1938	1,842	1,122	2.78	424	[1]
1939	1,528	1,562	3.87	0	[1]
1940	433	346	0.86	0	[1]
1941	1,940	1,271	3.15	351	[1]
1942	1,352	1,138	2.82	352	[1]
1943	1,206	934	2.31	313	[1]
1944	1,580	1,358	3.37	196	[1]
1945	892	687	1.70	229	[1]
1946	409	428	1.06	103	[1]
1947	1,764	990	2.45	832	[1]
1948	1,260	1,434	3.55	97	[1]
1949	1,802	1,290	3.20	286	[1]
1950	192	382	0.95	0	[1]
1951	1,403	934	2.31	234	[1]
1952	1,695	1,476	3.66	84	[1]
1953	315	255	0.63	80	[1]
1954	0	37	0.09	0	[1,3]
1955	0	0	0.00	0	[1,3]
1956	0	0	0.00	0	[1,3]

Water Year	Water Stored (Ac-Ft)	Deliverable Yield (Ac-Ft)	Deliverable Yield (AF/Share)	Carryover Storage (Ac-Ft)	Notes
1957	1,577	602	1.49	825	[1]
1958	917	859	2.13	668	[1]
1959	1,232	869	2.15	1,011	[1]
1960	1,176	954	2.36	747	[1]
1961	1,252	724	1.79	1,342	[1]
1962	850	1,176	2.91	397	[1]
1963	0	256	0.63	67	[1]
1964	1,046	703	1.74	235	[1]
1965	1,016	172	0.43	1,560	[1]
1966	770	1,264	3.13	225	[1]
1967	1,472	822	2.04	720	[1]
1968	1,200	1,160	2.87	420	[1]
1969	1,520	812	2.01	1,140	[1]
1970	955	844	2.09	840	[1]
1971	940	1,216	3.01	245	[1]
1972	205	200	0.50	200	[1]
1973	1,400	484	1.20	995	[1]
1974	650	488	1.21	1,035	[2,3]
1975	704	546	1.35	1,056	[2]
1976	608	396	0.98	1,169	[2]
1977	690	702	1.74	976	[2]
1978	609	598	1.48	837	[2]
1979	890	486	1.20	1,120	[2]
1980	530	585	1.45	919	[2]
1981	484	362	0.90	951	[2]
1982	245	53	0.13	1,130	[2,3]
1983	619	519	1.29	1,100	[2]
1984	111	229	0.57	925	[2]
1985	862	598	1.48	1,039	[2]
1986	99	324	0.80	733	[2]
1987	1,275	831	2.06	969	[2,3]
1988	434	610	1.51	416	[2]
1989	741	333	0.82	741	[2,3]
1990	1,231	489	1.21	1,101	[2]
1991	714	644	1.60	957	[2]
1992	952	556	1.38	1,214	[2]
1993	362	370	0.92	1,114	[2]
1994	447	482	1.20	958	[2]
1995	803	401	0.99	1,260	[2]
1996	511	438	1.09	1,223	[2]
1997	418	306	0.76	1,259	[2]

Water Year	Water Stored (Ac-Ft)	Deliverable Yield (Ac-Ft)	Deliverable Yield (AF/Share)	Carryover Storage (Ac-Ft)	Notes
1998	361	275	0.68	1,276	[2]
1999	504	334	0.83	1,363	[2]
2000	334	421	1.04	1,171	[2]
2001	613	474	1.17	1,192	[2]
2002	218	546	1.35	728	[2]
2003	1,096	572	1.42	1,109	[2]
2004	598	185	0.46	1,476	[2]
2005	237	353	0.87	1,272	[2]
2006	159	542	1.34	754	[2]
2007	1,026	510	1.26	1,142	[2]
2008	777	565	1.40	1,135	[2]
2009	922	646	1.60	1,221	[2]
2010	554	517	1.28	1,111	[2]
2011	574	239	0.59	1,307	[2]
Average	808	628	1.56	731	
Maximum	1,940	1,562	3.87	1,560	
Minimum	0	0	0.00	0	

Notes:

[1] From TZA Water Engineers, "Evaluation of Foothills Planned Uses of Water Supplied by the Bergen Ditch and Reservoir Company", November 2002.

[2] Derived from DWR Records

[3] Incomplete or missing records

The Bergen Board meets annually to assess storage conditions, available water, the water supply outlook, and to set the annual allocation of AF per share, which is used to determine annual water delivery to shareholders, and when possible, leave a reasonable carryover for future years. In the past few years, reservoirs have typically filled in the spring and the annual allocation by the Board has averaged around 2.5 AF/share. In 8 of the past 10 years all reservoirs were filled prior to the beginning of the irrigation season. In a typical irrigation season all reservoirs are filled usually by mid-May and then water is drawn down based on irrigation needs during the year.

The storage capacity of the three main reservoirs allows for storage of enough water to handle shareholder irrigation needs for approximately two irrigation seasons. The current primary demand for water originates from Foothills for park and golf course irrigation, and they use from 503 to 612 AF per year depending on weather conditions; thus storage capacity within the system is critical to continue to allow storage for up to two irrigation seasons of water use.

Adequacy related to demand for 20-year loan period

Turkey Creek is not a highly reliable water source, due primarily to the fact the drainage basin for Turkey Creek is relatively small and is situated at lower elevation than other major front-range creeks and rivers. Consequently the storage rights and ability to store water are very critical to Bergen, including storage within Bergen No. 2 Reservoir. Within the last half century there have been two time periods; 3 years in the mid 1950s and 3 years in the late 1980s, when there was not sufficient water to meet irrigation needs of the shareholders. Since 1990 there have been 4 irrigation seasons when there was not sufficient water to fill reservoirs completely during the primary diversion time in the spring.

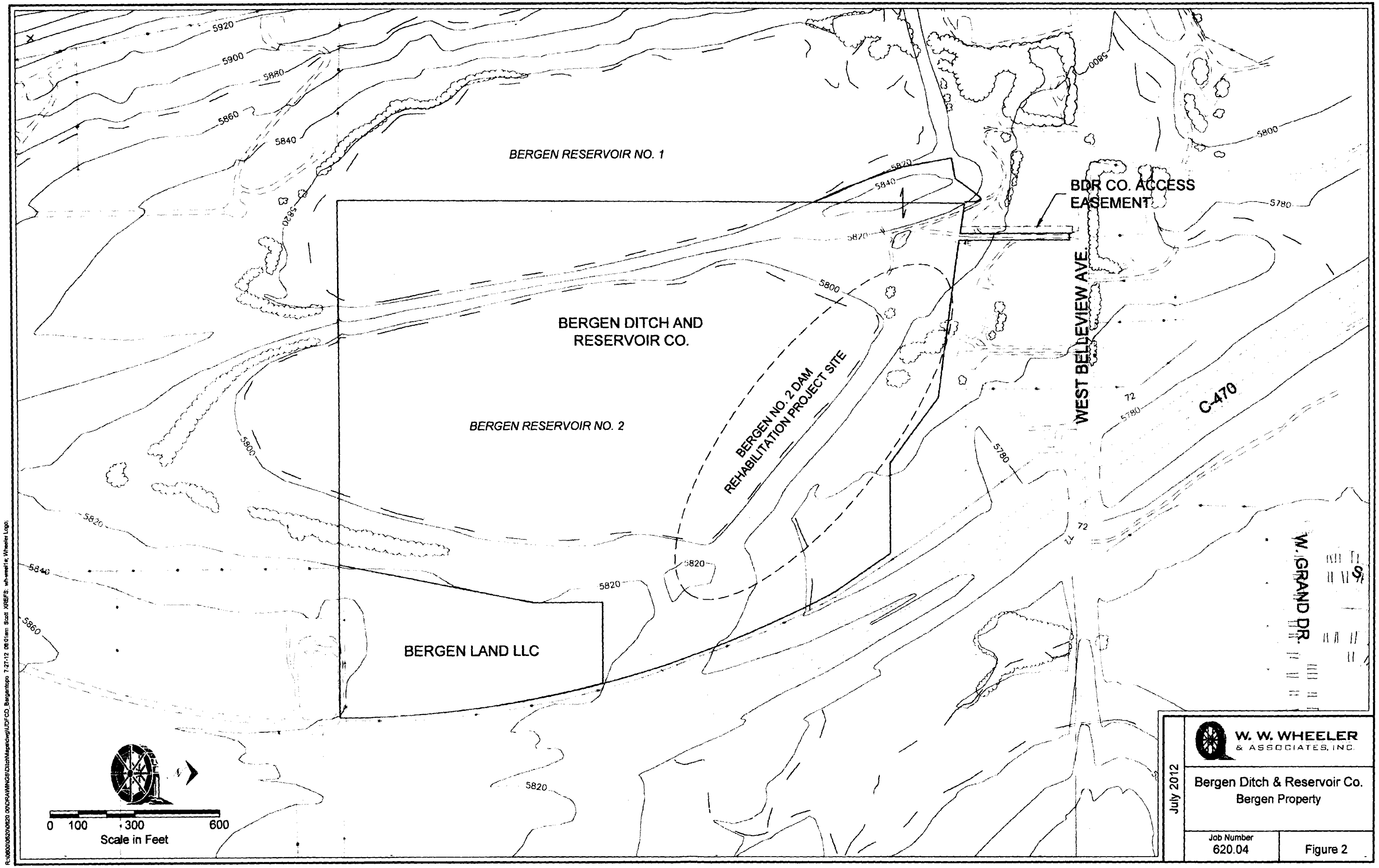
During the water shortage period in the late 80s, water restrictions were imposed at the irrigated park and the golf course to preserve water for subsequent year's use. Though historic water supply would indicate a high probability for adequate water related to demand for a 20-year loan period, it is also likely there will be times of shortage when Bergen and shareholders will need to ration use in order to preserve water for subsequent years. Fortunately, the highest user, the golf course, since opening in 1984 has never had to close or restrict play due to insufficient water. The primary water user, Foothills, also has decreed storage capacity within irrigation ponds on the golf course totaling 196 AF. Consequently, Bergen is of the opinion that the adequacy of water related to demand for the loan period is good. There are no current plans to expand the golf course or the irrigated park, and the user agencies/shareholders are well aware of the limited irrigation water supply that will dictate limits on expansion.

Project Description

The proposed project is described in detail in the attached engineering reports and feasibility analysis provided to Bergen by Kumar and Associates and by W. W. Wheeler and Associates located in Appendix C. The basic project is to provide required dam improvements to an existing water storage reservoir owned by Bergen Ditch and Reservoir Company. Proposed improvements include replacement of outlet works, reconstruction of the earthen dam and toe drains, and (if funds are available) minor improvements to other Bergen facilities. The general project area is shown on Figure No. 2.

Refer to the Kumar Report for details on the proposed embankment repairs:

Figure 20	Dam Modification Plan
Figures 21-22	Dam Modification Sections
Figure 23	Dam Modification Details



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July 2012

W. W. WHEELER & ASSOCIATES, INC.

Bergen Ditch & Reservoir Co.
Bergen Property

Job Number 620.04

Figure 2

Refer to the Wheeler Report for details on the outlet works replacement:

Figure 1	Outlet Works Replacement Options
Figure 2	Outlet Works Replacement Details

Analysis of Alternatives

Bergen's available alternatives include 1) no action; 2) replace outlet but not rehabilitate the dam; 3) replace outlet and rehabilitate the dam.

1. *No action alternative* - No action will ultimately render the outlet works inoperable, increase seepage, and maintain status quo or further deteriorate the existing dam and reservoir and would not address safety and liability concerns over current dam conditions. If improvements are not made there will likely be future restrictions on storage by SEO, which will restrict water supply to users, and also impact revenue from lease of recreation rights and possible Foothills revenue from lost golf play. Alternative water supplies to meet Foothill's irrigation needs are not available due to the location of their facilities far from the S. Platte River, Denver Water is not serving large park facilities with new municipal water supplies, due to the generally over appropriated water supplies in the local streams, and the lack of water rights for sale on the local streams.

2. *Second alternative* - Replace the outlet works pipe and intake structure (but not rehabilitate the dam) to reduce seepage and make the outlet structure dependable and to allow for quick draining of the reservoir and safe reservoir operation. This will require significant earthwork and breeching of the dam, to an extent that approaches a significant portion of the full rehabilitation of the dam. The cost for this alternative is estimated at $550,000.

3. *The third alternative and our selected alternative* - Replacement of the outlet works combined with a complete rehabilitation of the dam. Bergen is of the opinion this is the most cost effective long term solution to our repair needs. The cost of this alternative is estimated to be $2,200,000 (rounded), and our loan application is for approximately 90 percent of that amount.
   - Current water supply/storage capacity of Bergen No. 2 is 726 AF, which will not increase or decrease as a result of this project. We expect storage capacity will be preserved, and dam safety and operational efficiency will be improved by this work.

- Our objectives with this project are to preserve the reservoir's current storage capacity, renovate the outlet works, improve stability to allow Bergen Reservoir No. 2 to function and meet company needs for the foreseeable future, and to address dam safety concerns and items noted in recent SEO inspection reports for the reservoir. This dam is rated as a high hazard dam with a breach resulting in possible loss of life, so addressing that hazard by dam rehabilitation is very important.
- Outcomes with or without the project:
    - **Without** the project the expected outcome will be eventual storage restrictions and increased dam safety issues due to seepage, embankment instability and the inability to quickly drain the reservoir if needed.
    - **With** the project, safety will be enhanced, storage capacity preserved, service to shareholders preserved, and SEO concerns addressed to generally meet their current guidelines.
- The third and recommended alternative above will avoid the added and somewhat duplicate cost of replacing the outlet works and then rehabilitating the remainder of the embankment fill at a later date. A significant portion of the proposed grading and earthwork may be duplicated if these two items are not done at the same time.

A fourth alternative has been discussed and quickly dismissed as impractical and too expensive. That alternative was to abandon the existing reservoir and construct a new reservoir on the nearby Meadows Golf Course. Estimated cost of that alternative is twice the amount of any other alternatives, and would require expensive and time consuming Water Court proceedings to move storage to a new location.

The alternatives analyses are summarized in Table No. 4.

Table No. 4

Analysis of Alternatives

	Description	Capital Cost and cost per ac-ft (2)	Cost Per Share (1)	Impacts
Alternative No. 1	No action	$0 $0/af	$0	Reservoir will continue to deteriorate, seepage will continue, and safety concerns and SEO requirements will eventually result in increased storage restrictions or draining. Does nothing to address liability and safety issues, and eventual loss of water supplies.
Alternative No. 2	Replace outlet works only	$546,000 $752/af	$1,353	Will solve problems regarding outlet controls and ability to drain reservoir, but will not address all seepage and stability issues. Addresses only a portion of liability and safety issues.
Alternative No. 3	Replace outlet works and rehabilitate dam	$2,000,000 $2,754/af	$4,957	Most cost effective alternative and will address long term needs for stability, seepage control, and respond to all current SEO concerns. Most effective alternative to address liability and safety issues.

Notes: (1) 403.5 shares total.
(2) 726 AF total in reservoir.

Selected Alternative

The selected alternative, alternative no. 3, is replacement of the outlet works and rehabilitation of the dam at an estimated cost of $2 million. We believe this is the most cost effective alternative to give immediate attention to long term repair needs, dam stability, and gaining functioning outlet works. All of these improvements will address SEO concerns and improve our operational efficiency Along with addressing liability and safety issues. Since this is the rehabilitation of an existing reservoir we do not anticipate that maintenance and operations costs will change significantly, however our ability to store water and control water flows will be dramatically improved with these proposed renovations. Cost estimate summary for the selected alternative is presented in Table No. 5.

Additional information on the selected alternative, including preliminary drawings is provided in the Kumar and Wheeler reports included in Appendix C.

Table No. 5

Cost Estimate for Dam Rehabilitation and Outlet Replacement
Bergen No. 2 Dam

Full Reconstruction for Bergen No. 2 Dam, Main Embankment Section
Outlet Repair Option No. 1, Complete Replacement of Outlet Works

	Item	Quantity	Unit	Unit Price	Total
Outlet Works					
1	Excavate Trench	30,000	cy	$ 4.00	$ 120,000
2	Intake Structure Concrete	1	ls	$ 7,000	$ 7,000
3	Intake Trash Rack - SS	1	ls	$ 5,000	$ 5,000
4	Gate, Stem, Stem Wall & Operator	1	ls	$ 36,000	$ 36,000
5	Outlet Structure Concrete	1	ls	$ 5,000	$ 5,000
6	Outlet Pipe - 18" HDPE, Concrete Encased	260	ft	$ 350	$ 91,000
7	Backfill Trench	30,000	cy	$ 5.00	$ 150,000
8	Unscheduled Items	10	%	$ 41,400	$ 41,000
	Subtotal				***$ 455,000***
Embankment					
1	Mobilization	1	ls	$ 105,000	$ 105,000
2	Clearing and Stripping	4	acre	$ 4,500	$ 18,000
3	Dewatering	1	ls	$ 20,000	$ 20,000
4	Required Excavation	20,000	cy	$ 5.00	$ 100,000
5	Embankment Fill	30,000	cy	$ 5.00	$ 150,000
6	Drain Aggregate	2,700	cy	$ 50	$ 135,000
7	Drain Pipe	610	ft	$ 30	$ 18,300
8	Drain Manhole	1	ls	$ 4,000	$ 4,000
9	Granular Fill	2,700	cy	$ 14	$ 38,000
10	Riprap	4,800	cy	$ 70	$ 336,000
11	Riprap Bedding	1,800	cy	$ 50	$ 90,000
12	Surface Course	400	cy	$ 35	$ 14,000
13	Re-vegetation	5	acre	$ 5,000	$ 25,000
14	Unscheduled Items	10	%	$ 105,310	$ 105,000
	Subtotal				***$ 1,158,000***
	Outlet Works Subtotal				$ 455,000
	Embankment Subtotal				$ 1,158,000
	Base Total				$ 1,614,000
	Contingency	18	%		$ 290,000
	Engineering Design & Permitting	8	%		$ 129,000
	Construction Management	10	%		$ 161,000
	Total				***$ 2,195,000***

- Amortized over time and by per AF Amortized 30 years = $104,000 year. At a cost of $2,000,000 to *preserve* 726 AF of storage capacity, the per AF cost for this project is $2,754/AF.
- Increase or decrease O and M None anticipated, rather than increased costs we do expect some increased operational efficiency with less seepage and improved control of outlet works.
- Impact of shut down alternative If reservoir is shut down it would severely limit our ability to store and deliver water to irrigation customers and it would result in the loss of 70 percent of our annual recreation revenues.
- Analysis, narrative, maps, and preliminary design for the selected alternative are included in the attached Kumar and Wheeler reports attached in Appendix C

Supplemental Work

Bergen may have the opportunity to perform additional repair and improvement work on its facilities if construction costs for the dam rehabilitation work come in at the low end of the project cost estimate, and allow a budget for the additional work. This work could include:

1. Install a sand separator on the inlet ditch near the headgate structure to reduce the sand loading in the ditch. Estimated Cost: $100,000.

2. Perform minor slope repairs and rip-rap replacement to Middle Dike separating Bergen No. 1 Reservoir and Bergen No. 2 Reservoir. Estimated Cost: $100,000.

3. Replace control gates at the river headgate and modify bypass to provide for better control of bed load. Estimated Cost: $80,000.

Bergen would plan to seek a modification in the project scope to accomplish these additional improvements if circumstances allow.

Man Made and Natural Impacts

Adjacent homes and properties, Minimal impact expected; there are 5 or 6 homes below the reservoir that would experience noise and possible dust impacts during construction. Positive impacts would be elimination of minor seepage issues below the dam that have periodically impacted those properties. Grazing lease on property may need to be suspended for one season during construction

Utilities: To our knowledge no utilities will be impacted.

Recreation use: Use will be impacted by draining of reservoir, construction activity and refilling. We plan to complete the proposed improvements during off season but there is a potential interruption of one recreation season. Our recreation lease provides for abatement of payments and suspension of use if water level is not conducive to recreation use.

Minimal impacts are expected on vegetation; construction area is generally native grasses and a few small shrubs, with some trees already identified by SEO as required to be removed. No impact anticipated on stream flow; the reservoir is off-channel and is fed and drained by head gates controlled solely by Bergen. There will be increased stream flow in Weaver Creek located downstream from Bergen No. 2 when reservoir is drained, however Bergen will control those flows to minimize impact. Because of the age and sediments at the bottom of the reservoir it is anticipated there may be some short-term odor issues when the reservoir is drained.

Minimal wildlife impact is anticipated, there are no know endangered species on site and current wildlife population is mostly deer, coyotes, foxes, birds, rodents, water fowl and an occasional bear or mountain lion. All of these will likely be temporarily displaced but no permanent impact is anticipated. We plan to consult with the Division of Wildlife for possible relocation of game fish to our adjacent Bergen No. 1 Reservoir or Deane Reservoir (Hine Lake).

Long term impacts from the completion of this project are all positive. The project will impact adjacent property owners by decreasing the amount of seepage from the reservoir, will improve the dam safety rating and the ability to quickly drain the reservoir in the event of flood conditions or dam emergency, will improve the general condition of the reservoir for recreation purposes, and should have no impact on existing or future water quality.

Permitting and Implementation Schedule (estimated)

Loan application submitted October 2012
Project/loan approval in January 2013
Detailed design completed April 2013
SEO review and approval by June 2013
Bidding starting June 2013 and Bid accepted July 2013
Construction starting in late summer 2013 and completion by spring 2014. If design or SEO approval delays are encountered then project schedule will be adjusted for a late summer 2014 start.

Institutional Considerations

- Permits required will include:
  - Jefferson County - Grading and Erosion Control
  - State Health Department - Fugitive Dust and Air Pollution Notice
  - State of Colorado – Storm Water Discharge and Management
  - SEO - Construction Plans and Specifications
  - Division of Wildlife - possible assistance with fish relocation
  - Corps of Engineers 404 permit if applicable (not anticipated)

- Notifications will be made to:
  - Jefferson County
  - Bergen Shareholders
  - Adjacent property owners
  - SEO
  - Recreation leaseholder
  - Grazing leaseholder

- Bergen will provide overall project coordination including design by consultants Kumar and Wheeler, and construction management by Wheeler, and CWCB along with SEO coordination as needed.

Financial Feasibility

- At present we anticipate a project cost of $2.2 *million* and loan amount of $2.0 million, a 30-year loan term and a 3.15 percent interest rate.
- Bergen's source of funds for future debt payments will be existing and proposed increased assessments on current shareholders.
- Describe financial impact on agency and shareholders. Financial impact will be approximately $257 per share/per year to be assessed on current shareholders. This increased assessment will be imposed for the 30 year life of the loan. The increased assessments and debt payment will increase Bergen's current annual budget by approximately 1/3. The two largest Bergen shareholders are government agencies that rely on tax revenue and fees and charges to generate funds to pay the increased assessment. Both are aware of the additional assessment and both support this project with a commitment to vote their majority (and controlling) shares in favor of the loan application and payment contract. Bergen will review project with and gain voted approval from shareholders once the final project scope and loan amount are determined.
- Collateral. Bergen will pledge assessment revenues backed by a rate covenant guaranteeing Bergen assessment rates will be set at an amount adequate to

cover all debt obligations. Copies of 2009-2011 budgets and balance sheets are attached in Appendix F.

- A financial projection schedule is presented in Table No. 6.

Table No. 6

30-Year Financial Projections Beginning January 2013

Total Project Loan -- $2,000,000 @ 3.15%

Year	Annual Revenues	Annual Operating Costs	Annual Operations Assessment	Loan Payment	Loan Reserve	Total Loan Costs	Loan Assessment	Annual Assessment Per Share
2013	$ 215,825	$ 217,983	$ 450	$ 104,027	$ 11,037	$ 115,064	$ 285	$ 735
2014	$ 220,600	$ 220,162	$ 450	$ 104,027	$ 11,037	$ 115,064	$ 285	$ 735
2015	$ 220,600	$ 220,162	$ 450	$ 104,027	$ 11,037	$ 115,064	$ 285	$ 735
2016	$ 220,600	$ 223,363	$ 450	$ 104,027	$ 11,037	$ 115,064	$ 285	$ 735
2017	$ 221,662	$ 223,363	$ 475	$ 104,027		$ 104,027	$ 257	$ 732
2018	$ 221,662	$ 225,596	$ 475	$ 104,027		$ 104,027	$ 257	$ 732
2019	$ 221,662	$ 225,596	$ 475	$ 104,027		$ 104,027	$ 257	$ 732
2020	$ 221,662	$ 227,851	$ 475	$ 104,027		$ 104,027	$ 257	$ 732
2021	$ 221,662	$ 227,851	$ 475	$ 104,027		$ 104,027	$ 257	$ 732
2022	$ 231,750	$ 230,129	$ 500	$ 104,027		$ 104,027	$ 257	$ 757
2023	$ 231,750	$ 230,129	$ 500	$ 104,027		$ 104,027	$ 257	$ 757
2024	$ 231,750	$ 232,430	$ 500	$ 104,027		$ 104,027	$ 257	$ 757
2025	$ 231,750	$ 232,430	$ 500	$ 104,027		$ 104,027	$ 257	$ 757
2026	$ 231,750	$ 234,754	$ 500	$ 104,027		$ 104,027	$ 257	$ 757
2027	$ 241,837	$ 234,754	$ 525	$ 104,027		$ 104,027	$ 257	$ 782
2028	$ 241,837	$ 237,101	$ 525	$ 104,027		$ 104,027	$ 257	$ 782
2029	$ 241,837	$ 237,101	$ 525	$ 104,027		$ 104,027	$ 257	$ 782
2030	$ 241,837	$ 239,472	$ 525	$ 104,027		$ 104,027	$ 257	$ 782
2031	$ 241,837	$ 239,472	$ 525	$ 104,027		$ 104,027	$ 257	$ 782
2032	$ 241,837	$ 241,866	$ 525	$ 104,027		$ 104,027	$ 257	$ 782
2033	$ 251,925	$ 244,284	$ 550	$ 104,027		$ 104,027	$ 257	$ 807
2034	$ 251,925	$ 245,505	$ 550	$ 104,027		$ 104,027	$ 257	$ 807
2035	$ 251,925	$ 246,732	$ 550	$ 104,027		$ 104,027	$ 257	$ 807
2036	$ 251,925	$ 247,965	$ 550	$ 104,027		$ 104,027	$ 257	$ 807
2037	$ 251,925	$ 249,204	$ 550	$ 104,027		$ 104,027	$ 257	$ 807
2038	$ 251,925	$ 250,450	$ 550	$ 104,027		$ 104,027	$ 257	$ 807
2039	$ 262,012	$ 251,702	$ 575	$ 104,027		$ 104,027	$ 257	$ 832
2040	$ 262.012	$ 252,960	$ 575	$ 104,027		$ 104,027	$ 257	$ 832
2041	$ 262,012	$ 254,224	$ 575	$ 104,027		$ 104,027	$ 257	$ 832

Year	Annual Revenues	Annual Operating Costs	Annual Operations Assessment	Loan Payment	Loan Reserve	Total Loan Costs	Loan Assessment	Annual Assessment Per Share
2042	$ 262,012	$ 255,495	$ 575	$ 104,027		$ 104,027	$ 257	$ 832
2043	$ 262,012	$ 256,772	$ 575	$ 0		$ 0	$ 0	$ 575

Notes: Annual operating costs include $30,000 per year set aside for facility capital repairs
Operating costs calculated to increase at rate of approximately 1/2 of 1 percent per year
Every $10 increase in assessment rate generates $4,035 in revenue
Annual revenues include assessments and recreation lease (lease generates $30,000/yr)
Annual assessment rate drops by $248 at end of loan period
Loan reserve calculated for 4 years only because Bergen will pledge $60,000 of current reserves
Current $4,000 per year in miscellaneous revenues not included in calculations

Important Note: Approximately $198 of the 2012 annual assessment per share ($450) is presently used to generate capital repair funds and to contribute to the company's general reserve fund. All or a portion of that $198 may be reallocated to assist in debt retirement payments. For example, if all of the $198 is used, then assessment for new debt might be as low $59 per share; if half of that is used then assessment for new debt will be $158 per share. For the purpose of this application it is assumed new debt will be funded entirely with a new assessment. Bergen will determine annually whether to reduce current assessment or change allocation between O&M and debt, with guarantee that annual assessment will be sufficient to pay debt obligations. This will allow Bergen to evaluate and fund other needed capital repairs on an annual basis, while keeping the combined operations/debt assessment as low as possible.

Overall Financial Summary

Project cost (estimated)	$2,200,000 (rounded)
Loan Amount requested	$2,000,000
Annual CWCB Payment (30-year loan)	$104,027
Total shares of outstanding Bergen stock	403.5
Current assessment	$450 per share, per year
Estimated future assessment (annual)	$735 - $907 per share
Project cost, per acre foot	$2,754
Approximate annual debt cost to be paid by shareholders	$257 per share/yr

Economic Impacts

- Cost to shareholders. Approximately $257 per share/per year in additional assessments over the 30 year life of the loan. This will add a $104,000 per year debt payment component to our current $242,000/year budget, a budget increase of approximately 1/3. The $257 increase in assessment rate is a 57 percent increase over current rates.
- If there is a deficit, how will it be addressed? Any deficit impacting debt re-payment will be addressed by increasing shareholder assessments to cover the deficit. The elected Bergen Board has the authority to raise assessments as needed to cover operating and debt costs.

Credit Worthiness

The following positive factors contribute to Bergen's ability to repay the requested loan:

- no other current debt

- ability to increase annual assessments to meet debt and operating costs
- additional annual revenue from recreation lease ($30,000 per year)
- current reserve funds totaling approximately $60,000 and estimated to be $80,000 by the end of 2012
- sufficient assets to provide additional collateral, if required
- favorable historic budget and balance sheet performance

Conclusions

- Bergen has responded to SEO inspections and conducted two comprehensive reports to determine what improvements are needed to Bergen No. 2. After careful design and financial consideration we have determined that the herein selected option for dam rehabilitation and replacement of outlet works on Bergen No. 2 is our best course of action.
- This proposed project will provide the repairs and improvements needed to the subject dam while generating a manageable financial impact on company shareholders.
- The public agency assets that receive irrigation water through this reservoir and ditch system will be preserved and long term irrigation needs provided in a more predictable manner.
- Successful completion of this project will preserve the function and purpose of the ditch company, address safety concerns, reduce liability concerns, and provide a continued reliable irrigation source for shareholders and key public facilities served.
- The selected alternative is the most economical and will eliminate duplication of costs associated with other possible alternatives.
- The impact on the minor Bergen shareholders will be minimal, and the major financial impacts of the increased assessments for debt will be borne by the major shareholders who will also benefit the most from the proposed improvements.

Summary of Supplemental Data Submitted

Tables (all attached to Feasibility Study):

1. List of Water Rights
2. Senior Reservoir Water Rights Downstream on Turkey Creek, Bear Creek, and South Platte River
3. Summary of the Historic Operation of Bergen Reservoir
4. Analysis of Alternatives
5. Cost Estimate for Dam Rehabilitation and Outlet Replacement – Option 1
6. 30-Year Financial Projections Beginning January 2013

Figures (all attached to Feasibility Study):

1. Bergen Ditch System
2. Bergen Property Map

Reference Figures (all are included in consultant reports in Appendix C):

Drawings of the selected alternative:

Kumar Report, Located in Appendix C

Figure 20	Dam Modification Plan
Figures 21-22	Dam Modification Sections
Figure 23	Dam Modification Details

Wheeler Report, Located in Appendix C

Figure 1 Outlet Works Replacement Options
Figure 2 Outlet Works Replacement Details

Index of Appendices (all attached to Feasibility Study):

Appendix A	2011 SEO Inspection Report
Appendix B	BasePoint Design, dam safety review report
Appendix C	Kumar and Associates: Geotechnical Engineering Study and Feasibility Level Design, Proposed Modifications to Bergen Dam No. 2; and W. W. Wheeler and Associates: Bergen Dam No. 2, Outlet Works Replacement
Appendix D	Articles of Incorporation
Appendix E	Bergen Bylaws
Appendix F	2009-2011 financial statements and 2012 operating budget
Appendix G	Summary of Bergen Reservoir Storage and Headgate Diversions

Loan Application Form (separate document):

Insurance Certificate
Bergen Contact List
Shareholders List

ENGINEER'S INSPECTION REPORT

INSPECTOR: GGH

OFFICE OF THE STATE ENGINEER - DIVISION OF WATER RESOURCES - DAM SAFETY BRANCH 1313 SHERMAN STREET, ROOM 818, DENVER, CO 80203, (303) 866-3581

DAM NAME:	BERGEN WEST			T: 050S R: 0690W S: 18		COUNTY:	JEFFERSON	DATE OF INSPECTION:	4/13/2010
DAM ID:	090105	YRCompl:	1888	DAM HEIGHT(FT):	25.0	SPILLWAY WIDTH(FT):	5.0	PREVIOUS INSPECTION:	9/30/2008
CLASS:	Significant hazard			DAM LENGTH(FT):	500.0	SPILLWAY CAPACITY(CFS):	2440.0	NORMAL STORAGE (AF):	373.0
DIV:	1	WD:	9	CRESTWIDTH(FT):	8.0	FREEBOARD (FT):	6.0	SURFACE AREA(AC):	26.0
EAP:	1/2/2008			CRESTELEV(FT):	5825.0	DRAINAGE AREA (AC.):	210.0	OUTLET INSPECTED:	11/19/1997

CURRENT RESTRICTION: -- NONE --

OWNER:	BERGEN DITCH & RESERVOIR COMPANY	OWNER REP.:	BOB EASTON
ADDRESS:	9329 LARK SPARROW TRAIL	CONTACT NAME:	BOB EASTON
	HIGHLANDS RANCH CO 80126	CONTACT PHONE:	(303) 987-3602

INSPECTION PARTY: Scott Sauvageau, Al Sebold

REPRESENTING:

FIELD CONDITIONS OBSERVED

WATER LEVEL: BELOW DAM CREST _____ FT. Above Spillway at spill FT. GAGE ROD READING 22.3

GROUND MOISTURE CONDITION: [✓] DRY [ ] WET [ ] SNOWCOVER OTHER WINDY!

DIRECTIONS: MARK AN X FOR CONDITIONS FOUND AND UNDERLINE WORDS THAT APPLY

UPSTREAM SLOPE

PROBLEMS NOTED: [ ] (0)NONE [✓] (1)RIPRAP - MISSING, SPARSE, DISPLACED, WEATHERED [✓] (2) WAVE EROSION - WITH SCARPS

[ ] (3) CRACKS WITH DISPLACEMENT [ ] (4) SINKHOLE [✓] (5) APPEARS TOO STEEP [ ] (6) DEPRESSIONS OR BULGES [ ] (7) SLIDES

[ ] (8) CONCRETE FACING - HOLES, CRACKS, DISPLACED, UNDERMINED [ ] (9) OTHER

Typically steep, irregular slope with fair armoring of cobble to small boulder sized riprap. Impounded water depth against the slope is minor due to sediment deposits along the embankment. This condition is most pronounced to the left of the outlet, where the sediments have created a forest in the "reservoir" area. Left of the outlet, the upstream slope has no exposure to the lake.

CONDITIONS OBSERVED: [ ] Good [X] Acceptable [X] Poor

CREST

PROBLEMS NOTED: [ ] (10) NONE [ ] (11) RUTS OR PUDDLES [ ] (12) EROSION [ ] (13) CRACKS - WITH DISPLACEMENT [ ] (14) SINKHOLES

[✓] (15) NOT WIDE ENOUGH [ ] (16) LOW AREA [✓] (17) MISALIGNMENT [✓] (18) IMPROPER SURFACE DRAINAGE [ ] (19) OTHER

Narrow, with rounding shoulders. Elevation varies across the length of the dam, but freeboard is maintained. Abutments are higher than the center of the dam.

CONDITIONS OBSERVED: [ ] Good [X] Acceptable [ ] Poor

DOWNSTREAM SLOPE

PROBLEMS NOTED: [ ] (20) NONE [ ] (21) LIVESTOCK DAMAGE [ ] (22) EROSION OR GULLIES [ ] (23) CRACKS - WITH DISPLACEMENT [ ] (24) SINKHOLE

[ ] (25) APPEARS TOO STEEP [✓] (26) DEPRESSIONS OR BULGES [ ] (27) SLIDE [ ] (28) SOFT AREAS [ ] (29) OTHER

Slightly steeper than is desired. Slope is generally even with local irregularities due to old tree and brush damage. Slope supports a fair to good grass cover, which is imporving as trees and brush have been removed from the slope.

CONDITIONS OBSERVED: [ ] Good [X] Acceptable [ ] Poor

SEEPAGE

PROBLEMS NOTED: [✓] (30) NONE [ ] (31) SATURATED EMBANKMENT AREA [ ] (32) SEEPAGE EXITS ON EMBANKMENT

[ ] (33) SEEPAGE EXITS AT POINT SOURCE [ ] (34) SEEPAGE AREA AT TOE [ ] (35) FLOW ADJACENT TO OUTLET [ ] (36) SEEPAGE INCREASED / MUDDY

DRAIN OUTFALLS SEEN [ ] No [ ] Yes Show location of drains on sketch and indicate amount and quality of discharge. [ ] (37) FLOW INCREASED / MUDDY [ ] (38) DRAIN DRY / OBSTRUCTED

[ ] (39) OTHER

No drains provided. Area at toe was dry this date. This area has typically displayed saturated ground or standing water during periods of high lake level, but, was dry and firm today. Scott reported that the lake had been full for a couple weeks. He also offered that with many of the trees removed from the toe and slope of the dam, the ground was now better exposed to allow evaporation and drying from rain and snow.

CONDITIONS OBSERVED: [ ] Good [X] Acceptable [ ] Poor

ENGINEER'S INSPECTION REPORT
DAM NAME: BERGEN WEST

DATE.: 4/13/2010
DAM I.D.: 090105

OUTLET

PROBLEMS NOTED: ☑ (40) NONE ☐ (41) NO OUTLET FOUND ☐ (42) POOR OPERATING ACCESS ☐ (43) INOPERABLE
☐ (44) UPSTREAM OR DOWNSTREAM STRUCTURE DETERIORATED (45) OUTLET OPERATED DURING INSPECTION ☐ YES ☑ NO
INTERIOR INSPECTED ☑ (120) NO ☐ (121)YES ☐ (46) CONDUIT DETERIORATED OR COLLAPSED ☐ (47) JOINTS DISPLACED ☐ (48) VALVE LEAKAGE
☐ (49) OTHER

Outlet was lined with HDPE in 1987. An internal inspection is due.

CONDITIONS OBSERVED: ☐ Good ☒ Acceptable ☒ Poor

SPILLWAY

PROBLEMS NOTED: ☑ (50) NONE ☐ (51) NO EMERGENCY SPILLWAY FOUND ☐ (52) EROSION WITH BACKCUTTING ☐ (53) CRACK - WITH DISPLACEMENT
☐ (54) APPEARS TO BE STRUCTURALLY INADEQUATE ☐ (55) APPEARS TOO SMALL ☐ (56) INADEQUATE FREEBOARD ☐ (57) FLOW OBSTRUCTED
☐ (58) CONCRETE DETERIORATED / UNDERMINED ☐ (59) OTHER

Rock channel at right end of the dike between the reservoir and Bergen East (#2). An emergency channel is also provided at the left end of the dike.

CONDITIONS OBSERVED: ☐ Good ☒ Acceptable ☐ Poor

MONITORING

EXISTING INSTRUMENTATION FOUND ☐ (110) NONE ☑ (111) GAGE ROD ☐ (112) PIEZOMETERS ☐ (113) SEEPAGE WEIRS / FLUMES
☐ (114) SURVEY MONUMENTS ☐ (115) OTHER

MONITORING OF INSTRUMENTATION ☐ (116) NO ☑ (117) YES PERIODIC INSPECTIONS BY: ☑ (118) OWNER ☐ (119) ENGINEER

A new staff gage has been installed on the access bridge to the outlet operator.

CONDITIONS OBSERVED: ☐ Good ☒ Acceptable ☐ Poor

MAINTENANCE AND REPAIRS

PROBLEMS NOTED: ☑ (60 NONE ☐ (61) ACCESS ROAD NEEDS MAINTENANCE ☐ (62) CATTLE DAMAGE
☐ (63) BRUSH ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE ☑ (64) TREES ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE
☐ (65) RODENT ACTIVITY ON UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, TOE ☐ (66) DETERIORATED CONCRETE - FACING, OUTLET, SPILLWAY
☐ (67) GATE AND OPERATING MECHANISM NEED MAINTENANCE ☐ (68) OTHER

A concerted effort has been made to reduce and remove undesirable vegetation from the dam. Some brush and trees remain over and around the outlet, and a couple clusters of small trees remain toward the right end of the dam. These are located on the dam slope itself and should be removed while still small in size, and easily cleared.

CONDITIONS OBSERVED: ☐ Good ☒ Acceptable ☐ Poor

Go to next page for Overall Conditions and Items Requiring Actions

ENGINEER'S INSPECTION REPORT
DAM NAME: BERGEN WEST

DATE.: 4/13/2010
DAM I.D.: 090105

OVERALL CONDITIONS

The dam has been significantly improved over recent years as the dam slopes have been cleared of almost all undesirable vegetation. On this date, the lake was full, and had been for a couple weeks, and displayed no signifcant adverse conditions. The upstream slope could be improved but, the impounded depth against the slope is only a few feet.

Based on this Safety Inspection and recent file review, the overall condition is determined to be:

☑ (71) SATISFACTORY ☐ (72) CONDITIONALLY SATISFACTORY ☐ (73) UNSATISFACTORY

ITEMS REQUIRING ACTION BY OWNER TO IMPROVE THE SAFETY OF THE DAM

The State Engineer, by providing this dam safety inspection report, does not assume responsibility for any unsafe condition of the subject dam. The sole responsibility for the safety of this dam rests with the reservoir owner or operator, who should take every step necessary to prevent damages caused by leakage or overflow of waters from the reservoir or floods resulting from a failure of the dam.

MAINTENANCE - MINOR REPAIR - MONITORING

- ☐ (80) PROVIDE ADDITIONAL RIPRAP:
- ☐ (81) LUBRICATE AND OPERATE OUTLET GATES THROUGH FULL CYCLE:
- ☑ (82) CLEAR TREES AND/OR BRUSH FROM: **around outlet and on dam slope**
- ☐ (83) INITIATE RODENT CONTROL PROGRAM AND PROPERLY BACKFILL EXISTING HOLES:
- ☐ (84) GRADE CREST TO A UNIFORM ELEVATION WITH DRAINAGE TO THE UPSTREAM SLOPE:
- ☐ (85) PROVIDE SURFACE DRAINAGE FOR:
- ☐ (86) MONITOR:
- ☐ (87) DEVELOP AND SUBMIT AN EMERGENCY ACTION PLAN:
- ☐ (88) OTHER
- ☐ (89) OTHER

ENGINEERING - EMPLOY AN ENGINEER EXPERIENCED IN DESIGN AND CONSTRUCTION OF DAMS TO: (Plans and Specifications must be approved by State Engineer prior to construction.

- ☐ (90) PREPARE PLANS AND SPECIFICATIONS FOR REHABILITATION OF THE DAM:
- ☐ (91) PREPARE AS -BUILT DRAWINGS OF:
- ☐ (92) PERFORM A GEOTECHNICAL INVESTIGATION TO EVALUATE THE STABILITY OF THE DAM:
- ☐ (93) PERFORM A HYDROLOGIC STUDY TO DETERMINE REQUIRED SPILLWAY SIZE:
- ☐ (94) PREPARE PLANS AND SPECIFICATIONS FOR AN ADEQUATE SPILLWAY:
- ☐ (95) SET UP A MONITORING SYSTEM INCLUDING WORK SHEETS, REDUCED DATA AND GRAPHED RESULTS:
- ☑ (96) PERFORM AN INTERNAL INSPECTION OF THE OUTLET:
- ☐ (97) OTHER:
- ☐ (98) OTHER:
- ☐ (99) OTHER:

SAFE STORAGE LEVEL: RECOMMENDED AS A RESULT OF THIS INSPECTION

- ☑ (101) FULL STORAGE
- ☐ (102) CONDITIONAL FULL STORAGE
- ☐ (103) RECOMMENDED RESTRICTION → { _ FT. BELOW DAM CREST; _ FT. BELOW SPILLWAY CREST; _ FT. GAGE HEIGHT; NO STORAGE-MAINTAIN OUTLET FULLY OPEN
- ☐ (104) CONTINUE EXISTING RESTRICTION

REASON FOR RESTRICTION

ACTIONS REQUIRED FOR CONDITIONAL FULL STORAGE OR CONTINUED STORAGE AT THE RESTRICTED LEVEL:

Engineer's Signature _____ INSPECTED BY

Owner's Signature _____ OWNER/OWNER'S REPRESENTATIVE DATE: ___/___/___

GUIDELINES FOR DETERMINING CONDITIONS

CONDITIONS OBSERVED - APPLIES TO UPSTREAM SLOPE, CREST, DOWNSTREAM SLOPE, OUTLET, SPILLWAY

GOOD
In general, this part of the structure has a near new appearance, and conditions observed in this area do not appear to threaten the safety of the dam.

ACCEPTABLE
Although general cross-section is maintained, surfaces may be irregular, eroded, rutted, spalled, or otherwise not in new condition. Conditions in this area do not currently appear to threaten the safety of the dam.

POOR
Conditions observed in this area appear to threaten the safety of the dam.

CONDITIONS OBSERVED - APPLIES TO SEEPAGE

GOOD
No evidence of uncontrolled seepage. No unexplained increase in flows from designed drains. All seepage is clear. Seepage conditions do not appear to threaten the safety of the dam.

ACCEPTABLE
Some seepage exists at areas other than the drain outfalls, or other designed drains. No unexplained increase in seepage. All seepage is clear. Seepage conditions observed do not currently appear to threaten the safety of the dam.

POOR
Seepage conditions observed appear to threaten the safety of the dam. Examples:
1) Designed drain or seepage flows have increased without increase in reservoir level.
2) Drain or seepage flows contain sediment, i.e., muddy water or particles in jar samples.
3) Widespread seepage, concentrated seepage, or ponding appears to threaten the safety of the dam.

CONDITIONS OBSERVED - APPLIES TO MONITORING

GOOD
Monitoring includes movement surveys and leakage measurements for all dams, and piezometer readings for High hazard dams. Instrumentation is in reliable, working condition. A plan for monitoring the instrumentation and analyzing results by the owner's engineer is in effect. Periodic inspections by owner's engineer.

ACCEPTABLE
Monitoring includes movement surveys and leakage measurements for High and Significant hazard dams; leakage measurements for Low hazard dams. Instrumentation is in serviceable condition. A plan for monitoring instrumentation is in effect by owner. Periodic inspections by owner or representative. OR, NO MONITORING REQUIRED.

POOR
All instrumentation and monitoring described under "ACCEPTABLE" here for each class of dam, are not provided, or required periodic readings are not being made, or unexplained changes in readings are not reacted to by the owner.

CONDITIONS OBSERVED - APPLIES TO MAINTENANCE AND REPAIR

GOOD
Dam appears to receive effective on-going maintenance and repair, and only a few minor items may need to be addressed.

ACCEPTABLE
Dam appears to receive maintenance, but some maintenance items need to be addressed. No major repairs are requirecl

POOR
Dam does not appear to receive adequate maintenance. One or more items needing maintenance or repair has begun to threaten the safety of the dam.

OVERALL CONDITIONS

SATISFACTORY
The safety inspection indicates no conditions that appear to threaten the safety of the dam, and the dam is expected to perform satisfactorily under all design loading conditions. Most of the required monitoring is being performed.

CONDITIONALLY SATISFACTORY
The safety inspection indicates symptoms of structural distress (seepage, evidence of minor displacements, etc.), which, if conditions worsen, could lead to the failure of the dam. Essential monitoring, inspection, and maintenance must be performed as a requirement for continued full storage in the reservoir.

UNSATISFACTORY
The safety inspection indicates definite signs of structural distress (excessive seepage, cracks, slides, sinkholes, severe deterioration, etc.), which could lead to the failure of the dam if the reservoir is used to full capacity. The dam is judged unsafe for full storage of water.

SAFE STORAGE LEVEL

FULL STORAGE
Dam may be used to full capacity with no conditions attached.

CONDITIONAL FULL STORAGE
Dam may be used to full storage if certain monitoring, maintenance, or operational conditions are met.

RESTRICTION
Dam may not be used to full capacity, but must be operated at some reduced level in the interest of public safety.

HAZARD CLASSIFICATION OF DAMS

High hazard
Loss of human life is expected in the event of failure of the dam, while the reservoir is at the high water line.

Significant hazard
Significant damage to improved property is expected in the event of failure of the dam while the reservoir is at the high water line, but no loss of human life is expected.

Low hazard
Loss of human life is not expected, and damage to improved property is expected to be small, in the event of failure of the dam while the reservoir is at high water fine.

NPH hazard - No loss of life or damage to improved property, or loss of downstream resource is expected in the event of failure of the dam while the reservoir is at the high water line.

Dam-Safety Review
Of Four Dams

Bergen Ditch and Reservoir Company
Jefferson County, Colorado

Project BP0717
March 7, 2008

BasePoint Design Corporation
Civil / Geotechnical Design Services

Dam-Safety Review
Of Four Dams

Bergen Ditch and Reservoir Company
Jefferson County, Colorado

Project BP0717
March 7, 2008

Prepared for

Bergen Ditch and Reservoir Company
c/o Foothills Park and Recreation District
6612 South Ward Street
Littleton, Colorado 80127

Prepared by

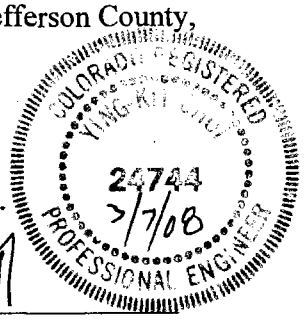
BasePoint Design Corporation
2280 South Xanadu Way, Suite 250
Aurora, Colorado, 80014

Table of Contents

LIST OF APPENDICES

Certification

I, the undersigned, hereby certify that this report entitled "Dam-Safety Review of Four Dams," was prepared by me, or was prepared under my direct supervision for Bergen Ditch and Reservoir Company, Jefferson County, Colorado.



Ying-Kit Choi, Colorado P.E. #24744
BasePoint Design Corporation

1.0 INTRODUCTION

1.1 Purpose

This report summarizes the results of dam-safety review and recommendations for course of actions to address any potential dam-safety related problems for four dams owned by the Bergen Ditch and Reservoir Company and located in Jefferson County, Colorado.

1.2 Scope of Work

The following scope of work was performed for this study:

- Visited the project site for the four dams: Bergen West Dam (a.k.a Bergen Dam No. 1), Bergen East Dam (a.k.a Bergen Dam No. 2), Bergen West Dike Dam (a.k.a. Bergen Middle Dike), and Polly A. Deane Dam.
- Reviewed available records and documents on the dams and appurtenant structures.
- Evaluated the performance of the dams based on information furnished and site observations
- Recommended a course of action for interim and long-term rehabilitation of each of the dams.
- Attended a meeting to discuss our recommendations on March 5, 2008.
- Prepared this study report.

1.3 Authorization

The scope of work listed above is authorized in a signed proposal and agreement between Bergen Ditch and Reservoir (Owner) and BasePoint Design Corporation dated May 24, 2007.

1.4 Personnel

The study team consists of the following personnel:

Project Manager/Geotechnical Engineer	Y. Kit Choi, Ph.D., P.E.

We are grateful for the assistance and coordination from Mr. James Ferentchak of W. W. Wheeler and Associates (Wheeler), the engineer for the Owner during the course of this study. The assistance of Mr. Scott Sauvageau, caretaker of the dam, during our site visit for the Bergen Dams, is also acknowledged.

2.0 SITE AND PROJECT DESCRIPTIONS

2.1 Site Description

General – The Bergen Dams and Reservoirs (Bergen No. 1, Bergen No. 2, and Bergen Middle Dike) and Polly A. Deane Dam and Reservoir are off-stream storage facilities owned and operated by the Bergen Ditch and Reservoir Company. The Bergen facilities are located just east of the C-470 freeway and south of Belleview Avenue, in Jefferson County, Colorado. The Polly A. Deane facility is located east of the C-470 freeway and south of Bowles Avenue, also in Jefferson County, Colorado. A site location map is contained on Figure 1. The two facilities are about one mile from each other. Both facilities are jurisdictional to the Colorado State Engineer's Office (SEO), and must meet all dam-safety guidelines [1]. It is important to point out that the dam names on SEO records are different than that shown in historical documents and other project correspondence. In the SEO records, Bergen Dam No. 1 is referred to as "Bergen West Dam", Bergen Dam No. 2 is referred to as "Bergen East Dam", and Bergen Middle Dike is referred to as "Bergen West Dike Dam". In this report, the more common names for these dams (Bergen No. 1, Bergen No. 2, and Bergen Middle Dike) are used throughout.

Bergen Reservoir No. 1 and Bergen Reservoir No. 2 are separated by a natural rock ridge on which the Bergen Middle Dike was constructed. Bergen Reservoir No. 1 is upstream of Bergen Reservoir No. 2. Bergen Reservoir No. 1 is filled via the Bergen Ditch, which discharges into the reservoir on the left abutment (looking downstream) of the dam. Bergen Reservoir No. 2 is filled through the spillways located on Bergen Middle Dike.

Bergen Dam No. 1 – Bergen Dam No. 1 is an existing significant-hazard earthfill embankment with a height of 21 feet. The dam crest has a length of 620 feet at elevation 5825.7. The upstream slope ranges from 2H:1V (horizontal:vertical) to 2.5H:1V, and is protected with riprap. The downstream slope ranged from 2H:1V to 2.5H:1V, and is protected with grass. With the reservoir at normal water surface elevation of 5819.7, the reservoir has an area of 26 acres and a capacity of 373 acre-feet.

Appurtenant structures of this dam consist of a low-level outlet works, a service spillway, and an emergency spillway. The low-level outlet works under the embankment was rehabilitated in 1987 [2], and consists of a precast concrete intake riser structure that houses a 12-inch slide gate and an 8-inch HDPE liner inside a 12-inch cast iron pipe that discharges into a plunge pool. The intake elevation of the outlet works is El. 5812.5. The service spillway is an uncontrolled earth channel located on the south abutment of the middle dike. The service spillway width ranges from 5 to 7 feet, with a crest elevation of 5819.7. The emergency spillway was constructed in 1999 [3], and consists of an uncontrolled rock-cut channel on the north abutment of the middle dike. The emergency spillway width is 87 feet with a nominal crest elevation 5820.5.

Bergen Middle Dike – Bergen Middle Dike is an existing low-hazard earthfill embankment with an apparent fill height of 14 feet. In the SEO records [7], the dam height was shown to be 25 feet. According to Mr. Ferentchak, the jurisdictional height of

the dike is 32 feet, which is measured to the invert of the outlet works. The dike crest has a length of 1700 feet at crest elevation 5824.4. The upstream slope (west side of embankment) was originally designed for 1.5H:1V to 2H:1V, but the current conditions are poor (see our site observations and photographs). The downstream slope (east side of embankment) was 1.5H:1V to 2H:1V, and protected with grass. Two spillways constructed on the abutments of this dike serve as spillways for Bergen Dam No. 1. There is an inoperable low-level outlet works under the dike, and there is only limited record of this outlet works in available information. The south abutment of this dike also contains a pumping facility that delivers water to Polly A. Deane Reservoir via the Bergen Ditch.

Bergen Dam No. 2 – Bergen Dam No. 2 is an existing high-hazard earthfill embankment with a height of 40 feet. The dam crest has a length of 1300 feet at crest elevation 5816.5. The upstream slope was designed for 2H:1V, and the current conditions are poor (see our site observations and photographs). The downstream slope is 3H:1V and protected with grass. With reservoir at normal water surface elevation of 5808, the reservoir has an area of 40 acres and a capacity of 726 acre-feet.

Appurtenant structures of this dam consist of a low-level outlet works and an emergency spillway. There is no information available on the outlet works, and this structure has failed and maybe unsafe to operate or inoperable (see site observations and photographs). The emergency spillway is located on the right abutment, and this structure was constructed in 1999 [3]. The emergency spillway consists of an approach channel, a 20-foot-wide upstream concrete control sill wall at crest elevation 5807.96, and an earth discharge channel and a second concrete cutoff wall.

Polly A. Deane Dam – Polly A. Deane Dam is an existing significant-hazard earthfill embankment with a height of 25 feet. The dam was rehabilitated in 1987 [4], which included improvements to the existing outlet works, new drains and filters, new riprap and bedding on the upstream slope, and a new emergency spillway. The embankment dam has a crest length of 1230 feet at elevation 5448. The upstream slope is 3H:1V and protected with riprap and bedding. The downstream slope is 3H:1V and protected with grass. With the reservoir at normal water surface elevation of 5843, the reservoir has an area of 38 acres and a capacity of 512 acre-feet.

Appurtenant structures for this dam consist of a low-level outlet works and an emergency spillway. The outlet works is located under the embankment, and consists of an intake structure that houses a sloping 12-inch slide gate, an 18-inch-diameter reinforced concrete pipe, and a concrete impact stilling basin. The emergency spillway is located on the right side of the embankment, and consists of an approach channel, a 25-foot-wide concrete-lined crest slab with a crest elevation 5843, and an earth discharge channel.

We understand that there are two pump stations on the left abutment that provide irrigation water to local parks and a golf course.

2.2 Project Description

This project consists of providing an independent assessment of the current dam-safety and other non-dam-safety issues identified by the SEO for the Bergen Dams, and recommendations and approach to mitigate these issues and to address SEO's concerns:

- Interim, short-term solutions for issues that required immediate attention.
- Engineering studies to characterize the dam sites and to provide additional data and more definitive identification of any dam-safety deficiencies.
- Permanent, long-term solutions to improve the safe performance of these dams.

There are no significant issues for Polly A. Deane Dam, which has been recently rehabilitated. We understand this dam was added to this project for completeness only, and because it is close to the Bergen Dams.

3.0 DOCUMENT REVIEW

3.1 General

For this study, Wheeler provided us with the following documents for review:

Geotechnical Investigation Report, Bergen Reservoirs No. 1 and 2, Jefferson County, Colorado, prepared by Chen and Associates, Denver, Colorado, September 28, 1984.

Slope Stability Analysis Report, Bergen Reservoirs No. 1 and 2, Jefferson County, Colorado, prepared by Chen and Associates, Denver, Colorado, October 15, 1984.

Geotechnical Analysis Report, Bergen Reservoisr No. 1 and 2, Jefferson County, Colorado, prepared by Chen and Associates, Denver, Colorado, November 5, 1985.

Hydrology Report for the Reconfiguration of Hine Lake (Polly A. Deane Reservoir), prepared by Holland West Inc., Englewood, Colorado, December 22, 1986.

Feasibility Report, Polly A. Deane Reservoir, Jefferson County, Colorado, prepared by CTL Thompson Inc., Denver, Colorado, August 29, 1986.

Technical construction specifications and drawings for Bergen Dam and Reservoir No. 1, Repair of North Outlet, prepared by W. W. Wheeler and Associates, Englewood, Colorado, January, 1987.

Construction specifications and drawings, Repair of Polly A. Deane Reservoir, Jefferson County, Colorado, prepared by CTL Thompson Inc., Denver, Colorado (draft), 1987.

Design Report, Bergen Reservoirs No. 1 and 2, Emergency Spillway Improvement, prepared by W. W. Wheeler and Associates, Englewood, Colorado, December, 1998.

Flood Hydrology Report, Bergen Reservoirs No. 1 and 2, prepared by W. W. Wheeler and Associates, Englewood, Colorado, November 1998 (Revised March, 1999).

Technical specifications and drawings for Bergen Reservoirs No. 1 and 2, Emergency Spillway Improvements, prepared by W. W. Wheeler and Associates, Englewood, Colorado, September, 1999.

Miscellaneous Colorado State Engineer Office records on Bergen Dam No. 1, Bergen Dam No. 2, Bergen Middle Dike, and Polly A. Deane Reservoir.

Miscellaneous drawings and figures on Bergen Dam No. 1, Bergen Dam No. 2, Bergen Middle Dike, and Polly A. Deane Reservoir.

We reviewed these documents to become familiar with the background of this project, and to understand the previously identified problems that were reported in the SEO inspection. There was no analysis performed for this study. A summary of our review is given below.

3.2 Review of Available Documents

A review of available documents that were furnished to us by Wheeler revealed the following information for the four dams:

Bergen Dam No. 1:

- The subsurface conditions of Bergen Dam No. 1 were investigated in 1984 [9] with two boreholes in the dam. These two boreholes indicated that the embankment fill in the dam consisted of 18 to 24 feet of medium stiff to very stiff sandy clay (CL) to clayey sand (SC). The foundation of the dam consisted of 8 to 12 feet of medium stiff to very stiff sandy clay (CL) over claystone bedrock.
- There were no records of any drains in the dam.
- A slope stability analysis performed in 1984 [9, 10, 11] indicated that the computed factor of safety for the upstream slope under rapid drawdown condition and the computed factor of safety for the downstream slope under steady-seepage condition (with reservoir at El. 5818) both met minimum SEO guidelines.
- The bedrock geology at the Bergen Dams consisted of interbedded shale and limestone dipping 30 to 35 degrees from the horizontal. There are four shale formations at the site: Pierre, Smoky Hill, Carlile, and Graneros. There are two limestone formations at the site: Fort Hays and Greenhorn. Most bedrock was mantled by colluvial soils and was not exposed except in excavations. The pseudo-static seismic load at the site is 0.1 g.
- The original outlet works consisted of a 16-inch steel pipe with a valve inside a rock masonry well. The outlet works was repaired in 1958 for leakage, and it appeared that the 16-inch pipe was replaced with a 12-inch cast-iron pipe and clay tile pipe. A major repair of the outlet works was constructed in 1987 [2], and consisted of the following components:
  a. Removed the old intake riser structure in the reservoir, and abandoned the upstream 12-inch clay tile pipe.
  b. Constructed a new precast concrete intake riser structure upstream of the old riser, including a new 12-inch Waterman slide gate, new gate platform, and new trashrack on top of the riser.
  c. Abandoned and removed the old 12-inch gate valve inside the old riser.
  d. Slip-lined an 8-inch SDR 17 HDPE pipe inside the 12-inch cast iron pipe.

- The current inflow design flood for the dam is 75 percent of the probable maximum precipitation, which exceeds the design storm for a significant-hazard dam. At the time when the new emergency spillway was constructed in 1999 [3], the required design storm was 50-percent of the probable maximum flood. Therefore, there is reserved hydraulic capacity in the spillways for this dam.

Bergen Dam No. 2

- Bergen Dam No. 2 was constructed in 1876 and was raised 10 feet in 1915. This dam has a long history of slumping of the embankment slopes (both upstream and downstream), and seepage problems. Specifically, cracking of the upstream slope had been reported east of the outlet works. The embankment and drains were repaired in 1925, 1943, 1947-1949.
- The embankment was designed with tile drains of various sizes: 4 inch, 6 inch, and 10 inch in diameter. Some of the tile drains appeared to be located as far upstream as under the dam crest. The locations of these drains are not well documented. In 1984, weirs were installed to monitor the seepage.
- The bedrock geology at the Bergen Dams consisted of interbedded shale and limestone dipping 30 to 35 degrees from the horizontal. There are four shale formations at the site: Pierre, Smoky Hill, Carlile, and Graneros. There are two limestone formations at the site: Fort Hays and Greenhorn. Most bedrock was mantled by colluvial soils and was not exposed except in excavations. The pseudo-static seismic load at the site is 0.1 g.
- A subsurface investigation, consisting of drilling five boreholes in the dam and downstream of the dam, was performed in 1984[9]. These boreholes indicated that the embankment fill consisted of 31 to 52 feet of stiff to very stiff sandy clay (CL) to clay sand (SC). The foundation of the dam consisted of 10 to 17 feet of very soft to stiff clay (CL), overlying interbedded claystone and sandstone. Some boreholes appeared to show that the embankment was constructed directly over claystone bedrock.
- A slope stability analysis performed in 1984 [9, 10] indicated that Bergen Dam did not have adequate slope stability under the steady seepage conditions (reservoir at El. 5813) and rapid drawdown condition. This conclusion is consistent with the slumping and cracking problems observed in the embankment slopes. However, subsequent stability analysis performed in 1998 [13] indicated that the upstream slope stability was adequate under rapid drawdown conditions for reservoir elevation 5808.
- The current spillway was constructed in 1999 [3], with a design storm of 75 percent of the probable maximum precipitation, which met the SEO guidelines for a high hazard dam at the time of the construction. The lower spillway channel, however, was only designed for the 100-year-flood flows, and some erosion damages of the lower channel during storms larger than the 100-year storm would be expected.

Bergen Middle Dike

- This dike has the least documented records. Specifically, there were no records of the design and construction of the dike embankment and outlet works. There were also no records of any repair work at this dike.
- This dike was investigated concurrent with the investigation of Bergen Dam No. 1 and No. 2 [9]. Based on four boreholes, the dike fill consisted of 7 to 12 feet of stiff to very stiff clayey sand (SC). The dike appeared to have founded directly on bedrock, which is a fractured limestone.
- Spillways on this dam have been discussed under Bergen Dam No. 1.

Polly A. Deane Dam

- The year of the original dam construction was not known. The dam was repaired and modified in 1950, and the work included raising the dam from 20 to 23 feet (downstream raise), and replacing a 12-inch outlet pipe with an 18-inch reinforced concrete pipe (RCP) with concrete cradle and cutoff collars.
- The geology at the site consisted of residual and alluvial overburden over Pierre Shale. The shale dipped steeply about 70 degrees from the horizontal.
- Eight boreholes were drilled in 1986 to investigate the dam and foundation [12]. These boreholes indicated that the embankment consisted of 7 to 19 feet of medium stiff to very stiff sandy clay (CL). The foundation consisted of 2 to 8 feet of stiff to very stiff sandy clay (CL) overlying claystone bedrock with sandstone interbeds.
- A seismic hazard study was performed for this dam, and no faults were reported under the dam [12]. That study did not include any seismic stability evaluation, and there are no records of any seismic stability analysis for this dam.
- The dam underwent a major rehabilitation in 1987 [4], which included the following work:
    1. Flattened the downstream slope to 3H:1V.
    2. Added a 2-foot-thick drain blanket and a 6-inch perforated PVC toe drain pipe with a gravel envelope.
    3. Regraded the upstream slope to 3H:1V, and added 18-inch thick riprap over 9-inch thick bedding.
    4. Added a concrete pavement on the dam crest.
    5. Modified the existing outlet works with a new concrete intake structure, a new 12-inch cast iron slide gate, a downstream extension of the 18-inch RCP, and a new energy dissipator stilling basin.
    6. Filled the old spillway channel, and constructed a new emergency spillway with a concrete cutoff sill and grouted riprap channel lining.
    7. Re-shaped the reservoir rim for development.

3.3 Inspection Records

Recent inspections by the SEO between 2003 and 2007 indicated the following potential deficiencies for the following dams:

Bergen Dam No. 1 (Bergen West) [5]:

- The upstream slope was too steep.
- The dam crest was not wide enough, misaligned, had a low area, and was improperly drained.
- The downstream slope was too steep, contained depressions from tree removal, with rodent damage, and some brush and trees.
- There was seepage at the toe of the dam on the right side of the outlet works.
- The gage rod was damaged.
- There were brush and trees on the upstream slope of the dam.

Bergen Dam No. 2 (Bergen East) [6]:

- The upstream slope was too steep, contained wave erosion scarps, had inadequate riprap armoring, and showed cracking.
- The dam crest was not wide enough, contained a low area, with ruts, and improperly drained.
- The downstream slope on the left end was too steep, with depressions from tree removal.
- The outlet works was deteriorated and close to collapse. The riser structure was damaged in 2006, with repair plans underway.
- There was erosion damage in the spillway channel, but the erosion was well below the control sill.
- The SEO had not received recent monitoring data.

Bergen Middle Dike (Bergen West Dike) [7]:

- The upstream slope was inadequately armored, with erosion scarps.
- The dam crest was not wide enough, with low area and improperly drained.
- The downstream slope was too steep, contained depressions, with point-source seepage left of the pumping facility.
- The outlet works was inoperable, with buckled gate stem and collapsed walkway.

Polly A. Deane Dam [8]:

- The upstream slope had inadequate riprap protection (locally).
- There were ruts in the footpath.
- The downstream slope had local bare spots, with rodent damage.

- The ground at both sides of the outlet works stilling basin was saturated.
- There was cracking in the grouted riprap spillway channel, with undercutting left side of the spillway inlet.

Action items recommended in the SEO reports for these four dams include:

Bergen Dam No. 1 (Bergen West Dam) [5]:

- Provide additional riprap as necessary on the upstream slope.
- Clear trees and brush on the dam.
- Provide rodent control.
- Monitor wet area at the downstream toe.
- Repair damaged gage rod.

Bergen Dam No. 2 (Bergen East Dam) [6]:

- Provide additional riprap on the upstream slope.
- Lubricate and exercise outlet gate.
- Provide rodent control.
- Improve drainage on dam crest.
- Monitor seepage and submit data.
- Install survey monuments on dam crest.
- Inspect outlet works internally.

Bergen Middle Dike (Bergen West Dike) [7]:

- Provide riprap on the upstream slope.
- Lubricate and test outlet gate.
- Grade dam crest to slope upstream.
- Monitor seepage

Polly A. Deane Dam [8]:

- Provide rodent control.
- Monitor flows in toe drains and submit data.
- Flush toe drains.
- Inspect outlet works internally.

4.0 SITE VISIT OBSERVATIONS

We visited the four dam sites on August 21, 2007 to observe the conditions and other features of the dams and foundations. Other personnel in the site visit included:

James Ferentchak – W. W. Wheeler & Associates
Scott Sauvageau – Dam caretaker

On the day of the site visit, skies were clear, and temperatures ranged from 80s to 90s degrees Fahrenheit. The following features of the dams were observed: upstream slope, crest, and downstream slope of the embankment, downstream toe of the embankment, outlet works, and spillways. Several representative photographs of the sites taken during our visit are contained in Appendix A (Bergen Dam No. 1), Appendix B (Bergen Dam No. 2), Appendix C (Bergen Middle Dike), and Appendix D (Polly A. Deane Dam).

The following is a summary of our observations:

Bergen Dam No. 1

1. The exact reservoir elevation on the day of the site visit was not known, but is estimated to be lower than El. 5816.8. According to Mr. Scott Sauvageau, the reservoir elevation on August 1, 2007 was 5816.8, and it is likely the reservoir level had dropped somewhat below that elevation. There was no water diverted through the inlet, and the outlet gate was closed. Neither the service spillway nor the emergency spillway was in operation.
2. The upstream slope is in acceptable condition (see Photo A1). The slope above the water line was armored with sound riprap in the range of 12 to 24 inches in size. No obvious displacements were noted. The top 8 to 10 feet of the slope was about 1H:1V (horizontal:vertical) to 1.5H:1V, and the slope appeared to "beach" below the water line. The upstream slope west of the outlet works was overgrown with woody vegetation, with some trees as large as 24 inches in trunk diameter (see Photo A2).
3. The dam crest is in good condition (see Photo A3). The crest width was measured to be about 10 feet, which is narrower than the SEO minimum guidelines. The crest is protected with grass, with no noticeable low areas, misalignment, rutting, or adverse drainage.
4. The downstream slope is in acceptable condition (see Photo A3). The slope was observed to be 1.5H:1V to 2H:1V, and protected with grass. The grass on the slope was only partially mowed because of the presence of a wire fence at the toe of the slope (see Photo A4).
5. The abutments and downstream toe areas are in poor conditions. No evidence of seepage was observed along the toe; however, there was a near-continuous line of trees and brush along the entire toe (see Photo A4). We understand that Mr. Scott Sauvageau and Mr. James Ferentchak had reported non-point-source seepage along the right downstream toe at higher reservoir levels. According to Mr. Scott

Sauvageau, removing these trees and brush along the toe was complicated by two factors:

- The vegetation is grown downstream of the fence, which is outside the ditch company's property.
- The fence makes it difficult to cut the trees and brush with mechanized equipment.

6. The right abutment has a 1- to 2-foot low area (see Photo A6). This low area may jeopardize the available minimum freeboard during the spillway design flood.
7. The recently rehabilitated low-level outlet works is in good condition (see Photo A6). The on-going sediment accumulation at the diversion inlet location near the intake structure (see Photo A7) presents a continuous maintenance problem to the operation of the outlet works. According to Mr. Scott Sauvageau, sediments would enter into the outlet intake well through the trash screen, and the outlet gate would need to be operated every month to flush out the sediments inside the well.
8. The outlet works discharges into a small plunge pool without a stilling basin. There was no water in the pool, and no riprap protection was observed in the pool. We did not observe any erosion damage in the plunge pool.
9. The service spillway is adjacent to the pump station (see Photo C10) on the south abutment of the Bergen Middle Dike. The spillway crest control (see Photo C6 in Appendix C) appears to be the access road, and is unlined. No erosion damage to the spillway crest was observed. The spillway discharge channel slopes steeply into Bergen Reservoir No. 2, and the channel was excavated in the Fort Hays Limestone Formation. Portion of the spillway channel on the right side (looking downstream) was undercut by previous discharges, but presented no dam-safety problem (see Photo C7 in Appendix C).
10. The emergency spillway is an open channel excavated in the Fort Hays Limestone Formation in the north abutment of Bergen Middle Dike (see Photo C8 in Appendix C). The exposed bedrock is tan-colored, with some weathering and fractures, and appeared to be in sound condition (see Photo C9 in Appendix C).

<u>Bergen Dam No. 2</u>

1. The exact reservoir elevation on the day of the site visit was not known, but is estimated to be lower than El. 5809.2. According to Mr. Scott Sauvageau, the reservoir elevation on August 1, 2007 was El. 5809.2, and it is likely the reservoir had dropped somewhat below that elevation. The outlet works was closed and not functioning. The spillway was not in operation.
2. The upstream slope is in very poor condition. The visible portion of the slope is too steep, and is inadequately protected from wave erosion (wind and speed-boat generated). The slope ranged from near vertical to 1H:1V above the water line (see Photo B1 in Appendix B). There was a relatively new vertical scarp near the right end (looking downstream) of the dam (see Photo B2); according to Mr. Scott Sauvageau, this may be related to the higher operating pool in the past two years. The riprap coverage is inadequate, with numerous areas lacking any rocks. The riprap appeared to be undersized, ranging from 4 to about 15 inches in sizes, and does not have any bedding. Some cracks were observed near the right end of the

dam (see Photo B3 and B4), indicating evidences of past or on-going slope movements. There were numerous dead willows stumps along the entire slope, apparently a result of periodic vegetation control. Near the left abutment, the upstream slope has several large trees growing in this area (see Photo B5).

3. The dam crest is in acceptable condition (see Photo B6). The crest width is non-uniform, ranging from 12 to about 16 feet. The crest is protected with a grass cover, and some minor rutting was observed. There were no survey monuments or station marker on the dam crest of this high-hazard dam.
4. The downstream slope is in good condition (see Photo B7), and was mowed and well maintained. The slope is generally about 3H:1V, with a steeper slope of about 1.5H:1V near the left end (looking downstream) of the dam. Some isolated depressions were observed on the slope, apparently caused by past tree-removal activities. There were no woody vegetation on the entire slope.
5. The right abutment is in poor condition because of a vertical scarp just upstream of the dam (see Photo B8). The scarp was up to about 10 feet high, and appeared to be caused by wave erosion. There was no erosion protection of the right abutment.
6. The seepage conditions of the dam are poor, and there was evidence of active piping through one of the tile drains, discharging into Weir No. 2 (Fig. 2). There are several weirs (e.g. see Photo B10 and B11) and flumes to monitor seepage along the toe and downstream of the dam, but these devices are all in poor conditions. In addition, these monitoring devices are not protected from cows grazing along the toe of the dam, and there appeared to be some animal damage.
7. A seepage area was observed downstream and to the east of the outlet works discharge (see Photo B9). This seepage area is generally along the outlet channel, and flows up to about 1 to 2 gallons per minute (gpm) were observed. Flows appeared to be clear, and we were unable to locate any point-source discharge causing these flows.
8. Evidence of piping (internal erosion) was observed at a 6-inch tile drain outlet located just upstream of Weir No. 2 (see Photo B11). The drain was flowing clear water at a rate of about 2 to 3 gpm. Silty sand sediments were accumulated at the bottom half of the drain outlet (see Photo B12), and these materials were also observed between the drain outlet and the weir.
9. The outlet works had been damaged and is not operable (see Photo B13). At the time of our visit, the riser structure was tilted, and the damaged portion was under water. A photograph provided by Mr. James Farentchack of W. W. Wheeler and Associates (Wheeler) showed that the bottom of the riser structure had collapsed (see Photo B14).
10. The downstream end of the outlet pipe was 18 inches in diameter, but whether the entire pipe was 18 inches and the gate size are unknown.
11. The spillway is in good condition (see Photo B15). According to Mr. Scott Sauvegeau, there is a low area along the discharge channel (see Photo B16) downstream of the control sill which would pond water when it rains, and the low area appeared to be created from spillway construction. There was some erosion downstream of the spillway channel (see Photo B17), but the erosion is too far downstream to be a dam-safety problem.

Bergen Middle Dike

1. Bergen Middle Dike separates Bergen Reservoir No. 1 and No. 2 (see Photo C1). The service spillway and emergency spillway of Bergen Dam No. 1 and a pumping facility are located along this dike and its abutments. The "upstream slope" of this dike is the west-facing slope on the Bergen No. 1 Reservoir side, and the "downstream slope" is the east-facing slope on the Bergen No. 2 Reservoir side.
2. The upstream slope of the dike is in poor condition (see Photo C4). The upper 7 to 8 feet of the slope was very steep, and the lower portion was protected with 12- to 18-inch riprap with no apparent bedding. Some dead stumps of willows were present along the slope.
3. The dike crest is in acceptable condition (see Photo C1, C3, and C4). The crest width is 7 to 8 feet, which does not meet SEO minimum guidelines. The crest surface is protected with grass, with no rutting, but appeared to slope toward the downstream side.
4. The downstream slope of the dike is in acceptable condition (see Photo C2 and C3). The slope is protected with grass, with some woody vegetation. Part of the slope is locally steep, about 1H:1V. Because of the locally steep slope, and the reservoir at the bottom of the slope, part of the slope cannot be mowed safely.
5. Limestone bedrock (see Photo C7 and C9) was observed in both north and south abutments of the dike. The service spillway of Bergen Dam No. 1 (see Photo C6 and C7) is located on the south abutment, and the emergency spillway of Bergen Dam No. 1 (see Photo C8) is located on the north abutment. Descriptions of the conditions of these two spillways are provided in the observations for Bergen Dam No. 1.
6. A low-level outlet works pipe was reported under this dike, but this outlet works is not functioning because the control riser structure and the walkway had collapsed (see Photo C5).

Polly A. Deane Dam

1. The exact reservoir elevation on the day of the site visit was not known, but is estimated to be lower than El. 5839.1. According to Mr. Scott Sauvageau, the reservoir elevation on August 1, 2007 was 5839.1, and it is likely the reservoir level had dropped somewhat below that elevation. The outlet works appeared to be closed, and the spillway was not in operation.
2. The upstream slope is in good condition (see Photo D1 in Appendix D). The uniform slope was well protected with sound riprap 18 to 24 inches in sizes. Minor brush was observed on the slope near the left end of the dam (see Photo D5).
3. The dam crest is in good condition (see Photo D2). The crest is surfaced with a concrete slab with a grass shoulder on the upstream side. There was minor rutting on the grass shoulder. The concrete slab is in good condition.

4. The downstream slope is in good condition (see Photo D2). The slope is protected with grass, and is well maintained. There were two minor erosion areas on the slope face caused by pedestrian foot traffic (see Photo D3 and D4). Both areas are on the left side (looking downstream) of the outlet works.
5. Both abutments and the downstream toe are in good condition. No seepage was observed along the toe of the dam. A small tree was growing at the toe just to the left of the outlet works stilling basin (see Photo D6).
6. Three 6-inch outfalls, each with a V-notch weir, are located on the stilling basin wall (see Photo D7). The following is our estimate of the flows from the drains:

   Left drain: < 1 gpm
   Middle drain: 2 – 3 gpm
   Right drain: < 1 gpm
7. The outlet works control was located within a fence, and was not operated during our visit. The exposed gate stem along the upstream face appeared to be in good condition. The outlet pipe at the discharge end is submerged by the backwater in the outlet channel, which did not allow visual observation of the interior of the pipe or allow an estimate of any gate leakage. Some debris was observed in the outlet channel just downstream of the stilling basin (see Photo D8).
8. The spillway is in good condition (see Photo D9). There were several grown trees and numerous tree saplings along the approach channel (see Photo D10 and D12). Some stones were missing in the grouted riprap along the left side of the approach channel (see Photo D11).

5.0 EVALUATIONS

5.1 Evaluation of Bergen Dam No. 1

There are no apparent dam safety deficiencies for Bergen Dam No. 1. With the exception of the difficulty to control some woody vegetation on the dam, the dam is considered to be well maintained. In spite of the absence of any potential dam safety deficiencies, the on-going accumulation of sediments around the outlet works intake would eventually affect the function of this structure, and would need to be addressed over long term.

Bergen Dam No. 1 appeared to be designed as a homogeneous embankment based on limited subsurface investigation data. The fill appeared to be adequately compacted based on the stiff consistency from the borehole samples. There were no internal drains in the dam for seepage control. The dam crest width is too narrow, and it does not meet current SEO guidelines.

The 1987 repair of the outlet works had significantly improved the safety of this structure. We have the following comments regarding the 1987 design of the repair:

- The 8-inch HDPE outlet pipe is assumed large enough for reservoir evacuation, but is considered to be too small in modern-day outlet works. In spite of a trashrack, the 8-inch pipe would still be subject to clogging by debris that escapes through the trashrack openings, and the small size would only allow remote inspection. Manual repair and maintenance of a pipe this small would be impossible. Having pointed this out, it is our opinion that the pipe size does not constitute a deficiency, and does not require any action at this time.
- There is no filter collar around the outlet pipe for seepage control. No seepage has been observed or reported around the conduit, and the lack of filter collar is not considered to be a problem at this time.
- There are no design provisions to mitigate the accumulation of significant sediments around the outlet intake. The current method of monthly flushing may be adequate as a short-term solution to prevent plugging of the intake. This method may not be effective if more sediments continue to accumulate around the intake.

Even though this dam was not designed with any seepage control provisions, the seepage performance of this dam has been acceptable thus far. The SEO reported a non-point-source seepage area on the right side of the outlet works, but no seepage was observed during our site visit, and the downstream toe of the dam was dry. Because of the adequate seepage performance, it is our opinion that a new toe drain is not needed at this time, unless future seepage observations reveal any evidence of significant uncontrolled seepage problems (such as excessive flows, evidence of piping, etc.).

5.2 Evaluation of Bergen Dam No. 2

The overall condition of Bergen Dam No. 2 is considered to be unsatisfactory. This dam has a long history of poor performance in terms of seepage and stability, and the current performance of this dam is poor in many areas, as discussed below. In addition, the outlet works has failed and is inoperable. There are numerous potential dam-safety deficiencies for this dam, including:

Seepage – The seepage control provisions in this dam are inadequate, and uncontrolled seepage has been observed, including some evidence of active piping in one of the tile drains. This dam was designed as a homogeneous embankment, and records indicated that tile drains (4-inch, 6-inch, 10-inch diameter) were used in the dam to control seepage. However, these tile drains typically have open joints without gasket seals, and there appeared to be no filter envelopes around the drains. During our site visit, we observed sediments inside and outside the outfall of one of the drain pipes (see site observations), which may be evidence of active piping (internal erosion) of the embankment fill and/or foundation soils. At this time, monitoring and reporting of the seepage are considered as inadequate, and the current instruments (weirs, flumes) would need to be improved for better collection and measurement, and also protected from grazing animals. The three drain manholes collect seepage from various drains, but flows are not measurable in these manholes, and observation of flows in the manholes are not possible because there is no access to the bottom of the manholes. There are no piezometers in this dam that would provide information on the internal water levels for seepage analysis. We also observed other uncontrolled seepage areas just downstream of the outlet works (see site observations).

Stability – The stability of the upstream slope is inadequate, based on the observed poor performance. Slumping and cracking of the slope had been observed and reported, and these problems appear to be on-going (see site observations). The cause of the slope movements is not known, and there is no effective monitoring program to investigate the slope movements. It is unclear whether the movements are limited to the top portion of the slope which is oversteepened by wave erosion, or the movements are indicative of a more deep-seated foundation problem.

Upstream slope erosion protection – The erosion protection of the upstream slope is unacceptable. The riprap on the slope is undersized and has no granular bedding, and is missing in many places. Wave erosion (whether wind-generated or from speed boats) has caused significant scouring and over-steepening of the top portion of the slope. This problem appears to be worsening, perhaps in part from operating the reservoir at higher levels in recent years.

Failed outlet works – This dam does not have a functional outlet works because the riser structure has failed and may be inoperable. An inoperable outlet works in a high hazard dam is considered to be a dam-safety deficiency because it prevents the ability

to lower the reservoir quickly in the event of an emergency. In addition, it is not clear at this time whether the failure of the riser structure will cause any uncontrolled seepage along the conduit.

5.3 Evaluation of Bergen Middle Dike

The overall condition of Bergen Middle Dike is considered to be unsatisfactory, primarily because of the poor condition of the upstream slope. The difficulty to maintain the steep downstream slope of the embankment is a maintenance issue. Contrary to Bergen Dam No. 2, the failed outlet works for this dam is not considered to be a dam-safety problem, as discussed further below. The narrow crest width currently does not meet minimum SEO guidelines.

The condition of the upstream slope is considered to be a dam-safety deficiency. The riprap on the upstream slope is undersized and does not have a granular bedding, and riprap is missing in many places. Wave erosion (whether wind generated or by speed boats) has caused significant scour and over-steepening of the top portion of the slope. Continued erosion of the upstream slope may cause overall stability problem of the embankment, and may encroach on the already narrow dam crest.

The seepage condition of the dam is considered to be acceptable at this time. This dam was designed as a homogeneous embankment, with no drains for seepage control. Previous investigation indicated that the dike embankment was constructed directly on limestone bedrock. The bedrock is jointed and fractured, and it is doubtful that the bedrock had been treated prior to the dike fill placement. Some seepage had been reported by the SEO at the toe of a "stone wall", with clear flow of 3 to 5 gpm, and also left of the pumping facility. These seepage sources were not verified during our site visit. In spite of the lack of seepage control, dike foundation treatment, and observed seepage, it is our opinion that the seepage condition is acceptable because of the low hydraulic gradient (that is, small head difference between the two reservoirs) across the dike under normal operating conditions.

The failed outlet works for this dike is not considered a dam-safety issue because the lack of low-level flow control from Reservoir No. 1 to Reservoir No. 2 is an operational issue. The dike is a low-hazard dam, and a hypothetical failure of the outlet conduit with uncontrolled release of water from Reservoir No. 1 will be safely contained in Reservoir No. 2. It would appear that the pumping facility and the siphon pipe allows water to be moved from one reservoir to another, and the need for a replacement outlet works for the failed structure is questionable. Nevertheless, the presence of a failed structure in the dike should be addressed: it can be either grouted or removed.

We understand that some woody vegetation is still left on the downstream slope of the dike because of the steep slope in those areas and the presence of Reservoir No. 2 at the toe of the slope. Mr. Scott Sauvageau indicated it is unsafe to mow or remove the woody vegetation in those areas, and we concur. Consideration should be given to flatten the

downstream slope for maintenance of this slope, and to add a safety barrier at the toe for worker safety.

5.4 Evaluation of Polly A. Deane Dam

The overall condition of Polly A. Deane Dam is good and well maintained. This dam has undergone a major rehabilitation in 1987, and there is no dam-safety deficiency. We have the following comments regarding the 1987 rehabilitation design:

- There is no filter collar around the 18-inch outlet pipe. The new drain blanket that was added on the downstream side is above the pipe, and does not provide seepage protection for the pipe.
- The inlet openings of the new drain pipes appear to be smaller than what are typically used. All three of the drains appear to be functioning and flowing. The SEO has suggested flushing of the toe drains, and it should be done if clogging of the drains becomes a problem.
- The outlet works installed in 1950 included concrete cutoff collars around the conduit, and these collars remain in the current outlet works. Cutoff collars for outlet conduit are no longer used in dam design because of the potential for poor compaction around these features and other related seepage problems. There is no uncontrolled seepage reported for this outlet works.
- The outlet pipe is submerged by the tailwater in the outlet channel. This condition is undesirable from the standpoint of monitoring because the submergence does not allow observation of any leakage of the control gate and also visual observation of the pipe interior condition. This condition can be improved by lowering the outlet channel by about 2 feet to expose the 18-inch pipe.

6.0 RECOMMENDED COURSE OF ACTIONS

6.1 General

Our recommended course of action for each of the four dams includes data collection or study, interim repair and maintenance, monitoring, and long-term repair and upgrade. The purpose for each of the four action categories is:

Data collection or study – This action item is intended to obtain additional data because the currently available information is insufficient to assess a potential dam-safety problem. This item includes field investigations, surveys, laboratory testing, and engineering analysis and evaluation.

Interim repairs and maintenance – This action item is intended to provide short term solutions to developing problems while more costly long-term solutions are being evaluated. This item also includes maintenance work that has been identified by either SEO inspections or in this study. Generally, completion of this action item can be accomplished with owner's maintenance work force without engaging a contractor, and approval by the SEO is not required.

Monitoring – This action item is intended to identify specific performance behavior which will be useful to assess a potential dam-safety problem, and generally includes visual observation, reading of existing instruments, and installation and reading of new instruments. It is important that for those dams with dam instrumentations such as weirs, flumes, and survey monuments, the data that are read should be evaluated by a qualified engineer and also submitted periodically to the SEO.

Long-term upgrades and repair – This action item is intended to mitigate a potential or definitive dam-safety deficiency, and typically involves a structural modification to the dam with contract construction. Construction documents are required for this work, with approval of the design by the SEO.

Table 1 is a summary of the recommended course of actions for the four dams. Table 1 lists the recommended priority among the four dams, with Bergen Dam No. 2 being the highest priority, and Polly A. Deane Dam being the lowest priority. In addition, under each action category, the recommended work is numbered in order of priority and importance. The order of priority is based on our assessment as to how probable an observed adverse behavior (e.g. uncontrolled seepage, slope movement, inoperable outlet works) would lead to a particular mode of failure. In general, problems that develop under usual loading conditions (i.e. normal pool) such as uncontrolled seepage, wave erosion, and slope movements would be more urgent than other problems involving more remote loadings such as large storms or earthquakes.

6.2 Recommendations for Bergen Dam No. 1

Recommended course of action for Bergen Dam No. 1 is summarized in Table 1. None of the recommendations is considered to be urgent. Some of the interim repairs are routine maintenance items such as monthly flushing of the outlet works, tree removal and repair of the damaged gage rod. The low area in the right abutment should be filled to match the dam crest elevation so that the abutment will have adequate residual freeboard during the inflow design flood (IDF) or will not be overtopped during the IDF.

The current sediment problem around the outlet works intake should be addressed over the long term. At this time, it appears the problem is mitigated with monthly flushing. However, as more sediments accumulate in this area, it is possible that flushing may not be effective to prevent blockage of the outlet works intake, and renders the outlet works non-functional. The loss of the outlet works function will be a dam-safety deficiency because the reservoir cannot be drained quickly in the event of an emergency. We recommend a study to investigate options (such as extending the intake structure into the reservoir away from the sediments) to modify the existing outlet works to avoid the sediments.

If the outlet works will be modified, then we recommend also that the dam crest be widened to the required minimum of 15 feet during that construction.

6.3 Recommendations for Bergen Dam No. 2

Recommended course of action for Bergen Dam No. 2 is summarized in Table 1. There are two action items that would deserve immediate attention, and both items should be considered as urgent:

> *Mitigate uncontrolled seepage problem* – Historically, the most common mode failure for embankment dams is seepage and piping (internal erosion), and Bergen Dam No. 2 has shown poor seepage performance with potential active piping in one of the embankment drains. The dam is designed with deficient drains, with ungasketed joints and no filters around the drains. There is a lack of understanding of the seepage conditions in the dam, with no piezometers to provide water levels in the dam, and seepage monitoring is ineffective.
>
> Recommended actions to mitigate the uncontrolled seepage problem include:
>
> a. Collect data to provide a comprehensive seepage study. The required data collection include a camera survey to inspect the existing drains for sediments and damages, installing piezometers in the dam, flow and sediment observations from the existing drains, and flows inside the three existing manholes.
> b. Improve current seepage monitoring program by repairing the existing weirs and providing access to the bottom of the manholes to observe flows

from the drains. Specifically, seepage monitoring at Weir No. 2 should include observation and measurement of sediment accumulation upstream of the weir from the 6-inch tile drain. All of the weirs and flumes should be protected from damage from cows which graze freely at the toe of the dam.

c. A comprehensive seepage study should include a better understanding of the current configurations and locations of all of the drains in the dam that were installed at different times, seepage analysis to estimate expected flows for comparison with observed flows, identification of potential uncontrolled seepage and piping paths, evaluation of any potential voids in the embankment and foundation from past piping, and long-term mitigation solution options. This study should preferably be performed concurrent with the data collection and monitoring under the direction of a qualified geotechnical engineer.

d. Long-term repair should be implemented as soon as possible after completion of the seepage study. Long-term repair should address the presence of the ungasketed tile drains in the dam, the lack of downstream filters, and possible voids in the dam and foundation.

Repair outlet works – The existing outlet works is damaged and inoperable, and should be repaired immediately. The internal inspection of the outlet works should be performed as suggested by the SEO to obtain a better understanding of the existing configuration of this structure such as pipe size(s), type of pipe, type of valve, joint conditions, lengths, etc. We understand there is an on-going study on options to repair the outlet works. The outlet works repair should be constructed as soon as possible.

Construction of the outlet works repair would require draining of the reservoir. The temporary removal of the reservoir would affect the recommended seepage monitoring, and should be properly timed in order to obtain as much seepage monitored data as possible. In addition, if the reservoir is drained for the outlet works construction, then that would be a good opportunity to rebuild the upstream slope and riprap protection.

The repair of the upstream slope should also deserve a high priority, even though the poor conditions of the slope does not immediately jeopardize the safety of the dam. Prior to the re-construction of the upstream slope, there are several interim repairs that should be done before they become more serious problems. These include:

a. Stabilizing the vertical scarps near the right end of the dam and in the right abutment.

b. Collect data and perform a geotechnical investigation to understand the reason for the upstream slope movement. The current monitoring of the slope movement with driven rebars does not appear to be effective, and installation of properly constructed surface survey monuments as well as

inclinometers in boreholes is recommended for better understanding of the source of the movement.

Re-construction of the upstream slope should include excavation of the existing riprap, re-shaping and flattening of the slope to mitigate any stability problem in the dam or foundation, and placement of adequately sized riprap on a granular bedding. The right abutment is subject to wave erosion, and should be protected with riprap as well. If the upstream slope is modified, then the dam crest can be widened to the required minimum of 18 feet toward the upstream side in order to avoid disturbing the acceptable downstream slope.

Other recommended interim repairs and maintenance work include tree removal near the left abutment, filling in a low area in the spillway channel, and filling in some erosion in the lower spillway channel. None of this work is considered as critical and would be considered as low priority.

The installation of survey monuments and station markers on the dam crest is to comply with the SEO requirements for a high-hazard dam which requires these instrumentations. Because of the all the future monitoring for seepage, slope movements, wave damages, etc., the installation of station markers will allow more meaningful reporting of these problems, and facilitate future evaluations and communication on the problem areas.

6.4 Recommendations for Bergen Middle Dike

Recommended course of action for Bergen Middle Dike is summarized in Table 1. The top priority for this dam is repair of the upstream slope over long term. The reported seepage by the SEO should be monitored visually, and it is our opinion that the seepage problem is not critical for this dam (see Section 5.3). The damaged outlet works should be inspected internally so that a study can be done to determine whether it should be repaired or abandoned. As discussed in Section 5.3, an inoperable outlet works for this dike is not considered as a dam-safety deficiency, but would still need to be addressed eventually.

Re-construction of the upstream slope of the dike should include excavation of the existing riprap, and placement of adequately sized riprap on a granular bedding. If the upstream slope is modified, then the dike crest can be widened to the required minimum of 13 feet. Whether it is more economical to widen the crest on the upstream side or downstream side is not known at this time. If the outlet works for Bergen Dam No. 1 needs to be modified, and the reservoir is drained for that construction (see Section 6.1), then it would be a good opportunity to re-construct the upstream slope of Bergen Middle Dike.

6.5 Recommendations for Polly A. Deane Dam

Recommended course of action for Polly A. Deane Dam is summarized in Table 1. None of the recommended action items is considered to be high priority. However, some of the

recommended interim repair and maintenance items should be performed in the next few years before they become bigger problems. These include:

- Removal of trees and saplings along the spillway approach channel.
- Removal of a tree adjacent to the outlet works stilling basin.
- Armoring of the foot paths on the downstream slope of the dam. Re-seeding of the foot paths may not be effective because the public would likely keep using these paths for downstream access. Instead, more hardened surface such as precast concrete blocks flush-mounted with the ground surface can be considered.

The SEO recommended that the toe drains be flushed, and we concur that this should be a periodic maintenance item if blockage by algae is a problem.

The reasons for lowering the outlet works discharge channel are discussed in Section 5.4. It is possible that modification to the channel may require SEO approval before construction.

7.0 REFERENCES

[1] Colorado State Engineer Office, *Rules and Regulations for Dam Safety Construction*, Division of Water Resources, Department of Natural Resources, January 1, 2007.

[2] W. W. Wheeler and Associates, Inc. "Technical construction specifications and drawings for Bergen Dam and Reservoir No. 1, Repair of North Outlet", January, 1987.

[3] W. W. Wheeler and Associates, Inc. "Technical specifications and drawings for Bergen Reservoirs No. 1 and 2, Emergency Spillway Improvements", September, 1999.

[4] CTL Thompson Inc. "Construction specifications and drawings (draft), Repair of Polly A. Deane Reservoir, Jefferson County, Colorado", 1987.

[5] Colorado State Engineer Office, "Engineers Inspection Report, Bergen Dam West (Bergen Dam No. 1)," Division of Water Resources, Dam Safety Branch, Denver, Colorado, July 7, 2004.

[6] Colorado State Engineer Office, "Engineers Inspection Report, Bergen Dam East (Bergen Dam No. 2)," Division of Water Resources, Dam Safety Branch, Denver, Colorado, March 21, 2007.

[7] Colorado State Engineer Office, "Engineers Inspection Report, Bergen West Dike (Bergen Middle Dike)," Division of Water Resources, Dam Safety Branch, Denver, Colorado, March 21, 2007.

[8] Colorado State Engineer Office, "Engineers Inspection Report, Polly A. Deane Dam," Division of Water Resources, Dam Safety Branch, Denver, Colorado, May 20, 2003.

[9] Chen and Associates, "Geotechnical Investigation Report, Bergen Reservoirs No. 1 and 2, Jefferson County, Colorado", September 28, 1984.

[10] Chen and Associates, "Slope Stability Analysis Report, Bergen Reservoirs No. 1 and 2, Jefferson County, Colorado" October 15, 1984.

[11] Chen and Associates, "Geotechnical Analysis Report, Bergen Reservoisr No. 1 and 2, Jefferson County, Colorado", November 5, 1985.

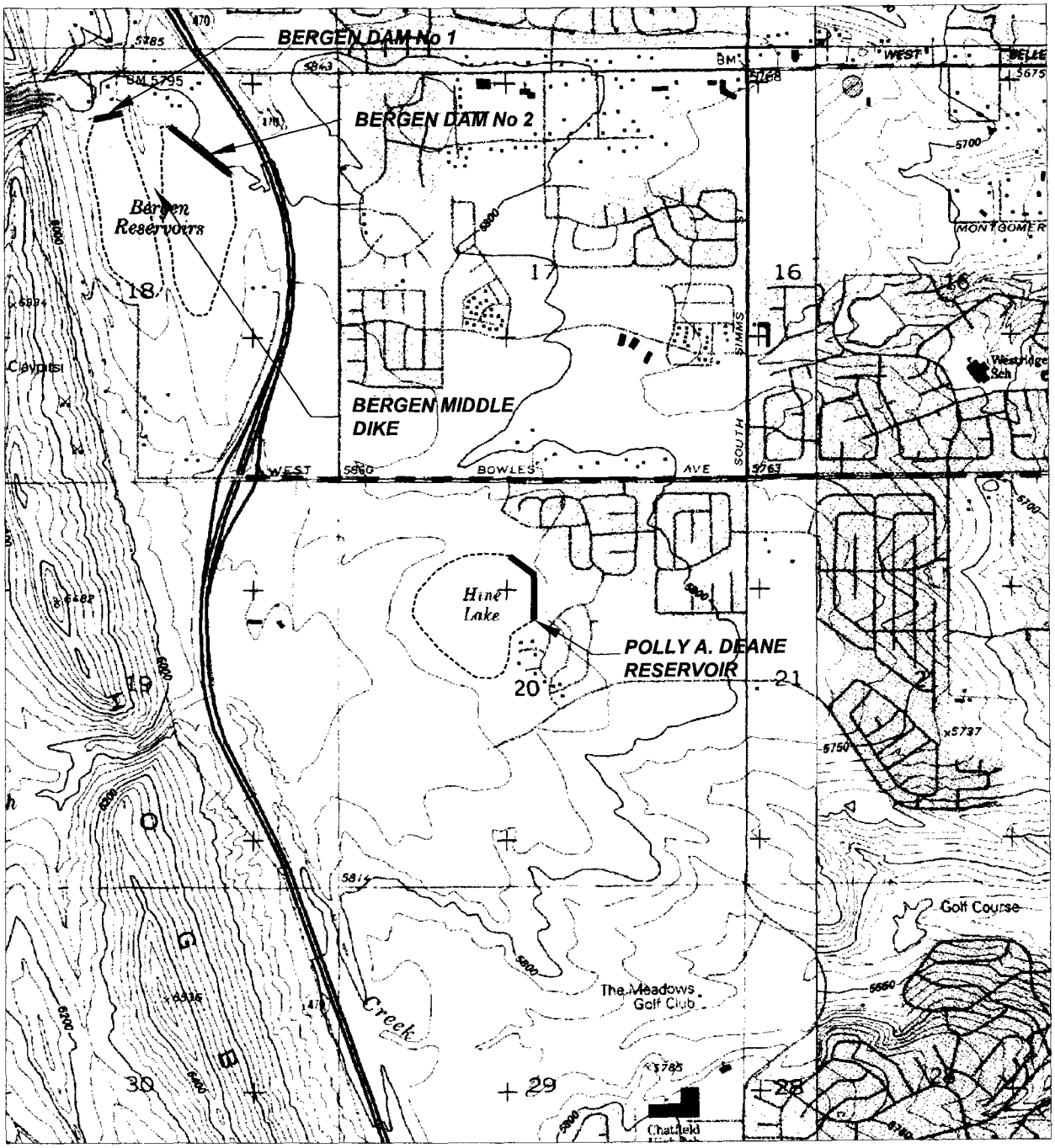
[12] CTL Thompson, Inc. "Feasibility Report, Polly A. Deane Reservoir, Jefferson County, Colorado", August 29, 1986.

[13] W. W. Wheeler and Associates, Inc. "Design Report, Bergen Reservoirs No. 1 and 2, Emergency Spillway Improvement", December, 1998.

Table 1
Summary of Recommended Course of Actions
Safety Evaluation of Four Dams
Bergen Ditch and Reservoir Company

Name of Dam (Note 1)	Data Collection/Study (Note 2)	Interim Repairs/Maintenance (Note 2)	Monitoring (Note 2)	Long-Term Upgrades and Repair (Note 2)
1. Bergen Dam No. 2	1. Inspect outlet works internally 2. Inspect dam drains internally 3. Perform geotechnical study to investigate seepage, dam stability, and install piezometers	1. Repair weirs and provide animal guards. 2. Provide access to bottom of 3 manholes 3. Stabilize vertical scarps near right end of embankment and at right abutment. 4. Repair erosion in lower spillway channel. 5. Remove trees on upstream slope near left abutment 6. Fill in low area in spillway channel between cutoff walls.	1. Monitor sediments from toe drain at Weir No. 2. 2. Monitor seepage with upgraded weirs and flumes and submit data to SEO. 3. Install piezometers 4. Monitor drains inside manholes 5. Install inclinometers at right side of dam 6. Install survey monuments. 7. Install station markers	1. Mitigate seepage deficiency in the dam. 2. Repair and re-construct outlet works. 3. Rebuild upstream slope with new slope, riprap, and granular bedding. 4. Armor right abutment from wave erosion. 5. Widen dam crest to 18 feet.
2. Bergen Middle Dike	1. Inspect outlet works internally 2. Evaluate need for existing outlet works and method of abandonment or replacement if necessary.	1. Remove trees at downstream slope and toe.	1. Monitor seepage visually along downstream slope and toe.	1. Rebuilt upstream slope with new slope, riprap, and granular bedding. 2. Repair or abandon damaged outlet works. 3. Flatten downstream slope to facilitate maintenance and improve safety 4. Widen dam crest to 13 feet
3. Bergen Dam No. 1	1. Evaluate permanent solution to control blockage of outlet works by sediments	1. Continue flushing of outlet works to control sediments 2. Remove trees on upstream slope, downstream slope, and downstream toe 3. Fill in low area in right abutment 4. Repair damaged gage rod	1. Monitor downstream toe seepage visually	1. Modify outlet works to mitigate sediment problem 2. Widen dam crest to 15 feet
4. Polly A. Deane Dam	None	1. Flush toe drains 2. Remove trees on upstream slope near left end of embankment, at downstream toe adjacent to outlet works, and along spillway approach channel. 3. Repair hole in grouted riprap on left side of spillway approach channel. 4. Remove debris in outlet channel. 5. Provide concrete blocks for foot traffic on downstream slope	1. Monitor flows in dam drains with V-notch weirs and submit data to SEO.	1. Lower outlet works channel by 2 feet to expose outlet pipe.

Notes: 1. Listed in order of recommended priority for the four dams.
2. Listed in order of recommended priority for each of the action categories.



BERGEN DITCH & RESERVOIR COMPANY, COLORADO	BERGEN DAMS & POLLY A. DEANE DAM JEFFERSON COUNTY, COLORADOO	SITE LOCATION MAP
BasePoint Design Civil / Geotechnical Design Services	PROJECT BP-0717	SEPT. 2007 | FIGURE 1

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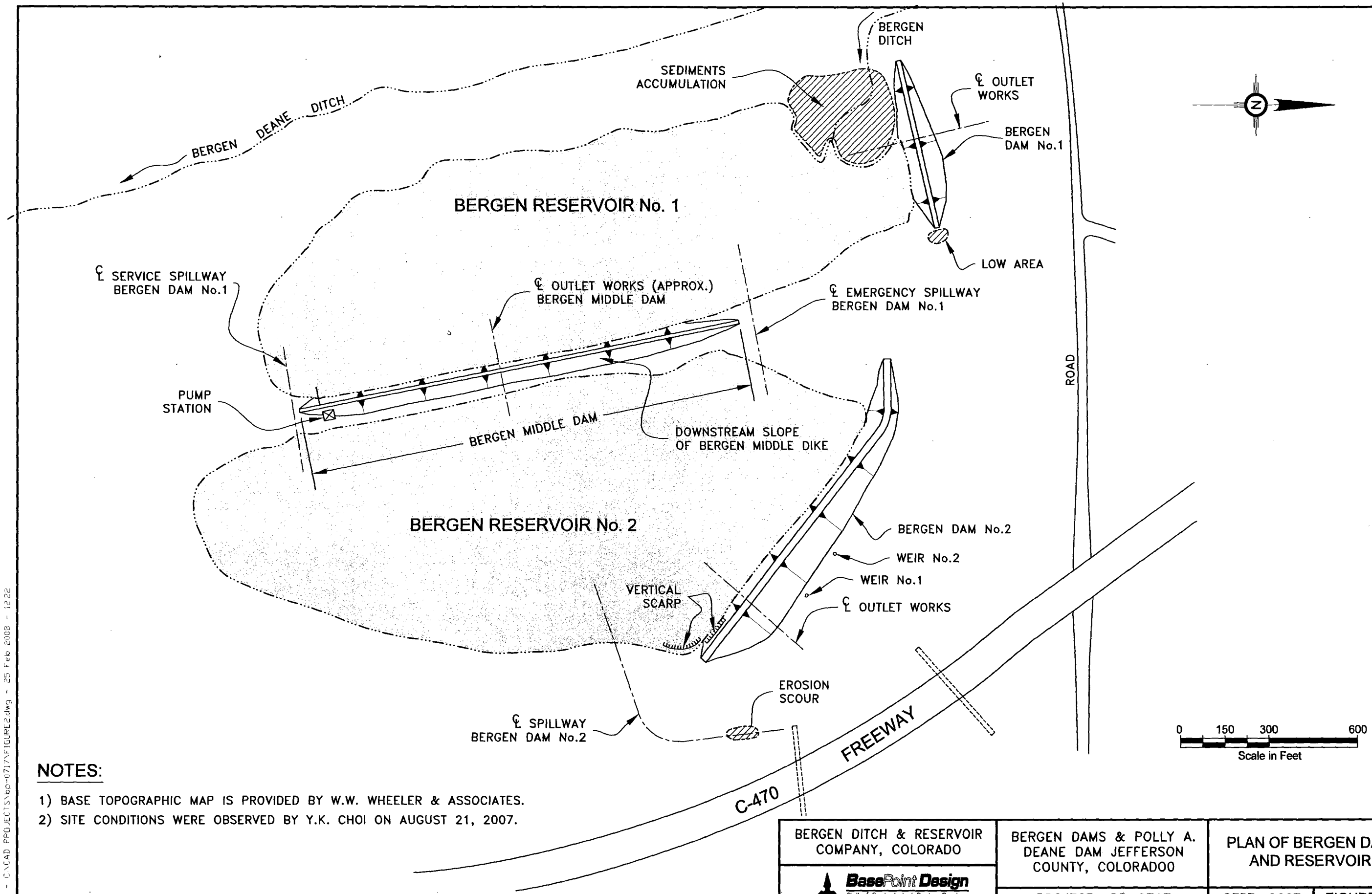

NOTES:

1) BASE TOPOGRAPHIC MAP IS PROVIDED BY W.W. WHEELER & ASSOCIATES.
2) SITE CONDITIONS WERE OBSERVED BY Y.K. CHOI ON AUGUST 21, 2007.

BERGEN DITCH & RESERVOIR COMPANY, COLORADO	BERGEN DAMS & POLLY A. DEANE DAM JEFFERSON COUNTY, COLORADOO	PLAN OF BERGEN DAMS AND RESERVOIRS	
BasePoint Design Civil / Geotechnical Design Services	PROJECT BP-0717	SEPT. 2007	FIGURE 2

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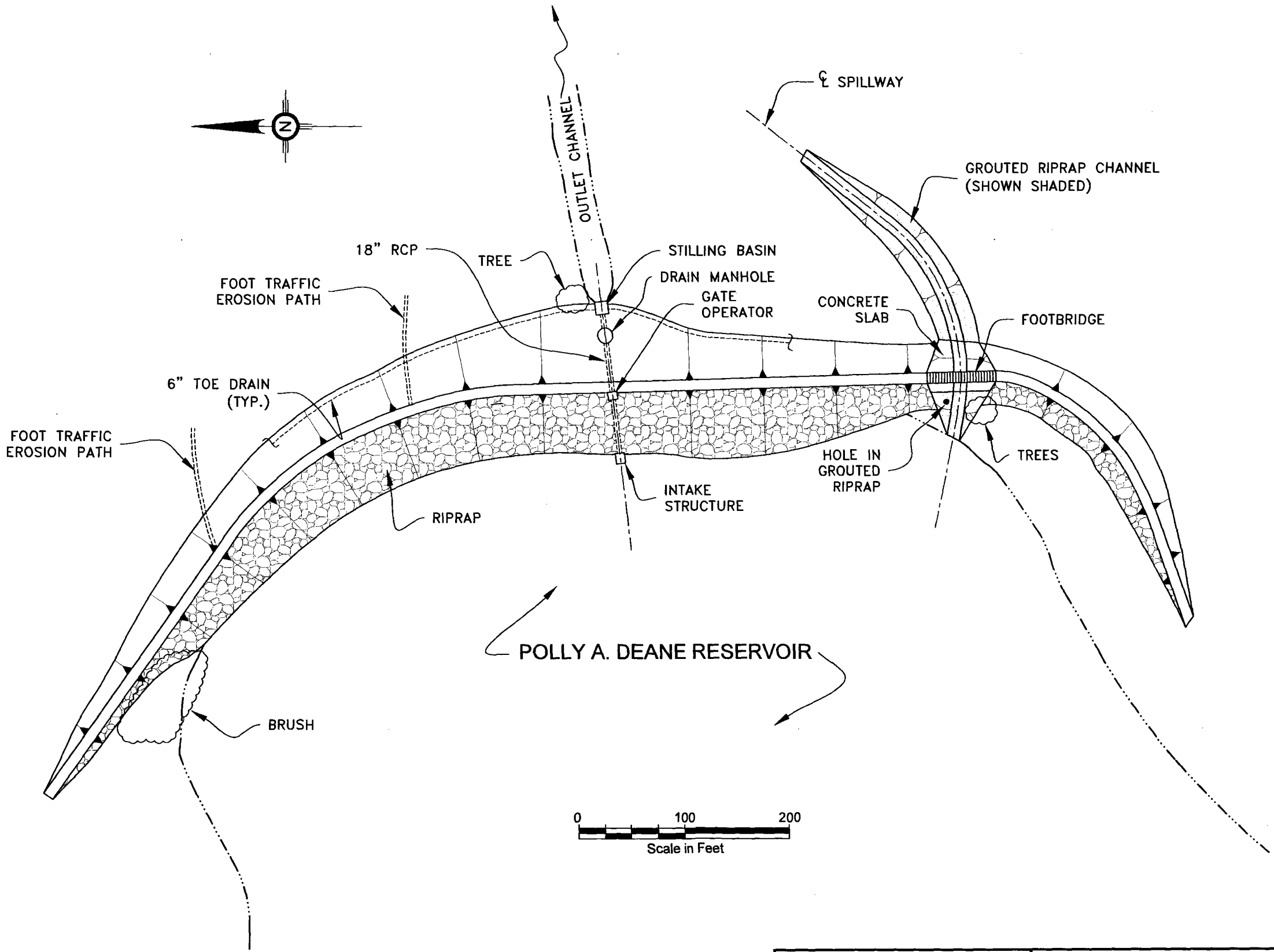

NOTES:

1) BASE MAP IS OBTAINED FROM CONSTRUCTION DRAWINGS FOR POLLY A. DEANE RESERVOIR, SHEET 2 OF 4, CTL/THOMPSON,, INC., NOVEMBER, 1986.
2) SITE CONDITIONS WERE OBSERVED BY Y.K. CHOI ON AUGUST 21, 2007.

BERGEN DITCH & RESERVOIR COMPANY, COLORADO	BERGEN DAMS & POLLY A. DEANE DAM JEFFERSON COUNTY, COLORADOO	PLAN OF POLLY A. DEANE DAM
BasePoint Design Civil / Geotechnical Design Services	PROJECT BP-0717	SEPT. 2007 / FIGURE 3

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Appendix A
Site Visit Photographs
Bergen Dam No. 1
August 21, 2007

APPENDIX A
BERGEN DAM NO. 1
AUGUST 21, 2007

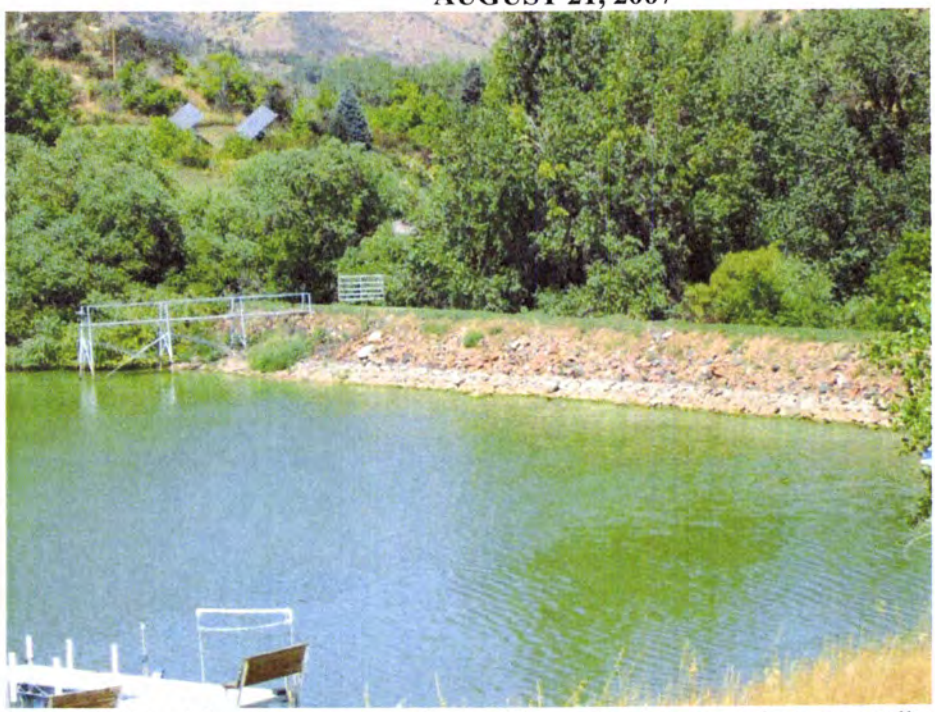

PHOTO A1 – View of upstream slope of the embankment and access walkway for the outlet works. The upstream slope and riprap protection are in good conditions.

PHOTO A2 – View of upstream slope west of the swing gate, looking toward the right abutment. Note heavy vegetation on the embankment slope.

APPENDIX A
BERGEN DAM NO. 1
AUGUST 21, 2007

PHOTO A3 – View of dam crest and downstream slope, looking from the right abutment. Note heavy vegetation along entire toe of dam.

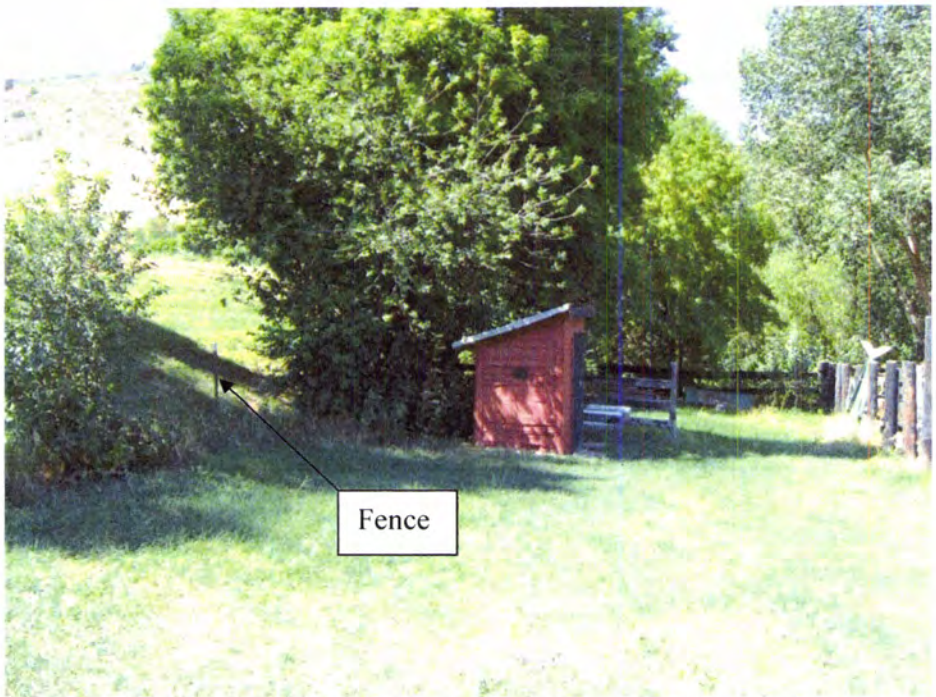

PHOTO A4 – View of the downstream toe of the dam, showing trees at the Toe, and the fence that is an obstacle for maintenance.

APPENDIX A
BERGEN DAM NO. 1
AUGUST 21, 2007

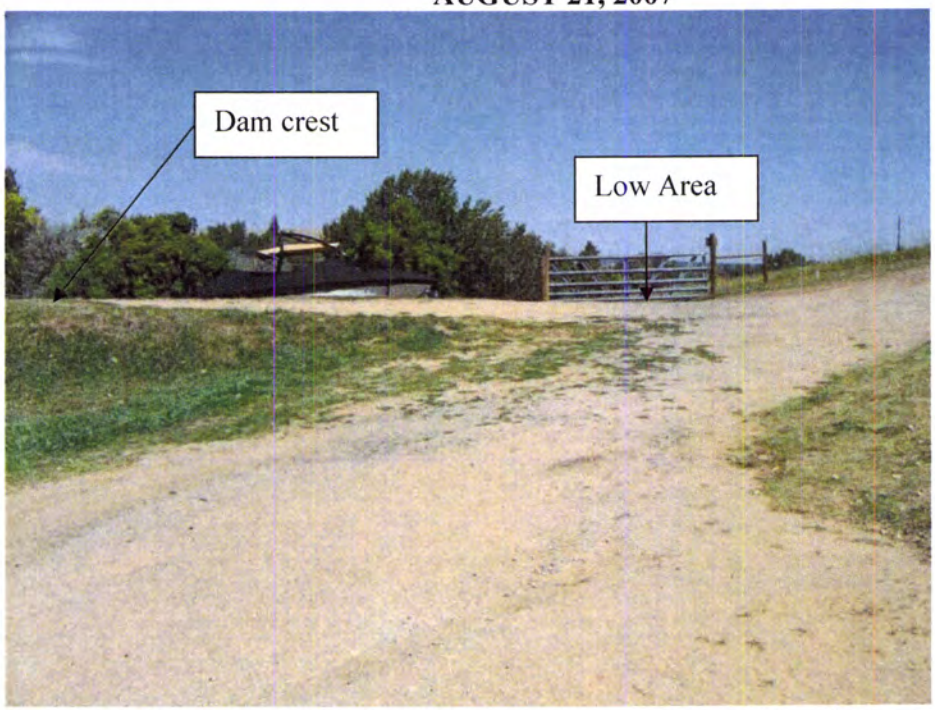

PHOTO A5 – View of right abutment, looking downstream. Note the low area in the right abutment.

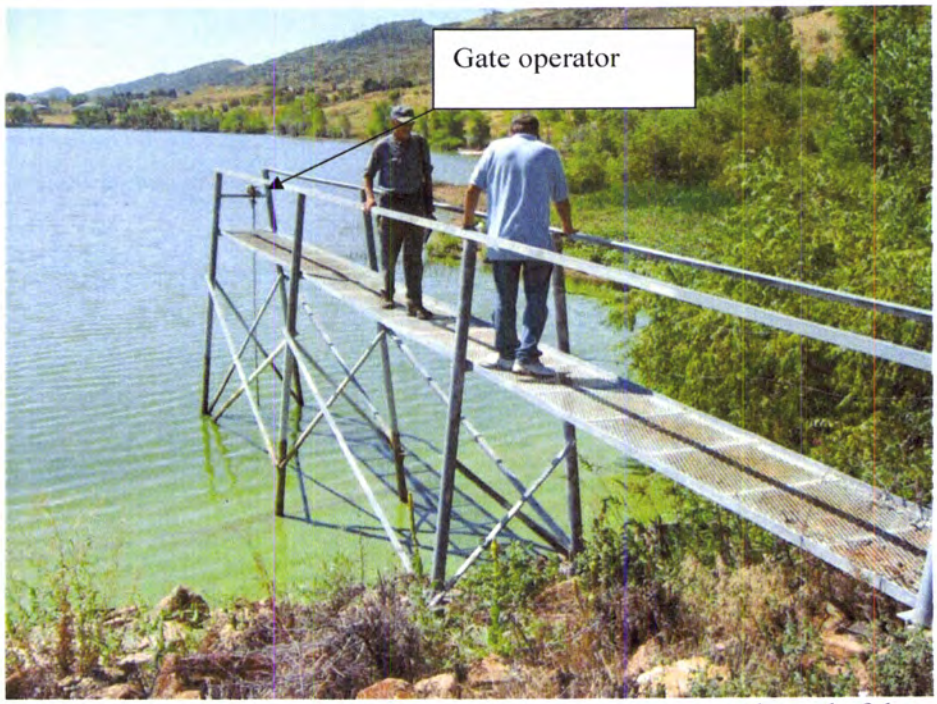

PHOTO A6 – Outlet works walkway. Note gate operator at the end of the walkway.

APPENDIX A
BERGEN DAM NO. 1
AUGUST 21, 2007

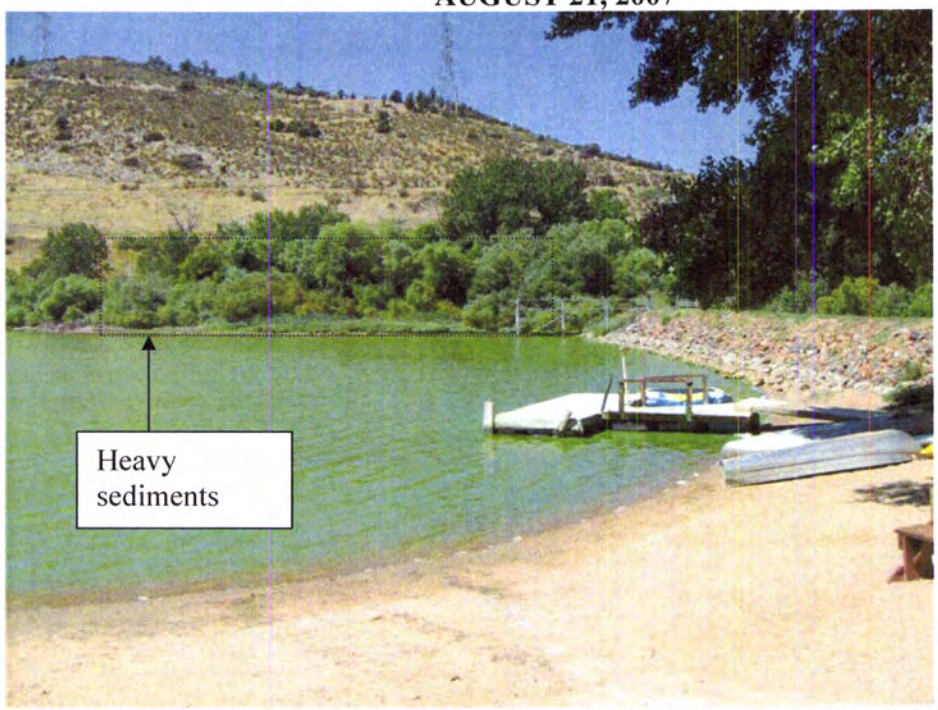

PHOTO A7 – West reservoir rim at the diversion inlet area. Note significant sediments accumulated at the inlet area.

Appendix B
Site Visit Photographs
Bergen Dam No. 2
August 21, 2007

APPENDIX B
BERGEN DAM NO. 2
AUGUST 21, 2007

PHOTO B1 – View of upstream slope, looking toward the left abutment. The slope is too steep, and riprap erosion protection is inadequate.

PHOTO B2 – View of upstream slope near the right abutment, looking toward the left abutment (west). Note near-vertical erosion scarp at the top 8 to 10 feet of the slope.

APPENDIX B
BERGEN DAM NO. 2
AUGUST 21, 2007

PHOTO B3 – Closeup of longitudinal crack at the top of the upstream slope near the right end of the embankment.

PHOTO B4 – View of the upstream slope near the right abutment. This area of the slope has no riprap protection and showed evidence of slumping and cracking.

APPENDIX B
BERGEN DAM NO. 2
AUGUST 21, 2007

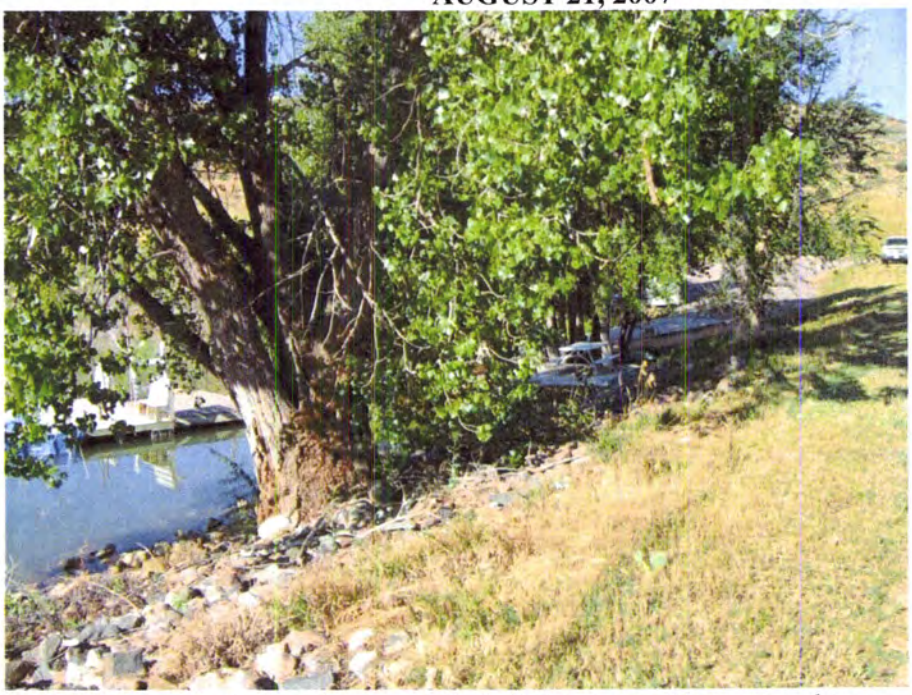

PHOTO B5 – Upstream slope near the left abutment. Note several trees growing on the slope in this area.

PHOTO B6 – General view of the dam crest, looking east toward the right abutment. Note minor ruts on the grass-lined crest surface.

APPENDIX B
BERGEN DAM NO. 2
AUGUST 21, 2007

PHOTO B7 – View of the downstream slope, looking west toward the left abutment. The downstream slope is well maintained and in good condition.

PHOTO B8 – Vertical scarp in the upstream right abutment just upstream of the dam.

APPENDIX B
BERGEN DAM NO. 2
AUGUST 21, 2007

PHOTO B9 – Seepage area at the downstream toe of the dam just downstream of the outlet works discharge.

PHOTO B10 – Weir No. 1 just west of outlet works. No flow was observed.

APPENDIX B
BERGEN DAM NO. 2
AUGUST 21, 2007

PHOTO B11 – Weir No. 2 just downstream of a 6-inch tile drain. Significant Sediments were accumulated between the weir and the tile drain.

PHOTO B12 – Exposed 6-inch tile drain flowing about several gallons per minute. Sediments were observed at the bottom one-third of the drain. Cloudy water was caused by attempt to remove the sediments, and water became clear shortly thereafter.

APPENDIX B
BERGEN DAM NO. 2
AUGUST 21, 2007

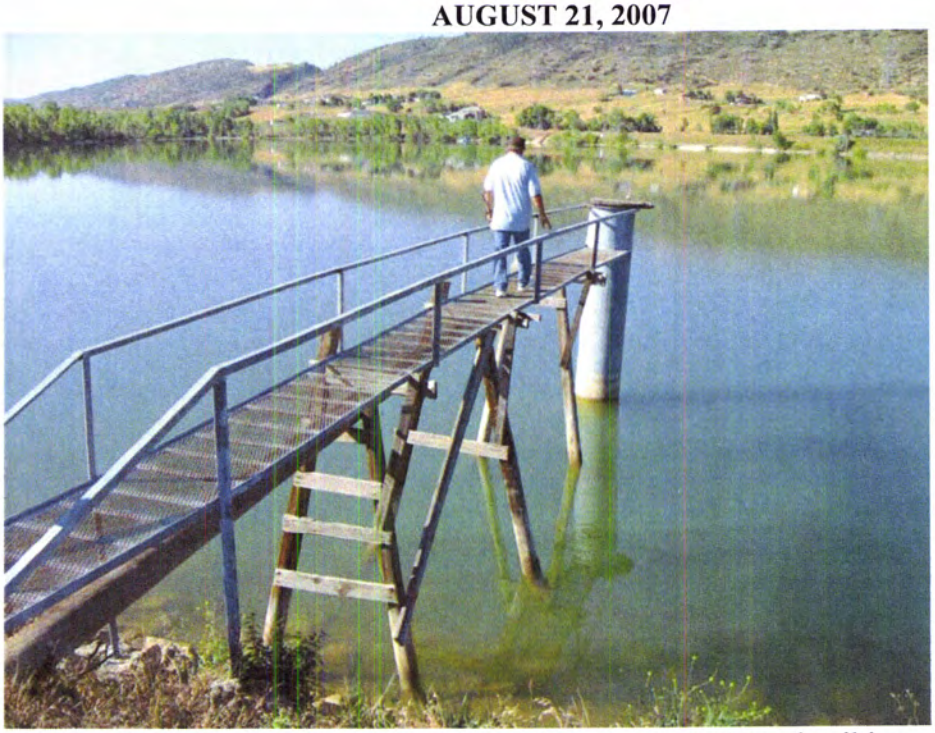

PHOTO B13 – Outlet works walkway and riser structure. Note the tilting of the riser structure.

PHOTO B14 – Condition of the damaged riser structure of the outlet works. (Photo was taken on January 11, 2007 during low reservoir level, courtesy of W. W. Wheeler & Associates).

APPENDIX B
BERGEN DAM NO. 2
AUGUST 21, 2007

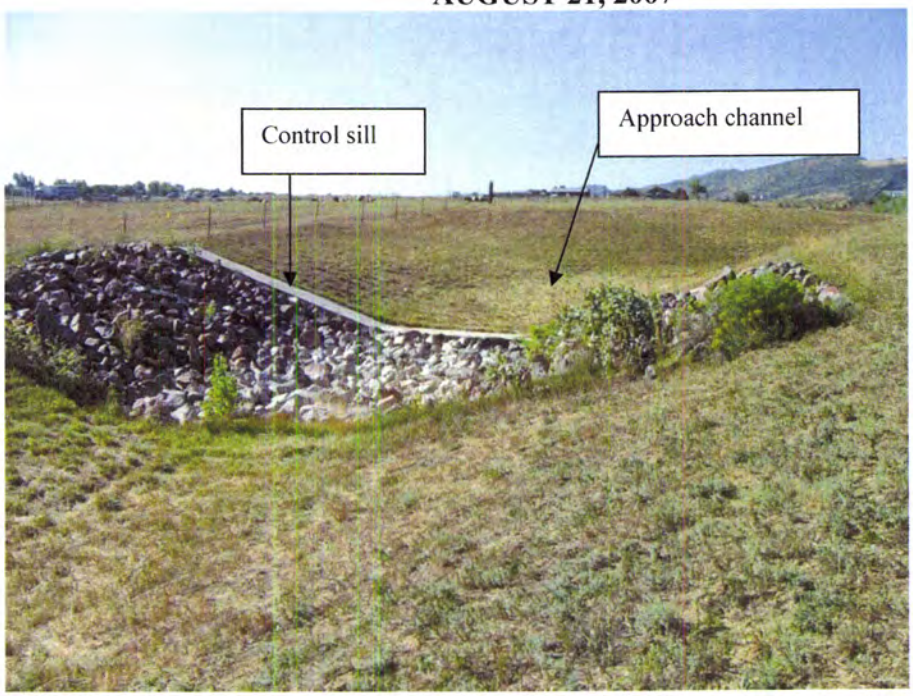

PHOTO B15 – General view of spillway channel, looking upstream. Approach channel, control sill and riprap are in good condition.

PHOTO B16 – Spillway discharge channel downstream of control sill, looking downstream. Low areas were reported in this channel. Otherwise channel is in good condition.

APPENDIX B
BERGEN DAM NO. 2
AUGUST 21, 2007

PHOTO B17 – Erosion in spillway discharge area, downstream of the downstream cutoff wall. This erosion area is at least 200 feet from the dam, and is not a dam-safety problem.

Appendix C
Site Visit Photographs
Bergen Middle Dike
August 21, 2007

APPENDIX C
BERGEN MIDDLE DIKE
AUGUST 21, 2007

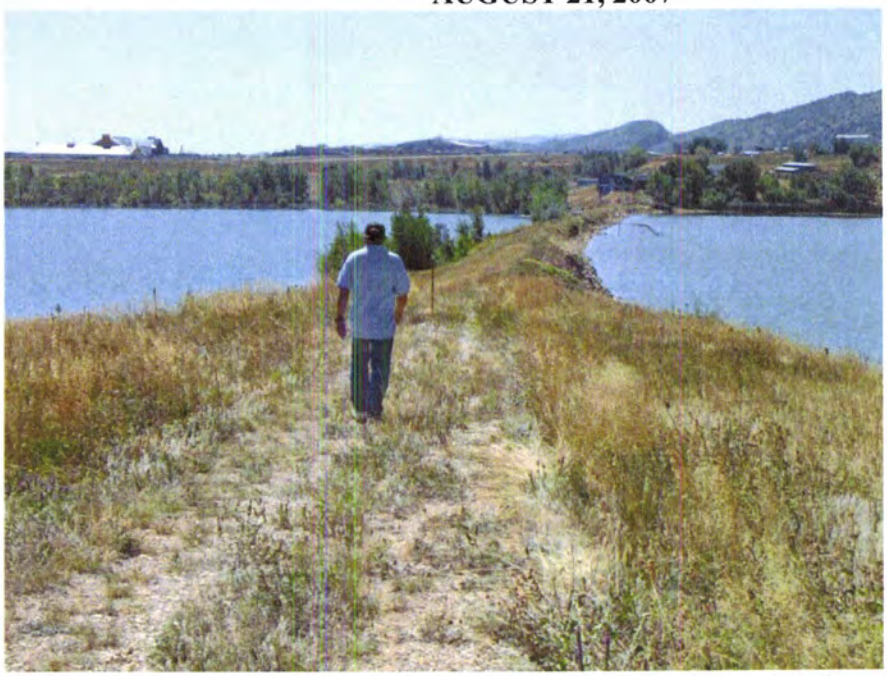

PHOTO C1 – General view of dike, looking south from the north abutment. Bergen Reservoir No. 1 is at the right side of the photo.

PHOTO C2 – Downstream slope of the dike, looking south. Overall condition of the slope is acceptable. Bergen Reservoir No. 2 is at left side.

APPENDIX C
BERGEN MIDDLE DIKE
AUGUST 21, 2007

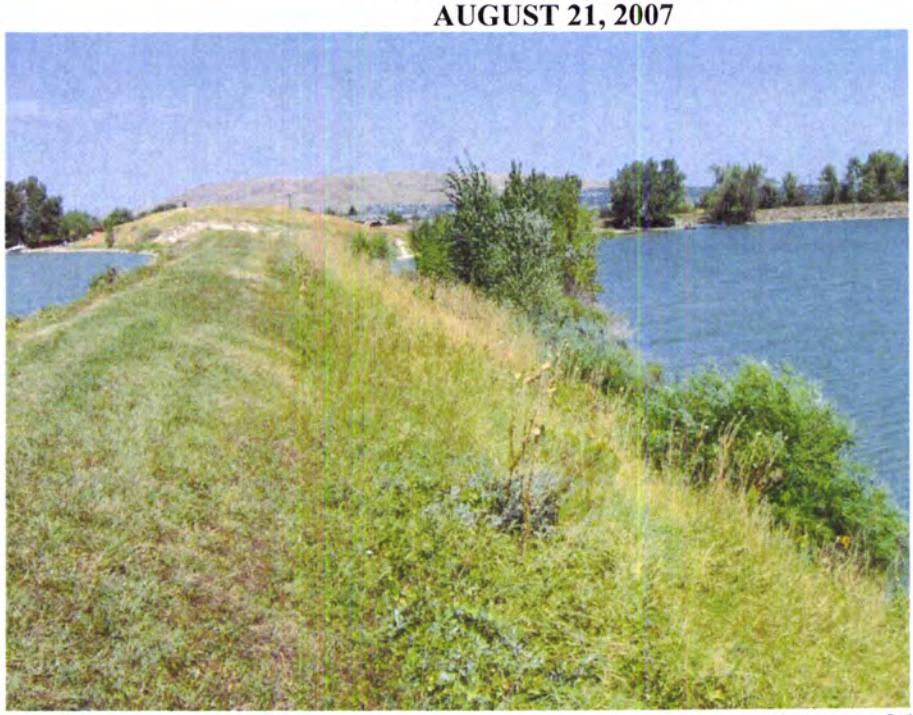

PHOTO C3 – Downstream slope of the dike looking south. This area of the slope is locally steep and includes some woody vegetation.

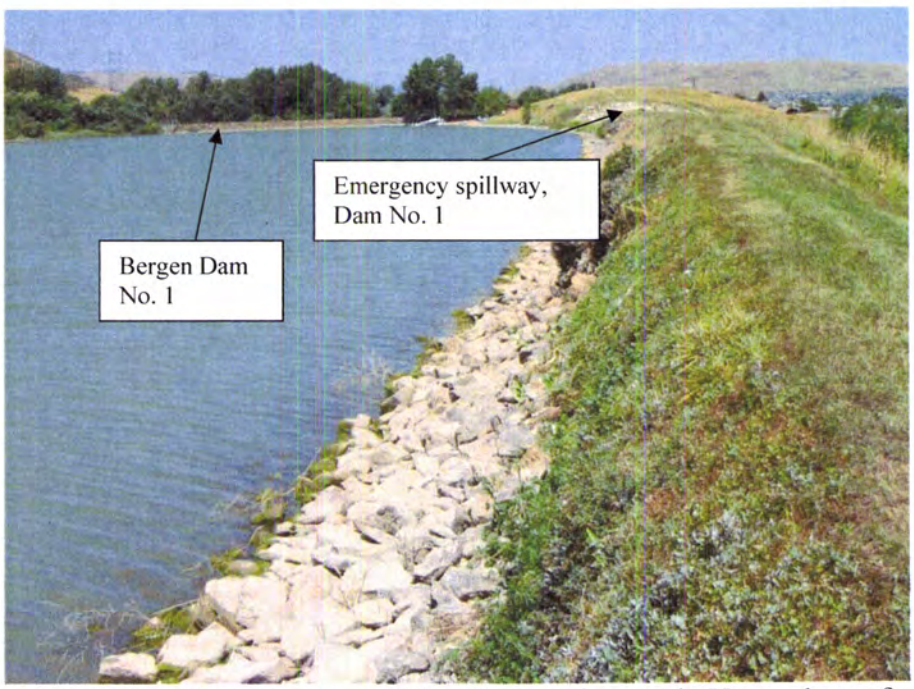

PHOTO C4 – Upstream slope of the dike, looking south. Upper slope of the dike is grass lined, and very steep. Bergen Dam No. 1 and its emergency spillway can be seen in the background.

APPENDIX C
BERGEN MIDDLE DIKE
AUGUST 21, 2007

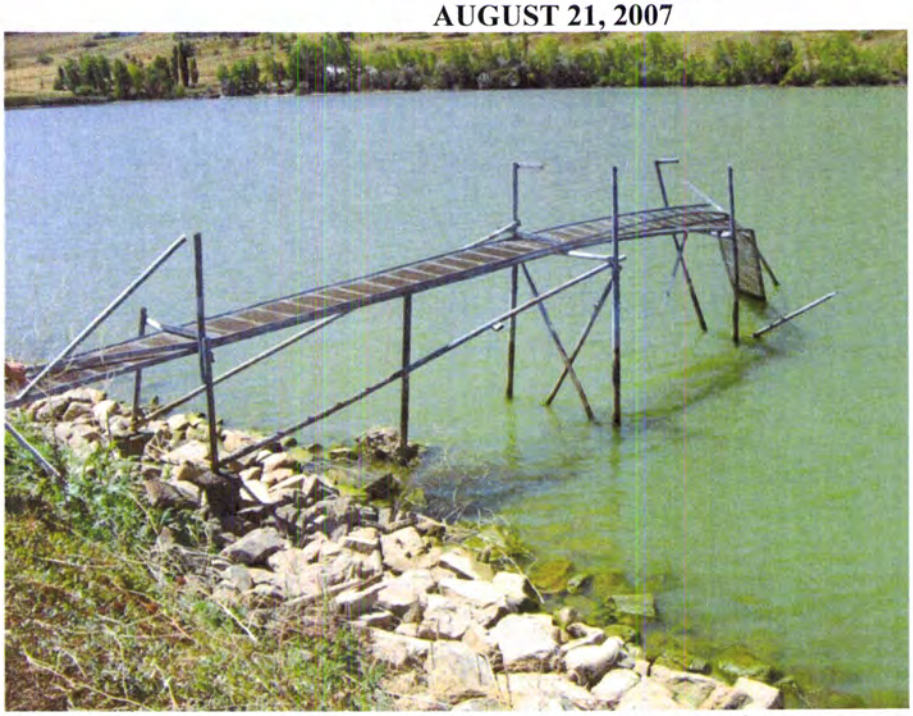

PHOTO C5 – Damaged walkway of the outlet works. The riser structure cannot be observed.

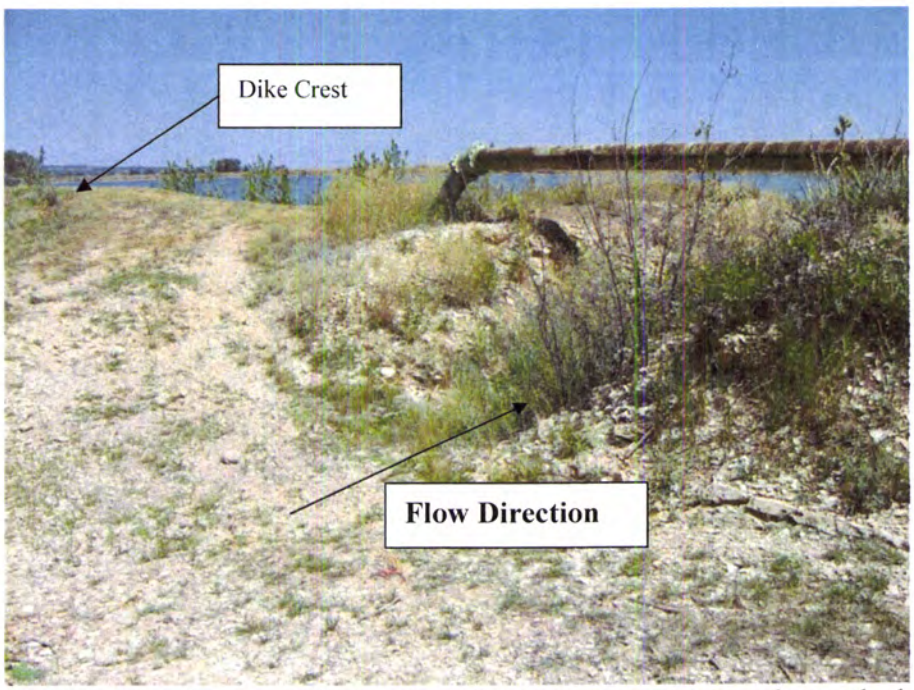

PHOTO C6 – Service spillway crest of Bergen Dam No. 1 on the north abutment of the dike. Flow is from left to right. There control crest is in acceptable condition.

APPENDIX C
BERGEN MIDDLE DIKE
AUGUST 21, 2007

PHOTO C7 – Exposed limestone bedrock along the service spillway discharge channel.

PHOTO C8 – Emergency spillway for Bergen Dam No. 1 at the south abutment of the dike, looking south. The condition of the rock spillway (limestone) is good.

APPENDIX C
BERGEN MIDDLE DIKE
AUGUST 21, 2007

PHOTO C9 – Closeup of the bedrock condition on the emergency spillway of Bergen Dam No. 1.

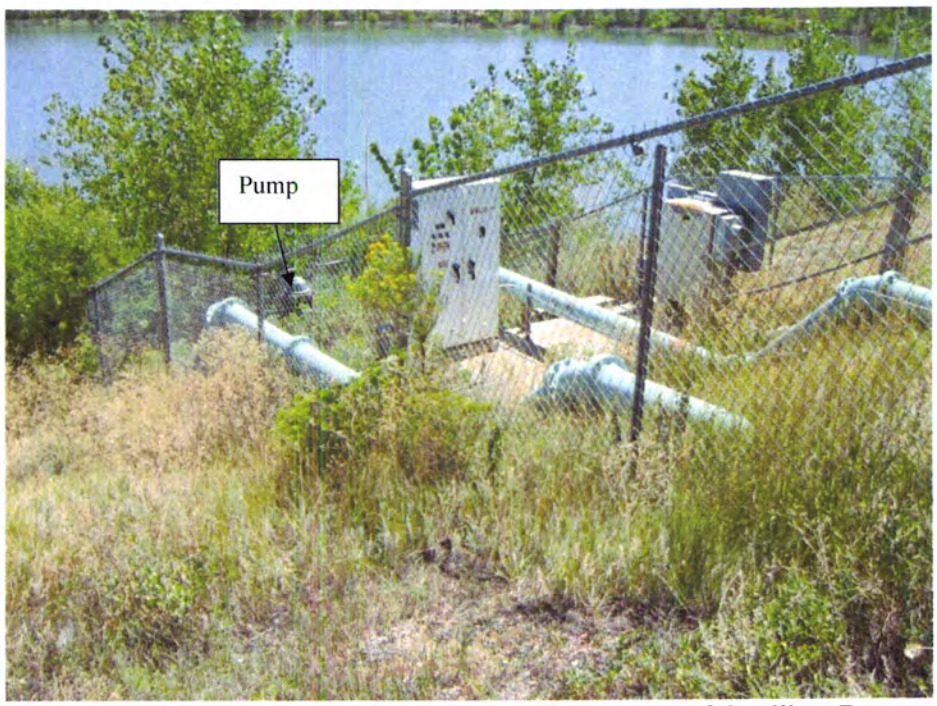

PHOTO C10 – Pumping facility on the north abutment of the dike. Bergen Reservoir No. 2 is in the background.

Appendix D
Site Visit Photographs
Polly A. Deane Dam
August 21, 2007

APPENDIX D
POLLY DEANE DAM
AUGUST 21, 2007

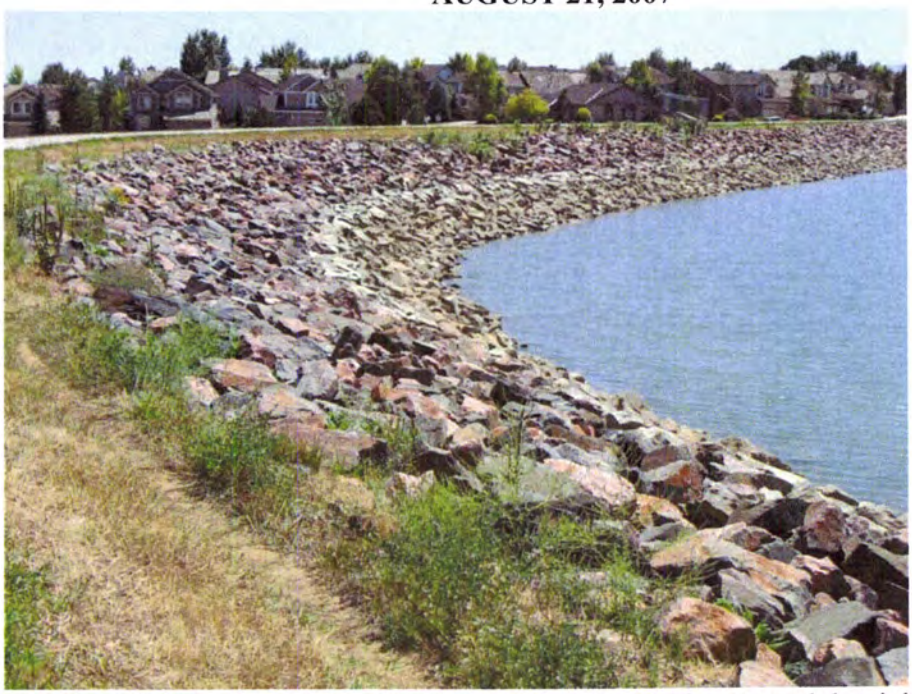

PHOTO D1 – General view of the upstream slope, looking toward the right abutment. The slope and riprap protection are in good conditions.

PHOTO D2 – General view of the dam crest and downstream slope. Both the dam crest and downstream slope conditions are good.

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PHOTO D3 – View of the downstream slope of the dam, looking downstream, showing minor erosion of the slope face from pedestrian foot traffic.

PHOTO D4 – View of the downstream slope of the dam, looking downstream, showing minor erosion of the slope face from a second footpath on the slope.

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PHOTO D5 – View of the upstream left abutment and left end of the dam. Note minor vegetation on the upstream slope among the riprap.

PHOTO D6 – View of the downstream toe of the dam at the outlet works discharge, looking downstream. Note drain manhole on the slope, outlet channel, and tree at the toe of the dam.

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PHOTO D7 – Typical seepage weir mounted on the outlet basin. Note rusting of the weir coating. Also note the backwater in the outlet channel has submerged the entire outlet pipe.

PHOTO D8 – View of the outlet channel just downstream of the basin. Note metal debris exposed and submerged in the channel.

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PHOTO D9 – Spillway discharge channel, looking upstream. The spillway crest control is concrete-lined and under the walkbridge.

PHOTO D10 – Spillway approach channel, right side. Note several grown trees in the channel.

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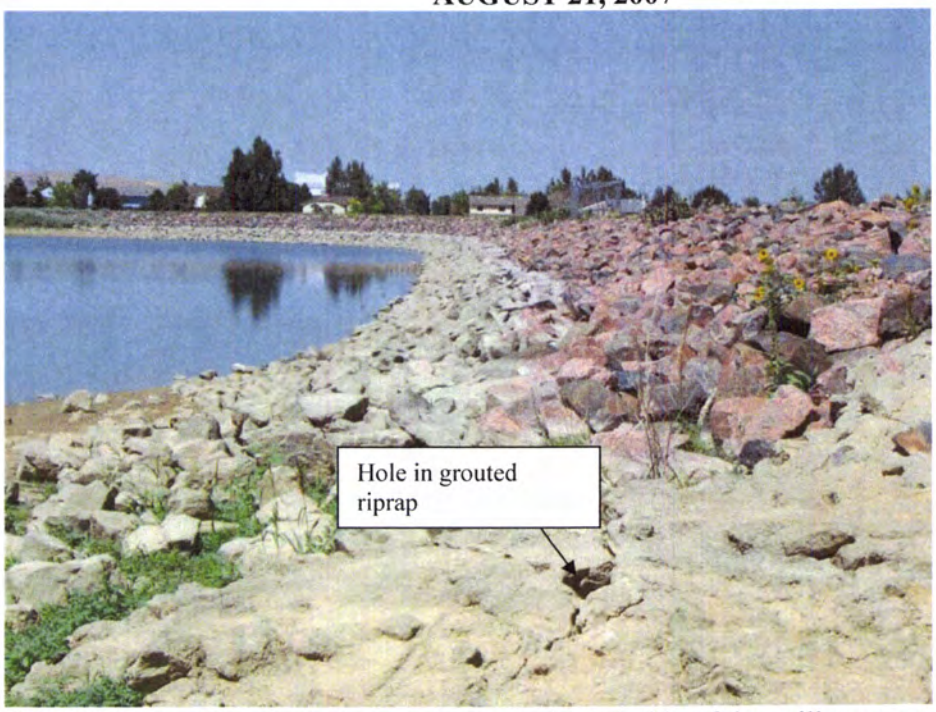

PHOTO D11 – Damaged grouted riprap on the left side of the spillway approach channel.

PHOTO D12 – Spillway approach channel, looking upstream. Note numerous tree saplings in the channel.

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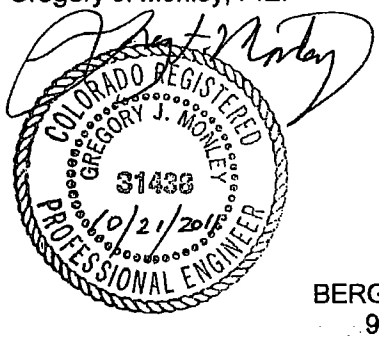
GEOTECHNICAL ENGINEERING STUDY AND FEASIBILITY-LEVEL DESIGN, PROPOSED MODIFICAITONS TO BERGEN DAM NO. 2 SOUTHWEST OF BELLVIEW AVENUE AND C-470 JEFFERSON COUNTY, COLORADO

Prepared By:

Gregory J. Monley, P.E.



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ATTENTION: Mr. Robert A. Easton

Project No. 09-1-211A

October 21, 2011

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PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical engineering study performed to evaluate the condition of existing Bergen Dam No. 2 with respect to seepage, slope stability, and riprap armoring along the upstream slope of the dam. A feasibility-level design for modifications to the dam structure to address deficiencies identified as part of the geotechnical study is also presented herein. The Bergen Dam No. 2 and reservoir are located southwest of Belleview Avenue and C-470 in Jefferson County, Colorado. The project site is shown on Fig. 1. The work presented herein was performed in accordance with the scopes of work presented in our Proposal No. P-09-204 dated March 18, 2009, and our Proposal No. P-11-183 dated March 16, 2011.

The initial results of our geotechnical engineering study, including initial slope stability analyses for the existing dam, were presented in an interim report under our Project No. 09-1-211 dated August 3, 2009. Information from that interim report is also included herein. The study included:

- A field exploration program consisting of exploratory borings conducted to obtain information on subsurface conditions beneath the crest and downstream toe of the dam. Information from previous geotechnical exploration performed by Chen & Associates and included a report under their Job No. 1 195 84 dated September 28, 1984 was also considered.
- Exploratory pits excavated in proposed on-site borrow areas for the purpose of evaluating on-site sources for embankment fill.
- Installation of piezometers at the crest and downstream toe of the dam, and monitoring of water levels measured in those piezometers in relation to changing reservoir levels. The piezometer data were used for slope stability and seepage analyses presented herein.
- Laboratory testing of samples obtained from the field exploration performed to help characterize the shear strength and engineering properties of the embankment fill and foundation bedrock.
- A seismicity evaluation performed to estimate the peak ground acceleration at the site resulting from earthquake shaking, performed in accordance with Colorado State Engineers Office (SEO) criteria.
- Slope stability analyses performed to evaluate the stability of the upstream and downstream slopes of the existing dam and of the dam following proposed modifications.
- Seepage analyses to evaluate the effectiveness and size of a proposed downstream toe drain and chimney drain system to control groundwater flows and mitigate the potential for internal erosion (piping) of fine-grained soils within the dam embankment.

- Development of a feasibility-level design for modifying the upstream and downstream slopes of the dam to address concerns related to slope stability, seepage, and upstream-slope armoring identified as part of the geotechnical study.
- Development of a feasibility-level cost estimate for the proposed dam modifications.

The feasibility-level design and cost estimate presented herein does not include replacement of the outlet works and modifications to the spillway. Based on discussion with W.W. Wheeler & Associates, Inc., an embankment excavation in the range of 25,000 cubic yards would be required to remove the existing outlet works. We understand that W.W. Wheeler, Inc. will prepare a separate feasibility evaluation for a possible new outlet works and spillway.

PROJECT DESCRIPTION AND BACKGROUND

Bergen Dam No. 2 is an existing high-hazard earthfill embankment dam. The dam is approximately 40 feet high and about 1,300 feet long. Based on the topographic information, the crest varies from about Elevation 5816 to Elevation 5818, and is at about Elevation 5817.5 in the vicinity of the outlet works.

The dam was originally constructed in 1876 and raised 10 feet in 1915. It has experienced slope movements, erosion and seepage problems, and has undergone several remedial repairs to address those problems. Currently, there are concerns regarding the stability and seepage condition of the existing dam that include the following:

- Unknowns regarding the stability of the dam embankment slopes, particularly the upstream slope where longitudinal cracking along the crest and upper portion of the upstream slope are apparent, particular to the east (right) of the outlet works where a near-vertical scarp continues into the upstream right abutment.

- Unknowns regarding the location and performance of an existing embankment drainage system, believed to primarily consist of clay tile drains that could potentially extend from beneath the crest of the dam to the downstream toe.

- Unknowns regarding seepage conditions in the dam embankment, particularly with respect to the potential for piping around existing clay-tile drain pipes, and in the right abutment area of the dam where a possible seep located immediately downstream of

that area is apparent and may be associated with potential higher-gradient flow conditions where the dam embankment is constructed directly above claystone, sandstone and limestone bedrock.

- Deterioration of the upstream riprap armoring and a lack of bedding material beneath the riprap, particularly on the upstream slope to the right of the outlet works where very steep to near-vertical head scarps along the upper portion of the upstream slope are apparent.

- Impacts to the embankment caused by rodent holes, and brush and tree growth, particularly along the upstream slope.

The dam previously operated at a normal high water level (NHWL) at Elevation 5813.3 feet. However, the Bergen Ditch and Reservoir Company has recently modified the spillway to maintain a reservoir level at or below Elevation 5809.3 feet due to concerns regarding the condition of the dam.

SUBSURFACE CONDITIONS

General: A field exploration program consisting of exploratory borings and exploratory pits was conducted on April 27 through May 6, 2009. Five (5) exploratory borings (KB-09-1 through KB-09-5) were completed, including three borings (KB-09-1 through KB-09-3) along the dam crest, and two borings (KB-09-4 and KB-09-5) on the downstream slope near the downstream toe of the dam. The borings were drilled to depths ranging from 25 to 56 feet. These borings were made to supplement information on subsurface conditions from five exploratory borings, located along the dam crest and beyond the downstream embankment toe, completed as part of a geotechnical engineering study by Chen & Associates and presented in a report under their Project No. 1-195-84 dated September 28, 1984.

In addition, six (6) exploratory pits were excavated in proposed on-site borrow areas, including an area within and on the east side of the reservoir (referred to as the "Reservoir Borrow Area" herein) and an area to the east of the reservoir (referred to as the "East Borrow Area" herein). The pits were excavated to a depth of about 12 feet.

The locations of the borings and pits are shown on Fig. 1. The dam alignment stationing shown along the crest of the dam in that figure is based on the stationing for the dam shown on a 1949 drawing titled "Plans for Repair of Dam of Bergen Reservoir Number 2"; the stationing was superimposed from the 1949 drawing onto the figure, and should be considered approximate for that reason. The Logs of the exploratory borings drilled as part of this study are presented on Fig. 2. Logs of the exploratory pits are presented on Fig. 3. A legend and notes for the exploratory logs and pits are presented on Fig. 4. Logs of the borings presented in Chen & Associates' 1983 report are presented in Appendix A.

Following exploration, Borings KB-09-1 through KB-09-5 were completed as piezometers for the purpose of monitoring changes in ground water levels within the dam embankment in response to changes in reservoir levels, and for the purpose of evaluating seepage conditions within the embankment and underlying foundation.

Subsurface Conditions - Dam Embankment: Subsurface conditions encountered in Borings KB-09-1, KB-09-2, and KB-09-3, located along the crest of the dam, consisted of approximately 22 to 43 feet of embankment fill material composed of sandy lean clay and occasional clayey sand. The fill appeared to be generally stiff to hard based on field blow count information. The fill material was underlain by firm to very hard claystone bedrock that extended to the explored depths of 25 to 56 feet. The upper 5 feet of the bedrock was generally composed of more weathered, firm to medium hard claystone bedrock, and the bedrock below that depth was composed of less weathered, hard to very hard claystone bedrock.

Subsurface conditions encountered in Borings KB-09-4 and KB-09-5, located near the downstream toe of the dam, generally consisted of up to 6 inches of vegetated topsoil underlain by approximately 17 to 19.2 feet of embankment fill material composed of apparently stiff to very stiff sandy lean clay and occasional clayey sand. The fill material was underlain by medium hard to very hard claystone bedrock that extended to the explored depth of 25 feet in each boring.

Subsurface conditions encountered in the above-described borings are generally similar to those reported by the logs of borings completed by Chen & Associates ("Chen") and included in the 1984 report. Subsurface conditions encountered in the Chen crest borings generally consisted of about 31 to 52 feet of embankment fill composed of apparently stiff to hard sandy

clay, which was underlain by medium hard to very hard claystone bedrock. Subsurface conditions encountered in the two Chen borings located about 50 feet downstream from the toe of the dam generally consisted of about 10 to 17 feet of soft to stiff, sandy lean clay, which was underlain by firm to hard claystone bedrock, and occasional sandstone bedrock, that extended to the explored depth of 21 feet to 25 feet in those two borings.

Ground water was initially encountered only in Boring KB-09-2 (on the crest of the dam) at a depth of approximately 35 feet, and in Boring KB-09-4 (near the downstream toe of the dam embankment) at a depth of approximately 20 feet, at the time of drilling. However, ground water was measured in all the piezometers installed in the completed borings, with the exception of Boring KB-09-1, when measured over time in response to increases in reservoir level. The results of ground water monitoring are discussed later in this section.

Subsurface Conditions - Proposed Borrow Area: Subsurface conditions encountered beneath about 2 inches of soft lake bottom sediments in Pits KP-09-1 through KP-09-3 within the Reservoir Borrow Area, and beneath about 4 inches of topsoil in Pits KP-09-4 through KP-09-6 within the East Borrow Area, generally consisted of approximately 1.5 to 3 feet of apparently medium stiff to very stiff sandy lean clay. This material was in turn underlain by nil to 3 feet of weathered claystone bedrock. The claystone bedrock appeared to decrease in weathering and increase in hardness with depth, and extended to the explored depth of about 12 feet in each pit. Ground water was encountered only in Pit KP-09-3 at the time of excavation, and relatively dry conditions were observed in the remaining pits, particularly the pits within the East Borrow Area.

Ground Water Monitoring: Following exploration, the caretaker for Bergen Dam No. 2 assisted Kumar & Associates by monitoring ground water levels in the installed piezometers on a weekly basis from May 2009 to the present. The level of the reservoir was also recorded at the time of each reading. A plot showing measured ground water levels in the piezometers in response to changes in reservoir level, for the period from May 2009 to June 2011, is presented on Fig. 5.

Ground water levels observed in Piezometers KB-09-2 and KB-09-3 (located on the centerline of the dam crest) and Piezometers KB-09-4 and KB-09-5 (located on the downstream slope near the toe of the dam) appeared to be respond more quickly to changes in reservoir level than what we have observed for other dam embankments composed of clay. The piezometers also

indicate relatively high ground water levels throughout the embankment, particularly near the right abutment where ground water levels within approximately 15 feet of the surface were measured in Piezometer KB-09-3, and beneath the downstream toe of the dam where ground water levels within approximately 6 feet of the surface were measured in Piezometers KB-09-4 and KB-09-5.

LABORATORY TESTING

The results of the laboratory tests performed on selected samples obtained from the borings are presented to the right of the boring and pit logs in Figures 2 and 3, and on Figs 6, 7 and 8. Test results are also summarized in Table 1. A discussion of specific tests is presented below.

Triaxial Shear Strength Testing: Shear strength testing was performed to supplement similar tests performed by Chen & Associates, and for the purpose of evaluating the shear strength of the existing embankment fill and underlying bedrock foundation, as well as on-site materials for new embankment fill. The estimated shear strengths obtained from those tests were considered in evaluating the stability of the embankment slopes under various loading conditions, discussed in the "Slope Stability" section of this report.

Three (3) sets of consolidated undrained triaxial tests with pore pressure measurements (TX/CU/PP) were performed on selected samples obtained for the exploratory borings and pits. Two tests were performed on samples of existing embankment fill material obtained with a Shelby tube sampler, which was used to reduce the effect of sample disturbance during sampling. The third test was performed on a sample of remolded claystone bedrock material obtained from the proposed borrow area. The tested sample was remolded to 95% of the standard Proctor maximum dry density (ASTM D 698) at the optimum moisture content, to simulate properly compacted embankment fill. Interpreted drained and undrained shear strengths of the materials tested for this study are presented below.

Material	Location	Drained Shear Strength		Undrained Shear Strength	
		Φ' (deg)	Cohesion, c' (psf)	Φ (deg)	Cohesion, c (psf)
Borrow Area: Claystone Fill	KP-09-1@ 2 to 5 ft	25.5	150	16.5	75
Embankment Fill: Clayey Sand (SC)	KB-09-1@ 7 to 9 ft	31.5	100	12	250
Embankment Fill: Sandy Lean Clay (CL)	KB-09-2@ 5 to 7 ft	27.5	75	18	75

The results of three triaxial shear strength tests (TX/CU/PP) on samples of embankment fill and foundation claystone material, performed as part of the 1984 Chen & Associates study, were also considered. Estimated drained and undrained shear strengths, interpreted or reported in the referenced 1984 Chen & Associates report, are presented below:

Material	Location	Drained Shear Strength		Undrained Shear Strength	
		Φ' (deg)	Cohesion, c' (psf)	Φ (deg)	Cohesion, c (psf)
Embankment Fill: Clayey Sand (SC)	CB-84-1@ 14 to 16 ft	33	170	18	313
Embankment Fill: Fat Clay (CH)	CB-84-8@ 15 to 17 ft	22.5	360	19	100
Foundation: Claystone Bedrock	CB-84-9@ 40 ft	30	180	24.5	40

The results of testing performed for both this study and the Chen & Associates study generally indicate relatively low undrained shear strengths for the existing embankment fill. In addition, a similar low undrained shear strength is indicated for the remolded sample developed from a claystone sample obtained from Exploratory Pit KP-09-1 within the Reservoir Borrow Area. The results of that test are presented in the first table above. Although we anticipated a possible higher shear strength for properly compacted embankment fill compared to that for the existing embankment where the method and level of compaction are unknown, the results generally indicated a similar, low undrained shear strengths for both the existing embankment fill and fill remolded to that for properly compacted embankment fill. The undrained shear strength of the embankment material is critical to the slope-stability performance of dams when subjected to relatively rapid or quick loading conditions, including the rapid drawdown condition and the pseudo-static earthquake condition. The results of slope stability analyses performed for those conditions are presented in the "Slope Stability" section of this report.

Gradation and Hydrometer Testing: The results of 4 gradation tests and hydrometer/gradation tests performed on samples of soil and bedrock obtained from the exploratory borings and pits are presented on Figs. 6 and 7. The gradation tests were performed to characterize the existing embankment fill and the proposed borrow area material. The hydrometer tests, in addition to Atterberg limits testing, were performed to provide information for estimating the residual shear strength of the dam foundation bedrock material based on a published correlation of residual shear strength to the liquid limit and clay content (percent passing 0.002 mm from the hydrometer tests) (Stark and Eid, 1994), shown on Fig. 9. Based on the test results and using the referenced correlation, a residual shear strength friction angle, Φ_r, ranging from 16 degrees to 24 degrees, and averaging 18 degrees was estimated for the weathered foundation bedrock material. It should be noted that features associated with claystone materials that exhibit residual shear strength behavior, including the presence of slickensides or shear zones containing clay gouge, were not observed in samples of the natural weathered and unweathered claystone encountered beneath the dam structure.

Standard Proctor Compaction Testing: One (1) standard Proctor moisture-density relationship test was performed on a selected sample of claystone from an exploratory pit completed in the proposed borrow area. The testing was performed in accordance with ASTM D 698. The results of that test are presented on Fig. 8.

Pinhole Dispersion Testing: Two (2) pinhole dispersion tests were performed, including one on a sample of existing embankment fill material, and one on a sample of material obtained from the proposed borrow areas for new embankment fill. The samples were remolded to their present/anticipated in-place dry density and moisture content, and tested in accordance with ASTM D 4647, Method A. The test results are summarized in Table 1 and generally indicate that the existing embankment fill material consisting of lean clay with sand (CL) generally classifies under Dispersion Category ND3 and the proposed borrow area material consisting of claystone bedrock generally classifies under Dispersion Category ND 2. Category ND2 represents soils that are considered non-dispersive and Category ND3 represents soils that are considered slightly dispersive. In our opinion, given the generally low dispersion potential indicated by the test results, we believe that the potential for internal erosion of the existing and proposed embankment fill composed of these materials should be adequately low.

EXISTING DRAINAGE SYSTEM

An evaluation of the existing embankment drain line system within Bergen Dam No. 2 was performed to better evaluate the influence of the existing drains on the performance of the dam, particularly with respect to observed seeps and potential piping conditions within the dam. The exact locations of existing drain lines, reportedly installed in the dam from 1925 to 1949, are not known. However, the approximate locations and invert elevations of those lines have been interpreted from historic drawings provided to us, and by measuring the invert elevations of drain pipes daylighting into existing manholes along the downstream slope of the dam, and at the downstream toe of the dam. It should be noted the locations or actual existence of the drain lines shown on the figure have not been substantiated by field exploration, such as excavating pits down to the lines at various locations. A plan showing the interpreted location of existing clay-tile drain lines within the dam embankment is presented in Fig. 11, and a description of the plan is presented below:

- The approximate locations of proposed and existing drain lines shown on design drawings dated 1925, 1943 and 1949 were initially superimposed over the AutoCAD base plan provided to us. In general, the locations of the lines with respect to the existing manholes, and where the drains tie into the manholes, agreed reasonably well with the historical drawings.

- The depth to apparent drain line outfalls observed in the three existing manholes, and at the two seepage-channel outfalls, was measured. The elevation of each measured outfall was then converted to an elevation based on interpolation of the AutoCAD base plan and/or survey information (i.e., the elevation at the top of each manhole).

- The elevation of each measured outfall was then compared to the reference elevation for the outfall shown on the historic drawings. The invert elevation of drain lines connecting to the measured outfalls was then estimated by determining the difference between the outfall reference elevation and other the reference elevations at other locations along each drain line, and adding that to the interpolated elevation for the outfall.

Interpreted invert elevations for the reported drain lines are presented in the table on Fig. 11, and correspond to the numbered locations shown on the plan. The basis for each interpreted

drain invert elevation at the numbered locations is also presented in the table. Items of particular interest are discussed below:

- The 1925 plan titled "Repairs and Drainage Design, Restoring Bergen Dam No. 2" shows a proposed 4-inch drain line running parallel to and upstream of the dam crest between about Stations 1+60 and 5+15. That section of line is shown to connect to a 4-inch tile oriented perpendicular to the dam alignment at about Station 1+60, which eventually ties into Manhole No. 1 as shown on the figure. However, the subsequent 1943 drawings, which show previously installed existing drain lines, do not show the portion of the 4-inch tile drain running parallel to the dam alignment, suggesting that that portion of the drain line may not have been installed.

- The 1925 plan shows a "650' long" 10-inch diameter tile drain running approximately north from Manhole No. 2. The reported drain line appears to tie into an existing manhole located about 410 feet north of Manhole No. 2, and an existing cut slope bordering Highway C470 is located north of the manhole. It is our understanding that the manhole was installed to capture water from the drain line, and the portion of that drain tile located north of the manhole was removed during subsequent excavation and grading for the highway project.

- The 4-inch drain tile oriented perpendicular to the dam alignment at about Station 1+60 is a concern because it could serve as a potential high-gradient path for seepage flows through the dam. The potential for internal erosion or piping through dams generally increases where localized high gradient seepage flows through the dam exist.

- The 1949 plan shows an "obsolete" 10-inch diameter "tile line with a single invert elevation referenced in the plan. An invert at Elevation 5801 was interpolated. The line is a concern because it is oriented perpendicular to the dam alignment, and could serve as a potential high-gradient path for seepage flows through the dam if it exists. There is no explanation in the drawing as to what is meant by "obsolete".

- Flows within the manholes were monitored periodically as the reservoir was being filled. It was noted that significant flows, in the range of 1 to 2 gallons per minute were flowing into Manhole No. 1. The flows were coming in on the south side of the manhole,

apparently from the 4-inch drain tile, and exiting on the west side of the manhole, apparently into the 6-inch drain tile. However, no flows from that 6-inch drain tile were observed flowing into the bottom of Manhole No. 2 on the east side of that manhole. The results suggest that the 6-inch tile drain located between Manhole No. 1 and Manhole No. 2 may have been damaged or plugged, and that water flowing out of Manhole No. 1 is being discharged in an uncontrolled manner within the embankment fill at or near Manhole No. 1.

The existing drain lines apparently consist of clay tiles placed directly within the embankment fill. There is no information that a sand filter was placed around any of the drain lines to mitigate erosion or localized piping between the drain lines and the embankment fill, which was not a common practice at the time the drain lines were installed. The potential for piping along the drain lines, particularly lines that are oriented perpendicular to the dam alignment, is a concern because prolonged erosion could result in increased seepage losses, and a potential failure of the dam. However, we did not observe features such as sand boils that would suggest that significant piping is occurring.

SEISMICITY AND LIQUEFACTION POTENTIAL

The horizontal peak ground acceleration (PGA) at the site was estimated to develop a pseudo-static coefficient for evaluating the slope stability of the dam under the pseudo-static earthquake condition. The PGA was estimated using probabilistic ground motion information provided by the USGS. Based on the USGS information, a PGA of 0.12 g. was determined based on a 2% chance of exceedance in 50 years. Using Colorado State Engineers Office (SEO) criteria, a PGA equal to twice that value, or 0.24 g. was considered.

The embankment fill and underlying foundation soils encountered in exploratory borings for this study and reported by the referenced previous study performed by Chen & Associates generally consisted of low to high plasticity, medium stiff to hard, lean to fat clay with sand and sandy clay, and medium hard to very hard claystone. Loose granular soils, which can be potentially susceptible to liquefaction under earthquake loading conditions dependent on the level of earthquake shaking (i.e., the peak ground acceleration), were not encountered in the exploratory borings. In our opinion, the potential for liquefaction of the embankment and foundation soils is adequately low such that liquefaction is not considered a dam safety issue for the dam.

SLOPE STABILITY

Existing Dam: Slope stability analyses were initially performed to evaluate the slope stability of the existing embankment dam under the long-term steady state seepage, pseudo-static earthquake and rapid drawdown conditions. The analyses were performed using Spencer's method and the computer program titled UTEXAS3 (Wright, 1991). A cross section at the outlet works location and near the apparent maximum section of the existing embankment (Station 3+04 on Fig. 11) was used for that evaluation, which also considered the following minimum allowable factors of safety based on SEO criteria:

Loading Condition	Minimum Acceptable Factor of Safety
Long-Term Steady State Seepage	1.5
Pseudo-Static Earthquake	1.0
Rapid Drawdown	1.2

The piezometric (groundwater) surface used to model the groundwater level in the embankment and foundation was developed considering the ground water elevations measured in the piezometers, and using the normal high water level (NHWL) for the existing dam at Elevation 5809.3 feet, and a rapid drawdown water level at Elevation 5780 feet.

Estimated drained and undrained shear strengths for the dam embankment and foundation materials were developed using information obtained from field exploration and laboratory testing, including the triaxial shear strength test results, in addition to published correlations between shear strengths and other engineering properties for similar materials and our experience with similar materials. Drained (effective) shear strengths were used for all materials for modeling the long-term steady state seepage condition. Undrained (total) shear strengths were used to model the clayey embankment fill and foundation soil, and drained shear strengths were used for the remaining materials for modeling the pseudo-static earthquake condition. Consolidated-undrained shear strength envelopes were calculated for the existing and proposed embankment fill using procedures developed by Duncan, Wright and Wong for three-stage stability analyses (Wright, 1991). The consolidated-undrained shear strengths and drained shear strengths were then used for those materials, and drained shear strengths were used for the remaining materials for evaluating the rapid drawdown in accordance with the referenced three-stage procedure. The geometry of the modeled section, and a table summarizing shear strengths used for the stability analyses are presented on Fig. 12.

The stability of the dam slopes under a pseudo-static earthquake loading was evaluated using a seismic coefficient of 0.12. That seismic coefficient is equal to 50% of the numeric value of the estimated peak ground acceleration, 0.24 g. discussed early in the "Seismicity and Liquefaction Potential" section of this report, and was determined in accordance with SEO Criteria.

The results of analyses performed to evaluate the slope stability of the existing dam under the long-term steady state, pseudo-static earthquake, and rapid drawdown conditions are summarized on Fig. 12. The results indicate a satisfactory factor of safety of 1.5 for the long-term steady state condition. However, a factor of safety of 0.7 was calculated for the downstream slope under the pseudo-static earthquake condition, and the factor of safety of 1.0 was calculated for the upstream slope for the rapid drawdown condition. Those factors of safety are significantly below the minimum acceptable factors of safety for those conditions. The low factors of safety for both conditions are significantly influenced by the low undrained shear strength for the materials indicated by the triaxial shear strength test results and used in the analyses.

Modified Dam: Subsequent slope stability analyses were performed that develop modifications to the upstream and downstream slopes of the dam in order to satisfy the minimum safety factors indicated in the above table. The proposed modifications included the following:

- Placement of embankment fill on a portion of the upstream slope to reduce the slope inclination as needed to achieve a minimum factor of safety of 1.2 for the rapid drawdown condition.

- Excavation of a trench down to bedrock along a portion of the downstream slope of the dam, and placement of a toe and chimney drain, granular fill and embankment fill in the trench to reconstruct the downstream slope. The drainage system is intended to improve slope stability to achieve a minimum factor of safety of 1.0 for the pseudo-static earthquake condition.

The slope stability analyses were performed for three sections of the dam (Stations 3+04, 6+00 and 8+00) to consider variations in dam height and interpreted ground water conditions along the dam alignment. The analysis for each section considered the stability of the modified dam at both the current normal high water level (NHWL) Elevation 5809.3 feet, and at the original unrestricted NHWL

Elevation 5813.3 feet. The analyses also considered a dam crest at Elevation 5817.5 feet, which approximates a crest elevation of 5817.8 feet. We understand that that crest elevation is needed to provide adequate freeboard above the current spillway level at Elevation 5809.3 feet required to contain the design flood based on information provided by W.W. Wheeler & Associates. The embankment geometry for the three sections, and tables summarizing the shear strengths of the embankment and foundation materials are presented on Figs. 13 through 16.

The analyses were performed for the steady state seepage, rapid drawdown, and pseudo-static earthquake conditions similar to the analysis for the existing dam. In addition, the stability of the downstream slope under the steady state seepage condition was evaluated considering weakened residual shear strength for the weathered and unweathered claystone foundation. The stability of the downstream excavation required to construct the downstream modifications was also considered. The residual shear strength of a material is generally reached once that material has undergone significant shearing, which often results in the formation of significantly weakened shear zones characterized by slickensides and/or shear gouge. Features suggesting significant weak zones in the claystone foundation were not encountered during exploration. However, we believe it is prudent to evaluate the stability of the dam using the lower strength to substantiate that the modified dam has a factor of safety that is marginally greater than 1.0 using the reduced foundation shear strength. A minimum allowable factor of safety of 1.05 was used. The analyses performed to evaluate the temporary stability of the temporary cut-slope for the shear key excavation on the downstream slope assumed that the reservoir is maintained at Elevation 5780 feet during that work. A minimum acceptable factor of safety of 1.3 was used to evaluate the slope stability of the excavation cut in accordance with SEO criteria for the end-of-construction condition.

Similar shear strengths were used to model the existing embankment fill and foundation materials. A slightly higher drained shear strength was used to model new embankment fill required for the slope modifications in comparison to that used for the existing embankment fill, to account for an anticipated strength gain resulting from proper compaction of the material during construction. However, the undrained shear strength of the new fill was assumed to be similar to that used for the existing embankment fill, primarily because the triaxial test results did not indicate a significant increase in that strength for embankment fill materials remolded to the required compaction of at least 95% of the standard Proctor density (ASTM D 698). A drained shear strength consisting of a 34 degree friction angle and zero cohesion was used to model the granular fill and drainage aggregate materials. That shear strength is considered reasonable for granular material satisfying material requirements for CDOT Class 1 Structure Backfill, which is specified for granular fill material in the feasibility-level design presented later in this report. The actual shear strength of the material

will need to be substantiated once a source of granular fill material is identified. A shear strength friction angle of 17 degrees and zero cohesion was used to model the residual shear strength of the foundation claystone for the condition described above. That shear strength was selected based on the results of laboratory Atterberg limits and hydrometer testing discussed in the "Laboratory Testing" section of this report, and the published correlation between residual shear strength and the liquid limit and clay content of clay material presented on Fig. 9.

The analysis results are presented on Figs. 13 through 16 and support the following modifications to the dam:

- Placement of embankment fill to reduce the inclination of the upstream slope to a 3.5:1 (horizontal:inclination) is required to satisfy the factor of safety for the rapid drawdown condition for the modified dam sections at Stations 3+04 and 6+00, as shown on Figs. 13 and 14. The analysis results indicate that a slightly steeper upstream slope inclination will satisfy the stability requirement for the section at Station 8+00; primarily because the height of the dam at that location is shorter than that at Stations 3+04 and 6+00. Those results are presented on Fig. 15.

- Construction of a drainage system and shear key beneath the downstream slope, as shown for the sections at Stations 3+04 and 6+00 on Figs. 13 and 14, respectively, is required to satisfy a minimum acceptable factor of safety of 1.0 for the pseudo-static earthquake condition. The analysis results for the section at Station 8+00, presented on Fig. 15, indicate that the existing downstream slope satisfies minimum factor of safety requirements, indicating that modifications to the downstream slope are not required at that location.

- Based on the results of slope stability analyses presented on Fig. 16, the temporary cut slope into the existing dam for the excavation required to construct the drainage system and shear key should be inclined no steeper than 2:1 (horizontal:vertical) in order to satisfy the minimum factor of safety of 1.3.

SEEPAGE

Seepage analyses were performed to evaluate the effectiveness of installing a chimney filter and toe drain at the downstream toe of the dams for better controlling seepage through the embankment dam. The analyses were performed using the two-dimensional finite element analysis program SEEPW (Geo-Slope International, 2004). A section at dam Station 3+04, similar to the section used

for the slope stability analyses described above, was developed for the analyses.

Calibration Model: Analyses were initially performed to calibrate the hydraulic conductivity values for the modeled embankment and foundation material to produce calculated groundwater levels approximating those measured within piezometers installed along the crest and downstream toe of the dam during field exploration, as described earlier in this report. The calibration model, and the hydraulic conductivity values used for the embankment and foundation materials are presented on Fig. 17.

A range of horizontal and vertical hydraulic conductivity values was initially selected for clayey embankment fill, and weathered and unweathered claystone bedrock. Permeability testing was not performed to obtain hydraulic conductivities for those materials. Instead, a range of hydraulic conductivities were estimated for each material based on the results of laboratory Atterberg limits and gradation tests used to characterize the materials, published ranges of hydraulic conductivity for similar materials developed by the U.S. Bureau of Reclamation, and our experience with similar materials. Several analyses were performed in which the hydraulic conductivity values for the embankment fill and the underlying, interbedded sandy clay and clayey sand foundation were varied within the estimated hydraulic conductivity range for each material, and until groundwater levels for the selected reservoir level approximated those measured based on the plotted information presented on Fig. 5. Groundwater levels measured in the piezometers when the reservoir level was at the normal high water level (NHWL) Elevation 5809.3 feet were considered.

It was not possible to approximate the groundwater level within the embankment dam without considering flows collected by the existing system of tile drains. For that reason, a drain was modeled beneath the downstream slope within the vicinity of two existing tile drains indicated by the historical drawings discussed earlier in the "Existing Drainage System" section of this report. Based on visual observations when the reservoir was near the above NHWL, flows from existing drains entering into Manhole No. 2 were estimated to be in the range of 2 to 3 gpm. The analysis results presented on Fig. 17 indicate a calculated flow from the existing drain lines of 0.0113 gpm per foot length of dam when the hydraulic conductivity values for the embankment and foundation materials presented in the table on that figure are used. The estimated total length of the existing drain lines on each side of the manhole is about 220 feet, which, when multiplied by the above flow rate per foot results in a total calculated flow of about 2.5 gpm. The calculated ground water surface (piezometric surface) shown in the section on Fig. 17 is also in relatively good agreement with ground water levels interpreted for that section based on the groundwater data. Given the significant unknowns regarding the condition of the existing drain lines, and seepage conditions in the right abutment of

the dam that appear to be anomalous compared to other portions of the dam, we believe that seepage analyses can only roughly approximate seepage conditions. However, we believe the calibration model is reasonable for approximating flows into a toe and chimney drain system considered as part of the modified dam, discussed below.

Drainage System for Modified Dam: Seepage analyses were subsequently performed to evaluate the effectiveness of installing a toe drain and chimney drain beneath the downstream toe of the dam as part of the downstream modification to the dam. The same dam section at Station 3+04 used for the existing dam was modified to include modifications to the upstream and downstream slopes described in the "Slope Stability" section of this report. A toe drain extending one to two feet into the bedrock underlying the embankment, and a connecting 3-foot wide chimney drain extending up to Elevation 5790 feet was modeled. Hydraulic conductivity values for the new embankment fill placed on the upstream and downstream slope, and the drainage aggregate and granular fill for the shear key located beneath the downstream slope were estimated using the published USBR correlations discussed above, and our experience with similar materials. A reservoir water level at the unrestricted NHWL Elevation 5813.3 feet was used to consider higher flow conditions anticipated at the higher reservoir level.

The analysis results are presented on Fig. 18 and indicate calculated flows to the new drain of 0.011 gpm per foot of dam length. It should be noted that the calculated flows to the new drain are marginally less than those calculated for the existing drain lines as shown on Fig. 17. We believe this is due in part to the modeled location of the existing drains, which is closer to the upstream slope face compared to the new drain for the modified dam. The closer distance results in a shorter seepage path, which can result in increased seepage flows. The analysis results were considered in evaluating requirements for a new toe drain for the modified dam, discussed later in this report.

UPSTREAM SLOPE ARMORING

Riprap Size and Thickness Evaluation: Analyses were performed to estimate the size and thickness of riprap required for armoring the reservoir-side slopes of the dam. The analyses were performed using procedures presented in the Soil Conservation Service publication "Riprap for Slope Protection Against Wave Action" (SCS Technical Release No. 69, February 1983). A maximum wind velocity of 80 miles per hour based on a 50-year recurrence was interpolated from published figures, which was used to estimate a design wind velocity over water of 83 miles per hour following the procedure. A design wind direction of 29 degrees (azimuth) was estimated using available monthly wind direction

data, which was used to calculate an effective fetch of 0.24 miles using the procedure. Based on that information, a significant wave height of 2.0 feet was estimated.

In evaluating the size of riprap material required for armoring, an upstream slope inclined 3.5:1 (horizontal:vertical) approximating the proposed upstream slope inclination for the modified dam was considered. Assuming a specific gravity of 2.60 for rock riprap material, riprap D_{50} size of approximately 8.5 inches was determined. Based on those results, Type L riprap as specified by the Urban Drainage Flood Control District (UDFCD) was selected. Type L riprap has a mean particle size, D 50, of 9 inches. Gradation limits for Type L Riprap are presented below and shown on Fig. 19.

GRADATION LIMITS FOR TYPE L RIPRAP

% Smaller Than Given Size by Weight	Intermediate Rock Dimension (inches)
70-100	15
50-70	12
35-50	9
2-10	3

The gradation limits for proposed riprap bedding to be placed beneath the riprap is also included in that figure and presented below.

GRADATION LIMITS FOR RIPRAP BEDDING

Sieve Size	% Passing
3 Inch	100
1 ½ Inch	70-100
¾ Inch	52-90
No. 4	20-60
No. 10	8-40
No. 30	0-15
No. 200	0-3

The bedding material generally satisfies filter-compatibility requirements with respect to mitigating against migration of bedding material through the riprap. However, it only marginally satisfies filter-compatibility requirements with respect to placement against the clayey embankment fill. We believe this is adequate considering the increased resistance of the clayey embankment fill to erosion because of the moderate plasticity of that material. The gradation limits of the bedding layer are designed to be filter-compatible with the riprap, and are similar to the gradation limits used for bedding and riprap placed against embankments dams and impoundment liners consisting of moderately plastic clay and claystone fill that have been constructed in the Denver front range area for several years.

Existing Riprap: A reconnaissance was performed during exploration to document the type, size range and thickness of the existing riprap material along the upstream slope of the dam. An observational inventory of the riprap observed along the upstream right abutment, and at 100-foot station offsets along the dam from Stations 0+00 to 8+00, was conducted. The results of that reconnaissance are summarized in Table 2. The observed riprap generally consisted of both very hard granitic rock and softer sandstone rock fragments anticipated to be less resistant to erosion. Observed rock sizes ranged from approximately 3 inches to 36 inches in size, and the estimated median rock size appeared to range from about 12 inches to 20 inches. The nominal thickness of the existing riprap observed at each dam station (averaging out the thickness between pockets of smaller rock compared to larger rock ranging up to 36 inches) appeared to range from about 8 to 15 inches. Approximately 2,000 cubic yards of existing riprap is estimated. The possible uses of the existing riprap are discussed in the "Feasibility-Level Design" section of this report, below.

FEASIBILITY-LEVEL DESIGN

A plan showing a proposed feasibility-level design for modifying the dam is presented on Fig. 20, and sections for the proposed modifications are presented on Figs. 21 and 22. Details for the design are presented on Fig. 23. The design was developed based on the results of slope stability, seepage, and upstream-slope armoring evaluations presented above. A summary of the feasibility-level design is presented below:

- The design includes a 14-foot wide dam crest at Elevation 5817.5 feet, and placement of a 6-inch layer of surface course (CDOT Class 6 aggregate base course). The crest width is less than that recommended by the SEO (an 18-foot width is estimated for the 40-foot high dam based on their criteria), but we believe this may be acceptable given that the work involves modifications to an existing dam with no significant increase in the height of the dam. We

recommend that a surface course be considered to protect the dam crest from rutting, and to maintain positive drainage across the road.

- The upstream modifications include placement of embankment fill to reduce the inclination of the upstream slope. The fill includes that placed against the steep scarp formed in the upstream right abutment of the dam, and on the upstream slope from Stations 0+00 to 8+50. The fill extends from the dam crest down to where it catches the existing ground surface, and is sloped 3:1 (horizontal:vertical) along the upstream right abutment and to Station 0+50, transitions from a 3:1 slope to a 3.5:1 slope from Stations 0+50 to 1+00, is sloped 3.5:1 from Stations 1+00 to 7+00, transitions from a 3.5:1 slope to a 3:1 slope from Stations 7+00 to 8+00, and is sloped 3:1 from Stations 8+00 to 8+50 where the fill is terminated as shown on Fig. 20. The fill slopes were selected based on the results of the slope stability analyses. Placement of fill material along the upstream right abutment is intended to stabilize the scarp and increase the seepage path in order to reduce the apparent elevated groundwater levels observed near the right abutment when compared to those measured along other portions of the dam. New embankment fill composed of clayey material similar to that used for the existing dam is assumed such that the new fill can be obtained from on-site borrow sources.

- Riprap and riprap bedding extends along the upstream slope from the right abutment scarp fill to Station 12+50, which is near the dam station where the existing riprap ends. Riprap and bedding placed on top of the proposed upstream fill extends down to Elevation 5795 feet. That elevation is generally below the normal drawdown level for the reservoir based on the water-level monitoring data provided to us, and below an elevation for which significant wave erosion is anticipated. It may be practical to increase the riprap toe elevation based on further evaluation during final design. The proposed riprap consists of hard, durable riprap satisfying requirements for Type L Riprap. A minimum 16-inch thickness is used, which is slightly larger than the maximum riprap size of 15 inches specified for that riprap. The riprap is underlain by a 6-inch layer of riprap bedding satisfying the gradation limits presented on Fig. 19. The possible use of the existing riprap material to supplement imported riprap is discussed later in this section.

- The downstream modifications include initially excavating a trench along the downstream slope below Elevation 5810 feet, from Dam Stations 0+50 to 7+20. The upstream side of the trench is sloped 2:1 (horizontal:vertical), in addition to maintaining the reservoir at the full drawdown level of about Elevation 5780 feet (corresponding to the estimated invert elevation for the outlet works inlet within the reservoir), to maintain a stable cut-slope during the

downstream-slope construction. The trench is intended to extend about 1 to 4 feet into the bedrock underlying the dam embankment, as shown by Sections 1 through 4 on Figs. 21 and 22.

- An approximately 600-foot long toe drain is located at the bottom of the completed excavation as shown in the sections on Fig. 21, and extends from Stations 1+00 to 7+00. The toe drain pipe flows into a new manhole positioned at about Station 3+45 and about 40 feet downstream of existing Manhole No. 2 (as shown on Fig. 11). The two drain inlets entering the right and left side of the manhole (as shown on Fig. 20) are at invert Elevation 5770.5 feet, and the outflow pipe is located at invert Elevation 5768.7, which corresponds to the estimated invert elevation of the existing discharge pipe where it exits Manhole No. 2. This is intended to allow use of the existing discharge pipe for delivering flows to the storm drain and manhole to the north of the dam as shown on Fig. 20. An inspection to assess the condition and integrity of the existing pipe and storm-drain manhole for carrying flows will need to be performed for final design. Drain pipe clean-outs are located on each end of the toe drain as shown on Fig. 20, and a clean-out detail is presented on Fig. 23. The clean-outs allow for inspection and cleaning of the toe-drain pipe.

- The toe drain consists of a perforated (slotted) 6-inch diameter Schedule 40 PVC pipe embedded in a graded filter that consists of coarse drain material (No. 67 Aggregate) surrounded by a fine filter material (ASTM C33 fine aggregate), as presented in Detail 2 on Fig. 23. Based on flow calculations and assuming that the drain pipe can maintain a slope of at least 2% toward the manhole, we estimate a flow capacity greater than 250 gpm when the 6-inch diameter drain pipe is running half full. The seepage analyses for the modified dam indicate a calculated flow at the drain of 0.011 gpm per foot length of pipe, which results in a total calculated flow of less than 7 gpm for the proposed 600-foot toe drain. However, there are significant unknowns regarding the construction of the existing drainage system, and flows in excess of that determined from the seepage analyses could be encountered. A 6-inch diameter pipe was considered for the feasibility design for that reason.

- The toe drain is hydraulically connected to a chimney drain that has a horizontal thickness of 5 feet (2.23 feet thick measured normal to the drain) and extends up the 2:1 cut-slope behind the toe drain up to Elevation 5790 feet, as shown on Figs. 21 through 23. The chimney drain is composed of ASTM C33 fine aggregate, and is intended to control and route groundwater flows to the toe drain. It will also act as a filter for mitigating internal erosion (piping) of fine materials, including potential erosion that may be occurring along existing drainage conduits.

We do not recommend plugging the ends of existing drainage conduits that may be encountered on the 2:1 cut-slope during excavation, because plugging the conduits could result in increasing ground water levels within the dam. Instead, we recommend increasing the thickness of the chimney drain where it abuts against the exposed end of the drain to allow existing drain flow to enter the chimney drain while stopping the migration of fines that may be carried inside or surrounding the existing drain conduits. There is a possibility that some existing drains may extend into the bedrock below the proposed bottom of the toe drain. However, based on our assessment of the historical drawings and our field measurements, we believe that potential is low. This can be further substantiated by performing exploratory pits during excavation, particularly in areas where existing fill is encountered below the proposed bottom of the toe drain.

- A granular fill is placed above the toe drain and in front of the chimney drain for the portion of the downstream slope where the downstream toe extends below Elevation 5780 feet. The granular material consists of imported material satisfying requirements for CDOT Class 1 Structure Back Fill, and is intended to provide a zone of higher shear resistance (i.e., shear key) as discussed in the "Slope Stability" section of this report.

Reuse of Existing Riprap Materials: Based on our site observations, the existing riprap does not adequately protect the upstream slope from wave run-up erosion. This is due in part to the absence of granular bedding beneath the riprap, the relatively large size of the riprap material, and the randomness in the size and type of riprap material. A significant portion of the existing riprap is composed of sandstone rock fragments, which is generally not recommended for riprap due to the greater susceptibility to wave run-up erosion when compared to granitic riprap. Significant effort will likely be required to remove, stockpile and process the on-site material for riprap. However, we believe that it may be possible to reuse a large portion of the existing material in areas along the upstream slope where significant wave run-up scarps have not been observed, and/or along the lower portion of the upstream slope where wave run-up energy is anticipated to be relatively small. Those areas could possibly include the lower portion of the riprap placed on the reconstructed upstream slope (e.g., below Elevation 5805 feet), and along portions of the upstream slope that do not show significant head scarps near the top of the slope because they are better shielded from wave run-up (e.g., from about Stations 9+00 to 12+50). If re-use of part of the existing riprap material is considered, placement of a two-layer riprap bedding beneath the riprap will likely be necessary. The gradation of the existing riprap roughly approximates that for H-size riprap having a d_{50} size of 18 inches. Given the larger sizes of the existing riprap, and the variable dimension and type of rock composing that material, it may be necessary to use a graded bedding beneath the on-

site riprap material. The graded bedding would be composed of two bedding layers such as the Type I/Type II bedding satisfying gradation requirements of the Urban Drainage and Flood Control District (UDFCD). That graded bedding consists of 4 inches of Type I bedding over 6 inches of Type II bedding, resulting in a 10-inch thick bedding layer compared to 6 inches where imported Type L riprap is used. The feasibility of using the on-site riprap should be considered further in final design.

FEASIBILITY-LEVEL COST ESTIMATE

A feasibility-level cost estimate for the proposed feasibility-level design is presented in Table 3. The unit prices for Items presented in the table are based on cost information from recent large earthwork construction in the metropolitan Denver area and other areas in Colorado, and published cost information. The table does not represent an engineer's estimate of the probable cost of construction. Instead, it provides an approximate estimate of the construction cost based on limited information, and for a design that has not yet been fully developed. It should therefore be considered an approximation of cost, and should be used only for planning purposes related to possible further development of the design.

The cost estimate presented on Table 3 does not consider the possible re-use of existing riprap materials. An evaluation was performed to estimate the possible savings of using the on-site materials. The evaluation assumed 2,000 cy of available on-site riprap, a nominal riprap thickness of 24 inches to account for the wide and variable range of rock sizes ranging up to 36 inches, and placement of a 10-inch thick graded Type I/Type II bedding layer beneath that riprap. A unit price of $15/cy was estimated for stockpiling, mixing and placing the on-site riprap material.

The on-site riprap could be used to cover an approximate area of 27,000 ft^2 based on the estimated available volume of 2,000 cy and a nominal riprap thickness of 24 inches. Using the unit prices for riprap and riprap bedding presented in Table 3, this would result in an estimated savings of about $68,000 for a 16-inch thick layer of imported riprap underlain by 6 inches of bedding placed over that area.

The estimated cost of on-site riprap placed over a graded bedding was then estimated. Because of the increased thickness of the on-site riprap (24 inches compared to 16 inches for imported riprap), the estimated replacement volume of on-site riprap required to fill the above area is about 50% greater than that for the imported riprap. Likewise, the increase in bedding thickness (from 6 inches for bedding underlying imported riprap to 10 inches for a graded bedding underlying the on-site riprap) results in a 67% increase in the quantity of bedding. Using a unit price of $15/cy for

placement and handling of on-site riprap, and the unit price for riprap bedding presented in Table 3, we estimate an approximate cost of $59,155. Therefore, the resulting saving of using on-site riprap compared to importing riprap is estimated to be in the range of about $9,000. It should be recognized that the estimate is approximate, and does not account for possible costs associated with disposal or burial of existing riprap if it isn't used. The actual unit price for handling and placing the on-site riprap is also approximate and could range to as low as $10/cy. However, the results of the evaluation suggests that the possible costs may not be significant enough to consider using a lesser-quality on-site riprap in comparison to imported riprap.

LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering practices in this area for exclusive use by the client for design purposes. The conclusions, recommendations, and feasibility-level design presented in this report are based upon the data obtained from the exploratory borings at the locations indicated on Fig. 1, information from exploration performed by others, and historical drawings provided for previous modifications to the dam. This report may not reflect subsurface variations that occur between the exploratory borings, or interpreted from information from previous studies and modifications done by others. The nature and extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, Kumar & Associates, Inc. should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. Kumar & Associates, Inc. is not responsible for liability associated with interpretation of subsurface data by others.

GJM/av

cc: Book, file

100 0 100 200

APPROXIMATE SCALE-FEET

NORTHBOUND C-470

SOUTHBOUND C-470

WEST BELLEVIEW AVENUE

EXISTING OUTLET BASIN AND CHANNEL

EXISTING OUTLET TOWER

BERGEN DAM No. 2

APPROXIMATE DAM AXIS AND STATIONING BASED ON 1949 DRAWING

BERGEN No. 2 RESERVOIR

BERGEN No. 1 RESERVOIR

KB-09-1
KB-09-2
KB-09-3
KB-09-4
KB-09-5

CB-84-7
CB-84-8
CB-84-9
CB-84-10
CB-84-11

KP-09-1
KP-09-2
KP-09-3
KP-09-4
KP-09-5
KP-09-6

LEGEND:

- KB-09-3 — ● LOCATION OF EXPLORATORY BORING PERFORMED FOR THIS STUDY
- KP-09-2 — ■ LOCATION OF EXPLORATORY PIT PERFORMED FOR THIS STUDY
- CB-84-9 — ▲ LOCATION OF EXPLORATORY BORING FROM PREVIOUS 1984 STUDY BY CHEN & ASSOCIATES JOB No. 1 195 84

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09-1-211A	Kumar & Associates	BERGEN DAM No. 2	LOCATIONS OF EXPLORATORY BORINGS AND PITS	Fig. 1

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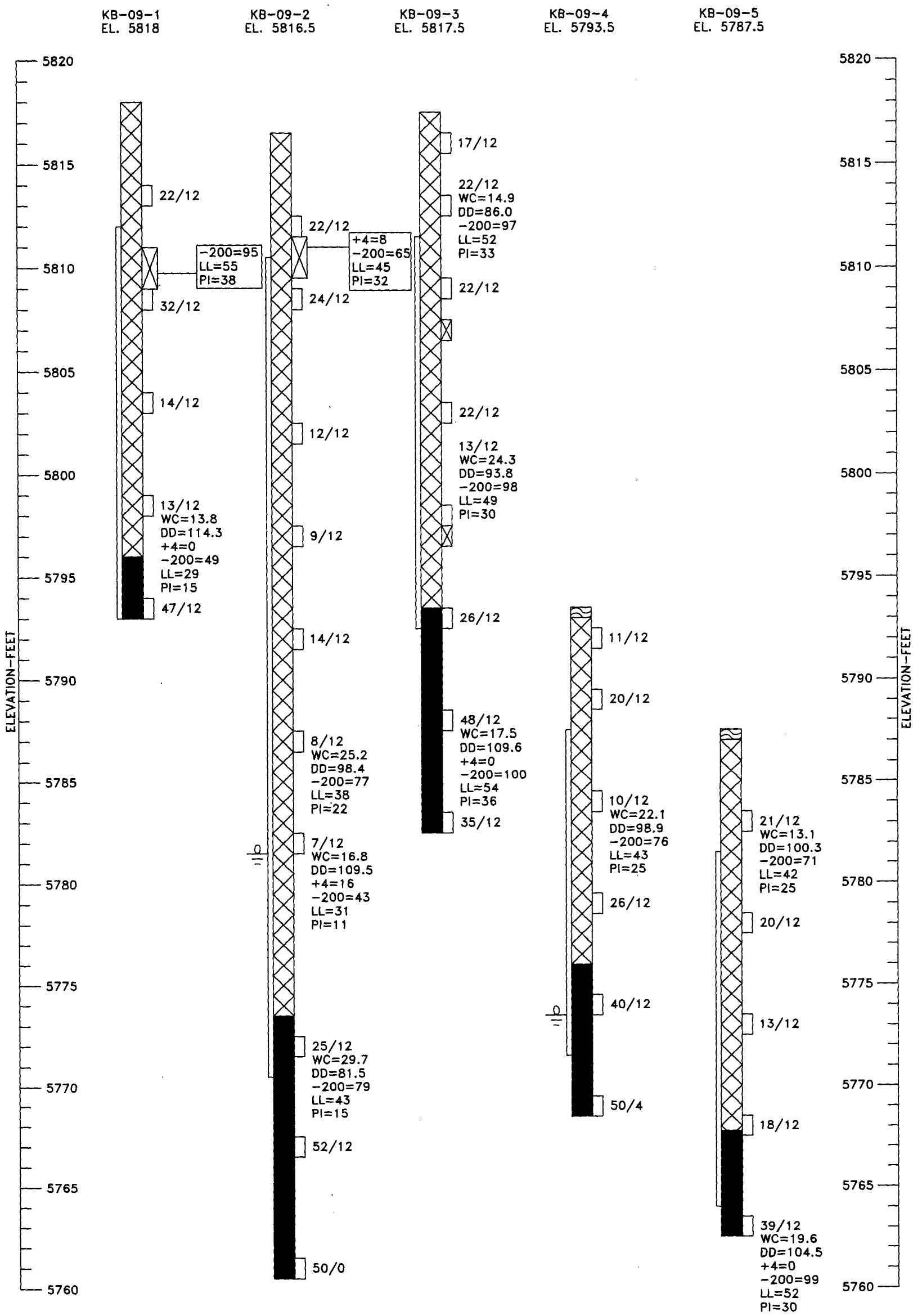
09-1-211A

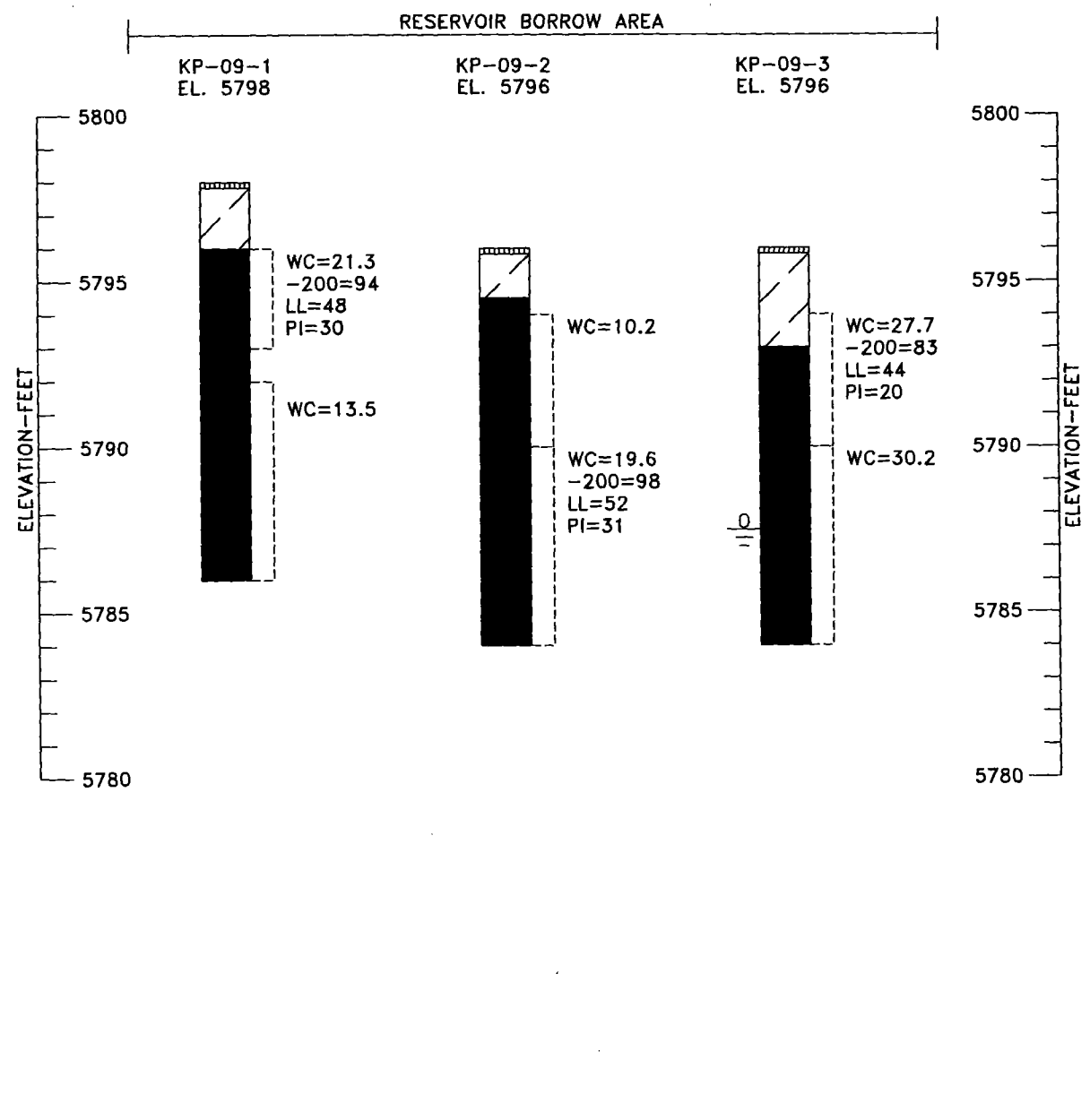
Kumar & Associates

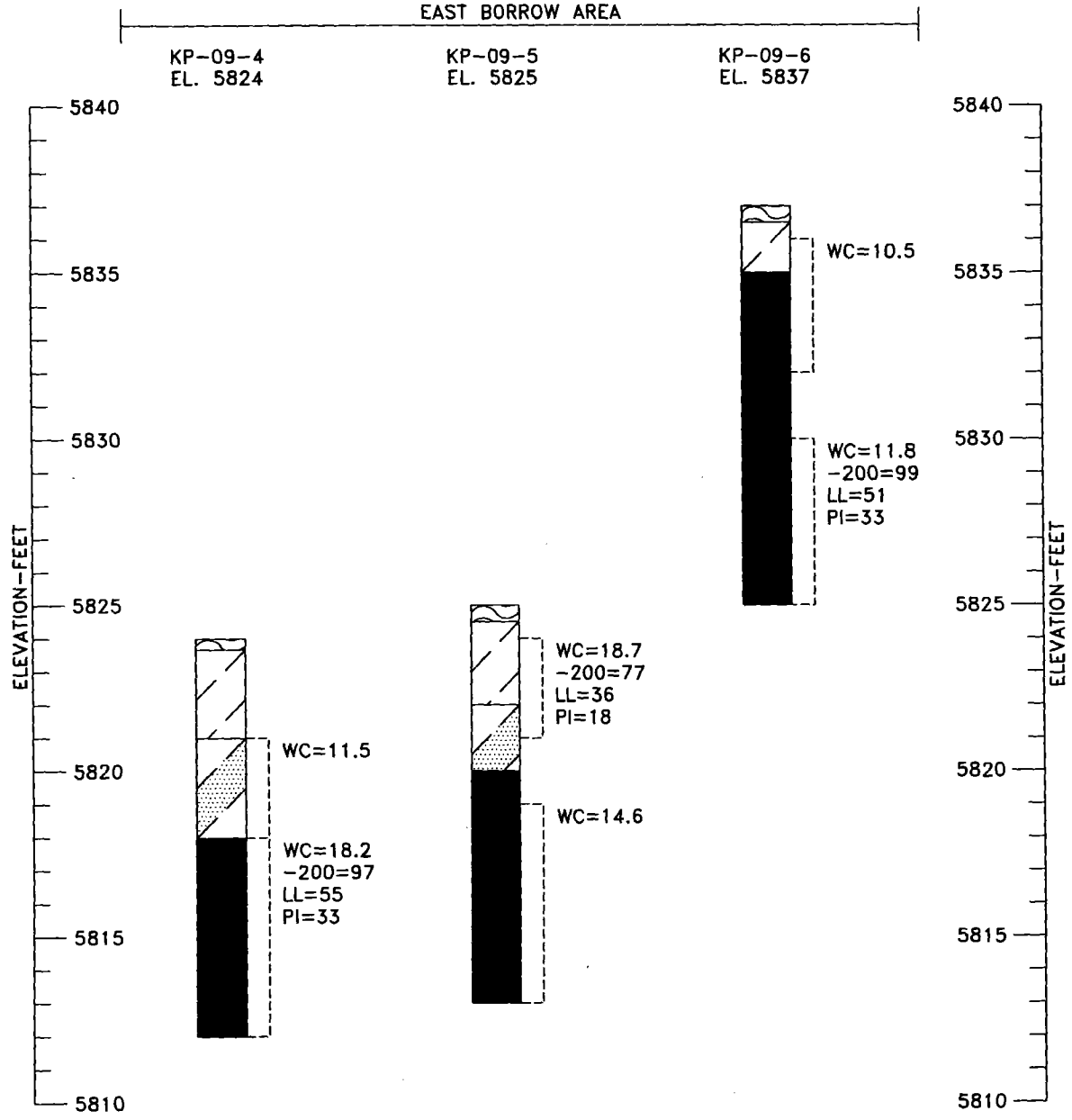
BERGEN DAM No. 2

LOGS OF EXPLORATORY BORINGS

Fig. 2







09-1-211A	Kumar & Associates	BERGEN DAM No. 2	LOGS OF EXPLORATORY PITS	Fig. 3

LEGEND

TOPSOIL.

LAKE BOTTOM SEDIMENT.

FILL: SANDY LEAN CLAY (CL), OCCASIONAL CLAYEY SAND (SC), APPARENT STIFF TO VERY STIFF CONSISTENCY BASED ON BLOW COUNT INFORMATION, MOIST, RED–BROWN, GREEN–BROWN AND MOTTLED GREEN AND BROWN, OCCASIONAL POCKETS OF ORGANIC–RICH SOIL CONTAINING FINE GRASS ROOTS.

CLAYSTONE BEDROCK, OCCASIONAL SILTSTONE, WEATHERED TO VERY HARD, MOIST, RED–BROWN, TAN, AND GRAY, APPARENT SECONDARY MINERALIZATION OF GYPSUM IN HEALED DISCONTINUITIES, MANGANESE STAINING, OCCASIONAL LIGHT TO MODERATE CEMENTATION OBSERVED IN EXPLORATORY PITS.

WEATHERED CLAYSTONE, OCCASIONALLY LIGHTLY TO MODERATELY CEMENTED, APPARENT WEATHERED CONSISTENCY, MOIST TO WET, BROWN TO ORANGE–BROWN, OCCASIONALLY CALCAREOUS.

SANDY LEAN CLAY (CL), APPARENT MEDIUM STIFF TO STIFF CONSISTENCY, MOIST TO VERY MOIST, LIGHT BROWN TO DARK BROWN.

DRIVE SAMPLE, 2–INCH I.D. CALIFORNIA LINER SAMPLE.

SHELBY TUBE SAMPLE.

DISTURBED BULK SAMPLE.

SCREEN INTERVAL FOR PIEZOMETER INSTALLED IN COMPLETED EXPLORATORY BORING.

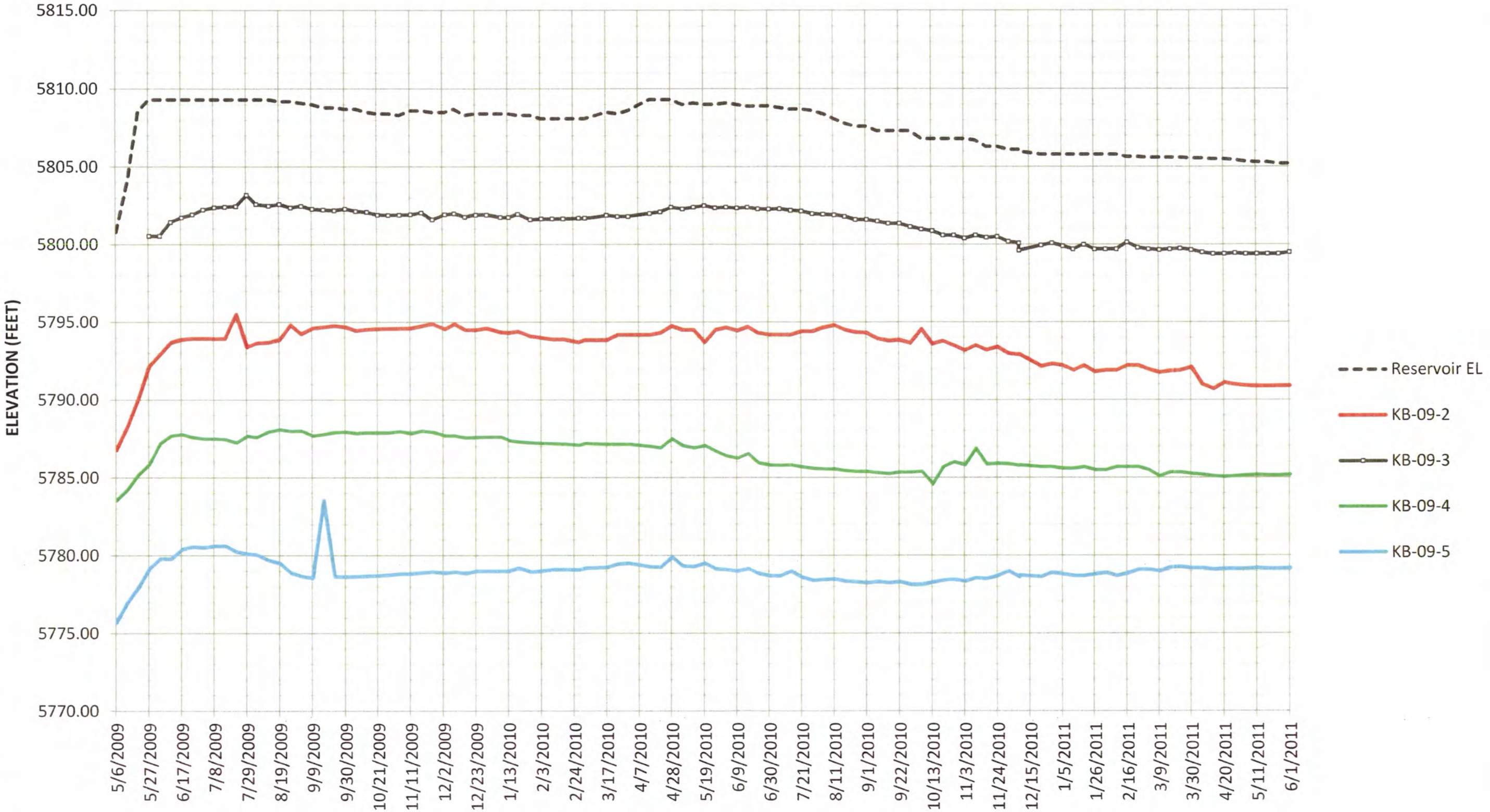
23/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 23 BLOWS OF A 140–POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

$\frac{0}{\equiv}$ DEPTH TO WATER LEVEL AND NUMBER OF DAYS AFTER DRILLING MEASUREMENT WAS MADE.

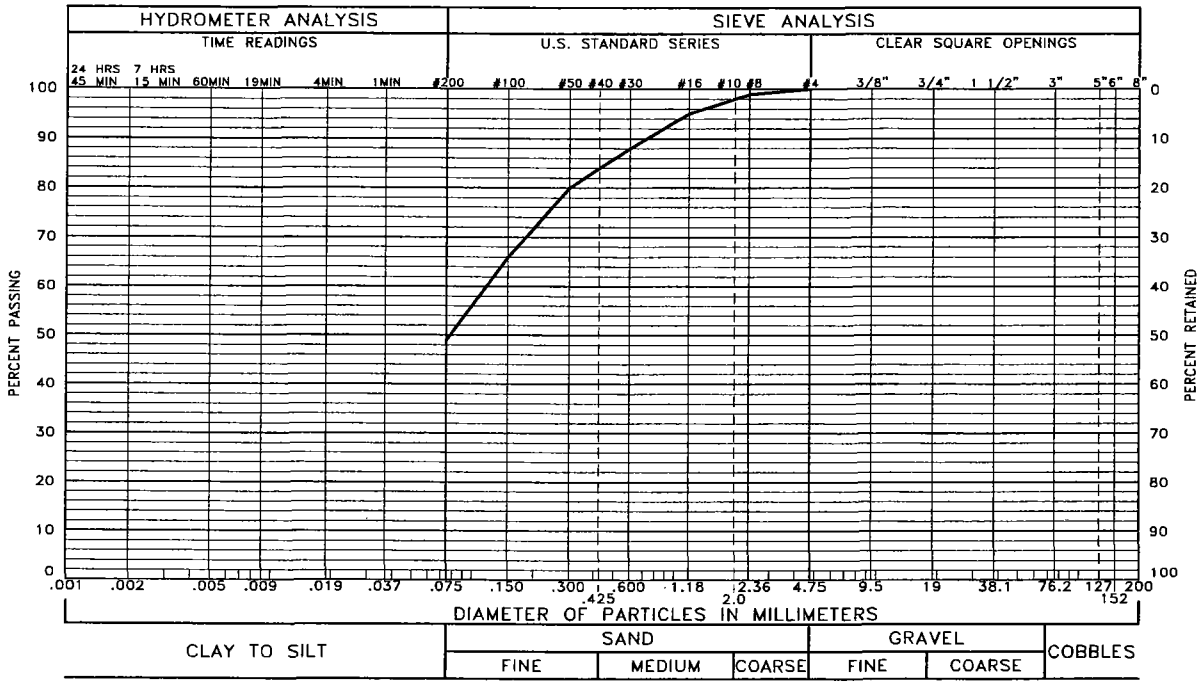
NOTES

1. THE EXPLORATORY BORINGS WERE DRILLED ON APRIL 27 AND 28, 2009 WITH A 7–INCH DIAMETER CONTINUOUS FLIGHT HOLLOW STEM POWER AUGER. THE EXPLORATORY PITS WERE EXCAVATED ON MAY 6, 2009 WITH A RUBBER TIRE BACKHOE.
2. THE LOCATIONS OF THE EXPLORATORY BORINGS AND PITS WERE MEASURED APPROXIMATELY BY PACING FROM FEATURES SHOWN ON THE SITE PLAN PROVIDED.
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS AND PITS WERE OBTAINED BY INTERPOLATION BETWEEN CONTOURS ON THE SITE PLAN PROVIDED.
4. THE EXPLORATORY BORING AND PIT LOCATIONS AND ELEVATIONS SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.
5. THE LINES BETWEEN MATERIALS SHOWN ON THE EXPLORATORY BORING AND PIT LOGS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES AND THE TRANSITIONS MAY BE GRADUAL.
6. GROUND WATER LEVELS SHOWN ON THE LOGS WERE MEASURED AT THE TIME AND UNDER CONDITIONS INDICATED. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.
7. LABORATORY TEST RESULTS:
   WC = WATER CONTENT (%) (ASTM D 2216);
   DD = DRY DENSITY (pcf) (ASTM D 2216);
   +4 = PERCENTAGE RETAINED ON NO. 4 SIEVE (ASTM D 422);
   −200 = PERCENTAGE PASSING NO. 200 SIEVE (ASTM D 1140);
   LL = LIQUID LIMIT (ASTM D 4318);
   PI = PLASTICITY INDEX (ASTM D 4318);
   NP = NON–PLASTIC (ASTM D 4318);
   NV = NO LIQUID LIMIT VALUE (ASTM D 4318);
   PDP = PINHOLE DISPERSION POTENTIAL (ASTM D 4647).

09–1–211A	Kumar & Associates	BERGEN DAM No. 2	LEGEND AND NOTES	Fig. 4



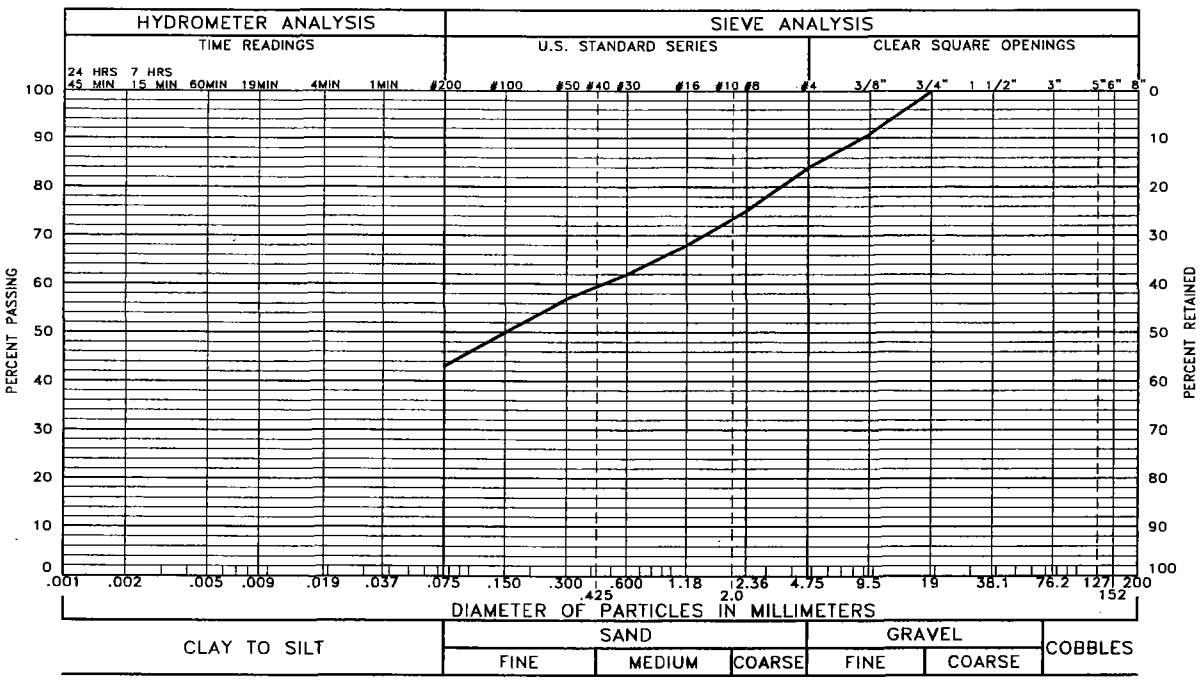
09-1-211A	Kumar & Associates	BERGEN DAM NO. 2	PIEZOMETER WATER LEVEL MONITORING DATA	Fig. 5



GRAVEL 0 % SAND 51 % SILT AND CLAY 49 %

LIQUID LIMIT 29 PLASTICITY INDEX 15

SAMPLE OF: Fill: Clayey Sand FROM: Boring KB-09-1 @ 19'

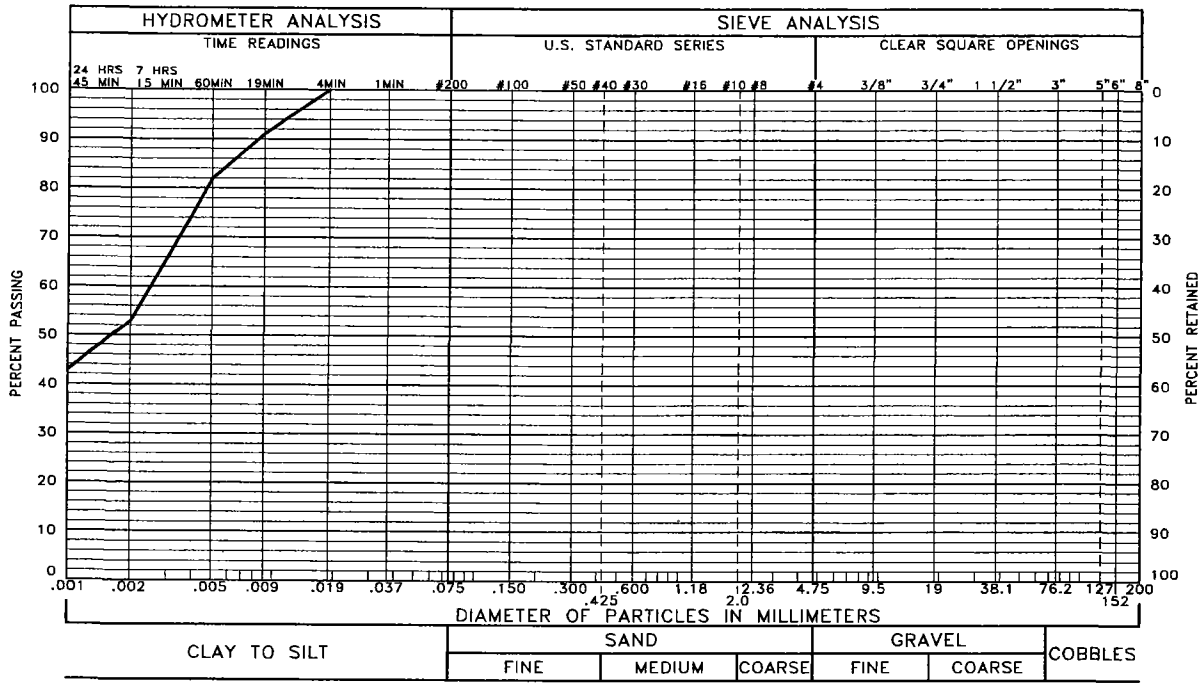


GRAVEL 16 % SAND 41 % SILT AND CLAY 43 %

LIQUID LIMIT 31 PLASTICITY INDEX 11

SAMPLE OF: Fill: Clayey Sand with Gravel FROM: Boring KB-09-2 @ 34'

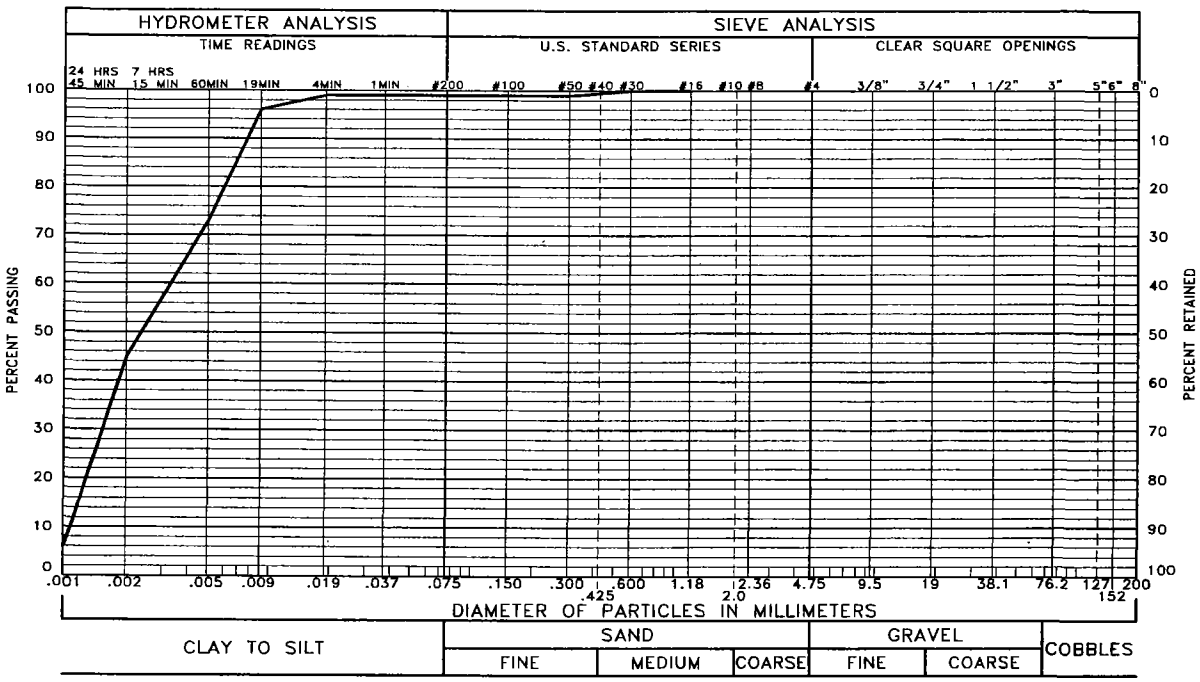
09-1-211A	Kumar & Associates	GRADATION TEST RESULTS	Fig. 6



GRAVEL 0 % SAND 0 % SILT AND CLAY 100 %

LIQUID LIMIT 54 PLASTICITY INDEX 36

SAMPLE OF: Claystone Bedrock FROM: Boring KB-09-3 @ 29'

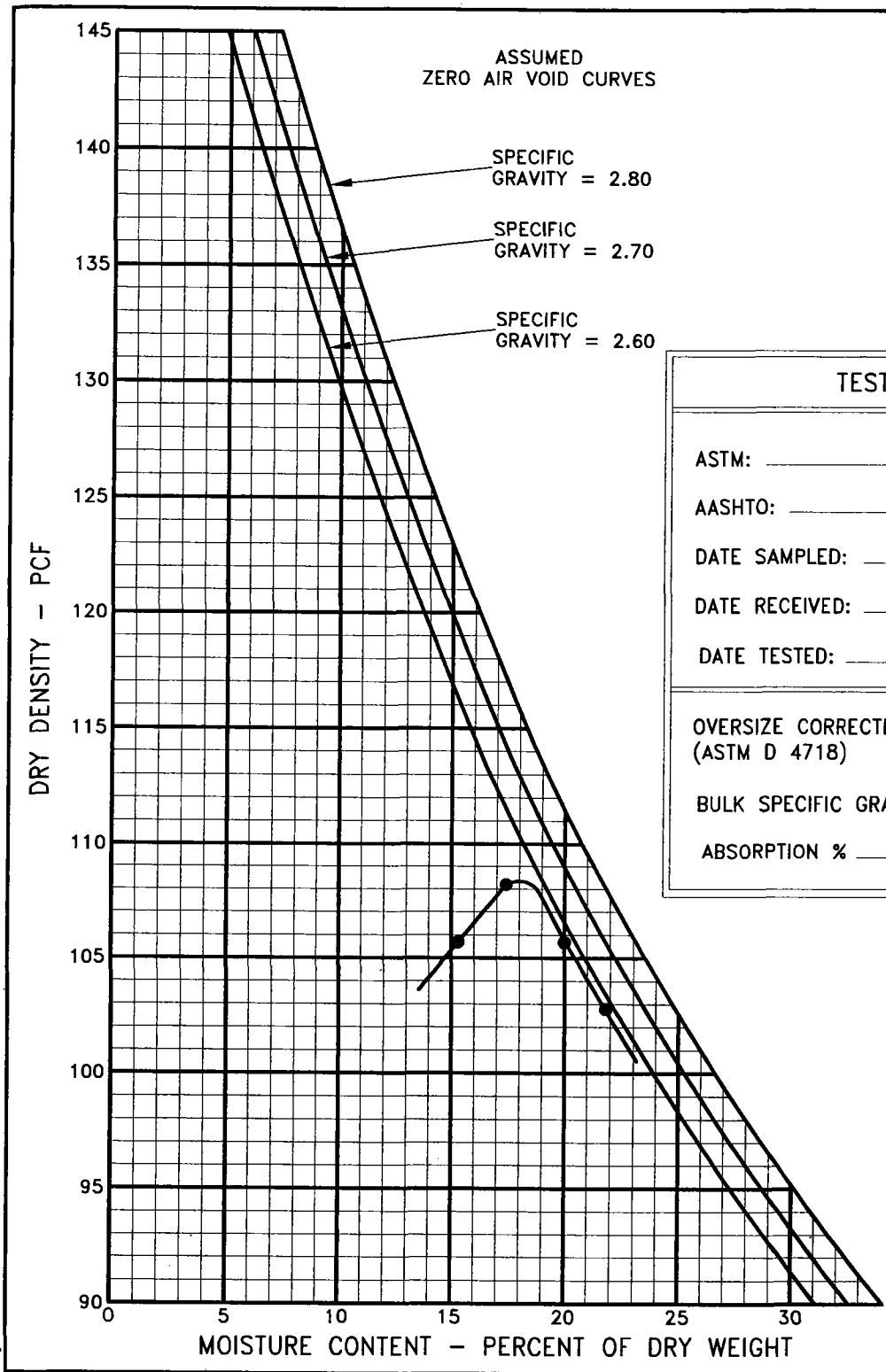


GRAVEL 0 % SAND 1 % SILT AND CLAY 99 %

LIQUID LIMIT 52 PLASTICITY INDEX 30

SAMPLE OF: Claystone Bedrock FROM: Boring KB-09-5 @ 24'

09-1-211A	Kumar & Associates	GRADATION TEST RESULTS	Fig. 7



TEST METHOD	
ASTM:	D 698-07A
AASHTO:	
DATE SAMPLED:	06-24-09
DATE RECEIVED:	06-24-09
DATE TESTED:	06-24-09
OVERSIZE CORRECTION (ASTM D 4718)	N/A
BULK SPECIFIC GRAVITY	
ABSORPTION %	

MAXIMUM DRY DENSITY: 108.3 pcf OPTIMUM MOISTURE CONTENT: 18.0 %

SOIL TYPE: Claystone Bedrock

SAMPLE NO.:

GRAVEL: %

SAND: %

SILT AND CLAY(-200): 94 %

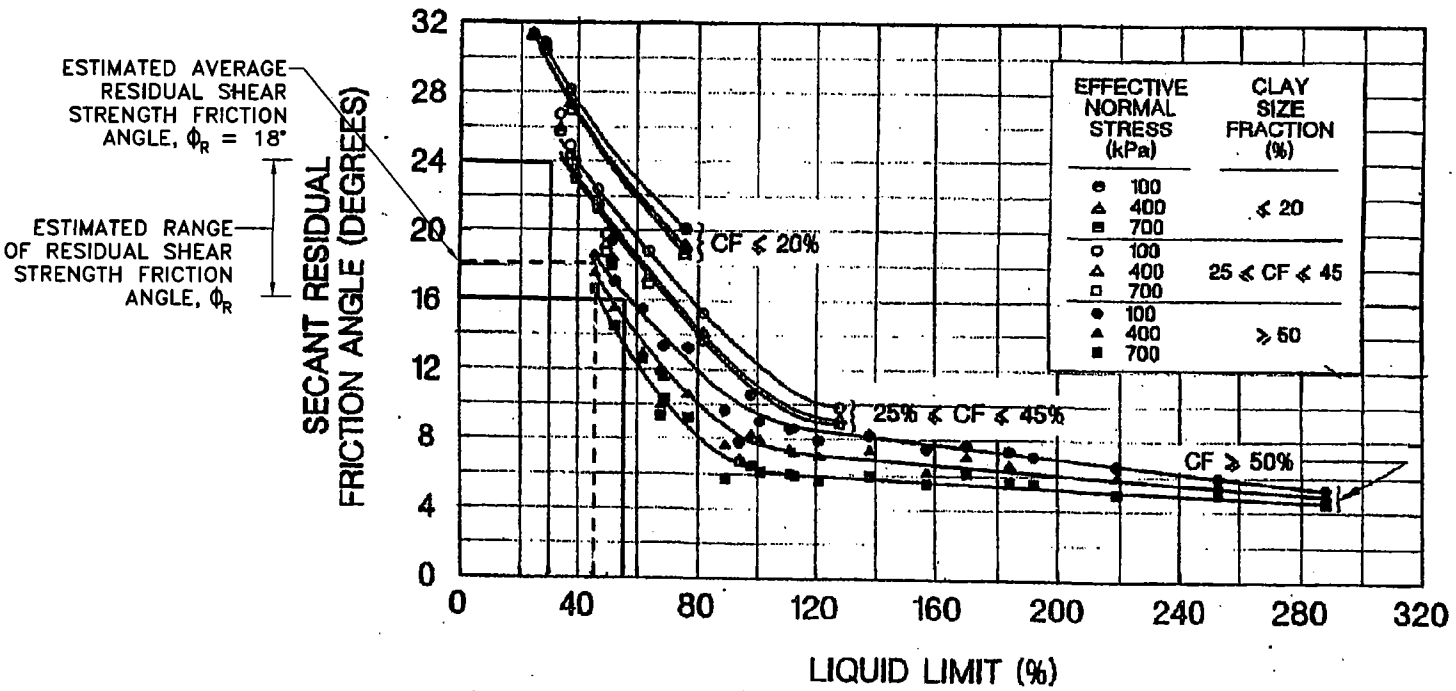
LIQUID LIMIT: 48

PLASTICITY INDEX: 30

LOCATION:

BORING NO.: KP-09-1 DEPTH: 2'-5'

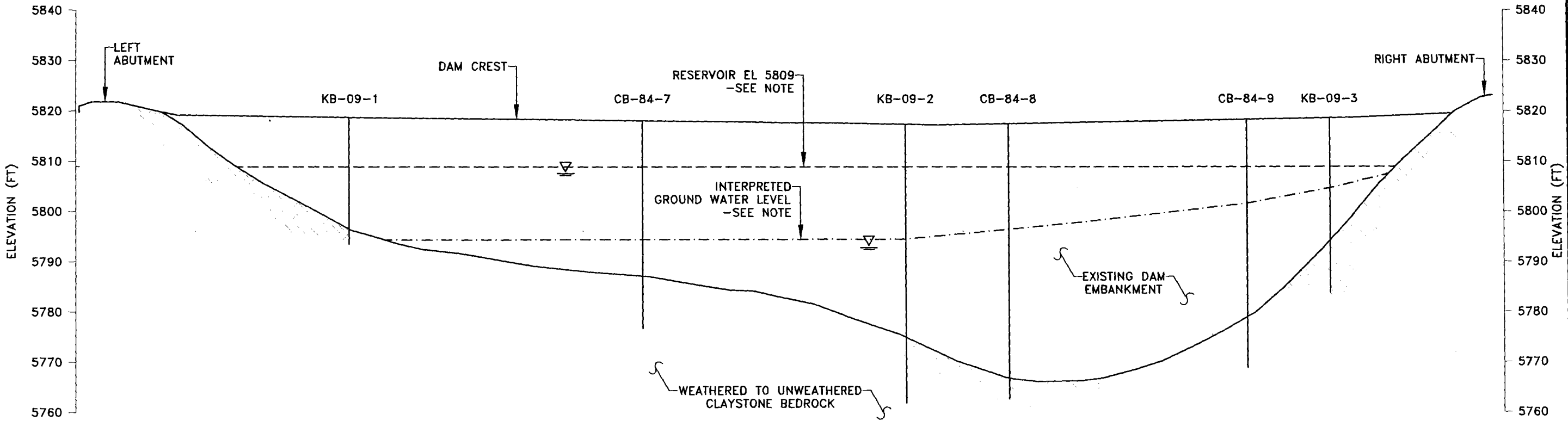
09-1-211A	Kumar & Associates	MOISTURE-DENSITY RELATIONSHIPS	Fig. 8



NOTE:

RELATIONSHIP DEVELOPED BY STARK AND EID (ASCE JOURNAL OF GEOTECHNICAL ENGINEERING, MAY, 1994)

09-1-211A	Kumar & Associates	RELATIONSHIP BETWEEN DRAINED RESIDUAL FRICTION ANGLE AND LIQUID LIMIT	FIG. 9



14+00 10+00 5+00 0+00

APPROXIMATE DAM STATIONING

50 0 50 100

HORIZONTAL SCALE-FEET

10 0 10 20

VERTICAL SCALE-FEET

NOTE:

GROUND WATER LEVEL MEASURED IN KUMAR PIEZOMETERS WHEN RESERVOIR LEVEL WAS AT APPROXIMATE EL 5809'

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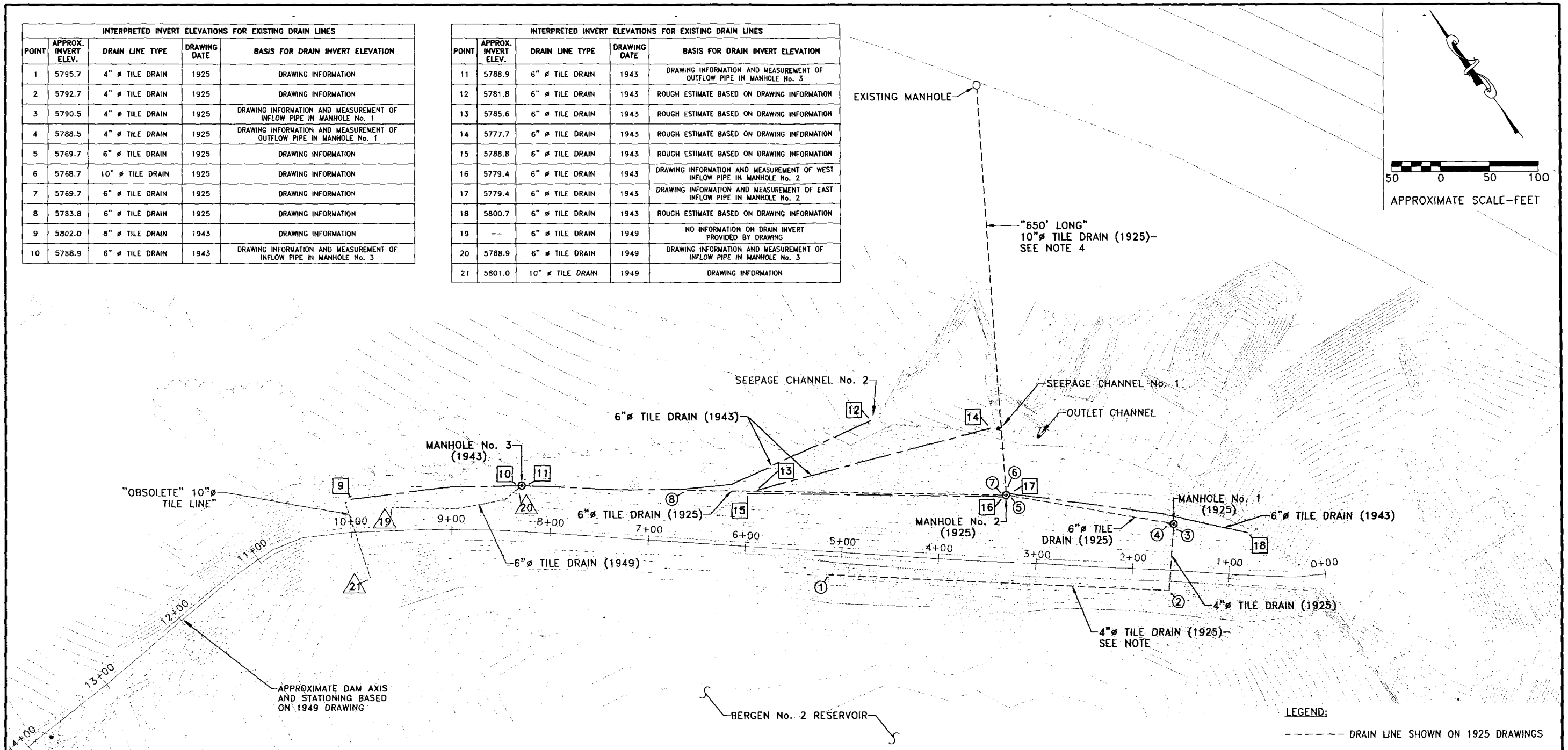
09-1-211A	Kumar & Associates	BERGEN DAM No. 2	INTERPRETED GEOLOGIC PROFILE ALONG DAM CREST	Fig. 10

INTERPRETED INVERT ELEVATIONS FOR EXISTING DRAIN LINES				
POINT	APPROX. INVERT ELEV.	DRAIN LINE TYPE	DRAWING DATE	BASIS FOR DRAIN INVERT ELEVATION
1	5795.7	4" ø TILE DRAIN	1925	DRAWING INFORMATION
2	5792.7	4" ø TILE DRAIN	1925	DRAWING INFORMATION
3	5790.5	4" ø TILE DRAIN	1925	DRAWING INFORMATION AND MEASUREMENT OF INFLOW PIPE IN MANHOLE No. 1
4	5788.5	4" ø TILE DRAIN	1925	DRAWING INFORMATION AND MEASUREMENT OF OUTFLOW PIPE IN MANHOLE No. 1
5	5769.7	6" ø TILE DRAIN	1925	DRAWING INFORMATION
6	5768.7	10" ø TILE DRAIN	1925	DRAWING INFORMATION
7	5769.7	6" ø TILE DRAIN	1925	DRAWING INFORMATION
8	5783.8	6" ø TILE DRAIN	1925	DRAWING INFORMATION
9	5802.0	6" ø TILE DRAIN	1943	DRAWING INFORMATION
10	5788.9	6" ø TILE DRAIN	1943	DRAWING INFORMATION AND MEASUREMENT OF INFLOW PIPE IN MANHOLE No. 3

INTERPRETED INVERT ELEVATIONS FOR EXISTING DRAIN LINES				
POINT	APPROX. INVERT ELEV.	DRAIN LINE TYPE	DRAWING DATE	BASIS FOR DRAIN INVERT ELEVATION
11	5788.9	6" ø TILE DRAIN	1943	DRAWING INFORMATION AND MEASUREMENT OF OUTFLOW PIPE IN MANHOLE No. 3
12	5781.8	6" ø TILE DRAIN	1943	ROUGH ESTIMATE BASED ON DRAWING INFORMATION
13	5785.6	6" ø TILE DRAIN	1943	ROUGH ESTIMATE BASED ON DRAWING INFORMATION
14	5777.7	6" ø TILE DRAIN	1943	ROUGH ESTIMATE BASED ON DRAWING INFORMATION
15	5788.8	6" ø TILE DRAIN	1943	ROUGH ESTIMATE BASED ON DRAWING INFORMATION
16	5779.4	6" ø TILE DRAIN	1943	DRAWING INFORMATION AND MEASUREMENT OF WEST INFLOW PIPE IN MANHOLE No. 2
17	5779.4	6" ø TILE DRAIN	1943	DRAWING INFORMATION AND MEASUREMENT OF EAST INFLOW PIPE IN MANHOLE No. 2
18	5800.7	6" ø TILE DRAIN	1943	ROUGH ESTIMATE BASED ON DRAWING INFORMATION
19	--	6" ø TILE DRAIN	1949	NO INFORMATION ON DRAIN INVERT PROVIDED BY DRAWING
20	5788.9	6" ø TILE DRAIN	1949	DRAWING INFORMATION AND MEASUREMENT OF INFLOW PIPE IN MANHOLE No. 3
21	5801.0	10" ø TILE DRAIN	1949	DRAWING INFORMATION



NOTES:

1. APPROXIMATE LOCATIONS AND INVERT ELEVATIONS FOR EXISTING DRAIN LINES SHOWN ARE BASED ON INTERPRETATION OF LOCATION AND INVERT-ELEVATION INFORMATION FROM HISTORIC DESIGN DRAWINGS DATED 1923, 1943 AND 1949, AND APPROXIMATE FIELD MEASUREMENTS OF SOME DRAIN DISCHARGE POINTS IN EXISTING MANHOLES AND CHANNELS. THE ACTUAL EXISTENCE OF THE DRAIN LINES HAS NOT BEEN SUBSTANTIATED BY FIELD EXPLORATION OR OTHER METHODS.
2. HISTORICAL DRAWINGS USED TO DEVELOP PLAN SHOWN INCLUDE THE FOLLOWING:
   - 1925 PLAN TITLE "REPAIRS AND DRAINAGE DESIGN, RESTORING BERGEN DAM No. 2" AND ACCOMPANYING DRAWING SHOWING PROFILES FOR PROFILED DRAINS.
   - 1943 PLAN AND SECTION TITLED" PLANS FOR REPAIR DAM FOR BERGEN RESERVOIR No. 2", AND SHOWING THE PREVIOUSLY INSTALLED DRAINS, AND PROPOSED NEW DRAINS.
   - 1949 PLAN TITLED " PLANS FOR REPAIR AND DAM OF BERGEN RESERVOIR NUMBER 2"

NOTES: (CONT.)

3. THE 4-INCH DIAMETER TILE DRAIN SHOWN BENEATH THE UPSTREAM SLOPE OF THE DAM AND RUNNING PARALLEL TO THE DAM ALIGNMENT, IN THE REFERENCED 1925 PLAN IS NOT SHOWN AS AN EXISTING DRAIN LINE IN THE 1943 PLAN, AND MAY NOT HAVE BEEN INSTALLED.
4. "650-FOOT 10-INCH DIAMETER TILE DRAIN, SHOWN IN 1925 PLAN, APPEARS TO END AT EXISTING MANHOLE. PORTION OF DRAIN LINE MAY HAVE BEEN REMOVED BY SUBSEQUENT GRADING FOR HIGHWAY C-470.

LEGEND:

- ------ DRAIN LINE SHOWN ON 1925 DRAWINGS
- — - — DRAIN LINE SHOWN ON 1943 DRAWINGS
- ---------- DRAIN LINE SHOWN ON 1949 DRAWINGS
- (1) PIPE INV. LOCATION FOR DRAIN LINE SHOWN ON 1925 DRAWING SEE DRAIN SCHEDULE.
- [9] PIPE INV. LOCATION FOR DRAIN LINE SHOWN ON 1943 DRAWING SEE DRAIN SCHEDULE.
- △19 PIPE INV. LOCATION FOR DRAIN LINE SHOWN ON 1949 DRAWING SEE DRAIN SCHEDULE.

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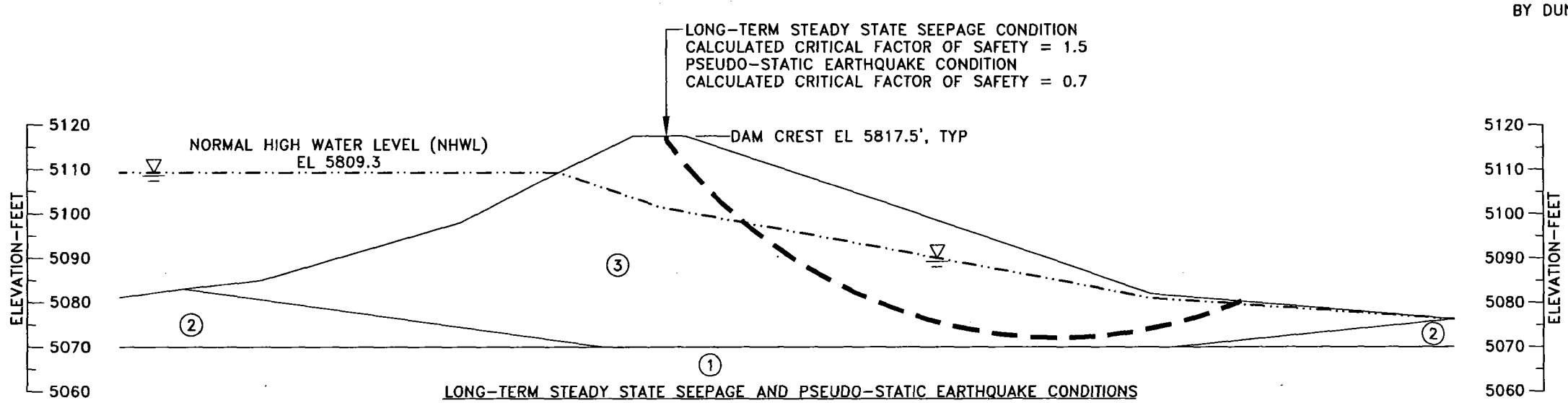
09-1-211A	Kumar & Associates	BERGEN DAM No. 2	EXISTING DRAIN PLAN	Fig. 11

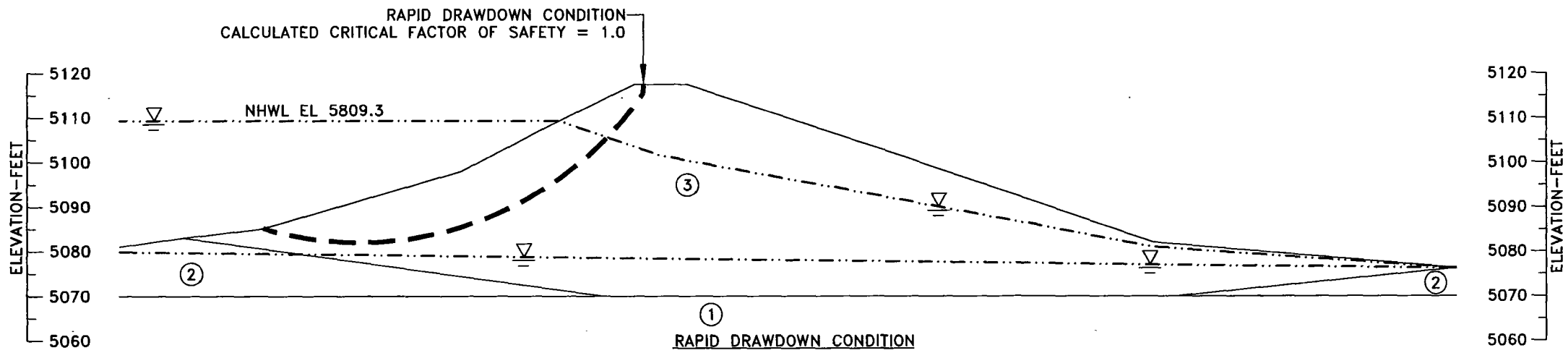
MATERIAL UNIT WEIGHTS AND SHEAR STRENGTHS

MATERIAL NO.	MATERIAL	UNIT WEIGHT (PCF)	DRAINED SHEAR STRENGTHS		UNDRAINED SHEAR STRENGTHS	
			ϕ' (DEG.)	COHESION (PSF)	ϕ (DEG.)	COHESION (PSF)
①	CLAYSTONE BEDROCK	130	28	1,000	–	–
②	WEATHERED CLAYSTONE	130	28	500	–	–
③	EXISTING EMBANKMENT FILL	125	26	100	17	75

* CONSOLIDATED UNDRAINED SHEAR STRENGTH CALCULATED USING DRAINED AND UNDRAINED SHEAR STRENGTH, AND PROCEDURE FOR RAPID DRAWDOWN ANALYSES DEVELOPED BY DUNCAN, WRIGHT, AND WONG (1990).



LONG-TERM STEADY STATE SEEPAGE AND PSEUDO-STATIC EARTHQUAKE CONDITIONS



RAPID DRAWDOWN CONDITION

15 0 15 30

APPROXIMATE SCALE-FEET

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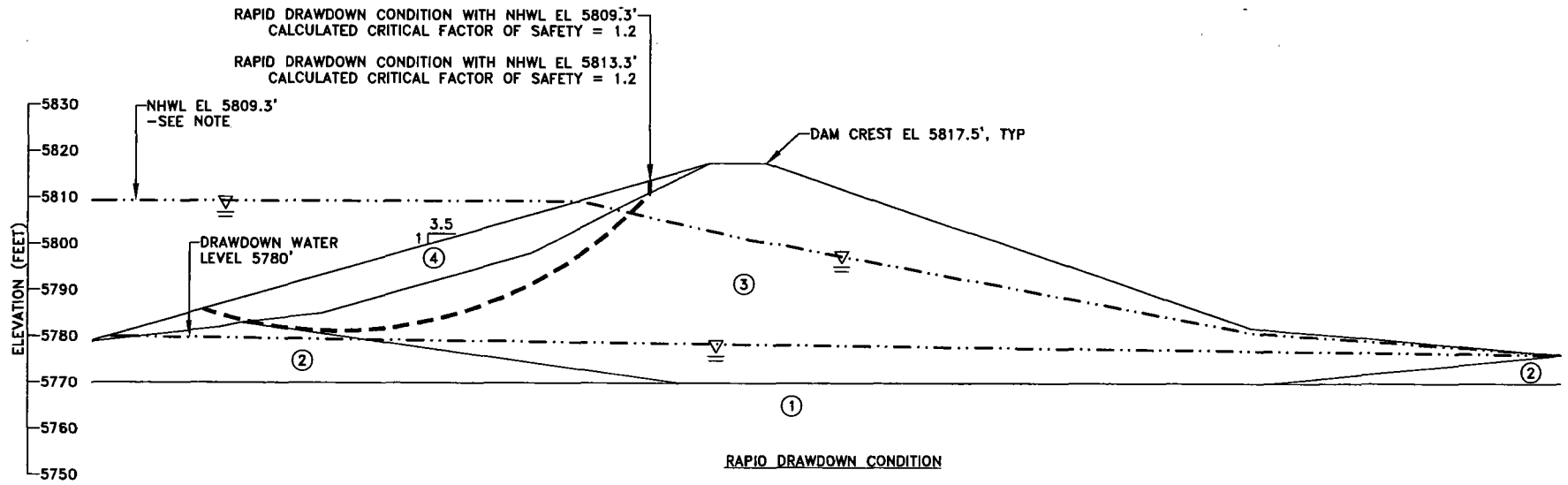
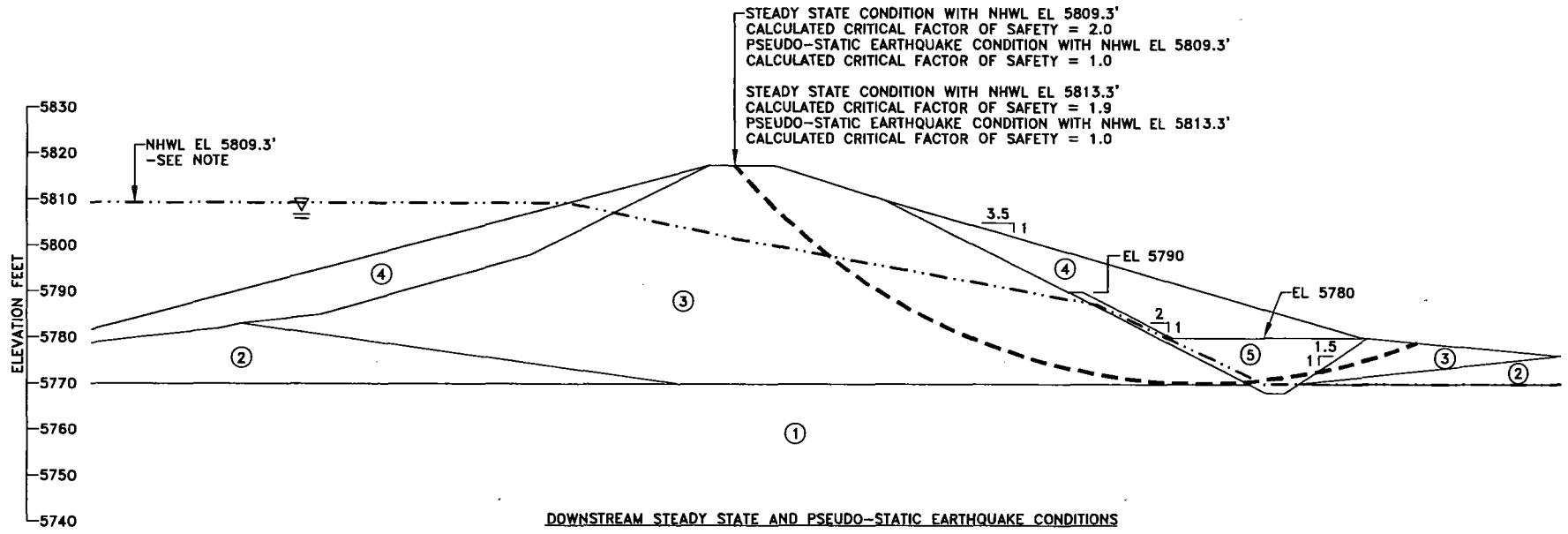
09-1-211A	Kumar & Associates	BERGEN DAM No. 2	SLOPE STABILITY ANALYSIS RESULTS EXISTING DAM STATION 3+04	Fig. 12



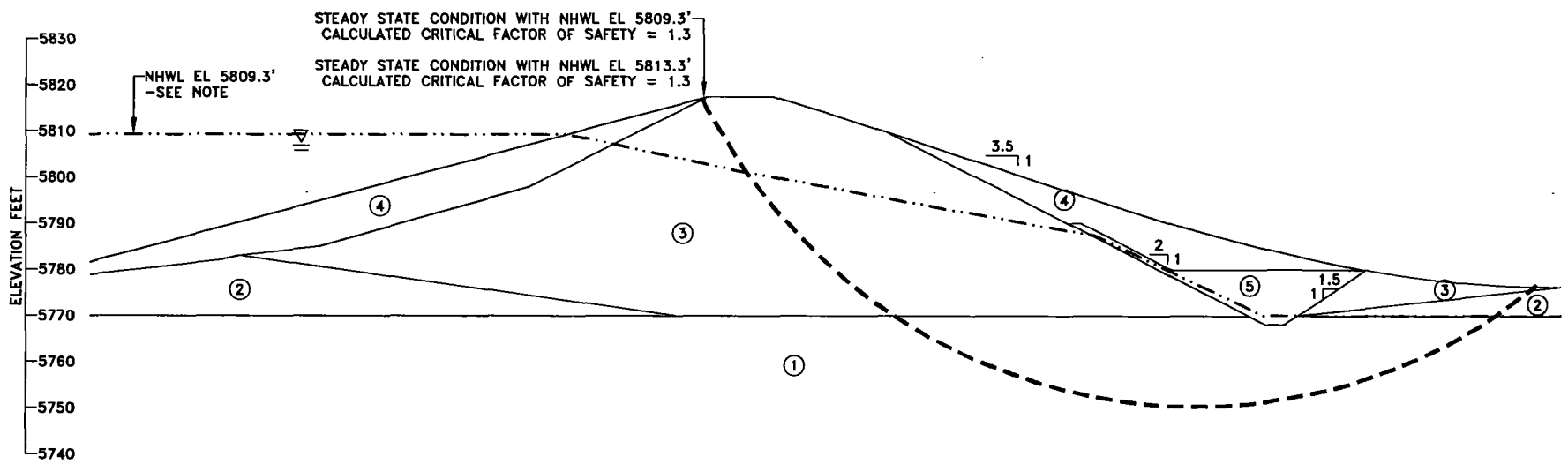
RAPID DRAWDOWN CONDITION

MATERIAL UNIT WEIGHTS AND SHEAR STRENGTHS

MATERIAL NO.	MATERIAL	UNIT WEIGHT (PCF)	DRAINED SHEAR STRENGTH		UNDRAINED SHEAR STRENGTH		RESIDUAL SHEAR STRENGTH	
			ϕ (DEG.)	COHESION (PSF)	ϕ (DEG.)	COHESION (PSF)	ϕ_R (DEG.)	COHESION (PSF)
①	CLAYSTONE BEDROCK	130	28	1000	28	1000	17	0
②	WEATHERED CLAYSTONE BEDROCK	130	28	500	28	500	17	0
③	EXISTING EMBANKMENT FILL	125	26	100	17	100	–	–
④	NEW EMBANKMENT FILL	125	26	150	17	100	–	–
⑤	GRANULAR FILL/DRAIN AGGREGATE	130	34	0	34	0	–	–



DOWNSTREAM STEADY STATE AND PSEUDO-STATIC EARTHQUAKE CONDITIONS



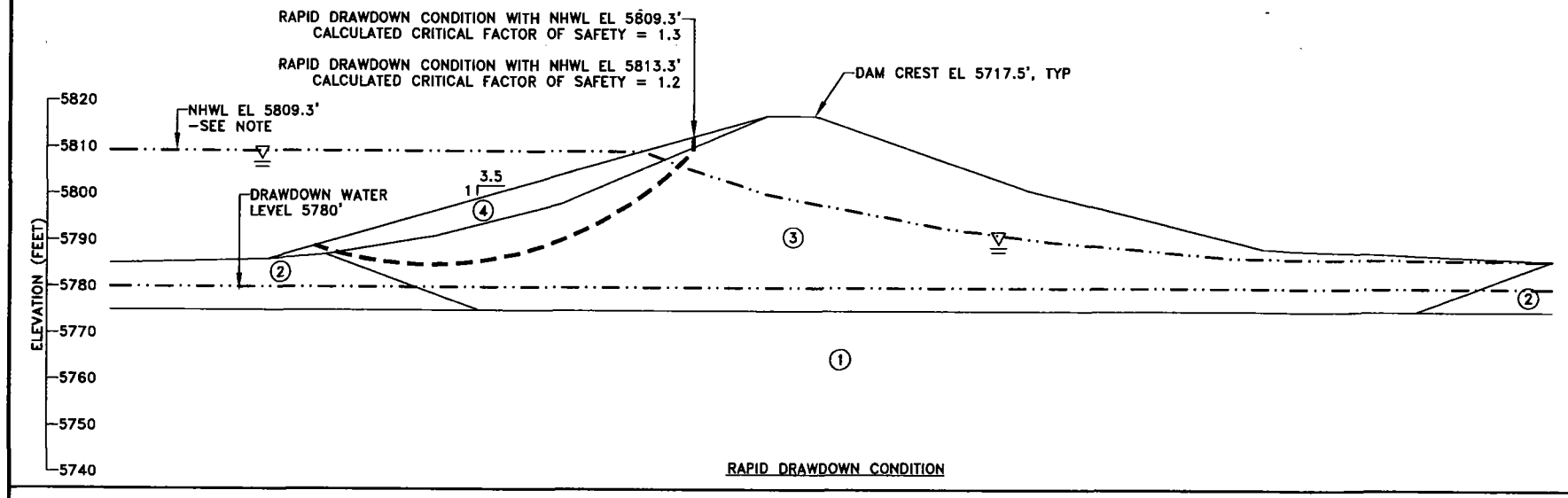
DOWNSTREAM STEADY STATE CONDITION USING RESIDUAL SHEAR STRENGTH FOR BEDROCK

NOTE:

PHREATIC SURFACE AND SLOPE STABILITY SHEAR CIRCLE SHOWN FOR UNRESTRICTED NORMAL HIGH WATER LEVEL ELEVATION 5813.3' ARE NOT SHOWN.

09-1-211A	Kumar & Associates	BERGEN DAM No. 2	SLOPE STABILITY ANALYSIS RESULTS FOR MODIFIED DAM – STATION 3+04

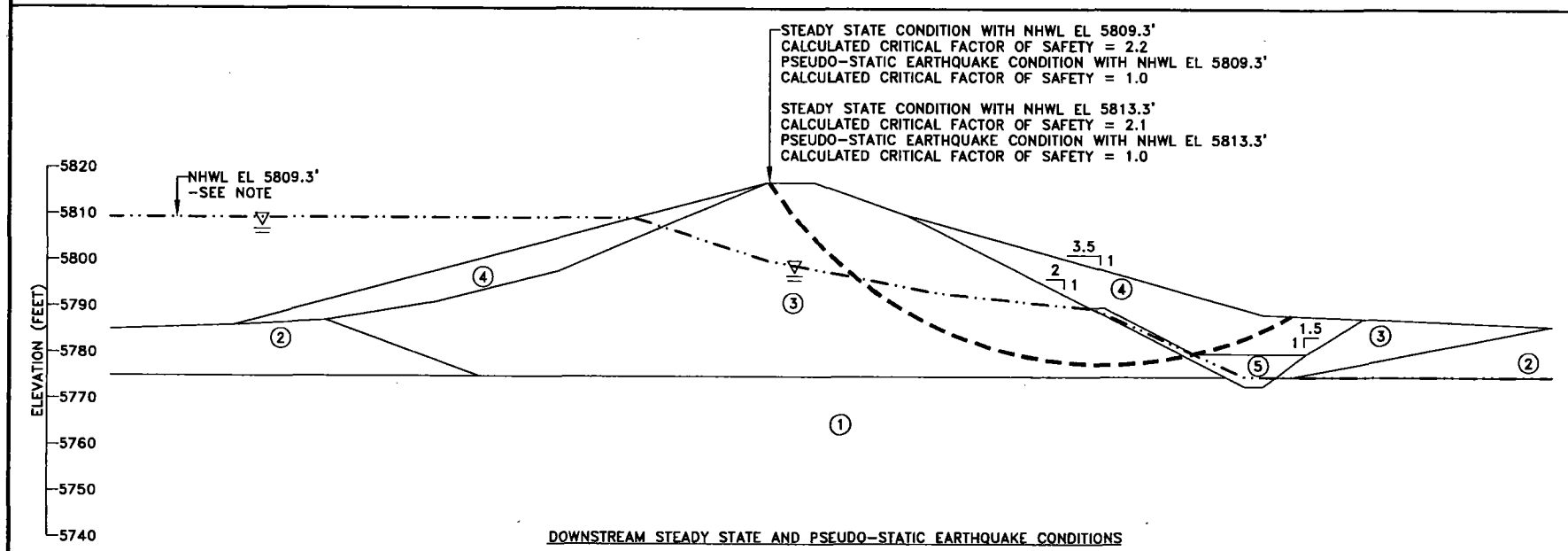
Fig. 13



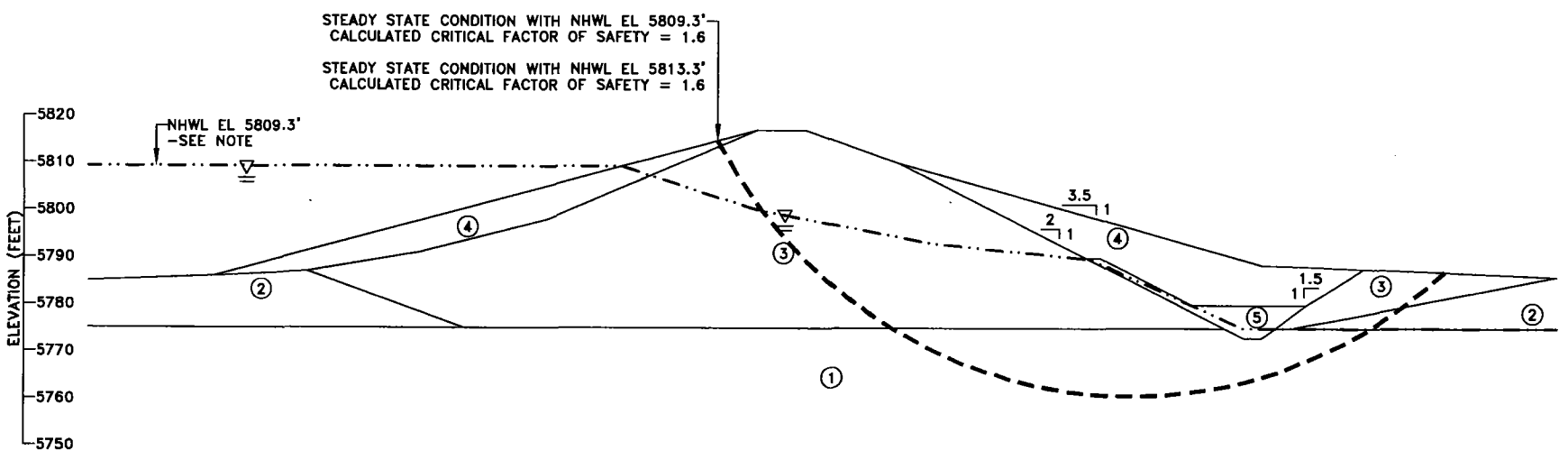
RAPID DRAWDOWN CONDITION

MATERIAL UNIT WEIGHTS AND SHEAR STRENGTHS

MATERIAL NO.	MATERIAL	UNIT WEIGHT (PCF)	DRAINED SHEAR STRENGTH		UNDRAINED SHEAR STRENGTH		RESIDUAL SHEAR STRENGTH	
			ϕ (DEG.)	COHESION (PSF)	ϕ (DEG.)	COHESION (PSF)	ϕ_R (DEG.)	COHESION (PSF)
①	CLAYSTONE BEDROCK	130	28	1000	28	1000	17	0
②	WEATHERED CLAYSTONE BEDROCK	130	28	500	28	500	17	0
③	EXISTING EMBANKMENT FILL	125	26	100	17	100	–	–
④	NEW EMBANKMENT FILL	125	26	150	17	100	–	–
⑤	GRANULAR FILL/DRAIN AGGREGATE	130	34	0	34	0	–	–



DOWNSTREAM STEADY STATE AND PSEUDO-STATIC EARTHQUAKE CONDITIONS



DOWNSTREAM STEADY STATE CONDITION USING RESIDUAL SHEAR STRENGTH FOR BEDROCK

NOTE:

PHREATIC SURFACE AND SLOPE STABILITY SHEAR CIRCLE SHOWN FOR UNRESTRICTED NORMAL HIGH WATER LEVEL ELEVATION 5813.3' ARE NOT SHOWN.

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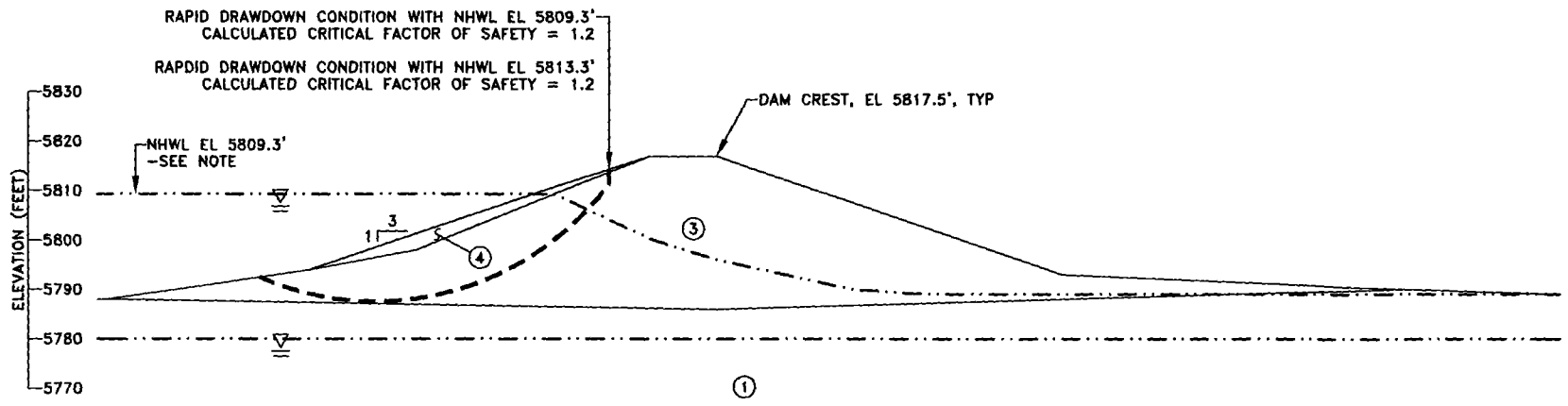
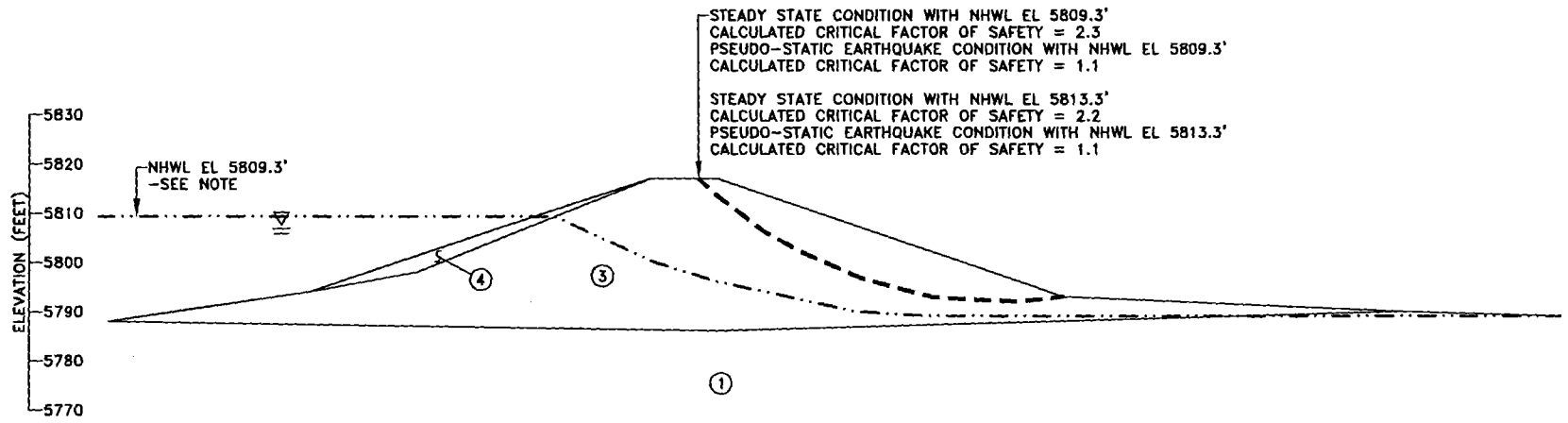
09-1-211A	Kumar & Associates	BERGEN DAM No. 2	SLOPE STABILITY ANALYSIS RESULTS FOR MODIFIED DAM – STATION 6+00	Fig. 14



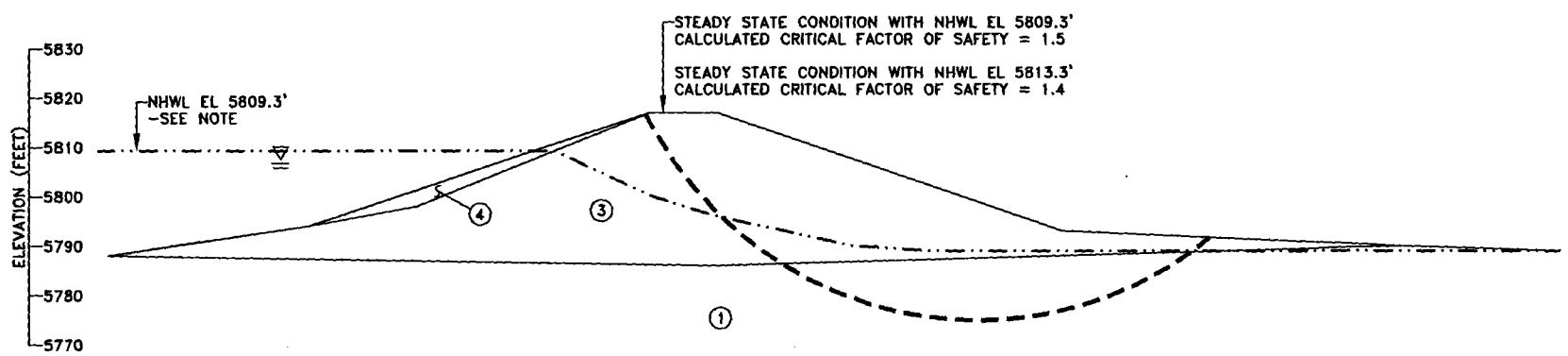
RAPID DRAWDOWN CONDITION

MATERIAL UNIT WEIGHTS AND SHEAR STRENGTHS

MATERIAL NO.	MATERIAL	UNIT WEIGHT (PCF)	DRAINED SHEAR STRENGTH		UNDRAINED SHEAR STRENGTH		RESIDUAL SHEAR STRENGTH	
			ϕ (DEG.)	COHESION (PSF)	ϕ (DEG.)	COHESION (PSF)	ϕ_R (DEG.)	COHESION (PSF)
①	CLAYSTONE BEDROCK	130	28	1000	28	1000	17	0
②	WEATHERED CLAYSTONE BEDROCK	130	28	500	28	500	17	0
③	EXISTING EMBANKMENT FILL	125	26	100	17	100	–	–
④	NEW EMBANKMENT FILL	125	26	150	17	100	–	–
⑤	GRANULAR FILL/DRAIN AGGREGATE	130	34	0	34	0	–	–



DOWNSTREAM STEADY STATE AND PSEUDO-STATIC EARTHQUAKE CONDITIONS



DOWNSTREAM STEADY STATE CONDITION USING RESIDUAL SHEAR STRENGTH FOR BEDROCK

NOTE:

PHREATIC SURFACE AND SLOPE STABILITY SHEAR CIRCLE SHOWN FOR UNRESTRICTED NORMAL HIGH WATER LEVEL ELEVATION 5813.3' ARE NOT SHOWN.

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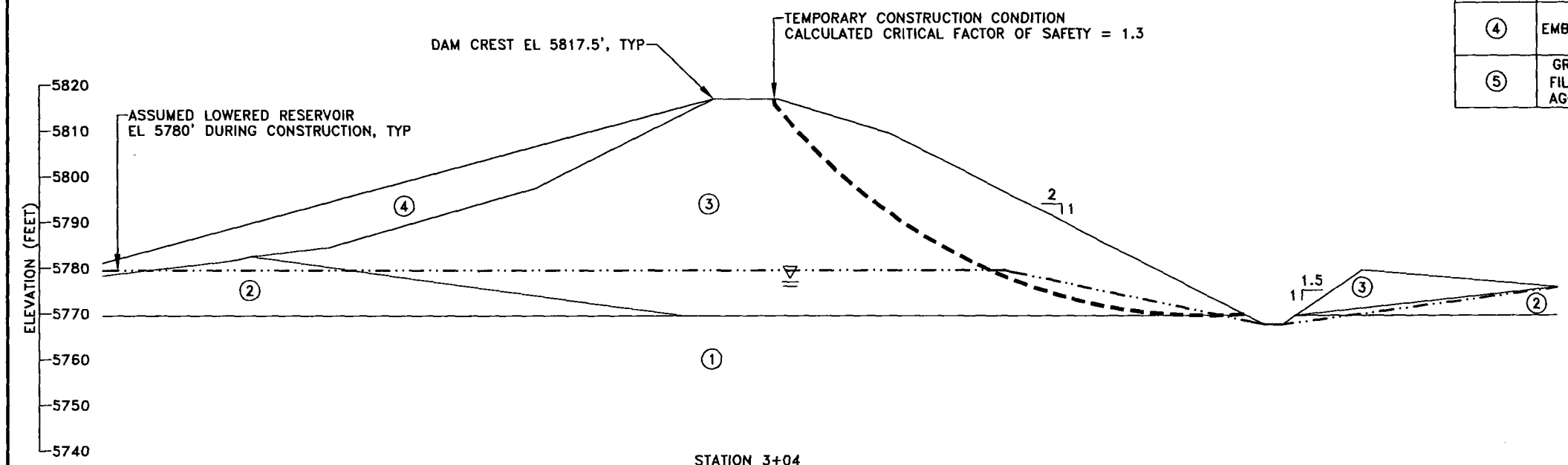
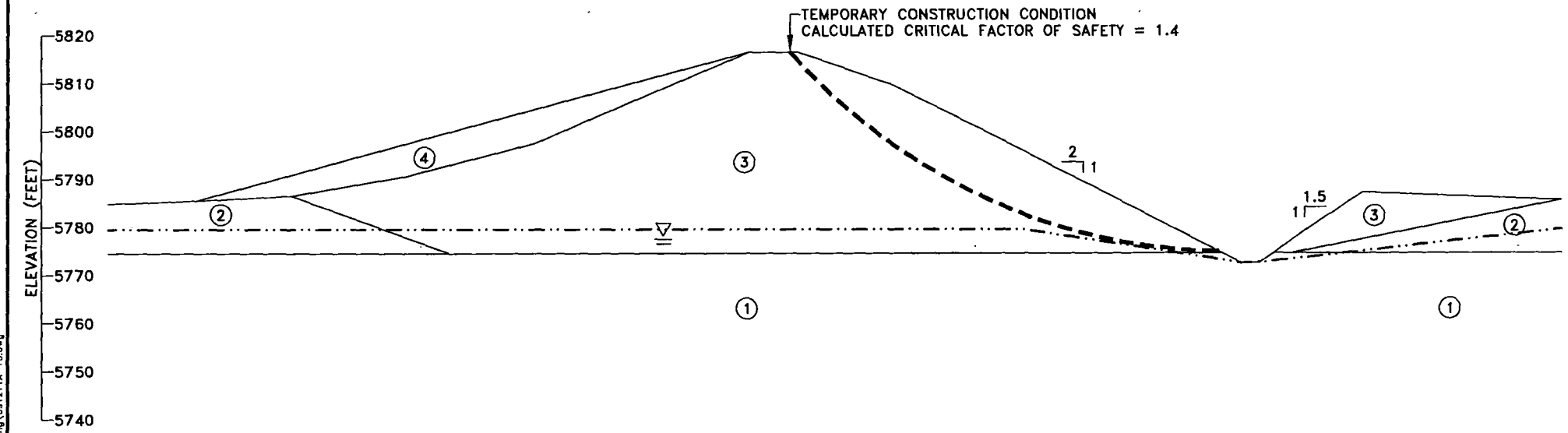
09-1-211A	Kumar & Associates	BERGEN DAM No. 2	SLOPE STABILITY ANALYSIS RESULTS FOR MODIFIED DAM – STATION 8+00	Fig. 15

MATERIAL UNIT WEIGHTS AND SHEAR STRENGTHS

MATERIAL NO.	MATERIAL	UNIT WEIGHT (PCF)	DRAINED SHEAR STRENGTH		UNDRAINED SHEAR STRENGTH		RESIDUAL SHEAR STRENGTH	
			ϕ (DEG.)	COHESION (PSF)	ϕ (DEG.)	COHESION (PSF)	ϕ_R (DEG.)	COHESION (PSF)
①	CLAYSTONE BEDROCK	130	28	1000	28	1000	17	0
②	WEATHERED CLAYSTONE BEDROCK	130	28	500	28	500	17	0
③	EXISTING EMBANKMENT FILL	125	26	100	17	100	–	–
④	NEW EMBANKMENT FILL	125	26	150	17	100	–	–
⑤	GRANULAR FILL/DRAIN AGGREGATE	130	34	0	34	0	–	–



STATION 3+04



STATION 6+00

NOTE:

PHREATIC SURFACE AND SLOPE STABILITY SHEAR CIRCLE SHOWN FOR UNRESTRICTED NORMAL HIGH WATER LEVEL ELEVATION 5813.3' ARE NOT SHOWN.

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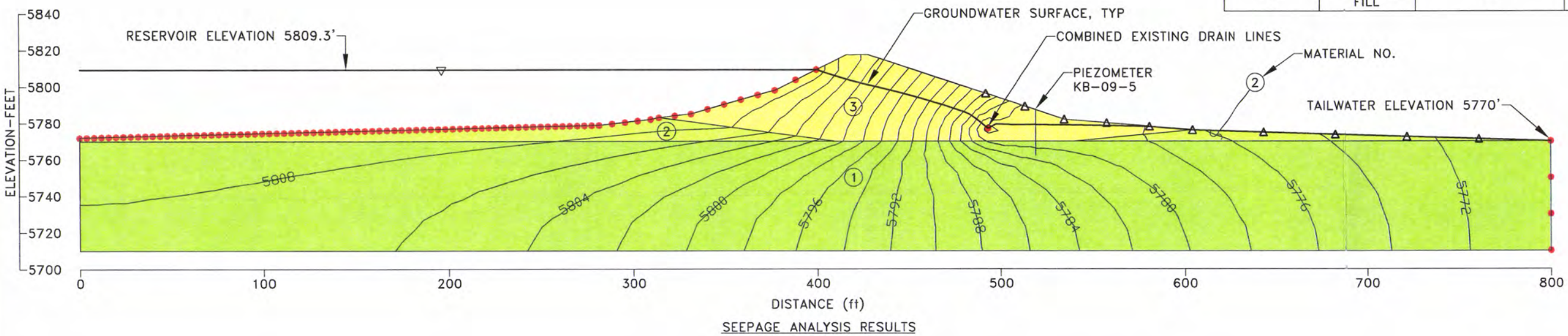
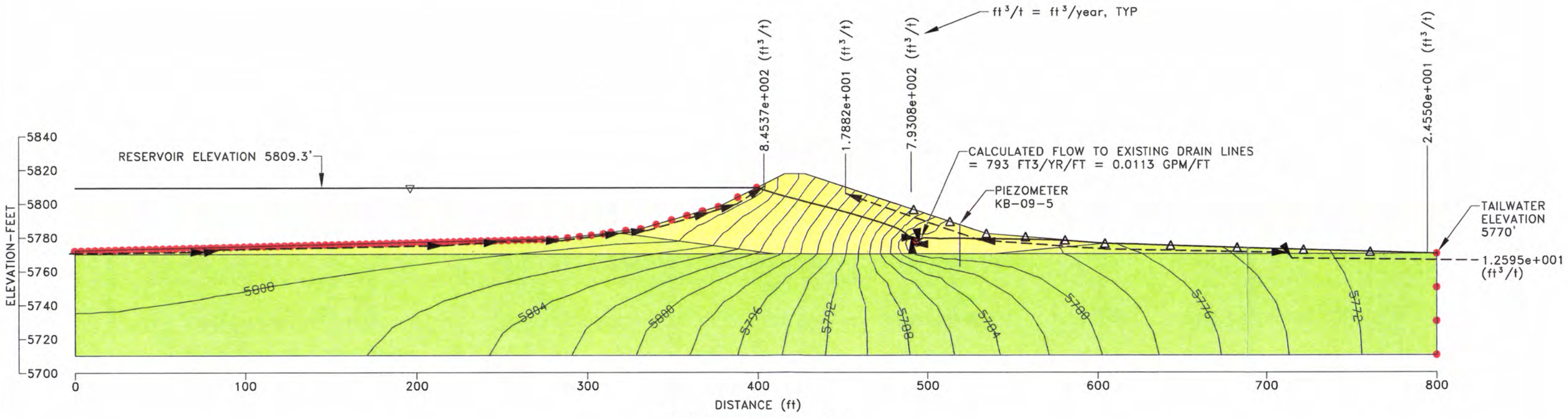
09-1-211A	Kumar & Associates	SLOPE STABILITY ANALYSIS RESULTS FOR MODIFIED DAM	SLOPE STABILITY ANALYSIS RESULTS FOR MODIFIED DAM - TEMPORARY DOWNSTREAM EXCAVATION CONDITION	Fig. 16

MATERIAL NO.	MATERIAL	HYDRAULIC CONDUCTIVITY, K (FT/YR)	
		$K_{HORIZONTAL}$	$K_{VERTICAL}$
①	FRESH CLAYSTONE	1	0.1
②	WEATHERED CLAYSTONE	1	0.1
③	EXISTING EMBANKMENT FILL	100	30



SEEPAGE ANALYSIS RESULTS



CALCULATED SEEPAGE FLOWS

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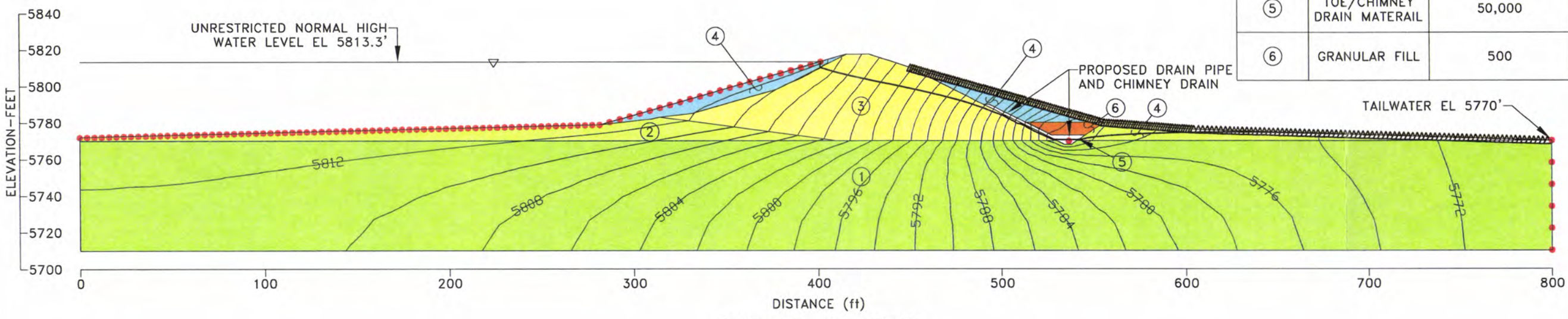
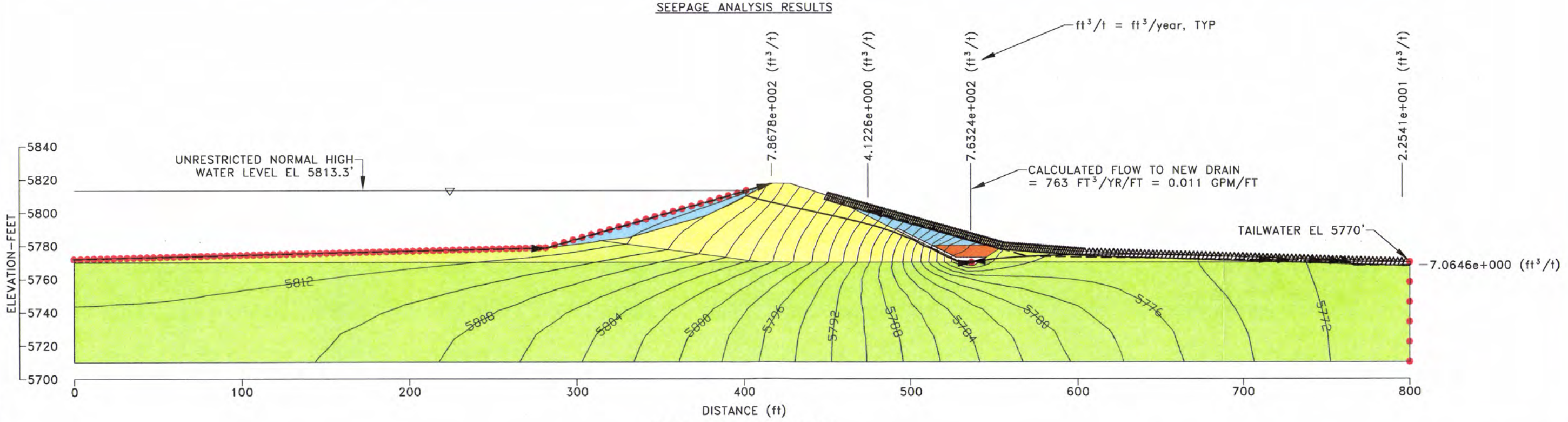
09-1-211A	Kumar & Associates	BERGEN DAM NO. 2	SEEPAGE ANALYSIS CALIBRATION OF EXISTING DAM	Fig. 17

MATERIAL NO.	MATERIAL	HYDRAULIC CONDUCTIVITY, K (FT/YR)	
		$K_{HORIZONTAL}$	$K_{VERTICAL}$
①	FRESH CLAYSTONE	1	0.1
②	WEATHERED CLAYSTONE	1	0.1
③	EXISTING EMBANKMENT FILL	100	30
④	NEW EMBANKMENT FILL	50	15
⑤	TOE/CHIMNEY DRAIN MATERAIL	50,000	15,000
⑥	GRANULAR FILL	500	150



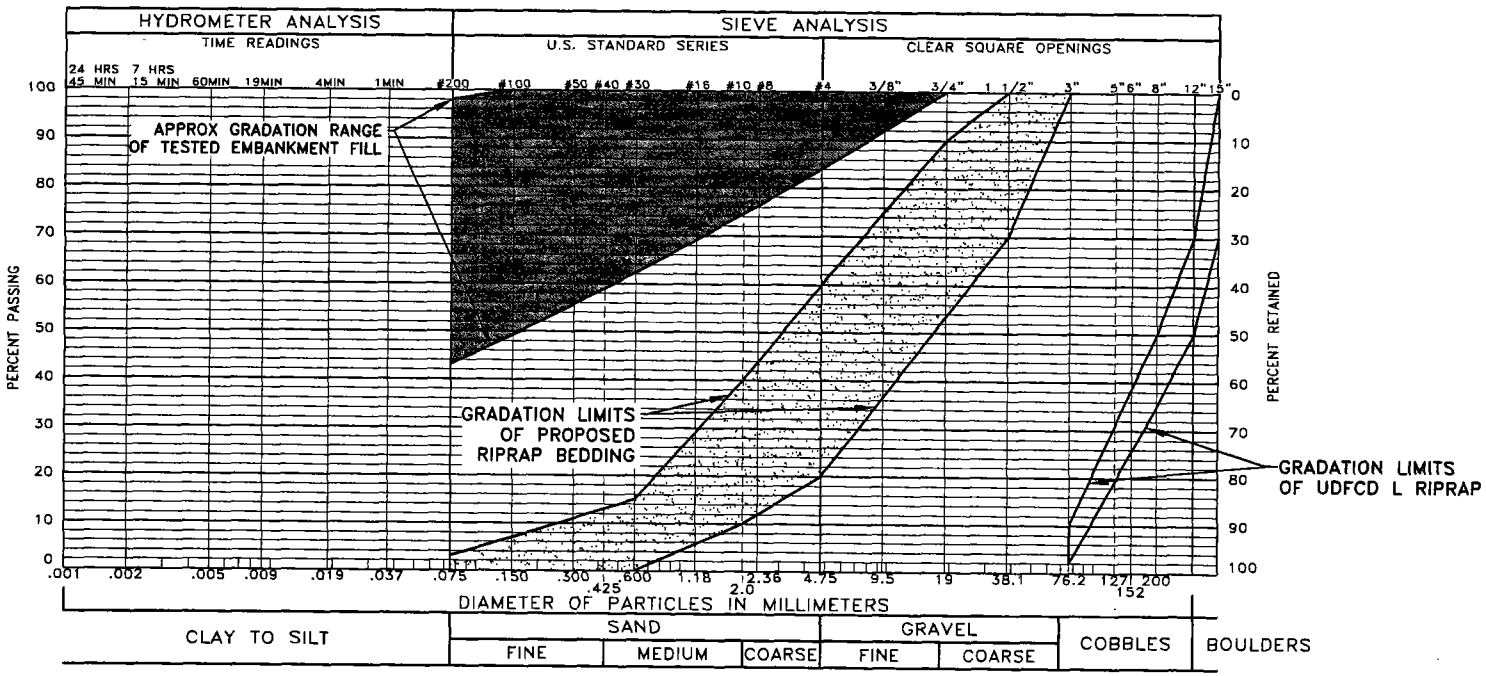
SEEPAGE ANALYSIS RESULTS



CALCULATED SEEPAGE FLOWS

September 06, 2011 - 04:15pm
W:\Projects\2009\09-1-211A\Drafting\091211A-18.dwg

09-1-211A	Kumar & Associates	BERGEN DAM NO. 2	SEEPAGE ANALYSIS RESULTS FOR MODIFIED DAM	Fig. 18



October 20, 2011 - 03:55pm
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09-1-211A	Kumar & Associates	PROPOSED GRADATION LIMITS FOR RIPRAP AND RIPRAP BEDDING	Fig. 19

EXISTING MANHOLE

EXISTING DISCHARGE PIPE

50 0 50 100

SCALE–FEET

DRAIN MANHOLE AT STA 3+45
DRAIN INFLOW INV EL 5770.5
DISCHARGE OUTFLOW INV EL 5768.7

TOE–DRAIN PIPE ALIGMENT

END TOE DRAIN
STA 7+00
DRAIN INV EL 5783.0'

DRAIN CLEAN OUT

EXISTING FENCE

START TOE DRAIN
STA 1+00
DRAIN INV EL 5796.0'

DRAIN CLEAN OUT

START DOWNSTREAM EMBANKMENT FILL
STA 0+50

END DOWNSTREAM FILL STA 7+20

TOP OF DOWNSTREAM FILL EL 5810

DAM CREST EL 5817.8'

3.5:1

3.5:1 / 3:1 TRANSITION

3:1

END UPSTREAM FILL
STA 8+50

UPSTREAM BUTRESS SLOPE 3:1

END RIPRAP ARMORING
STA 12+50

RIPRAP SLOPE ARMORING

RIPRAP TOE EL 5795
AT TOE OF UPSTREAM FILL

TOE OF UPSTREAM FILL

RIGHT ABUTMENT SCARP FILL

START UPSTREAM FILL/RIPRAP ARMORING IN RIGHT ABUTMENT SCARP AREA

09–1–211A	Kumar & Associates	BERGEN DAM NO 2	FEASIBILITY–LEVEL DAM MODIFICATION PLAN	Fig. 20

September 06, 2011 - 04:17pm
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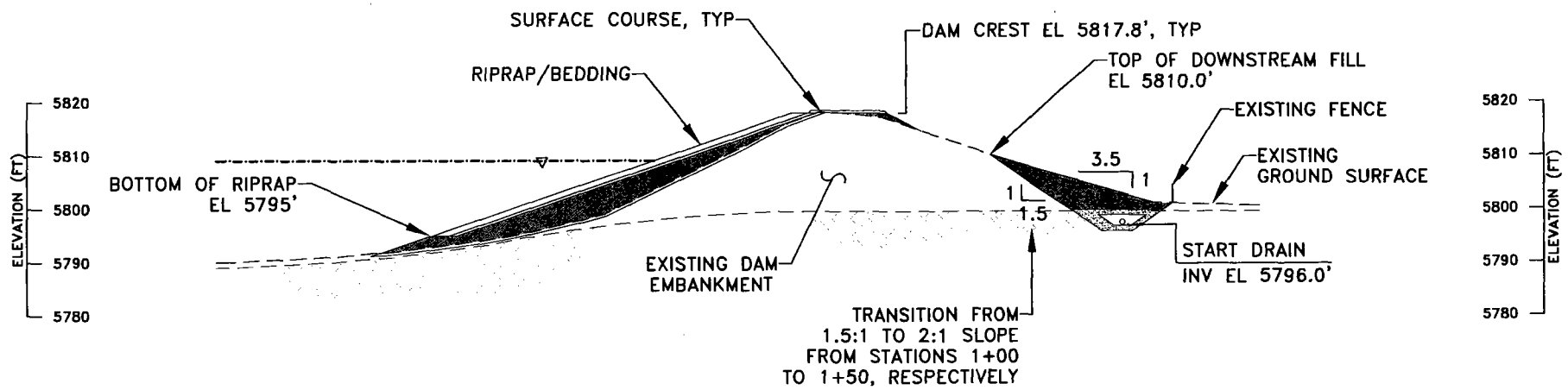
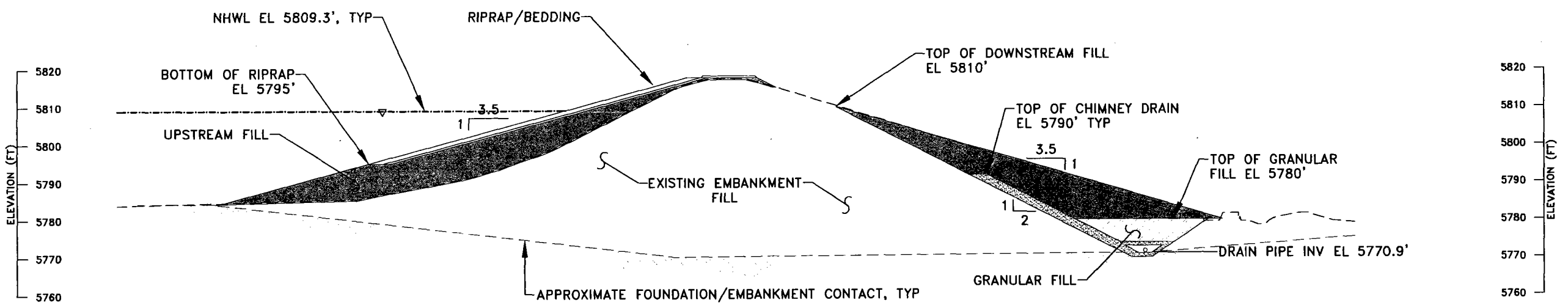


STA 1+00 SECTION (1)



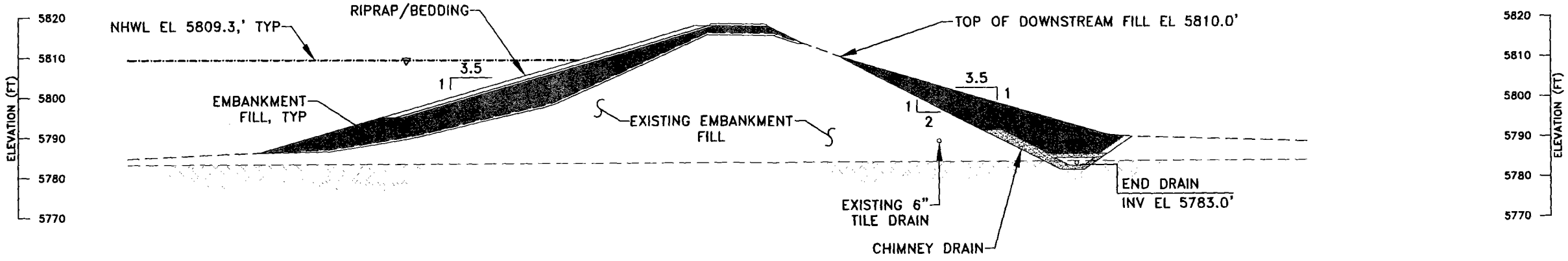
STA 3+04 SECTION (2)

15 0 15 30

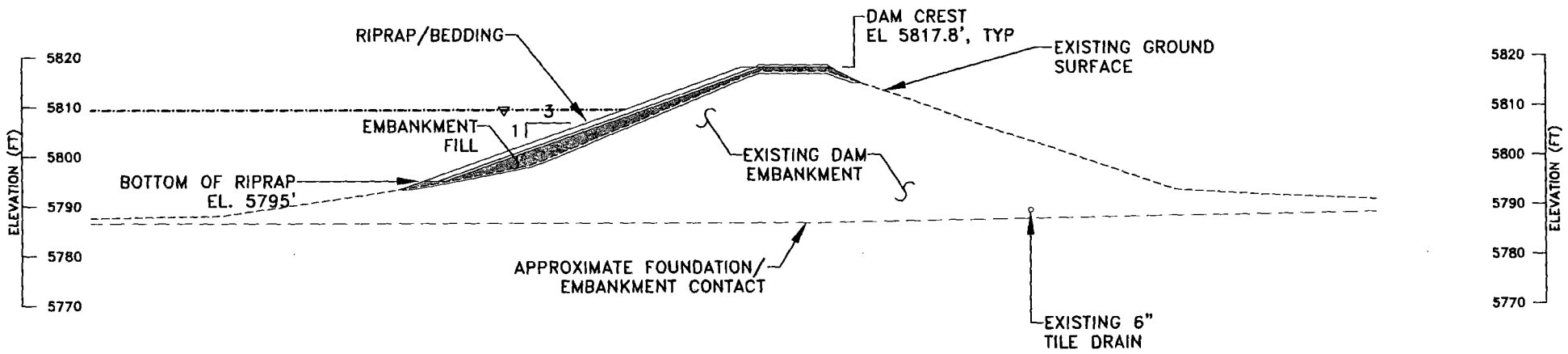
SCALE-FEET

09-1-211A	Kumar & Associates	BERGEN DAM No. 2	FEASIBILITY-LEVEL DAM MODIFICATION SECTIONS	Fig. 21

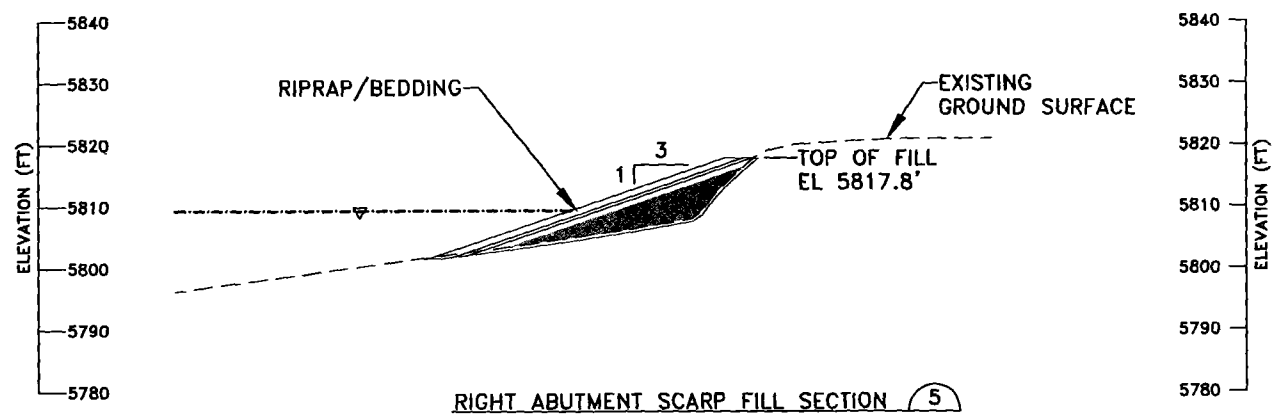
Oct 20, 11Y - 15:53pm
V:\Projects\2009\09-1-211A\Drafting\091211A-21.dwg



STA 7+00 SECTION (3)



STA 8+00 SECTION (4)



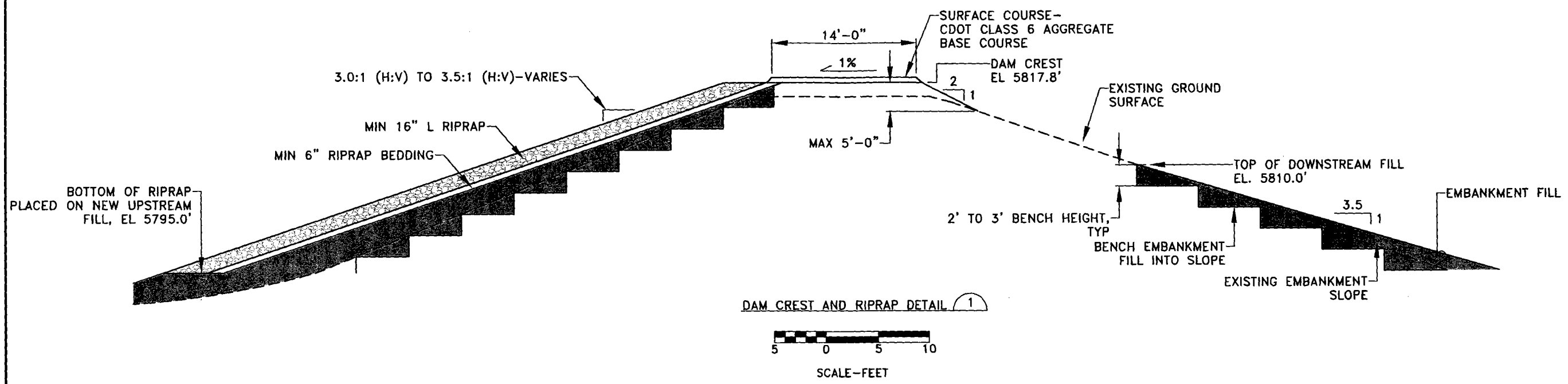
RIGHT ABUTMENT SCARP FILL SECTION (5)

15 0 15 30

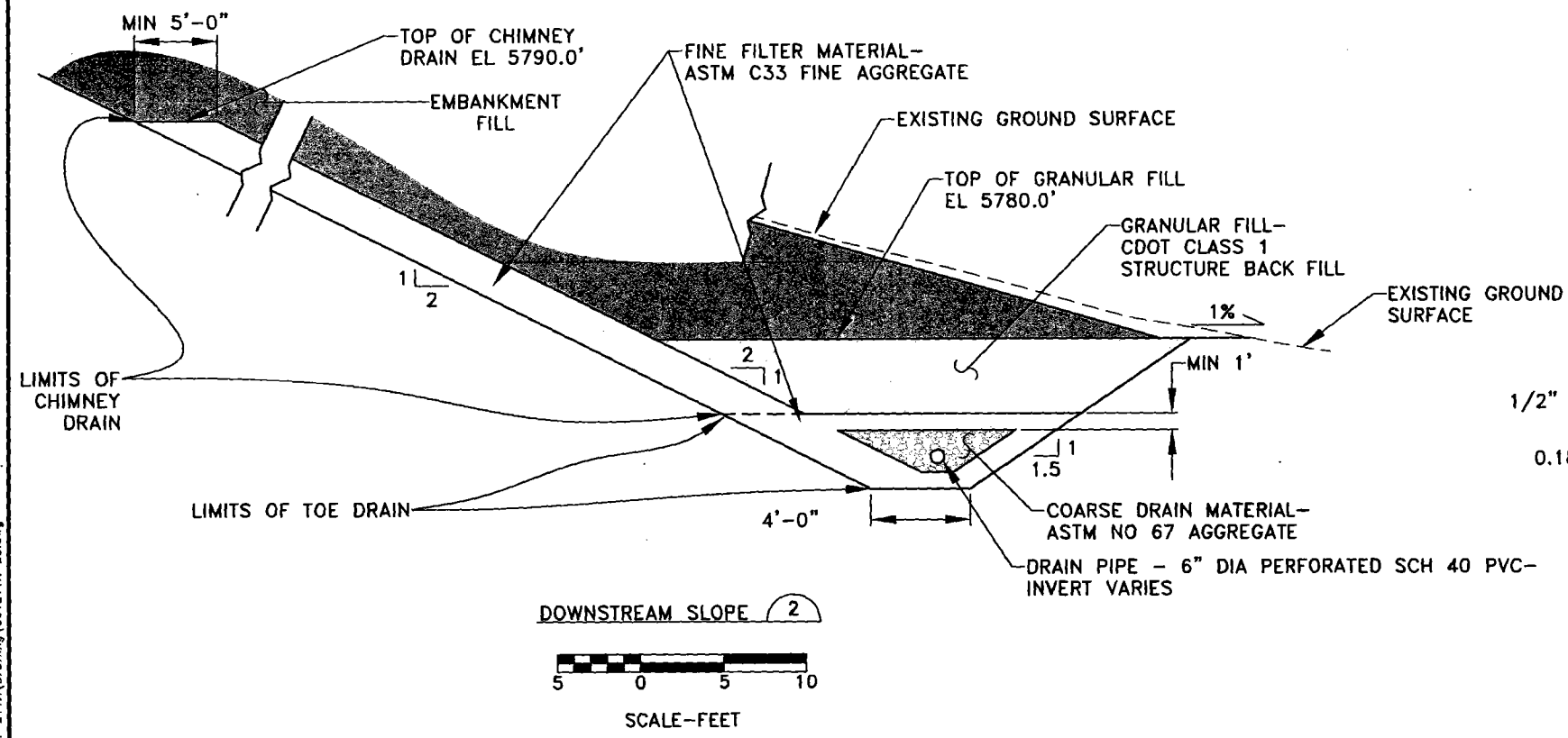
SCALE–FEET

Oct 20, 11Y - 15:53pm
V:\Projects\2009\09-1-211A\Drafting\091211A-22.dwg

09-1-211A	Kumar & Associates	BERGEN DAM No. 2	FEASIBILITY–LEVEL DAM MODIFICATION SECTIONS	Fig. 22



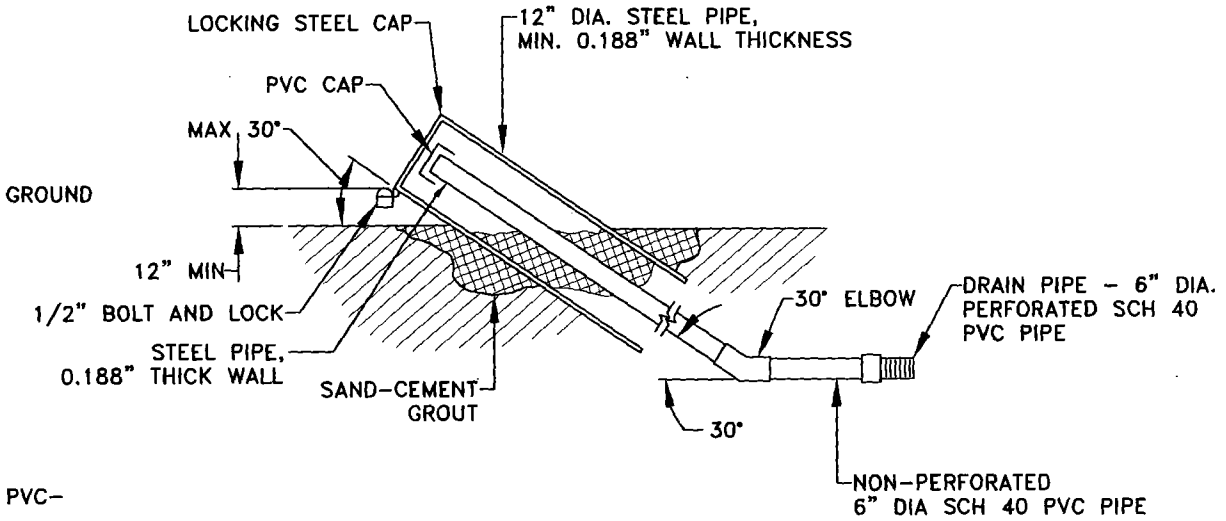
DAM CREST AND RIPRAP DETAIL 1



DOWNSTREAM SLOPE 2

5 0 5 10

SCALE-FEET



CLEAN-OUT DETAIL 3

NOT TO SCALE

Oct 20, 11Y - 15:54pm
V:\Projects\2009\09-1-211A\Drafting\091211A-23.dwg

09-1-211A	Kumar & Associates	BERGEN DAM No. 2	DAM MODIFICATION DETAILS	Fig. 23

TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

PROJECT NO.: 09-1-211
PROJECT NAME: Bergen Dam No. 2
DATE SAMPLED: 4-27-09 to 4-28-09 and 5-6-09
DATE RECEIVED: 5-1-09 and 5-7-09

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		PINHOLE DISPERSION RATING	SOIL OR BEDROCK TYPE
BORING	DEPTH (feet)				GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)		
KB-09-1	7-9	5-13-09					95	55	38		Fill: Fat Clay
KB-09-1	19	5-8-09	13.8	114.6	0	51	49	29	15		Fill: Clayey Sand
KB-09-2	5-7	5-13-09			8	27	65	45	32		Fill: Sandy Lean Clay
KB-09-2	29	5-8-09	25.2	98.4			77	38	22		Fill: Lean Clay with Sand
KB-09-2	34	5-8-09	16.8	109.5	16	41	43	31	11		Fill: Clayey Sand with Gravel
KB-09-2	44	5-8-09	29.7	81.5			79	43	15		Siltstone Bedrock
KB-09-3	4	5-8-09	14.9	86.0			97	52	33		Fill: Fat Clay
KB-09-3	19	5-8-09	24.3	93.8			98	49	30		Fill: Lean Clay
KB-09-3	29	5-8-09	17.5	109.6	0	0	100	54	36		Claystone Bedrock
KB-09-4	9	5-8-09	22.1	98.9			76	43	25	ND 3	Fill: Lean Clay with Sand
KB-09-5	4	5-8-09	13.1	100.3			71	42	25		Fill: Lean Clay with Sand
KB-09-5	24	5-8-09	19.6	104.5	0	1	99	52	30		Claystone Bedrock
KP-09-1	2-5	5-8-09	21.3				94	48	30		Claystone Bedrock
KP-09-1	6-12	5-8-09	13.5								Claystone Bedrock
KP-09-2	2-6	5-8-09	10.2								Claystone Bedrock
KP-09-2	6-12	5-8-09	19.6				98	52	31		Claystone Bedrock
KP-09-3	2-6	5-8-09	27.7				83	44	20	ND 2	Claystone Bedrock
KP-09-3	6-12	5-8-09	30.2								Claystone Bedrock
KP-09-4	3-6	5-8-09	11.5								Claystone Bedrock
KP-09-4	6-12	5-8-09	18.2				97	55	33		Claystone Bedrock
KP-09-5	1-4	5-8-09	18.7				77	36	18		Claystone Bedrock
KP-09-5	6-12	5-8-09	14.6								Claystone Bedrock
KP-09-6	1-5	5-8-09	10.5								Claystone Bedrock
KP-09-6	7-12	5-8-09	11.8				99	51	33		Claystone Bedrock

TABLE 2 - SUMMARY OF EXISTING SLOPE PROTECTION ROCK OBSERVATIONS

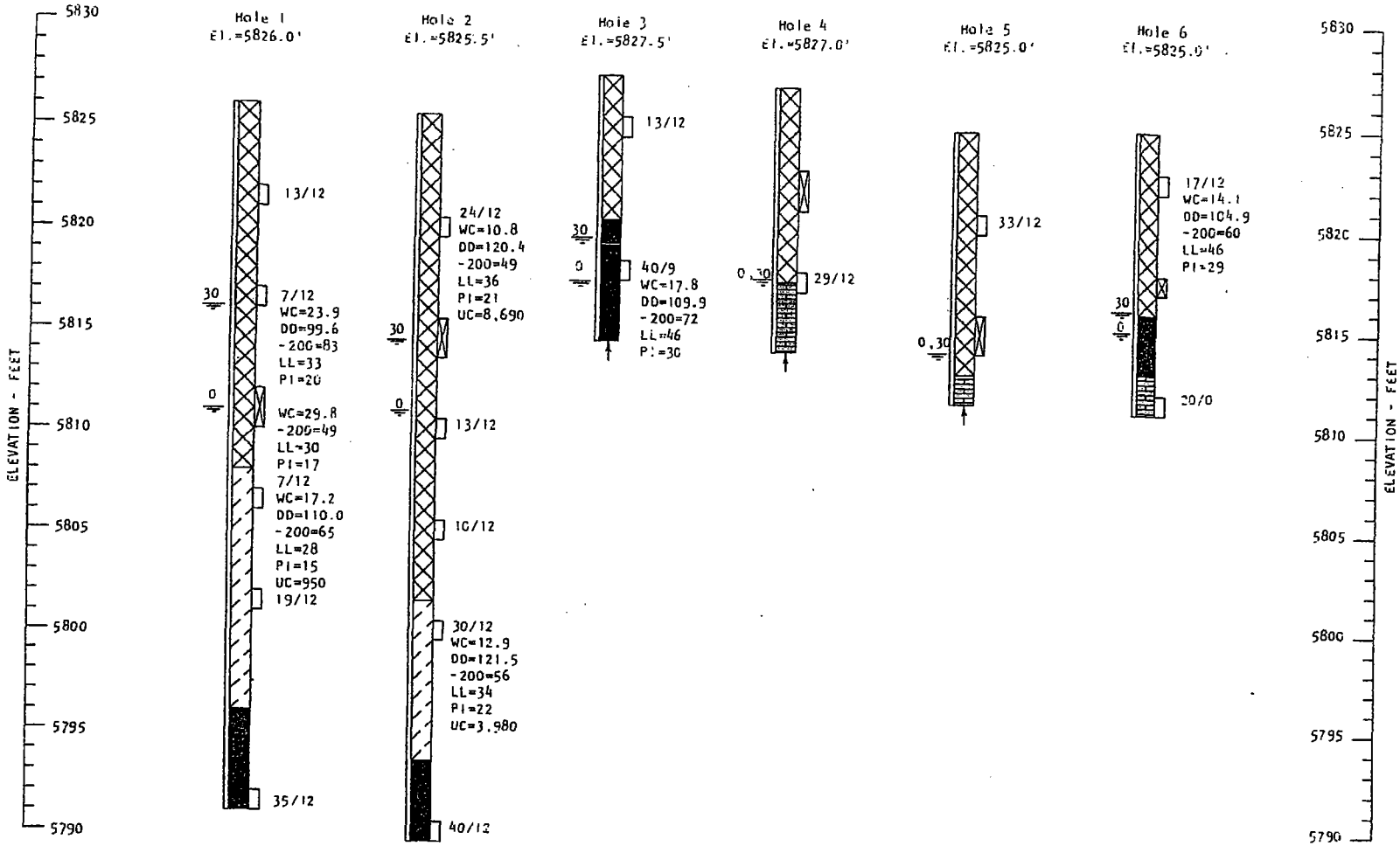
Dam Station/ Location	Average Rock Thickness (in)	Approx Size (inch)		Observed Rock Types	General Description
		Median	Range		
Right Abutment	8	12	3 - 20	Primarily sandstone rock.	Approx 200' from Dam Station 0+00. Approx 9' high exposed head scarp near top. Pocket of slope protection rock located below toe of head scarp
Right Abutment	8	20	3 - 36	Primarily granitic rocks on head scarp. Mixture of sandstone and granitic rock below head scarp.	Approx 100' from Dam Station 0+00. Approx 7' high exposed head scarp near top. Pocket of slope protection rock located below toe of scarp.
0+00	8	18	3 - 24	Primarily granitic rocks on head scarp. Mixture of sandstone and granitic rock below head scarp (majority sandstone).	Approx 9' high exposed head scarp near top.
1+00	12	18	3 - 36	Mixture of granitic and sandstone rocks on head scarp (majority granitic). Mixture of sandstone and granitic rock below head scarp (majority sandstone).	Approx 10' high exposed head scarp near top.
2+00	12	16	3 - 24	Primarily sandstone rock on and below head scarp.	Approx 10' high exposed head scarp near top.
3+00	9	16	3 - 28	Primarily granitic rocks on head scarp. Mixture of sandstone and granitic rock below head scarp (majority granitic).	Approx 10' to 12' high exposed head scarp near top.
4+00	10	16	3 - 24	Primarily granitic rocks on head scarp. Primarily sandstone rock below head scarp.	Approx 10' high exposed head scarp near top.
5+00	15	18	3 - 36	Primarily granitic rocks on head scarp. Primarily sandstone rock below head scarp.	Head scarp covered in brush and slope protection rock.
6+00	15	18	5 - 24	Primarily granitic rocks on head scarp. Mixture of sandstone and granitic rock below head scarp (majority sandstone).	Head scarp covered in brush and slope protection rock.
7+00	15	18	5 - 24	Primarily granitic rocks on head scarp. Primarily sandstone rock below head scarp.	Head scarp covered in brush and slope protection rock.
8+00	12	20	5 - 24	Primarily granitic rocks on head scarp. Primarily sandstone rock below head scarp.	Head scarp covered in brush and slope protection rock.

TABLE 3. FEASIBILITY-LEVEL COST ESTIMATE
FEASIBILITY-LEVEL DAM MODIFICATION DESIGN FOR BERGEN DAM NO. 2

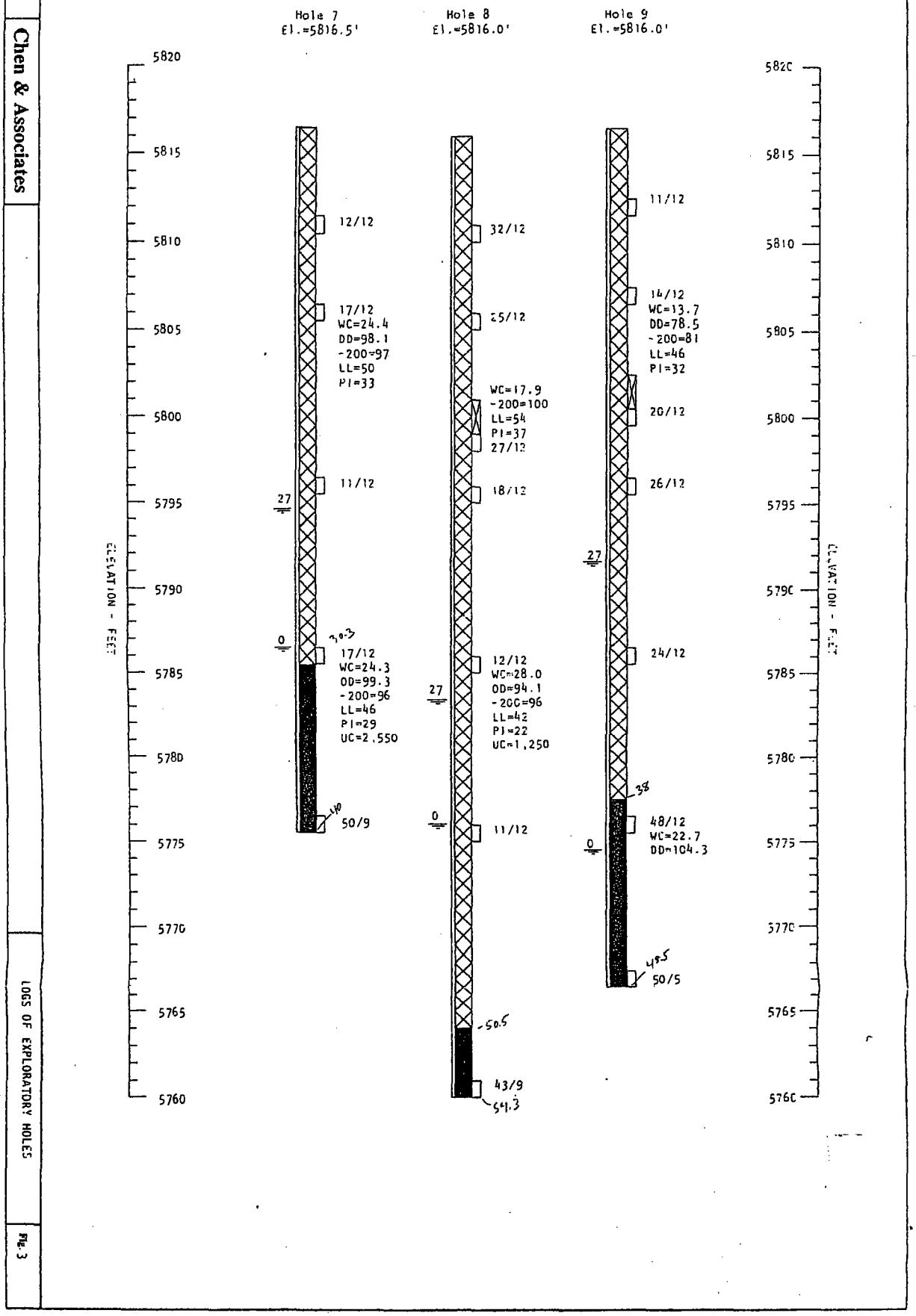
Item No.	Item Description	Quantity	Unit	Unit Price	Item Amount
1	Mobilization	1.0	lump sum	$75,000.00	$75,000
2	Clearing and Stripping	4.0	acre	$5,000.00	$20,000
3	Dewatering	1.0	lump sum	$20,000.00	$20,000
4	Required Excavation	20,000.0	cubic yards	$4.00	$80,000
5	Embankment Fill	30,000.0	cubic yards	$4.00	$120,000
6	Drain Aggregate	2,700.0	cubic yards	$35.00	$94,500
7	Drain Pipe	610.0	lineal foot	$30.00	$18,300
8	Drain Manhole	1.0	lump sum	$4,000.00	$4,000
9	Granular Fill	2,700.0	cubic yards	$14.00	$37,800
10	Riprap	4,800.0	cubic yards	$38.00	$182,400
11	Riprap Bedding	1,800.0	cubic yards	$35.00	$63,000
12	Surface Course	400.0	cubic yards	$35.00	$14,000
13	Revegetation	5.0	acre	$4,500.00	$22,500
	Subtotal				$751,500
	Unlisted Items (10% of Subtotal)				$75,150
	Contingency (15% of Subtotal)				$112,725
	Total Estimated Cost				$939,375

Notes: 1. Mobilization assumed equal to 10% of Subtotal Cost.
2. Clearing and Stripping includes removal and stockpiling existing riprap material.
3. Required Excavation includes excavating on the downstream slope of the dam.
4. Embankment fill consists of fill developed from required excavations and on-site borrow pits.
5. Granular fill assumed to be material imported from off site.
6. Riprap includes imported riprap material, and does not include use of on-site material for riprap.
7. Revegetation includes area along downstream slope of modified dam, in addition to approximately 3 acre borrow area following borrow development.

APPENDIX A
INFORMATION FROM EXPLORATON PERFORMED BY OTHERS



1 195 84	**Chen & Associates**	BERGEN RESERVOIRS	LOGS OF EXPLORATORY HOLES	Fig. 2

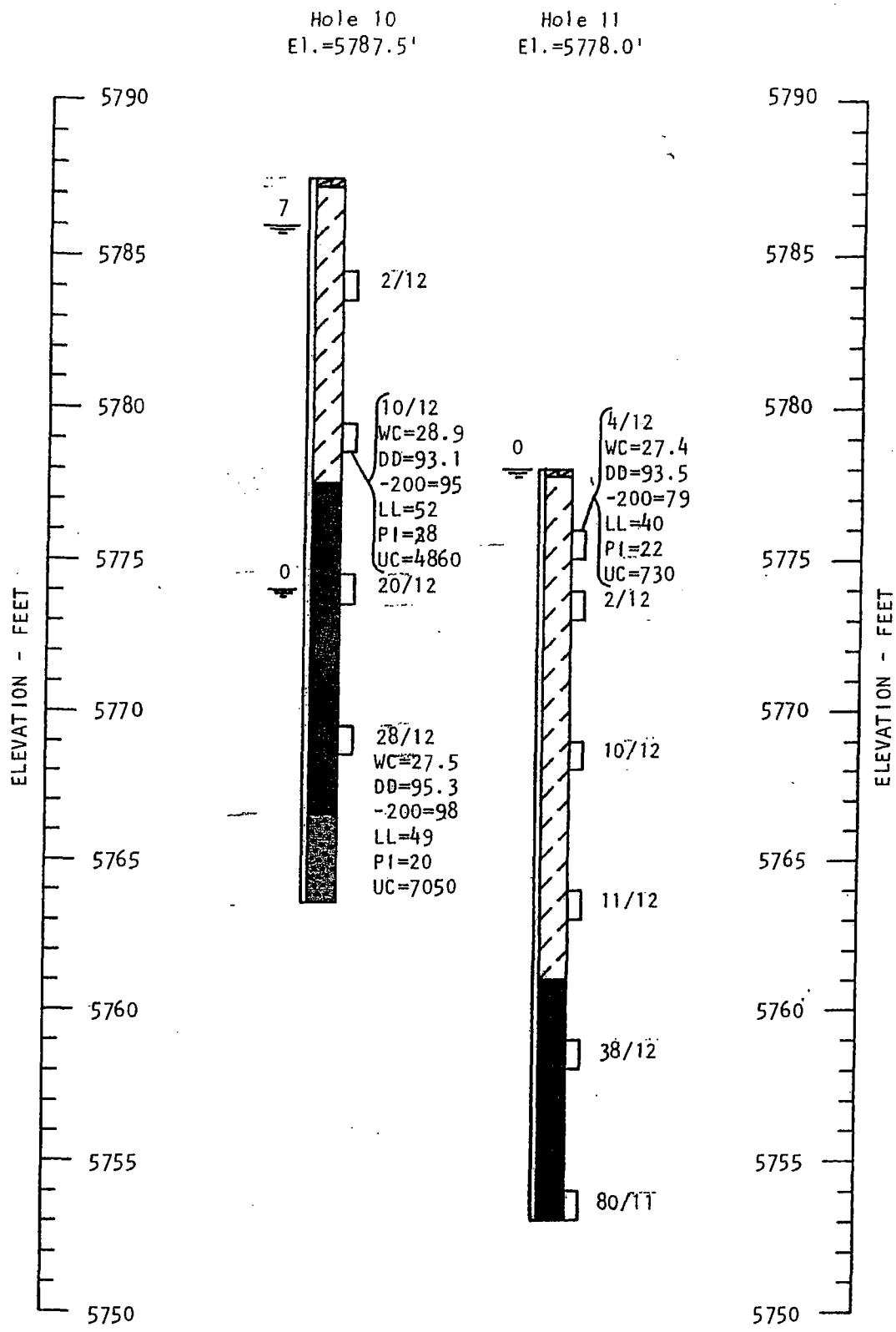


1 195 84

Chen & Associates

LOGS OF EXPLORATORY HOLES

Fig. 3



1 195 84	**Chen & Associates**	LOGS OF EXPLORATORY HOLES	Fig. 4

LEGEND:

Fill, sandy clay to clay and sand mixture, scattered pieces of claystone and sandstone, moist to very moist, browns and gray.

Clay (CL), sandy to very sandy, very stiff, moist, brown.

Claystone bedrock, sandy, occasional lenses of sandstone, hard to very hard, moist, gray and brown.

Sandstone , clayey, fine grained, local cemented, very hard, slightly moist, brown.

Limestone bedrock, thin bedded fractures, occasional thin shale beds, very hard, slightly moist, brown.

Indicates PVC pipe installed in hole to depth shown.

Drive sample, 2-inch I.D. California liner sample.

11/12 Drive sample blow count. Indicates that 11 blows of a 140-pound hammer falling 30 inches were required to drive the California sampler 12 inches.

Shelby tube.

$\frac{0.7}{\nabla}$ Depth to water level and number of days after drilling measurement was made.

Practical rig refusal.

NOTES:

1. Test Holes 1 through 9 were drilled on May 18 & 21, 1984 and Test Holes 10 & 11, were drilled on August 8, 1984. All test holes were drilled with a 4-inch diameter continuous flight power auger.
2. Locations of test holes were measured approximately by taping with measuring wheel from features shown on the site plan provided.
3. Elevations of test holes were obtained by interpolation between contours on the plan provided.
4. The lines between materials shown on the test hole logs represent the approximate boundaries between material types and the transitions may be gradual.
5. Water level readings shown on the logs were made at the time and under conditions indicated. Fluctuations in the water level may occur with time.
6. Laboratory Test Results:
   WC=Water Content (%);
   DD=Dry Density (pcf);
   -200=Percentage passing No. 200 Sieve;
   LL=Liquid Limit (%);
   PI=Plasticity Index (%);
   UC=Unconfined compressive strength (psf).

1 195 84	Chen & Associates		LEGEND AND NOTES	Fig. 5

CHEN AND ASSOCIATES

TABLE A-1

SUMMARY OF LABORATORY TEST RESULTS

1 195 84
1 of 2

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (PCF)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH (PSF)		SOIL OR BEDROCK TYPE
HOLE	DEPTH (FEET)			GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)			
1	9	23.9	99.6			83	33	20			Fill, sandy clay
	14-16	29.8	-			49	30	17			Fill, sand & clay
	19	17.2	110.0			65	28	15	950		Very sandy clay
2	5	10.8	120.4			49	36	21	8,690		Fill, sand & clay
	25	12.9	121.5			56	34	22	3,980		Clay & sand
3	9	17.8	109.9			72	46	30			Sandy claystone
6	2	14.1	104.9			60	46	29			Fill, very sandy clay
7	10	24.4	98.1			97	50	33			Fill, clay & claystone
	30	24.3	99.3			96	46	29	2,550		Claystone
8	15-17	17.9	-			100	54	37			Fill, clay & claystone
	30	28.0	94.1			96	42	22	1,250		Fill, clay
9	9	13.7	78.5			81	46	32			Fill, sandy clay
	40	22.7	104.3								Claystone

APPENDIX B
TRIAXIAL SHEAR STRENGTH TEST RESULTS

ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	B-1	DATE SAMPLED	
DEPTH	7.0-9.5'	DATE TESTED	05/13/09 LB
SAMPLE NO.			
SOIL DESCR.	09-1-211		
LOCATION	Bergen Dam		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	6.43	6.42	6.44
Wt Dish & Dry Soil	5.65	5.66	5.70
Wt of Moisture	0.78	0.76	0.74
Wt of Dish	1.13	1.15	1.16
Wt of Dry Soil	4.52	4.51	4.54
Moisture Content	17.26	16.85	16.30

Liquid Limit Determination — Device Number 0966

	1	2	3	4
Number of Blows	18	22	25	28
Wt Dish & Wet Soil	11.47	8.24	11.02	11.23
Wt Dish & Dry Soil	7.67	5.70	7.52	7.69
Wt of Moisture	3.80	2.54	3.50	3.54
Wt of Dish	1.13	1.15	1.12	1.15
Wt of Dry Soil	6.54	4.55	6.40	6.54
Moisture Content	58.10	55.82	54.69	54.13

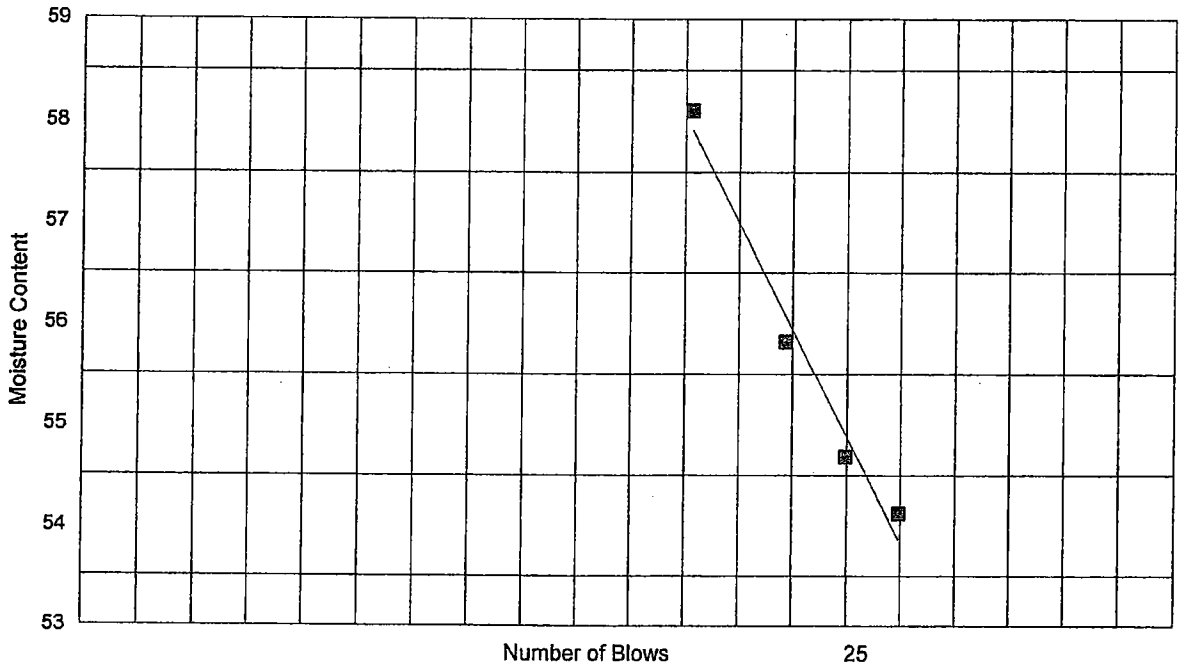
Liquid Limit	54.9
Plastic Limit	16.8
Plasticity Index	38.1

Atterberg Classification CH

Data entry by:	MLM	Date:	05/14/2009
Checked by: cal		Date: 5/16/09	
FileName:	KAG0795		

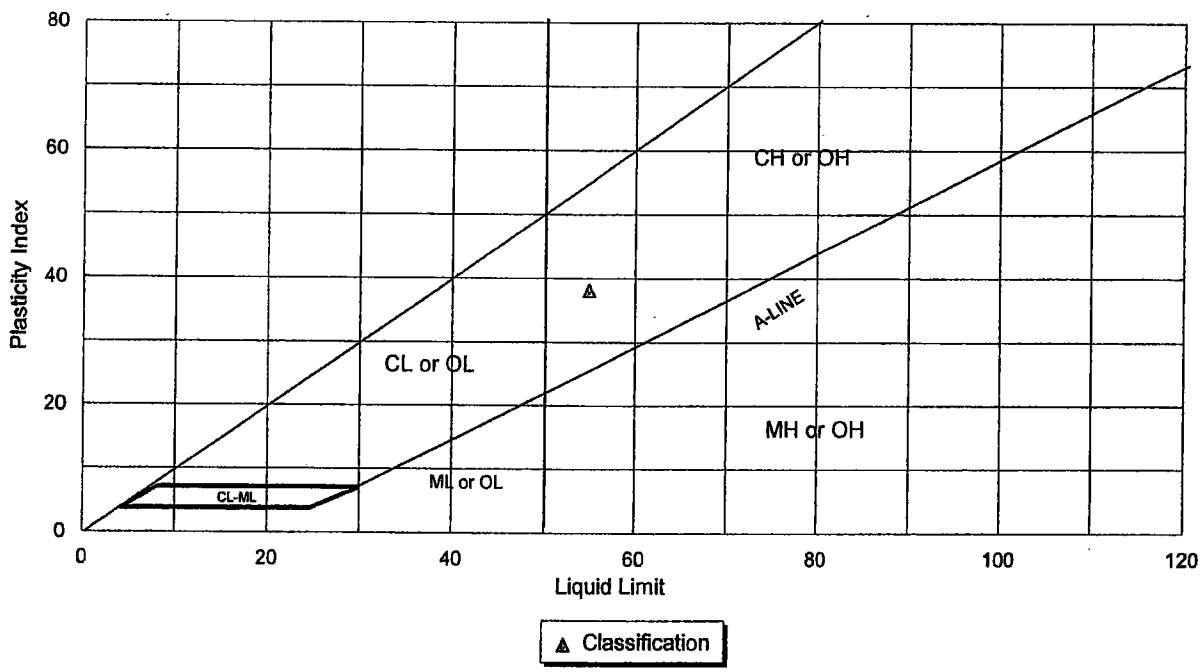
Atterberg Limits, Flow Curve

B-1, 7.0-9.5',



PLASTICITY CHART

B-1, 7.0-9.5',



ATTERBERG LIMITS TEST
ASTM D 4318

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	KB-2	DATE SAMPLED	
DEPTH	5.0'	DATE TESTED	05/07/09 WAR
SAMPLE NO.			
SOIL DESCR.	09-1-211		
LOCATION	Bergen Dam		

Plastic Limit Determination

	1	2	3
Wt Dish & Wet Soil	12.28	11.92	11.10
Wt Dish & Dry Soil	10.99	10.66	9.96
Wt of Moisture	1.29	1.26	1.14
Wt of Dish	1.12	1.13	1.12
Wt of Dry Soil	9.87	9.53	8.84
Moisture Content	13.07	13.22	12.90

Liquid Limit Determination — Device Number 0966

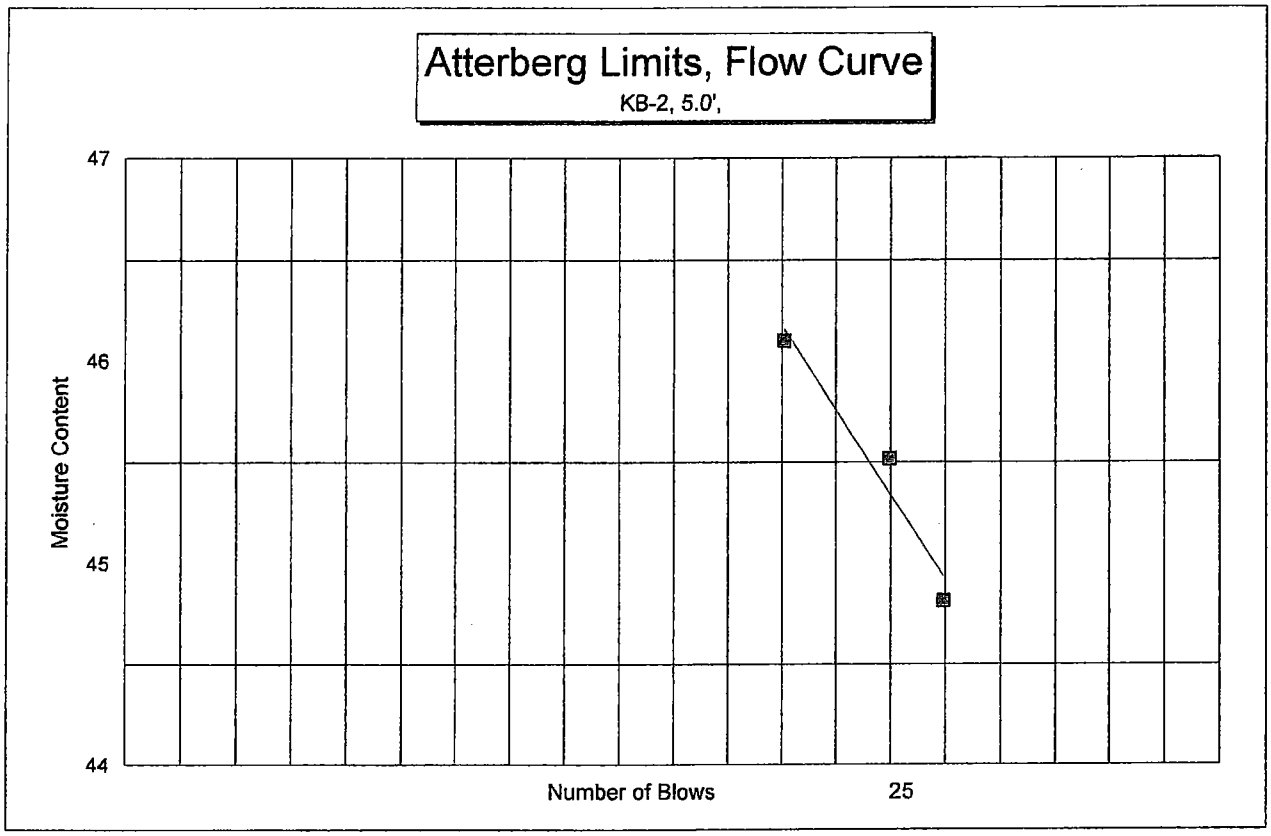
	1	2	3
Number of Blows	20	28	25
Wt Dish & Wet Soil	15.36	17.20	15.58
Wt Dish & Dry Soil	10.87	12.23	11.06
Wt of Moisture	4.49	4.97	4.52
Wt of Dish	1.13	1.14	1.13
Wt of Dry Soil	9.74	11.09	9.93
Moisture Content	46.10	44.82	45.52

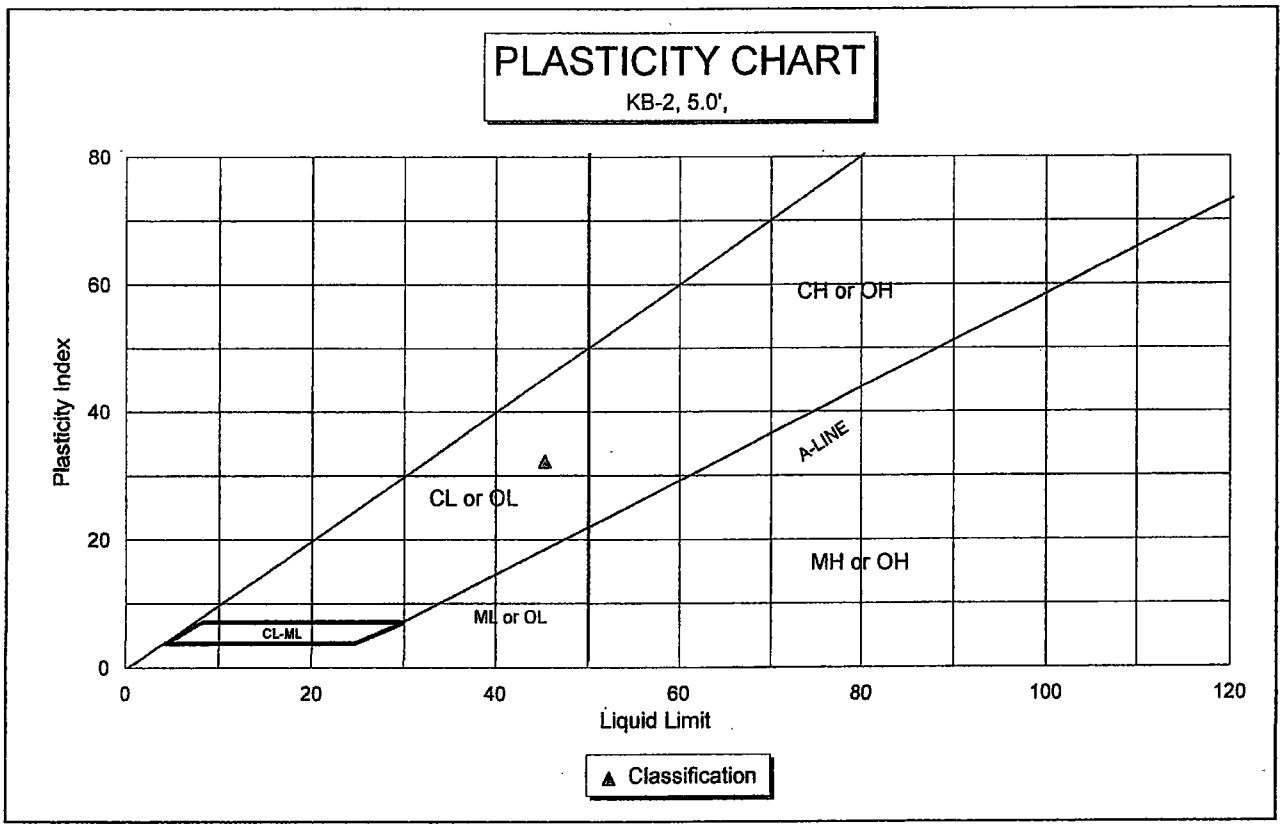
Liquid Limit	45.3
Plastic Limit	13.1
Plasticity Index	32.3

Atterberg Classification CL

Data entry by: MLM Date: 05/08/2009
Checked by: ar Date: 5/8/09
FileName: KAG0KB2

ADVANCED TERRA TESTING, INC. ATT


Atterberg Limits, Flow Curve
KB-2, 5.0',
47
46
45
44
Moisture Content
Number of Blows
25


PLASTICITY CHART
KB-2, 5.0',
80
60
40
20
0
Plasticity Index
0
20
40
60
80
100
120
Liquid Limit
CH or OH
A-LINE
CL or OL
MH or OH
ML or OL
CL-ML
Classification

GRAIN SIZE ANALYSIS

PERCENT FINES, -200 SEIVE ONLY

ASTM D 1140

MECHANICAL ANALYSIS - SIEVE TEST DATA
-#200 SIEVE ONLY
ASTM D 1140

CLIENT Kumar & Associates

JOB NO. 2203-47

BORING NO.	B-1	SAMPLED	
DEPTH	7.0-9.5'	DATE TESTED	
SAMPLE NO.		WASH SIEVE	Yes
SOIL DESCR.	09-1-211	DRY SIEVE	No
LOCATION	Bergen Dam		

WASH SIEVE ANALYSIS

Wt. Wet Soil & Pan Before Washing (g)	181.9
Wt. Dry Soil & Pan Before Washing (g)	161.7
Weight of Pan (g)	8.1
Wt. of Dry Soil Before Washing	153.7
Wt. Dry Soil & Pan After Washing (g)	15.6
Wt. of Dry Soil After Washing (g)	7.5
-#200 Wash. Out %	95.1

Data entry by: MLM Date: 05/12/2009
Data checked by: cac Date: 5/13/09
Filename: KAS0795

ADVANCED TERRA TESTING, INC. ATT

MECHANICAL ANALYSIS

ASTM D 6913

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D 1140

CLIENT Kumar & Associates

JOB NO. 2203-47

BORING NO.	KB-2	SAMPLED	
DEPTH	5.0'	DATE+#4 WASHED	05/07/09 TMR
SAMPLE NO.		DATE -#4 WASHED	05/07/09 TMR
SOIL DESCR.	09-1-211	WASH SIEVE	Yes
LOCATION	Bergen Dam	DRY SIEVE	No

MOISTURE DATA

HYGROSCOPIC	Yes
NATURAL	No

Wt. Wet Soil & Pan (g)	131.56
Wt. Dry Soil & Pan (g)	121.83
Wt. Lost Moisture (g)	9.73
Wt. of Pan Only (g)	3.23
Wt. of Dry Soil (g)	118.60
Moisture Content %	8.2
Wt. Partial -#4 Sample Wet (g)	279.79
Wt. Partial Sample Dry (g)	258.58

WASH SIEVE ANALYSIS

Wt. Total Sample Wet (g)	1501.84
Weight of + #4 Before Washing (g)	121.74
Weight of + #4 After Washing (g)	115.38
Weight of - #4 Wet (g)	1380.10
Weight of - #4 Dry (g)	1281.34
Wt. Total Sample Dry (g)	1396.72
Calc. Wt. "W" (g)	281.86
Calc. Mass + #4	23.28

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
#4	0.00	115.38	115.38	115.38	8.3	91.7
#200	1029.46	1104.97	75.51	75.51	35.1	64.9

Data entered by: MLM Date: 05/08/2009
Data checked by: LB Date: 5-13-2009
FileName: KAM0KB2

ADVANCED TERRA TESTING, Inc. ATT

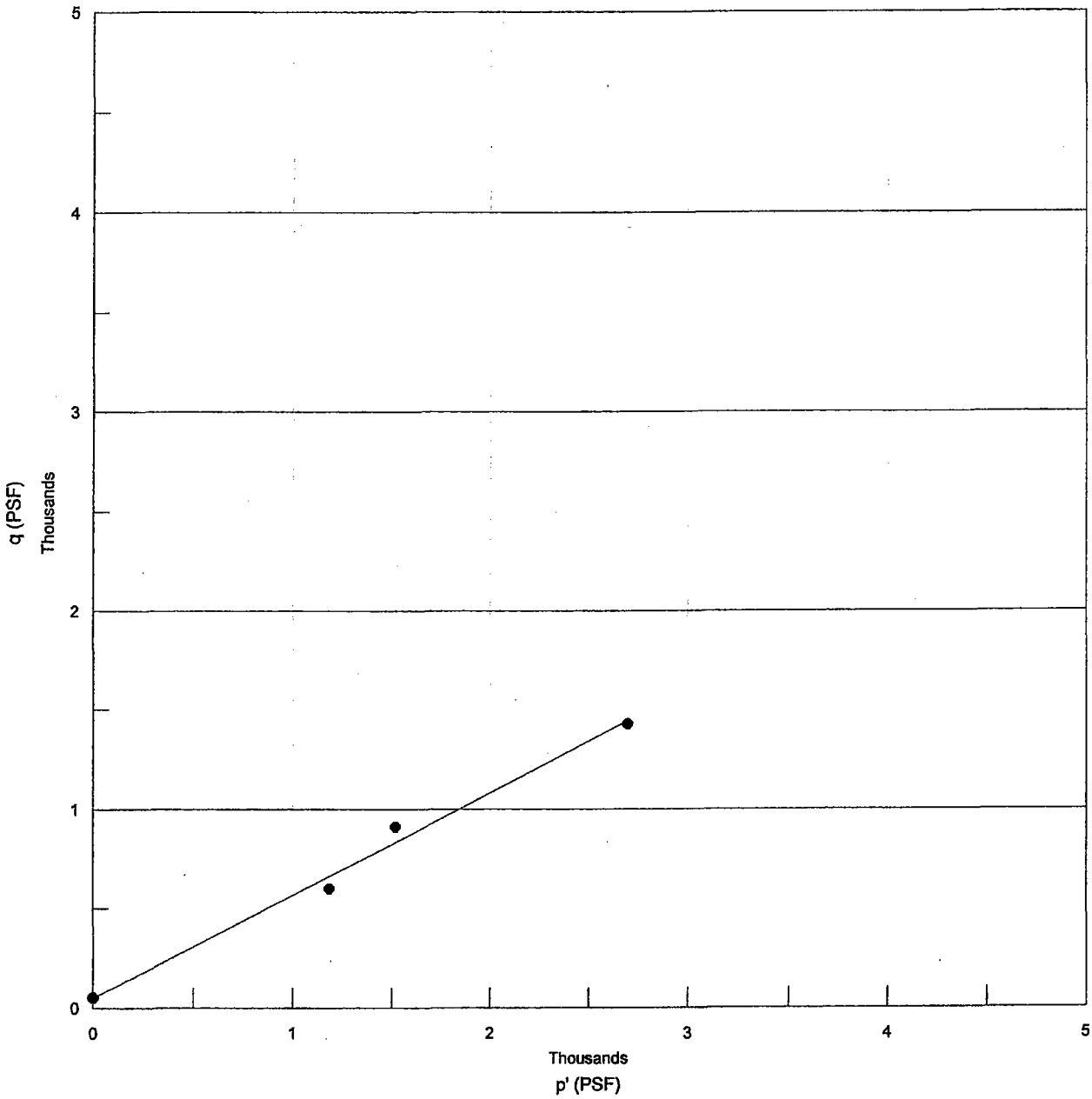
TRIAXIAL SHEAR TEST

TX/CUPP

ASTM D 4767

Effective Stress Path Analysis - p'-q Regression Plot

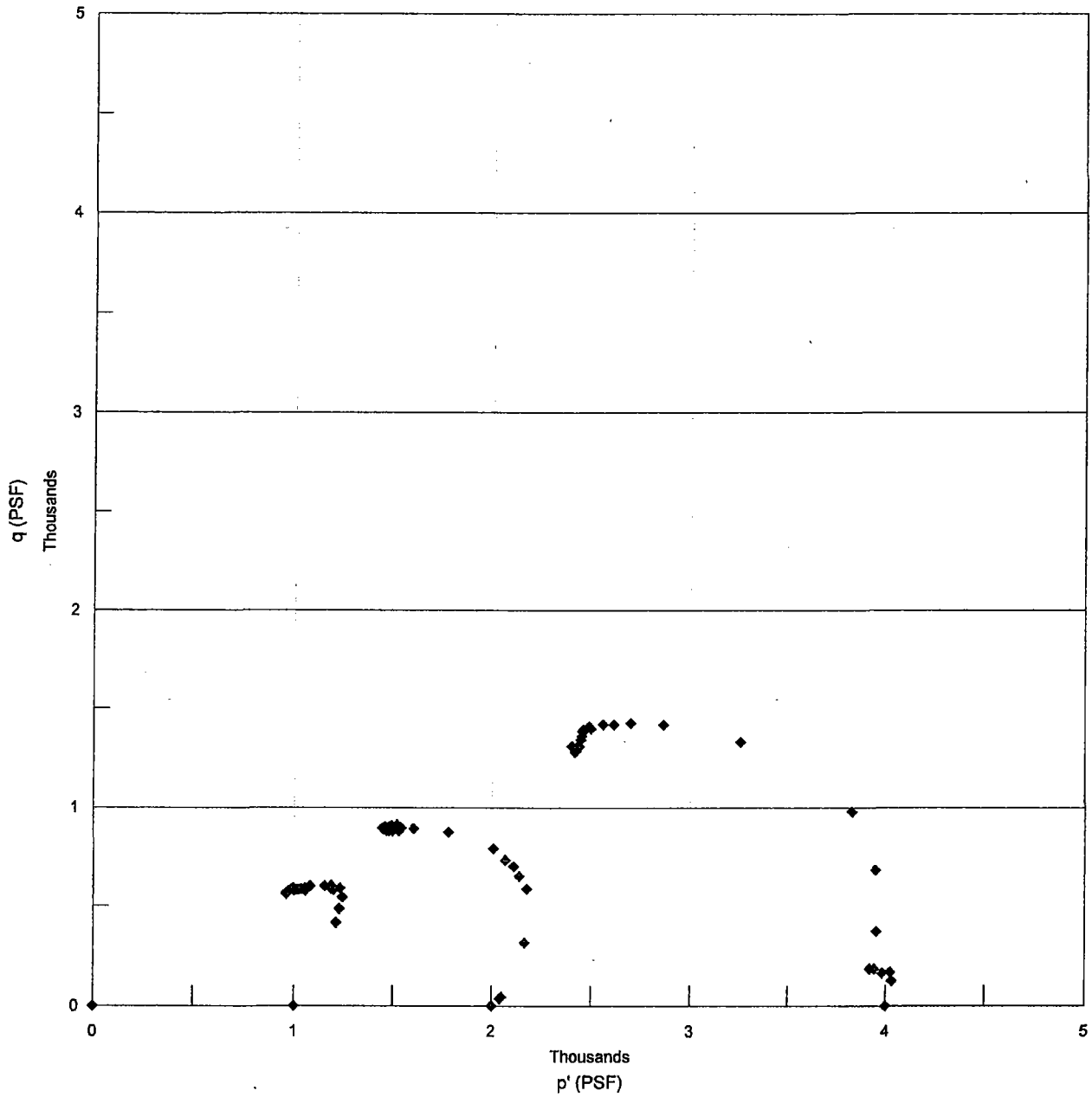
Kumar & Associates,Bergen Dam,09-1-211,B-1,Pt. A, B & C,7.0-9.5'



● Shear Data – Best Fit Line Tau = 27.2 degrees a = 54.0 PSF

Effective Stress Path Analysis - p' q Plots

Kumar & Associates,Bergen Dam,09-1-211,B-1,Pt. A, B & C,7.0-9.5'



EFFECTIVE STRESS PATH ANALYSIS TEST DATA
ASTM D4767

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	B-1		
DEPTH	7.0-9.5'	SAMPLED	
SAMPLE NO.	Pt. A, B & C	SATURATED TEST	
SOIL DESCR.	09-1-211	TEST TYPE	TX/CUPP
LOCATION	Bergen Dam	Peak Points	

					p' PSF	q PSF
CONF. PRES. PSF	SAMPLE A	4000	PSF	SAMPLE A	2700	1425
	SAMPLE B	2000	PSF	SAMPLE B	1519	912
	SAMPLE C	1000	PSF	SAMPLE C	1186	604

SAMPLE A				SAMPLE B				SAMPLE C			
σ 3' PSF	σ 1' PSF	p' PSF	q PSF	σ 3' PSF	σ 1' PSF	p' PSF	q PSF	σ 3' PSF	σ 1' PSF	p' PSF	q PSF
4000	4000	4000	0	2000	2000	2000	0	1000	1000	1000	0
3904	4159	4032	127	2004	2078	2041	37	794	1630	1212	418
3853	4193	4023	170	2002	2093	2048	45	741	1710	1225	485
3816	4150	3983	167	1846	2483	2164	318	698	1786	1242	544
3755	4131	3943	188	1585	2762	2174	588	639	1819	1229	590
3732	4105	3919	186	1485	2787	2136	651	616	1779	1198	582
3574	4331	3952	378	1407	2810	2109	702	598	1773	1186	587
3264	4632	3948	684	1334	2798	2066	732	582	1790	1186	604
2848	4807	3827	979	1215	2798	2007	792	553	1754	1154	600
1929	4586	3258	1329	906	2655	1781	874	470	1645	1057	587
1447	4283	2865	1418	714	2497	1606	891	418	1579	999	580
1275	4125	2700	1425	647	2408	1527	881	401	1522	962	561
1194	4030	2612	1418	614	2374	1494	880	394	1531	962	568
1140	3978	2559	1419	594	2355	1475	881	393	1543	968	575
1100	3898	2499	1399	581	2347	1464	883	394	1536	965	571
1080	3896	2488	1408	580	2361	1471	891	400	1564	982	582
1070	3839	2454	1385	560	2338	1449	889	406	1586	996	590
1070	3854	2462	1392	548	2337	1443	894	405	1579	992	587
1073	3848	2460	1387	555	2359	1457	902	412	1578	995	583
1076	3840	2458	1382	567	2361	1464	897	420	1590	1005	585
1094	3710	2402	1308	577	2381	1479	902	430	1595	1013	582
1094	3813	2454	1359	585	2400	1492	908	439	1608	1024	584
1105	3792	2448	1344	593	2401	1497	904	451	1621	1036	585
1121	3743	2432	1311	607	2431	1519	912	465	1642	1053	589
1132	3747	2440	1308	618	2426	1522	904	478	1632	1055	577
1140	3709	2424	1284	629	2414	1522	892	470	1642	1056	586
1138	3695	2417	1278	635	2431	1533	898	480	1681	1081	600
1139	3700	2419	1281	640	2437	1539	899	478	1681	1080	601

Data entry by: MLM Date: 05/27/2009
Data checked by: DRM Date: 5/28/09
FileName: KAPQ795

ADVANCED TERRA TESTING, Inc. ATT

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	B-1	SAMPLED	
DEPTH	7.0-9.5'	TEST STARTED	05/09/09 CAL
SAMPLE NO.	Pt. A	TEST FINISHED	05/19/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	1N
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp		
		CONF. PRES. PSF	4000

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1019.4	1135.8
Wt. Wet Soil & Pan (g)	1033.7	1150.0
Wt. Dry Soil & Pan (g)	919.3	919.3
Wt. Lost Moisture (g)	114.3	230.7
Wt. of Pan Only (g)	14.3	14.3
Wt. of Dry Soil (g)	905.1	905.1
Moisture Content %	12.6	25.5
Wet Density PCF	101.9	128.5
Dry Density PCF	90.5	102.4

Init. Diameter (in)	2.846
Init. Area (sq in)	6.362
Init. Height (in)	5.991
Vol. Bef. Consol. (cu ft)	0.02206
Vol. After Consol. (cu ft)	0.01949

Notes & Comments:

Data entry by: MLM Date: 05/21/2009
Data checked by: ce Date: 5/23/09
FileName: KAT0795A

ADVANCED TERRA TESTING, INC. ATT

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	B-1	SAMPLED	
DEPTH	7.0-9.5'	TEST STARTED	05/09/09 CAL
SAMPLE NO.	Pt. A	TEST FINISHED	05/19/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	1N
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp	CONF. PRES. PSF	4000

SATURATION DATA

Cell Pres. (PSI)	Back Pres. (PSI)	Burette Reading (CC)		Pore Pressure (PSI)		Change	B
		Close	Open	Close	Open		
40.0	38.0	17.4	41.4				
50.0	48.0	37.9	40.5	38.9	46.7	7.8	0.78
60.0	58.0	40.1	41.4	48.7	56.8	8.1	0.81
70.0	68.0	40.6	42.2	58.7	66.9	8.2	0.82
80.0	78.0	42.2	42.7	68.7	76.8	8.1	0.81
90.0	88.0	42.6	43.5	78.2	87.5	9.3	0.93
100.0	98.0	43.3	44.2	88.3	97.7	9.4	0.94
110.0		43.7	44.0	98.4	108.2	9.8	0.98

CONSOLIDATION DATA

Elapsed Time (Min)	SQRT TIME (Min)	Burette Reading (CC)	Vol. Defl. (CC)
0.00	0.0	0.0	0.00
0.25	0.5	32.5	-32.50
0.5	0.7	39.0	-39.00
1	1.0	44.9	-44.90
2	1.4	49.8	-49.75
4	2.0	52.2	-52.20
9	3.0	54.0	-54.00
16	4.0	55.2	-55.20
30	5.5	56.1	-56.10
60	7.7	56.8	-56.80
120	11.0	57.5	-57.50
240	15.5	57.9	-57.90
360	19.0	58.1	-58.10

Initial Height (in)	5.991	Init. Vol. (CC)	624.65
Height Change (in)	0.206	Vol. Change (CC)	85.90
Ht. After Cons. (in)	5.785	Cell Exp. (CC)	13.11
Initial Area (sq in)	6.362	Net Change (CC)	72.79
Area After Cons. (sq in)	5.820	Cons. Vol. (CC)	551.87

Data entry by: MLM Date: 05/21/2009
Data checked by: Date: 5/23/09
FileName: KAT0795A

ADVANCED TERRA TESTING, Inc. ATT

TRIAXIAL COMPRESSION TEST DATA

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	B-1	SAMPLED	
DEPTH	7.0-9.5'	TEST STARTED	05/09/09 CAL
SAMPLE NO.	Pt. A	TEST FINISHED	05/19/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	1N
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp	CONF. PRES. PSF	4000

Init. Ht. (in)	5.991	Init. Area (sq in)	6.362
Consol. Ht. (in)	5.785	Consol. Area (sq in)	5.820
Back Pres. PSI	98.5	Strain Rate (in/min)	0.0054

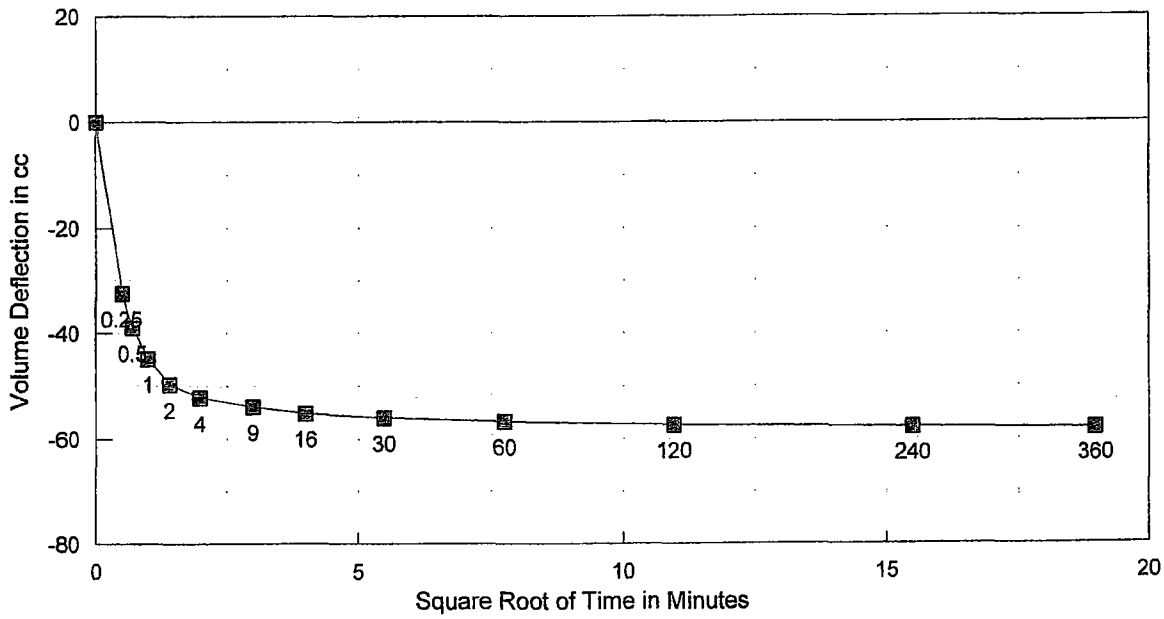
Axial Load Lbs.	Axial Load PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Dev. Stress PSF	Pore Pres. PSI	Delta Pres. PSF	Sigma 3 PSF	Sigma 1 PSF	Prin. Stress Ratio
0.0	0	0.000	0.00	5.820	0	98.5	0	4000	4000	1.00
10.3	255	0.012	0.20	5.832	255	99.2	96	3904	4159	1.07
13.8	342	0.018	0.30	5.838	341	99.5	147	3853	4193	1.09
13.6	335	0.024	0.41	5.844	334	99.8	184	3816	4150	1.09
15.3	378	0.035	0.61	5.856	376	100.2	245	3755	4131	1.10
15.2	376	0.041	0.72	5.862	373	100.4	268	3732	4105	1.10
30.8	763	0.047	0.81	5.868	757	101.5	426	3574	4331	1.21
55.8	1381	0.052	0.91	5.874	1368	103.6	736	3264	4632	1.42
80.1	1981	0.063	1.09	5.885	1959	106.5	1152	2848	4807	1.69
109.6	2712	0.116	2.01	5.940	2658	112.9	2071	1929	4586	2.38
118.6	2935	0.193	3.34	6.021	2837	116.2	2553	1447	4283	2.96
120.5	2980	0.253	4.37	6.086	2850	117.4	2725	1275	4125	3.24
120.9	2990	0.299	5.18	6.138	2835	118.0	2806	1194	4030	3.37
122.2	3022	0.352	6.08	6.197	2838	118.4	2860	1140	3978	3.49
121.7	3011	0.410	7.08	6.264	2797	118.6	2900	1100	3898	3.54
123.8	3064	0.468	8.10	6.333	2816	118.8	2920	1080	3896	3.61
123.2	3047	0.527	9.11	6.404	2769	118.9	2930	1070	3839	3.59
125.2	3098	0.586	10.13	6.476	2784	118.9	2930	1070	3854	3.60
126.2	3123	0.644	11.14	6.550	2775	118.8	2927	1073	3848	3.59
127.2	3147	0.703	12.15	6.626	2764	118.8	2924	1076	3840	3.57
121.7	3012	0.760	13.13	6.700	2617	118.7	2906	1094	3710	3.39
127.6	3157	0.803	13.89	6.759	2719	118.7	2906	1094	3813	3.48
127.5	3156	0.859	14.85	6.835	2687	118.6	2895	1105	3792	3.43
126.2	3123	0.929	16.05	6.934	2622	118.5	2879	1121	3743	3.34
127.9	3165	1.006	17.39	7.045	2615	118.4	2868	1132	3747	3.31
127.7	3160	1.083	18.72	7.161	2569	118.4	2860	1140	3709	3.25
128.3	3173	1.124	19.42	7.223	2557	118.4	2862	1138	3695	3.25
129.0	3190	1.141	19.72	7.250	2561	118.4	2861	1139	3700	3.25

Data entry by: MLM Date: 05/21/2009
Data checked by: ae Date: 5/23/09
FileName: KAT0795A

ADVANCED TERRA TESTING, INC. ATT

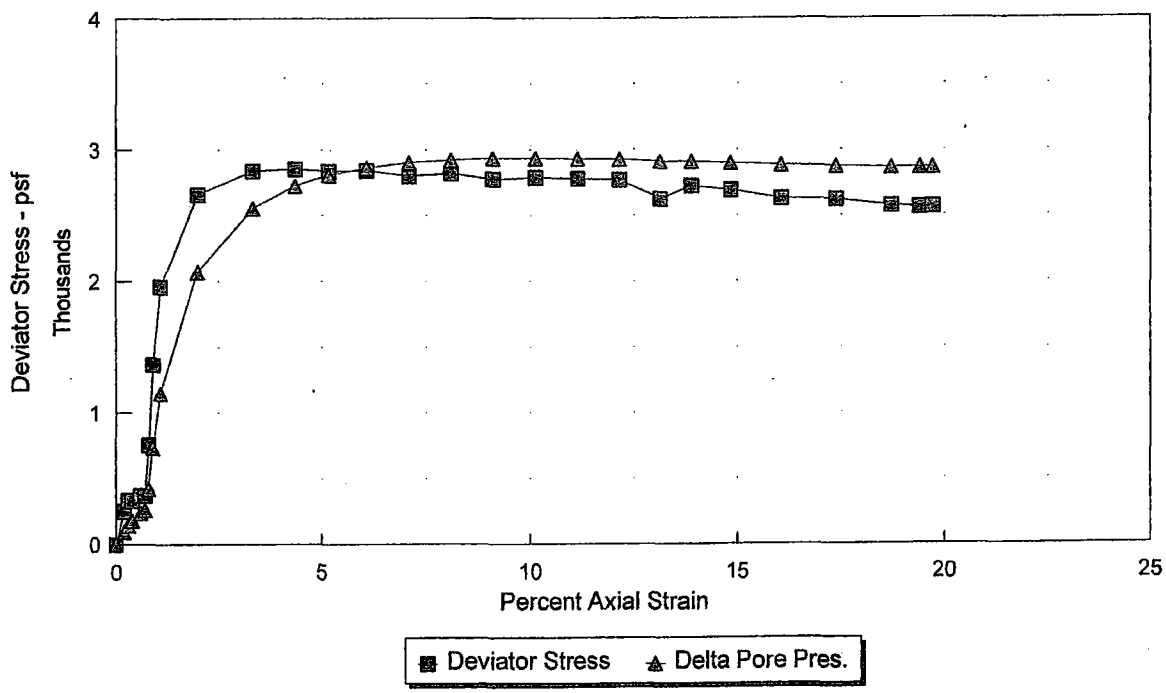
CONSOLIDATION DATA

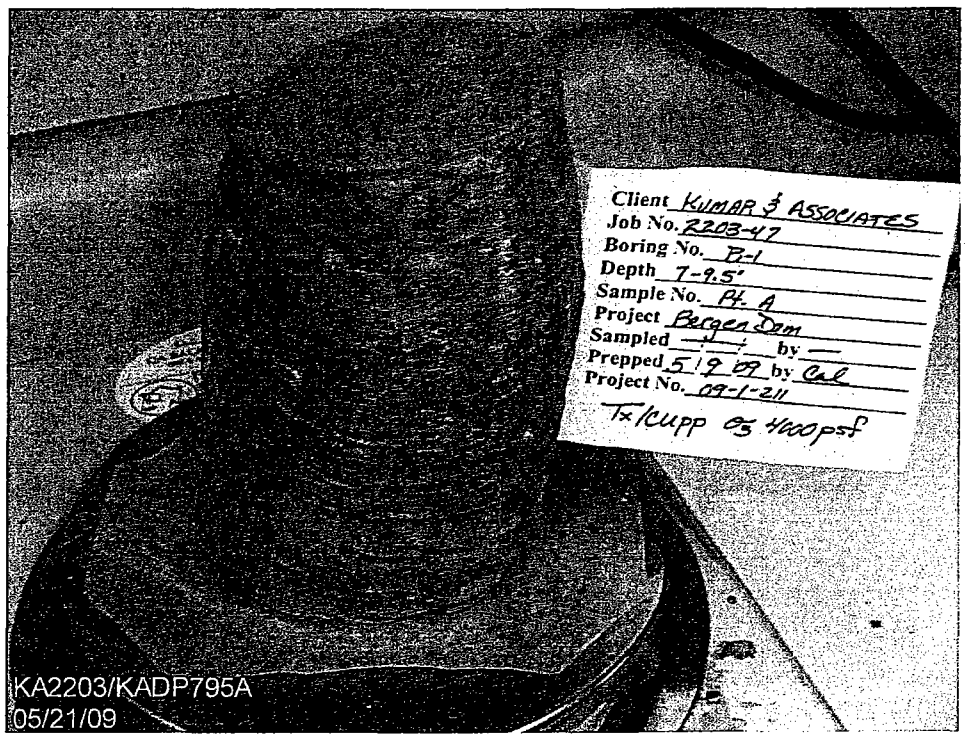
B-1, 7.0-9.5', Pt. A



TRIAXIAL TEST - TX/CUpp

B-1, 7.0-9.5', Pt. A




Client KUMAR & ASSOCIATES
Job No. 2203-47
Boring No. B-1
Depth 7-9.5'
Sample No. PT. A
Project Bergen Dam
Sampled ___ by ___
Prepped 5/9/09 by Cal
Project No. 09-1-211
Tx/CUPP @ 4000psf
KA2203/KADP795A
05/21/09

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	B-1	SAMPLED	
DEPTH	7.0-9.5'	TEST STARTED	05/09/09 CAL
SAMPLE NO.	Pt. B	TEST FINISHED	05/19/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	2N
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp		
		CONF. PRES. PSF	2000

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1061.8	1169.9
Wt. Wet Soil & Pan (g)	1075.7	1183.8
Wt. Dry Soil & Pan (g)	940.5	940.5
Wt. Lost Moisture (g)	135.2	243.2
Wt. of Pan Only (g)	13.9	13.9
Wt. of Dry Soil (g)	926.7	926.7
Moisture Content %	14.6	26.2
Wet Density PCF	109.8	126.5
Dry Density PCF	95.8	100.2

Init. Diameter (in)	2.855
Init. Area (sq in)	6.402
Init. Height (in)	5.754
Vol. Bef. Consol. (cu ft)	0.02132
Vol. After Consol. (cu ft)	0.02040

Notes & Comments:

Data entry by: MLM Date: 05/20/2009
Data checked by: cal Date: 5/23/09
FileName: KAT0795B

ADVANCED TERRA TESTING, INC.
ATT

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	B-1	SAMPLED	
DEPTH	7.0-9.5'	TEST STARTED	05/09/09 CAL
SAMPLE NO.	Pt. B	TEST FINISHED	05/19/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	2N
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp	CONF. PRES. PSF	2000

SATURATION DATA

Cell Pres. (PSI)	Back Pres. (PSI)	Burette Reading (CC)		Pore Pressure (PSI)		Change	B
		Close	Open	Close	Open		
40.0	38.0	10.7	22.4				
50.0	48.0	21.8	23.4	38.2	45.3	7.1	0.71
60.0	58.0	22.0	23.9	49.0	56.5	7.5	0.75
70.0	68.0	23.6	24.7	58.2	65.9	7.7	0.77
80.0	78.0	24.4	25.0	68.0	76.3	8.3	0.83
90.0	88.0	25.0	25.3	78.2	87.0	8.8	0.88
100.0		25.2	25.3	88.5	98.0	9.5	0.95

CONSOLIDATION DATA

Elapsed Time (Min)	SQRT TIME (Min)	Burette Reading (CC)	Vol. Defl. (CC)
0.00	0.0	0.7	0.00
0.25	0.5	15.3	-14.60
0.5	0.7	18.4	-17.70
1	1.0	20.0	-19.30
2	1.4	21.3	-20.60
4	2.0	22.0	-21.30
9	3.0	22.8	-22.10
16	4.0	23.2	-22.50
30	5.5	23.7	-23.00
60	7.7	24.2	-23.50
120	11.0	24.7	-24.00
240	15.5	25.2	-24.50
360	19.0	25.4	-24.70

Initial Height (in)	5.754	Init. Vol. (CC)	603.74
Height Change (in)	0.038	Vol. Change (CC)	41.10
Ht. After Cons. (in)	5.716	Cell Exp. (CC)	15.02
Initial Area (sq in)	6.402	Net Change (CC)	26.08
Area After Cons. (sq in)	6.166	Cons. Vol. (CC)	577.66

Data entry by: MLM Date: 05/20/2009
Data checked by: cc Date: 5/23/09
FileName: KAT0795B

ADVANCED TERRA TESTING, Inc. ATT

TRIAXIAL COMPRESSION TEST DATA

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	B-1	SAMPLED	
DEPTH	7.0-9.5'	TEST STARTED	05/09/09 CAL
SAMPLE NO.	Pt. B	TEST FINISHED	05/19/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	2N
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp	CONF. PRES. PSF	2000

Init. Ht. (in)	5.754	Init. Area (sq in)	6.402
Consol. Ht. (in)	5.716	Consol. Area (sq in)	6.166
Back Pres. PSI	88.5	Strain Rate (in/min)	0.0051

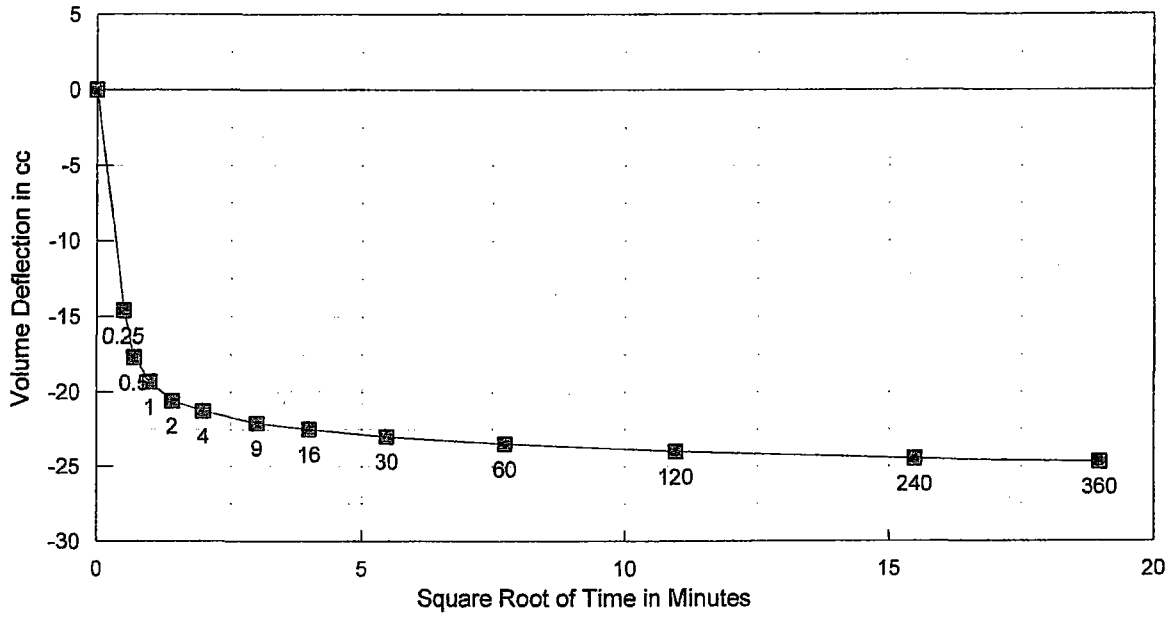
Axial Load Lbs.	Axial Load PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Dev. Stress PSF	Pore Pres. PSI	Delta Pres. PSF	Sigma 3 PSF	Sigma 1 PSF	Prin. Stress Ratio
0.0	0	0.000	0.00	6.166	0	88.5	0	2000	2000	1.00
3.2	74	0.011	0.19	6.178	74	88.5	-4	2004	2078	1.04
3.9	91	0.016	0.29	6.184	90	88.5	-2	2002	2093	1.05
27.4	639	0.021	0.36	6.189	637	89.6	154	1846	2483	1.35
50.6	1182	0.031	0.54	6.199	1176	91.4	415	1585	2762	1.74
56.1	1311	0.036	0.63	6.205	1303	92.1	515	1485	2787	1.88
60.5	1413	0.041	0.73	6.211	1403	92.6	593	1407	2810	2.00
63.2	1476	0.047	0.82	6.217	1464	93.1	666	1334	2798	2.10
68.5	1600	0.058	1.01	6.229	1583	94.0	785	1215	2798	2.30
76.3	1783	0.109	1.91	6.286	1749	96.1	1094	906	2655	2.93
78.9	1842	0.185	3.24	6.372	1783	97.4	1286	714	2497	3.50
78.8	1839	0.244	4.26	6.441	1761	97.9	1353	647	2408	3.72
79.4	1853	0.290	5.08	6.496	1759	98.1	1386	614	2374	3.86
80.2	1873	0.342	5.98	6.558	1761	98.3	1406	594	2355	3.96
81.3	1899	0.399	6.99	6.629	1766	98.4	1419	581	2347	4.04
82.9	1936	0.458	8.01	6.703	1781	98.4	1420	580	2361	4.07
83.7	1955	0.517	9.04	6.779	1779	98.5	1440	560	2338	4.18
85.2	1989	0.575	10.06	6.856	1789	98.6	1452	548	2337	4.26
86.8	2028	0.631	11.04	6.932	1804	98.5	1445	555	2359	4.25
87.4	2040	0.689	12.06	7.011	1794	98.5	1433	567	2361	4.17
88.9	2076	0.748	13.09	7.095	1804	98.4	1423	577	2381	4.13
90.3	2109	0.796	13.93	7.164	1815	98.3	1415	585	2400	4.10
91.0	2125	0.854	14.93	7.248	1807	98.3	1407	593	2401	4.05
93.1	2175	0.923	16.15	7.353	1824	98.2	1393	607	2431	4.00
93.8	2191	0.999	17.48	7.472	1808	98.1	1382	618	2426	3.93
94.1	2199	1.076	18.82	7.595	1785	98.0	1371	629	2414	3.84
95.6	2232	1.116	19.52	7.661	1796	98.0	1365	635	2431	3.83
96.0	2241	1.133	19.82	7.690	1797	98.0	1360	640	2437	3.81

Data entry by: MLM Date: 05/20/2009
Data checked by: ae Date: 5/23/09
FileName: KAT0795B

ADVANCED TERRA TESTING, Inc. ATT

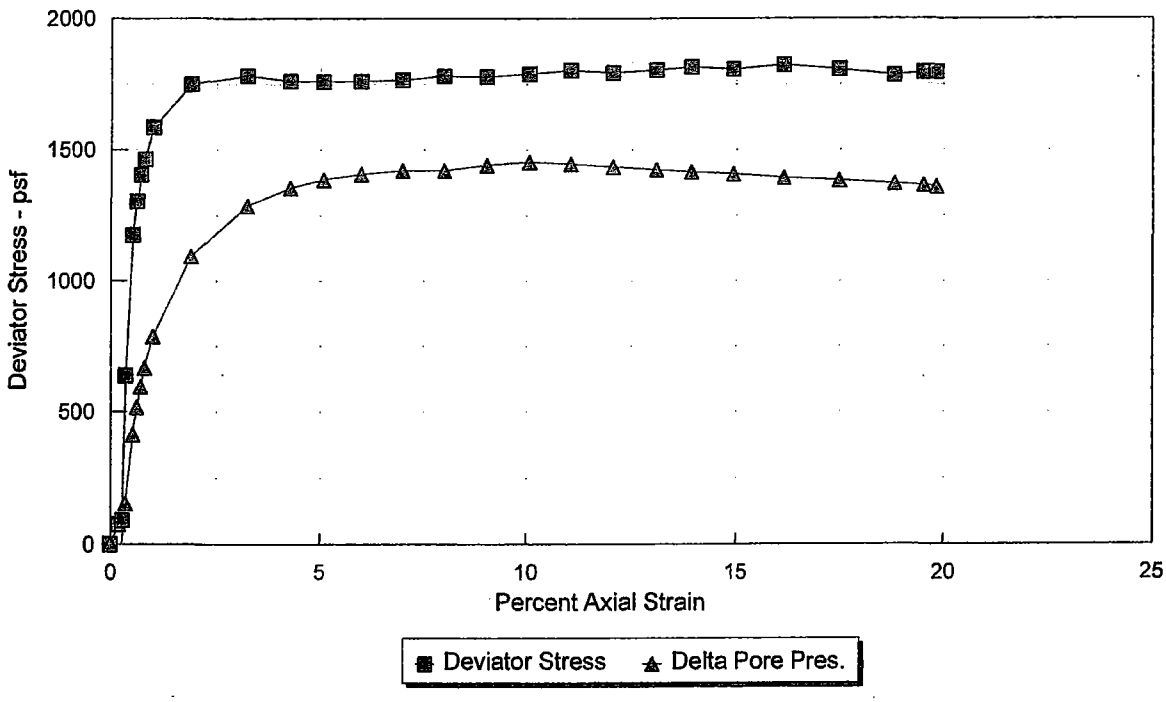
CONSOLIDATION DATA

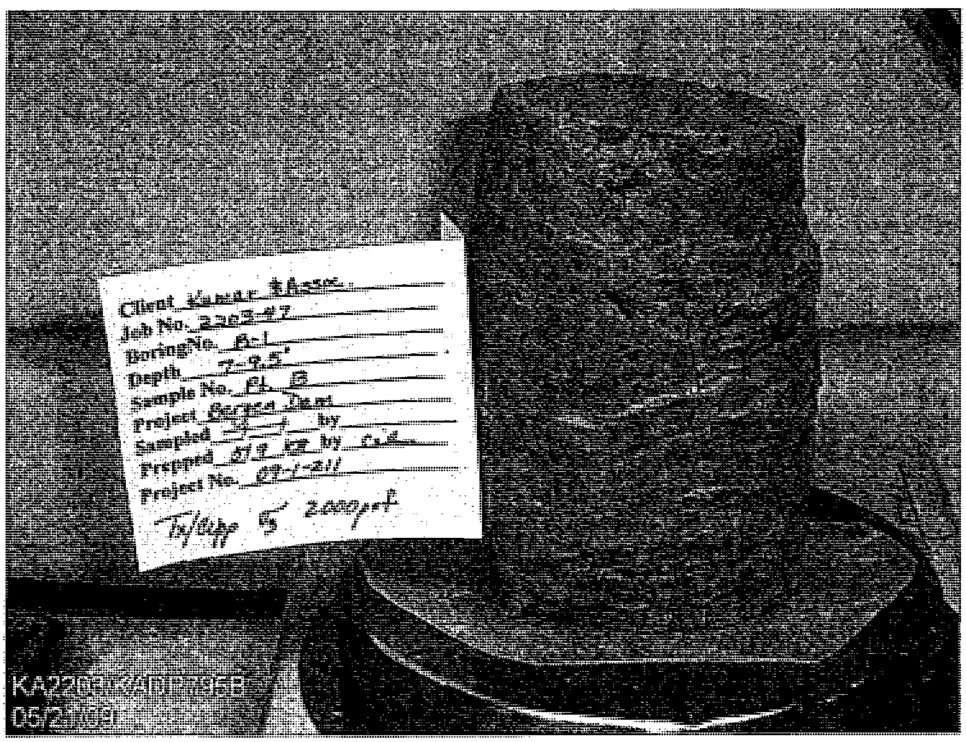
B-1, 7.0-9.5', Pt. B



TRIAXIAL TEST - TX/CUpp

B-1, 7.0-9.5', Pt. B




Client
Job No. 2203-47
Boring No. B-1
Depth 7-9.5'
Sample No.
Project
Sampled by
Prepped by
Project No. 09-1-211
2000psf

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	B-1	SAMPLED	
DEPTH	7.0-9.5'	TEST STARTED	05/09/09 CAL
SAMPLE NO.	Pt. C	TEST FINISHED	05/20/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	8S
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp		
		CONF. PRES. PSF	1000

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1111.7	1224.2
Wt. Wet Soil & Pan (g)	1125.9	1238.4
Wt. Dry Soil & Pan (g)	987.9	987.9
Wt. Lost Moisture (g)	138.0	250.4
Wt. of Pan Only (g)	14.2	14.2
Wt. of Dry Soil (g)	973.7	973.7
Moisture Content %	14.2	25.7
Wet Density PCF	113.8	125.4
Dry Density PCF	99.7	99.8

Init. Diameter (in)	2.862
Init. Area (sq in)	6.433
Init. Height (in)	5.784
Vol. Bef. Consol. (cu ft)	0.02153
Vol. After Consol. (cu ft)	0.02152

Notes & Comments:

Data entry by: MLM Date: 05/21/2009
Data checked by: CL Date: 5/23/09
FileName: KAT0795C

ADVANCED TERRA TESTING, INC.
ATT

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	B-1	SAMPLED	
DEPTH	7.0-9.5'	TEST STARTED	05/09/09 CAL
SAMPLE NO.	Pt. C	TEST FINISHED	05/20/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	8S
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp	CONF. PRES. PSF	1000

SATURATION DATA

Cell Pres. (PSI)	Back Pres. (PSI)	Burette Reading (CC)		Pore Pressure (PSI)		Change	B
		Close	Open	Close	Open		
40.0	38.0	6.2	16.9				
50.0	48.0	7.9	10.5	38.2	46.3	8.1	0.81
60.0	58.0	10.2	11.8	48.5	56.7	8.2	0.82
70.0	68.0	11.6	12.8	58.6	67.8	9.2	0.92
80.0	78.0	12.6	13.3	68.7	77.3	8.6	0.86
90.0	88.0	13.3	13.8	78.6	87.5	8.9	0.89
100.0	98.0	13.8	14.7	89.0	98.4	9.4	0.94
110.0		14.8	15.0	98.6	108.2	9.6	0.96

CONSOLIDATION DATA

Elapsed Time (Min)	SQRT TIME (Min)	Burette Reading (CC)	Vol. Defl. (CC)
0.00	0.0	15.0	0.00
0.25	0.5	19.7	-4.70
0.5	0.7	20.3	-5.30
1	1.0	20.7	-5.70
2	1.4	21.2	-6.15
4	2.0	21.5	-6.50
9	3.0	21.9	-6.90
16	4.0	22.1	-7.10
30	5.5	22.4	-7.40
60	7.7	22.6	-7.60
120	11.0	22.9	-7.90
240	15.5	23.1	-8.10
360	19.0	23.2	-8.20

Initial Height (in)	5.784	Init. Vol. (CC)	609.87
Height Change (in)	-0.002	Vol. Change (CC)	18.20
Ht. After Cons. (in)	5.786	Cell Exp. (CC)	17.68
Initial Area (sq in)	6.433	Net Change (CC)	0.52
Area After Cons. (sq in)	6.426	Cons. Vol. (CC)	609.35

Data entry by: MLM Date: 05/21/2009
Data checked by: cel Date: 5/23/09
FileName: KAT0795C

ADVANCED TERRA TESTING, Inc. ATT

TRIAXIAL COMPRESSION TEST DATA

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	B-1	SAMPLED	
DEPTH	7.0-9.5'	TEST STARTED	05/09/09 CAL
SAMPLE NO.	Pt. C	TEST FINISHED	05/20/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	8S
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp	CONF. PRES. PSF	1000

Init. Ht. (in)	5.784	Init. Area (sq in)	6.433
Consol. Ht. (in)	5.786	Consol. Area (sq in)	6.426
Back Pres. PSI	98.2	Strain Rate (in/min)	0.0038

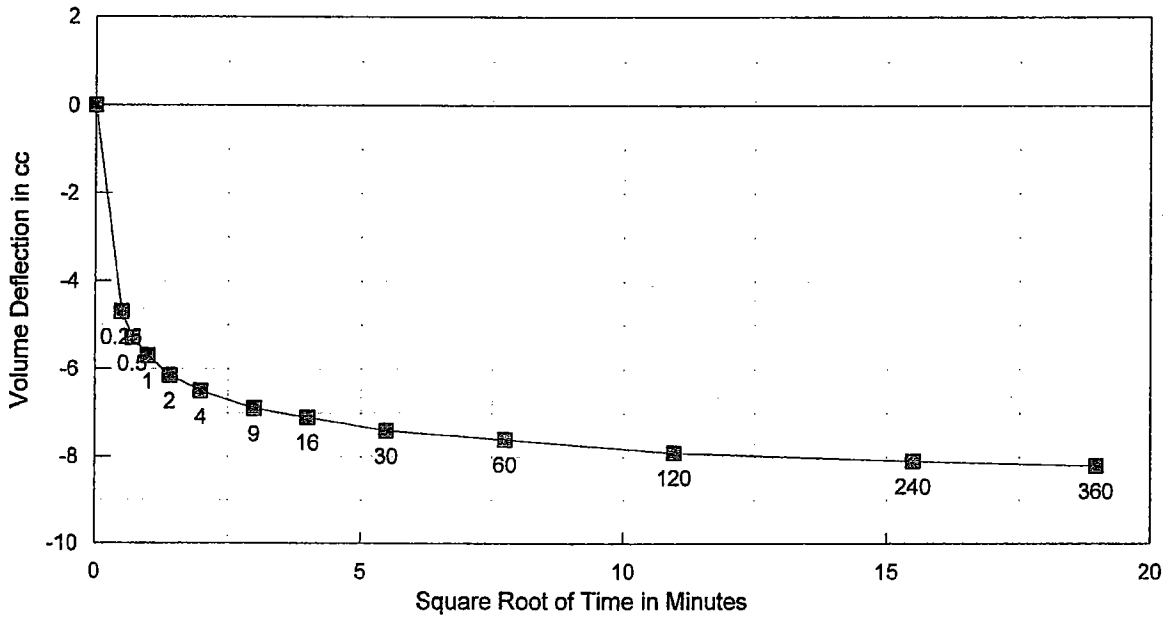
Axial Load Lbs.	Axial Load PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Dev. Stress PSF	Pore Pres. PSI	Delta Pres. PSF	Sigma 3 PSF	Sigma 1 PSF	Prin. Stress Ratio
0.0	0	0.000	0.00	6.426	0	98.2	0	1000	1000	1.00
37.4	837	0.010	0.17	6.436	836	99.6	206	794	1630	2.05
43.4	972	0.015	0.26	6.442	970	100.0	259	741	1710	2.31
48.7	1092	0.021	0.36	6.449	1088	100.3	302	698	1786	2.56
53.0	1187	0.033	0.57	6.462	1180	100.7	361	639	1819	2.85
52.2	1171	0.038	0.67	6.469	1163	100.8	384	616	1779	2.89
52.8	1184	0.044	0.76	6.475	1175	101.0	402	598	1773	2.96
54.4	1218	0.049	0.84	6.480	1208	101.1	418	582	1790	3.07
54.1	1213	0.060	1.03	6.492	1200	101.3	447	553	1754	3.17
53.4	1198	0.111	1.92	6.551	1175	101.9	530	470	1645	3.50
53.5	1199	0.185	3.20	6.638	1160	102.2	582	418	1579	3.77
52.2	1170	0.242	4.19	6.706	1121	102.3	599	401	1522	3.80
53.4	1196	0.289	4.99	6.763	1137	102.4	606	394	1531	3.89
54.5	1222	0.340	5.87	6.826	1150	102.4	607	393	1543	3.93
54.7	1226	0.398	6.88	6.900	1142	102.4	606	394	1536	3.90
56.4	1263	0.455	7.86	6.974	1164	102.3	600	400	1564	3.91
57.7	1294	0.512	8.86	7.050	1179	102.3	594	406	1586	3.90
58.1	1303	0.570	9.85	7.127	1174	102.3	595	405	1579	3.90
58.4	1308	0.627	10.83	7.206	1167	102.3	588	412	1578	3.83
59.1	1325	0.679	11.74	7.281	1170	102.2	580	420	1590	3.78
59.6	1335	0.737	12.73	7.363	1165	102.1	570	430	1595	3.71
60.3	1352	0.784	13.55	7.433	1169	102.1	561	439	1608	3.66
61.1	1369	0.841	14.54	7.519	1170	102.0	549	451	1621	3.60
62.4	1398	0.911	15.75	7.627	1178	101.9	535	465	1642	3.53
62.1	1391	0.986	17.03	7.745	1154	101.8	522	478	1632	3.41
64.0	1434	1.061	18.34	7.869	1171	101.9	530	470	1642	3.49
66.2	1483	1.101	19.03	7.936	1201	101.8	520	480	1681	3.50
66.5	1491	1.119	19.33	7.966	1203	101.8	522	478	1681	3.51

Data entry by: MLM Date: 05/21/2009
Data checked by: [illegible] Date: 5/23/09
FileName: KAT0795C

ADVANCED TERRA TESTING, INC. ATT

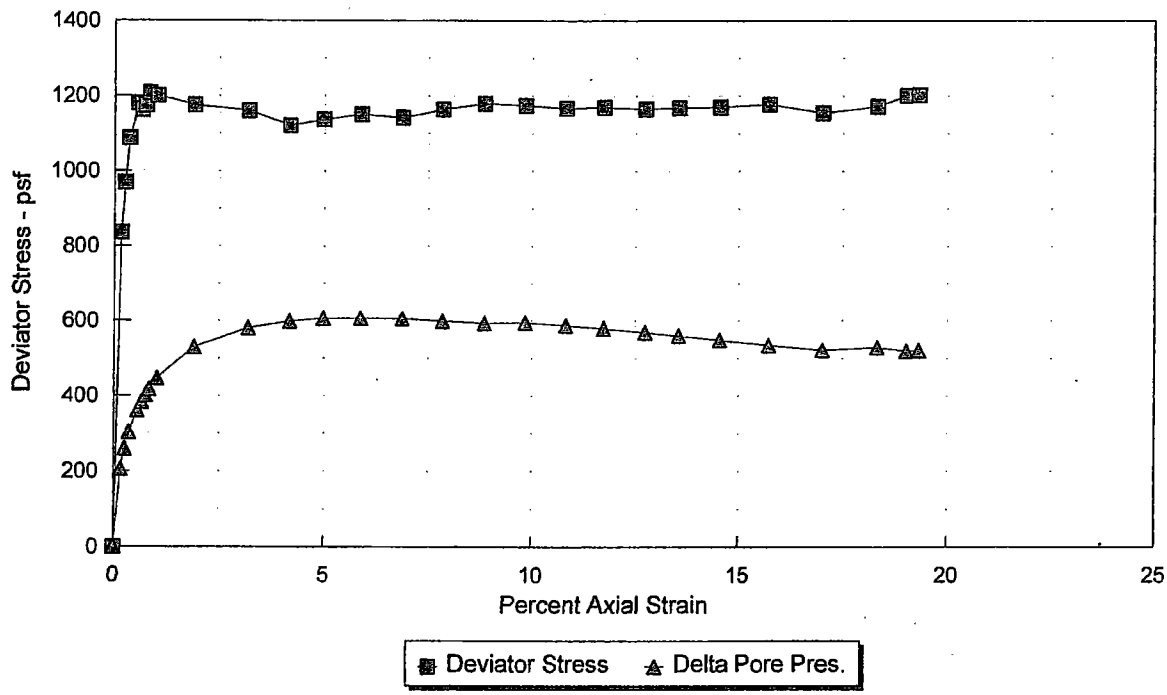
CONSOLIDATION DATA

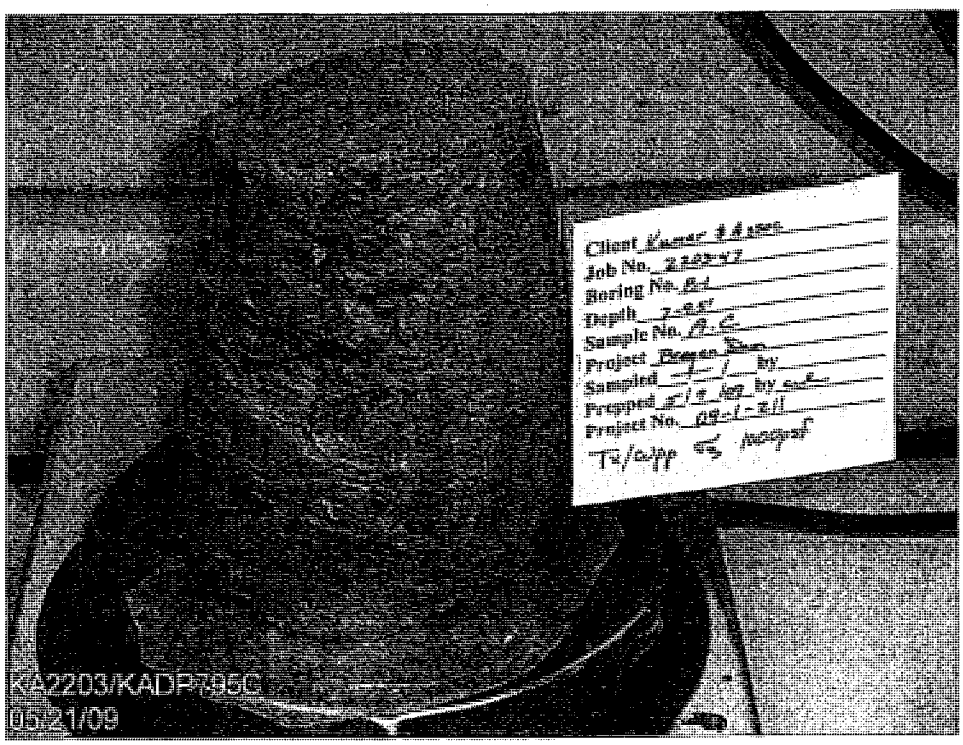
B-1, 7.0-9.5', Pt. C



TRIAXIAL TEST - TX/CUpp

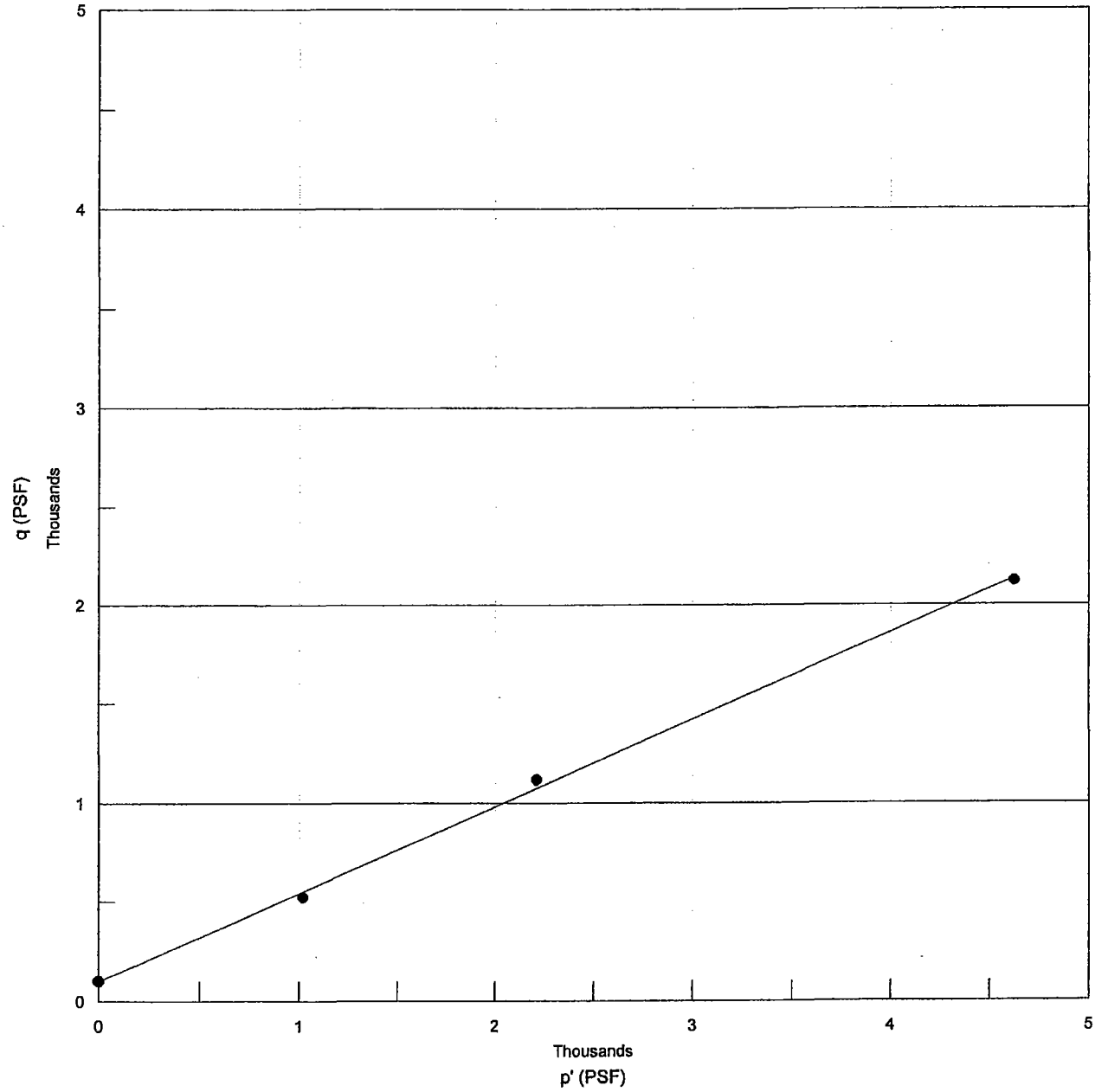
B-1, 7.0-9.5', Pt. C




Client
Job No.
Boring No.
Depth
Sample No.
Project
Sampled
Prepped
Project No.
KA2203/KADP795G
05/21/09

Effective Stress Path Analysis - p'-q Regression Plot

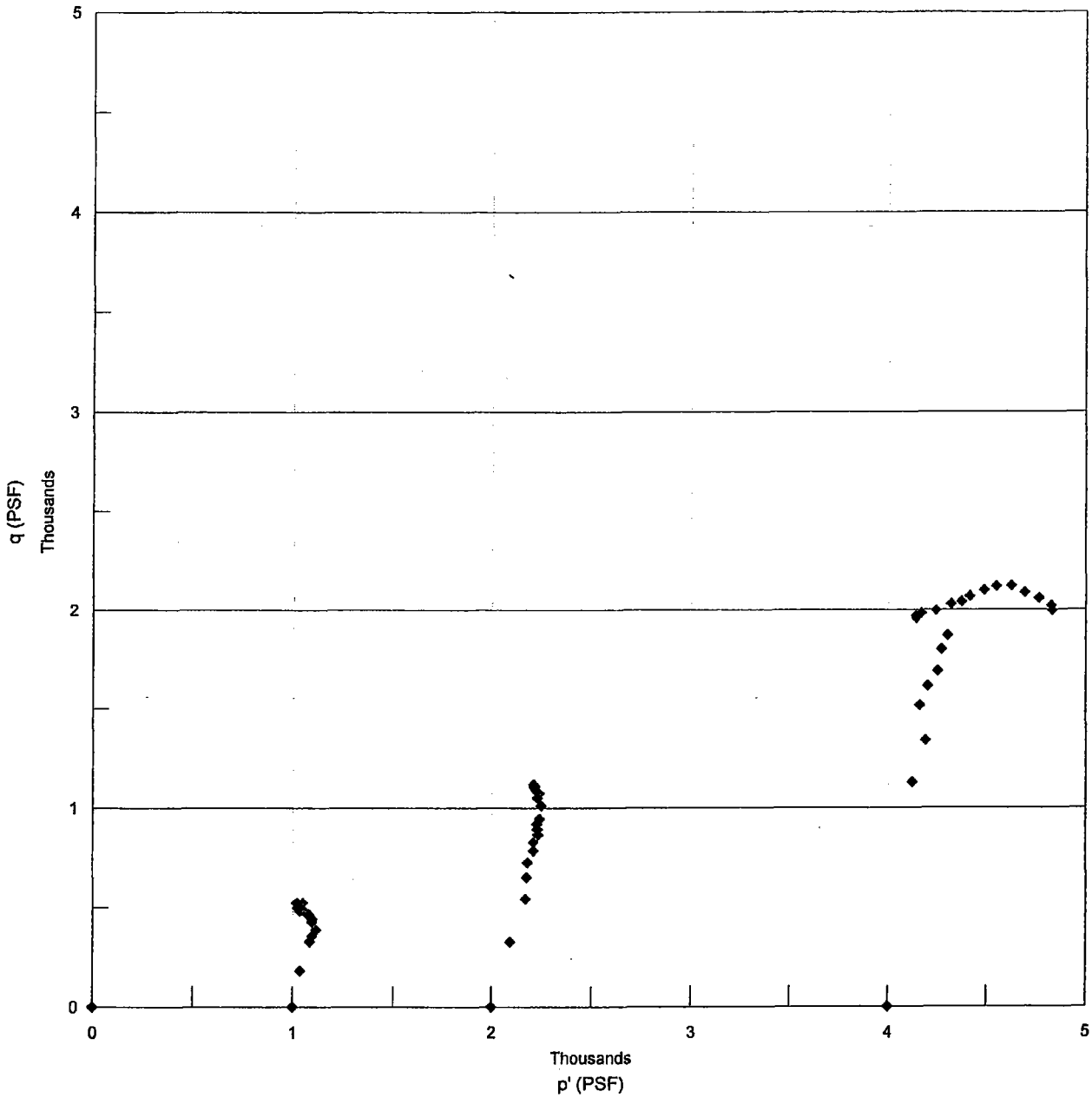
Kumar & Associates,Bergen Dam,09-1-211,KB-2,Stg. 1, 2 & 3,5.0



● Shear Data – Best Fit Line Tau = 23.7 degrees a = 104.7 PSF

Effective Stress Path Analysis - p' q Plots

Kumar & Associates,Bergen Dam,09-1-211,KB-2,Stg. 1, 2 & 3,5.0



EFFECTIVE STRESS PATH ANALYSIS TEST DATA
ASTM D4767

CLIENT	Kumar & Associates					JOB NO.	2203-47		
BORING NO.	KB-2								
DEPTH	5.0					SAMPLED			
SAMPLE NO.	Stg. 1, 2 & 3					SATURATED TEST			
SOIL DESCR.	09-1-211					TEST TYPE	TX/CUPP		
LOCATION	Bergen Dam						Peak Points		
							p'	q	
							PSF	PSF	
CONF. PRES. PSF		STAGE 1	1000	PSF		STAGE 1	1021	525	
		STAGE 2	2000	PSF		STAGE 2	2209	1116	
		STAGE 3	4000	PSF		STAGE 3	4623	2121	

STAGE 1				STAGE 2				STAGE 3			
σ 3' PSF	σ 1' PSF	p' PSF	q PSF	σ 3' PSF	σ 1' PSF	p' PSF	q PSF	σ 3' PSF	σ 1' PSF	p' PSF	q PSF
1000	1000	1000	0	2000	2000	2000	0	4000	4000	4000	0
856	1218	1037	181	1770	2421	2095	326	2992	5246	4119	1127
755	1412	1084	328	1626	2711	2168	543	2848	5527	4187	1339
741	1452	1096	356	1525	2827	2176	651	2646	5673	4160	1513
726	1503	1115	388	1453	2905	2179	726	2589	5813	4201	1612
669	1520	1094	426	1424	2995	2209	785	2560	5938	4249	1689
654	1537	1096	441	1381	3037	2209	828	2474	6063	4268	1795
626	1539	1082	457	1366	3097	2232	865	2430	6165	4298	1867
611	1545	1078	467	1338	3121	2229	892	2186	6096	4141	1955
582	1536	1059	477	1309	3145	2227	918	2171	6106	4139	1967
554	1517	1035	482	1294	3184	2239	945	2186	6145	4165	1980
539	1521	1030	491	1237	3259	2248	1011	2243	6236	4239	1996
539	1528	1034	495	1179	3280	2230	1051	2286	6345	4316	2029
525	1521	1023	498	1165	3312	2238	1074	2330	6411	4370	2041
525	1571	1048	523	1136	3308	2222	1086	2344	6478	4411	2067
496	1539	1017	521	1107	3314	2210	1103	2387	6582	4484	2097
496	1546	1021	525	1107	3327	2217	1110	2430	6664	4547	2117
				1093	3326	2209	1116	2502	6744	4623	2121
								2603	6781	4692	2089
								2704	6817	4761	2057
								2805	6844	4824	2020
								2834	6822	4828	1994

Data entry by: MLM Date: 05/27/2009
Data checked by: DPM Date: 5/28/09
FileName: KAPQKB25

ADVANCED TERRA TESTING, INC. ATT

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	KB-2	SAMPLED	
DEPTH	5.0	TEST STARTED	05/05/09 CAL
SAMPLE NO.		TEST FINISHED	05/20/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	3N
LOCATION	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp, Stage 1	CONF. PRES. PSF	1000

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1172.6	1248.4
Wt. Wet Soil & Pan (g)	1188.4	1264.2
Wt. Dry Soil & Pan (g)	1023.0	1023.0
Wt. Lost Moisture (g)	165.4	241.3
Wt. of Pan Only (g)	15.8	15.8
Wt. of Dry Soil (g)	1007.1	1007.1
Moisture Content %	16.4	24.0
Wet Density PCF	114.7	120.9
Dry Density PCF	98.5	97.5

Init. Diameter (in)	2.875
Init. Area (sq in)	6.492
Init. Height (in)	5.998
Vol. Bef. Consol. (cu ft)	0.02253
Vol. After Consol. (cu ft)	0.02277

Notes & Comments: Sample was not cylindrical. One side of the tube was flat.

Data entry by: MLM Date: 05/22/2009
Data checked by: cue Date: 5/23/09
FileName: KAT0KB25

ADVANCED TERRA TESTING, INC. ATT

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	KB-2	SAMPLED	
DEPTH	5.0	TEST STARTED	05/05/09 CAL
SAMPLE NO.		TEST FINISHED	05/20/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	3N
LOCATION	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp, Stage 1	CONF. PRES. PSF	1000

SATURATION DATA

Cell Pres. (PSI)	Back Pres. (PSI)	Burette Reading (CC)		Pore Pressure (PSI)		Change	B
		Close	Open	Close	Open		
40.0	38.0	5.7	32.8				
50.0	48.0	7.1	8.5	37.6	44.5	6.9	0.69
60.0	58.0	3.4	5.4	48.5	56.9	8.4	0.84
70.0	68.0	4.4	6.0	58.7	67.3	8.6	0.86
80.0	78.0	5.2	6.6	68.3	76.8	8.5	0.85
90.0	88.0	6.4	7.3	77.7	87.0	9.3	0.93
100.0	98.0	6.9	7.9	88.3	97.6	9.3	0.93
110.0		7.9	7.9	98.4	108.1	9.7	0.97

CONSOLIDATION DATA

Elapsed Time (Min)	SQRT TIME (Min)	Burette Reading (CC)	Vol. Defl. (CC)
0.00	0.0	7.90	0.00
0.25	0.5	8.90	-1.00
0.5	0.7	9.20	-1.30
1	1.0	9.70	-1.80
2	1.4	10.40	-2.50
4	2.0	11.20	-3.30
9	3.0	12.30	-4.40
16	4.0	12.95	-5.05
30	5.5	13.60	-5.70
60	7.7	14.20	-6.30
120	11.0	14.50	-6.60
240	15.5	14.75	-6.85
360	19.0	14.75	-6.85

Initial Height (in)	5.998	Init. Vol. (CC)	638.19
Height Change (in)	0.003	Vol. Change (CC)	9.70
Ht. After Cons. (in)	5.995	Cell Exp. (CC)	16.32
Initial Area (sq in)	6.492	Net Change (CC)	-6.62
Area After Cons. (sq in)	6.562	Cons. Vol. (CC)	644.81

Data entry by: MLM Date: 05/22/2009
Data checked by: ecc Date: 5/23/09
FileName: KAT0KB25

TRIAXIAL COMPRESSION TEST DATA

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	KB-2	SAMPLED	
DEPTH	5.0	TEST STARTED	05/05/09 CAL
SAMPLE NO.		TEST FINISHED	05/20/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	3N
LOCATION	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp, Stage 1	CONF. PRES. PSF	1000
Init. Ht. (in)	5.998	Init. Area (sq in)	6.492
Consol. Ht. (in)	5.995	Consol. Area (sq in)	6.562
Back Pres. PSI	98.6	Strain Rate (in/min)	0.002

Axial Load Lbs.	Axial Load PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Dev. Stress PSF	Pore Pres. PSI	Delta Pres. PSF	Sigma 3 PSF	Sigma 1 PSF	Prin. Stress Ratio
0.0	0	0.000	0.00	6.562	0	98.6	0	1000	1000	1.00
16.5	362	0.004	0.07	6.567	362	99.6	144	856	1218	1.42
30.0	658	0.012	0.20	6.576	657	100.3	245	755	1412	1.87
32.5	713	0.016	0.27	6.580	711	100.4	259	741	1452	1.96
35.5	779	0.020	0.33	6.584	776	100.5	274	726	1503	2.07
39.0	856	0.032	0.53	6.598	851	100.9	331	669	1520	2.27
40.5	889	0.040	0.67	6.606	883	101.0	346	654	1537	2.35
42.0	922	0.052	0.87	6.620	914	101.2	374	626	1539	2.46
43.0	944	0.060	1.00	6.629	934	101.3	389	611	1545	2.53
44.0	966	0.072	1.20	6.642	954	101.5	418	582	1536	2.64
44.5	976	0.080	1.33	6.651	963	101.7	446	554	1517	2.74
45.5	998	0.100	1.67	6.674	982	101.8	461	539	1521	2.82
46.0	1009	0.120	2.00	6.696	989	101.8	461	539	1528	2.83
46.5	1020	0.140	2.34	6.719	997	101.9	475	525	1521	2.90
49.0	1075	0.160	2.67	6.742	1047	101.9	475	525	1571	2.99
49.0	1075	0.180	3.00	6.766	1043	102.1	504	496	1539	3.10
49.5	1086	0.200	3.34	6.789	1050	102.1	504	496	1546	3.12

Data entry by: MLM Date: 05/22/2009
Data checked by: ewe Date: 5/23/09
FileName: KAT0KB25

ADVANCED TERRA TESTING, INC. ATT

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	KB-2	SAMPLED	
DEPTH	5.0	TEST STARTED	05/05/09 CAL
SAMPLE NO.		TEST FINISHED	05/20/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	3N
LOCATION	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp, Stage 2	CONF. PRES. PSF	2000

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1172.6	1248.4
Wt. Wet Soil & Pan (g)	1188.4	1264.2
Wt. Dry Soil & Pan (g)	1023.0	1023.0
Wt. Lost Moisture (g)	165.4	241.3
Wt. of Pan Only (g)	15.8	15.8
Wt. of Dry Soil (g)	1007.1	1007.1
Moisture Content %	16.4	24.0
Wet Density PCF	113.5	123.9
Dry Density PCF	97.5	100.0

Init. Diameter (in)	2.940
Init. Area (sq in)	6.789
Init. Height (in)	5.795
Vol. Bef. Consol. (cu ft)	0.02277
Vol. After Consol. (cu ft)	0.02221

Notes & Comments:

Data entry by: MLM Date: 05/22/2009
Data checked by: ewl Date: 5/23/09
FileName: KAT0KB25

ADVANCED TERRA TESTING, Inc. ATT

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	KB-2	SAMPLED	
DEPTH	5.0	TEST STARTED	05/05/09 CAL
SAMPLE NO.		TEST FINISHED	05/20/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	3N
LOCATION	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp, Stage 2	CONF. PRES. PSF	2000

CONSOLIDATION DATA

Elapsed Time (Min)	SQRT TIME (Min)	Burette Reading (CC)	Vol. Defl. (CC)
0.00	0.0	19.60	0.00
0.25	0.5	20.60	-1.00
0.5	0.7	20.80	-1.20
1	1.0	21.10	-1.50
2	1.4	21.70	-2.10
4	2.0	22.50	-2.90
9	3.0	23.80	-4.20
16	4.0	25.20	-5.60
30	5.5	26.60	-7.00
60	7.7	28.10	-8.50
120	11.0	29.20	-9.60
240	15.5	29.70	-10.10
360	19.0	30.00	-10.40

Initial Height (in)	5.795	Init. Vol. (CC)	644.81
Height Change (in)	0.000	Vol. Change (CC)	16.30
Ht. After Cons. (in)	5.795	Cell Exp. (CC)	0.60
Initial Area (sq in)	6.789	Net Change (CC)	15.70
Area After Cons. (sq in)	6.624	Cons. Vol. (CC)	629.10

Data entry by: MLM Date: 05/22/2009
Data checked by: Cal Date: 5/23/09
FileName: KAT0KB25

ADVANCED TERRA TESTING, INC.
ATT

TRIAXIAL COMPRESSION TEST DATA

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	KB-2	SAMPLED	
DEPTH	5.0	TEST STARTED	05/05/09 CAL
SAMPLE NO.		TEST FINISHED	05/20/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	3N
LOCATION	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp, Stage 2	CONF. PRES. PSF	2000

Init. Ht. (in)	5.795	Init. Area (sq in)	6.789
Consol. Ht. (in)	5.795	Consol. Area (sq in)	6.624
Back Pres. PSI	98.5	Strain Rate (in/min)	0.002

Axial Load Lbs.	Axial Load PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Dev. Stress PSF	Pore Pres. PSI	Delta Pres. PSF	Sigma 3 PSF	Sigma 1 PSF	Prin. Stress Ratio
0.0	0	0.000	0.00	6.624	0	98.5	0	2000	2000	1.00
30.0	652	0.004	0.07	6.628	652	100.1	230	1770	2421	1.37
50.0	1087	0.008	0.14	6.633	1086	101.1	374	1626	2711	1.67
60.0	1304	0.012	0.21	6.637	1302	101.8	475	1525	2827	1.85
67.0	1457	0.016	0.28	6.642	1453	102.3	547	1453	2905	2.00
72.5	1576	0.020	0.35	6.646	1571	102.5	576	1424	2995	2.10
76.5	1663	0.024	0.41	6.651	1656	102.8	619	1381	3037	2.20
80.0	1739	0.028	0.48	6.656	1731	102.9	634	1366	3097	2.27
82.5	1794	0.032	0.55	6.660	1784	103.1	662	1338	3121	2.33
85.0	1848	0.036	0.62	6.665	1836	103.3	691	1309	3145	2.40
87.5	1902	0.040	0.69	6.670	1889	103.4	706	1294	3184	2.46
94.0	2044	0.060	1.04	6.693	2022	103.8	763	1237	3259	2.64
98.0	2131	0.080	1.38	6.716	2101	104.2	821	1179	3280	2.78
100.5	2185	0.100	1.73	6.740	2147	104.3	835	1165	3312	2.84
102.0	2218	0.120	2.07	6.764	2172	104.5	864	1136	3308	2.91
104.0	2261	0.140	2.42	6.788	2206	104.7	893	1107	3314	2.99
105.0	2283	0.160	2.76	6.812	2220	104.7	893	1107	3327	3.00
106.0	2305	0.180	3.11	6.836	2233	104.8	907	1093	3326	3.04

Data entry by: MLM Date: 05/22/2009
Data checked by: ewr Date: 5/23/09
FileName: KAT0KB25

ADVANCED TERRA TESTING, INC. ATT

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	KB-2	SAMPLED	
DEPTH	5.0	TEST STARTED	05/05/09 CAL
SAMPLE NO.		TEST FINISHED	05/20/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	3N
LOCATION	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp, Stage 3	CONF. PRES. PSF	4000

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	1172.6	1248.4
Wt. Wet Soil & Pan (g)	1188.4	1264.2
Wt. Dry Soil & Pan (g)	1023.0	1023.0
Wt. Lost Moisture (g)	165.4	241.3
Wt. of Pan Only (g)	15.8	15.8
Wt. of Dry Soil (g)	1007.1	1007.1
Moisture Content %	16.4	24.0
Wet Density PCF	116.4	126.4
Dry Density PCF	100.0	102.0

Init. Diameter (in)	2.950
Init. Area (sq in)	6.836
Init. Height (in)	5.615
Vol. Bef. Consol. (cu ft)	0.02221
Vol. After Consol. (cu ft)	0.02177

Notes & Comments:

Data entry by: MLM Date: 05/22/2009
Data checked by: CAR Date: 5/23/09
FileName: KAT0KB25

ADVANCED TERRA TESTING, INC. ATT

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	KB-2	SAMPLED	
DEPTH	5.0	TEST STARTED	05/05/09 CAL
SAMPLE NO.		TEST FINISHED	05/20/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	3N
LOCATION	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp, Stage 3	CONF. PRES. PSF	4000

CONSOLIDATION DATA

Elapsed Time (Min)	SQRT TIME (Min)	Burette Reading (CC)	Vol. Defl. (CC)
0.00	0.0	0.30	0.00
0.25	0.5	1.65	-1.35
0.5	0.7	1.80	-1.50
1	1.0	2.00	-1.70
2	1.4	2.40	-2.10
4	2.0	3.00	-2.70
9	3.0	4.00	-3.70
16	4.0	5.05	-4.75
30	5.5	6.55	-6.25
60	7.7	8.45	-8.15
120	11.0	10.40	-10.10
240	15.5	11.80	-11.50
360	19.0	12.30	-12.00

Initial Height (in)	5.615	Init. Vol. (CC)	629.10
Height Change (in)	-0.004	Vol. Change (CC)	13.60
Ht. After Cons. (in)	5.619	Cell Exp. (CC)	1.18
Initial Area (sq in)	6.836	Net Change (CC)	12.42
Area After Cons. (sq in)	6.696	Cons. Vol. (CC)	616.69

Data entry by: MLM Date: 05/22/2009
Data checked by: ae Date: 5/23/09
FileName: KAT0KB25

ADVANCED TERRA TESTING, Inc. ATT

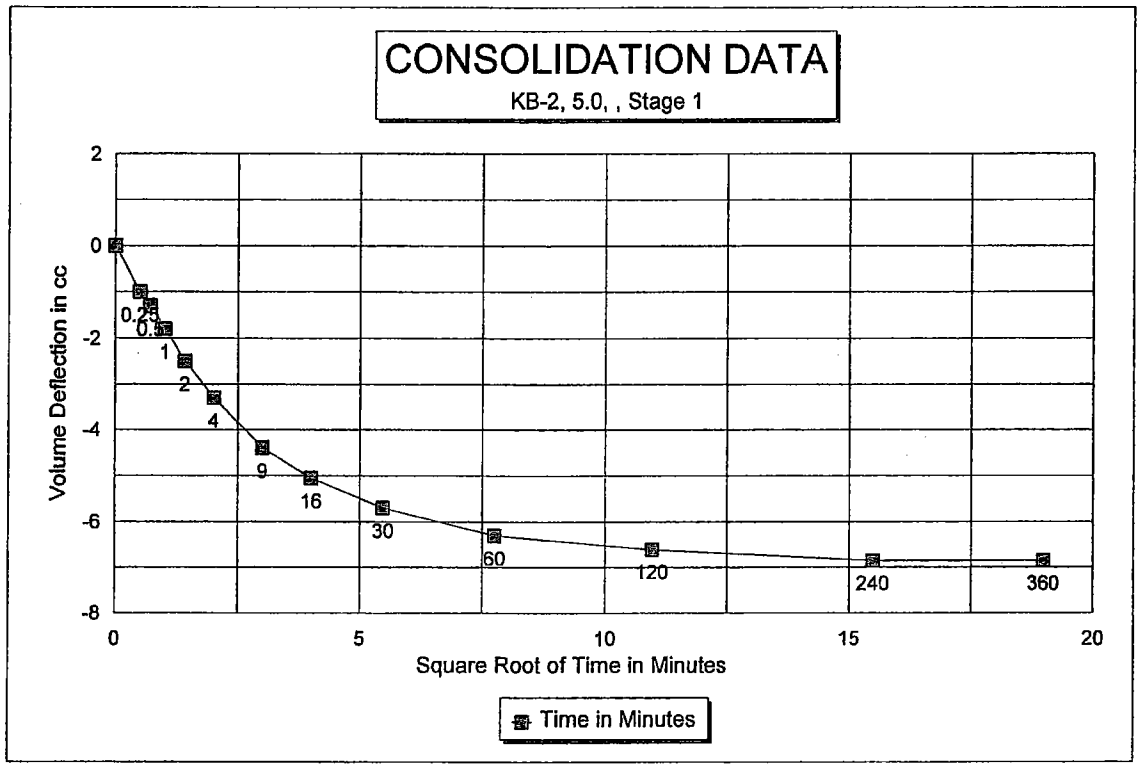
TRIAXIAL COMPRESSION TEST DATA

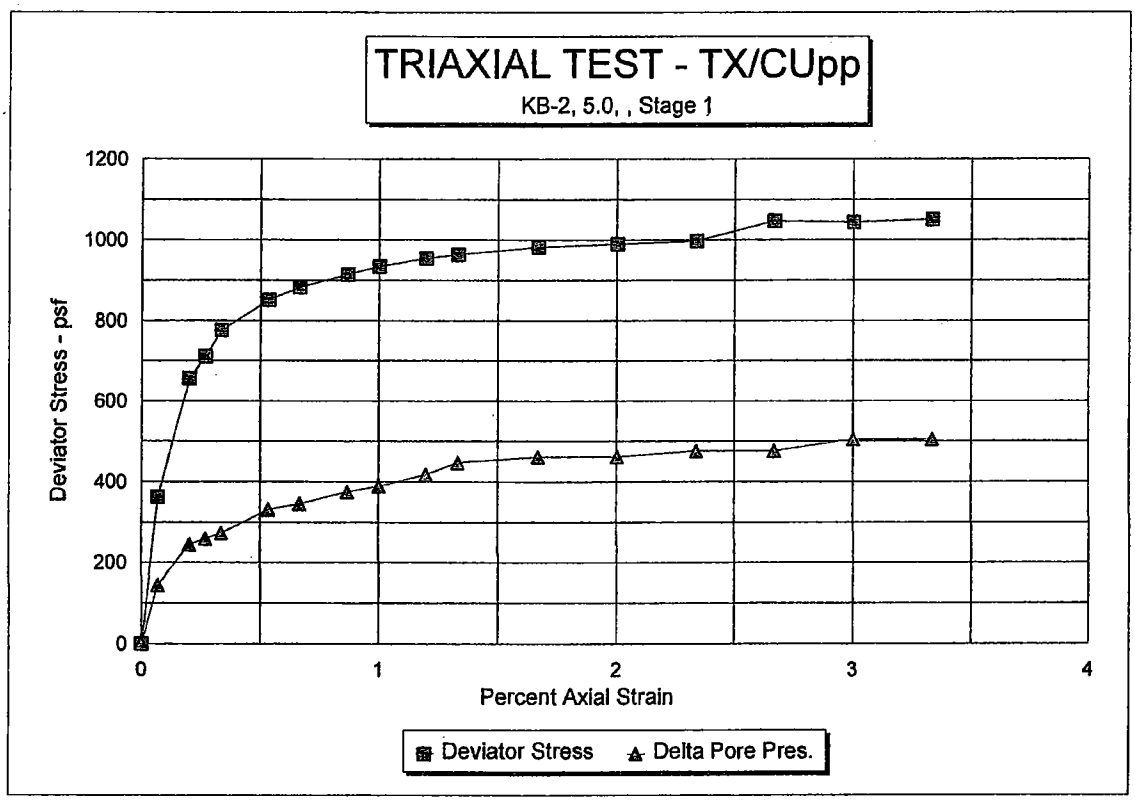
CLIENT	Kumar & Associates	JOB NO.	2203-47
BORING NO.	KB-2	SAMPLED	
DEPTH	5.0	TEST STARTED	05/05/09 CAL
SAMPLE NO.		TEST FINISHED	05/20/09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	3N
LOCATION	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp, Stage 3	CONF. PRES. PSF	4000
Init. Ht. (in)	5.615	Init. Area (sq in)	6.836
Consol. Ht. (in)	5.619	Consol. Area (sq in)	6.696
Back Pres. PSI	98.8	Strain Rate (in/min)	0.001

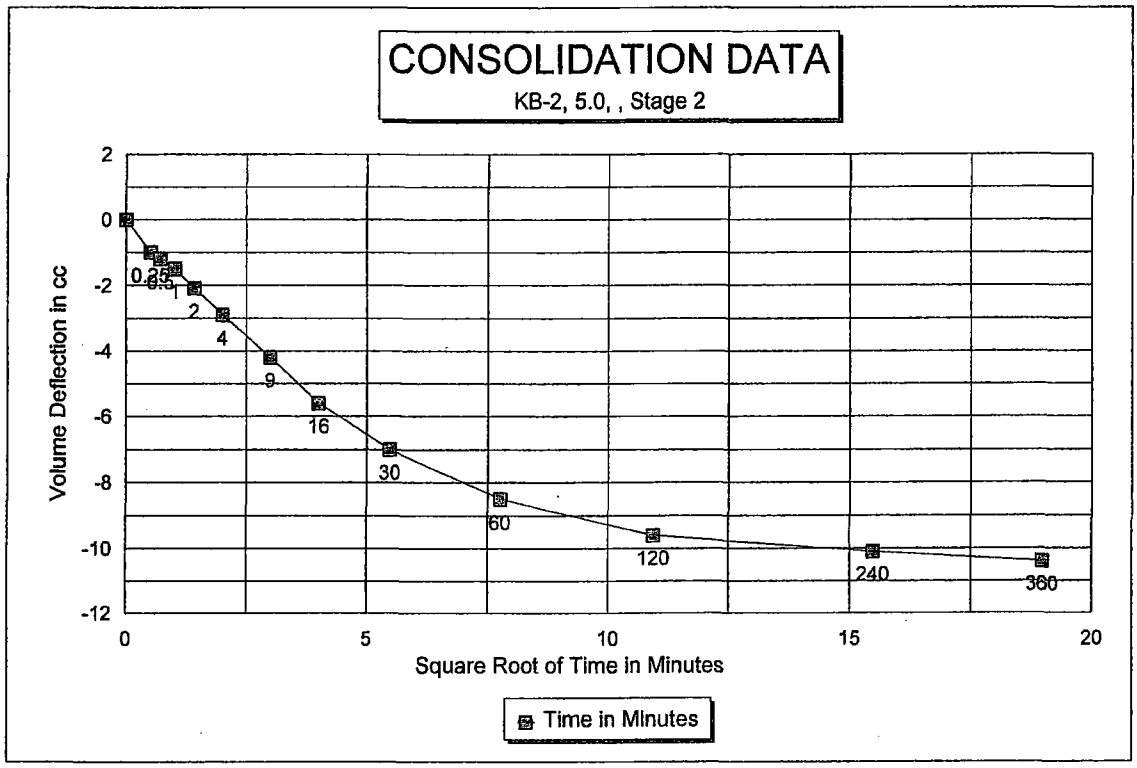
Axial Load Lbs.	Axial Load PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Dev. Stress PSF	Pore Pres. PSI	Delta Pres. PSF	Sigma 3 PSF	Sigma 1 PSF	Prin. Stress Ratio
0.0	0	0.000	0.00	6.696	0	98.8	0	4000	4000	1.00
105.0	2258	0.010	0.18	6.708	2254	105.8	1008	2992	5246	1.75
125.0	2688	0.020	0.36	6.720	2679	106.8	1152	2848	5527	1.94
141.5	3043	0.030	0.53	6.732	3027	108.2	1354	2646	5673	2.14
151.0	3247	0.040	0.71	6.744	3224	108.6	1411	2589	5813	2.25
158.5	3409	0.050	0.89	6.756	3378	108.8	1440	2560	5938	2.32
169.0	3634	0.070	1.25	6.781	3589	109.4	1526	2474	6063	2.45
176.5	3796	0.090	1.60	6.805	3735	109.7	1570	2430	6165	2.54
186.5	4011	0.140	2.49	6.867	3911	111.4	1814	2186	6096	2.79
188.0	4043	0.150	2.67	6.880	3935	111.5	1829	2171	6106	2.81
189.5	4075	0.160	2.85	6.892	3959	111.4	1814	2186	6145	2.81
192.5	4140	0.200	3.56	6.943	3992	111.0	1757	2243	6236	2.78
197.5	4247	0.250	4.45	7.008	4058	110.7	1714	2286	6345	2.77
200.5	4312	0.300	5.34	7.074	4082	110.4	1670	2330	6411	2.75
205.0	4408	0.350	6.23	7.141	4134	110.3	1656	2344	6478	2.76
210.0	4516	0.400	7.12	7.209	4195	110.0	1613	2387	6582	2.76
214.0	4602	0.450	8.01	7.279	4233	109.7	1570	2430	6664	2.74
216.5	4656	0.500	8.90	7.350	4241	109.2	1498	2502	6744	2.69
217.5	4677	0.600	10.68	7.497	4178	108.5	1397	2603	6781	2.60
218.5	4699	0.700	12.46	7.649	4113	107.8	1296	2704	6817	2.52
219.0	4710	0.800	14.24	7.808	4039	107.1	1195	2805	6844	2.44
218.5	4699	0.850	15.13	7.890	3988	106.9	1166	2834	6822	2.41

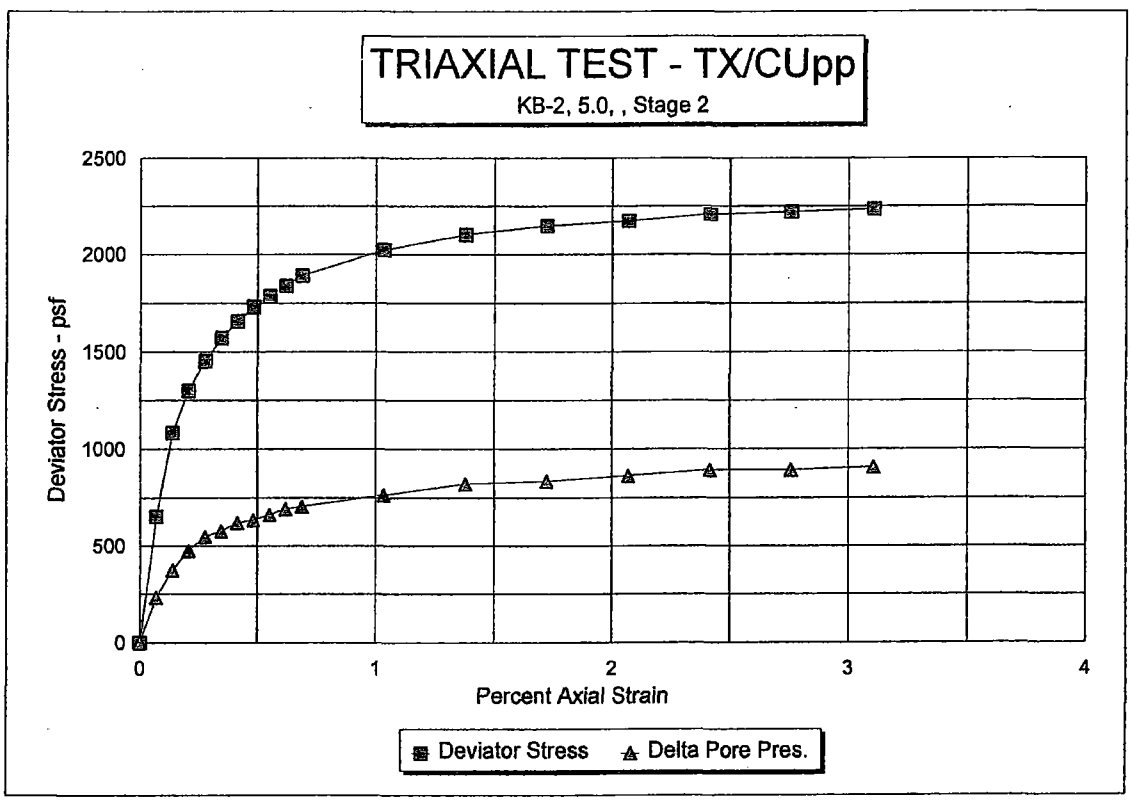
Data entry by: MLM Date: 05/22/2009
Data checked by: ae Date: 5/23/09
FileName: KAT0KB25

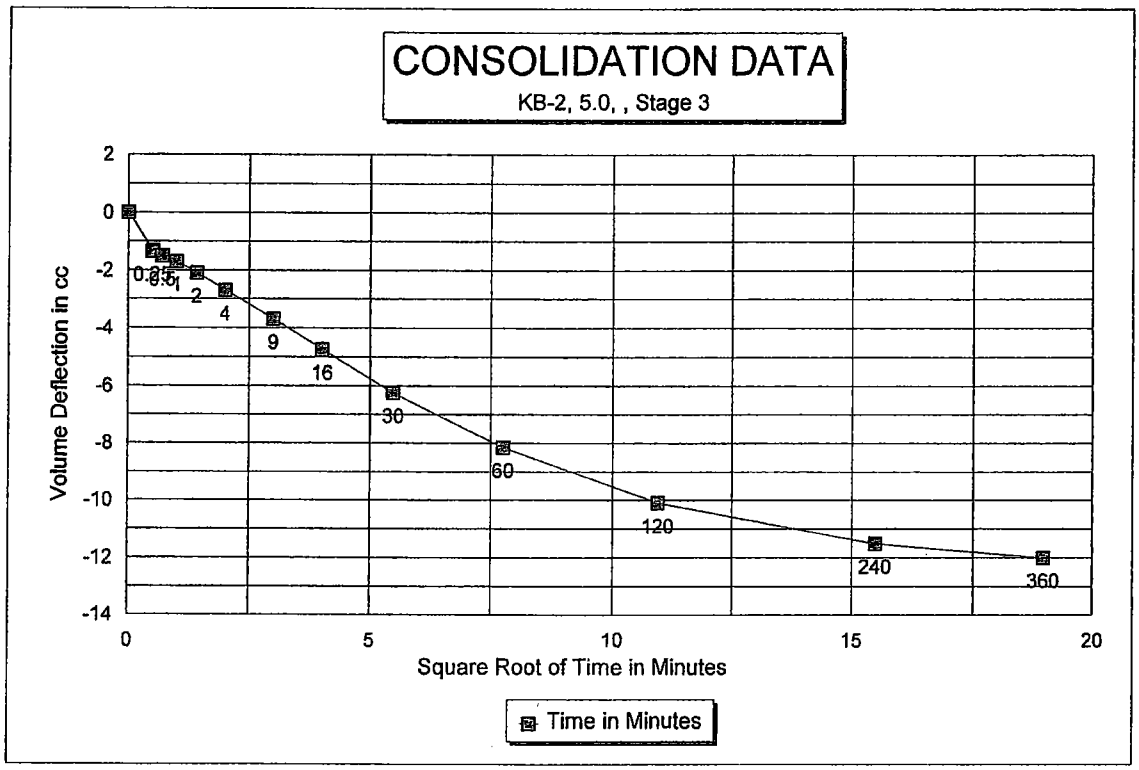
ADVANCED TERRA TESTING, Inc. ATT

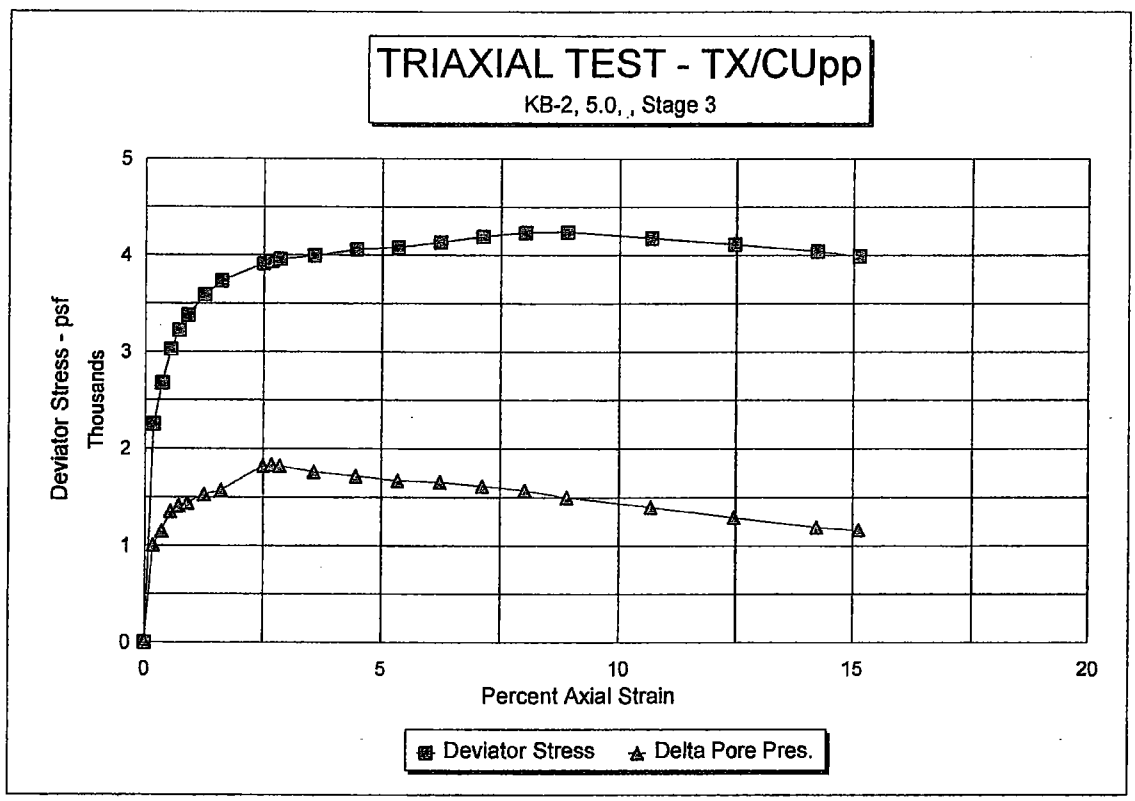

CONSOLIDATION DATA
KB-2, 5.0, , Stage 1
Volume Deflection in cc
2
0
-2
-4
-6
-8
0.25
0.5
1
2
4
9
16
30
60
120
240
360
0
5
10
15
20
Square Root of Time in Minutes
Time in Minutes

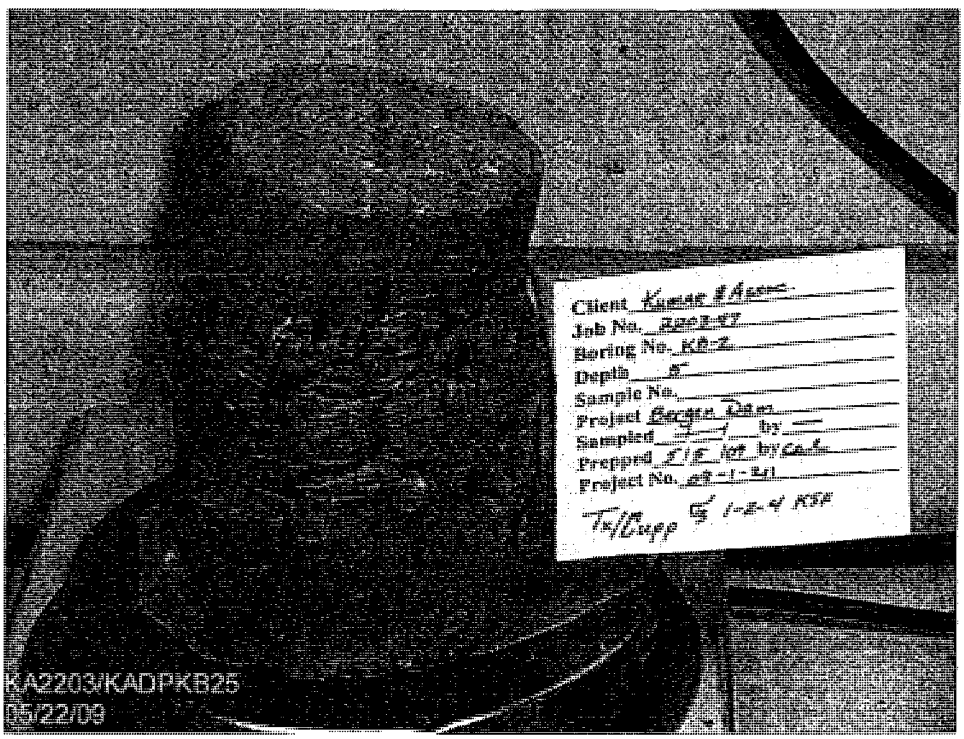

TRIAXIAL TEST - TX/CUpp
KB-2, 5.0, , Stage 1
Deviator Stress - psf
1200
1000
800
600
400
200
0
0
1
2
3
4
Percent Axial Strain
Deviator Stress
Delta Pore Pres.


CONSOLIDATION DATA
KB-2, 5.0, , Stage 2
Volume Deflection in cc
2
0
-2
-4
-6
-8
-10
-12
0.25
0.5
1
2
4
9
16
30
60
120
240
360
0
5
10
15
20
Square Root of Time in Minutes
Time in MInutes


TRIAXIAL TEST - TX/CUpp
KB-2, 5.0, , Stage 2
Deviator Stress - psf
2500
2000
1500
1000
500
0
0
1
2
3
4
Percent Axial Strain
Deviator Stress
Delta Pore Pres.


CONSOLIDATION DATA
KB-2, 5.0, , Stage 3
Volume Deflection in cc
2
0
-2
-4
-6
-8
-10
-12
-14
0.25
0.5
1
2
4
9
16
30
60
120
240
360
0
5
10
15
20
Square Root of Time in Minutes
Time in Minutes


TRIAXIAL TEST - TX/CUpp
KB-2, 5.0, , Stage 3
Deviator Stress - psf
Thousands
5
4
3
2
1
0
0
5
10
15
20
Percent Axial Strain
Deviator Stress
Delta Pore Pres.


Client
Job No.
Boring No. KB-2
Depth
Sample No.
Project
Sampled
by
Prepped
Project No.
KA2203/KADPKB25
05/22/09

EFFECTIVE STRESS PATH ANALYSIS TEST DATA
ASTM D4767

CLIENT	Kumar & Associates	JOB NO.	2203-48
BORING NO.	KP-1		
DEPTH	2.0-5.0'	SAMPLED	
SAMPLE NO.	Pt. A	SATURATED TEST	
SOIL DESCR.	09-1-211	TEST TYPE	TX/CUPP
LOCATION	Bergen Dam	Peak Points	

					p' PSF	q PSF
CONF. PRES. PSF	SAMPLE A	4000	PSF	SAMPLE A	4065	1872
	SAMPLE B	2000	PSF	SAMPLE B	1988	963
	SAMPLE C	1000	PSF	SAMPLE C	1105	575

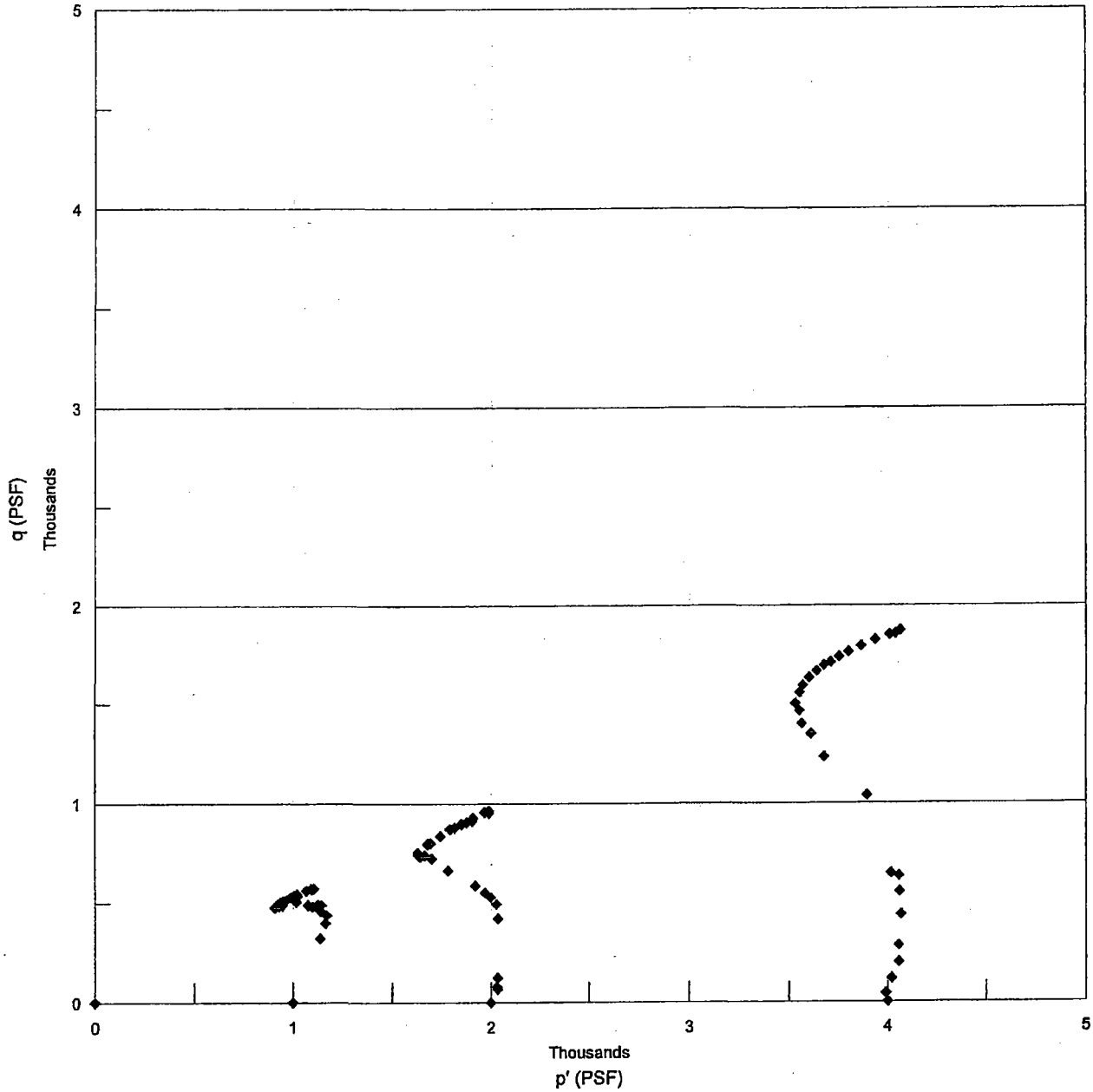
SAMPLE A				SAMPLE B				SAMPLE C			
σ 3' PSF	σ 1' PSF	p' PSF	q PSF	σ 3' PSF	σ 1' PSF	p' PSF	q PSF	σ 3' PSF	σ 1' PSF	p' PSF	q PSF
4000	4000	4000	0	2000	2000	2000	0	1000	1000	1000	0
3950	4035	3992	42	1969	2103	2036	67	814	1463	1138	325
3905	4138	4022	117	1950	2111	2031	80	764	1564	1164	400
3859	4255	4057	198	1911	2158	2035	123	730	1609	1169	439
3775	4337	4056	281	1614	2460	2037	423	675	1601	1138	463
3632	4506	4069	437	1531	2522	2026	496	654	1633	1144	490
3508	4614	4061	553	1467	2528	1998	530	633	1617	1125	492
3423	4693	4058	635	1416	2522	1969	553	617	1582	1099	482
3371	4664	4017	647	1328	2507	1917	589	587	1565	1076	489
2857	4935	3896	1039	1114	2447	1780	667	510	1523	1016	507
2448	4911	3680	1231	974	2426	1700	726	460	1434	947	487
2267	4962	3614	1347	923	2405	1664	741	442	1414	928	486
2168	4967	3568	1399	903	2374	1639	735	435	1424	930	494
2093	5020	3556	1464	887	2375	1631	744	430	1384	907	477
2034	5034	3534	1500	874	2381	1628	753	428	1411	920	491
1999	5110	3554	1556	877	2481	1679	802	429	1410	920	491
1978	5165	3571	1594	880	2475	1677	797	431	1436	934	503
1972	5240	3606	1634	890	2496	1693	803	437	1440	938	502
1973	5309	3641	1668	903	2582	1743	840	442	1465	954	511
1982	5375	3679	1696	918	2666	1792	874	450	1483	966	517
2001	5427	3714	1713	932	2694	1813	881	458	1514	986	528
2015	5494	3755	1740	950	2749	1849	900	466	1543	1004	538
2039	5569	3804	1765	967	2783	1875	908	476	1566	1021	545
2074	5660	3867	1793	991	2816	1903	913	489	1559	1024	535
2114	5760	3937	1823	978	2836	1907	929	503	1630	1066	563
2160	5857	4009	1849	1007	2924	1965	958	517	1663	1090	573
2184	5893	4038	1854	1026	2951	1988	963	526	1666	1096	570
2193	5937	4065	1872	1034	2942	1988	954	530	1680	1105	575

Data entry by: MLM Date: 07/08/2009
Data checked by: ewl Date: 7/08/09
FileName: KAPQKP1

ADVANCED TERRA TESTING, INC. ATT

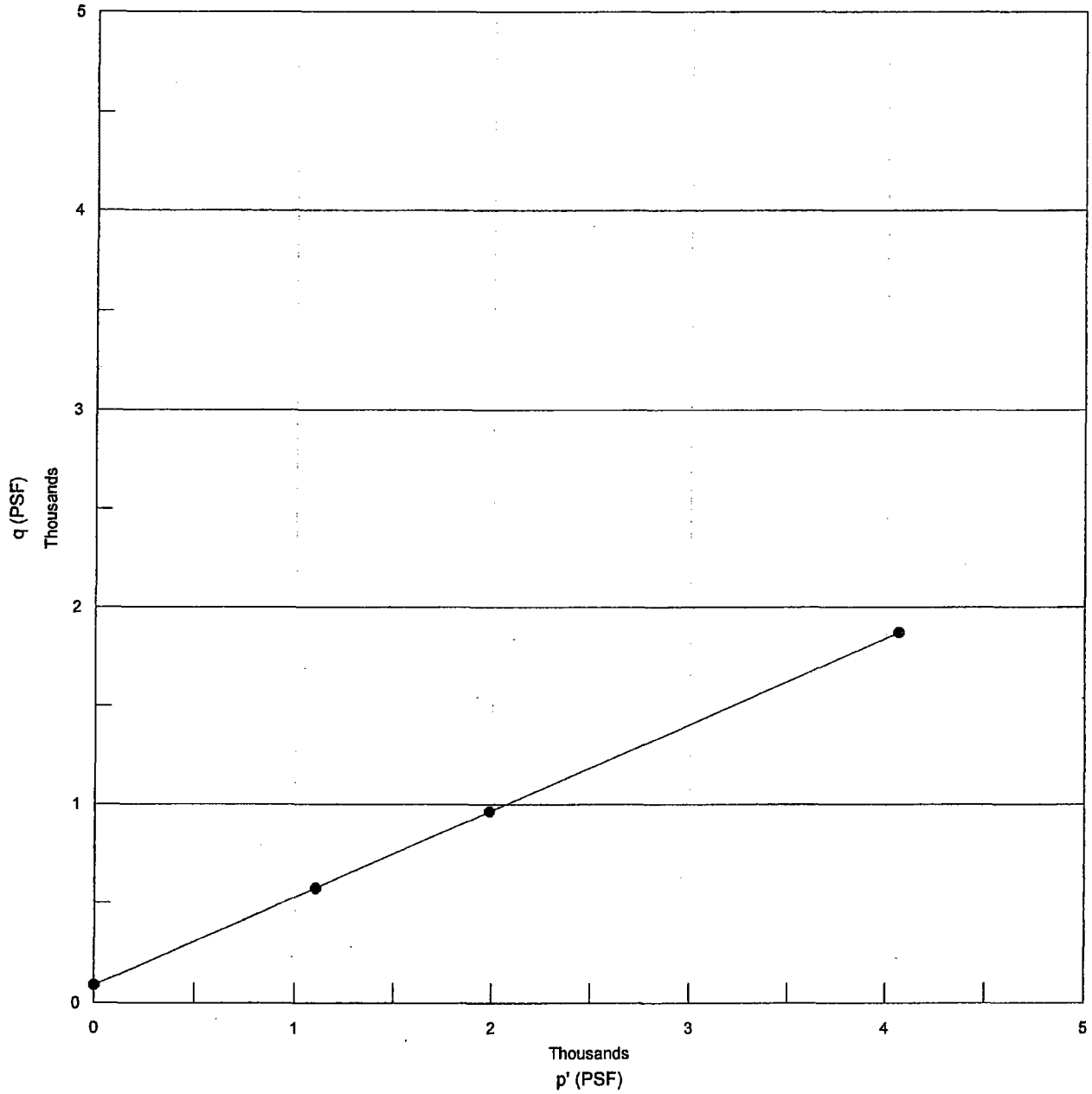
Effective Stress Path Analysis - p' q Plots

Kumar & Associates,Bergen Dam,09-1-211,KP-1,Pt. A,2.0-5.0'



Effective Stress Path Analysis - p'-q Regression Plot

Kumar & Associates,Bergen Dam,09-1-211,KP-1,Pt. A,2.0-5.0'



● Shear Data – Best Fit Line Tau = 23.7 degrees a = 91.2 PSF

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-48
BORING NO.	KP-1	SAMPLED	
DEPTH	2.0-5.0'	TEST STARTED	6-26-09 CAL
SAMPLE NO.	Pt. A	TEST FINISHED	7-4-09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	17S
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp		
		CONF. PRES. PSF	4000

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	720.9	748.1
Wt. Wet Soil & Pan (g)	736.3	763.5
Wt. Dry Soil & Pan (g)	627.9	627.9
Wt. Lost Moisture (g)	108.4	135.6
Wt. of Pan Only (g)	15.4	15.4
Wt. of Dry Soil (g)	612.5	612.5
Moisture Content %	17.7	22.1
Wet Density PCF	121.1	131.5
Dry Density PCF	102.9	107.7

Init. Diameter (in)	2.401
Init. Area (sq in)	4.528
Init. Height (in)	5.010
Vol. Bef. Consol. (cu ft)	0.01313
Vol. After Consol. (cu ft)	0.01254

Notes & Comments: Remolded.

Data entry by: MLM Date: 07/07/2009
Data checked by: cer Date: 7/08/09
FileName: KAT0KP1A

ADVANCED TERRA TESTING, INC.
ATT

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-48
BORING NO.	KP-1	SAMPLED	
DEPTH	2.0-5.0'	TEST STARTED	6-26-09 CAL
SAMPLE NO.	Pt. A	TEST FINISHED	7-4-09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	17S
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp	CONF. PRES. PSF	4000

SATURATION DATA

Cell Pres. (PSI)	Back Pres. (PSI)	Burette Reading (CC)		Pore Pressure (PSI)		Change	B
		Close	Open	Close	Open		
41.0	38.0	3.6	4.0				
51.0	48.0	0.5	2.3	38.3	46.2	7.9	0.79
61.0	58.0	1.4	2.5	48.4	57.0	8.6	0.86
71.0	68.0	2.3	3.3	58.6	67.2	8.6	0.86
81.0	78.0	3.2	4.0	68.4	77.6	9.2	0.92
91.0	88.0	4.1	4.9	78.5	87.9	9.4	0.94
101.0		4.9	5.0	88.2	97.9	9.7	0.97

CONSOLIDATION DATA

Elapsed Time (Min)	SQRT TIME (Min)	Burette Reading (CC)	Vol. Defl. (CC)
0.00	0.0	0.0	0.00
0.25	0.5	7.9	-7.90
0.5	0.7	9.5	-9.50
1	1.0	11.3	-11.30
2	1.4	13.3	-13.30
4	2.0	15.3	-15.30
9	3.0	17.9	-17.90
16	4.0	20.0	-20.00
30	5.5	22.5	-22.50
60	7.7	25.0	-25.00
120	11.0	27.1	-27.10
240	15.5	28.5	-28.50
360	19.0	29.1	-29.10

Initial Height (in)	5.010	Init. Vol. (CC)	371.78
Height Change (in)	0.075	Vol. Change (CC)	31.40
Ht. After Cons. (in)	4.935	Cell Exp. (CC)	14.88
Initial Area (sq in)	4.528	Net Change (CC)	16.52
Area After Cons. (sq in)	4.392	Cons. Vol. (CC)	355.27

Data entry by: MLM/CAL Date: 07/08/2009
Data checked by: cal Date: 7/08/09
FileName: KAT0KP1A

ADVANCED TERRA TESTING, INC. ATT

TRIAXIAL COMPRESSION TEST DATA

CLIENT	Kumar & Associates	JOB NO.	2203-48
BORING NO.	KP-1	SAMPLED	
DEPTH	2.0-5.0'	TEST STARTED	6-26-09 CAL
SAMPLE NO.	Pt. A	TEST FINISHED	7-4-09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	17S
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp	CONF. PRES. PSF	4000

Init. Ht. (in)	5.010	Init. Area (sq in)	4.528
Consol. Ht. (in)	4.935	Consol. Area (sq in)	4.392
Back Pres. PSI	88.1	Strain Rate (in/min)	0.0024

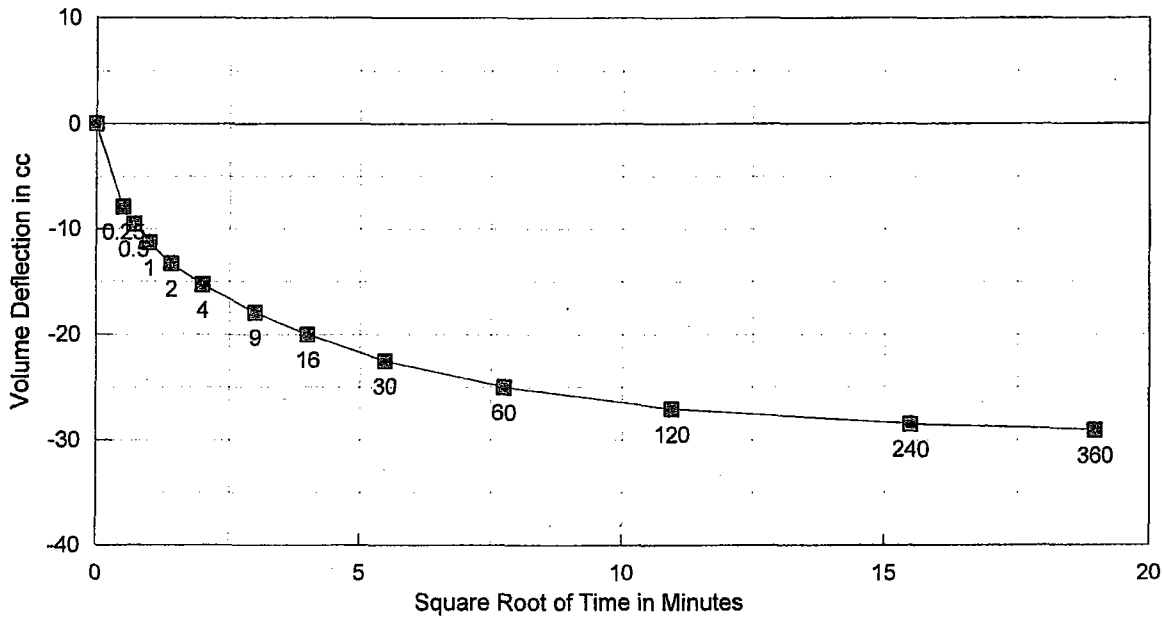
Axial Load Lbs.	Axial Load PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Dev. Stress PSF	Pore Pres. PSI	Delta Pres. PSF	Sigma 3 PSF	Sigma 1 PSF	Prin. Stress Ratio
0.0	0	0.000	0.00	4.392	0	88.1	0	4000	4000	1.00
2.6	85	0.008	0.17	4.400	85	88.5	50	3950	4035	1.02
7.1	234	0.012	0.24	4.403	233	88.8	95	3905	4138	1.06
12.1	397	0.016	0.31	4.406	396	89.1	141	3859	4255	1.10
17.2	565	0.021	0.43	4.411	562	89.7	225	3775	4337	1.15
26.8	878	0.024	0.49	4.414	874	90.7	368	3632	4506	1.24
33.9	1112	0.027	0.54	4.416	1106	91.5	492	3508	4614	1.32
39.0	1277	0.030	0.60	4.419	1269	92.1	577	3423	4693	1.37
39.7	1303	0.033	0.68	4.422	1294	92.5	629	3371	4664	1.38
64.2	2106	0.066	1.35	4.452	2077	96.1	1143	2857	4935	1.73
77.0	2524	0.120	2.42	4.501	2463	98.9	1552	2448	4911	2.01
84.9	2784	0.159	3.23	4.539	2694	100.2	1733	2267	4962	2.19
88.8	2911	0.190	3.86	4.568	2799	100.8	1832	2168	4967	2.29
93.6	3068	0.227	4.60	4.604	2927	101.4	1907	2093	5020	2.40
96.7	3172	0.267	5.41	4.643	3000	101.8	1966	2034	5034	2.48
101.2	3317	0.307	6.21	4.683	3111	102.0	2001	1999	5110	2.56
104.6	3428	0.347	7.03	4.724	3187	102.2	2022	1978	5165	2.61
108.2	3547	0.387	7.85	4.767	3268	102.2	2028	1972	5240	2.66
111.4	3652	0.427	8.66	4.809	3336	102.2	2027	1973	5309	2.69
114.3	3748	0.468	9.48	4.852	3393	102.1	2018	1982	5375	2.71
116.5	3819	0.508	10.30	4.897	3426	102.0	1999	2001	5427	2.71
119.2	3907	0.540	10.94	4.932	3479	101.9	1985	2015	5494	2.73
122.0	4000	0.580	11.75	4.977	3530	101.7	1961	2039	5569	2.73
125.4	4110	0.628	12.73	5.033	3586	101.5	1926	2074	5660	2.73
129.0	4228	0.679	13.76	5.093	3647	101.2	1886	2114	5760	2.73
132.4	4342	0.732	14.83	5.157	3698	100.9	1840	2160	5857	2.71
133.7	4383	0.760	15.40	5.192	3709	100.7	1816	2184	5893	2.70
135.4	4438	0.772	15.63	5.206	3744	100.7	1807	2193	5937	2.71

Data entry by: MLM Date: 07/07/2009
Data checked by: ae Date: 7/08/09
FileName: KAT0KP1A

ADVANCED TERRA TESTING, Inc. ATT

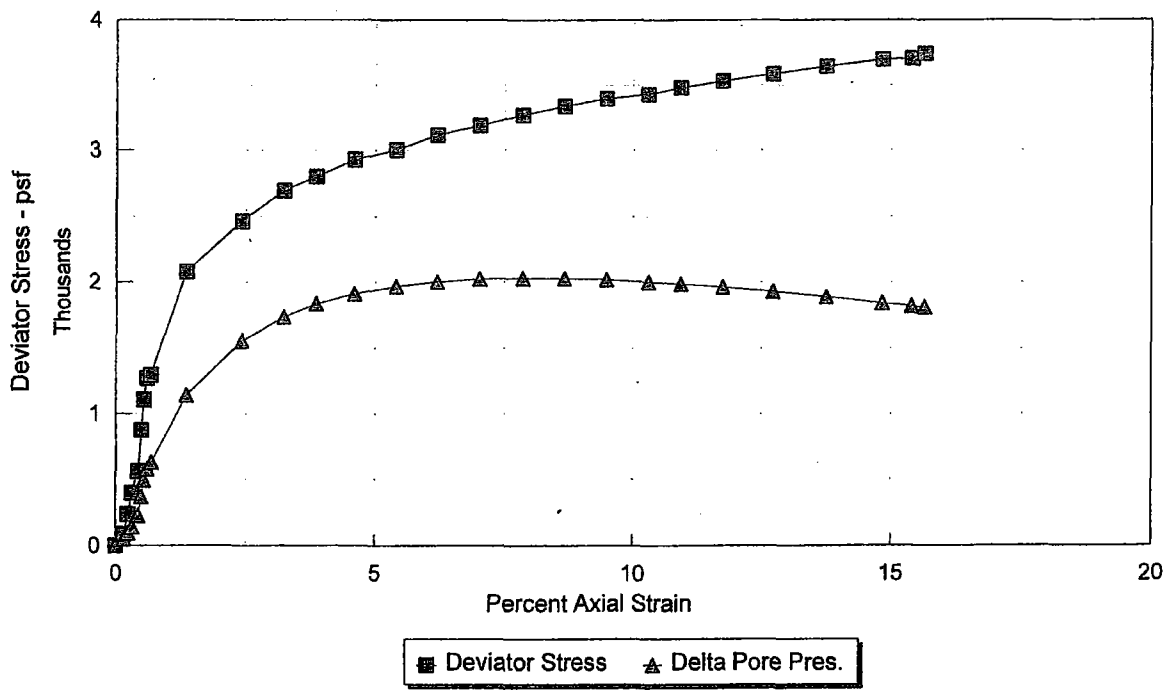
CONSOLIDATION DATA

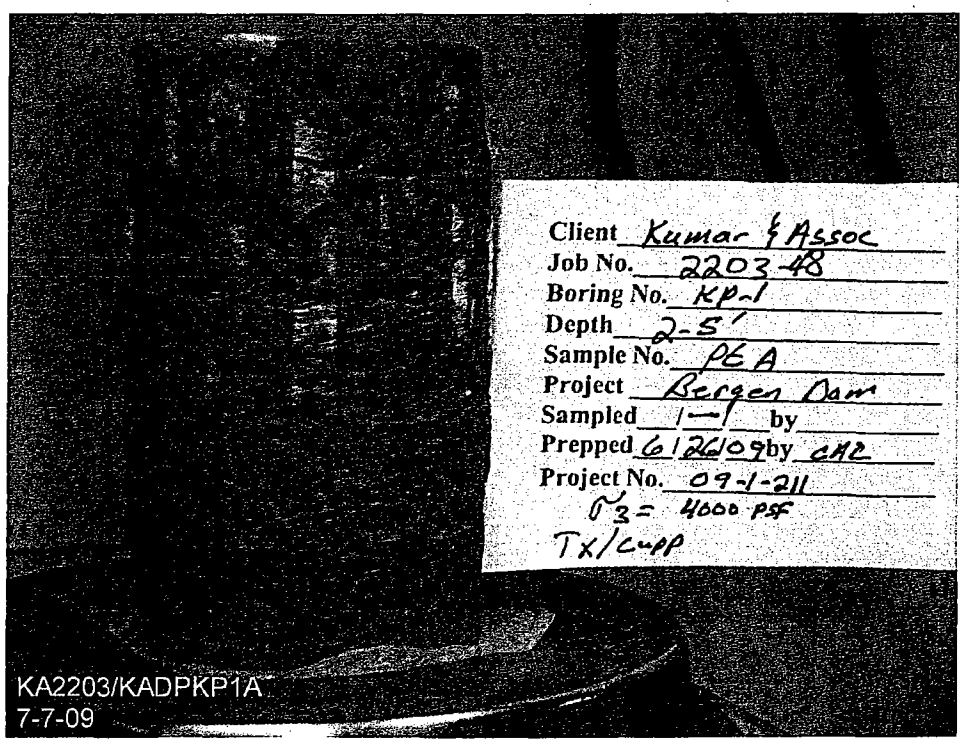
KP-1, 2.0-5.0', Pt. A



TRIAXIAL TEST - TX/CUpp

KP-1, 2.0-5.0', Pt. A




Client Kumar & Assoc
Job No. 2203-48
Boring No. KP-1
Depth 2-5'
Sample No. PEA
Project Bergen Dam
Sampled 1-1 by
Prepped 6/26/09 by CAZ
Project No. 09-1-211
σ3 = 4000 psf
TX/CUPP
KA2203/KADPKP1A
7-7-09

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-48
BORING NO.	KP-1	SAMPLED	
DEPTH	2.0-5.0'	TEST STARTED	6-27-09 CAL
SAMPLE NO.	Pt. B	TEST FINISHED	7-7-09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	14S
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp		
		CONF. PRES. PSF	2000

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	720.6	758.2
Wt. Wet Soil & Pan (g)	734.6	772.2
Wt. Dry Soil & Pan (g)	622.0	622.0
Wt. Lost Moisture (g)	112.6	150.1
Wt. of Pan Only (g)	14.0	14.0
Wt. of Dry Soil (g)	608.0	608.0
Moisture Content %	18.5	24.7
Wet Density PCF	121.4	129.1
Dry Density PCF	102.4	103.5

Init. Diameter (in)	2.398
Init. Area (sq in)	4.516
Init. Height (in)	5.007
Vol. Bef. Consol. (cu ft)	0.01309
Vol. After Consol. (cu ft)	0.01295

Notes & Comments: Remolded sample.

Data entry by: MLM Date: 07/08/2009
Data checked by: ae Date: 7/08/09
FileName: KAT0KP1B

ADVANCED TERRA TESTING, INC. ATT

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-48
BORING NO.	KP-1	SAMPLED	
DEPTH	2.0-5.0'	TEST STARTED	6-27-09 CAL
SAMPLE NO.	Pt. B	TEST FINISHED	7-7-09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	14S
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp	CONF. PRES. PSF	2000

SATURATION DATA

Cell Pres. (PSI)	Back Pres. (PSI)	Burette Reading (CC)		Pore Pressure (PSI)		Change	B
		Close	Open	Close	Open		
41.0	38.0	4.2	8.7				
51.0	48.0	3.5	5.0	38.1	46.3	8.2	0.82
61.0	58.0	4.8	5.7	48.3	57.0	8.7	0.87
71.0	68.0	5.4	6.1	58.4	67.0	8.6	0.86
81.0	78.0	6.3	7.1	68.0	77.3	9.3	0.93
91.0	88.0	7.1	7.7	78.0	87.3	9.3	0.93
101.0		7.6	7.4	88.2	97.8	9.6	0.96

CONSOLIDATION DATA

Elapsed Time (Min)	SQRT TIME (Min)	Burette Reading (CC)	Vol. Defl. (CC)
0.00	0.0	7.4	0.00
0.25	0.5	12.4	-5.00
0.5	0.7	13.0	-5.60
1	1.0	14.4	-7.00
2	1.4	16.0	-8.60
4	2.0	17.4	-10.00
9	3.0	18.9	-11.50
16	4.0	19.8	-12.40
30	5.5	20.6	-13.20
60	7.7	21.2	-13.75
120	11.0	21.5	-14.10
240	15.5	21.8	-14.40
360	19.0	22.0	-14.60

Initial Height (in)	5.007	Init. Vol. (CC)	370.63
Height Change (in)	0.027	Vol. Change (CC)	18.70
Ht. After Cons. (in)	4.980	Cell Exp. (CC)	14.78
Initial Area (sq in)	4.516	Net Change (CC)	3.92
Area After Cons. (sq in)	4.493	Cons. Vol. (CC)	366.71

Data entry by: MLM Date: 07/08/2009
Data checked by: ae Date: 7/08/09
FileName: KAT0KP1B

ADVANCED TERRA TESTING, INC.
ATT

TRIAXIAL COMPRESSION TEST DATA

CLIENT	Kumar & Associates	JOB NO.	2203-48
BORING NO.	KP-1	SAMPLED	
DEPTH	2.0-5.0'	TEST STARTED	6-27-09 CAL
SAMPLE NO.	Pt. B	TEST FINISHED	7-7-09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	14S
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp	CONF. PRES. PSF	2000

Init. Ht. (in)	5.007	Init. Area (sq in)	4.516
Consol. Ht. (in)	4.980	Consol. Area (sq in)	4.493
Back Pres. PSI	88.4	Strain Rate (in/min)	0.0038

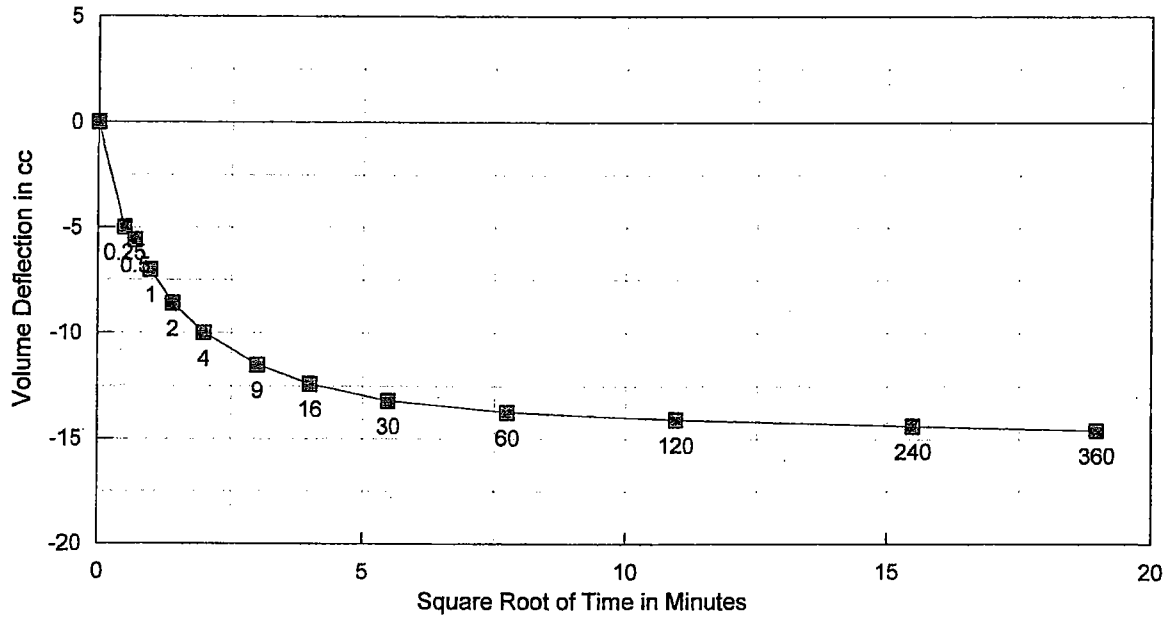
Axial Load Lbs.	Axial Load PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Dev. Stress PSF	Pore Pres. PSI	Delta Pres. PSF	Sigma 3 PSF	Sigma 1 PSF	Prin. Stress Ratio
0.0	0	0.000	0.00	4.493	0	88.4	0	2000	2000	1.00
4.2	134	0.010	0.19	4.501	134	88.6	31	1969	2103	1.07
5.0	161	0.015	0.29	4.506	160	88.7	50	1950	2111	1.08
7.7	248	0.020	0.40	4.511	247	89.0	89	1911	2158	1.13
26.5	850	0.029	0.59	4.519	845	91.1	386	1614	2460	1.52
31.1	998	0.034	0.69	4.524	991	91.7	469	1531	2522	1.65
33.4	1069	0.040	0.79	4.529	1061	92.1	533	1467	2528	1.72
34.8	1116	0.045	0.90	4.533	1106	92.4	584	1416	2522	1.78
37.2	1192	0.055	1.11	4.543	1179	93.1	672	1328	2507	1.89
42.4	1360	0.097	1.95	4.582	1333	94.6	886	1114	2447	2.20
46.8	1500	0.160	3.21	4.642	1452	95.5	1026	974	2426	2.49
48.3	1547	0.208	4.17	4.688	1482	95.9	1077	923	2405	2.61
48.2	1545	0.240	4.82	4.720	1471	96.0	1097	903	2374	2.63
49.2	1579	0.286	5.74	4.767	1488	96.1	1113	887	2375	2.68
50.4	1616	0.336	6.74	4.818	1507	96.2	1126	874	2381	2.72
54.2	1739	0.387	7.77	4.871	1603	96.2	1123	877	2481	2.83
54.5	1748	0.437	8.77	4.925	1595	96.2	1120	880	2475	2.81
55.5	1780	0.486	9.76	4.979	1607	96.1	1110	890	2496	2.81
58.7	1882	0.536	10.76	5.035	1679	96.0	1097	903	2582	2.86
61.8	1982	0.587	11.79	5.093	1748	95.9	1082	918	2666	2.90
63.1	2021	0.637	12.80	5.152	1763	95.8	1068	932	2694	2.89
65.0	2083	0.678	13.61	5.200	1799	95.7	1050	950	2749	2.89
66.3	2126	0.727	14.59	5.260	1816	95.6	1033	967	2783	2.88
67.6	2168	0.787	15.81	5.336	1825	95.4	1009	991	2816	2.84
69.9	2241	0.852	17.12	5.421	1858	95.5	1022	978	2836	2.90
73.3	2349	0.918	18.43	5.508	1916	95.3	993	1007	2924	2.90
74.3	2381	0.953	19.13	5.556	1925	95.2	974	1026	2951	2.88
73.9	2368	0.968	19.44	5.577	1907	95.1	966	1034	2942	2.84

Data entry by: MLM Date: 07/08/2009
Data checked by: ae Date: 7/08/09
FileName: KAT0KP1B

ADVANCED TERRA TESTING, INC. ATT

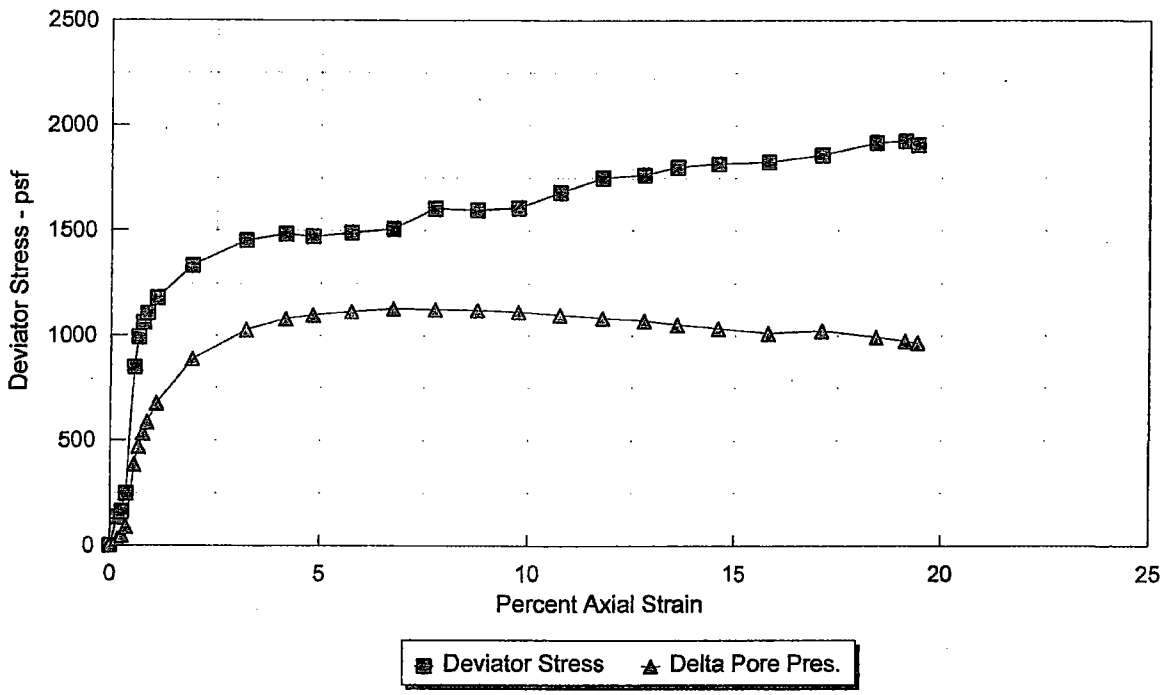
CONSOLIDATION DATA

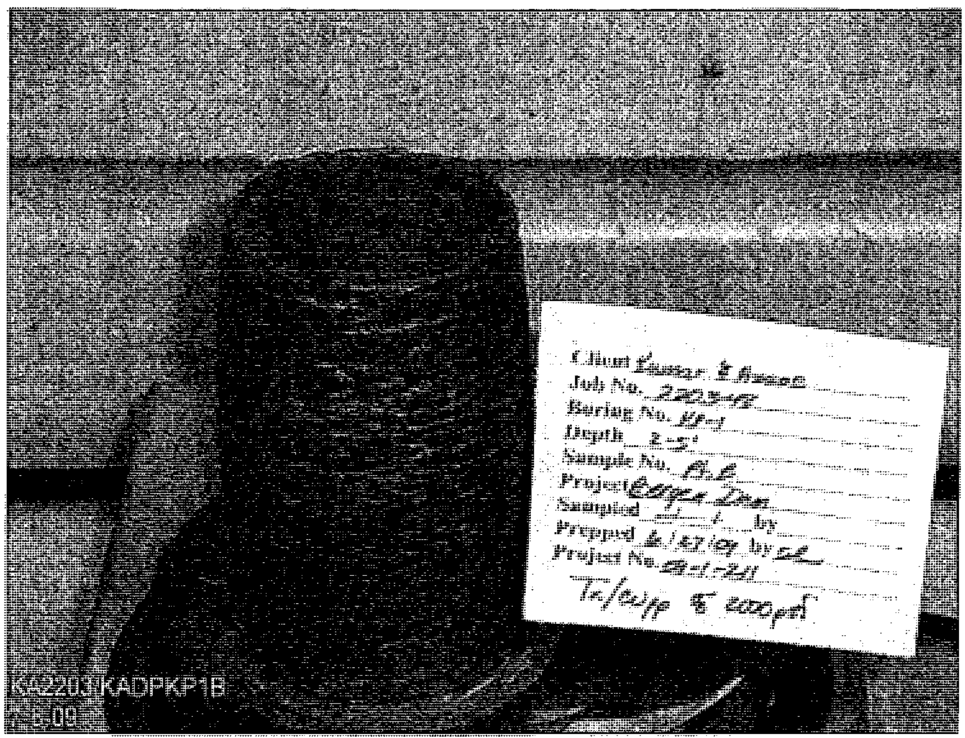
KP-1, 2.0-5.0', Pt. B



TRIAXIAL TEST - TX/CUpp

KP-1, 2.0-5.0', Pt. B




Client
Job No.
Boring No.
Depth 2-5'
Sample No.
Project
Sampled
by
Prepped
by
Project No.
KA2203 KADPKP1B

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-48
BORING NO.	KP-1	SAMPLED	
DEPTH	2.0-5.0'	TEST STARTED	6-26-09 CAL
SAMPLE NO.	Pt. C	TEST FINISHED	7-6-09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	13S
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp		
		CONF. PRES. PSF	1000

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	720.8	769.5
Wt. Wet Soil & Pan (g)	734.8	783.5
Wt. Dry Soil & Pan (g)	626.7	626.7
Wt. Lost Moisture (g)	108.1	156.8
Wt. of Pan Only (g)	14.0	14.0
Wt. of Dry Soil (g)	612.7	612.7
Moisture Content %	17.6	25.6
Wet Density PCF	121.2	126.9
Dry Density PCF	103.0	101.1

Init. Diameter (in)	2.400
Init. Area (sq in)	4.524
Init. Height (in)	5.008
Vol. Bef. Consol. (cu ft)	0.01311
Vol. After Consol. (cu ft)	0.01336

Notes & Comments: Remolded sample.

Data entry by: MLM/CAL Date: 07/08/2009
Data checked by: Cal Date: 7/08/09
FileName: KAT0KP1C

ADVANCED TERRA TESTING, INC. ATT

TRIAXIAL COMPRESSION TEST DATA
ASTM D 4767

CLIENT	Kumar & Associates	JOB NO.	2203-48
BORING NO.	KP-1	SAMPLED	
DEPTH	2.0-5.0'	TEST STARTED	6-26-09 CAL
SAMPLE NO.	Pt. C	TEST FINISHED	7-6-09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	13S
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp	CONF. PRES. PSF	1000

SATURATION DATA

Cell Pres. (PSI)	Back Pres. (PSI)	Burette Reading (CC)		Pore Pressure (PSI)		Change	B
		Close	Open	Close	Open		
41.0	38.0	3.8	5.0				
51.0	48.0	-0.1	1.1	38.5	46.8	8.3	0.83
61.0	58.0	0.9	1.9	48.7	57.4	8.7	0.87
71.0	68.0	1.9	2.7	58.6	67.4	8.8	0.88
81.0	78.0	2.8	3.6	68.3	77.6	9.3	0.93
91.0		3.5	3.6	78.3	87.9	9.6	0.96

CONSOLIDATION DATA

Elapsed Time (Min)	SQRT TIME (Min)	Burette Reading (CC)	Vol. Defl. (CC)
0.00	0.0	0.0	0.00
0.25	0.5	1.7	-1.70
0.5	0.7	2.0	-2.00
1	1.0	2.4	-2.40
2	1.4	2.8	-2.80
4	2.0	3.3	-3.30
9	3.0	3.6	-3.60
16	4.0	3.8	-3.80
30	5.5	3.9	-3.90
60	7.7	4.1	-4.05
120	11.0	4.2	-4.15
240	15.5	4.3	-4.30
360	19.0	4.4	-4.40

Initial Height (in)	5.008	Init. Vol. (CC)	371.33
Height Change (in)	0.002	Vol. Change (CC)	4.90
Ht. After Cons. (in)	5.006	Cell Exp. (CC)	12.07
Initial Area (sq in)	4.524	Net Change (CC)	-7.17
Area After Cons. (sq in)	4.613	Cons. Vol. (CC)	378.49

Data entry by: MLM/CAL Date: 07/08/2009
Data checked by: ae Date: 7/08/09
FileName: KAT0KP1C

TRIAXIAL COMPRESSION TEST DATA

CLIENT	Kumar & Associates	JOB NO.	2203-48
BORING NO.	KP-1	SAMPLED	
DEPTH	2.0-5.0'	TEST STARTED	6-26-09 CAL
SAMPLE NO.	Pt. C	TEST FINISHED	7-6-09 CAL
SOIL DESCR.	09-1-211	CELL NUMBER	13S
LOCATION:	Bergen Dam	SATURATED TEST	Yes
TEST TYPE	TX/CUpp	CONF. PRES. PSF	1000

Init. Ht. (in)	5.008	Init. Area (sq in)	4.524
Consol. Ht. (in)	5.006	Consol. Area (sq in)	4.613
Back Pres. PSI	78.0	Strain Rate (in/min)	0.0045

Axial Load Lbs.	Axial Load PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Dev. Stress PSF	Pore Pres. PSI	Delta Pres. PSF	Sigma 3 PSF	Sigma 1 PSF	Prin. Stress Ratio
0.0	0	0.000	0.00	4.613	0	78.0	0	1000	1000	1.00
20.8	650	0.007	0.14	4.619	649	79.3	186	814	1463	1.80
25.7	802	0.011	0.22	4.623	800	79.7	236	764	1564	2.05
28.2	882	0.015	0.30	4.627	879	79.9	270	730	1609	2.20
29.8	930	0.024	0.48	4.635	926	80.3	325	675	1601	2.37
31.5	985	0.028	0.57	4.639	979	80.4	346	654	1633	2.50
31.7	991	0.033	0.66	4.644	984	80.6	367	633	1617	2.55
31.1	972	0.038	0.75	4.648	965	80.7	383	617	1582	2.56
31.6	988	0.047	0.94	4.657	978	80.9	413	587	1565	2.67
33.1	1032	0.091	1.83	4.699	1013	81.4	490	510	1523	2.99
32.2	1005	0.154	3.07	4.759	974	81.8	540	460	1434	3.12
32.4	1013	0.202	4.04	4.807	972	81.9	558	442	1414	3.20
33.3	1039	0.241	4.82	4.846	989	81.9	565	435	1424	3.27
32.4	1011	0.284	5.67	4.890	954	82.0	570	430	1384	3.22
33.7	1053	0.333	6.64	4.941	983	82.0	572	428	1411	3.29
34.0	1062	0.382	7.63	4.994	981	82.0	571	429	1410	3.29
35.3	1101	0.432	8.62	5.048	1006	82.0	569	431	1436	3.34
35.6	1110	0.482	9.63	5.104	1003	81.9	563	437	1440	3.30
36.7	1144	0.531	10.61	5.160	1023	81.9	558	442	1465	3.31
37.4	1168	0.580	11.59	5.218	1033	81.8	550	450	1483	3.30
38.7	1208	0.629	12.57	5.276	1056	81.8	542	458	1514	3.30
39.8	1243	0.669	13.36	5.324	1077	81.7	534	466	1543	3.31
40.8	1272	0.718	14.35	5.386	1090	81.7	524	476	1566	3.29
40.6	1267	0.778	15.54	5.462	1070	81.6	511	489	1559	3.19
43.4	1354	0.841	16.79	5.544	1127	81.5	497	503	1630	3.24
44.8	1399	0.904	18.07	5.630	1146	81.4	483	517	1663	3.22
45.0	1403	0.938	18.74	5.677	1140	81.3	474	526	1666	3.17
45.5	1420	0.953	19.03	5.697	1150	81.3	470	530	1680	3.17

Data entry by: MLM/CAL Date: 07/08/2009
Data checked by: ae Date: 7/08/09
FileName: KAT0KP1C

ADVANCED TERRA TESTING, Inc. ATT

CONSOLIDATION DATA

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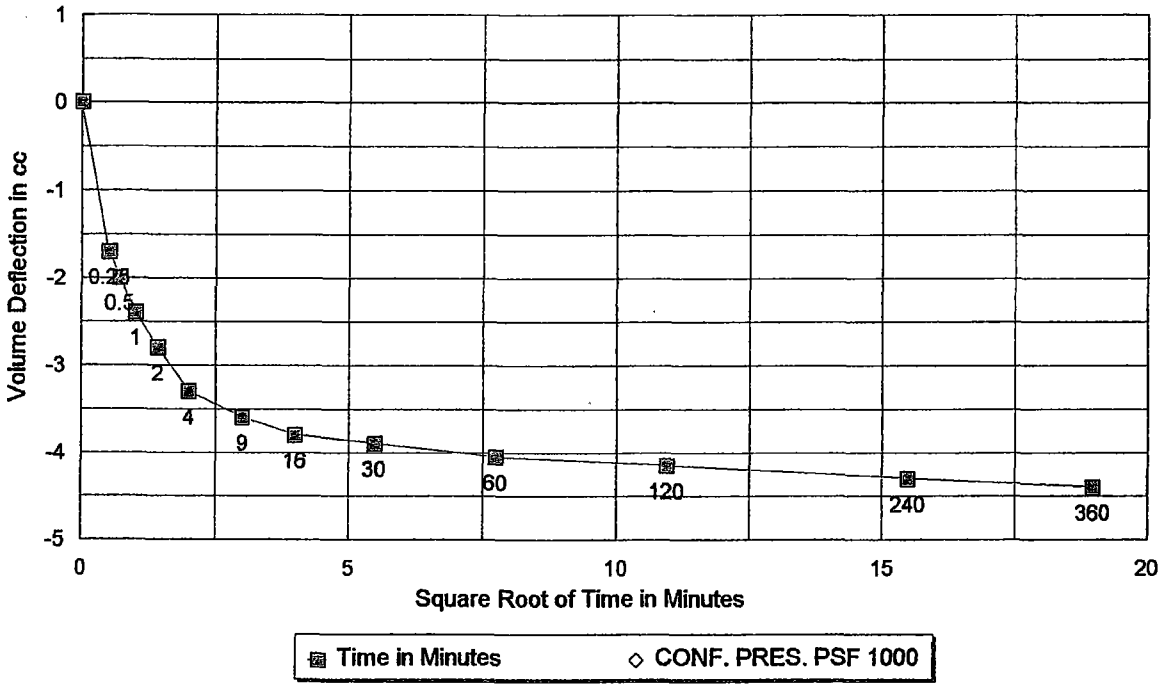

TRIAXIAL TEST - TX/CUpp

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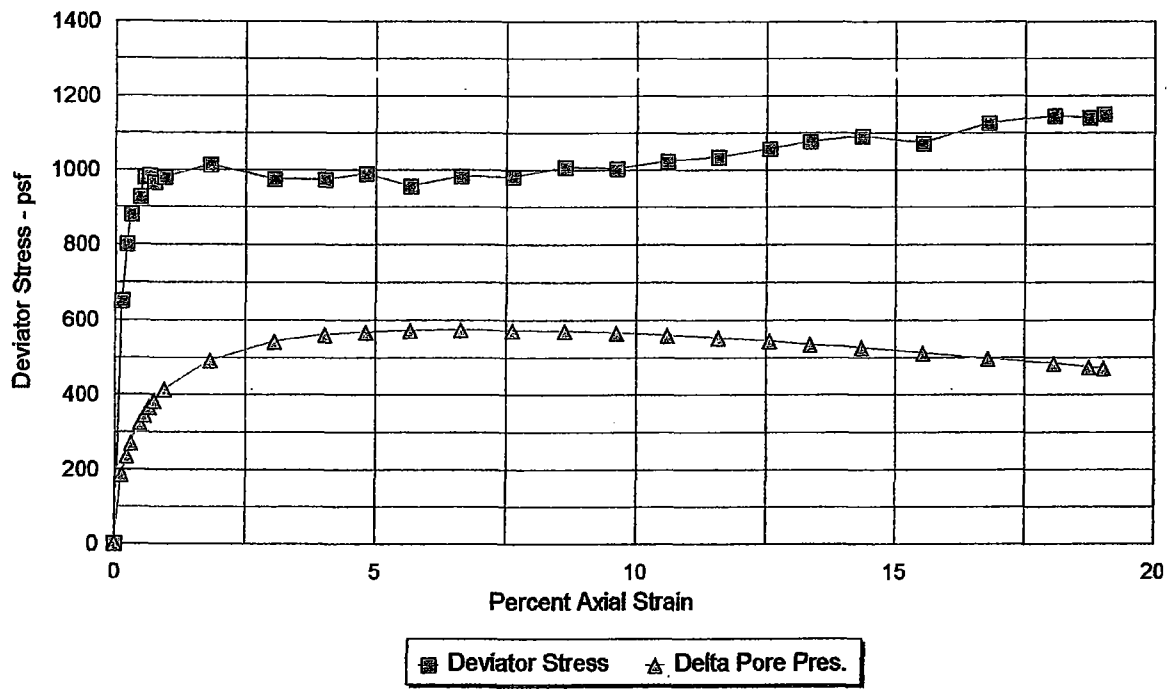
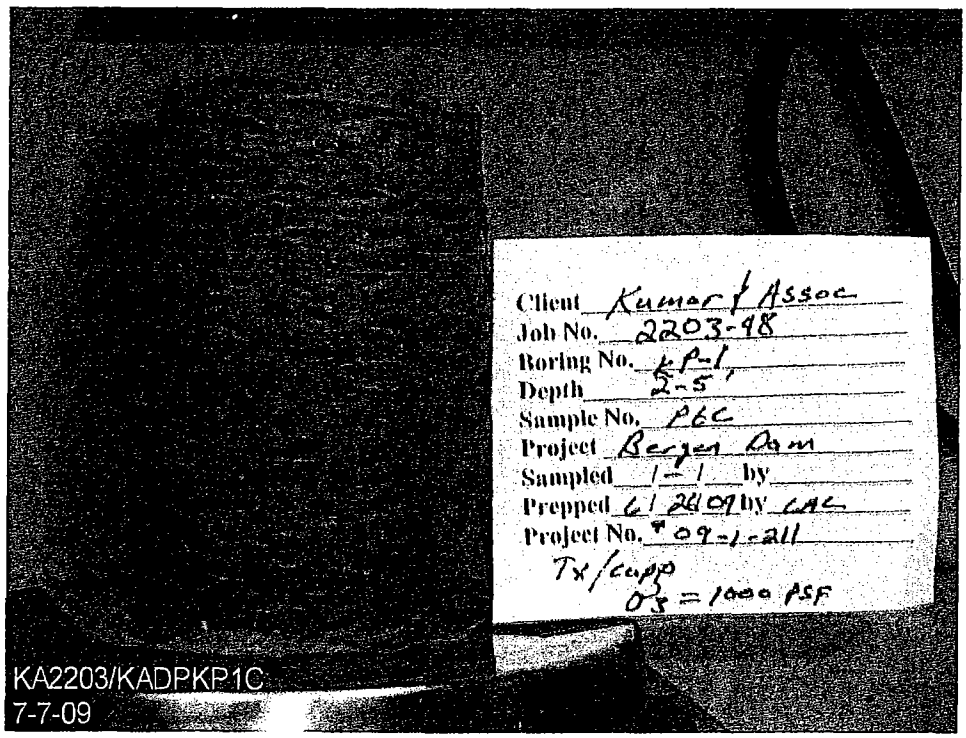
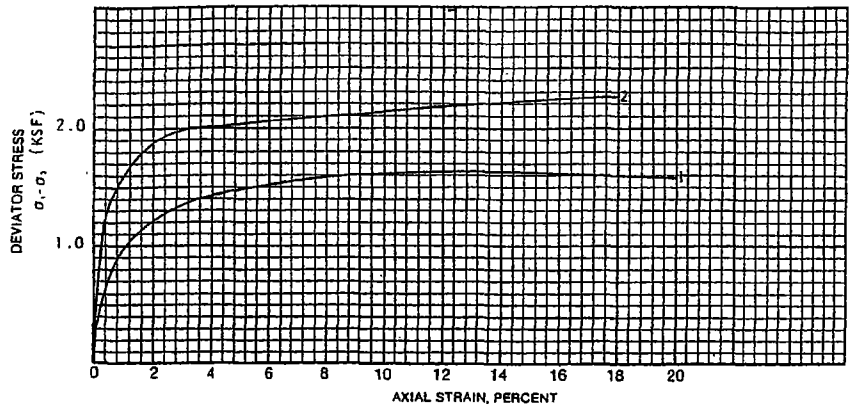
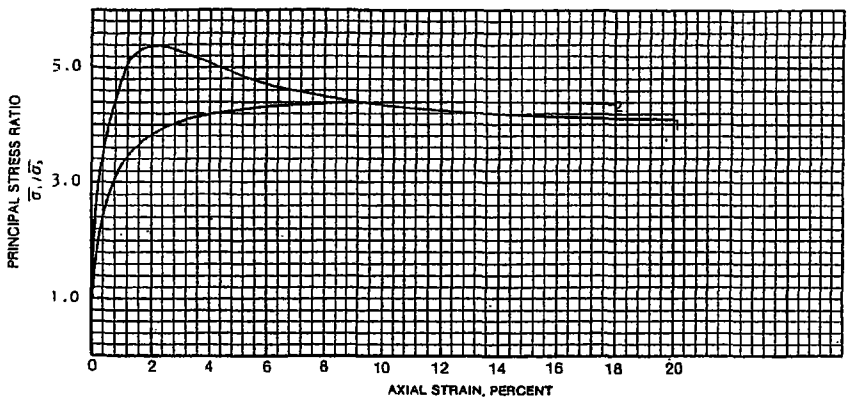
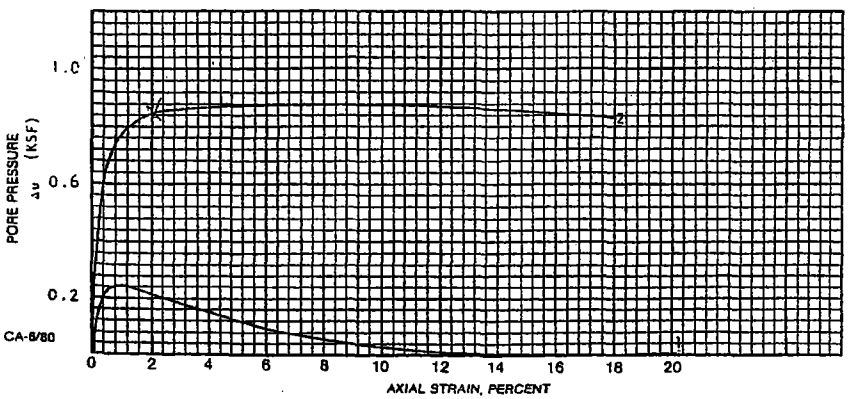



Client Kumar & Assoc
Job No. 2203-98
Boring No. KP-1,
Depth 2-5'
Sample No. P6C
Project Bergen Dam
Sampled 1-1 by
Prepped 6/26/09 by CAC
Project No. 09-1-211
Tx/cupp
σ3 = 1000 PSF
KA2203/KADPKP1C
7-7-09





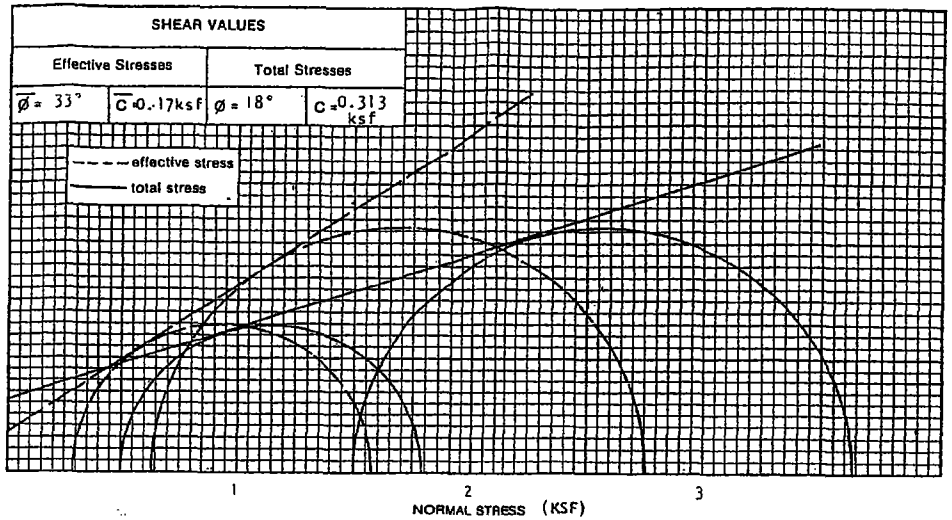


CA-6/80

SHEAR STRENGTH OF SOIL IN TRIAXIAL COMPRESSION

Job No. 1 195 84
Date 6-11-84
Type of Test Saturated, consolidated
Undrained shear with pore pressure measurement

SHEAR VALUES			
Effective Stresses		Total Stresses	
$\bar{\phi}$ = 33°	$\bar{C}$ = 0.17ksf	ϕ = 18°	C = 0.313 ksf



Specimen Number	Specimen Location		Initial Specimen Data					Soil Description
	Boring Number	Depth (Ft)	Sample Type	Length (in)	Diameter (in)	Dry Density (P.C.F.)	Moisture Content (%)	
1	1	14-16	Shelby	5.95	2.85	94.2	28.0	Fill, sand & clay
2	1	14-16	Shelby	5.94	2.85	106.9	20.1	Fill, sand & clay

Specimen Number	"B" Parameter	Test Values at Failure-Maximum Peak σ_1/σ_3							Remarks
		Total Confining Stress σ_3	Total Axial Stress σ_1	Deviator Stress $\sigma_1-\sigma_3$	Effective Lateral Stress $\bar{\sigma}_3$	Effective Axial Stress $\bar{\sigma}_1$	Pore Pressure μ	Percent Strain ϵ%	
1	.98	0.5	1.78	1.28	0.29	1.57	0.22	2.2	All units
2	.99	1.5	3.63	2.13	0.62	2.75	0.88	10.0	In KSF

Remarks:

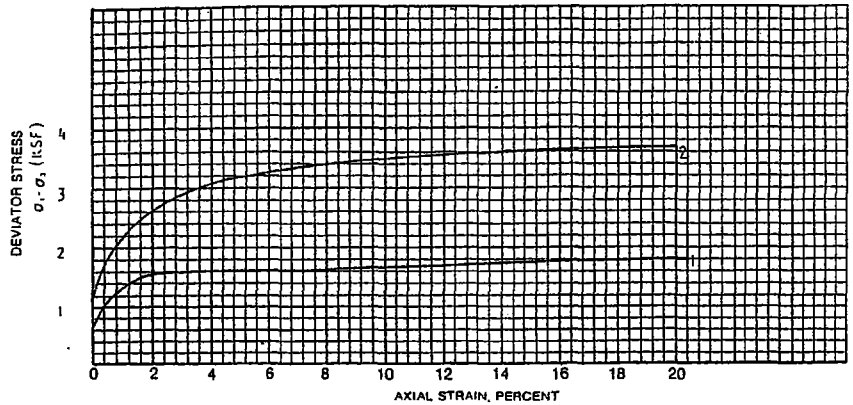
Fig. A-1

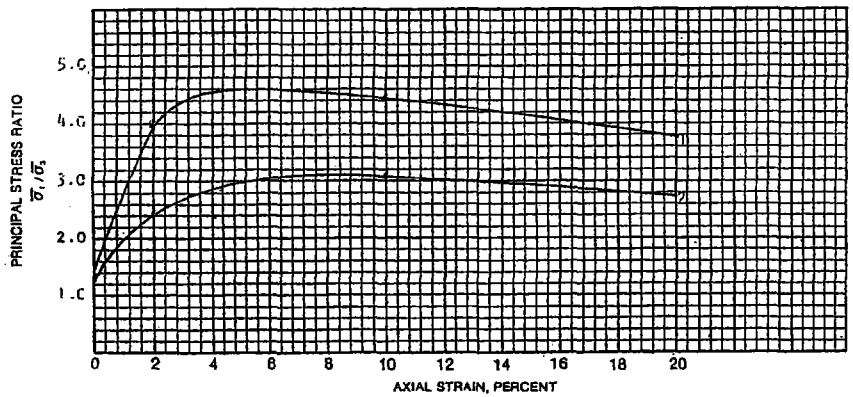
SHEAR STRENGTH OF SOIL IN TRIAXIAL COMPRESSION

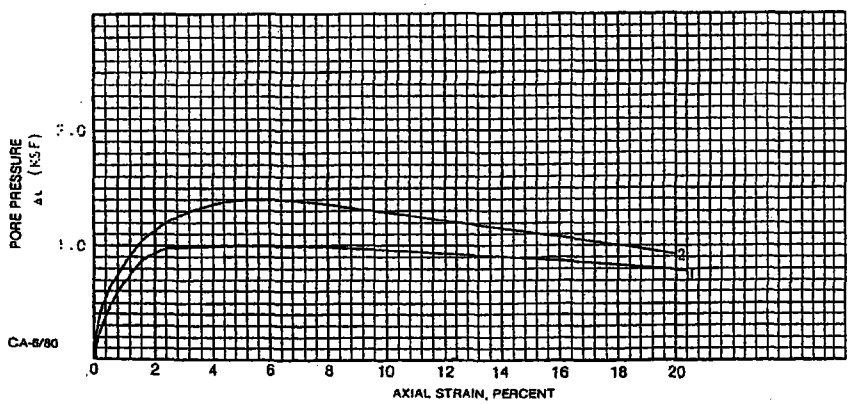
Job No. 1 195 84

Date 6-11-84

Type of Test Saturated, consolidated Undrained shear with pore pressure measurement.

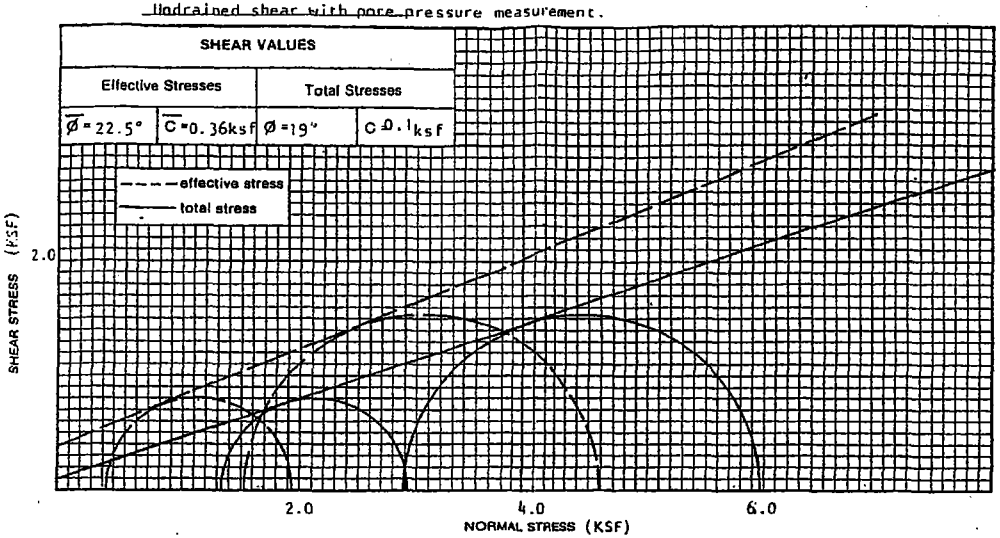






CA-6/80

SHEAR VALUES			
Effective Stresses		Total Stresses	
$\bar{\phi}$ = 22.5°	$\bar{C}$ = 0.36ksf	ϕ = 19°	C 0.1 ksf

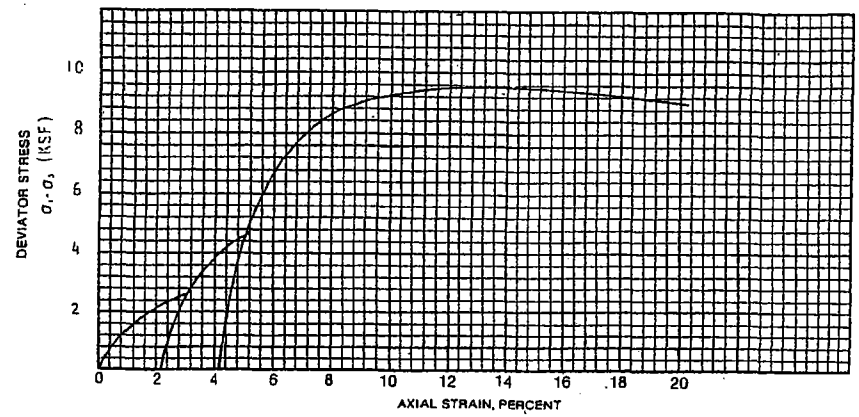


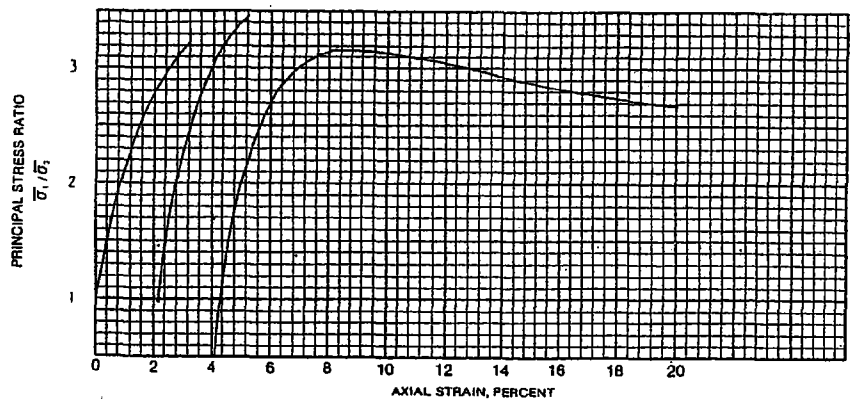
Specimen Number	Specimen Location		Initial Specimen Data					Soil Description
	Boring Number	Depth (Ft)	Sample Type	Length (in)	Diameter (in)	Dry Density (P.C.F.)	Moisture Content (%)	
1	8	15-17	Shelby	6.07	2.87	101.0	17.2	Fill, claystone & clay
2	8	15-17	Shelby	5.17	2.87	104.2	17.9	Fill, claystone & clay

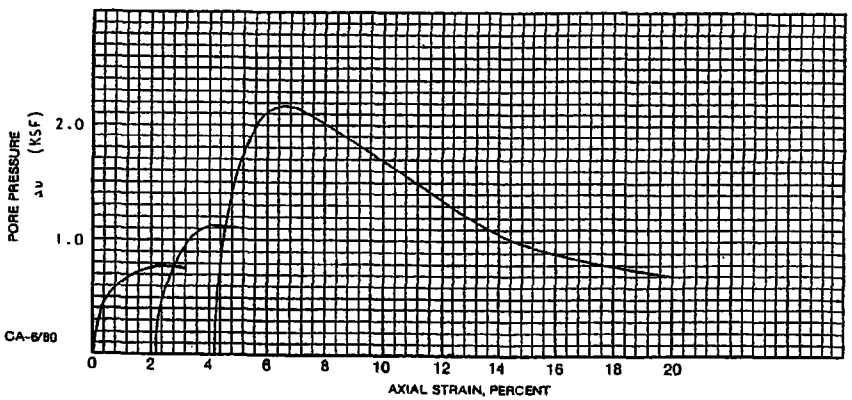
Specimen Number	"B" Parameter	Test Values at Failure-Maximum 4% Strain							Remarks
		Total Confining Stress σ_3	Total Axial Stress σ_1	Deviator Stress $\sigma_1-\sigma_3$	Effective Lateral Stress $\bar{\sigma}_3$	Effective Axial Stress $\bar{\sigma}_1$	Pore Pressure μ	Percent Strain ε%	
1	.95	1.44	3.03	1.59	0.45	2.03	0.99	4.0	All units in KSF
2	.90	3.0	6.07	3.07	1.64	4.71	1.35	4.0	All units in KSF

Remarks:

Fig. A-2





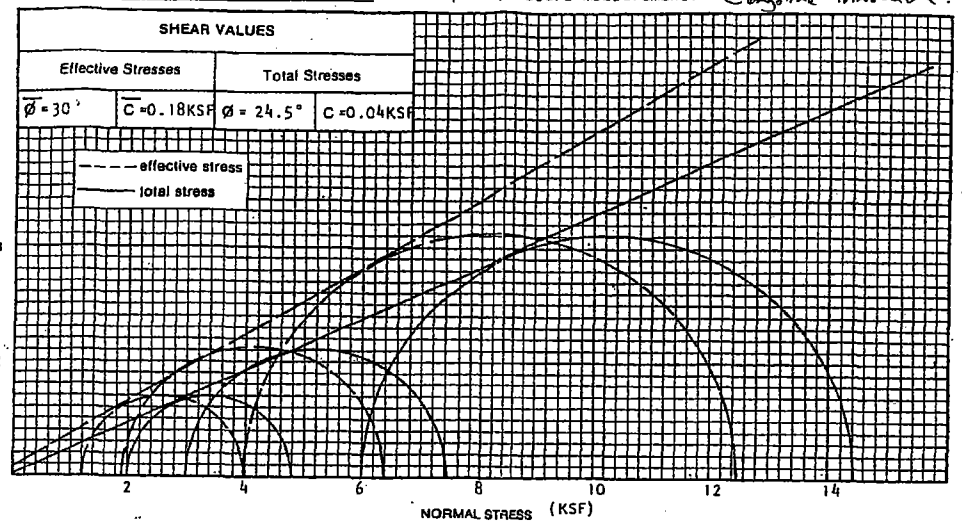


CA-6/80

SHEAR STRENGTH OF SOIL IN TRIAXIAL COMPRESSION

Job No. 1 195 84
Date 6-11-84

Type of Test Multistaged, saturated, Consolidated, undrained shear with pore pressure measurement. Claystone Formation.



Specimen Number	Specimen Location		Initial Specimen Data					Soil Description
	Boring Number	Depth (Ft)	Sample Type	Length (In)	Diameter (In)	Dry Density (P.C.F.)	Moisture Content (%)	
1,2,3	9	40	CA	3.637	1.934	104.3	22.7	Claystone

Specimen Number	"B" Parameter	Test Values at Failure-Maximum							Remarks
		Total Confining Stress σ_3	Total Axial Stress σ_1	Deviator Stress $\sigma_1-\sigma_3$	Effective Lateral Stress $\bar{\sigma}_3$	Effective Axial Stress $\bar{\sigma}_1$	Pore Pressure μ	Percent Strain ϵ%	
1	.96	2.0	4.80	2.80	1.24	4.03	0.78	3.2	All units in KSF
2	.96	3.0	7.49	4.49	1.90	6.39	1.12	4.8	
3	.96	6.0	14.47	8.47	3.97	12.44	2.07	7.7	

Remarks:

Fig. A-3

W. W. Wheeler and Associates, Inc.
Water Resources Engineers

MEMORANDUM

620.04

December 7, 2011

To: Board of Directors
Bergen Ditch and Reservoir Company

By: James A. Ferentchak, P.E.
W. W. Wheeler and Associates, Inc.

Re: Feasibility-Level Cost
Bergen No. 2 Dam, Outlet Works Replacement

This memorandum provides feasibility-level designs of outlet works replacement options for the Bergen No. 2 Dam, and feasibility-level opinions of probable construction costs for the reconstruction and replacement of the outlet works on the Bergen No. 1 Dam. Three options are evaluated, ranging from the minimum repair likely to be allowed by the State Engineer based on the proposed embankment reconstruction, to a complete replacement of the entire outlet works. A discussion of the proposed project work follows.

Summary of the Existing Outlet Works

The existing outlet works consists of the following items, from upstream to downstream, which except as noted are assumed to range from 100 to 130 years old:

1. An unknown and undocumented lake intake structure; its location also not documented;
2. An estimated 50 to 100 feet of intake pipe extending from the lake intake to the existing control valve, constructed of unknown material but assumed to be 12-inch ductile iron pipe (DIP), similar to that indicated for the downstream pipe;
3. The existing gate valve at the bottom of a 40-foot tall pipe-control tower structure;
4. Approximately 140 feet of 12-inch pipe, located downstream from the control tower, reported on drawings to be DIP;
5. Approximately 50 feet of a concrete or clay tile pipe installed at the downstream end of outlet works pipe, believed to date from the 1940s; and
6. The existing concrete outlet structure, also believed to date from the 1940s.
7. The maximum depth of burial of the outlet works is approximately 40-feet at the center of the dam.
8. The outlet works pipe bedding and installation is not known.

3700 South Inca Street Englewood, Colorado 80110 Phone (303) 761-4130 Fax (303) 761-2802

9. A recent video inspection of the interior of the outlet works pipe, between the control valve and the pipe outfall, indicated three bends in the pipe alignment, and one leak into the pipe.

Issues Regarding the Existing Outlet Works

There is no information regarding the existing intake structure. It is assumed that the intake is old, and likely not protected with a trash rack. There may not even be an intake structure.

The outlet pipe is old and is expected to be decaying; one leak has been observed just downstream from the gate valve. The pipe is also installed with several bends, limiting rehabilitation options. The small 12-inch inside diameter of the pipe limits emergency releases, and also limits options for rehabilitating the pipe in-place (lining of the pipe).

The existing gate valve is old, the bonnet or stem seal leaks, and the valve has shown past evidence of seizing. Valves typically failed prior to reaching this age. The possibility for this valve to fail in the near future is high. Failure of the valve will greatly complicate the dam and outlet rehabilitation if failure occurs when closed due to the difficulty in draining the reservoir. Failure of the valve may greatly stress the Company's water management, water supply and timing of the dam rehabilitation if it fails in the open position, thereby allowing possible loss of the reservoir storage at an unplanned time. The location of the existing valve is at the bottom of a deep 30-inch diameter well, which precludes its replacement at the existing location. Today, it is not recommended to install outlet valves in the middle of the dam without significant design considerations for the pipe upstream from the valve.

Outlet works older than about 50 years are generally considered to be inadequate based on current design standards. And outlet works failures are a common mechanism for initiating destructive dam failures.

Direct Construction Impacts on the Outlet Works

The proposed dam rehabilitation construction will require the removal of approximately 60 feet of the downstream end of the existing outlet works and the associated outlet structure

due to the downstream seepage control and embankment strengthening components of the project. The construction will also require removal of the existing upstream outlet intake structure and 30 feet or more of the existing outlet pipe at the upstream end to allow for construction operations and upstream embankment repairs. It is assumed that these sections will be replaced during the dam and outlet rehabilitation work.

Rehabilitation Options

The outlet works is a moderate expense item for a new dam, as it is generally installed near the beginning of the embankment construction process requiring only limited special excavation and backfill requirements. However, outlet replacement in a higher existing dam becomes a significant cost item due to the need to excavate significant volumes of embankment to perform replacement. Newer directional drilling, pipe jacking, and similar type pipe replacement methodologies will not work for outlet replacement in an embankment dam due to the creation of seepage paths along the outside of the pipe with these installation techniques, which can potentially lead to internal erosion in the dam and possible failure. A number of options for lining of outlet pipes exist, but the most preferred options require a straight outlet pipe, or use of flexible liners (HDPE pipe) that would significantly reduce the outlet capacity of the existing 12-inch pipe so as to render it nearly useless. For the following outlet works rehabilitation options which assume that some portion of the existing outlet pipe will remain in service, we have assuming lining of the outlet works pipe with a Cured-In-Place Pipe (CIPP). InsituForm is a name-brand of CIPP liner. The CIPP liner is a resin-saturated felt-type material that is inserted into a pipe, is inflated and cured into a strong plastic pipe using high temperature water or steam.

Three rehabilitation options for the Bergen No. 2 Dam outlet works were formulated, ranging from minimal pipe replacement and lining most of the existing pipe, to 100% replacement of the outlet works. These options are discussed in more detail below. The outlet works rehabilitation options are shown on the attached Figure 1, with key design details shown on Figure 2.

Option 1 – Full Replacement

This option would require full excavation to remove the existing outlet work, and full replacement of the outlet works. Key features of this work includes:

1. Excavation and replacement of approximately 30,000 cy of dam fill, to a depth of approximately 40-feet.
2. Install a new upstream intake structure with a new gate, trash rack and slope operator.
3. Install a new concrete-encased outlet pipe thru the dam section.
4. Install a new filter sand encased outlet pipe at downstream end.
5. Install a new downstream concrete outlet structure.

Option 2 – Upstream Replacement to Tower

This option would require excavation and removal of the existing outlet works pipe from the lake intake to just downstream of the outlet tower, replacement of the same with a new concrete-encased pipe, and replacement of the downstream portion of the outlet works removed during downstream dam embankment work. The existing outlet works pipe left in-place through the middle section of the dam would be lined with a CIPP. Replacement is taken to the tower in order to remove the existing valve and the known leaking pipe section. Key features of this work includes:

1. Excavation and replacement of approximately 15,000 cy of dam fill, to a maximum depth of approximately 23-feet.
2. Install a new upstream intake structure with a new gate, trash rack and slope operator.
3. Install a new concrete-encased outlet pipe in the upstream section of the outlet works.
4. Install a new CIPP liner in the existing outlet pipe thru the interior section of the dam.
5. Install a new filter sand-encased outlet pipe at downstream end.
6. Install a new downstream concrete outlet structure.

Option 3 – Minimum Upstream Replacement

This option would includes a limited excavation and limited removal of the upstream end of the existing outlet works pipe only as required to reconstruct and repair the upstream slope and install a new control gate, replacement of the same, and replacement of the downstream portion of the outlet works removed during downstream dam embankment work. The existing outlet works pipe left in-place through the middle section of the dam, including the existing valve casing, would be lined with a Cured-In-Place Pipe (CIPP). The

existing outlet tower pipe would be cut off at ground level and filled with concrete. Key features of this work includes:

1. Excavation and replacement of approximately 2,000 cy of dam fill, to a maximum depth of approximately 10-feet.
2. Install a new upstream intake structure with new gate, trash rack and slope operator.
3. Install a new concrete-encased outlet pipe in the upstream section of the outlet works.
4. Install a new CIPP liner in the existing outlet pipe thru the interior section of the dam.
5. Install a new filter sand encased outlet pipe at downstream end.
6. Install a new downstream concrete outlet structure.

Feasibility-Level Opinion of Construction Costs

Wheeler has prepared feasibility-level opinions of probable construction costs for the three options. These are presented in Table No. 1, No. 2 and No. 3 for Option No. 1, No. 2 and No. 3, respectively. Included in the cost tables are feasibility level quantities and unit pricing. The outlet works replacement is projected to range from $240,000 for the minimum replacement option to nearly $550,000 for the complete replacement option.

Discussion

Given the relatively small increment of improvement to the outlet works of Option No. 2 compared to Option No. 3, we do not recommend Option No. 2. The longevity of the CIPP liner has not been fully demonstrated to meet a 100-year life, which is the ideal life expectancy for an embankment dam. Given the project is intended to fully rehabilitate the Bergen No. 2 Dam for an indefinite, but extended life, we would prefer to see Option No. 1 implemented, the full replacement of the outlet works.

Table No. 1

Cost Estimate for Outlet Replacement
Bergen No. 2 Dam

Option No. 1
Replace Complete Outlet Works

	Item	Quantity	Unit	Unit Price	Total
1	Excavate Trench	30,000	cy	$ 4.00	$ 120,000
2	Intake Structure - CIP Concrete	1	ls	$ 7,000	$ 7,000
3	Intake Trash Rack - SS	1	ls	$ 5,000	$ 5,000
4	Gate, Stem, Stem Wall & Operator	1	ls	$ 36,000	$ 36,000
5	Outlet Structure - CIP Concrete	1	ls	$ 5,000	$ 5,000
6	Outlet Pipe - 18" HDPE, Concrete Encased	260	ft	$ 350	$ 91,000
7	Backfill Trench	30,000	cy	$ 5.00	$ 150,000
8	Unscheduled Items	10	%	$ 41,400	$ 41,400
	Base Total				$ 455,400
	Contingency	20	%		$ 91,080
	Total				$ 546,480

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3-Dec-11

Table No. 2

Cost Estimate for Outlet Replacement
Bergen No. 2 Dam

Option No. 2

Upstream Outlet Works replacement toTower, and Downstream in Dam Reconstruction Area

	Item	Quantity	Unit	Unit Price	Total
1	Excavate Trench	15,000	cy	$ 4.50	$ 67,500
2	Intake Structure - CIP Concrete	1	ls	$ 7,000	$ 7,000
3	Intake Trash Rack - SS	1	ls	$ 5,000	$ 5,000
4	Gate, Stem, Stem Wall & Operator	1	ls	$ 36,000	$ 36,000
5	Outlet Structure - CIP Concrete	1	ls	$ 5,000	$ 5,000
6	Upstream Outlet Pipe - 18" HDPE, Concrete Encased	80	ft	$ 400	$ 32,000
7	Backfill Trench	15,000	cy	$ 5.50	$ 82,500
8	CIPP Liner, 140 ft	1	ls	$ 55,000	$ 55,000
9	Downstream Outlet Pipe, 18" HDPE, Filter Encased	60	ft	$ 165	$ 9,900
10	Unscheduled Items	15	%	$ 44,985	$ 44,985
	Base Total				$ 344,885
	Contingency	20	%		$ 68,977
	Total				$ 413,862

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3-Dec-11

Table No. 3

Cost Estimate for Outlet Replacement
Bergen No. 2 Dam

Option No. 3
Minimum Upstream Outlet Works Replacement, and Downstream in Reconstruction Area

	Item	Quantity	Unit	Unit Price	Total
1	Excavate Trench	2,000	cy	$ 6	$ 12,000
2	Intake Structure - CIP Concrete	1	ls	$ 7,000	$ 7,000
3	Intake Trash Rack - SS	1	ls	$ 5,000	$ 5,000
4	Gate, Stem, Stem Wall & Operator	1	ls	$ 36,000	$ 36,000
5	Outlet Structure - CIP Concrete	1	ls	$ 5,000	$ 5,000
6	Upstream Outlet Pipe - 18" HDPE, Concrete Encased	40	ft	$ 400	$ 16,000
7	Fill Tower with Concrete	5	cy	$ 400	$ 2,000
8	Backfill Trench	2,000	cy	$ 8	$ 16,000
9	CIPP Liner, 180 ft	1	ls	$ 65,000	$ 65,000
10	Downstream Outlet Pipe, 18" HDPE, Filter Encased	60	ft	$ 165	$ 9,900
11	Unscheduled Items	15	%	$ 26,085	$ 26,085
	Base Total				$ 199,985
	Contingency	20	%		$ 39,997
	Total				$ 239,982

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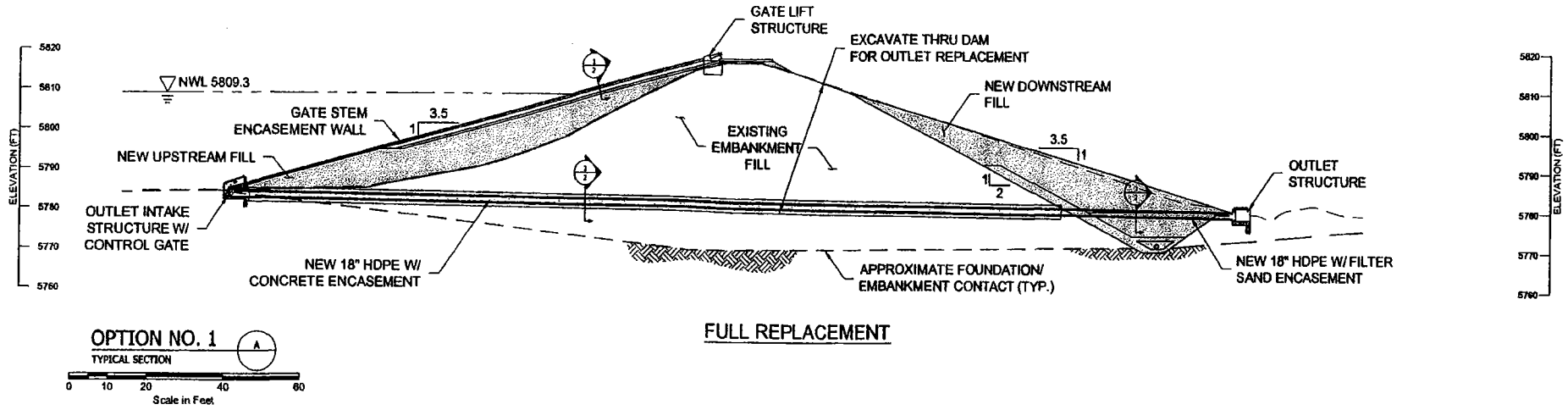
3-Dec-11



OPTION NO. 1
TYPICAL SECTION
A
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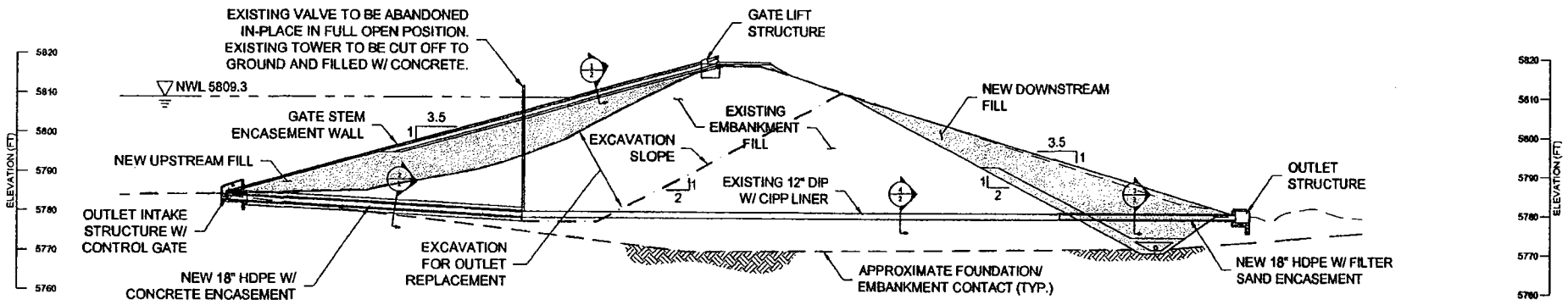
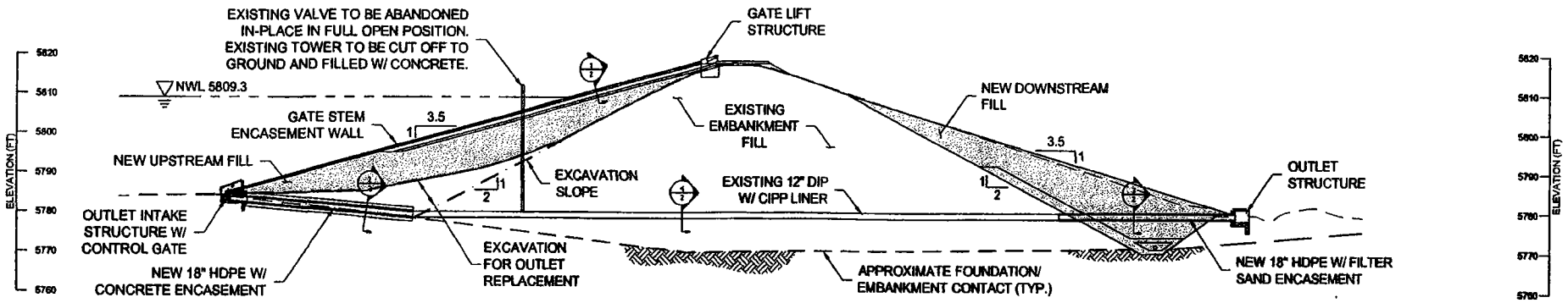
Scale in Feet

FULL REPLACEMENT



OPTION NO. 2
TYPICAL SECTION
B
0 10 20 40 60
Scale in Feet

UPSTREAM REPLACEMENT TO TOWER



OPTION NO. 3
TYPICAL SECTION
C
0 10 20 40 60
Scale in Feet

MINIMUM UPSTREAM REPLACEMENT

REFERENCE

DRAWING NO.	REFERENCE

REVISIONS

NO.	DATE	MADE BY	CKD. BY	REMARKS
1				
2				
3				
4				
5				
6				
7				

File Record	Record	By	Date
ORIGINAL PAPER SIZE 24" x 36"	Design	JAF	12/11
	Drawn	BAA	12/11
PLOT SCALE	Check		
			/
PEN SETTINGS DWG			/
			/
			/

Bergen Dam #2
Jefferson County, CO

Bergen Dam #2 Rehabilitation
Outlet Works Replacement Options

W. W. Wheeler and Associates, Inc.
Water Resources Engineers
Englewood, Colorado 80110

CLIENT: Bergen Ditch & Reservoir Co.

Wheeler Number: 620.04

SHEET

Scale: As Noted

Figure 1

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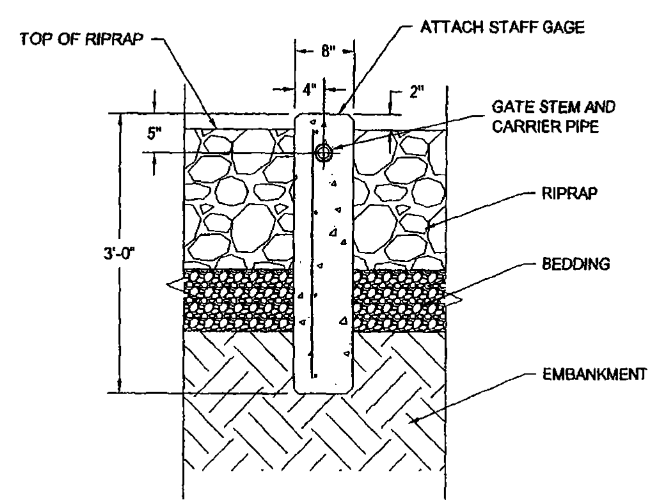
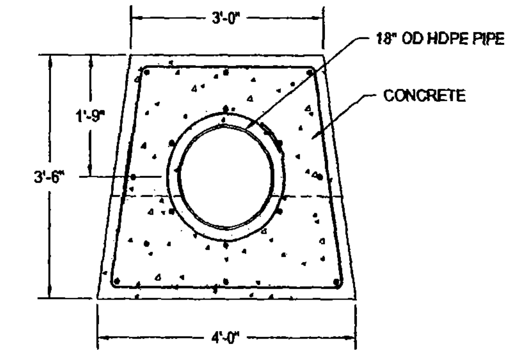


GATE STEM CONCRETE ENCASEMENT WALL (1)
SECTION
0 ½ 1 2 3
Scale In Feet



CONCRETE ENCASEMENT (2)
TYPICAL SECTION
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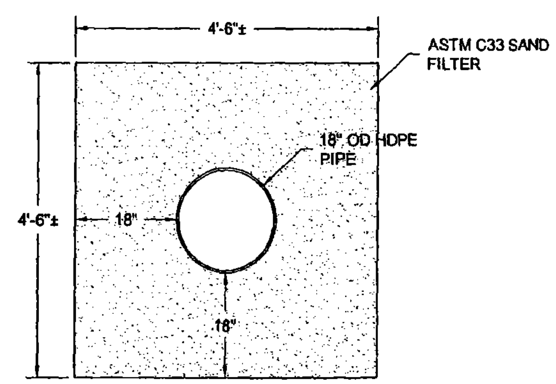
Scale In Feet



SAND FILTER COLLAR (3)
TYPICAL SECTION
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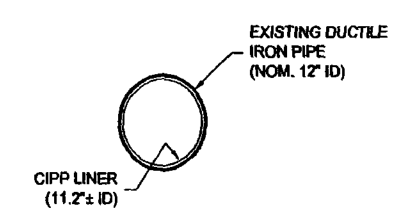
Scale In Feet



EXISTING 12" DIP WITH CIPP LINER (4)
TYPICAL SECTION
0 ½ 1 2 3
Scale In Feet

REFERENCE

DRAWING NO.	REFERENCE

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Bergen Dam #2
Jefferson County, CO

Bergen Dam #2 Rehabilitation
Outlet Works Replacement
Details

W. W. Wheeler and Associates, Inc.
Water Resources Engineers
Englewood, Colorado 80110

CLIENT: Bergen Ditch & Reservoir Co.

Wheeler Number: 620.04
SHEET
Scale: As Noted
Figure 2

Consolidated

Certificate of Incorporation

of

Bergen Ditch and Reservoir Co.

with Amendments through 11/18/68

Know all men by these presents that the undersigned, Thomas C. Bergen, George W. Harriman & John Morcam do hereby and by these presents become a body Corporate and Politic by and under the General Incorporation Laws of the State of Colorado.

1st. The name of said Corporation shall be the Bergen Ditch & Reservoir Co.

2nd. The object for which said Company is Incorporated is to construct and Maintain Ditches and Reservoirs for Storing and Selling Water for Irrigating purposes. The Reservoirs to be four in number said Reservoirs are Situated on Section Seventeen (17) & Eighteen (18) in Township five (5) south of Range Sixty nine (69) West in the County of Jefferson and State of Colorado. The part of said section (17) Seventeen to be used being a part of the W½ of the Northwest quarter ½ the ballance of said Reservoir being on Section Eighteen (18) near the middle thereof and on each and all of the quarters of said Section.

The Water for Supplying said Reservoirs to be taken from Turkey Creek near the South West corner of Section twelve (12) in Township five (5) S. Range Seventy west by a dtich Starting from the last named point and running thence in an Easterly or Northeasterly direction through said Section twelve (12) and through a part of Section Eighteen in Township five Range Sixty nine to the Reservoir afforesaid;

and also to acquire ditches and reservoirs for storing water and water rights, by purchase and otherwise, provided always that said company shall furnish no water to any persons except stockholders of the company. (4/22/93)

This corporation shall be known as a Mutual Ditch Company, not for profit, under the provisions of Secs. 2353 to 2364, inclusive, of the Compiled Laws of Colorado 1921 (2/24/27)

3rd. The Capital Stock of said Company shall be Twenty One Thousand Dollars ($21,000).

4th. Said Corporation shall exist for a perpetual term. (11/18/68).

5th. The Capital Stock of this Company shall be divided into Four Hundred and Twenty Shares of the par value of Fifty Dollars per share, which Stock shall be assessed as mutual ditch stock and subject to all of the provisions of the statute in such case made and provided. (10/7/37)

6th. The Trustees for the Management of the business of said Company for the first year shall be three (3) in number and shall be Thomas C. Bergen, George W. Harriman and John Morcam.

7th. The principal office of the company shall be maintained at Mt. Morrison in the County of Jefferson and the principal place of business of the company shall be the County of Jefferson, State of Colorado. The office of the Secretary shall be located from time to time by the Board of Directors; and meetings of the stockholders of the company may be held in the State of Colorado, wherever the directors may determine. (10/2/24)

8th. The Board of Directors shall have power to make suitable by-laws, and to amend or repeal the same; they shall also have power to make needful rules and regulations for the equitable and economical use of water, pro rata among the stockholders of the company; and to levy and collect assessments against the stockholders for the maintenance of the company's property; and to pay claims constituting valid indebtedness against the company, and for such purpose as may be permitted by law, and to enforce the collection of said assessments by the sale of the stock of any delinquent stockholder. At all stockholders' meetings, cumulative voting shall be allowed. (10/2/26)

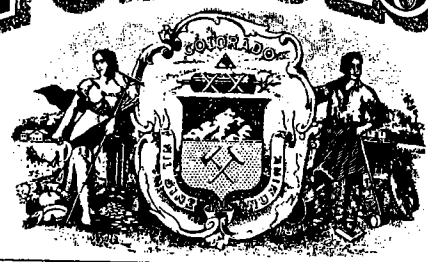
(Signrd) Thomas C. Bergen

" George W. Harriman

" John Morcam

A

STATE OF COLORADO



OFFICE OF THE SECRETARY OF STATE

UNITED STATES OF AMERICA,
STATE OF COLORADO. } ss.

CERTIFICATE.

I, Byron A. Anderson, Secretary of State of the State of Colorado, do hereby certify that the annexed are full, true and complete copies of Articles of Incorporation and Articles of Amendments to the Articles of Incorporation of

THE BERGEN DITCH AND RESERVOIR COMPANY

as filed in this office and admitted to record.

IN TESTIMONY WHEREOF I have hereunto set my hand and affixed the Great Seal of the State of Colorado, at the City of Denver this ---Twenty-First--- day of -------June--------- A. D. 1973

Byron A. Anderson
SECRETARY OF STATE.

BY Jeremiah J. Connolly
DEPUTY.

BYLAWS

OF THE

BERGEN DITCH AND RESERVOIR COMPANY

ARTICLE I
Principal Office

Section 1. The principal office and place of business of the Company in the State of Colorado shall be Foothills Park and Recreation District, 6612 South Ward Street, Littleton, Colorado 80127. Other offices and places of business may be established from time to time by resolution of the Board of Directors.

ARTICLE II
Shares and Transfer Thereof

Section 1. The shares of this Company shall be represented by certificates signed by the president or a vice president and the secretary or an assistant secretary of the Company and may be sealed with the seal of the Company or a facsimile thereof. The signatures of the president or vice president and the secretary or assistant secretary upon a certificate may be a facsimile if the certificate is countersigned by a transfer agent or registered by a registrar other than the Company itself or an employee of the Company. In case any officer who has signed a certificate shall have ceased to be such officer before such certificate is issued, it may be issued by the Company with the same effect as if he were such officer at the date of its issue.

Section 2. No new certificates evidencing shares shall be issued unless and until the old certificate or certificates in lieu of which the new certificate is issued shall be surrendered for cancellation except as provided in Section 3 of this Article II.

Section 3. In the case of loss or destruction of any certificate of shares, another certificate may be issued in its place upon satisfactory proof of such loss or destruction and, at the discretion of the Company, upon giving to the Company a satisfactory bond of indemnity issued by a corporate surety in an amount and for a period satisfactory to the Board of Directors.

Section 4. For the purpose of determining shareholders entitled to notice of or to vote at any meeting of shareholders or any adjournment thereof, or entitled to receive payment of any dividend, or in order to make a determination of shareholders for any other proper purpose, the Board of Directors may provide that the stock transfer books shall be closed for a stated period not to exceed in any case fifty (50) days. If the stock transfer books shall be closed for the purpose of determining shareholders entitled to notice of or to vote at a meeting of shareholders, such books shall be closed for at least ten (10) days immediately preceding such meeting. In lieu of closing the stock transfer

books, the Board of Directors may fix in advance a date as the record date for any such determination of shareholders, such date in any case to be not more that fifty (50) days and, in the case of a meeting of shareholders, not less than ten (10) days prior to the date on which the particular action requiring such determination of shareholders is to be taken. If the Board of Directors does not order the stock transfer books closed or fix in advance a record date as above provided, then the record date for the determination of shareholders entitled to notice of or to vote at any meeting of shareholders or any adjournment thereof, or entitled to receive payment of any dividend, or for the determination of shareholders for any proper purpose shall be thirty (30) days prior to the date on which the particular action requiring such determination of shareholders is to be taken.

ARTICLE III
Shareholders and Meetings Thereof

Section 1. Only shareholders of record on the books of the Company shall be entitled to be treated by the Company as holders in fact of the shares standing in their respective names, and the Company shall not be bound to recognize any equitable or other claim to or interest in any shares on the part of any other person, firm, whether or not it shall have express or other notice thereof, except as expressly provided by the laws of Colorado.

Section 2. Meetings of shareholders shall be held at such place as determined by the Board of Directors.

Section 3. In the absence of a resolution of the Board of Directors providing otherwise, the annual meeting of shareholders of the Company for the election of directors and for the transaction of such other business as may properly come before the meeting shall be held on the second Monday in January in each year if the same be not a legal holiday, and if a legal holiday, then on the next succeeding business day, at 5pm. If a quorum be not present, the meeting may be adjourned from time to time, but no single adjournment shall exceed sixty (60) days.

Section 4. Special meetings of shareholders may be called by the president (or in his absence by a vice president), the Board of Directors, or the holders of not less than one-tenth of all shares entitled to vote on the subject matter for which the meeting is called.

Section 5. Written notice stating the place, day and hour of the shareholders' meeting, and in case of a special meeting of shareholders the purpose or purposes for which the meeting is called, shall be delivered not less than ten (10) days or more than fifty (50) days before the date of the meeting, either personally or by mail at the direction of the president, the secretary, the Board of Directors or the officer or person calling the meeting, to each shareholder of record entitled to vote at such meeting, except that if the authorized shares are to be increased, at least thirty (30) days' notice shall be given. If mailed, such notice shall be deemed to be delivered when deposited in the United States

mail addressed to the shareholder at his address as it appears on the stock transfer books of the Company with postage thereon prepaid, but if three (3) successive letters mailed to the last-known address of any shareholder of record are returned as undeliverable, no further notices to such shareholder shall be necessary, until another address for such shareholder is made known to the Company. Failure to deliver such notice or obtain a waiver thereof shall not cause the meeting to be lost, but it shall be adjourned by the shareholders present for a period not to exceed sixty (60) days until any deficiency in notice of waiver shall be supplied.

Section 6. The officer or agent having charge of the stock transfer books for shares of this Company shall make, at least ten (10) days before each meeting of shareholders, a complete record of the shareholders entitled to vote at such meeting or any adjournment thereof, arranged in alphabetical order, with the address of and the number of shares held by each, which record, for a period of ten (10) days prior to such meeting shall be kept on file at the principal office of the Company, whether within or outside Colorado, and shall be subject to inspection by any shareholder for any purpose germane to the meeting at any time during usual business hours. Such record shall also be provided and kept open at the time and place of the meeting and shall be subject to the inspection of any shareholder during the whole time of the meeting. The original stock transfer books shall be prima facie evidence as to who are the shareholders entitled to examine such record or transfer books or to vote at any meeting of shareholders.

Section 7. A quorum at any meeting of shareholders shall consist of a majority of the shares of the Company entitled to vote thereat, represented in person or by proxy. If a quorum it present, the affirmative vote of a majority of the shares represented at the meeting and entitled to vote on the subject matter, shall be the act of the shareholders unless the vote of a greater number or voting by classes if required by law.

Section 8. A shareholder may vote either in person or by proxy executed in writing by the shareholder or by his duly authorized attorney in fact. No proxy shall be valid after eleven (11) months from the date of its execution unless otherwise provided in the proxy.

ARTICLE IV
Directors, Powers and Meetings

Section 1. The business and affairs of the Company shall be managed by a board of three (3) directors, each of whom shall be of the age eighteen (18) years or older, and are owners of at least one (1) share of stock or have a direct relationship, whether business or personal, to such shareholder(s), and who shall be elected at the annual meeting of shareholders or some adjournment thereof. At least one director shall be elected from the minority shareholders. Directors shall hold office until the next succeeding annual meeting of shareholders or until their successor shall have been elected and shall qualify; however, no provision of this Section shall be restrictive upon the right of the Board of Directors to fill vacancies or upon the right of shareholder to remove directors as is hereinafter provided.

Section 2. The annual meeting of the Board of Directors shall be held at the same place as and immediately after the annual meeting of shareholders, and no notice shall be required in connection therewith. The annual meeting of the Board of Directors shall be for the purpose of electing officers and the transaction of such other business as may come before the meeting.

Section 3. Special meetings of the Board of Directors may be called at any time by the president (or in his absence by a vice president) or by any director and may be held within or outside of the State of Colorado at such time and place as the notice of waiver thereof may specify. Notice of such meetings shall be mailed or telegraphed to the last-known address of each director in person or by telephone at least forty-eight (48) hours prior to the date or time fixed for the meeting. Special meetings of the Board of Directors may be held at any time that all Directors are present in person, and presence of any Director at a meeting shall constitute waiver of notice of such meeting except as otherwise provided by law. Unless specifically required by law or these Bylaws, neither the business to be transacted at, nor the purpose of any meeting of the Board of Directors need to specified in the notice or waiver of notice of such meeting.

Section 4. A quorum at all meetings of the Board of Directors shall consist of a majority of the number of Directors then fixed by these Bylaws, but a smaller number may adjourn from time to time without further notice until a quorum be secured. The act of a majority of the directors present at a meeting at which a quorum is present shall be the act of the Board of Directors unless the act of a greater number is required by law or these Bylaws.

Section 5. Any vacancy occurring in the Board of Directors may be filled by the affirmative vote of a majority of the remaining directors though less than a quorum of the Board of Directors. A director elected to fill a vacancy shall be elected for the unexpired term of his predecessor in office and shall hold such office until his successor is duly elected and shall qualify. Any directorship to be filled by reason of an increase in the number of directors shall be filled by the affirmative vote of a majority of the directors then in office or by an election at an annual meeting or at a special meeting of shareholders called for that purpose. A director chosen to fill a position resulting from an increase in the number of directors shall hold office until the next annual meeting of shareholders and until his successor shall have been elected and shall quality.

Section 6. Directors may receive such fees as may be established by appropriate resolution of the Board of Directors for attendance at meetings of the Board and in addition thereof shall receive reasonable traveling expense, or other actual expense if any is required, for attendance at such meetings.

Section 7. The Board of Directors may by resolution adopted by a majority of the number of directors, designate from among its members an executive committee, and one or more other committees, each of which, to the extent provided in the resol ution or the Bylaws of the Company, shall have all of the authority of the Board of Directors; but

no such committee shall have the authority of the Board of Directors in reference to amending the Bylaws, adopting a plan of merger or consolidation, recommending to the shareholders the sale, lease, exchange, or other disposition of all or substantially all of the property and assets of the Company otherwise than in the usual and regular course of its business, recommending to the shareholders a voluntary dissolution of the Company or a revocation thereof, or amending the Bylaws of the Company. The designation of such committees and the delegation thereto of authority shall not operate to relieve the Board of Directors, or any member thereof, of any responsibility imposed by law.

Section 8. The shareholders may, at a meeting called for the express purpose of removing Directors, by a majority vote of the shares entitled to vote at an election of Directors, remove the entire Board of Directors or any lesser number with or without cause.

Section 9. Members of the Board of Directors or any committee designated by the Board may participate in a meeting of the Board or committee by means of conference telephone or similar communications equipment by which all persons participating in the meeting can hear each other at the same time. Such participation shall constitute presence in person at the meeting.

Section 10. No contract or other transaction between a Company and one or more of its directors or any other company, firm, association, or entity in which one or more of its directors are directors or officers or are financially interested shall be either void or voidable solely because of such relationship or interest or solely because such directors are present at the meeting of the Board of Directors or a committee thereof which authorizes, approves or ratifies such contract or transaction or solely because their votes are counted for such purpose of:

(a) The fact of such relationship or interest is disclosed or known to the Board of Directors or committee which authorizes, approves, or ratifies the contract or transaction by a vote or consent sufficient for the purpose without counting the votes or consents of such interested directors; or

(b) The fact of such relationship or interest is disclosed or known to the shareholders entitled to vote and they authorize, approve, or ratify such contract or transaction by vote or written consent; or

(c) The contract or transaction is fair and reasonable to the Company.

Common or interested Directors may be counted in determining the presence of a quorum at a meeting of the Board of Directors or a committee thereof which authorizes, approves, or ratifies such contract or transaction.

ARTICLE V
Officers

Section 1. The elective officers of the Company shall be a president, one or more vice presidents, a secretary and a treasurer, who shall be at least eighteen (18) years old and who shall be elected by the Board of Directors at its first meeting after the annual meeting of shareholders. Unless removed in accordance with procedures established by law and these Bylaws, said officers shall serve until the next annual meeting of the Board of Directors and until their respective successors are elected and shall qualify. Any two offices, but not more than two, may be held by the same person at the same time, except that one person may not simultaneously hold the offices of president and vice president or those of president and secretary. The election of one or more vice presidents of the Company shall be optional with the Board of Directors.

Section 2. The Board may elect or appoint a general manager, one or more assistant secretaries and one or more assistant treasurers, as it may deem advisable, who shall hold office during the pleasure of the Board and shall be paid such compensation as may be directed by the Board.

Section 3. The officers of the Company shall respectively exercise and perform the respective powers, duties and functions as are stated below, and as may be assigned to them by the Board of Directors:

(a) The president shall be the chief executive officer of the Company and shall, subject to the control of the Board of Directors, have general supervision, direction and control of the business and officers of the Company. He shall preside at all meetings of the shareholders and of the Board of Directors. The president or a vice president, unless some other person is specifically authorized by the Board of Directors, shall sign all stock certificates, bonds, deeds, mortgages, leases and contracts of the Company. The president shall perform all the duties commonly incident to his office and such other duties as the Board of Directors shall designate.

(b) In the absence or disability of the president, the vice president or vice presidents in order of their rank as fixed by the Board of Directors, and if not ranked the vice presidents in the order designated by the Board of Directors, shall perform all the duties of the president and when so acting shall have all the powers of and be subject to all the restrictions of the president. Each vice president shall have such other powers and perform such other duties as may from time to time be assigned to him by the president.

(c) The secretary shall keep accurate minutes of all meetings of the shareholders and the Board of Directors. He shall keep or cause to be kept a register of the shareholders of the Company and shall be responsible for the giving of notice of the meetings of the shareholders or of the Board of Directors. The secretary shall be the custodian of the records and of the seal of the Company and shall attest the affixing of the seal of the Company when so authorized. The secretary shall perform all duties commonly incident to his office and

such other duties as may from time to time be assigned to him by the president.

(d) An assistant secretary may at the request of the secretary of in the absence or disability of the secretary, perform all of the duties of the secretary. He shall perform such other duties as may be assigned to him by the president or by the secretary.

(e) The treasurer, subject to the order of the Board of Directors, shall have the care and custody of the money, funds, valuable papers and documents of the Company. He shall keep accurate books of accounts of the Company's transactions which shall be the property of the Company, and shall render financial reports and statements of condition of the Company when so requested by the Board of Directors or president. The treasurer shall perform all duties commonly incident to his office and such other duties as may from time to time be assigned to him by the president.

(f) An assistant treasurer may at the request of the treasurer or in the absence or disability of the treasurer perform all of the duties of the treasurer. He shall perform such other duties as may be assigned to him by the president or by the treasurer.

Section 4. All officers of the Company may receive salaries or other compensation if so ordered and fixed by the Board of Directors. The Board shall have authority to fix salaries in advance for stated periods or render the same retroactive as the Board may deem advisable.

Section 5. In the event of absence or inability of any officer to act, the Board of Directors may delegate the powers or duties of such officer to any other officer, director or person whom it may select.

Section 6. Any officer or agent may be removed by the Board of Directors at a meeting called for that purpose whenever in its judgment the best interests of the Company will be served thereby, but such removal shall be without prejudice to the contract rights, if any, of the person so removed. Election or appointment of an officer or agent shall not of itself create contract rights.

ARTICLE VI

Section 1 – Shares of Stock and Water Rights. Each stockholder shall be entitled to a certificate representing his shares of stock. The shares of stock shall represent the rights of the respective owners to the use of water in the Company's system and ownership in the Company's land. Each share of the capital stock of this Company shall entitle its owners of record, on the books of the Company, to use each year a pro rata share of all the water carried and distributed in the waterways of said Company under the direction of the Board of Directors. No charge shall be made for the water; all expenses

shall be defrayed from assessments levied upon the stock. All water shall be measured at the point of delivery by the Company into the laterals of the consumers. No water shall be delivered or furnished to any stockholder who shall be in arrears in the payment of any assessment upon the shares of stock owned by him. If in times of shortage of water, the Company may devise a system of delivering water to groups of stockholders in rotation, no check or obstruction of any kind shall be placed in any ditch or lateral of the Company.

Shares of stock shall be freely transferable, but only upon the books of the Company upon the surrender of the original certificate, properly endorsed, and all certificates which are surrendered and cancelled shall be by the secretary reattached to the proper stubs in the certificate book. No stock shall be transferred until all assessments and charges thereon are fully paid.

Stock certificates for one or more shares will not be split and transferred in denominations less than one share after November 18, 1968, provided, however, that all certificates for less than one share outstanding on November 18, 1968, will continue to be transferable, but may not be split.

When the capacity of a lateral ditch is less than required to serve all stockholders using the ditch, priority shall be accorded to the users of the ditch in the order of first use. This priority shall survive the sale of the land so long as the shares shall be sold with the land to the same purchaser. The responsibility of lateral ditch operation and maintenance shall be on the stockholders using the lateral ditch.

Section 2 – Assessments. All assessments shall be levied by the Board of Directors pro rata upon all of the stock of the Company, and any assessment may be made payable in one or several installments. The time or times of payment of the assessments shall be determined in the resolution levying the same. The secretary shall mail to each stockholder of record, at his post office address, as shown on the books of the Company, a notice of such assessment, the amount thereof, and the time or times when the same is payable. If any stockholder shall not have registered his post office address with the secretary, he shall be deemed to have waived notice by mail of all assessments. All notice of levying of any assessment and the time of payment may be waived by unanimous consent of all the stockholders. The Company shall have a paramount lien on all stock held or subscribed by each stockholder to secure payment of the subscription price of assessments levied on the stock of each stockholder.

Section 3 – Collection of Assessments. If assessments are not paid, the interest upon such assessments and cost of collecting such assessments, and interest, by sale, suit or otherwise, shall be levied upon his stock at the time fixed for payment thereof shall pay interest upon his delinquent subscription, or upon all delinquent amounts, at the rate of eighteen percent (18%) per annum for each month or fraction thereof that such amount shall remain unpaid, and in case such default shall continue for the period of three calendar months, the secretary shall report the same to the Board of Directors, who may order the stock sold to the highest bidder at public auction, for the purpose of payment of

the amount due to the Company, and the costs and expenses of the sale. In the event the Board of Directors shall order the stock sold, as aforesaid, the secretary shall make demand upon the stockholder for the amount due by mailing a notice to his address, as shown upon the books of the Company, notifying him that said stock shall be sold if payment is not made. If payment shall not be made within ten (10) days from the mailing of such notice by the secretary, the secretary shall cause notice of public sale to be given by publishing the same for two weeks in any weekly newspaper published in Jefferson County, Colorado, which notice shall state the name or names of the delinquent stockholders, the number of shares delinquent, and the time and place of the sale; and he shall also deposit in the post office, postage prepaid, a similar notice addressed to the delinquent stockholders, and all other stockholders, at their addresses as the same appear upon the stock book of the Company. At such sale, sufficient of said stock shall be sold to pay the amount due, together with interest and cost of publication and making the sale. The amount realized from the sale in excess of the amount due on the subscription or assessment, with interest at eighteen percent (18%) per anum from the time when the same became due, and expense of the notice and sale, shall be paid to the stockholder or stockholders whole shares were forfeited and sold, a new certificate shall be issued to the purchaser at such sale for the stock so sold and a suitable notation made on the books of the Company to show such transfer. At the option of the Board of Directors, suit may be brought against any stockholder to recover the amount of any assessment or any part thereof remaining unpaid, and the interest due thereon.

ARTICLE VII
Finance

Section 1. The Board of Directors, in its uncontrolled discretion, may set aside from time to time out of the net profits or earned surplus of the Company, such sum or sums as it deems expedient as a reserve fund to meet contingencies, for equalizing dividends, for maintaining any property of the Company and for any other purpose.

Section 2. The moneys of the Company shall be deposited in the name of the Company in such bank or banks or trust companies as the Board of Directors shall designate and may be drawn out only on checks signed in the name of the Company by such person or persons as the Board of Directors by appropriate resolution may direct. Notes and commercial paper, when authorized by the Board, shall be signed in the name of the Company by such officer or officers or agent or agents as shall thereunto be authorized from time to time.

Section 3. The fiscal year of the Company shall be determined by resolution of the Board of Directors.

ARTICLE VIII
Waiver of Notice

Any shareholder, officer or director may waive in writing any notice required to be given by law or under these Bylaws whether before or after the time stated therein.

ARTICLE IX
Action Without A Meeting

Nothing contained in these Bylaws shall be construed so as to prevent any action required to be taken at a meeting of the Directors, executive committee, or other committees of the Directors if there be any, or shareholders of this Company, or any action which may be taken at a meeting of Directors, executive committee if there be one, or shareholders, to be taken without a meeting if a consent in writing setting forth the action so taken shall be signed by all of the Directors, committee members if there be any committees, or shareholders entitled to vote with respect to the subject matter thereof.

ARTICLE X
Indemnification of Directors and Officers

Section 1. The Company shall indemnify any person who was or is a party or is threatened to be made a party to any threatened, pending, or completed action, suit, or proceeding, whether civil, criminal, administrative, or investigative (other than an action by or in the right of the Company), by reason of the fact that he is or was a director, officer, employee, or agent of the Company or is or was serving at the request of the Company as a director, officer, employee, or agent of another company, partnership, joint venture, trust, or other enterprise, against expenses (including attorneys' fees), judgments, fines, and amounts paid in settlement actually and reasonably incurred by him in connection with such action, suit, or proceeding if he acted in good faith and in a manner he reasonably believed to be in the best interests of the Company and, with respect to any criminal action or proceeding, had no reasonable cause to believe his conduct was unlawful. The termination of any action, suit or proceeding by judgment, order, settlement, or conviction or upon a plea of nolo contendere or its equivalent shall not of itself create a presumption that the person did not act in good faith and in a manner which he reasonably believed to be in the best interests of the Company and, with respect to any criminal action or proceeding, had reasonable cause to believe that his conduct was unlawful.

Section 2. The Company shall indemnify any person who was or is a party or is threatened to be made a party to any threatened, pending, or completed action or suit by or in the right of the Company to procure a judgment in its favor by reason of the fact that he is or was a director, officer, employee, or agent of the Company or is or was serving at the request of the Company as a director, officer, employee, or agent of another company, partnership, joint venture, trust, or other enterprise against expenses (including attorneys' fees) actually and reasonably incurred by him in connection with the defense or settlement of such action or suit if he acted in good faith and in a manner reasonably believed to be in the best interests of the Company; but no indemnification shall be made in respect to any claim, issue, or matter as to which such person has been adjudged to be liable for negligence or misconduct in the performance of his duty to the Company unless and only to the extent that the court in which such action or suit was brought determines upon application that, despite the adjudication of liability, but in view of all circumstance

of the case, such person is fairly and reasonably entitled to indemnification for such expenses which such court deems proper.

Section 3. To the extent that a director, officer, employee, or agent of a Company has been successful on the merits in defense of any action, suit or proceeding referred to in Section 1 or 2 of this Article X or in defense of any claim, issue, or mater therein, he shall be indemnified against expenses (including attorneys' fees) actually and reasonably incurred by him in connection therewith.

Section 4. Any indemnification under Section 1 or 2 of this Article X (unless ordered by the court) shall be made by the Company only as authorized in the specific case upon a determination that indemnification of the director, officer, employee, or agent is proper in the circumstances because he has met the applicable standard of conduct set forth in said Section 1 or 2. Such determination shall be made by the Board of Directors by a majority vote of a quorum consisting of Directors who were not parties to such action, suit, or proceeding, or , if such a quorum is not obtainable or even if obtainable a quorum of disinterested directors so directs, by independent legal counsel in a written opinion, or by the shareholders.

Section 5. Expenses (including attorneys' fees) incurred in defending a civil or criminal action, suit, or proceeding may be paid by the Company in advance of the final disposition of such action, suit, or proceeding as authorized in Section 4 of this Article X upon receipt of an undertaking by or on behalf of the director, officer, employee, or agent to repay such amount unless it is ultimately determined that he is entitled to be indemnified by the Company as authorized in this Article X.

Section 6. The indemnification provided by this Article X shall not be deemed exclusive of any other rights to which those indemnified may be entitled by agreement, vote of shareholders or disinterested directors, or otherwise, and any procedure provided for by any of the foregoing, both as to action in his official capacity and as to action in another capacity while holding such office, and shall continue as to a person who has ceased to be a director, officer, employee, or agent and shall inure to the benefit of heirs, executors, and administrators of such a person.

Section 7. Upon approval of the Board of Directors, this Company may purchase and maintain insurance on behalf of any person who is or was a director, officer, employee, or agent of the Company or who is or was serving at the request of the Company as a director, officer, employee, or agent of another company, partnership, joint venture, trust, or other enterprise against any liability asserted against him and incurred by him in any such capacity or arising out of his status as such, whether or not the Company would have the power to indemnify him against such liability under the provisions of this Article X.

ARTICLE XI
Amendments

ARTICLE XI
Amendments

These Bylaws may be altered, amended or repealed at the annual meeting of the Board of Directors or at any special meeting of the Board called for that purpose subject to repeal or change by action of the shareholders, as required by law.

The above Bylaws were approved and adopted by the Bergen shareholders on the 9th day of January 2006.

Stanton La Breche

Stanton La Breche, Secretary

Table G-1
Bergen No. 1 Reservoir
First of Month Storage
(All Values in Acre-Feet)

Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1936	0	0	0	0	0	0	60	138	60	60	88	63
1937	102	102	160	158	152	158	158	125	185	75	39	0
1938	0	0	0	0	0	112	512	512	354	325	24	224
1939	125	173	195	220	224	512	512	470	165	165	50	0
1940	0	0	0	0	0	125	431	165	85	0	0	0
1941	0	0	0	0	0	224	415	512	384	302	204	125
1942	58	204	328	380	420	446	479	479	204	204	185	112
1943	112	112	112	112	112	224	400	512	446	302	185	145
1944	112	112	112	112	112	125	512	512	446	354	250	185
1945	13	13	13	13	17	112	415	479	384	98	85	85
1946	85	85	85	85	85	204	224	145	85	58	19	13
1947	13	13	185	185	185	446	512	512	512	446	224	112
1948	314	415	415	415	415	512	512	512	446	50	50	42
1949	42	42	42	42	42	42	185	446	512	512	224	112
1950	85	85	85	85	85	85	112	224	277	185	0	0
1951	0	0	0	0	0	0	250	384	446	302	25	13
1952	12	13	13	13	13	13	446	512	446	165	58	42
1953	25	25	25	25	25	25	25	185	125	58	42	42
1954	25	25	25	25	25	25	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	415	415	415	277	224	185
1958	185	185	185	185	145	165	328	446	446	302	277	277
1959	224	224	224	224	224	224	512	512	512	354	302	250
1960	277	277	277	227	227	227	512	512	446	384	277	277
1961	204	204	204	204	204	204	512	512	479	415	250	250
1962	302	302	302	302	302	302	512	512	415	112	85	72
1963	72	72	72	72	72	72	58	42	25	17	17	17
1964	17	17	17	17	17	17	150	150	125	85	72	58
1965	50	50	50	50	50	50	50	480	500	500	500	500
1966	500	500	500	500	500	475	400	300	100	70	60	60
1967	60	60	60	60	60	60	33	33	225	295	225	200
1968	70	70	70	70	70	60	475	475	350	300	285	200
1969	100	100	100	100	100	100	40	500	500	355	300	250
1970	250	250	384	384	384	384	512	512	445	385	250	145
1971	75	75	75	75	65	65	460	460	460	325	275	200
1972	130	130	130	130	130	100	95	95	75	75	70	70
1973	40	100	100	100	100	100	125	500	500	415	320	300
1974	300	300	300	300	300	300	515	515	515	415	384	384
1975	270	270	270	270	270	350	588	587	587	515	415	370
1976	354	354	354	354	340	328	372	587	587	479	415	354
1977	354	354	354	354	302	277	415	580	479	446	384	384
1978	328	277	277	277	277	277	277	415	479	415	328	277
1979	240	240	240	240	240	240	479	587	587	446	446	415
1980	415	415	415	415	415	415	446	512	527	415	384	354
1981	354	354	354	354	354	354	354	354	446	415	415	415
1982	384	384	384	384	384	384	384	384	512	479	446	446
1983	446	446	446	446	446	446	446	500	587	587	587	415
1984	302	302	302	302	302	302	302	302	302	277	277	250
1985	250	250	250	204	204	125	384	384	384	384	384	384
1986	384	384	384	384	384	384	384	384	384	354	354	354
1987	354	384	384	NR	NR	NR	NR	NR	NR	NR	NR	446
1988	446	446	446	446	446	479	479	479	354	380	380	380
1989	302	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	172
1990	172	172	186	188	207	294	400	406	395	383	361	350
1991	349	330	339	340	263	343	398	423	395	346	369	349
1992	216	228	247	288	312	390	398	403	380	371	360	349
1993	331	325	321	315	322	325	393	380	330	311	297	289
1994	290	283	280	280	290	301	396	371	324	299	291	264
1995	259	226	233	239	238	241	390	390	390	334	346	334
1996	319	319	305	294	297	297	430	430	423	384	369	334
1997	315	308	311	299	299	423	423	423	398	400	389	384
1998	384	380	384	396	413	423	412	396	386	372	372	352
1999	334	333	325	322	318	314	423	423	393	393	400	377
2000	365	368	371	371	371	365	381	390	374	378	349	340
2001	331	291	293	293	291	293	423	390	390	359	381	365
2002	394	280	280	280	291	322	359	317	204	162	148	144
2003	146	152	152	35	35	150	390	374	390	343	328	322
2004	313	313	313	313	313	390	390	390	390	390	390	390
2005	380	384	384	384	384	423	390	390	381	359	317	288
2006	274	274	299	299	299	328	328	319	308	250	235	235
2007	225	305	365	390	390	390	390	390	346	328	308	225
2008	144	144	144	144	144	390	390	390	453	343	334	272
2009	272	272	272	272	154	154	390	390	390	390	328	179
2010	74	74	74	74	74	359	390	390	390	296	277	272
2011	72	72	72	72	72	200	300	346	381	390	371	371

Table G-2
Bergen No. 2 Reservoir
First of Month Storage
(All Values in Acre-Feet)

Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1936	65	65	60	60	60	60	0	254	140	25	88	15
1937	131	131	182	180	176	264	398	500	500	280	122	104
1938	35	30	25	58	241	241	773	773	450	325	80	80
1939	50	113	113	113	113	372	863	684	390	94	50	0
1940	0	0	0	0	0	0	0	0	0	0	0	0
1941	0	0	0	0	0	67	645	910	684	490	192	94
1942	94	94	94	94	94	423	773	773	351	357	133	94
1943	172	172	172	172	172	172	342	490	423	325	192	113
1944	94	94	94	94	94	133	684	863	728	390	192	133
1945	133	133	133	133	133	133	172	357	325	133	133	133
1946	94	298	272	272	272	272	272	218	113	67	67	40
1947	40	40	272	272	272	272	684	910	910	750	490	390
1948	390	605	357	357	357	773	818	818	605	325	94	40
1949	21	67	21	21	21	21	133	567	863	773	390	133
1950	133	133	133	133	133	133	133	133	133	133	0	0
1951	0	0	0	0	0	0	94	218	605	298	272	218
1952	172	94	94	94	94	94	192	863	684	272	94	67
1953	40	40	40	40	0	0	0	53	53	40	26	26
1954	21	21	21	21	21	21	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	272	684	684	490	456	456
1958	390	390	390	390	325	325	728	728	728	684	490	423
1959	357	390	390	390	390	510	910	910	728	605	527	390
1960	560	605	645	645	645	775	910	910	818	490	490	456
1961	456	456	456	456	456	863	910	910	818	681	490	567
1962	728	863	863	863	863	863	910	818	605	278	245	218
1963	218	218	218	218	218	218	175	173	70	60	60	60
1964	40	40	40	40	40	40	863	685	645	357	300	245
1965	150	150	150	150	150	150	250	250	250	250	250	250
1966	775	775	775	775	775	820	850	500	94	80	70	70
1967	70	70	70	70	70	70	400	605	900	900	750	500
1968	300	300	300	300	300	680	900	900	600	450	400	325
1969	220	220	220	200	200	200	490	860	850	565	450	390
1970	490	645	775	775	775	775	850	850	850	680	490	450
1971	450	450	450	450	450	700	800	800	800	565	450	40
1972	30	30	30	30	30	55	100	175	190	175	150	150
1973	110	110	110	110	110	245	600	600	600	500	390	350
1974	350	350	350	350	350	500	600	600	600	525	490	490
1975	500	533	500	500	500	600	600	600	600	600	470	423
1976	390	390	390	390	390	525	525	527	527	527	527	527
1977	527	527	527	527	456	490	605	605	605	456	456	456
1978	423	423	423	423	423	456	490	645	645	605	567	567
1979	490	490	490	490	490	567	605	605	605	527	527	490
1980	423	423	423	423	423	456	605	605	605	527	415	415
1981	415	415	415	415	415	456	490	645	645	645	645	645
1982	567	567	567	567	567	567	567	684	684	684	684	684
1983	684	684	684	684	684	684	684	684	684	684	684	605
1984	456	456	456	456	456	456	490	490	567	527	527	423
1985	423	423	423	423	423	152	390	390	423	605	567	527
1986	527	527	527	527	527	490	490	567	567	490	456	298
1987	272	527	527	NR	NR	NR	NR	NR	NR	NR	NR	298
1988	298	298	298	298	298	384	423	400	360	325	245	113
1989	80	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	309
1990	309	309	309	290	282	298	510	610	606	520	259	429
1991	341	344	343	342	414	407	386	656	607	535	498	475
1992	344	344	468	468	462	628	652	590	612	559	552	490
1993	473	477	474	473	477	487	660	652	622	515	477	489
1994	456	446	443	439	440	446	672	660	593	523	484	456
1995	423	413	394	381	363	354	410	733	713	632	574	548
1996	530	519	501	491	508	508	456	456	672	606	535	512
1997	501	487	491	490	487	493	672	672	612	585	570	564
1998	564	601	601	612	632	656	696	686	678	612	603	582
1999	570	571	570	563	558	524	559	713	688	639	652	632
2000	612	614	617	617	614	621	602	645	722	673	602	556
2001	445	409	409	409	409	409	452	735	718	673	594	515
2002	449	452	449	449	442	449	442	439	396	374	393	353
2003	350	347	344	456	456	456	730	735	698	594	541	409
2004	380	380	377	377	377	386	755	755	755	693	726	713
2005	705	710	710	710	710	714	735	735	685	673	579	575
2006	556	556	452	452	452	452	393	384	362	350	255	248
2007	245	556	556	594	653	756	756	756	739	714	726	645
2008	567	567	567	567	567	567	756	756	693	685	673	594
2009	425	425	425	245	245	245	318	756	756	756	747	731
2010	673	730	718	714	706	706	756	756	756	718	685	673
2011	653	625	614	614	614	606	594	594	602	657	606	545

Table G-3
Deane Reservoir
First of Month Storage Contents
(All Values in Acre-Feet)

Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1936	50	50	12	12	12	12	12	60	95	12	17	12
1937	82	82	375	375	365	365	535	375	375	445	312	199
1938	150	128	128	128	230	230	475	510	445	410	250	250
1939	249	150	150	150	150	327	478	410	199	128	50	0
1940	0	0	0	0	0	2	2	0	0	0	0	0
1941	0	0	0	0	0	50	375	518	375	312	312	199
1942	199	199	199	199	199	252	445	445	312	282	107	68
1943	68	68	68	68	68	68	68	478	375	282	150	128
1944	107	107	107	107	107	107	375	518	445	342	107	50
1945	50	50	50	50	50	50	50	252	252	128	107	107
1946	50	0	0	0	0	0	0	50	34	34	50	50
1947	50	50	50	50	50	50	445	445	445	342	252	128
1948	128	128	128	128	128	128	282	312	282	128	34	34
1949	34	34	34	34	34	34	128	223	478	445	282	68
1950	68	68	68	68	68	68	68	68	68	68	0	0
1951	0	0	0	0	0	0	174	312	342	352	68	50
1952	50	19	19	19	19	19	128	445	375	150	107	34
1953	19	19	19	19	19	5	5	107	87	50	34	34
1954	34	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	225	478	478	375	252	252
1958	250	252	252	252	199	199	410	410	375	375	199	107
1959	87	87	87	87	87	87	478	478	445	252	225	174
1960	174	174	174	174	174	174	518	518	445	375	150	128
1961	87	87	87	87	87	87	500	500	445	375	200	200
1962	312	312	312	312	312	312	445	445	375	225	150	128
1963	107	107	107	107	107	107	50	34	19	10	10	10
1964	10	10	10	10	10	10	100	100	85	50	50	34
1965	35	35	35	35	35	35	285	300	500	450	400	375
1966	285	285	285	280	280	300	450	300	150	100	95	95
1967	95	95	95	95	95	95	100	135	475	475	375	300
1968	350	350	350	340	340	350	450	475	400	350	300	285
1969	100	100	100	100	100	100	175	315	500	375	340	285
1970	400	518	518	518	518	518	518	518	518	445	375	300
1971	315	315	315	315	300	300	480	480	480	375	300	175
1972	85	85	85	85	85	85	80	125	125	50	50	50
1973	50	85	85	85	85	110	315	500	500	410	375	345
1974	345	345	345	345	345	450	520	520	520	440	410	380
1975	265	285	285	285	285	340	495	518	515	445	400	400
1976	312	312	312	312	312	312	396	518	518	342	282	282
1977	288	288	288	288	320	375	520	520	478	342	312	282
1978	225	225	225	225	225	225	225	368	410	375	312	252
1979	107	107	107	107	107	128	342	535	535	445	375	342
1980	282	282	282	282	282	312	518	518	518	478	342	225
1981	150	150	150	150	150	150	150	199	312	312	174	34
1982	34	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	50
1983	50	50	50	50	50	50	68	199	445	478	478	410
1984	342	342	342	342	342	342	342	342	342	312	312	282
1985	252	252	252	252	225	225	312	375	375	312	252	225
1986	128	128	128	128	128	128	128	128	150	125	107	107
1987	107	110	128	NR	NR	NR	NR	NR	NR	NR	NR	225
1988	225	225	225	225	225	50	50	19	9	9	34	34
1989	34	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	260
1990	260	260	267	273	276	292	396	414	375	404	407	358
1991	411	411	411	400	400	397	389	393	481	455	444	475
1992	341	393	386	383	382	459	181	476	481	462	450	429
1993	410	407	407	404	404	481	481	470	447	404	407	372
1994	368	368	365	365	0	459	458	462	398	355	308	282
1995	276	305	295	267	273	276	295	470	485	455	436	418
1996	411	411	414	418	382	386	447	447	474	411	368	411
1997	407	402	402	397	393	418	493	485	481	379	331	311
1998	311	338	341	344	348	462	497	489	466	455	427	404
1999	372	356	355	326	312	351	497	493	466	433	422	404
2000	386	356	367	360	356	413	431	512	464	413	409	409
2001	395	381	381	384	398	402	483	483	468	449	438	405
2002	349	438	438	438	434	430	442	449	360	316	268	244
2003	232	223	223	223	223	296	483	468	468	456	388	456
2004	416	416	409	409	409	412	471	490	405	394	423	401
2005	391	384	384	384	384	504	508	449	431	413	420	453
2006	442	442	420	420	420	402	442	303	259	235	300	296
2007	284	442	442	442	442	449	504	516	431	349	377	353
2008	431	431	431	431	431	431	516	516	452	368	322	409
2009	438	438	438	438	438	438	438	516	516	471	406	456
2010	474	474	474	474	474	474	508	508	438	385	306	306
2011	385	385	385	385	378	375	368	348	319	287	284	309

Table G-4
Bergen Headgate Diversions
(All Values in Acre-Feet)

Year	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Total
1950	0.0	0.0	0.0	0.0	47.6	184.5	255.9	150.7	0.0	0.0	0.0	0.0	638.7
1951	0.0	0.0	0.0	0.0	0.0	456.2	410.6	476.0	0.0	0.0	0.0	0.0	1,342.8
1952	0.0	0.0	0.0	0.0	0.0	1,301.2	1,616.6	682.3	0.0	0.0	0.0	0.0	3,600.1
1953	0.0	0.0	0.0	0.0	0.0	202.3	366.9	152.7	0.0	0.0	0.0	0.0	722.0
1954	0.0	0.0	0.0	0.0	0.0	0.0	43.6	0.0	0.0	0.0	0.0	0.0	43.6
1955	0.0	0.0	0.0	0.0	55.5	119.0	0.0	0.0	0.0	0.0	0.0	0.0	174.5
1956	0.0	0.0	0.0	0.0	0.0	839.0	1,116.7	325.3	59.5	249.9	43.6	0.0	2,634.1
1957	0.0	0.0	0.0	0.0	99.2	847.0	495.9	420.5	0.0	0.0	0.0	0.0	1,862.5
1958	0.0	0.0	0.0	0.0	0.0	0.0	325.3	85.3	0.0	0.0	0.0	29.8	440.3
1959	0.0	0.0	0.0	0.0	0.0	0.0	83.3	95.2	0.0	0.0	0.0	0.0	178.5
1960	0.0	0.0	0.0	0.0	0.0	0.0	117.0	238.0	0.0	57.5	0.0	0.0	412.6
1961	0.0	0.0	0.0	0.0	0.0	0.0	311.4	101.2	0.0	0.0	0.0	0.0	412.6
1962	0.0	0.0	0.0	0.0	0.0	0.0	29.8	67.4	0.0	0.0	0.0	0.0	97.2
1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	101.2	176.5	232.1	99.2	29.8	638.7
1964	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1965	No Record												
1966	No Record												
1967	No Record												
1968	No Record												
1969	No Record												
1970	0.0	0.0	0.0	0.0	0.0	208.3	41.7	279.7	132.9	0.0	0.0	123.0	785.5
1971	0.0	0.0	0.0	0.0	119.0	337.2	529.6	79.3	0.0	0.0	0.0	0.0	1,065.1
1972	0.0	0.0	0.0	0.0	39.7	93.2	353.1	0.0	0.0	0.0	0.0	0.0	486.0
1973	No Record												
1974	0.0	0.0	0.0	0.0	0.0	117.0	244.0	134.9	123.0	123.0	119.0	123.0	983.8
1975	0.0	0.0	0.0	0.0	0.0	0.0	152.7	146.8	146.8	0.0	0.0	0.0	446.3
1976	0.0	0.0	0.0	0.0	0.0	0.0	47.6	101.2	0.0	0.0	0.0	0.0	148.8
1977	0.0	0.0	0.0	0.0	0.0	19.8	75.4	0.0	0.0	0.0	0.0	0.0	95.2
1978	0.0	0.0	0.0	0.0	0.0	0.0	27.8	0.0	0.0	0.0	0.0	0.0	27.8
1979	No Record												
1980	No Record												
1981	No Record												
1982	No Record												
1983	No Record												
1984	No Record												
1985	No Record												
1986	No Record												
1987	No Record												
1988	No Record												
1989	25.8	0.0	0.0	0.0	0.0	55.5	0.0	0.0	39.7	0.0	0.0	0.0	121.0
1990	0.0	0.0	0.0	0.0	37.1	82.5	203.5	293.8	12.5	20.3	0.0	0.0	649.7
1991	0.0	0.0	0.0	3.2	118.0	431.2	146.4	125.0	39.3	0.0	0.0	0.0	863.0
1992	15.3	7.3	0.0	4.2	40.1	113.1	328.3	146.6	3.6	1.0	5.0	0.0	664.3
1993	0.0	0.0	30.1	56.3	360.2	60.5	45.2	52.2	0.0	0.0	0.0	0.0	604.6
1994	0.0	0.0	0.0	11.9	110.3	338.2	0.0	0.0	0.0	0.0	0.0	0.0	460.4
1995	0.0	0.0	0.0	0.0	161.5	432.8	16.5	0.0	0.0	0.0	0.0	0.0	610.7
1996	0.0	0.0	0.0	0.0	6.5	293.4	651.2	31.1	0.0	0.0	0.0	0.0	982.2
1997	0.0	0.0	0.0	0.0	23.0	250.7	16.3	216.7	0.0	0.0	0.0	0.0	506.6
1998	0.0	0.0	0.0	0.0	223.3	467.7	32.3	12.1	0.0	0.0	0.0	0.0	735.5
1999	0.0	0.0	0.0	14.7	304.1	72.4	0.0	0.0	0.0	0.0	0.0	0.0	391.1
2000	0.0	0.0	0.0	0.0	50.0	306.5	133.9	0.0	0.0	0.0	0.0	0.0	490.3
2001	0.0	0.0	0.0	89.1	90.4	208.5	144.8	0.0	0.0	0.0	0.0	0.0	532.8
2002	0.0	0.0	0.0	0.0	129.6	399.9	280.5	0.0	0.0	0.0	0.0	0.0	810.1
2003	0.0	0.0	0.0	0.0	236.5	815.9	0.0	0.0	0.0	0.0	0.0	0.0	1,052.3
2004	0.0	0.0	0.0	0.0	56.1	708.6	255.3	140.2	120.8	91.5	35.7	0.0	1,408.3
2005	0.0	0.0	0.0	0.0	198.5	51.5	0.0	0.0	0.0	0.0	0.0	0.0	250.0
2006	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.2	0.0	0.0	0.0	53.2
2007	161.8	153.4	0.0	244.1	844.2	299.3	29.9	0.0	0.0	0.0	0.0	0.0	1,732.7
2008	0.0	0.0	0.0	0.0	357.7	327.3	0.0	0.0	0.0	0.0	0.0	0.0	685.0
2009	0.0	0.0	0.0	0.0	170.6	472.5	728.5	0.0	0.0	0.0	0.0	0.0	1,371.7
2010	0.0	0.0	0.0	0.0	303.0	59.7	0.0	0.0	0.0	0.0	0.0	0.0	362.6
2011	0.0	0.0	0.0	0.0	158.3	169.6	362.7	212.2	68.2	0.0	0.0	0.0	971.0
Average	3.3	2.6	0.5	6.7	68.9	176.9	159.0	77.3	15.5	12.3	4.8	4.8	729.3

Source: DWR Records

Table G-5
Maximum Annual Fill of Bergen Reservoirs [1]
(All Values in Acre-Feet)

Water Year	No. 1	No. 2	Deane	Total Maximum	Comments
Current Storage	390	726	516	1,632	Full
1950	277	133	68	478	Not Filled
1951	446	605	342	1,393	Not Filled
1952	512	863	445	1,820	
1953	185	53	107	345	Not Filled
1954	25	40	NR	84	Not Filled
1955	NR	NR	NR	NR	No Record
1956	NR	NR	NR	NR	No Record
1957	415	684	478	1,577	
1958	446	728	410	1,584	
1959	512	910	NR	1,596	
1960	512	910	518	1,940	
1961	512	910	500	1,922	
1962	512	NR	445	1,175	Not Filled
1963	72	218	128	418	Not Filled
1964	150	863	100	1,113	Not Filled
1965	500	750	500	1,750	
1966	500	850	450	1,800	
1967	295	900	475	1,670	
1968	475	900	475	1,850	
1969	500	860	500	1,860	
1970	512	850	518	1,880	
1971	NR	NR	NR	NR	No Record
1972	NR	NR	NR	NR	No Record
1973	NR	NR	NR	NR	No Record
1974	515	600	520	1,635	
1975	588	600	518	1,706	
1976	587	527	518	1,632	
1977	580	605	520	1,705	
1978	479	645	410	1,534	
1979	587	605	535	1,727	
1980	527	605	518	1,650	
1981	446	645	312	1,403	Not Filled
1982	512	684	NR	1,196	No Record
1983	587	684	478	1,749	
1984	302	567	342	1,211	Not Filled
1985	384	605	375	1,364	Not Filled
1986	384	567	150	1,101	Not Filled
1987	NR	NR	NR	NR	No Record
1988	479	423	225	1,127	Not Filled
1989	NR	NR	NR	NR	No Record
1990	406	610	414	1,430	Not Filled
1991	423	656	481	1,560	
1992	403	652	481	1,536	
1993	393	660	481	1,534	
1994	396	672	462	1,530	
1995	390	733	485	1,608	
1996	430	672	474	1,576	
1997	423	672	493	1,588	
1998	423	696	497	1,616	
1999	423	713	497	1,633	
2000	390	722	512	1,624	
2001	423	735	483	1,641	
2002	394	452	449	1,295	Not Filled
2003	390	735	483	1,608	
2004	390	755	490	1,635	
2005	423	735	508	1,666	
2006	328	556	442	1,326	Not Filled
2007	390	756	516	1,662	
2008	453	756	516	1,725	
2009	390	756	516	1,662	
2010	390	756	508	1,654	
2011	390	657	399	1,446	Not Filled

Notes: [1] Bergen No. 1, No. 2 and Deane Reservoirs

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