INTRODUCTION

The City of Fresno originally developed in the late 1800's in a natural low-lying area where Dry Creek emptied into the valley floor. The area was called the "Sinks of Dry Creek." As the City grew, its susceptibility to flood damages also grew. For many years the City addressed flooding conditions with limited solutions on an individual site basis of the flooding location. Often the burden of dealing with the flooding fell to the businesses and residents that had developed in the lower lying areas.

In order to address this problematic flooding, on May 13, 1955 the Fresno Metropolitan Flood Control Act became law, which was a result of efforts by the local citizenry. The Act created a special district to address drainage and flood control solutions. Since its formation the FMFCD has developed and is following a flood control and storm drainage master plan, which calls for the systematic completion of an area-wide flood control system and numerous local drainage systems. In the beginning, there was no coordinated or comprehensive flood control or drainage program in the community. Since that time, FMFCD developed a comprehensive storm drainage and flood control master plan and has worked jointly with the cities of Fresno and Clovis on many improvement projects. FMFCD has completed numerous facilities including major flood control structures, local drainage basins and many hundred miles of storm drainage pipelines that now provide permanent, local drainage service to more than 75% of the Fresno/Clovis area.

FMFCD's flood control program focuses on controlling flood flows from an extensive network of streams which extend into the Fresno/Clovis area from the adjoining foothills. The streams carry runoff from a 175 square mile area that reaches an elevation of 5,000 feet in the Sierra-Nevada. The streams flow to the valley floor where they periodically inundate farmland and urban development. Storm flows have caused the local streams and canals to overflow an average of once every four years since 1953. Until the late 1940's, the largest flood threat was from Big Dry Creek, an 81.7 square mile watershed upland of the City. In February 1948, the Big Dry Creek Dam was completed and provided protection that would control approximately a 60-year, 30-day event.

With the formation of the FMFCD, FMFCD was delegated the control of such storm flows through a planned system of dams and reservoirs, detention basins, channel improvements and stream controls. The initial planning work was completed in 1957 and it is documented in a report often referred to as the "Nolte Report".

Subsequently, FMFCD became the local sponsor of a federal project with responsibility for the major elements of the system. Please refer to Figure 3-1 as a general reference to features of the Project and its relationship to the federal project, identified as the Redbank and Fancher Creeks Flood Control Project, a cooperative effort by the United States Army Corps of Engineers ("USACE"), the State of California and the FMFCD.

In the Local Cooperation Agreement, between the USACE and the FMFCD, FMFCD accepted the responsibility for the operation and maintenance of the Big Dry Creek Dam and appurtenances from the federal government. Big Dry Creek Dam and all of its appurtenances are not part of the State Plan of Flood Control. Water Code Section 8523 defines the State Plan of Flood Control as limited to the Sacramento and San Joaquin River watersheds. Water Code Section 12646 (e) further states, "The Sacramento-San Joaquin Valley does not include the lands lying within the Tulare Lake basin, including the Kings River" (see Figure 3-10). Volume 3, Regional Reports (Tulare Lake) of the California Water Plan Update 2009 identifies the Fresno/Clovis area as being within the Tulare Lake Basin. Thus, the Fresno/Clovis metropolitan area is qualified for the Proposition 1E funds, which are designated for areas not part of the State Plan of Flood Control.

The Project will promote water conservation by (i) capturing stormwater and recharging it to the local groundwater aquifer (the primary source of drinking water supply - currently in substantial overdraft), (ii) improving the volume of imported water that can be recharged into the local groundwater basin during the non-rainy season, and (iii) using captured stormwater as a supply for irrigation of the perimeter of landscaped basins.

These benefits are incorporated into the Upper Kings Basin Integrated Regional Water Management Plan ("IRWMP"). The Fresno Metropolitan's Flood Control District Service Plan is a Foundational Action identified in the IRWMP, meeting the specific IRWMP objectives of conjunctive use, flood management, water quality, and environmental management. The IRWMP further describes how FMFCD, with the assistance of Fresno Irrigation District ("FID"), captures stormwater through joint use facilities designed for both flood control and groundwater recharge purposes. This strategy was listed as "a good example of how recharge/retention ponds and canal facilities can be integrated to meet multiple objectives…"

Functionality

FMFCD has a very complex flood control and urban storm drainage system. The flood control system is comprised of natural streams, flood control dams, reservoirs, and detention basins. The urban storm drainage system is comprised of pipeline collection systems and detention basins.

The Fresno area is unique such that there are no natural drainages that leave the area. The geology of the area is alluvium deposited by the San Joaquin River on the north and the Kings River on the south leaving the Fresno Area lower than the original banks of the rivers. An exception to this is the Big Dry Creek Channel, now mostly converted to an irrigation canal by the predecessors of the Fresno Irrigation District (FID). The Big Dry Creek conveyed storm water generated from the Dry Creek watershed southwesterly to the "Sinks of Dry Creek" where it would accumulate and eventually percolate into the soil. Without the natural drainages to remove flood water from the area, the local canals and pipelines owned by FID are utilized for this purpose. FMFCD has an agreement with FID to use their system for flood water conveyance, but their system has capacity limitations and discharges to it must be managed very carefully to avoid flooding outside of the canals.

FMFCD's urban storm water collection system is a combination of pipelines and storm water detention basin located throughout the Fresno and Clovis area. The basins have a finite capacity and are not designed to contain the total runoff from all storms that may occur. Generally they can store up to 6" of rainfall runoff. Due to this limited capacity, the captured storm water must be released from the basins as soon as possible to make room for additional water that may enter the system. The water is continually released into the FID system as canal capacity will permit. FMFCD's flood control system must also use the FID system to route the flood waters. During storm events, FMFCD's major flood control features north and easterly of the urban area capture and detain flood water before it enters the urban area. This allows the urban basins time to be "dewatered" and canal capacity made available for the flood water detained in the flood control reservoirs outside of the urban area. Most of the flood control facilities were designed and constructed by the USACE in the early 1990's as part of the Redbank and Fancher Creeks Project and provide as a minimum, protection from the 200 year return frequency storm event. Exception to this is the Redbank Creek Dam and Reservoir, the Holland Creek Re-Diversion Project and the Fancher Creek Detention Basin, which were constructed by FMFCD. The flood control features are located on major stream courses such as Fancher Creek, Redbank Creek, Pup Creek, Big Dry, and Dog Creek. FID's Big Dry Creek Canal is utilized to dewater 34 upland basins of FMFCD's 154 urban storm water management basins. However, because of the inter-relationship of flood flows routing in various canals and dewatering of urban stormwater basins, any storage increase lessens the burden of the flood flows in the canals. Having additional storage and flood routing capabilities generated by the Dry Creek Flood Control Improvement Project will greatly benefit the local area and the potential ground water recharge potential will benefit the overall regional groundwater basin.

Background/History

<u>Big Dry Creek Dam</u>

The Big Dry Creek Dam is located in the foothills of the western slopes of the Sierra Nevada Mountains, in eastern Fresno County, between the San Joaquin and Kings Rivers. The Big Dry Creek Dam is situated on Dry Creek at the northeasterly fringe of the Clovis City limits. The Big Dry Creek Dam was constructed by USACE in 1948 and later modified by the USACE. The original main embankment consisted of an earth filled dam with a maximum height of 37 feet and a length of 21,000 feet. The reservoir provided flood detention for a gross pool of 16,250 acre-feet. The reservoir was designed to provide a 60-year level of protection to the cities of Clovis and Fresno and suburban areas.

Modifications to the Big Dry Creek Dam started in 1992 as part of the Redbank and Fancher Creeks Project. The homogenous rolled earth filled dam was extended to 25,300 feet long with the crest being raised 7.5 feet to an elevation of 442.2 USGS datum (providing a maximum height of about 44 feet). The Big Dry Creek Dam has a concrete Ogee spillway with a crest length of 550 feet with a crest elevation of 432.7 USGS datum. The Standard Project Flood Pool is 30,300 acre-feet at a storage pool elevation of 432.7 USGS datum. The project was completed in August of 1993 and modifications were made to control flows from the upper 81.7 square mile of the Big Dry Creek and Dog Creek watersheds.

The maximum water historically stored behind the Big Dry Creek Dam, from the storm event of January, 1997, was about 12,632 acre-feet or a storage pool at 422.5 elevation USGS datum. Sustained seepage and sand boils were observed at the toe of the dam at the historical storage level. The diagram below identifies the proposed tow drain improvement of Big Dry Creek Dam as Figure 3-1-1.

Figure 3-1-1: Big Dry Creek Dam

Pup Creek-Enterprise Detention Basin

The Pup Creek-Enterprise Detention Basin is located in Fresno County, situated just easterly of the City of Clovis' Sphere of Influence and located approximately two (2) miles directly south of the Big Dry Creek Dam. It is generally located between Herndon, DeWolf, Paul and Leonard Avenues bordered to the north by the Enterprise Canal.

Figure 3-1-2: Pup Creek-Enterprise Detention Basin

The Pup Creek drainage system is comprised of four (4) different tributaries and referenced for identification purposes as; (i) the North Tributary, (ii) the main Pup Creek Channel, (iii) Tributary No. 1 and (iv) Tributary No. 2. The attenuation of peak flow is only needed on the main Pup Creek Channel. The main channel of Pup Creek flows generally through the center of the Pup Creek-Enterprise Detention Basin as it is shown in Figure 3-1-2. The Pup Creek-Enterprise Detention Basin site is 17 acres in size located partly within the 100-year floodplain (please see Figure 3-1-3 Floodplain Map). FMFCD utilizes a flood routing model created by the USACE to plan its flood routing and flood protection systems. The model was intended to safely route the 200 year flood event through the complex integrated stream and irrigation system through the urban area. However, the model has not proven to be fully accurate and FMFCD is correcting the model and adding flood protection features to do so. The model assumed the entire runoff from the Pup Creek watershed could be conveyed to the Pup Creek Detention Basin located approximately one mile downstream of the proposed Pup Creek-Enterprise Detention Basin. But, due to a flood routing deficiency at the Enterprise Canal, 147 cubic feet per second (cfs) of the peak flow in this tributary will overtop the bank and enter the Enterprise Canal. This is due to the limited capacity of the culvert under the Enterprise Canal and the head developed on the upstream side of the canal rising to overtop the bank. Currently, only 15 cfs will flow beneath the canal at the maximum head (Figure 3-1-4: Routing Diagram). Water entering the canal at this point will usurp capacity planned for other flood flow routing and overflow the canal banks downstream. Even without other flood flows in the canal, the downstream canal capacity is not adequate to convey 147 cfs. The Pup Creek Channel and floodplain between the proposed Pup Creek-Enterprise Detention Basin and the Pup Creek Basin has been encroached upon such that this channel too cannot convey the full flow without causing major flooding. As an additional benefit of the project feature, the flows will be detained in the basin and released at rates that will not cause flooding in the downstream area.

Figure 3-1-3: Floodplain Map

After considering several other alternates to convey this water to the original intended location of the Pup Creek Detention Basin, it became obvious that the best option was to purchase the Pup Creek-Enterprise Detention Basin site and create detention storage at that location. The 17 acre site is large enough when fully excavated to provide the offsetting capacity needed (approximately 200 acre-feet) to detain the flood flows and release it at the capacity available in either the Pup Creek channel or during non-critical flows to the Enterprise Canal.

Figure 3-1-4: Routing Diagram

The grant request excludes the excavation of the basin below grade to defer this large expense and allow contractors desiring fill material to remove the material without public expense. However, when such material is removed, the project feature will improve in its performance to attenuate peak flows.

The Pup Creek-Enterprise Detention Basin is tributary to the Big Dry Creek Channel. All of the water from the watershed is ultimately conveyed downstream in the Big Dry Creek (see Figure 3-1-5: Pup Creek-Dry Creek Routing Diagram). The Pup Creek system downstream of the Pup Creek Basin (before reaching Dry Creek) has limited capacity and also serves to convey water away from four (4) urban drainage systems in Clovis. Storage at the Pup Creek-Enterprise Detention Basin will provide additional control and relief of flood conditions in Clovis. The flood flow benefit also continues downstream of the confluence of Pup Creek with Dry Creek and several downstream urban drain systems will also benefit from any detained water (reduction in flow) at the Pup Creek-Enterprise Detention Basin.

The Pup Creek-Enterprise Detention Basin will also be utilized for groundwater recharge and provide additional wildlife habitat. The open space and water availability at this basin, like many other FMFCD detention facilities has demonstrated an attractive location for wildlife.

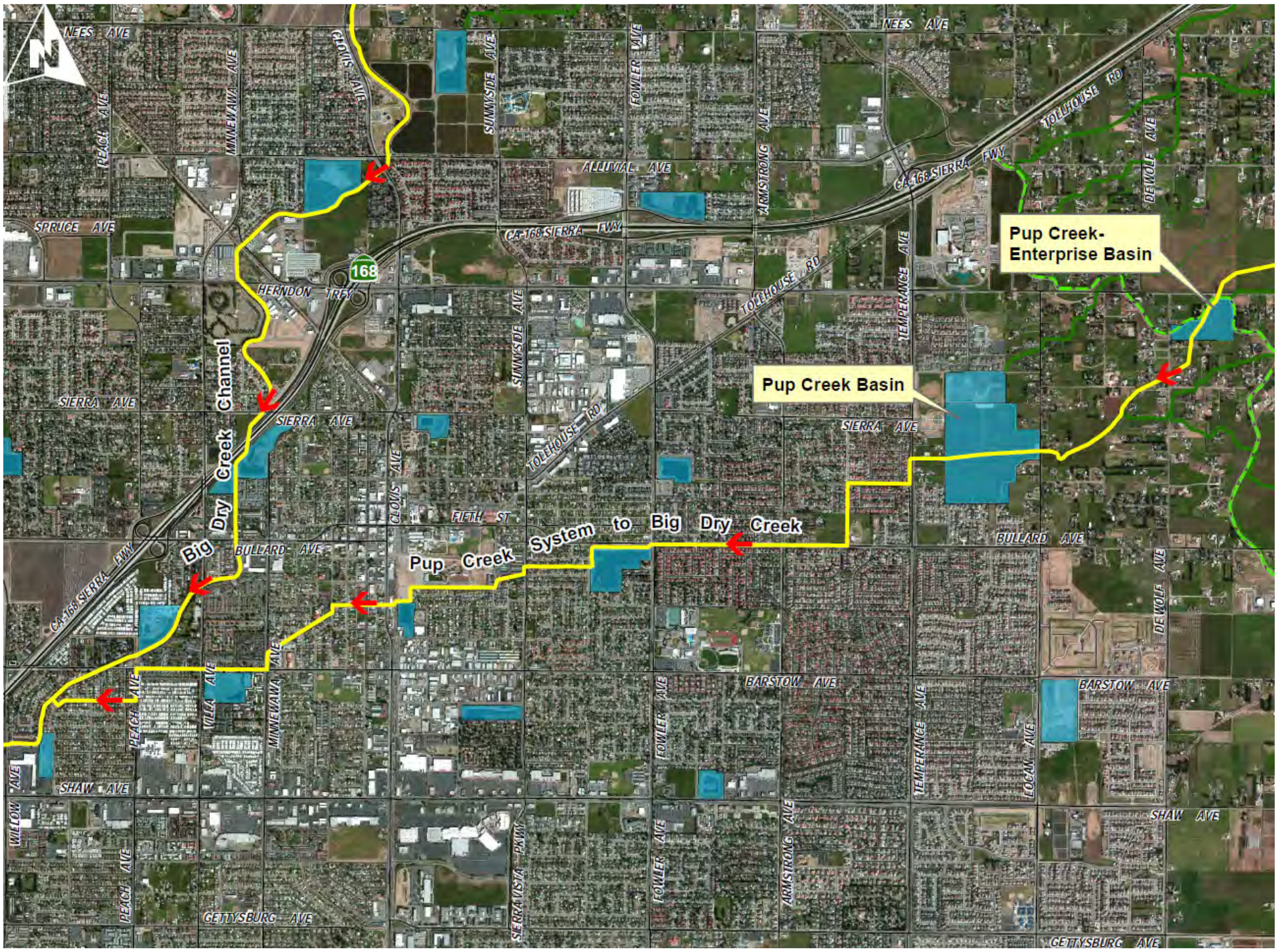

Figure 3-1-5: Pup Creek – Dry Creek Routing Diagram

<u>Big Dry Creek Detention Basin</u>

The Big Dry Creek Detention Basin is a 25 acre site and is positioned at the easterly side of the City of Fresno, located approximately seven (7) miles downstream of the Big Dry Creek Dam, south of Ashlan Avenue and east of Freeway 168. It is located adjacent to the City of Fresno's groundwater recharge facilities called Leaky Acres and at the confluence of Big Dry Creek and the Gould Canal. An 11.4 acre portion of the property is being acquired by the State of California (State) for drainage purposes for Freeway 168 and subsequently transferring ownership to the FMFCD. An additional 13.8 acres is owned by the City of Fresno, Department of Aviation and it is being acquired by FMFCD.

Presently, urban Drainage Area "C" does not meet FMFCD's stormwater storage capacity standards. With the combination of the parcels mentioned above and their convenient location, the design capacity for the site is a gross pool of approximately 259.8 acre-feet. Also, it will not only provide services to Freeway 168 but with the extra storage capacity, FMFCD can attenuate flood flows from Big Dry Creek and/or the Gould Canal and provide stormwater storage capacity for this area to bring the drainage area to FMFCD's standards.

Please reference Figure 3-1-6 for the proposed configuration of Big Dry Creek Detention Basin and for the location of Drainage Area "C".

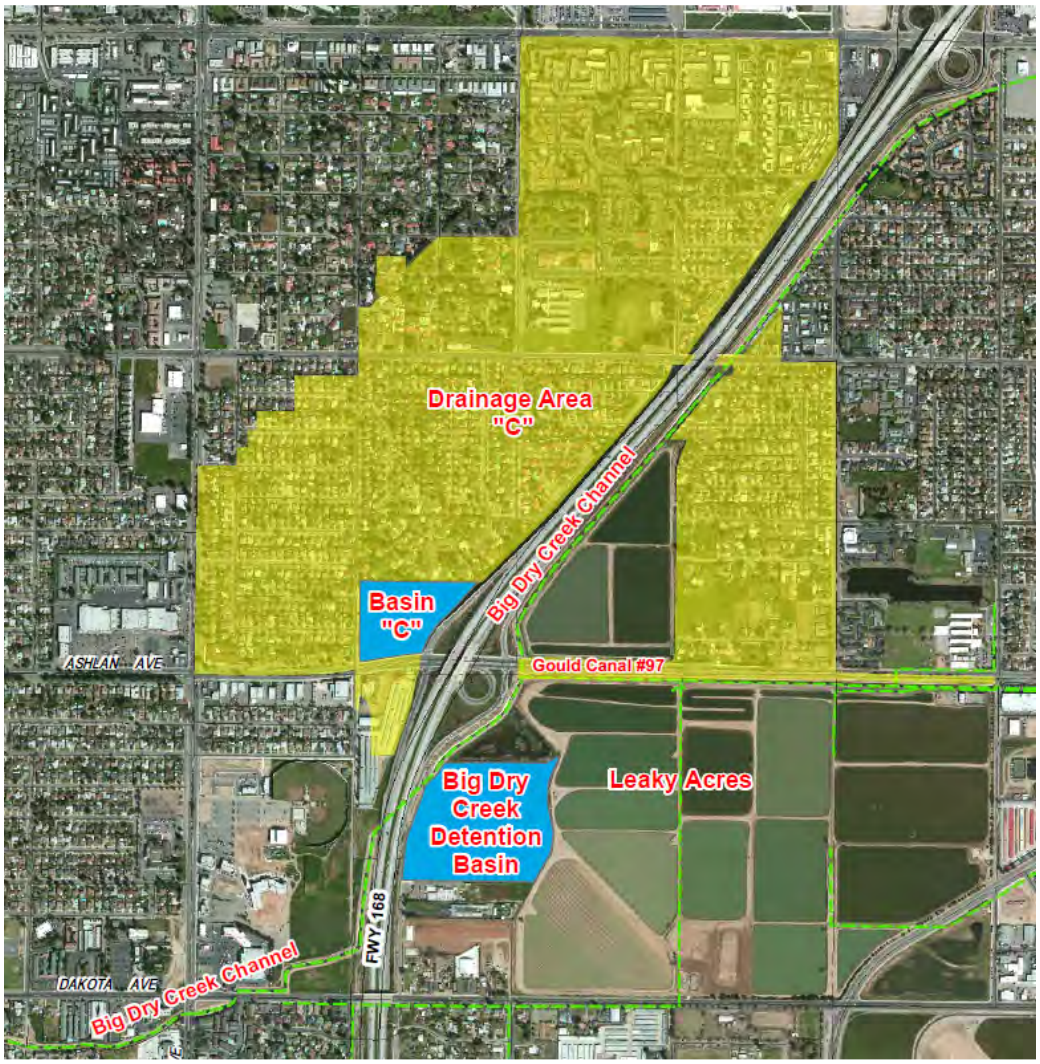

Figure 3-1-6: Big Dry Creek Detention Basin

<u>Dry Creek Extension Basin</u>

The Dry Creek Extension Basin is in Fresno County, located about 16 miles downstream of the dam. It is situated east of Dry Creek and just southwesterly of the Fresno City limits. Its general location is between Jensen, Annadale, Brawley and Blythe Avenues bordered to the north by the Fanning Ditch. FMFCD currently owns 20 acres and is interested in acquiring an adjacent 23 acres east of its 20 acre parcel. The proposal for this site is to convert it into one detention and recharge basin. According to the Ultimate Basin design, the basin will be capable of storing 795 acre-feet improving the overall flood protection and provide additional stormwater storage capacity. Currently, the excavation work for the 20 acre site is being completed by the former owner under contract with FMFCD.

Figure 3-1-7 shows the configuration of Dry Creek Extension Basin.

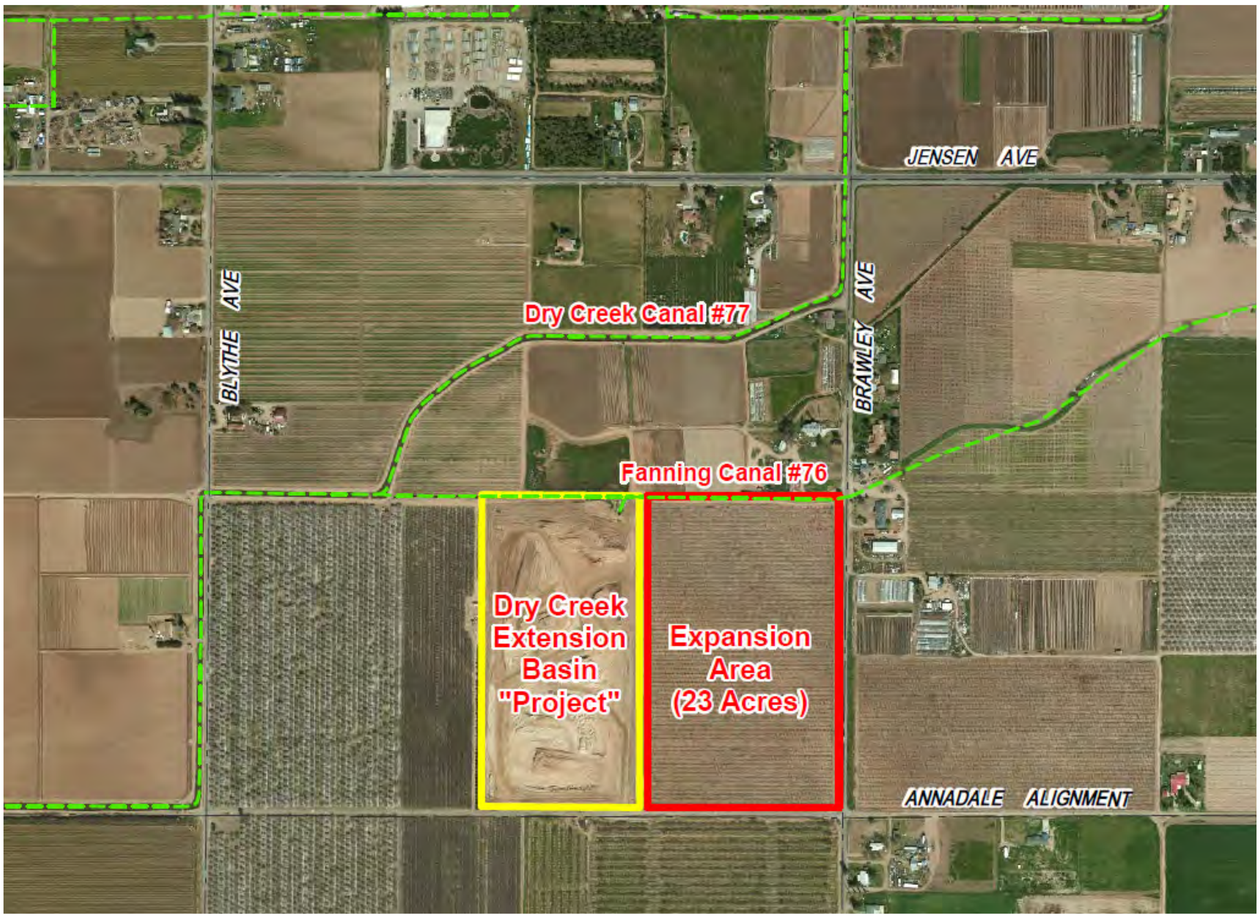

Figure 3-1-7: Dry Creek Extension Basin

September 14, 1995

Dam Breach Analysis for Big Dry Creek Dam, California

1. Introduction.

1.1 Purpose and Scope. This report describes the dam breach analysis of Big Dry Creek Dam in Fresno County, California. Inundation area maps have been developed for use in emergency planning. A table presenting approximate flood peak travel times from the dam to selected locations, peak water surface elevations, and maximum flow velocities, is included in section 6.2 of the report.

1.2 Previous Studies and References. Information used to perform the dam breach analysis was obtained from the following references.

1. Big Dry Creek Dam Probable Maximum Flood Inundation, PMF Inundation Maps, In House Report, US Army Corps of Engineers, Sacramento District, September 1992.

2. Big Dry Dam Breach Study, California, Inundation Area Maps, US Army Corps of Engineers, Sacramento District, March 1977.

3. DAMBRK, The NWS Dam-Break Flood Forecasting Model, Users Manual, National Weather Service, Documentation Prepared by the Hydrologic Engineering Center, US Army Corps of Engineers, February 1984.

4. HEC-1, Flood Hydrograph Package, User's Manual, US Army Corps of Engineers Hydrologic Engineering Center, September 1990.

5. Redbank and Fancher Creeks, California, Big Dry Creek Dam Feature Design Memorandum, US Army Corps of Engineers, Sacramento District, August 1990.

1.3 Reason for Restudy of Big Dry Creek Dam Breach. New dam-breach inundation maps are required for Big Dry Creek Dam due to modification of the original structure. The rolled earth fill dam has been raised 7.2 feet, from elevation 435.0 to 442.2 feet ngvd (1929 national geodetic vertical datum), to increase gross pool storage capacity from 16,500 acre-feet to 30,200 acre-feet. The spillway was changed from a broadcrested weir to an Ogee spillway, and has been raised from elevation 425.0 to 432.7 feet ngvd.

1.4 Breach Hydrograph. The modeled dam breach produced a hydrograph with a peak flow of 69,900 ft^3/s occurring one hour after the breach began to form. Muskingum-Cunge routing was used to route the hydrograph from the dam downstream through Fresno.

2. Description of Area.

2.1 Description of Big Dry Creek Dam and Reservoir. Big Dry Creek Dam Reservoir, at gross pool storage, impounds approximately 30,200 acre-feet and has a surface area of 2151 acres. The homogeneous rolled earth fill dam is 25,300 feet long, has a maximum section height of 45 feet, and a crest elevation of 442.2 ngvd. The concrete Ogee spillway has a crest length of 550 feet and crest elevation of 432.7 feet, ngvd. Pertinent data used in the dam breach analysis for Big Dry Creek Dam included:

Pertinent Data, See Ref. 5.

1. Drainage Area at Big Dry Creek Dam .... 81.7 mi^2
2. Type of Dam Structure .... Homogeneous Rolled Earth Fill
3. Top of Dam Crest Elevation, ngvd .... 442.2 ft
4. Spillway Crest Elevation, ngvd .... 432.7 ft
5. Gross Pool Storage .... 30,200 ac-ft
6. Max Height of Dam .... 45 ft
7. Invert Elevation of Big Dry Cr. Outlet Works @ impact basin, ngvd . . 392.5 ft

2.2 Location of Big Dry Creek Dam. Big Dry Creek Dam is located in the foothills of the western slopes of the Sierra Nevada Mountains, in eastern Fresno County, between the San Joaquin and Kings Rivers. The dam controls flow from the upper 81.7 mi^2 of the Big Dry Creek watershed. Big Dry Creek is a tributary to the San Joaquin River.

2.3 Topography. Local topography ranges from moderately steep to steep hills and ridges in the foothills in the upper Big Dry Creek watershed, to nearly level alluvial plains in the eastern San Joaquin Valley near Fresno and Clovis. Rolling hills and terraces, composed of alluvium, border the foothills east of Fresno.

2.4 Streams and Canals. Streams flow in natural channels through the foothills, however, the channels have been extensively modified below the dam. In effect, the channels are now dual-purpose, and convey both irrigation water supplies and storm runoff. The Big Dry Creek outlet works are located north of the original alignment of Big Dry Creek. The Little Dry Creek outlet works divert impounded water from Big Dry Creek northward into Little Dry Creek, near the confluence with the San Joaquin River. The major dual purpose channels are the Fresno Canal, Mill Ditch, Dry Creek Canal, and Herndon Canal. Other canals also cross the inundation area below the dam. The Friant-Kern Canal crosses the watershed upstream of the dam.

2.5 Vegetative Cover. Vegetative cover between the dam and the Fresno metropolitan area consists primarily of orchards, vineyards, pastures, and field crops. Hillier areas in the vicinity of the dam and Friant-Kern Canal are predominantly short-grass range land.

2.6 Climate and Precipitation. The climate of the area is semi-arid, with hot, dry summers and cool, moist winters. Fog can occur frequently in December and January, when a high pressure system traps marine air in the Valley. Average annual precipitation over the watershed varies from approximately 10.5 inches at Fresno to over 30 inches in the headwaters of Dry Creek. Most of this precipitation occurs between November and April. Thundershowers may move into the area during the summer. Winter precipitation usually falls as rain, although snowfall may occur down to 2,000 feet and occasionally lower.

2.7 Storm Characteristics. Flood producing storms in the area occur as rain during October through April. The majority of these storms occur from the latter part of December to the first part of April. There are two distinct types of flood producing storms: general storms that produce widespread heavy precipitation, and local storms that produce extremely heavy short-term precipitation over small areas.

3. Modeling the Dam Breach with HEC-1.

3.1 Breach Characteristics. Multiple dam breach scenarios were modeled using the dam breach and multiplan routines in HEC-1. Breach configuration was determined by trial and error and *Suggested Typical Ranges of Breach Parameters* from Table 3.1 (p. 3-2) of the DAMBRK Users Manual (Ref. 3). The target peak flow rate was determined from an enveloping curve developed from observed outflow rates from breached dams (outflow vs. hydraulic depth). The target peak discharge was a flow near, but not exceeding, the envelope curve value. The time distribution of the resulting hydrograph is relatively insensitive to differences in breach configuration for any given target peak outflow. To achieve the target peak discharge, breach the full height of the dam, and maintain the desired breach width at the invert (80 feet), the breach side slopes were kept relatively steep, at 0.5 to one. For an earthen dam, the recommended breach width is 0.5 to four dam heights, the recommended side slope of the breach is zero to one ft/ft, and the recommended time to achieve maximum breach size is 0.5 to four hours. The breach invert elevation corresponds to the outlet work invert elevation. Model parameters required by the dam break routine include: starting water surface elevation, elevation at invert of breach, breach dimensions, and the time to achieve maximum breach dimensions. The following breach parameters were used in the dam breach analysis for Big Dry Creek Dam:

Big Dry Creek Breach Parameters, See Ref. 3.

1. Starting Water Surface Elevation, ngvd .... 432.7 ft
2. Invert Elevation of Breach, ngvd .... 392 ft
3. Width of Breach at Invert .... 80 ft
4. Side Slope of Breach .... 0.5 H-1.0 V
5. Selected Time to Fully Formed Breach .... 1 hour
6. Hydraulic Depth of Water at Breach .... approx. 41 ft

3.2 Breach Hydrograph. The modeled dam breach produced a hydrograph with a peak flow of 69,900 ft^3/s occurring one hour after the breach began to form. Attenuation reduces the peak flow to 44,300 ft^3/s at the Southern Pacific rail line, above Hwy 99, approximately 12 miles below the dam. The flood wave travel time to this location is approximately 11 hours.

3.3 Conditions at Time of Breach. Most breaches occur after flow begins over the top-of-dam, however, for the purposes of this study, the simulated dam breach occurred with the water surface at spillway crest (from a piping failure), and after inflow to the reservoir has essentially ended. Such conditions simulate a dam breach with the greatest element of surprise; during a spillway flow event (or dam overtopping) emergency activities will already have begun, including evacuations, thereby reducing the impact of a dam breach. Although the simulated breach did not result from overtopping of the dam, a relatively short time of one hour was selected for the breach to become fully formed. A breach produced by overtopping of the dam may produce somewhat broader flood limits.

3.4 Breach Locations. The analyzed breach locations are at the original alignment of Big Dry Creek, and at the Little Dry Creek outlet works. Breach locations were selected based upon section height (water depth) and dam characteristics deemed most susceptible to breaching. Big Dry Creek outlet works are situated between the two breach locations analyzed. A breach at the Big Dry Creek outlet works would produce an inundation area contained within the mapped flood limits. Breach location influences the inundation area near the dam; however, flow paths from each simulation converge a relatively short distance below the dam (above Fresno).

3.5 Effect of Canals on Inundation Area. Flooding will occur during a time of year with low flows in irrigation canals, therefore, no significant contribution to flood waters will come from breached canals. Canal channel capacities are 2000 ft^3/s or less and do not represent a significant diversion of water (as a percentage of total flow) from the inundated area. Canals carrying flood waters may be flowing at greater than design capacity, and levee sections could potentially fail, producing shallow flooding over a broad area outside of the mapped inundation area.

Canal levees within the overflow limits are used to increase irrigation canal capacity and were not designed to control significant flood events. The breach hydrograph would overtop existing levees, and the levees would become ineffective or fail. The largest levees within the overflow area are located along Herndon Canal, which runs through the City of Fresno. Approximately 80% of Herndon Canal has levees. Water has historically ponded behind the levees and flooded homes to the north of the canal. Maximum height of the levees in the area of interest is approximately 4 feet; ponded depths will not greatly exceed this depth. The highest levees within the area of interest are located at the west edge of the inundation area, between Blackstone and Palm Avenues. The levees in this 1 mile section produce somewhat broader flood limits, and greater flood depths, than would otherwise occur. Elsewhere, ponding at levees, or levee breaks, would have no significant impact on the overflow limits. Most levee sections of the Herndon Canal (within the inundation area) are between 1 and 3 feet high. Some road crossings at the canals have inverted syphons; as the roads are not elevated to the height of the levees, heavier flows will occur at road crossings and breached levee sections. Water passing through road crossings would spread rapidly and fill in behind the levees. The low levees on the Enterprise Canal and Mill Ditch will be rapidly overtopped and breached.

3.6 Effect of Existing Flood Control Structures on Inundation Area. Alluvial Drain Detention Basin is contained within the area inundated by a dam breach at Big Dry Creek Dam. The storage within the detention basin (maximum storage = approx. 300 ac-ft) is insignificant compared to the volume in the breach hydrograph. A breach hydrograph from Big Dry Creek Dam may breach Alluvial Drain Detention basin as well, however, breaching Alluvial Drain D.B. would have no significant effect on the overflow limits. The detention basin is primarily below ground (excavated), and does not have potential to significantly alter the flood flows from a dam breach at Big Dry Creek Dam. If the detention basin were full at the time of the breach, and the dam breach induced a breach at the detention basin, there would be no significant impact on the mapped overflow limits. Conversely, if the detention basin were empty at the time of the dam breach, and the detention basin did not fail, the stored volume at the detention basin would not significantly reduce the overflow limits. Pup Creek Detention Basin, Redbank Creek Detention Basin, and Redbank Dam were not shown to be within the overflow limits from the dam breach.

4. Channel Routing of the Breach Hydrograph by the Muskingum-Cunge Method.

4.1 Use of Muskingum-Cunge Routing. Channel routing was performed by using Muskingum-Cunge routing with HEC-1. The Muskingum-Cunge routing method has been shown to compare well to full unsteady flow equations over a wide range of flow conditions. Muskingum-Cunge routing is not appropriate for routing rapidly rising hydrographs on very shallow slopes (slopes of 1 ft/mi or less). A description of Muskingum-Cunge routing begins on p. 30 of the *HEC-1 Users Manual* (Ref. 4). All of the routing reaches from the dam through the city of Fresno have slopes significantly greater than 1 ft per mile. Overbank areas with poor flow characteristics were modeled with very high N-values. In addition, ponded areas were subjectively mapped by interpretation of flow characteristics from map contours and spot elevations, using professional judgement. Backwater effects were not deemed of great enough significance to require use of the full unsteady flow equations. Few road surfaces or other man made features affecting flow (other than homes) are elevated above the ground surface.

4.2 Parameters for Muskingum-Cunge Routing. Eight-point cross-sections representing 17 routing reaches were used to model the main channel and overbank flows with Muskingum-Cunge routing. The distance between cross-sections varied as needed to define the inundation area. Each cross-section has separate N-values for the left overbank, main channel (cross-section center), and right overbank. N-values ranged from 0.01 immediately below the dam to 0.80 in overbank areas. See p. 35 of the *HEC-1 User's Manual* (ref. 4) for recommended overland flow N-values obtained from a variety of sources. A N-value range of 0.10 - 0.20 is recommended to represent areas of "short grass prairie" with shallow flow, while "sparse rangeland with debris" has a recommended N-value range of 0.05 to 0.34. A N-value 0.1 was selected for shallow flow over range and agricultural lands. Most reaches would have flows predominantly less than 3 ft in depth, especially in the urban areas; a composite N-value of 0.10 was selected for shallow flow in streets, around homes, and through yards. Areas modeled with higher N-values represent portions of the cross-section with restricted flow. A N-value of 0.01 was used for the bore of water immediately below the dam. Elsewhere, reaches with flows generally greater than 3 feet deep were given N-values ranging from 0.02 to 0.06. Other parameters required for Muskingum-Cunge routing include a reach length and water surface slope. An estimate of the water surface energy grade line slope was used for flows near the dam, while the land surface slope was used for routing reaches within the city. Reach length is considered to be the straight line distance between cross-sections, as a flood wave would overwhelm channels and flow directly downslope (overland).

5. Delineation of Inundation Area.

5.1 Comparison to Previous Work. New overflows are similar to overflows mapped in the previous dam breach analysis (with original spillway and dam height), and also those mapped when routing the PMF through the dam and downstream through Fresno. New overflow limits are somewhat broader at some locations due to the higher discharge routed in the reevaluation. In a very few locations, small areas previously mapped within the inundation area have been removed from the inundation area due to reevaluation of flow behavior. Previous analyses used the DAMBRK and DWOPER computer programs to develop the dam breach and perform the channel routings. HEC-1 was selected for use in the present study due to its superior error checking routines and ease-of-use.

5.2 Additional Flooding. Delineated flood limits represent the best estimate of expected flood limits. Additional areas of shallow sheet flooding (1 ft or less in depth) may occur along canals and streets outside of the delineated flood zone. Flooding outside the delineated flood zone (other than that within canals) is shallow flow with low velocity, and is generally non-life threatening.

5.3 Mapping of Inundation Area. Computed cross-section water surface elevations were plotted on 1:24,000 scale USGS topographic maps, and professional judgement was used to delineate flood limits between cross-sections. Professional judgement was also used to modify water surface elevations where backwater effects would occur. (HEC-1 does not model backwater effects.) The erosive action of the water was also considered; a narrow divide may be breached by floodflows, resulting in wider flood limits. Additionally, urban growth and agricultural activities have changed, and will continue to change, the land surface contours, increasing the uncertainty associated with the mapped flood zone.

5.4 High Ground Within the Inundation Area. Pockets of high ground will escape flooding within the delineated flood zone; however, they have not been mapped due to uncertainty as to their limits. The erosive action of the water may result in changing flow paths, especially nearer the dam. Many of the areas modeled as escaping flooding are at an elevation only a few tenths of a foot from becoming inundated; the modeling methods used do not have a level of accuracy sufficient to map these areas.

5.5 Interpretation of Delineated Flood Zone. Delineated flood limits are the outer limits of what may occur with different breach scenarios; a breach at the north end of the dam (near the spillway) may not result in flooding at the southern limit shown (or vice-versa). Flow paths from all breach scenarios converge into the same overflow area before reaching Fresno.

6. Flood Wave Travel Times.

6.1 Comparison to Previous Studies. Revised estimates of the overland flow N-values produced virtually no change in flood wave travel times from those previously presented in the Big Dry Creek PMF Inundation Maps (Ref. 1), and the Big Dry Dam Breach Study Inundation Area Maps (Ref. 2). Reevaluation of N-values produced generally lower N-values in areas with deeper flow, and higher N-values in reaches with shallow flow.

6.2 Flood Wave Travel Times. Travel times to locations near the dam are highly dependent on breach location; however, travel times further downstream are less dependent on breach location. Mapped travel times are composite values from multiple breach locations, but generally represent the fastest travel times that may be expected. The mapped travel times are the travel times of the hydrograph peak, which occurs 1 hour after the breach begins. The following table presents the flood peak travel time from the dam to selected locations, and maximum flow velocity, and water surface elevations, at the same locations. Breaches at other locations along the dam may result in significantly lower flood peaks and volumes, and longer travel times. Near the dam, the peak flow arrives less than one hour after the leading edge of the flood hydrograph, while, in the lower mapped regions, the peak follows the initial stages of flooding by approximately three hours.

Table of Approximate Travel Time of Flood Peak From Dam to Selected Locations.

Location	Distance to Dam (mi)	Max WSE* (ft)	Max Flow (ft3/s)	Arrival Time** (hrs)	Max Vel. (ft/s)
Intersection of Sunnyside Ave and Nees Ave	2.4	376	67,000	0.5	13***
Intersection of Peach Ave and Herndon Ave	4.0	362	62,000	2	2
Intersection of Bullard Ave (6th) and Clovis Ave, Clovis	4.1	362	62,000	2	2
Intersection of Millbrook Ave and Ashlan Ave, Fresno	7.9	325	55,000	6	1
Intersection of Clinton Ave and 1st St, Fresno	9.3	311	49,000	8	1
Intersection of McKenzie Ave and Blackstone Ave, Fresno	11.3	295	47,000	10	1

* Water surface elevation at cross-section through location indicated. Some locations within the cross-section may be at a higher elevation than the water surface.
** Travel time of hydrograph peak from dam to indicated location. Travel time estimates rounded to nearest 1/2 hour.
*** Flow rate exceeds 35 ft/s in upper reaches.

6.3 Flow Velocities. Modeled flow velocities ranged from nearly 40 ft/s in the first 1/2 mile below the dam, to wide shallow flow of approximately 0.6 ft/s below Hwy 99 in Fresno (see above table). Flow velocities at locations near the dam are highly dependent on breach location; however, velocities further downstream are less dependent on breach location. Velocities used for mapping are composite values from multiple breach locations, but generally represent the highest velocities that may be expected in overflow areas. Model parameters outside of the recommended ranges would generally be required to achieve significantly higher flow velocities or water surface elevations. Changes made to the water surface slope (energy grade line) could result in higher flow velocities or water surface elevations, but the model generally becomes computationally unstable when changes of this nature are made. Warnings of unstable computations in the model output are an indication that inappropriate parameter values have been selected.

6.4 Flood Depths. Modeled flood depths are generally 3 feet or less. Large areas will experience flooding of less than 2 feet in depth. Isolated low lying areas near channels may experience flooding of up to 6 feet in depth. Care should be taken in using the map to determine flood depths, as the map presents a composite overflow from multiple breach scenarios.

7. Conclusions.

The *Inundation Area Map* presents a conservative representation of the flood limits and flood peak travel times from a dam breach at Fancher Creek Dam. Model parameters used are conservative values falling within the ranges recommended by available guidelines. Model parameters outside of the recommended range would be required to achieve significantly higher computed flow velocities or water surface elevations. Computed flow peaks and velocities compare well with those of observed events and previous analyses.

Delineated flood limits are the outer limits of what may occur with different breach scenarios; therefore, mapped limits do not represent the limits from a breach at any one given location at the dam. Breaches at certain locations along the dam may result in significantly lower flood peaks and volumes, and longer travel times. Shallow, non-life threatening flooding may occur outside of the mapped inundation area. Near the dam, the peak flow arrives less than one hour after the leading edge of the flood hydrograph, while, in the lower mapped regions, the peak follows the initial stages of flooding by approximately three hours. *Actual warning time is dependent on discovery of the breach, and reaction time following discovery of the breach.* The table in section 6.2 presents the flood peak travel times to selected locations.

Although flooding will be extensive within developed areas, modeled flood depths and velocities are generally non-life threatening to healthy adults. Large areas will experience flooding of less than 2 feet in depth, however, low lying areas near channels may experience flooding of up to 6 feet in depth. Flow velocities are generally 2 feet per second or less *beyond 4 miles from the dam.* Very dangerous conditions will exist within 4 miles of the dam. Actual maximum inundation depths and flow velocities are dependant on dam breach location and the effect of local topographic features. For evacuation purposes, the potential flood limits and available response time are of more significance than flood depths.

```
1****************************************                              ****************************************
*                                       *                              *                                      *
*  FLOOD HYDROGRAPH PACKAGE   (HEC-1)   *                              *   U.S. ARMY CORPS OF ENGINEERS       *
*            JUN 09 1992                *                              *   HYDROLOGIC ENGINEERING CENTER      *
*          VERSION 4.0.3E               *                              *        609 SECOND STREET             *
*                                       *                              *     DAVIS, CALIFORNIA 95616          *
*  RUN DATE  07/18/95  TIME  08:52:09   *                              *        (916) 551-1748                *
*                                       *                              *                                      *
****************************************                              ****************************************


                 X       X  XXXXXXX   XXXXX          X
                 X       X  X        X     X        XX
                 X       X  X        X               X
                 XXXXXXX    XXXX     X       XXXXX   X
                 X       X  X        X               X
                 X       X  X        X     X         X
                 X       X  XXXXXXX   XXXXX         XXX


 THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

 THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
 THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
 NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
 DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
 KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1                                       HEC-1 INPUT                                                    PAGE  1

 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

   1           ID     DAM FAILURE ANALYSIS FOR DRY CREEK, CA        **** final results ***
   2           ID     FAIL LOCATION #1 ..........  DRYfailS.dat.............. GR ... 15 aug 1994
   3           ID     BREACH AT APPROX STA 119+00, NR BIG DRY CREEK OUTLET WORKS
   4           ID     "C" COEFFICIENT ON SL RECORD COMBINED VALUE BIG+LITTLE DRY CREEKS, Q=1600CFS
   5           ID     "C" COEF ON SS RECORD DETERMINED BY WORKING BACKWARDS FROM RATING CURVE
   6           ID     NO INFLOW, BREACH OCCURS W/ WSE AT SPILLWAY EL 432.7 FT
   7           ID     EARTHEN DAM
   8           ID     ** SOME X-SEC 8 THRU 17 FROM PREVIOUS DWOPER ANALYSIS **
   9           ID     ENVELOPE CURVE OF OBSERVED BREACH DISCHARGES @ 40FT DEPTH = 72,000 CFS
  10           ID
               *DIAGRAM
  11           IT       15 01JAN94    0100      200
  12           IO        3
               *  JP     3

  13           KK       IN BIG DRY CR DAM
  14           KM     CALCULATION OF INFLOW TO BIG DRY CR DAM
  15           BA      81.7
  16           PB        0
  17           PI        0       0       0       0       0       0       0       0       0       0
  18           PI        0       0       0       0       0       0       0       0       0       0
  19           PI        0       0       0       0       0       0       0       0       0       0
  20           PI        0       0       0       0       0       0       0       0       0       0
  21           LU        0       0       0
  22           US      4.8      .6
  23           BF        0       0      1.

  24           KK      OUT     BIG DRY CR DAM OUTFLOW
  25           KM     ROUTED FLOWS THROUGH RESERVOIR
  26           KO        4
               *  KP     1
  27           RS        1    ELEV   432.7
  28           SV        0     0.0     600    2300    9300   25000   30200   45983   46900
  29           SE      394     397     405     410  420.00  430.00   432.7   439.2  440.00
  30           SS    432.7     550     4.3     1.5
  31           ST    442.2      25     3.1     1.5
  32           SL    392.5      60     .53     0.5
               *  SB   392     100       0      .5   432.7
               *  KP     2
               *  SB   392     100       0       1   432.7
               *  KP     3
               *  KO     3       1
  33           SB      392      80      .5       1   432.7

  34           KK     RCH1
               *  KP     3
               *  KO     3
  35           KM     CHANNEL ROUTING DAM TO X1
  36           KM     EST WATER SURFACE ENERGY GRADE LINE SLOPE IS .40
  37           RD
  38           RC     .020    .010    .010    1400    .400     406
  39           RX        0     800    1300    2000    2600    3100    3300    3500
  40           RY      407     404     405     407     405     403     405     407
  41           ZW     A=BIGDRY B=REACH1 C=FLOW F=SOUTHBREACH
               *
1                                       HEC-1 INPUT                                                    PAGE  2

 LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10


  42           KK     RCH2
  43           KM     CHANNEL ROUTING X1 TO X2
```

```
 44     KM    LAND SURFACE SLOPE = .0058, EST WATER ENERGY GRADE LINE =.10
 45     RD
 46     RC    .020    .020    .020    1200     .10     401
 47     RX       0     100     200     500    1000    2000    2200    2900
 48     RY     401     400     393     400     402     398     400     404

 49     KK    RCH3
 50     KM    CHANNEL ROUTING X2 TO X3
 51     KM    LAND SURFACE SLOPE =.0021, EST WATER ENERGY GRADE LINE =.100
 52     RD
 53     RC    .030    .020    .030    3200   .1000     391
 54     RX       0    1100    2500    3400    3600    3900    4500    4900
 55     RY     393     390     385     390     389     390     390     395

 56     KK    RCH4
 57     KM    CHANNEL ROUTING X3 TO X4
 58     KM    LAND SURFACE SLOPE =.0021, EST WATER ENERGY GRADE LINE =.012
 59     RD
 60     RC    .030    .020    .030    1000   .0120     388
 61     RX       0     500    1200    1600    3000    3100    3300    4700
 62     RY     390     385     380     385     385     384     385     390

 63     KK    RCH5
 64     KM    CHANNEL ROUTING X4 TO X5
 65     KM    LAND SURFACE SLOPE =.0024, EST WATR ENERGY GRADE LINE .01
 66     RD
 67     RC    .030    .030    .030    4800   .0100     378
 68     RX       0    6500    7800   10600   11000   11500   12700   11300
 69     RY     380     376     377     375     368     375     370     380

 70     KK    RCH6
 71     KM    CHANNEL ROUTING X5 TO X6
 72     KM    EST WATR SURFACE ENERGY GRADE LINE SLOPE =.002
 73     RD
 74     RC    .060    .030    .060    3500   .0020     373
 75     RX       0    6100    6600   13000   17000   20400   24000   27900
 76     RY     375     370     373     369     373     366     368     375
        * KP     3
        * KO     3

 77     KK    RCH7
 78     KM    CHANNEL ROUTING X6 TO X7
 79     KM    HIGH n VALUE FOR LEFT BANK DUE TO BANK STORAGE
 80     RD
 81     RC    .060    .060    .060    4600   .0021     363
 82     RX       0    5800    6500    7200    8700   13800   23300   26900
 83     RY     365     360     359     361     360     359     360     365
        * KP     3
        * KO     3
```



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LINE    ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 84     KK    RCH8
 85     KM    CHANNEL ROUTING X7 TO X8
 86     RD
 87     RC    .100    .060    .100    5350   .0020     353
 88     RX       0    4800    6800    6900    7700   15200   21000   33500
 89     RY     355     350     350     348     350     351     351     355
        * KP     3
        * KO     3

 90     KK    RCH9
 91     KM    CHANNEL ROUTING X8 TO X9
 92     RD
 93     RC    .100    .060    .100    5425   .0020     348
 94     RX       0    8700    9100    9400   13700   20700   21200   23900
 95     RY     350     342     337     342     340     340     345     350
        * KP     3
        * KO     3

 96     KK    RCH10
 97     KM    CHANNEL ROUTING X9 TO X10
 98     RD
 99     RC    .100    .060    .100    6975   .0017     333
100     RX       0    8100    9400    9900   18300   18900   20700   25900
101     RY     335     330     325     330     325     324     330     335

102     KK    RCH11
103     KM    CHANNEL ROUTING X10- X11
104     RD
105     RC    .100    .100    .100    6675   .0018     319
106     RX       0    3100   14500   19500   23900   26500   27300   33200
107     RY     320     315     320     313     320     315     314     320

108     KK    RCH12
109     KM    CHANNEL ROUTING X11- X12
110     RD
111     RC    .100    .100    .100    5400   .0018     311
112     RX       0    8700   15800   21000   21500   21600   28100   31100
113     RY     315     310     305     310     303     310     310     315

114     KK    RCH13
115     KM    CHANNEL ROUTING X12- X13
116     RD
117     RC    .100    .100    .100    5700   .0015     305
118     RX       0    1700    5200    5500    6000   11000   13300   14200
119     RY     310     300     296     295     296     300     298     306
```

```
    120        KK   RCH14
    121        KM    CHANNEL ROUTING X13- X14
    122        RD
    123        RC    .100    .100    .100    3800   .0021    294
    124        RX       0   14000   24000   26900   30200   30500   35400   36400
    125        RY     300     290     300     292     289     287     295     301
```



```
   LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

    126        KK   RCH15
    127        KM    CHANNEL ROUTING X14- X15
    128        RD
    129        RC    .100    .100    .100    3800   .0011     291
    130        RX       0    3400    8700   17400   20900   28800   33000   36400
    131        RY     293     290     288     287     290     287     290     291

    132        KK   RCH16
    133        KM    CHANNEL ROUTING X15- X16
    134        RD
    135        RC    .100    .100    .100    3650   .0014     279
    136        RX       0    7200   10200   12800   15000   16200   21600   25500
    137        RY     280     275     275     273     275     290     274     280

    138        KK   RCH17
    139        KM    CHANNEL ROUTING X16- X17
               * KO     3
    140        RD
    141        RC    .100    .100    .100    5150   .0007     274
    142        RX       0    8300   20700   21600   22000   26200   27000   29200
    143        RY     275     270     270     272     270     269     270     275
    144        ZW   A=BIGDRY B=REACH17 C=FLOW F=SOUTHBREACH
    145        ZZ
1
                    SCHEMATIC DIAGRAM OF STREAM NETWORK
INPUT
 LINE     (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

 NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

  13        IN
             V
             V
  24       OUT
             V
             V
  34      RCH1
             V
             V
  42      RCH2
             V
             V
  49      RCH3
             V
             V
  56      RCH4
             V
             V
  63      RCH5
             V
             V
  70      RCH6
             V
             V
  77      RCH7
             V
             V
  84      RCH8
             V
             V
  90      RCH9
             V
             V
  96     RCH10
             V
             V
 102     RCH11
             V
             V
 108     RCH12
             V
             V
 114     RCH13
             V
             V
 120     RCH14
             V
             V
 126     RCH15
             V
             V
 132     RCH16
             V
             V
 138     RCH17

(***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*****************************************                           **************************************
 *                                       *                           *                                    *
```

```
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*          JUN 09 1992                 *
*         VERSION 4.0.3E               *
*                                      *
*  RUN DATE  07/18/95  TIME  08:52:09  *
*                                      *
****************************************
```

```
*  U.S. ARMY CORPS OF ENGINEERS        *
*  HYDROLOGIC ENGINEERING CENTER       *
*       609 SECOND STREET              *
*    DAVIS, CALIFORNIA 95616           *
*       (916) 551-1748                 *
*                                      *
****************************************
```

```
                    DAM FAILURE ANALYSIS FOR DRY CREEK, CA        **** final results ***
                    FAIL LOCATION #1 .......... DRYfailS.dat.............. GR ... 15 aug 1994
                    BREACH AT APPROX STA 119+00, NR BIG DRY CREEK OUTLET WORKS
                    "C" COEFFICIENT ON SL RECORD COMBINED VALUE BIG+LITTLE DRY CREEKS, Q=1600CFS
                    "C" COEF ON SS RECORD DETERMINED BY WORKING BACKWARDS FROM RATING CURVE
                    NO INFLOW, BREACH OCCURS W/ WSE AT SPILLWAY EL 432.7 FT
                    EARTHEN DAM
                    ** SOME X-SEC 8 THRU 17 FROM PREVIOUS DWOPER ANALYSIS **
                    ENVELOPE CURVE OF OBSERVED BREACH DISCHARGES @ 40FT DEPTH = 72,000 CFS

 12 IO         OUTPUT CONTROL VARIABLES
                    IPRNT          3  PRINT CONTROL
                    IPLOT          0  PLOT CONTROL
                    QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT          HYDROGRAPH TIME DATA
                     NMIN         15  MINUTES IN COMPUTATION INTERVAL
                    IDATE     1JAN94  STARTING DATE
                    ITIME       0100  STARTING TIME
                       NQ        200  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE     3JAN94  ENDING DATE
                   NDTIME       0245  ENDING TIME
                    ICENT         19  CENTURY MARK

                COMPUTATION INTERVAL    0.25 HOURS
                     TOTAL TIME BASE   49.75 HOURS

         ENGLISH UNITS
              DRAINAGE AREA          SQUARE MILES
              PRECIPITATION DEPTH    INCHES
              LENGTH, ELEVATION      FEET
              FLOW                   CUBIC FEET PER SECOND
              STORAGE VOLUME         ACRE-FEET
              SURFACE AREA           ACRES
              TEMPERATURE            DEGREES FAHRENHEIT

*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

          **************
          *            *
 13 KK    *      IN    *     BIG DRY CR DAM
          *            *
          **************
                       CALCULATION OF INFLOW TO BIG DRY CR DAM

           SUBBASIN RUNOFF DATA

 15 BA         SUBBASIN CHARACTERISTICS
                    TAREA      81.70  SUBBASIN AREA

 23 BF         BASE FLOW CHARACTERISTICS
                    STRTQ       0.00  INITIAL FLOW
                    QRCSN       0.00  BEGIN BASE FLOW RECESSION
                    RTIOR    1.00000  RECESSION CONSTANT

               PRECIPITATION DATA

 16 PB              STORM       0.00  BASIN TOTAL PRECIPITATION

 17 PI           INCREMENTAL PRECIPITATION PATTERN


 21 LU         UNIFORM LOSS RATE
                    STRTL       0.00  INITIAL LOSS
                    CNSTL       0.00  UNIFORM LOSS RATE
                    RTIMP       0.00  PERCENT IMPERVIOUS AREA

 22 US         SNYDER UNITGRAPH
                       TP       4.80  LAG
                       CP       0.60  PEAKING COEFFICIENT

               SYNTHETIC ACCUMULATED-AREA VS. TIME CURVE WILL BE USED

                                               ***

                                        UNIT HYDROGRAPH PARAMETERS
                                    CLARK   TC=  5.16 HR,        R=  4.88 HR
                                    SNYDER  TP=  4.80 HR,       CP=  0.60

                                             UNIT HYDROGRAPH
                                        115 END-OF-PERIOD ORDINATES
            80.      301.      620.     1001.     1427.     1889.     2379.     2891.     3422.     3967.
          4515.     5028.     5477.     5862.     6183.     6440.     6630.     6752.     6799.     6758.
          6584.     6294.     5979.     5680.     5396.     5127.     4870.     4627.     4395.     4176.
```

3967.	3769.	3580.	3401.	3231.	3070.	2916.	2770.	2632.	2500.
2375.	2257.	2144.	2037.	1935.	1838.	1746.	1659.	1576.	1497.
1422.	1351.	1284.	1219.	1158.	1101.	1046.	993.	944.	896.
852.	809.	769.	730.	694.	659.	626.	595.	565.	537.
510.	484.	460.	437.	415.	395.	375.	356.	338.	321.
305.	290.	276.	262.	249.	236.	224.	213.	203.	192.
183.	174.	165.	157.	149.	141.	134.	128.	121.	115.
109.	104.	99.	94.	89.	85.	80.	76.	73.	69.
66.	62.	59.	56.	53.					

*** *** *** *** ***

HYDROGRAPH AT STATION IN

TOTAL RAINFALL = 0.00, TOTAL LOSS = 0.00, TOTAL EXCESS = 0.00

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	49.75-HR
+ (CFS)	(HR)					
		(CFS)				
+ 0.	0.00		0.	0.	0.	0.
		(INCHES)	0.000	0.000	0.000	0.000
		(AC-FT)	0.	0.	0.	0.

CUMULATIVE AREA = 81.70 SQ MI

*** ***

```
              **************
              *            *
   24 KK      *    OUT     *        BIG DRY CR DAM OUTFLOW
              *            *
              **************
                              ROUTED FLOWS THROUGH RESERVOIR

   26 KO          OUTPUT CONTROL VARIABLES
                       IPRNT          4  PRINT CONTROL
                       IPLOT          0  PLOT CONTROL
                       QSCAL         0.  HYDROGRAPH PLOT SCALE

                 HYDROGRAPH ROUTING DATA

   27 RS          STORAGE ROUTING
                       NSTPS          1  NUMBER OF SUBREACHES
                       ITYP        ELEV  TYPE OF INITIAL CONDITION
                       RSVRIC    432.70  INITIAL CONDITION
                       X           0.00 WORKING R AND D COEFFICIENT

   28 SV           STORAGE       0.0      0.0    600.0   2300.0   9300.0  25000.0  30200.0  45983.0  46900.0

   29 SE          ELEVATION   394.00   397.00   405.00   410.00   420.00   430.00   432.70   439.20   440.00

   32 SL          LOW-LEVEL OUTLET
                       ELEVL     392.50  ELEVATION AT CENTER OF OUTLET
                       CAREA      60.00  CROSS-SECTIONAL AREA
                       COQL        0.53  COEFFICIENT
                       EXPL        0.50  EXPONENT OF HEAD

   30 SS          SPILLWAY
                       CREL      432.70  SPILLWAY CREST ELEVATION
                       SPWID     550.00  SPILLWAY WIDTH
                       COQW        4.30  WEIR COEFFICIENT
                       EXPW        1.50  EXPONENT OF HEAD

   31 ST          TOP OF DAM
                       TOPEL     442.20  ELEVATION AT TOP OF DAM
                       DAMWID     25.00  DAM WIDTH
                       COQD        3.10  WEIR COEFFICIENT
                       EXPD        1.50  EXPONENT OF HEAD

   33 SB          BREACH DATA
                       ELBM      392.00  ELEVATION AT BOTTOM OF BREACH
                       BRWID      80.00  WIDTH OF BREACH BOTTOM
                       Z           0.50  BREACH SIDE SLOPE
                       TFAIL       1.00  TIME FOR BREACH TO DEVELOP
                       FAILEL    432.70  W.S. ELEVATION TO TRIGGER FAILURE
```

***

COMPUTED OUTFLOW-ELEVATION DATA

(EXCLUDING FLOW OVER DAM)

OUTFLOW	0.00	343.11	380.59	427.26	486.98	566.11	675.93	838.62	1104.45	1617.02
ELEVATION	394.00	394.31	394.73	395.31	396.15	397.43	399.52	403.31	411.25	432.70
OUTFLOW	1667.88	2005.62	2908.34	4654.11	7521.00	11787.06	17730.33	25628.85	35760.64	48403.71
ELEVATION	432.78	433.00	433.36	433.88	434.53	435.34	436.28	437.38	438.62	440.00

BREACH BOTTOM ELEVATION CHANGED TO LOWEST RESERVOIR ELEVATION = 394.00

COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

(INCLUDING FLOW OVER DAM)

STORAGE	0.00	0.00	0.00	0.00	0.00	0.00	32.03	189.32	473.44	600.00
OUTFLOW	312.35	343.11	380.59	427.26	486.98	541.01	566.10	675.93	838.62	901.69
ELEVATION	394.00	394.31	394.73	395.31	396.15	397.00	397.43	399.52	403.31	405.00
STORAGE	2300.00	3177.56	9300.00	25000.00	30199.94	30383.99	30921.01	31810.96	33053.94	34650.01
OUTFLOW	1066.89	1104.45	1337.42	1561.77	1617.02	1667.87	2005.65	2908.35	4654.08	7521.04
ELEVATION	410.00	411.25	420.00	430.00	432.70	432.78	433.00	433.36	433.88	434.53
STORAGE	36599.02	38901.13	41556.26	44564.33	45983.00	46900.00				
OUTFLOW	11787.01	17730.36	25628.96	35760.57	40935.19	48403.71				
ELEVATION	435.34	436.28	437.38	438.62	439.20	440.00				

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          *            *
34 KK     *    RCH1    *
          *            *
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                    CHANNEL ROUTING DAM TO X1
                    EST WATER SURFACE ENERGY GRADE LINE SLOPE IS .40

            HYDROGRAPH ROUTING DATA

37 RD          MUSKINGUM-CUNGE CHANNEL ROUTING

38 RC          NORMAL DEPTH CHANNEL
                    ANL       0.020  LEFT OVERBANK N-VALUE
                    ANCH      0.010  MAIN CHANNEL N-VALUE
                    ANR       0.010  RIGHT OVERBANK N-VALUE
                    RLNTH     1400.  REACH LENGTH
                    SEL      0.4000  ENERGY SLOPE
                    ELMAX     406.0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                              CROSS-SECTION DATA
                  --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
40 RY    ELEVATION  407.00   404.00   405.00   407.00   405.00   403.00   405.00   407.00
39 RX    DISTANCE     0.00   800.00  1300.00  2000.00  2600.00  3100.00  3300.00  3500.00

                                         ***

                              COMPUTED STORAGE-OUTFLOW-ELEVATION DATA
```

STORAGE	0.00	0.14	0.56	1.26	2.24	3.51	5.05	7.01	9.83	13.54
OUTFLOW	0.00	75.67	480.45	1416.52	3050.65	5531.20	8994.34	13595.44	19694.09	27651.72
ELEVATION	403.00	403.16	403.32	403.47	403.63	403.79	403.95	404.11	404.26	404.42
STORAGE	18.15	23.66	30.06	37.35	45.47	54.40	64.16	74.72	86.10	98.30
OUTFLOW	37770.50	50324.53	65569.36	82751.93	101808.28	125086.64	152654.31	184652.94	221260.91	262675.38
ELEVATION	404.58	404.74	404.89	405.05	405.21	405.37	405.53	405.68	405.84	406.00

COMPUTED MUSKINGUM-CUNGE PARAMETERS

COMPUTATION TIME STEP

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
MAIN			0.33	700.00	69909.80	60.49	6.95	70.21

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
MAIN			15.00		69071.27	60.00	6.95	

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3030E+05 EXCESS=0.0000E+00 OUTFLOW=0.3030E+05 BASIN STORAGE=-.1382E+01 PERCENT ERROR= 0.0

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     ***          ***          ***          ***          ***

                 HYDROGRAPH AT STATION     RCH1

 PEAK FLOW     TIME                    MAXIMUM AVERAGE FLOW
                              6-HR       24-HR       72-HR     49.75-HR
+  (CFS)       (HR)
                      (CFS)
+  69071.      1.00          47997.     15276.       7369.       7369.
                   (INCHES)   5.462      6.954       6.954       6.954
                    (AC-FT)  23800.     30300.      30300.      30300.

                 CUMULATIVE AREA =   81.70 SQ MI

  -----DSS---ZOPEN:  New File Opened,  File: DRYFAILS.DSS
                     Unit:  71;  DSS Version: 6-GY
-----DSS---ZWRITE Unit  71; Vers.    1:  /BIGDRY/REACH1/FLOW/01JAN1994/15MIN/SOUTHBREACH/
-----DSS---ZWRITE Unit  71; Vers.    1:  /BIGDRY/REACH1/FLOW/02JAN1994/15MIN/SOUTHBREACH/
-----DSS---ZWRITE Unit  71; Vers.    1:  /BIGDRY/REACH1/FLOW/03JAN1994/15MIN/SOUTHBREACH/
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42 KK    *    RCH2  *
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                   CHANNEL ROUTING X1 TO X2
                   LAND SURFACE SLOPE = .0058, EST WATER ENERGY GRADE LINE =.10

           HYDROGRAPH ROUTING DATA

45 RD        MUSKINGUM-CUNGE CHANNEL ROUTING

46 RC        NORMAL DEPTH CHANNEL
                   ANL       0.020  LEFT OVERBANK N-VALUE
                   ANCH      0.020  MAIN CHANNEL N-VALUE
                   ANR       0.020  RIGHT OVERBANK N-VALUE
                   RLNTH     1200.  REACH LENGTH
                   SEL      0.1000  ENERGY SLOPE
                   ELMAX     401.0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                                   CROSS-SECTION DATA
                   --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
48 RY     ELEVATION  401.00   400.00   393.00   400.00   402.00   398.00   400.00   404.00
47 RX     DISTANCE     0.00   100.00   200.00   500.00  1000.00  2000.00  2200.00  2900.00

                                        ***

                         COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

   STORAGE      0.00      0.14      0.56      1.26      2.23      3.49      5.02      6.84      8.93     11.30
   OUTFLOW      0.00     42.21    268.00    790.16   1701.71   3085.40   5017.20   7568.09  10805.17  14792.39
 ELEVATION    393.00    393.42    393.84    394.26    394.68    395.11    395.53    395.95    396.37    396.79

   STORAGE     13.95     16.88     20.11     24.66     31.21     39.74     50.26     62.90     78.97     98.83
   OUTFLOW  19591.08  25260.32  30960.60  34147.89  41703.18  53117.67  68569.99  85345.30 104663.44 132586.66
 ELEVATION    397.21    397.63    398.05    398.47    398.89    399.32    399.74    400.16    400.58    401.00

                         COMPUTED MUSKINGUM-CUNGE PARAMETERS
                              COMPUTATION TIME STEP
        ELEMENT    ALPHA     M          DT        DX        PEAK     TIME TO    VOLUME    MAXIMUM
                                                                      PEAK                CELERITY
                                       (MIN)     (FT)      (CFS)     (MIN)      (IN)      (FPS)

          MAIN                          0.94    600.00  69274.63     61.17      6.95      21.25

                         INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

          MAIN                         15.00              67776.12     75.00      6.96

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3030E+05 EXCESS=0.0000E+00 OUTFLOW=0.3030E+05 BASIN STORAGE=-.2142E+01 PERCENT ERROR=   0.0


     ***        ***        ***        ***        ***

                 HYDROGRAPH AT STATION      RCH2

 PEAK FLOW    TIME                        MAXIMUM AVERAGE FLOW
                                6-HR        24-HR       72-HR      49.75-HR
+   (CFS)     (HR)
                      (CFS)
+   67776.    1.25               47992.      15281.      7372.       7372.
                    (INCHES)      5.462       6.956      6.956       6.956
                     (AC-FT)     23798.      30309.     30309.      30309.

                   CUMULATIVE AREA =   81.70 SQ MI


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         *          *
49 KK    *    RCH3  *
         *          *
         ************
                   CHANNEL ROUTING X2 TO X3
                   LAND SURFACE SLOPE =.0021, EST WATER ENERGY GRADE LINE =.100

           HYDROGRAPH ROUTING DATA

52 RD        MUSKINGUM-CUNGE CHANNEL ROUTING

53 RC        NORMAL DEPTH CHANNEL
                   ANL       0.030  LEFT OVERBANK N-VALUE
                   ANCH      0.020  MAIN CHANNEL N-VALUE
                   ANR       0.030  RIGHT OVERBANK N-VALUE
                   RLNTH     3200.  REACH LENGTH
                   SEL      0.1000  ENERGY SLOPE
                   ELMAX     391.0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                                   CROSS-SECTION DATA
                   --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
55 RY     ELEVATION  393.00   390.00   385.00   390.00   389.00   390.00   390.00   395.00
54 RX     DISTANCE     0.00  1100.00  2500.00  3400.00  3600.00  3900.00  4500.00  4900.00

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COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

STORAGE	0.00	1.69	6.74	15.17	26.96	42.13	60.66	82.57	107.84	136.49
OUTFLOW	0.00	125.83	798.98	2355.67	5073.24	9198.39	14957.60	22562.47	32213.05	44100.00
ELEVATION	385.00	385.32	385.63	385.95	386.26	386.58	386.89	387.21	387.53	387.84
STORAGE	168.50	203.89	242.64	284.97	333.52	389.10	453.99	535.05	619.38	706.98
OUTFLOW	58406.15	75307.65	94974.84	115151.63	135621.67	161821.20	194980.23	241306.11	294114.22	353094.47
ELEVATION	388.16	388.47	388.79	389.11	389.42	389.74	390.05	390.37	390.68	391.00

COMPUTED MUSKINGUM-CUNGE PARAMETERS
COMPUTATION TIME STEP

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
MAIN			1.87	1600.00	68242.80	63.50	6.96	28.56

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

MAIN			15.00		67765.13	75.00	6.96	

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3031E+05 EXCESS=0.0000E+00 OUTFLOW=0.3032E+05 BASIN STORAGE=-.1117E+02 PERCENT ERROR= 0.0

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HYDROGRAPH AT STATION RCH3

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	49.75-HR
+ (CFS)	(HR)					
		(CFS)				
+ 67765.	1.25		47953.	15294.	7378.	7378.
		(INCHES)	5.457	6.962	6.962	6.962
		(AC-FT)	23778.	30336.	30336.	30336.

CUMULATIVE AREA = 81.70 SQ MI

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56 KK      *    RCH4    *
           *            *
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CHANNEL ROUTING X3 TO X4
LAND SURFACE SLOPE =.0021, EST WATER ENERGY GRADE LINE =.012

HYDROGRAPH ROUTING DATA

59 RD MUSKINGUM-CUNGE CHANNEL ROUTING

60 RC NORMAL DEPTH CHANNEL

ANL	0.030	LEFT OVERBANK N-VALUE
ANCH	0.020	MAIN CHANNEL N-VALUE
ANR	0.030	RIGHT OVERBANK N-VALUE
RLNTH	1000.	REACH LENGTH
SEL	0.0120	ENERGY SLOPE
ELMAX	388.0	MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

CROSS-SECTION DATA

		--- LEFT OVERBANK --- +		------ MAIN CHANNEL ------- +			--- RIGHT OVERBANK ---		
62 RY	ELEVATION	390.00	385.00	380.00	385.00	385.00	384.00	385.00	390.00
61 RX	DISTANCE	0.00	500.00	1200.00	1600.00	3000.00	3100.00	3300.00	4700.00

***

COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

STORAGE	0.00	0.45	1.79	4.03	7.16	11.19	16.12	21.94	28.65	36.26
OUTFLOW	0.00	44.37	281.75	830.71	1789.03	3243.72	5274.65	7956.44	11359.62	15551.44
ELEVATION	380.00	380.42	380.84	381.26	381.68	382.11	382.53	382.95	383.37	383.79
STORAGE	44.92	55.54	69.97	98.00	127.58	158.70	191.37	225.59	261.36	298.67
OUTFLOW	20272.83	25867.12	25172.79	39762.94	58364.04	80747.71	106793.27	136434.33	169636.55	206386.02
ELEVATION	384.21	384.63	385.05	385.47	385.89	386.32	386.74	387.16	387.58	388.00

COMPUTED MUSKINGUM-CUNGE PARAMETERS
COMPUTATION TIME STEP

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
MAIN			2.25	500.00	67602.91	76.46	6.97	7.41

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

MAIN			15.00		67398.53	75.00	6.98	

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CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3034E+05 EXCESS=0.0000E+00 OUTFLOW=0.3038E+05 BASIN STORAGE=-.6600E+01 PERCENT ERROR=  -0.1


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                         HYDROGRAPH AT STATION      RCH4

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                     6-HR        24-HR        72-HR      49.75-HR
+   (CFS)       (HR)
                            (CFS)
+   67399.      1.25                 47957.      15329.       7395.       7395.
                          (INCHES)    5.458       6.978       6.978       6.978
                          (AC-FT)    23780.      30405.      30405.      30405.

                         CUMULATIVE AREA =    81.70 SQ MI


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              *            *
  63 KK       *     RCH5   *
              *            *
              **************
                            CHANNEL ROUTING X4 TO X5
                            LAND SURFACE SLOPE =.0024, EST WATR ENERGY GRADE LINE .01

              HYDROGRAPH ROUTING DATA

  66 RD         MUSKINGUM-CUNGE CHANNEL ROUTING

  67 RC         NORMAL DEPTH CHANNEL
                      ANL        0.030  LEFT OVERBANK N-VALUE
                     ANCH        0.030  MAIN CHANNEL N-VALUE
                      ANR        0.030  RIGHT OVERBANK N-VALUE
                    RLNTH        4800.  REACH LENGTH
                      SEL       0.0100  ENERGY SLOPE
                    ELMAX        378.0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                                        CROSS-SECTION DATA
                          --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
  69 RY       ELEVATION    380.00     376.00     377.00     375.00     368.00     375.00     370.00     380.00
  68 RX       DISTANCE       0.00    6500.00    7800.00   10600.00   11000.00   11500.00   12700.00   14300.00

                                                              ***

                                        COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

          STORAGE       0.00       1.96       7.85      17.66      31.64      57.84     100.18     158.66     233.26     324.00
          OUTFLOW       0.00      36.32     230.59     679.86    1465.70    2838.39    5241.79    9023.96   14485.03   21897.36
        ELEVATION     368.00     368.53     369.05     369.58     370.11     370.63     371.16     371.68     372.21     372.74

          STORAGE     430.88     553.89     693.03     848.30    1027.42    1252.73    1554.21    1990.80    2530.93    3125.95
          OUTFLOW   31514.12   43573.87   58303.59   75920.66   89539.88  110627.73  140101.50  179899.20  239941.55  312888.63
        ELEVATION     373.26     373.79     374.32     374.84     375.37     375.89     376.42     376.95     377.47     378.00

                                   COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                         COMPUTATION TIME STEP
                   ELEMENT    ALPHA      M          DT        DX        PEAK      TIME TO    VOLUME    MAXIMUM
                                                                                   PEAK                CELERITY
                                                  (MIN)      (FT)      (CFS)      (MIN)      (IN)      (FPS)

                     MAIN                          3.75    1200.00   67488.86     82.50      6.99      10.14

                                   INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                     MAIN                         15.00              66694.46     90.00      6.98

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3041E+05 EXCESS=0.0000E+00 OUTFLOW=0.3044E+05 BASIN STORAGE=-.3453E+02 PERCENT ERROR=   0.0


     ***            ***            ***            ***            ***

                         HYDROGRAPH AT STATION      RCH5

  PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                     6-HR        24-HR        72-HR      49.75-HR
+   (CFS)       (HR)
                            (CFS)
+   66694.      1.50                 47636.      15327.       7394.       7394.
                          (INCHES)    5.421       6.977       6.977       6.977
                          (AC-FT)    23621.      30400.      30400.      30400.

                         CUMULATIVE AREA =    81.70 SQ MI


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*             *
70 KK   *    RCH6     *
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CHANNEL ROUTING X5 TO X6
EST WATR SURFACE ENERGY GRADE LINE SLOPE =.002

HYDROGRAPH ROUTING DATA

73 RD MUSKINGUM-CUNGE CHANNEL ROUTING

74 RC NORMAL DEPTH CHANNEL

ANL	0.060	LEFT OVERBANK N-VALUE
ANCH	0.030	MAIN CHANNEL N-VALUE
ANR	0.060	RIGHT OVERBANK N-VALUE
RLNTH	3500.	REACH LENGTH
SEL	0.0020	ENERGY SLOPE
ELMAX	373.0	MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

CROSS-SECTION DATA

--- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---

76 RY	ELEVATION	375.00	370.00	373.00	369.00	373.00	366.00	368.00	375.00
75 RX	DISTANCE	0.00	6100.00	6600.00	13000.00	17000.00	20400.00	24000.00	27900.00

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COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

STORAGE	0.00	12.46	49.85	112.17	199.41	311.58	446.46	593.97	752.84	933.50
OUTFLOW	0.00	67.62	429.37	1265.92	2726.31	4943.13	8223.31	12555.59	17816.19	22559.62
ELEVATION	366.00	366.37	366.74	367.11	367.47	367.84	368.21	368.58	368.95	369.32
STORAGE	1153.59	1413.57	1722.83	2086.94	2505.90	2979.70	3508.36	4091.87	4730.22	5423.42
OUTFLOW	29455.71	38568.04	50073.94	64307.21	81592.91	102242.04	126552.82	154811.89	187295.61	224271.36
ELEVATION	369.68	370.05	370.42	370.79	371.16	371.53	371.89	372.26	372.63	373.00

COMPUTED MUSKINGUM-CUNGE PARAMETERS

ELEMENT	ALPHA	M	COMPUTATION TIME STEP DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
MAIN			4.50	700.00	65440.11	112.50	7.00	2.67

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
MAIN			15.00		65044.30	120.00	7.00	

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3040E+05 EXCESS=0.0000E+00 OUTFLOW=0.3050E+05 BASIN STORAGE=-.1331E+03 PERCENT ERROR= 0.1

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HYDROGRAPH AT STATION RCH6

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	49.75-HR
+ 65044.	2.00	(CFS)	47352.	15369.	7414.	7414.
		(INCHES)	5.389	6.996	6.996	6.996
		(AC-FT)	23480.	30485.	30485.	30485.

CUMULATIVE AREA = 81.70 SQ MI

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*             *
77 KK   *    RCH7     *
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CHANNEL ROUTING X6 TO X7
HIGH n VALUE FOR LEFT BANK DUE TO BANK STORAGE

HYDROGRAPH ROUTING DATA

80 RD MUSKINGUM-CUNGE CHANNEL ROUTING

81 RC NORMAL DEPTH CHANNEL

ANL	0.060	LEFT OVERBANK N-VALUE
ANCH	0.060	MAIN CHANNEL N-VALUE
ANR	0.060	RIGHT OVERBANK N-VALUE
RLNTH	4600.	REACH LENGTH
SEL	0.0021	ENERGY SLOPE
ELMAX	363.0	MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

CROSS-SECTION DATA

--- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---

83 RY	ELEVATION	365.00	360.00	359.00	361.00	360.00	359.00	360.00	365.00
82 RX	DISTANCE	0.00	5800.00	6500.00	7200.00	8700.00	13800.00	23300.00	26900.00

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COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

STORAGE	0.00	36.63	146.52	329.66	586.07	913.98	1275.03	1653.55	2049.52	2462.96
OUTFLOW	0.00	88.00	558.79	1647.51	3548.12	6582.04	11121.07	16669.81	23198.32	30691.71
ELEVATION	359.00	359.21	359.42	359.63	359.84	360.05	360.26	360.47	360.68	360.89
STORAGE	2892.77	3332.46	3780.95	4238.24	4704.33	5179.22	5662.91	6155.40	6656.69	7166.79
OUTFLOW	39359.82	49205.27	59997.32	71719.98	84361.00	97911.05	112363.05	127711.76	143953.44	161085.59
ELEVATION	361.11	361.32	361.53	361.74	361.95	362.16	362.37	362.58	362.79	363.00

COMPUTED MUSKINGUM-CUNGE PARAMETERS

ELEMENT	ALPHA	M	COMPUTATION TIME STEP DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
MAIN			5.25	511.11	64039.86	152.25	7.04	1.98

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

MAIN			15.00		64008.61	150.00	7.05	

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3050E+05 EXCESS=0.0000E+00 OUTFLOW=0.3070E+05 BASIN STORAGE=-.3245E+03 PERCENT ERROR= 0.4

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HYDROGRAPH AT STATION RCH7

PEAK FLOW (CFS)	TIME (HR)		6-HR	24-HR	72-HR	49.75-HR
			MAXIMUM AVERAGE FLOW			
+ 64009.	2.50	(CFS)	46526.	15491.	7473.	7473.
		(INCHES)	5.295	7.051	7.051	7.051
		(AC-FT)	23071.	30725.	30725.	30725.

CUMULATIVE AREA = 81.70 SQ MI

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              **************
              *            *
 84 KK        *    RCH8    *
              *            *
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CHANNEL ROUTING X7 TO X8

HYDROGRAPH ROUTING DATA

86 RD MUSKINGUM-CUNGE CHANNEL ROUTING

87 RC NORMAL DEPTH CHANNEL

ANL	0.100	LEFT OVERBANK N-VALUE
ANCH	0.060	MAIN CHANNEL N-VALUE
ANR	0.100	RIGHT OVERBANK N-VALUE
RLNTH	5350.	REACH LENGTH
SEL	0.0020	ENERGY SLOPE
ELMAX	353.0	MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

CROSS-SECTION DATA

--- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---

89 RY	ELEVATION	355.00	350.00	350.00	348.00	350.00	351.00	351.00	355.00
88 RX	DISTANCE	0.00	4800.00	6800.00	6900.00	7700.00	15200.00	21000.00	33500.00

***

COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

STORAGE	0.00	1.91	7.65	17.22	30.62	47.84	68.89	93.77	153.77	312.24
OUTFLOW	0.00	4.48	28.42	83.80	180.48	327.23	532.11	802.64	862.37	1437.62
ELEVATION	348.00	348.26	348.53	348.79	349.05	349.32	349.58	349.84	350.11	350.37
STORAGE	542.68	845.06	1325.14	1917.97	2545.54	3207.85	3904.90	4636.71	5403.25	6204.54
OUTFLOW	2801.53	5001.28	8769.75	14347.23	21262.52	29445.93	38865.55	49506.84	61365.11	74441.88
ELEVATION	350.63	350.89	351.16	351.42	351.68	351.95	352.21	352.47	352.74	353.00

COMPUTED MUSKINGUM-CUNGE PARAMETERS

ELEMENT	ALPHA	M	COMPUTATION TIME STEP DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
MAIN			5.25	486.36	60839.07	220.50	7.11	1.57

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

MAIN			15.00		60611.44	225.00	7.11	

```
CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3072E+05 EXCESS=0.0000E+00 OUTFLOW=0.3098E+05 BASIN STORAGE=-.3425E+03 PERCENT ERROR=   0.3


      ***          ***          ***          ***          ***

                 HYDROGRAPH AT STATION      RCH8

  PEAK FLOW    TIME                       MAXIMUM AVERAGE FLOW
                                 6-HR        24-HR        72-HR      49.75-HR
 +  (CFS)      (HR)
                          (CFS)
 +   60611.    3.75                45043.      15623.       7537.       7537.
                        (INCHES)    5.126       7.112       7.112       7.112
                        (AC-FT)    22335.      30989.      30989.      30989.

                     CUMULATIVE AREA =    81.70 SQ MI


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

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            *            *
  90 KK     *     RCH9   *
            *            *
            **************

                    CHANNEL ROUTING X8 TO X9

              HYDROGRAPH ROUTING DATA

  92 RD         MUSKINGUM-CUNGE CHANNEL ROUTING

  93 RC         NORMAL DEPTH CHANNEL
                     ANL         0.100  LEFT OVERBANK N-VALUE
                     ANCH        0.060  MAIN CHANNEL N-VALUE
                     ANR         0.100  RIGHT OVERBANK N-VALUE
                     RLNTH       5425.  REACH LENGTH
                     SEL        0.0020  ENERGY SLOPE
                     ELMAX       348.0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                                          CROSS-SECTION DATA
                            --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
  95 RY        ELEVATION    350.00    342.00    337.00    342.00    340.00    340.00    345.00    350.00
  94 RX        DISTANCE       0.00   8700.00   9100.00   9400.00  13700.00  20700.00  21200.00  23900.00

                                                            ***

                                          COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

          STORAGE       0.00       2.92      11.69      26.30      46.75      73.05     549.59    1216.11    1982.39    2845.13
          OUTFLOW       0.00       8.80      55.85     164.66     354.62     642.96    3122.35   10455.73   21664.30   37257.94
        ELEVATION     337.00     337.58     338.16     338.74     339.32     339.89     340.47     341.05     341.63     342.21

          STORAGE    3767.59    4739.63    5761.24    6832.42    7953.47    9136.31   10387.10   11705.82   13092.48   14547.07
          OUTFLOW   58296.84   83501.24  112623.70  145560.78  182168.92  222318.52  266415.06  314427.06  366376.09  422300.47
        ELEVATION     342.79     343.37     343.95     344.53     345.11     345.68     346.26     346.84     347.42     348.00

                                    COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                         COMPUTATION TIME STEP
                ELEMENT    ALPHA      M         DT        DX        PEAK     TIME TO    VOLUME    MAXIMUM
                                                                              PEAK                CELERITY
                                               (MIN)      (FT)      (CFS)     (MIN)      (IN)      (FPS)

                 MAIN                           5.25    678.13   59355.41    262.50      7.17      2.08

                                       INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL


                 MAIN                          15.00             58972.99    270.00      7.17

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3100E+05 EXCESS=0.0000E+00 OUTFLOW=0.3125E+05 BASIN STORAGE=-.2603E+03 PERCENT ERROR=   0.0


      ***          ***          ***          ***          ***

                 HYDROGRAPH AT STATION      RCH9

  PEAK FLOW    TIME                       MAXIMUM AVERAGE FLOW
                                 6-HR        24-HR        72-HR      49.75-HR
 +  (CFS)      (HR)
                          (CFS)
 +   58973.    4.50                43983.      15753.       7600.       7600.
                        (INCHES)    5.005       7.171       7.171       7.171
                        (AC-FT)    21810.      31246.      31246.      31246.

                     CUMULATIVE AREA =    81.70 SQ MI


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              *            *
   96 KK      *   RCH10    *
              *            *
              **************
                          CHANNEL ROUTING X9 TO X10

                HYDROGRAPH ROUTING DATA

   98 RD          MUSKINGUM-CUNGE CHANNEL ROUTING

   99 RC          NORMAL DEPTH CHANNEL
                          ANL        0.100  LEFT OVERBANK N-VALUE
                         ANCH        0.060  MAIN CHANNEL N-VALUE
                          ANR        0.100  RIGHT OVERBANK N-VALUE
                        RLNTH        6975.  REACH LENGTH
                          SEL       0.0017  ENERGY SLOPE
                        ELMAX        333.0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                                           CROSS-SECTION DATA
                             --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
  101 RY       ELEVATION   335.00    330.00    325.00    330.00    325.00    324.00    330.00    335.00
  100 RX       DISTANCE      0.00   8100.00   9400.00   9900.00  18300.00  18900.00  20700.00  25900.00

                                                      ***

                                      COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

              STORAGE       0.00      16.17      64.67     165.96     351.00     620.11     973.30    1410.57    1931.91    2537.32
              OUTFLOW       0.00      34.30     217.79     627.47    1615.13    3391.48    6145.03   10048.47   15262.35   21937.80
            ELEVATION     324.00     324.47     324.95     325.42     325.89     326.37     326.84     327.32     327.79     328.26

              STORAGE    3226.81    4000.38    4858.02    5800.37    6835.75    7966.70    9193.22   10515.31   11932.97   13446.21
              OUTFLOW   30218.38   40241.46   52139.11   66411.48   84164.83  104646.38  127715.89  153355.16  181589.06  212461.08
            ELEVATION     328.74     329.21     329.68     330.16     330.63     331.11     331.58     332.05     332.53     333.00

                                 COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                        COMPUTATION TIME STEP
                    ELEMENT     ALPHA       M         DT        DX        PEAK     TIME TO     VOLUME    MAXIMUM
                                                                                     PEAK                CELERITY
                                                     (MIN)      (FT)      (CFS)     (MIN)       (IN)      (FPS)

                      MAIN                            4.50    536.54   55431.52    342.00       7.23       1.92

                                    INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL


                      MAIN                           15.00             55378.82    345.00       7.23

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3125E+05 EXCESS=0.0000E+00 OUTFLOW=0.3151E+05 BASIN STORAGE=-.3513E+03 PERCENT ERROR=   0.3


        ***           ***           ***           ***           ***

                         HYDROGRAPH AT STATION     RCH10

     PEAK FLOW     TIME                          MAXIMUM AVERAGE FLOW
                                        6-HR        24-HR        72-HR      49.75-HR
  +    (CFS)       (HR)
                               (CFS)
  +    55379.      5.75                42538.       15885.        7663.        7663.
                            (INCHES)    4.841        7.231        7.231        7.231
                             (AC-FT)   21093.       31508.       31508.       31508.

                          CUMULATIVE AREA =    81.70 SQ MI



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              *            *
  102 KK      *   RCH11    *
              *            *
              **************
                          CHANNEL ROUTING X10- X11

                HYDROGRAPH ROUTING DATA

  104 RD          MUSKINGUM-CUNGE CHANNEL ROUTING

  105 RC          NORMAL DEPTH CHANNEL
                          ANL        0.100  LEFT OVERBANK N-VALUE
                         ANCH        0.100  MAIN CHANNEL N-VALUE
                          ANR        0.100  RIGHT OVERBANK N-VALUE
                        RLNTH        6675.  REACH LENGTH
                          SEL       0.0018  ENERGY SLOPE
                        ELMAX        319.0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                                           CROSS-SECTION DATA
                             --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
  107 RY       ELEVATION   320.00    315.00    320.00    313.00    320.00    315.00    314.00    320.00
  106 RX       DISTANCE      0.00   3100.00  14500.00  19500.00  23900.00  26500.00  27300.00  33200.00

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COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

STORAGE	0.00	10.26	41.04	92.35	173.64	302.32	478.78	711.91	1030.64	1437.17
OUTFLOW	0.00	12.37	78.52	231.50	508.66	986.63	1733.89	2796.02	4314.65	6418.17
ELEVATION	313.00	313.32	313.63	313.95	314.26	314.58	314.89	315.21	315.53	315.84
STORAGE	1931.52	2513.68	3183.66	3941.44	4787.04	5720.45	6741.67	7850.71	9047.56	10332.22
OUTFLOW	9205.73	12768.44	17191.79	22556.90	28941.38	36419.82	45061.30	54944.64	66128.67	78682.50
ELEVATION	316.16	316.47	316.79	317.11	317.42	317.74	318.05	318.37	318.68	319.00

COMPUTED MUSKINGUM-CUNGE PARAMETERS

ELEMENT	ALPHA	M	COMPUTATION TIME STEP DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
MAIN			6.00	417.19	51157.99	462.00	7.31	1.15

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

MAIN			15.00		51089.18	465.00	7.31

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3151E+05 EXCESS=0.0000E+00 OUTFLOW=0.3187E+05 BASIN STORAGE=-.4512E+03 PERCENT ERROR= 0.3

*** *** *** *** ***

HYDROGRAPH AT STATION RCH11

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	49.75-HR
+ (CFS)	(HR)					
		(CFS)				
+ 51089.	7.75		40562.	16024.	7750.	7750.
		(INCHES)	4.616	7.294	7.313	7.313
		(AC-FT)	20113.	31782.	31864.	31864.

CUMULATIVE AREA = 81.70 SQ MI

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          *            *
108 KK    *    RCH12   *
          *            *
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CHANNEL ROUTING X11- X12

HYDROGRAPH ROUTING DATA

110 RD MUSKINGUM-CUNGE CHANNEL ROUTING

111 RC NORMAL DEPTH CHANNEL

ANL	0.100	LEFT OVERBANK N-VALUE
ANCH	0.100	MAIN CHANNEL N-VALUE
ANR	0.100	RIGHT OVERBANK N-VALUE
RLNTH	5400.	REACH LENGTH
SEL	0.0018	ENERGY SLOPE
ELMAX	311.0	MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

CROSS-SECTION DATA

--- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---

113 RY	ELEVATION	315.00	310.00	305.00	310.00	303.00	310.00	310.00	315.00
112 RX	DISTANCE	0.00	8700.00	15800.00	21000.00	21500.00	21600.00	28100.00	31100.00

***

COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

STORAGE	0.00	0.94	3.77	8.48	15.07	25.24	76.14	183.00	345.80	564.56
OUTFLOW	0.00	1.70	10.79	31.81	68.51	95.88	227.51	653.97	1482.56	2817.44
ELEVATION	303.00	303.42	303.84	304.26	304.68	305.11	305.53	305.95	306.37	306.79
STORAGE	839.26	1169.91	1556.50	1999.05	2497.54	3051.98	3662.37	4455.59	5513.20	6622.23
OUTFLOW	4753.85	7380.15	10779.36	15030.22	20207.97	26384.91	33630.78	42476.64	54280.18	68364.74
ELEVATION	307.21	307.63	308.05	308.47	308.89	309.32	309.74	310.16	310.58	311.00

COMPUTED MUSKINGUM-CUNGE PARAMETERS

ELEMENT	ALPHA	M	COMPUTATION TIME STEP DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
MAIN			9.75	771.43	49077.53	546.00	7.38	1.38

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

MAIN			15.00		49041.54	540.00	7.38

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CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3187E+05 EXCESS=0.0000E+00 OUTFLOW=0.3216E+05 BASIN STORAGE=-.3678E+03 PERCENT ERROR=   0.3


    ***            ***          ***           ***          ***

                   HYDROGRAPH AT STATION     RCH12

 PEAK FLOW     TIME                        MAXIMUM AVERAGE FLOW
                                   6-HR        24-HR      72-HR      49.75-HR
+   (CFS)      (HR)
                        (CFS)
+   49042.     9.00               39568.      16015.      7819.       7819.
                      (INCHES)     4.503       7.290      7.378       7.378
                       (AC-FT)    19621.      31765.     32149.      32149.

                  CUMULATIVE AREA =    81.70 SQ MI


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            **************
            *            *
 114 KK     *    RCH13   *
            *            *
            **************
                         CHANNEL ROUTING X12- X13

             HYDROGRAPH ROUTING DATA

 116 RD          MUSKINGUM-CUNGE CHANNEL ROUTING

 117 RC          NORMAL DEPTH CHANNEL
                      ANL       0.100  LEFT OVERBANK N-VALUE
                     ANCH       0.100  MAIN CHANNEL N-VALUE
                      ANR       0.100  RIGHT OVERBANK N-VALUE
                    RLNTH       5700.  REACH LENGTH
                      SEL      0.0015  ENERGY SLOPE
                    ELMAX       305.0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                                        CROSS-SECTION DATA
                       --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
 119 RY        ELEVATION    310.00    300.00    296.00    295.00    296.00    300.00    298.00    306.00
 118 RX        DISTANCE       0.00   1700.00   5200.00   5500.00   6000.00  11000.00  13300.00  14200.00

                                                       ***

                                         COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

            STORAGE      0.00     14.50     58.23    159.54    337.87    593.22    927.66   1373.66   1942.45   2634.03
            OUTFLOW      0.00     26.26    164.11    526.85   1340.45   2765.59   4944.66   8084.24  12440.24  18227.97
          ELEVATION    295.00    295.53    296.05    296.58    297.11    297.63    298.16    298.68    299.21    299.74

            STORAGE   3434.33   4258.94   5093.80   5938.89   6794.23   7659.80   8535.62   9421.68  10317.97  11224.50
            OUTFLOW  26497.93  37256.39  49536.20  63263.49  78382.22  94848.26 112626.09 131686.48 152005.22 173561.95
          ELEVATION    300.26    300.79    301.32    301.84    302.37    302.89    303.42    303.95    304.47    305.00

                                 COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                      COMPUTATION TIME STEP
                  ELEMENT     ALPHA       M          DT        DX       PEAK     TIME TO     VOLUME    MAXIMUM
                                                                                  PEAK                 CELERITY
                                                   (MIN)      (FT)     (CFS)     (MIN)       (IN)      (FPS)

                   MAIN                            10.50    814.29  47699.39    609.00       7.49       1.32

                                       INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL


                   MAIN                            15.00            47587.45    615.00       7.49

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3216E+05 EXCESS=0.0000E+00 OUTFLOW=0.3264E+05 BASIN STORAGE=-.3874E+03 PERCENT ERROR=  -0.3


    ***            ***          ***           ***          ***

                   HYDROGRAPH AT STATION     RCH13

 PEAK FLOW     TIME                        MAXIMUM AVERAGE FLOW
                                   6-HR        24-HR      72-HR      49.75-HR
+   (CFS)      (HR)
                        (CFS)
+   47587.    10.25               38353.      16063.      7935.       7935.
                      (INCHES)     4.365       7.312      7.488       7.488
                       (AC-FT)    19018.      31861.     32626.      32626.

                  CUMULATIVE AREA =    81.70 SQ MI


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               *            *
 120 KK        *   RCH14    *
               *            *
               **************
                         CHANNEL ROUTING X13- X14

            HYDROGRAPH ROUTING DATA

 122 RD        MUSKINGUM-CUNGE CHANNEL ROUTING

 123 RC        NORMAL DEPTH CHANNEL
                         ANL      0.100  LEFT OVERBANK N-VALUE
                        ANCH      0.100  MAIN CHANNEL N-VALUE
                         ANR      0.100  RIGHT OVERBANK N-VALUE
                       RLNTH      3800.  REACH LENGTH
                         SEL     0.0021  ENERGY SLOPE
                       ELMAX      294.0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                                   CROSS-SECTION DATA
                        --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
 125 RY      ELEVATION   300.00    290.00    300.00    292.00    289.00    287.00    295.00    301.00
 124 RX      DISTANCE      0.00  14000.00  24000.00  26900.00  30200.00  30500.00  35400.00  36400.00

                                              ***

                                   COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

   STORAGE       0.00      4.51     18.06     40.63     72.22    112.85    164.34    235.07    326.08    447.80
   OUTFLOW       0.00     11.44     72.63    214.13    461.16    836.15   1306.52   2002.47   2987.93   4324.87
 ELEVATION     287.00    287.37    287.74    288.11    288.47    288.84    289.21    289.58    289.95    290.32

   STORAGE     617.91    836.72   1104.22   1420.42   1784.50   2189.98   2635.41   3120.81   3646.16   4211.48
   OUTFLOW    6171.87   8670.86  11942.48  16096.28  21361.16  27847.87  35445.22  44216.36  54223.44  65527.60
 ELEVATION     290.68    291.05    291.42    291.79    292.16    292.53    292.89    293.26    293.63    294.00

                               COMPUTED MUSKINGUM-CUNGE PARAMETERS
                                    COMPUTATION TIME STEP
            ELEMENT   ALPHA      M        DT       DX       PEAK    TIME TO    VOLUME   MAXIMUM
                                                                     PEAK               CELERITY
                                         (MIN)     (FT)     (CFS)    (MIN)      (IN)     (FPS)

             MAIN                         9.75    760.00  46811.22   663.00     7.53     1.33

                                  INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

             MAIN                        15.00            46810.32   660.00     7.53

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3264E+05 EXCESS=0.0000E+00 OUTFLOW=0.3283E+05 BASIN STORAGE=-.1959E+03 PERCENT ERROR=   0.0


     ***           ***           ***           ***           ***

                HYDROGRAPH AT STATION     RCH14

  PEAK FLOW    TIME                    MAXIMUM AVERAGE FLOW
                                6-HR      24-HR      72-HR     49.75-HR
 +  (CFS)      (HR)
                      (CFS)
 +  46810.    11.00             37714.    16065.      7981.      7981.
                   (INCHES)     4.292     7.313      7.531      7.531
                    (AC-FT)     18701.    31864.     32816.     32816.

                 CUMULATIVE AREA =    81.70 SQ MI


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               *            *
 126 KK        *   RCH15    *
               *            *
               **************
                         CHANNEL ROUTING X14- X15

            HYDROGRAPH ROUTING DATA

 128 RD        MUSKINGUM-CUNGE CHANNEL ROUTING

 129 RC        NORMAL DEPTH CHANNEL
                         ANL      0.100  LEFT OVERBANK N-VALUE
                        ANCH      0.100  MAIN CHANNEL N-VALUE
                         ANR      0.100  RIGHT OVERBANK N-VALUE
                       RLNTH      3800.  REACH LENGTH
                         SEL     0.0011  ENERGY SLOPE
                       ELMAX      291.0  MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

                                   CROSS-SECTION DATA
                        --- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---
 131 RY      ELEVATION   293.00    290.00    288.00    287.00    290.00    287.00    290.00    291.00
 130 RX      DISTANCE      0.00   3400.00   8700.00  17400.00  20900.00  28800.00  33000.00  36400.00

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COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

STORAGE	0.00	26.88	107.50	241.88	430.00	671.15	949.22	1257.65	1596.44	1965.58
OUTFLOW	0.00	33.94	215.52	635.43	1368.48	2528.12	4245.16	6391.07	8982.60	12038.32
ELEVATION	287.00	287.21	287.42	287.63	287.84	288.05	288.26	288.47	288.68	288.89
STORAGE	2365.07	2794.93	3255.13	3745.70	4266.62	4814.27	5379.86	5962.97	6563.62	7181.79
OUTFLOW	15577.91	19621.64	24190.10	29303.96	34983.86	41740.18	49314.16	57541.30	66416.13	75937.84
ELEVATION	289.11	289.32	289.53	289.74	289.95	290.16	290.37	290.58	290.79	291.00

COMPUTED MUSKINGUM-CUNGE PARAMETERS

COMPUTATION TIME STEP

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
MAIN			10.50	542.86	44332.38	745.50	7.60	0.87

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

MAIN			15.00		44260.14	750.00	7.60

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3283E+05 EXCESS=0.0000E+00 OUTFLOW=0.3312E+05 BASIN STORAGE=-.4817E+03 PERCENT ERROR= 0.6

*** *** *** *** ***

HYDROGRAPH AT STATION RCH15

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	49.75-HR
+ (CFS)	(HR)					
		(CFS)				
+ 44260.	12.50		36290.	16004.	8052.	8052.
		(INCHES)	4.130	7.285	7.598	7.598
		(AC-FT)	17995.	31744.	33105.	33105.

CUMULATIVE AREA = 81.70 SQ MI

*** ***

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           **************
           *            *
 132 KK    *   RCH16    *
           *            *
           **************
```

CHANNEL ROUTING X15- X16

HYDROGRAPH ROUTING DATA

134 RD MUSKINGUM-CUNGE CHANNEL ROUTING

135 RC NORMAL DEPTH CHANNEL

ANL	0.100	LEFT OVERBANK N-VALUE
ANCH	0.100	MAIN CHANNEL N-VALUE
ANR	0.100	RIGHT OVERBANK N-VALUE
RLNTH	3650.	REACH LENGTH
SEL	0.0014	ENERGY SLOPE
ELMAX	279.0	MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

CROSS-SECTION DATA

--- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---

137 RY	ELEVATION	280.00	275.00	275.00	273.00	275.00	290.00	274.00	280.00
136 RX	DISTANCE	0.00	7200.00	10200.00	12800.00	15000.00	16200.00	21600.00	25500.00

***

COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

STORAGE	0.00	10.03	40.11	90.25	163.31	264.56	394.12	603.28	860.26	1138.19
OUTFLOW	0.00	19.49	123.76	364.88	790.75	1465.16	2445.77	4088.52	6534.81	9624.55
ELEVATION	273.00	273.32	273.63	273.95	274.26	274.58	274.89	275.21	275.53	275.84
STORAGE	1437.08	1756.92	2097.71	2459.45	2842.15	3245.80	3670.41	4115.97	4582.48	5069.95
OUTFLOW	13345.70	17702.32	22705.08	28368.09	34707.35	41740.03	49483.96	57957.43	67178.95	77167.15
ELEVATION	276.16	276.47	276.79	277.11	277.42	277.74	278.05	278.37	278.68	279.00

COMPUTED MUSKINGUM-CUNGE PARAMETERS

COMPUTATION TIME STEP

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
MAIN			10.50	730.00	43117.69	798.00	7.64	1.23

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

MAIN			15.00		43051.59	795.00	7.64

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3311E+05 EXCESS=0.0000E+00 OUTFLOW=0.3332E+05 BASIN STORAGE=-.2846E+03 PERCENT ERROR= 0.2

*** *** *** *** ***

HYDROGRAPH AT STATION RCH16

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	49.75-HR
+ (CFS)	(HR)					
		(CFS)				
+ 43052.	13.25		35546.	15977.	8101.	8101.
		(INCHES)	4.045	7.273	7.644	7.644
		(AC-FT)	17626.	31690.	33308.	33308.

CUMULATIVE AREA = 81.70 SQ MI

*** ***

```
              **************
              *            *
 138 KK       *    RCH17   *
              *            *
              **************
```

CHANNEL ROUTING X16- X17

HYDROGRAPH ROUTING DATA

140 RD MUSKINGUM-CUNGE CHANNEL ROUTING

141 RC NORMAL DEPTH CHANNEL

ANL	0.100	LEFT OVERBANK N-VALUE
ANCH	0.100	MAIN CHANNEL N-VALUE
ANR	0.100	RIGHT OVERBANK N-VALUE
RLNTH	5150.	REACH LENGTH
SEL	0.0007	ENERGY SLOPE
ELMAX	274.0	MAX. ELEV. FOR STORAGE/OUTFLOW CALCULATION

CROSS-SECTION DATA

--- LEFT OVERBANK --- + ------ MAIN CHANNEL ------- + --- RIGHT OVERBANK ---

143 RY	ELEVATION	275.00	270.00	270.00	272.00	270.00	269.00	270.00	275.00
142 RX	DISTANCE	0.00	8300.00	20700.00	21600.00	22000.00	26200.00	27000.00	29200.00

***

COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

STORAGE	0.00	20.47	81.87	184.21	404.25	961.36	1540.98	2143.12	2767.77	3414.94
OUTFLOW	0.00	17.66	112.10	330.52	764.79	2094.63	4180.26	6910.05	10235.02	14127.59
ELEVATION	269.00	269.26	269.53	269.79	270.05	270.32	270.58	270.84	271.11	271.37
STORAGE	4084.62	4776.81	5490.57	6221.94	6970.51	7736.27	8519.22	9319.37	10136.71	10971.24
OUTFLOW	18571.00	23554.93	29170.72	35386.18	42131.77	49403.41	57198.49	65515.60	74354.20	83714.59
ELEVATION	271.63	271.89	272.16	272.42	272.68	272.95	273.21	273.47	273.74	274.00

COMPUTED MUSKINGUM-CUNGE PARAMETERS

COMPUTATION TIME STEP

ELEMENT	ALPHA	M	DT	DX	PEAK	TIME TO PEAK	VOLUME	MAXIMUM CELERITY
			(MIN)	(FT)	(CFS)	(MIN)	(IN)	(FPS)
MAIN			10.50	515.00	38318.23	934.50	7.78	0.83

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

ELEMENT	ALPHA	M	DT	DX	PEAK	TIME TO PEAK	VOLUME	MAXIMUM CELERITY
MAIN			15.00		38272.59	930.00	7.78	

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3332E+05 EXCESS=0.0000E+00 OUTFLOW=0.3390E+05 BASIN STORAGE=-.7612E+03 PERCENT ERROR= 0.6

*** *** *** *** ***

HYDROGRAPH AT STATION RCH17

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	49.75-HR
+ (CFS)	(HR)					
		(CFS)				
+ 38273.	15.50		32777.	15831.	8242.	8242.
		(INCHES)	3.730	7.206	7.777	7.777
		(AC-FT)	16253.	31401.	33888.	33888.

CUMULATIVE AREA = 81.70 SQ MI

-----DSS---ZWRITE Unit 71; Vers. 1: /BIGDRY/REACH17/FLOW/01JAN1994/15MIN/SOUTHBREACH/
-----DSS---ZWRITE Unit 71; Vers. 1: /BIGDRY/REACH17/FLOW/02JAN1994/15MIN/SOUTHBREACH/
-----DSS---ZWRITE Unit 71; Vers. 1: /BIGDRY/REACH17/FLOW/03JAN1994/15MIN/SOUTHBREACH/
1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	IN	0.	0.00	0.	0.	0.	81.70		
+ +	ROUTED TO	OUT	69894.	1.00	48004.	15275.	7369.	81.70	432.70	0.02
+	ROUTED TO	RCH1	69071.	1.00	47997.	15276.	7369.	81.70		
+	ROUTED TO	RCH2	67776.	1.25	47992.	15281.	7372.	81.70		
+	ROUTED TO	RCH3	67765.	1.25	47953.	15294.	7378.	81.70		
+	ROUTED TO	RCH4	67399.	1.25	47957.	15329.	7395.	81.70		
+	ROUTED TO	RCH5	66694.	1.50	47636.	15327.	7394.	81.70		
+	ROUTED TO	RCH6	65044.	2.00	47352.	15369.	7414.	81.70		
+	ROUTED TO	RCH7	64009.	2.50	46526.	15491.	7473.	81.70		
+	ROUTED TO	RCH8	60611.	3.75	45043.	15623.	7537.	81.70		
+	ROUTED TO	RCH9	58973.	4.50	43983.	15753.	7600.	81.70		
+	ROUTED TO	RCH10	55379.	5.75	42538.	15885.	7663.	81.70		
+	ROUTED TO	RCH11	51089.	7.75	40562.	16024.	7750.	81.70		
+	ROUTED TO	RCH12	49042.	9.00	39568.	16015.	7819.	81.70		
+	ROUTED TO	RCH13	47587.	10.25	38353.	16063.	7935.	81.70		
+	ROUTED TO	RCH14	46810.	11.00	37714.	16065.	7981.	81.70		
+	ROUTED TO	RCH15	44260.	12.50	36290.	16004.	8052.	81.70		
+	ROUTED TO	RCH16	43052.	13.25	35546.	15977.	8101.	81.70		
+	ROUTED TO	RCH17	38273.	15.50	32777.	15831.	8242.	81.70		

1

SUMMARY OF KINEMATIC WAVE - MUSKINGUM-CUNGE ROUTING
(FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)

ISTAQ	ELEMENT	DT (MIN)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	INTERPOLATED TO COMPUTATION INTERVAL DT (MIN)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)
RCH1	MANE	0.33	69909.80	60.49	6.95	15.00	69071.27	60.00	6.95

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3030E+05 EXCESS=0.0000E+00 OUTFLOW=0.3030E+05 BASIN STORAGE=-.1382E+01 PERCENT ERROR= 0.0

RCH2	MANE	0.94	69274.63	61.17	6.95	15.00	67776.12	75.00	6.96

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3030E+05 EXCESS=0.0000E+00 OUTFLOW=0.3030E+05 BASIN STORAGE=-.2142E+01 PERCENT ERROR= 0.0

RCH3	MANE	1.87	68242.80	63.50	6.96	15.00	67765.13	75.00	6.96

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3031E+05 EXCESS=0.0000E+00 OUTFLOW=0.3032E+05 BASIN STORAGE=-.1117E+02 PERCENT ERROR= 0.0

RCH4	MANE	2.25	67602.91	76.46	6.97	15.00	67398.53	75.00	6.98

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3034E+05 EXCESS=0.0000E+00 OUTFLOW=0.3038E+05 BASIN STORAGE=-.6600E+01 PERCENT ERROR= -0.1

RCH5	MANE	3.75	67488.86	82.50	6.99	15.00	66694.46	90.00	6.98

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3041E+05 EXCESS=0.0000E+00 OUTFLOW=0.3044E+05 BASIN STORAGE=-.3453E+02 PERCENT ERROR= 0.0

```
          RCH6  MANE        4.50  65440.11    112.50     7.00     15.00  65044.30    120.00       7.00

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3040E+05 EXCESS=0.0000E+00 OUTFLOW=0.3050E+05 BASIN STORAGE=-.1331E+03 PERCENT ERROR=   0.1

          RCH7  MANE        5.25  64039.86    152.25     7.04     15.00  64008.61    150.00       7.05

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3050E+05 EXCESS=0.0000E+00 OUTFLOW=0.3070E+05 BASIN STORAGE=-.3245E+03 PERCENT ERROR=   0.4

          RCH8  MANE        5.25  60839.07    220.50     7.11     15.00  60611.44    225.00       7.11

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3072E+05 EXCESS=0.0000E+00 OUTFLOW=0.3098E+05 BASIN STORAGE=-.3425E+03 PERCENT ERROR=   0.3

          RCH9  MANE        5.25  59355.41    262.50     7.17     15.00  58972.99    270.00       7.17

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3100E+05 EXCESS=0.0000E+00 OUTFLOW=0.3125E+05 BASIN STORAGE=-.2603E+03 PERCENT ERROR=   0.0

          RCH10  MANE       4.50  55431.52    342.00     7.23     15.00  55378.82    345.00       7.23

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3125E+05 EXCESS=0.0000E+00 OUTFLOW=0.3151E+05 BASIN STORAGE=-.3513E+03 PERCENT ERROR=   0.3

          RCH11  MANE       6.00  51157.99    462.00     7.31     15.00  51089.18    465.00       7.31

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3151E+05 EXCESS=0.0000E+00 OUTFLOW=0.3187E+05 BASIN STORAGE=-.4512E+03 PERCENT ERROR=   0.3

          RCH12  MANE       9.75  49077.53    546.00     7.38     15.00  49041.54    540.00       7.38

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3187E+05 EXCESS=0.0000E+00 OUTFLOW=0.3216E+05 BASIN STORAGE=-.3678E+03 PERCENT ERROR=   0.3

          RCH13  MANE      10.50  47699.39    609.00     7.49     15.00  47587.45    615.00       7.49

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3216E+05 EXCESS=0.0000E+00 OUTFLOW=0.3264E+05 BASIN STORAGE=-.3874E+03 PERCENT ERROR=  -0.3

          RCH14  MANE       9.75  46811.22    663.00     7.53     15.00  46810.32    660.00       7.53

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3264E+05 EXCESS=0.0000E+00 OUTFLOW=0.3283E+05 BASIN STORAGE=-.1959E+03 PERCENT ERROR=   0.0

          RCH15  MANE      10.50  44332.38    745.50     7.60     15.00  44260.14    750.00       7.60

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3283E+05 EXCESS=0.0000E+00 OUTFLOW=0.3312E+05 BASIN STORAGE=-.4817E+03 PERCENT ERROR=   0.6

          RCH16  MANE      10.50  43117.69    798.00     7.64     15.00  43051.59    795.00       7.64

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3311E+05 EXCESS=0.0000E+00 OUTFLOW=0.3332E+05 BASIN STORAGE=-.2846E+03 PERCENT ERROR=   0.2

          RCH17  MANE      10.50  38318.23    934.50     7.78     15.00  38272.59    930.00       7.78

CONTINUITY SUMMARY (AC-FT) - INFLOW=0.3332E+05 EXCESS=0.0000E+00 OUTFLOW=0.3390E+05 BASIN STORAGE=-.7612E+03 PERCENT ERROR=   0.6

1                         SUMMARY OF DAM OVERTOPPING/BREACH ANALYSIS FOR STATION      OUT
                       (PEAKS SHOWN ARE FOR INTERNAL TIME STEP USED  DURING BREACH FORMATION)

     PLAN  1 ..............              INITIAL VALUE     SPILLWAY CREST     TOP OF DAM
                           ELEVATION        432.70             432.70           442.20
                           STORAGE          30200.             30200.           49422.
                           OUTFLOW           1617.              1617.           71047.

                  RATIO    MAXIMUM      MAXIMUM    MAXIMUM    MAXIMUM    DURATION    TIME OF     TIME OF
                    OF     RESERVOIR    DEPTH      STORAGE    OUTFLOW    OVER TOP   MAX OUTFLOW  FAILURE
                   PMF     W.S.ELEV    OVER DAM    AC-FT       CFS        HOURS       HOURS       HOURS

                  1.00      432.70       0.00      30200.     69894.      0.00        1.00        0.00


*** NORMAL END OF HEC-1 ***


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             Number of Records:      6
             File Size:     14.2  Kbytes
             Percent Inactive:    0.0
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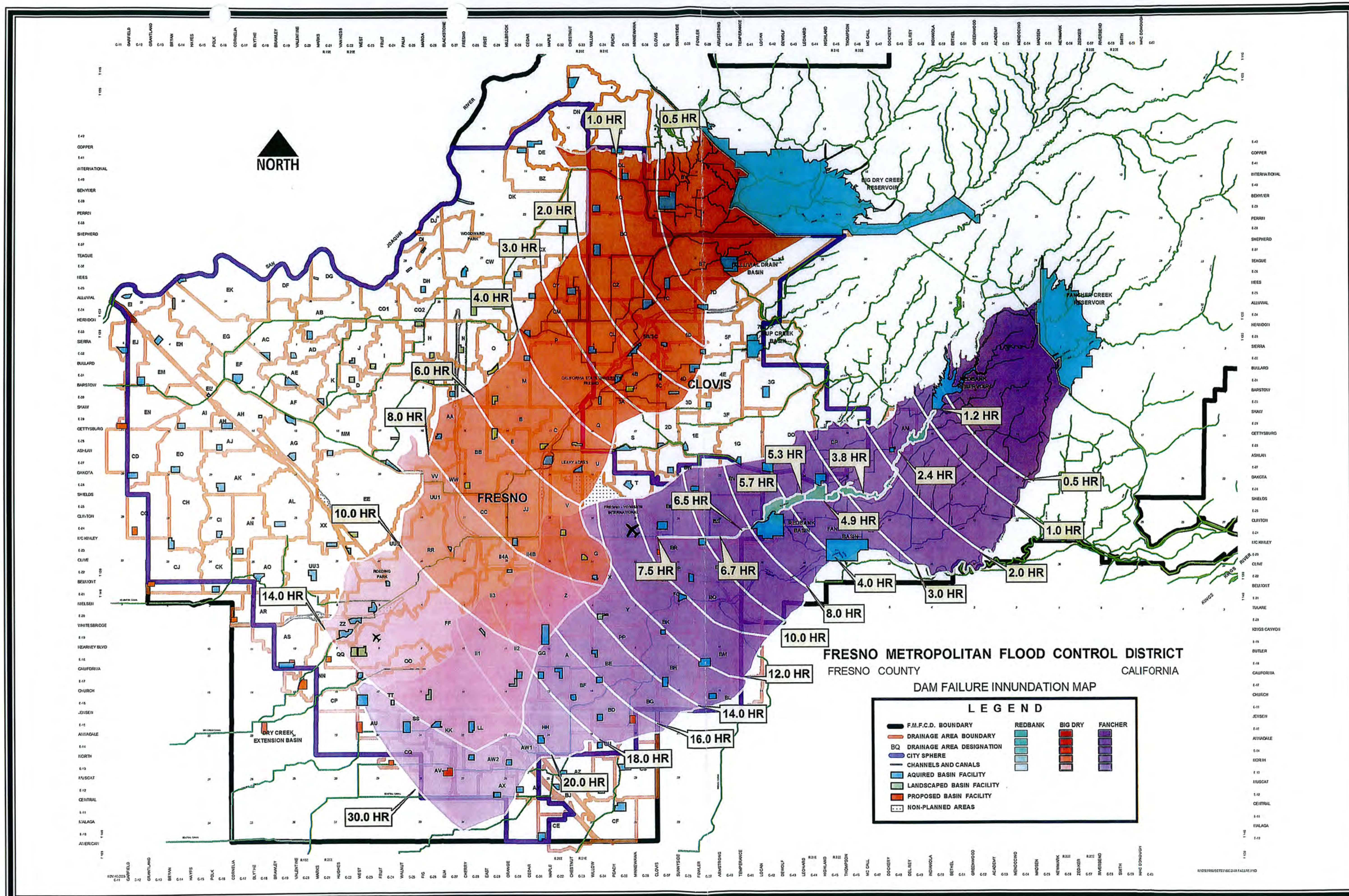


FRESNO METROPOLITAN FLOOD CONTROL DISTRICT
FRESNO COUNTY
CALIFORNIA
DAM FAILURE INNUNDATION MAP
LEGEND
F.M.F.C.D. BOUNDARY
DRAINAGE AREA BOUNDARY
BQ DRAINAGE AREA DESIGNATION
CITY SPHERE
CHANNELS AND CANALS
AQUIRED BASIN FACILITY
LANDSCAPED BASIN FACILITY
PROPOSED BASIN FACILITY
NON-PLANNED AREAS
REDBANK
BIG DRY
FANCHER
NORTH
FRESNO
CLOVIS
BIG DRY CREEK RESERVOIR
FANCHER CREEK RESERVOIR
REDBANK RESERVOIR
ALLUVIAL DRAIN BASIN
REDBANK BASIN
FANCHER BASIN
DRY CREEK EXTENSION BASIN
CALIFORNIA STATE UNIVERSITY FRESNO
WOODWARD PARK
ROEDING PARK
SAN JOAQUIN RIVER
KINGS RIVER
0.5 HR
1.0 HR
2.0 HR
3.0 HR
4.0 HR
6.0 HR
8.0 HR
10.0 HR
14.0 HR
1.2 HR
2.4 HR
3.8 HR
4.9 HR
5.3 HR
5.7 HR
6.5 HR
6.7 HR
7.5 HR
12.0 HR
16.0 HR
18.0 HR
20.0 HR
30.0 HR

Print Form

Notice of Determination

Appendix D

To:

☒ Office of Planning and Research

U.S. Mail:	*Street Address:*
P.O. Box 3044	1400 Tenth St., Rm 113
Sacramento, CA 95812-3044	Sacramento, CA 95814

☒ County Clerk
County of: Fresno
Address:

From:

Public Agency: Fresno Metro Flood Control District
Address: 5469 E. Olive Ave
Fresno, CA 93727
Contact: Kristine Johnson
Phone: 559-456-3292

Lead Agency (if different from above):

Address:

Contact:
Phone:

SUBJECT: Filing of Notice of Determination in compliance with Section 21108 or 21152 of the Public Resources Code.

State Clearinghouse Number (if submitted to State Clearinghouse): 2012021052

Project Title: Const. of Stormwater Ret Basin (Pup Creek Basin),Channel Re-Alignment and Culvert Replacement

Project Applicant: Fresno Metropolitan Flood Control District

Project Location (include county): Herndon and DeWolf Avenues, Clovis, CA, APN 553-120-05S

Project Description:
Construction of a stormwater retention basin south of the Enterprise Canal at Pup Creek. The basin design will provide 200 acre-feet of storage for stormwater. The culverts on Pup Creek that go under the Enterprise Canal will be replaced to increase capacity and prevent water from overtopping the Enterprise Canal banks and potential flooding downstream. Pup Creek will be re-routed to flow across the basin site to a control structure at the south of the property.

This is to advise that the Fresno Metropolitan Flood Control District (☒ Lead Agency or ☐ Responsible Agency) has approved the above described project on April 11, 2012 (date) and has made the following determinations regarding the above described project.

1. The project [☐ will ☒ will not] have a significant effect on the environment.
2. ☐ An Environmental Impact Report was prepared for this project pursuant to the provisions of CEQA.
   ☒ A Negative Declaration was prepared for this project pursuant to the provisions of CEQA.
3. Mitigation measures [☒ were ☐ were not] made a condition of the approval of the project.
4. A mitigation reporting or monitoring plan [☒ was ☐ was not] adopted for this project.
5. A statement of Overriding Considerations [☐ was ☒ was not] adopted for this project.
6. Findings [☒ were ☐ were not] made pursuant to the provisions of CEQA.

This is to certify that the final EIR with comments and responses and record of project approval, or the negative Declaration, is available to the General Public at:
Fresno Metropolitan Flood Control District, 5469 E. Olive Ave., Fresno, CA 93727

Signature (Public Agency): Bob Van Wyk Title: General Manager - Secretary

Date: April 12, 2012 Date Received for filing at OPR:

Authority cited: Sections 21083, Public Resources Code.
Reference Section 21000-21174, Public Resources Code.

Revised 2011

E201310000018

Notice of Exemption

To: County Clerk
County of Fresno

From: Fresno Metropolitan Flood Control District
5469 East Olive Avenue
Fresno, CA 93727

Project Title: Acquisition and Construction of Big Dry Creek Detention Basin

Project Location: Big Dry Creek Detention Basin is between State Route 168 and the City of Fresno's Leaky Acres, and just south of Ashlan Avenue and north of Hayston Avenue.

Project Location – City: Fresno **Project Location – County:** County of Fresno

Description of Nature, Purpose and Beneficiaries of Project:
Big Dry Creek Detention Basin project and property were previously studied under the Route 168 Between Route 180 and Temperance Avenue Environmental Impact Statement/Environmental Impact Report prepared by the U.S. Department of Transportation Federal Highway Administration and the State of California Department of Transportation in 1993 as a replacement site for Fresno Metropolitan Flood Control District stormwater detention basin property that was loss due to the construction of Route 168. (See Attachment No. 1) The project has been in progress for many years. The project area is fenced and is partially excavated with some pipelines and an outfall cage already installed. The project was re-evaluated since the original CEQA evaluation was done almost 20 years ago.

Big Dry Creek Detention Basin will provide multiple purposes and serve several communities. It will provide drainage service to 107 acres of Route 168 and provided the lost stormwater storage capacity from the construction of the freeway. The basin will also provide extra storage capacity to attenuate flood flows from Big Dry Creek and/or the Gould Canal improving the overall flood protection to downstream properties. Lastly, the basin will recharge approximately 660 acre-feet of water annually to the local area's groundwater aquifer.

Name of Public Agency Approving Project: Fresno Metropolitan Flood Control District

Name of Person or Agency Carrying Out Project: Fresno Metropolitan Flood Control District

Exempt Status:
Categorical Exemption Type: Existing Facilities Section #: 15301(b)

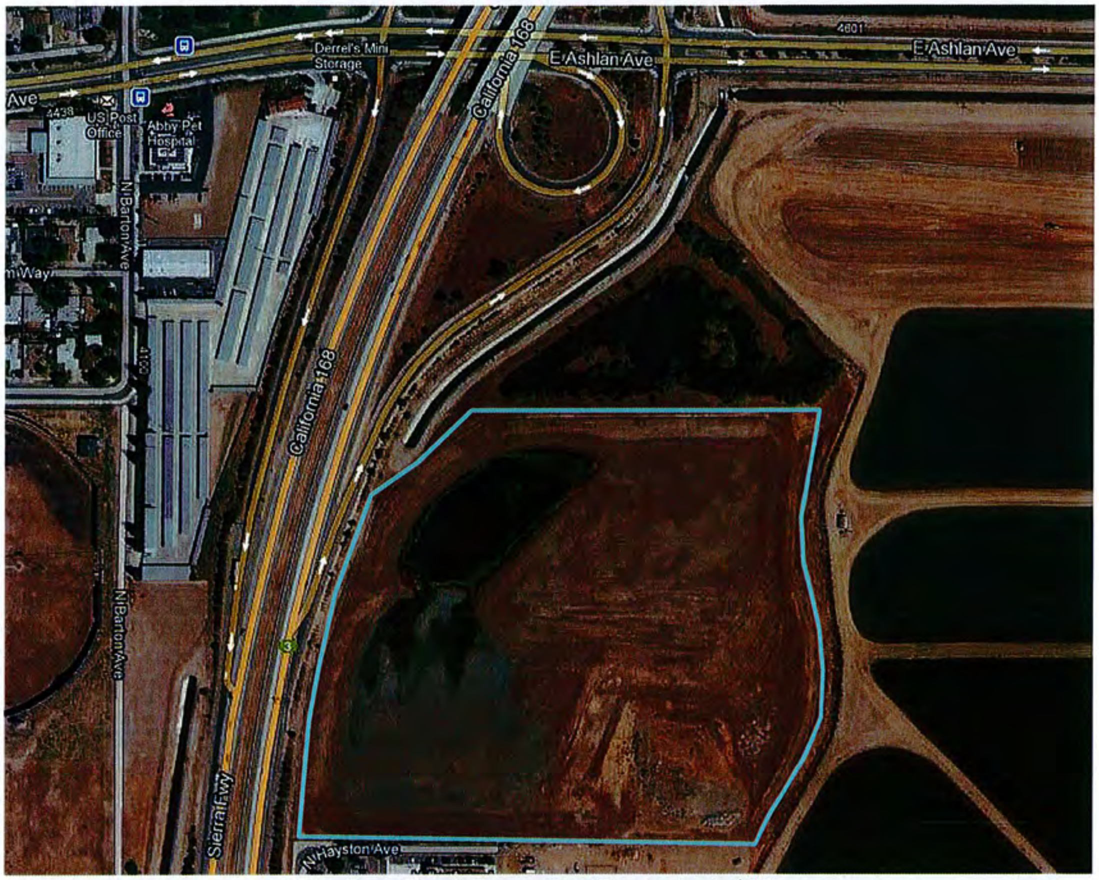
Reasons why project is exempt: Fresno Metropolitan Flood Control District is continuing a project currently being constructed and evaluated by CEQA in 1993. There are no new features or impacts associated with this project.

Lead Agency Contact Person: Kristine Johnson (559) 456-3292

FILED
JAN 24 2013
FRESNO COUNTY CLERK
By Victoria Villarreal DEPUTY

Signature: Daniel Rourke Date: 1-23-13 Title: Environmental Resources Manager

Attachment No. 1



Big Dry Creek Detention Basin Aerial View

Big Dry Creek Detention Basin from the southwest corner

STATE OF CALIFORNIA - THE RESOURCES AGENCY
DEPARTMENT OF FISH AND GAME

ENVIRONMENTAL FILING FEE CASH RECEIPT

Receipt # E201310000018

Lead Agency: FRESNO METROPOLITAN FLOOD CONTROL DIST. Date: 01/24/2013

County Agency of Filing: FRESNO COUNTY CLERK Document No: E201310000018

Project Title: ACQUISITION AND CONSTRUCTION OF BIG DRY CREEK DETENTION BASIN

Project Applicant Name: FRESNO METROPOLITAN FLOOD CONTROL DISTRICT Phone Number: (559) 456-3292

Project Applicant Address: 5469 E. OLIVE AVENUE, FRESNO, CA 93727

Project Applicant: LOCAL PUBLIC AGENCY

ADMINISTRATION FEE	$	50.00
CATEGORICAL EXEMPTION	$	0.00
Total Received	**$**	**50.00**

Signature and title of person receiving payment: Victoria L. Villicana

FRESNO COUNTY
CLERK'S OFFICE
BRANDI L. ORTH

2221 KERN STREET
FRESNO, CA 93721

Finalization 2013132124
01/24/2013 09:03am
80 vcorrales

Item Title	Count
1 EIRA	1
EIR Administrative Fee	

Document ID	Amount
DOC# E201310000017	50.00
Time Recorded 09:03 am	

Total	50.00

Payment Type	Amount
Cash	50.00
Amount Due	0.00

Thank You
Please Retain This Receipt
For Your Records

FILED

NOV 21 2002

FRESNO COUNTY CLERK
By [signature] DEPUTY

Fresno Metropolitan Flood Control District
Notice of Determination

To: Fresno County Clerk
2221 Kern St
Fresno, CA 93721

From: Fresno Metropolitan Flood Control District
5469 E. Olive Avenue
Fresno, CA 93727

E200210000340

Subject: Filing of Notice of Determination in compliance with Section 21108 or 21152 of the Public Resources Code.

Project Title: Acquisition and Construction of Dry Creek Extension Basin

Project Location: The study area for the proposed Dry Creek Extension Basin encompasses 20 acres located on the north side of W. Annadale Avenue, approximately 825 feet west of S. Brawley Avenue in Fresno County (Assessors Parcel Number 327-030-51 [western 20 acres]).

Project Description: The proposed basin will be a rural streams flood control feature and will be utilized for groundwater recharge. Water will be supplied to the basin by pipeline from the Fanning Canal located directly north of the property and the Dry Creek Canal located approximately 400 feet to the west of the property. The facility will provide no urban drainage services.

The ultimate size of the basin will be approximately 20 acres and will have capacity for approximately 166 acre-feet of water. Side slopes will be constructed at a 5:1 steepness ratio, and the basin will be excavated to an average depth of 17.5 feet. A 6-foot high permanent perimeter fence will be installed around the site.

Determinations:
This is to advise that the Fresno Metropolitan Flood Control District (Lead Agency) has approved the above-described project on November 20, 2002, and has made the following determinations regarding the above-described project:

1. The project will not have a significant effect on the environment.
2. A Mitigated Negative Declaration was prepared for this project pursuant to the provisions of CEQA.
3. Mitigation measures were incorporated into the project.

This is to certify that the final Mitigated Negative Declaration with comments and responses and record of project approval is available to the general public at the District address noted above.

[signature] 11-21-02

David Pomaville, Environmental Resources Manager — Date

59826 11/21/2002 2:22:14 PM

FILED

NOV 21 2002

FRESNO COUNTY CLERK
By [signature] DEPUTY
E200210000340

Fresno Metropolitan Flood Control District
Mitigated Negative Declaration

( ) Proposed
(X) Final

Name of Project: Acquisition and Construction of Dry Creek Extension Basin

Entity or Person Undertaking Project:
Fresno Metropolitan Flood Control District
5469 E. Olive Avenue
Fresno, CA 93727

Contact: Christine Kelley
Staff Analyst
(559) 456-3292
fmfcd.env@verizon.net

Project Location:
The study area for the proposed Dry Creek Extension Basin encompasses 20 acres located on the north side of W. Annadale Avenue, approximately 825 feet west of S. Brawley Avenue in Fresno County (Assessors Parcel Number 327-030-51 [western 20 acres]).

Project Description:
The proposed basin will be a rural streams flood control feature and will be utilized for groundwater recharge. Water will be supplied to the basin by pipeline from the Fanning Canal located directly north of the property and the Dry Creek Canal located approximately 400 feet to the west of the property. The facility will provide no urban drainage services.

The ultimate size of the basin will be approximately 20 acres and will have capacity for approximately 166 acre-feet of water. Side slopes will be constructed at a 5:1 steepness ratio, and the basin will be excavated to an average depth of 17.5 feet. A 6-foot high permanent perimeter fence will be installed around the site.

Finding:
It is hereby found that although the above-mentioned project could have a significant effect on the environment, there will not be a significant effect in this case because the mitigation measures described in the Initial Study have been added to the project.

Initial Study:
An Initial Study of this project was undertaken and prepared in accordance with the California Environmental Quality Act Guidelines for the purpose of ascertaining whether this project might have a significant effect on the environment. A copy of the Initial Study is attached and is incorporated in this Mitigated Negative Declaration by reference. The Initial Study document gives reason to support the above finding.

Mitigation Measures:
The mitigation measures listed in the attached Initial Study have been included in the project to avoid potentially significant effects.

Date: 11-21-02

[signature]
David Pomaville, Environmental Resources Manager

FILED

NOV 21 2002

FRESNO COUNTY CLERK
By ______ DEPUTY

E200210000341 0

Fresno Metropolitan Flood Control District
Certificate of Fee Exemption

De Minimis Impact Finding

To: County Clerk, Fresno County
2221 Kern Street
Fresno, CA 93721

From: Fresno Metropolitan Flood Control District
5469 E. Olive Avenue
Fresno, CA 92727

Project Title/Location/Proponent:

Title: Acquisition and Construction of Dry Creek Extension Basin

Location: The study area for the proposed Dry Creek Extension Basin encompasses 20 acres located on the north side of W. Annadale Avenue, approximately 825 feet west of S. Brawley Avenue in Fresno County (Assessors Parcel Number 327-030-51 [western 20 acres]).

Proponent: Fresno Metropolitan Flood Control District
5469 E. Olive Avenue
Fresno, CA 93727

Project Description:
The proposed basin will be a rural streams flood control feature and will be utilized for groundwater recharge. Water will be supplied to the basin by pipeline from the Fanning Canal located directly north of the property and the Dry Creek Canal located approximately 400 feet to the west of the property. The facility will provide no urban drainage services.

The ultimate size of the basin will be approximately 20 acres and will have capacity for approximately 166 acre-feet of water. Side slopes will be constructed at a 5:1 steepness ratio, and the basin will be excavated to an average depth of 17.5 feet. A 6-foot high permanent perimeter fence will be installed around the site.

Finding of Exemption:

1. An Initial Study has been conducted by the Fresno Metropolitan Flood Control District, which has evaluated the potential for this project to cause any adverse effect, either individually or cumulatively, on wildlife resources. For this purpose, wildlife is defined as "all wild animals, birds, plants, fish, amphibians, and related ecological communities, including the habitat upon which the wildlife depends for its continued viability." (Section 711.1 of the Fish and Game Code)
2. The proposed project will not have an adverse effect on wildlife resources based to the following considerations:
   a. Based on the environmental review process and hearing record, there is no evidence that the proposed project would have any potential for adverse effect on wildlife resources.
   b. Based on the environmental review process and hearing record, although the proposed project could potentially have an adverse effect on wildlife resources, the potential for such adverse effect has been reduced to less than significance by mitigation measures.

Certification:
I hereby certify that the Fresno Metropolitan Flood Control District, as lead agency, has made the above findings of fact, and based upon the environmental review process and hearing record, the proposed project will not individually or cumulatively have an adverse effect on wildlife resources, as defined in Section 711.1 of the Fish and Game Code.

Date: 11-21-02

David Pomaville, Environmental Resources Manager

208030

STATE OF CALIFORNIA - THE RESOURCES AGENCY
DEPARTMENT OF FISH AND GAME
ENVIRONMENTAL FILING FEE CASH RECEIPT
DFG 753.5a (6-01)

Lead Agency: FRESNO METROPOLITAN FLOOD CONTROL DISTRICT   Date: 11/21/2002

County / State Agency of Filing: FRESNO COUNTY CLERK   Document No. E200210000340

Project Title: Acquisition & Construction of Dry Creek Extension Basin

Project Applicant Name: Christine Kelley, Staff Analyst, Fresno Metropolitan Flood Control District   Phone Number: 456-3292

Project Applicant Address: 5469 E. OLIVE AVE., FRESNO CA 93727

Project Applicant *(check appropriate box)*: Local Public Agency [ ] School District [ ] Other Special District [X] State Agency [ ] Private Entity [ ]

CHECK APPLICABLE FEES:

( ) Environmental Impact Report	$850.00	$Ø
( ) Negative Declaration	$1,250.00	$Ø
( ) Application Fee Water Diversion *(State Water Resources Control Board Only)*	$850.00	$Ø
( ) Projects Subject to Certified Regulatory Programs	$850.00	$Ø
(X) County Administrative Fee	$25.00	$25.00
(X) Project that is exempt from fees/De Minimis		
TOTAL RECEIVED		$25.00

Signature and title of person receiving payment: [signature] Clara Mendez, Deputy

WHITE-PROJECT APPLICANT   YELLOW-DFG/FASB   PINK-LEAD AGENCY   GOLDENROD-STATE AGENCY OF FILING

CLERK'S FEES

Transaction ID: 59626   by: CLARA
11/21/2002 02:22:14 PM

Description	Qty	Amt
EIR		
EIR COUNTY ADMINISTRATIO	1	$25.00
Pay by Check		$25.00
Total Amt. Due		$25.00
Total Received		$25.00

CESPK-ED-GS

13 April 2006

MEMORANDUM FOR RECORD

SUBJECT: Inspection of Reported Boils and Seepage Conditions at Big Dry Creek Dam, Fresno County California.

1. General. On 10 April, 2006 the Fresno Metropolitan Flood Control District (FMFCD) contacted the SPK EOC and requested a joint inspection with DSOD of the subject project. On 11 April 2006 the undersigned accompanied the following list of personnel for the inspection.

Lakhbir Singh, Engineer, DSOD
Jerry Lakeman, District Engineer; Assistant General Manager, FMFCD
Peter Sanchez, Operations Engineer, FMFCD
Brent Sunamoto, Engineer, Operations, FMFCD
Verlyn Neufeld, Facilities Manager, FMFCD
Paul Allen, Facilities Section Leader, Operations, FMFCD
Bil Garcia, Facilities Technician, Operations, FMFCD
Kurt Hupp, Rural Program Manager, Operations, FMFCD
Tom Snyder, Engineer, Rural Division, Operations, FMFCD

At the time of the inspection it was partly cloudy and the temperature was in the low 60's °F. The elevation of the pool was 421.0-feet equating to storage of approximately 9,500 acre-ft (**Figure 1 and Photo 1**). The inflow was 53-cfs and the outflow was being increased to 115-cfs. Similar conditions to what is described below were observed for the maximum pool of record (422.5-feet) in January 1997 (**Figure 2**). Gross pool and storage for the project are elevation 432.7-feet and 30,200 acre-ft respectively. During the in briefing the project staff indicated a total of 28 boils and pin boils had been observed. Following the in briefing the FMFCD directed Mr. Lakhbir Singh and the undersigned to the areas of concern described below.

2. Stations 62+70 to 68+40. Seepage was visible exiting the drain rock along toe (**Photo 2**). One location of concentrated seepage near station 63+70 was sandbagged to determine; however, the flow was too small to be quantified (**Photo 3**). Several small pin boils were also observed with the largest being near station 65+70. Several of the pin boils showed suspended sand, but all were flowing clean with no fines present. In this vicinity, water along the toe collects and flows to an 18-inch CMP near Station 63+00. The estimated flow through this culvert was approximately 20 gpm (**Photo 4**).

3. Stations 78+40 to 89+70. Ponding water and very soft soil conditions were present along the toe from approximately station 79+00 to 86+00 (**Photo 5**). In addition, small boils were observed at the following approximate locations:

-Station 81+00, a small boil flowing clear and free of fines was observed.

-Station 82+82 a 1-inch diameter boil was observed. The flow exiting the boil was estimated at 1-cup per minute, and was clear and free of fines **(Photo 6)**.

-Station 89+00 a small boil flowing clear and free of fines was observed **(Photo 7)**.
-Station 89+70 a small boil was observed. The flow from the boil was moving sand, but was flowing clear with no fines present **(Photo 8)**. The flow was approximately 1-quart per minute.

4. Stations 121+35. Four small boils were observed approximately 50-feet from the toe of the dam and was encircled by a sandbag ring. The total flow from the area was estimated at ¼ gallon per minute and was clear and absent of fines **(Photo 9)**.

5. Approximate Station 135+00. RW-06 was opened and inspected **(Photo 10)**. The top of water in the relief well was about 10-feet below the ground surface. Observation of the water in present the casing and casing condition suggest that the relief wells may need to be cleaned and inspected.

6. Spillway Approach and Control Structure. Ponded water was observed both upstream and downstream of the spillway sill location. According to the project personnel this area is wet nearly year-round as a result of high groundwater in the vicinity **(Photo 11)**. The approach cannel was clear and free of debris **(Photo 12)**.

7. Conclusions and Recommendations. The inspection revealed no immediate imminent threat at this time, but the locals should continue to monitor the situation and identify areas of concern. None of the small boils showed signs of migrating fines or muddy water. The larger pin boils should be ringed with sand bags (to a height of less than 1-foot) and fitted with a small outlet pipe to measure and quantify flow. On 13 April 2006 the undersigned contacted Mr. Peter Sanchez of FMFCB. Mr. Sanchez indicated that the reservoir was on its way back down and that warm temperatures on the previous day (12 April) dried up most of the seepage and small boil locations along the toe. He also indicated that sandbag rings were placed around some of the small boils to measure flow rate; however, the flow at each location ceased following the placement.

There is no past performance data of the project above elevation 422.5 feet. Therefore, 24-hr surveillance is recommended if the reservoir is to rise at or above this elevation. In addition, it is recommended that sufficient supplies be on site and available for flood fighting if the elevation is to go above 422.5-feet. The undersigned also recommends a review of project documentation and performance history of the project by the Sacramento District. An additional field inspection may be required during this review.

CESPK-ED-GS

Please contact the undersigned if you have any questions.

David Serafini, PE
Soil Design Section

CC: CESPK-ED-GS (file)
CESPK-ED-G (Hess)
CESPK-ED-GS

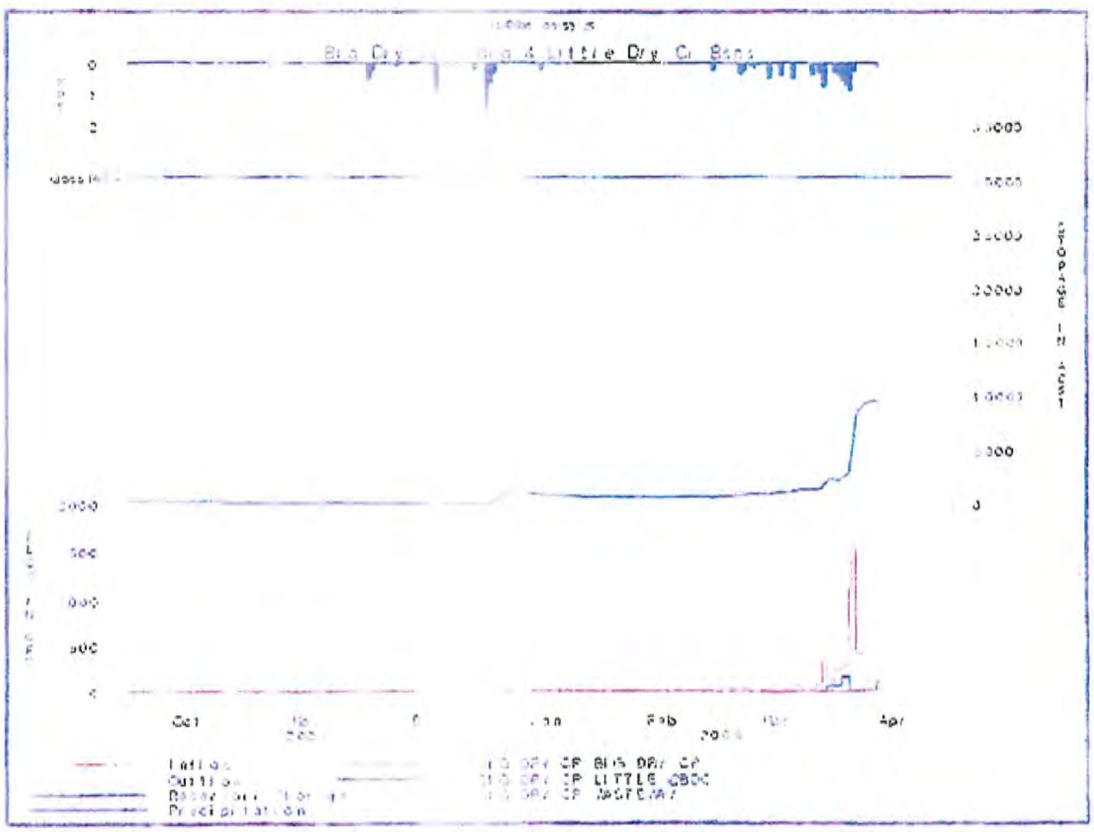


Figure 1: Reservoir Storage and Operation OCT 2005 – April 2006

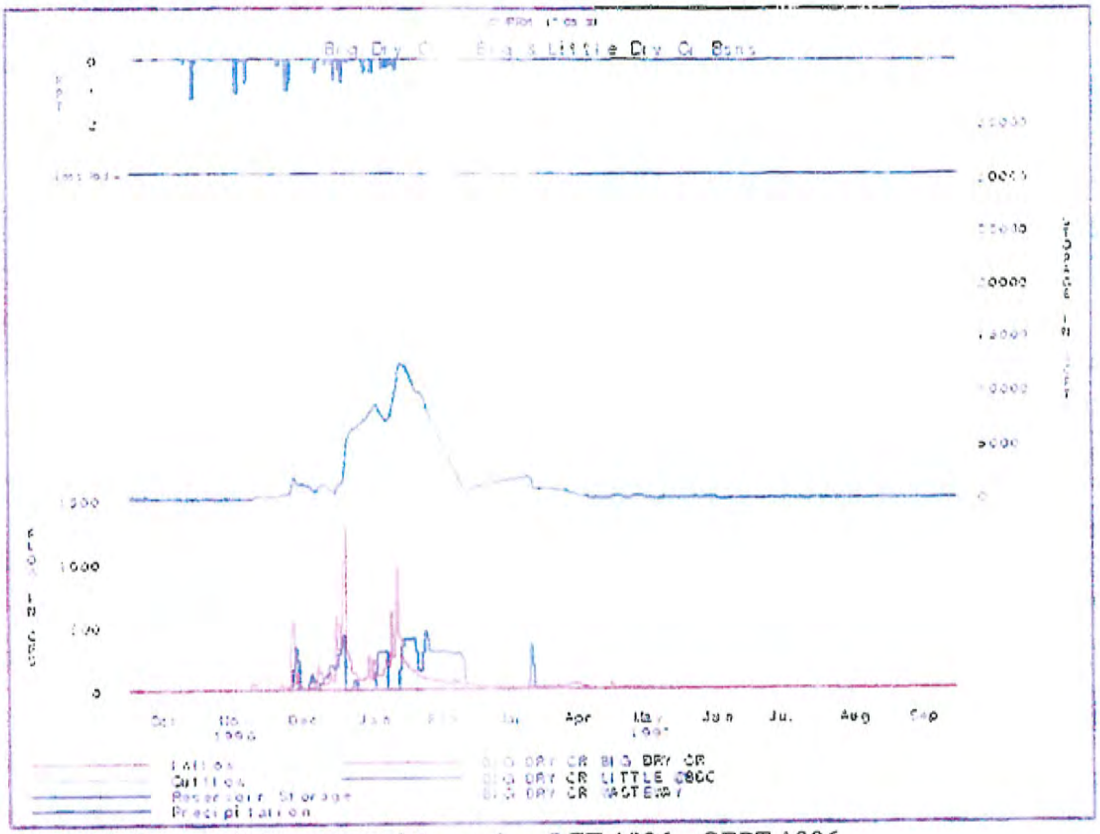


Figure 2: Reservoir Storage and Operation OCT 1996 – SEPT 1996

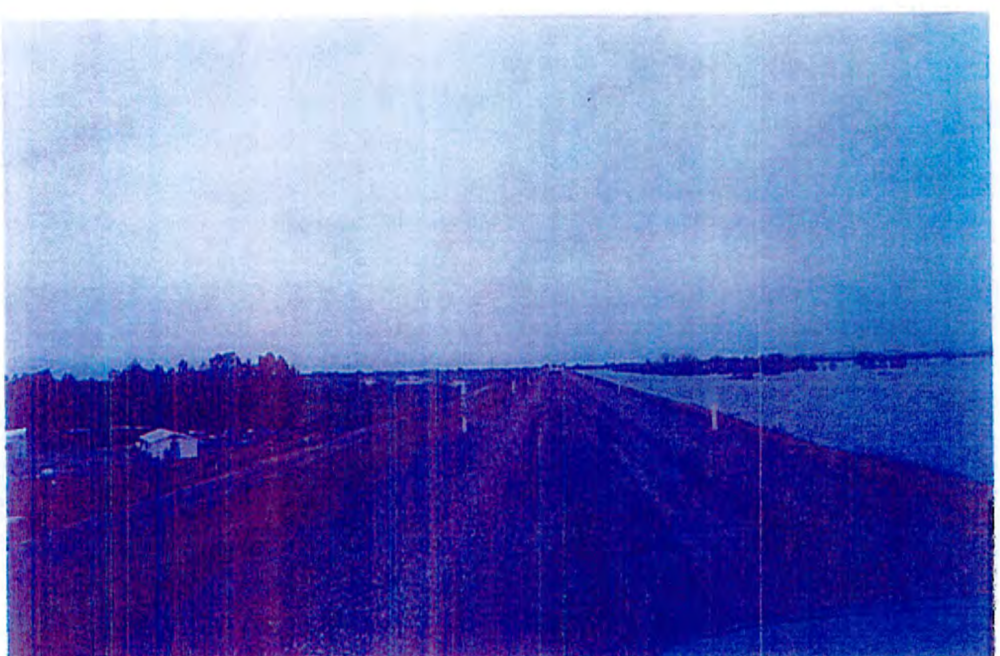


Photo 1: View of top of dam looking towards the right abutment

Photo 2: View seepage exiting the drain near Station 62+70

Photo 3: View of the seepage collection from the drain near Station 63+70

Photo 4: View of approximate 20-gpm seepage flow exiting the 18-inch CMP

Photo 5: View of the ponded water between Stations 79+00 and 86+00

Photo 6: View of the small 1-inch diameter boil near Station 82+82

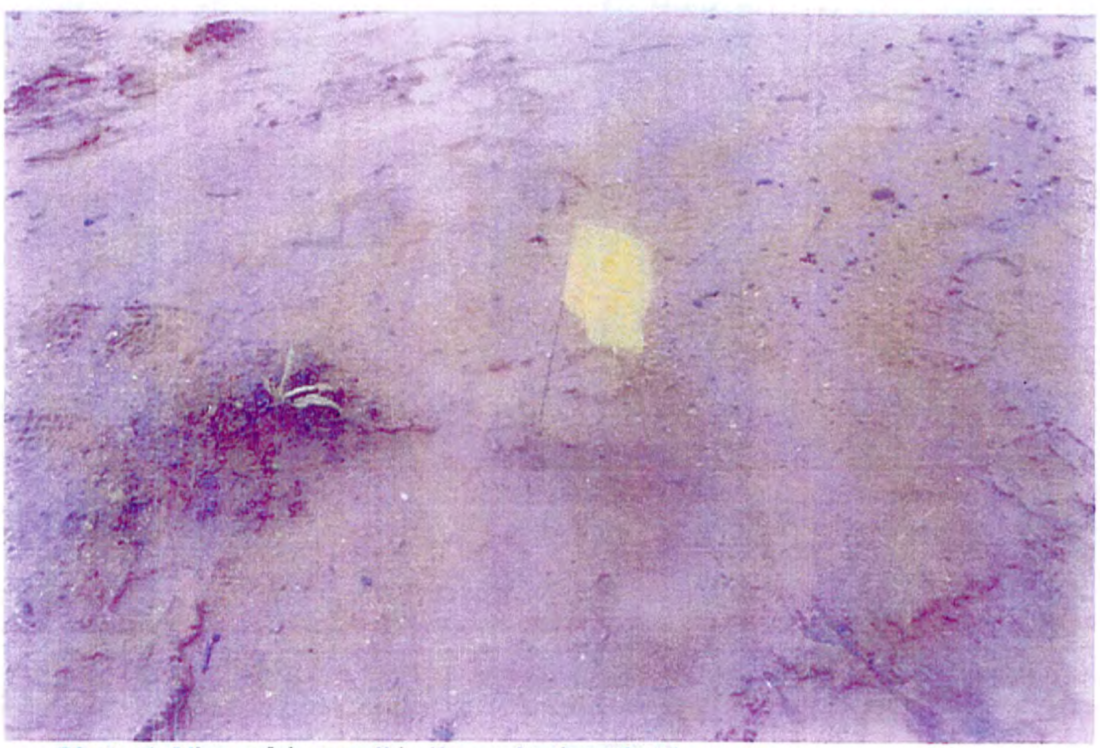


Photo 7: View of the small boil near Station 89+00

Photo 8: View of the small boil near Station 89+70

Photo 9: View of the four small boils near station 121+35

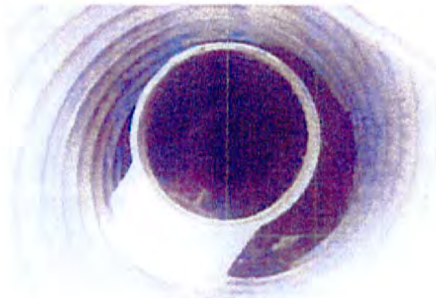


Photo 10: View of the protective casing and the inside of relief well RW-6

Photo 11: View of the spillway approach channel from the left side of the spillway

Photo 12: View of ponded water upstream and downstream of the spillway control structure and sill

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, SACRAMENTO
CORPS OF ENGINEERS
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

APR 29 2008

Flood Protection and Navigation Section

Mr. Jerry Lakeman, District Engineer
Fresno Metropolitan Flood Control District
5469 E. Olive
Fresno, CA 93727

SUBJECT: Big Dry Creek Dam Seepage and Redbank Detention Basin Control Structure Settlement and Cracking

Dear Mr. Lakeman:

I am writing this letter on behalf of Colonel Thomas C. Chapman in response to your letter dated June 19, 2007, addressing Big Dry Creek seepage during the high water event of April 2006 and settlement and cracking of the Redbank Detention Basin control structure.

In response to your request, as an interim action, a Corps team of geologists and engineers (Ms. Mahvash Arani, Mr. Michael Ramsbotham, Mr. Kim Jorgensen, and Mr. Robert Thompson), accompanied by representatives of FMFCD, visited the sites on Tuesday, December 4, 2007. As the result of this visit, a memorandum was prepared by Engineering Division including recommendations for a more in depth inspection of Redbank Detention Basin control structure by a structural engineer and materials engineer. Mr. William Halczak, materials engineer, and Mr. Thomas Walker, structural engineer inspected the Redbank Creek Detention Basin control structure on Monday, December 11, 2007, and prepared a written memorandum of their recommendations.

The concerns stated in your June 19, 2007 letter were:

1. *Big Dry Creek seepage during the high water event of April 2006. As per reported joint inspection of FMFCD and California Division of Safety of Dams (DSOD) on April 11, 2006, the water surface elevation in the Big Dry Creek was 421-feet (storage of 9,500-acre-feet). The gross pool and storage for the dam are 432.7-feet / 30,200-acre-feet. FMFCD staff indicated observation of 28 boils at the time of inspection.*

2. *Settlement and Crack of the Redbank Detention Basin Control Structure. FMFCD staff has reported that the Control Structure on Redbank Detention Basin has settled and cracked since its construction in 1990. FMFCD is concerned that this cracking is of sufficient width and depth that the reinforcement steel may become exposed. Also, as a consequence of this differential settlement FMFCD is concerned that the gate may no longer function as it was designed and built.*

In response to your first concern, the December 6, 2007, memo (encl 1) recommendations describe areas of additional study, as well as updates to the Emergency Action Plan for Big Dry Creek Dam seepage that are necessary.

In response to your second concern, the February 28, 2008, memo (encl 2) describes the likely cause of the cracking at the Redbank Creek Detention Basin to be the result of alkali silica reactions and not the result of foundation materials or foundation settlement. Additionally, the memo recommends that concrete coring and petrography examination be conducted to better define the cause of the cracks. It is our opinion that the gates are not in immediate jeopardy of failing or not operating. Both memos discuss monitoring and sealing of the cracks. This is recommended as an interim measure.

As the non-federal sponsor, FMFCD is responsible for operation, maintenance, repair, rehabilitation, and replacement of the facility. The corrective actions for remediation of the system are contained in the enclosure memos for FMFCD execution.

Should you have any questions, please contact Ms. Mahvash Arani, Flood Protection and Navigation Section, at (916) 557-5282 or via e-mail at Mahvash.arani@usace.army.mil.

Sincerely,

Kevin Knuuti

Kevin Knuuti, P.E.
Chief, Engineering Division

Enclosures

CESPK-ED-GS 6 December 2007

EK

Memorandum For: CESPK-CO-OR (Attention Arani)

Subject: Big Dry Dam and Redbank Detention Basin Control Structure

1. References:

a) Fresno Metropolitan Flood Control District Letter to Colonel Ronald Light, Subject: Big Dry Creek Dam Seepage, Redbank Creek Detention Basin Control Structure Settlement and Cracking, dated 19 June, 2007.

b) CESPK-ED-GS Memorandum for Record, Subject: Inspection of Reported Boils and Seepage Conditions at Big Dry Creek Dam, Fresno County California, dated 13 April 2006.

2. At the request of Operations Branch, a site visit was made on 4 December 2007 to the Redbank Creek Detention Structure and Big Dry Dam to investigate the issues raised by Fresno Metropolitan Flood Control District (FMFCD) in a letter dated 19 June 2007. The Corps team, (Arani, Ramsbotham, Jorgensen, and Thompson), met with and were briefed by representatives of FMFCD before going to the sites. A short out briefing was conducted prior to leaving. The out briefing included much of the following information.

3. Big Dry Dam Seepage: Based on my understanding of as-built conditions and the reported performance of the dam at relatively low pool elevations (Reference Memorandum for Record dated 13 April 2006), the reported seepage problem at Big Dry Dam deserves additional study. Initial first steps and potential interim actions should include:

- As built records for the original structure and rehabilitation / raise project should be reviewed.
- Geology and subsurface information should be assembled for the areas / reaches that seepage and boils were observed.
- Preliminary seepage and stability modeling should be performed based on the existing information.
- Additional subsurface information based on new explorations, drilling and sampling and laboratory testing should be obtained.
- Based on the Dam's performance history, reservoir pool elevation threshold values should be established that trigger elevated surveillance and monitoring. Based on the information provided by FMFCD it appears the threshold values corresponds to roughly pool elevation 410, depending on storm / pool duration.
- The Emergency Action Plan should be updated to include the pool elevations at which increased surveillance is required, new inundation mapping, and dam break scenarios.
- The Emergency Action Plan should be exercised, particularly for a potential seepage and piping failure mode.

Encl 1

- The addition of instrumentation, piezometers and observation wells, should be considered.

- An emergency fix should be "designed" and sufficient construction materials obtained and stockpiled for an initial flood fight implementation. The emergency materials should include a geotextile filter fabric, drain rock, sand and sand bags.

4. Redbank Detention Basin Control Structure: Based on my observations of conditions at the control structure, the cracking observed at the gate supports is unusual and thus the structure deserves additional study / evaluation by structural and materials engineers. Initial first steps and potential interim actions discussed in the field included:

- A Structural Engineer and Materials Engineer should perform another inspection of the entire structure looking at all of the distress / cracking identified by FMFCD.
- The entire structure and associated retaining wall should be surveyed to determine current relative elevations and potential direction of movements.
- The large cracks in the gate support blocks should be monitored under several different environmental and loading conditions. Attach crack monitoring devices to be used in the monitoring program.
- Monitoring conditions should include at a minimum: 1) monthly readings; 2) readings prior to, during, and subsequent to gate operations; and 3) changes in impoundment water surface elevations at 5 foot increments.
- The original basis of design should be reviewed.
- If approved by the structural and material engineers, the large gate block cracks should be sealed with a flexible sealant to keep out water and debris.

5. Thank you for this opportunity to participate in this inspection. If you have any questions please give me a call.

Michael D. Ramsbotham

Michael D. Ramsbotham, P.E., G.E.
Regional Geotechnical Specialist
Soil Design Section
916 557 7174.

CESPK-ED-GS 28 Feb 08

MEMORANDUM FOR CESPK-CO-OR (Arani)

SUBJECT: Red Bank Detention Basin Control Structure, Fresno Metropolitan Flood Control District, Fresno, California

1. Reference:

a) CESPK-ED-GS, Memorandum for Record, Subject: Big Dry Dam and Red Bank Detention Basin Control Structure, dated 6 December 2007.

b) As Built Drawings, Red Bank Detention Basin Control Structure, USACE, Sacramento District, 16 Jul 1990.

2. An inspection of the Red Bank Detention Basin Control Structure was performed on 10 Dec 07 by W. Halczak CESPK-ED-GS and T. Walker CESPK-ED-DR. The inspection was requested by M. Arani CESPK-CO-OR. This inspection was performed subsequent to the inspection described in reference (a) above. Verlyn Neufeld of FMFCD also participated in the inspection. The purpose of the inspection was to evaluate cracks in the structural elements of the control structure. It had been postulated that settlement of the foundation was producing distortion and consequent cracking of the structure.

3. A brief level survey was run of selected points on the center divider wall and the side walls of the structure downstream of the gates. This survey was performed to determine if differential settlement could have caused tension across the top of the wall and thus could have produced the cracking exhibited in the fate center divider wall. Within the limits of accuracy of the survey; no differential settlement which could have produced the cracks was noted.

4. Photographs 1 and 2 show a typical longitudinal crack along the upstream edge of the wall. The crack is discontinuous in the areas of the vertical risers where the gate controls rest. This type of crack could potentially be evidence of an Alkali Silica Reaction (ASR). The drawings indicate that there is more reinforcement present in the location of the gate controls. Mild Alkali Silica reactions can be suppressed by reinforcement. ASR

5. Photographs 3 and 4 show the longitudinal crack along the center line of the center divider wall. There appear to be ASR reactions occurring along other structural elements in the gate structure. We closely examined the crack and found that it had exposed a Number 8 reinforcing steel bar. It is possible that the bar was initially exposed to moisture as a result of the ASR reaction noted elsewhere. Once the bar was exposed to moisture, it oxidized. The oxidation of the steel produces additional expansion. It appears that the metal oxidation in addition to the initial ASR has accelerated the crack formation. It appears that the cracking is related to ASR expansion complicated by oxidation of the longitudinal reinforcement.

6. A Review of the design documents, reference (b); Sheets S-39 and S-40 of the As Constructed Plans indicate that the only reinforcement on the top of the wall is three number eight bars placed longitudinally. The drawings indicate no transverse steel on the top of the center divider wall.

7. Some chemical attack is occurring to the concrete surfaces, typically as shown in photograph 5. This reaction is evident in both the upstream and downstream side of the structure. The attack on the upstream side is more advanced. This is related to chemicals carried in the water. These reactions are not significant at this time and do not immediately require corrective action. These reactions should continue to be monitored.

Encl 2

8. There are two classes of distress noted in the above inspection; the cracking potentially produced by physio-chemical reactions and the chemical attack on the surfaces as noted in photograph 5. The chemical attacks on the surfaces are not of structural consequence although they should be monitored. The cracking is cause of greater concern. Given the operational characteristics of the gates; it does not appear that catastrophic failure of the gates is likely under anticipated typical operating conditions.

9. Visual evidence suggests that the reactions and cause and effects are as described above. To properly define the cause of the distress, it is recommended that an investigation be completed to determine the direct cause. Cores should be recovered from various locations and the cores should be petrographically examined to determine the exact mode of distress.

CORES ASR

10. Although the diagnosed ASR reaction will not cause an immediate failure in the structure, it is recommended that corrective action be taken in order to enhance the performance of the structure over it's anticipated life cycle. The following short-term and long term repairs are presented.

(a) As an expedient repair, small cracks (generally less than 1/2-inch widths) may be sealed with an epoxy bonding materials. These epoxy bonding materials should be in general conformance with the requirements of ASTM C 881, Type IV. Cracks larger than ½-inch widths may be sealed with a flexible sealant. Prior to installation of the flexible sealant; backer rods should be installed to prevent deep penetration of the sealant. It is important that all flexible sealant be removed prior to final repairs.

(b) Based on the limited visual observation of the structure, and the likely cause of cracking being ASR, the following long term or permanent repair is recommended. The unsound concrete along the divider wall should be removed. This should be removed to a depth of approximately eighteen to twenty-four inches, below the existing top surface, or to the elevation that the trunnion bearings rest. Any cracks or openings below these removal depths can be epoxy grouted. Once all unsound concrete is removed new reinforcing steel should be doweled and epoxy grouted into the sound concrete. This steel should be bent to provide horizontal steel in the top face of the wall. Longitudinal steel, as in the original design, should also be included in the replacement reinforcement cage so that all faces of the section are reinforced in both directions. An epoxy bonding layer should be applied to the surface of the exposed concrete and then replacement concrete should be placed to return the section to it's original geometry.

William Halczak
William Halczak
CESPK-ED-GS

Thomas J Walker
CESPK-ED-DR

Encl 2

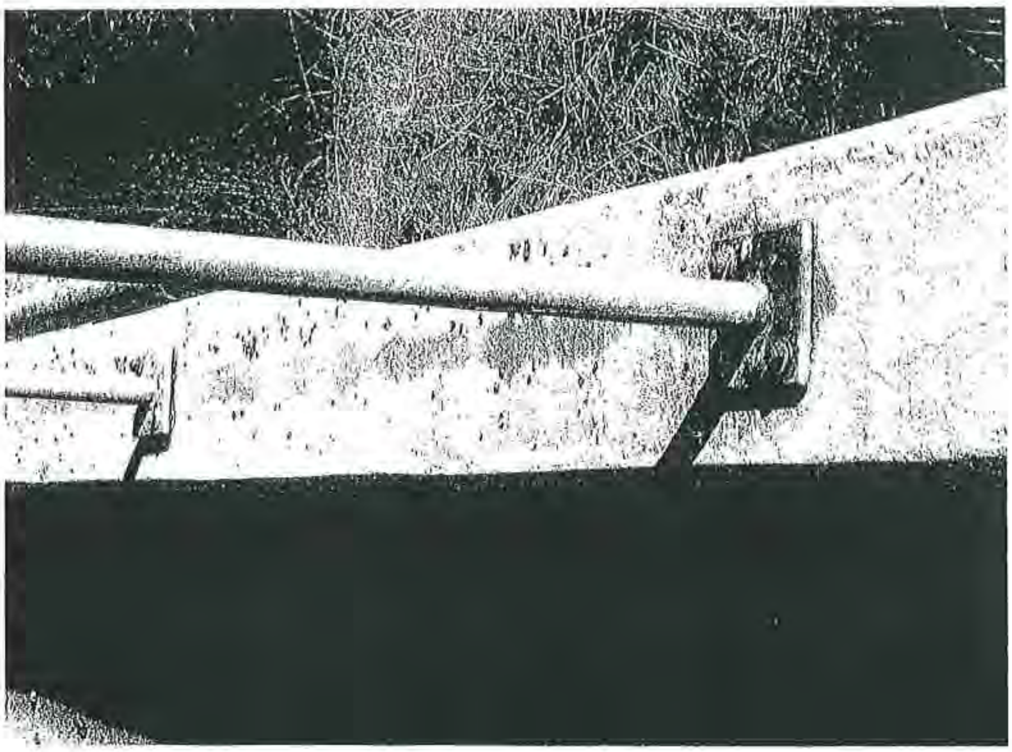


Photo 1- Longitudinal Crack in Upstream Wall

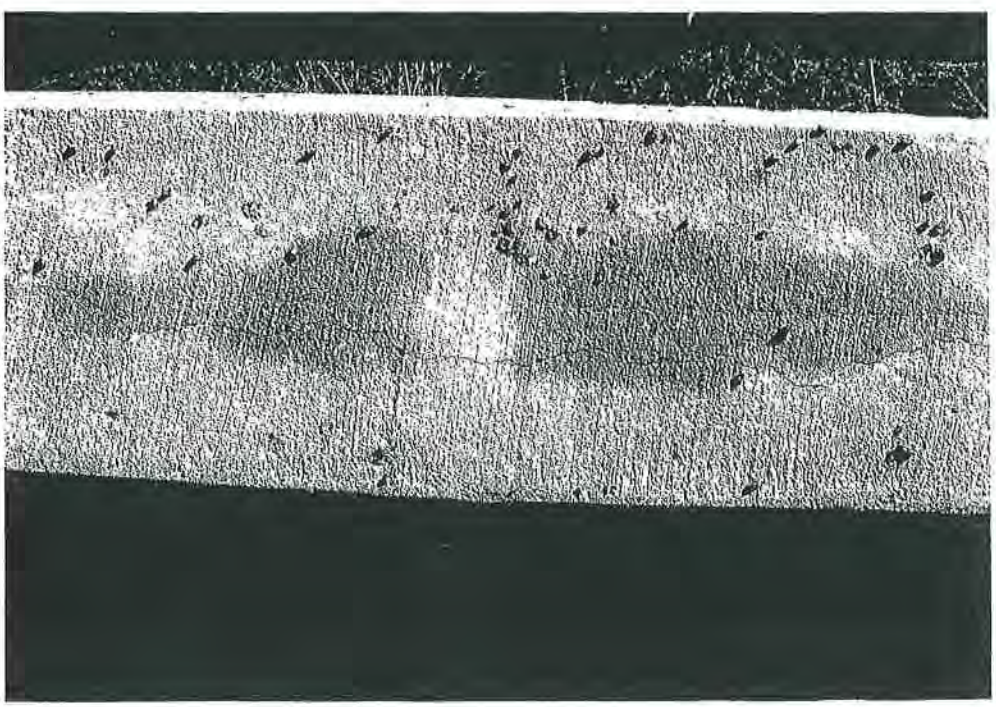


Photo 2 – Detail of Longitudinal Crack

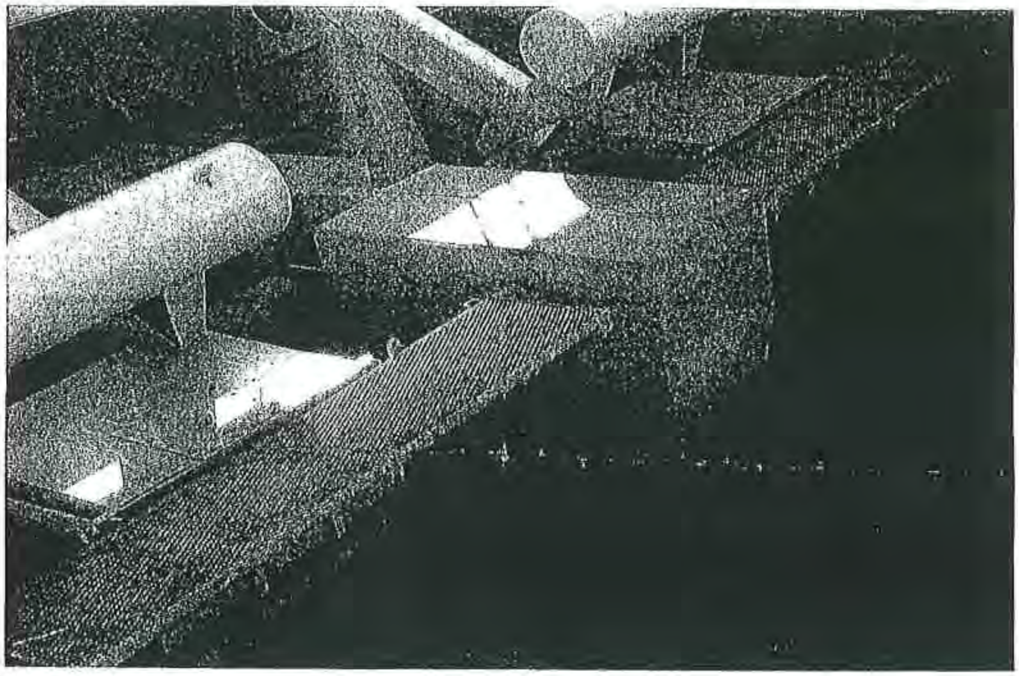


Figure 3 Overview of cracked block.

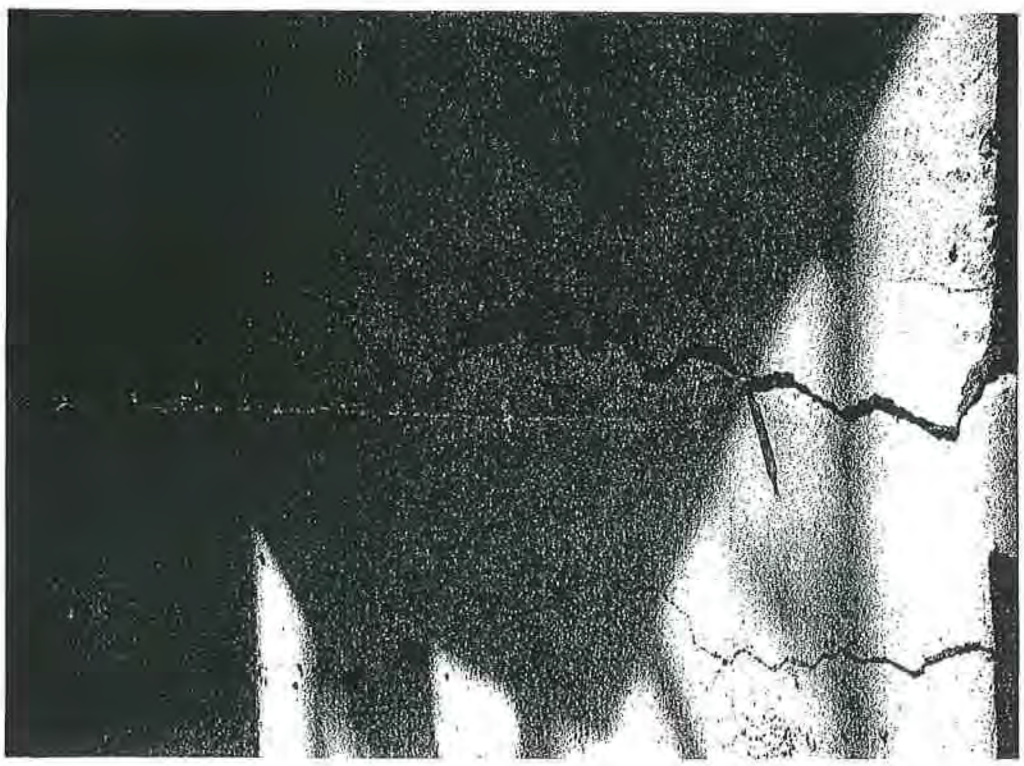


Figure 4 – Detail of Cracked Block

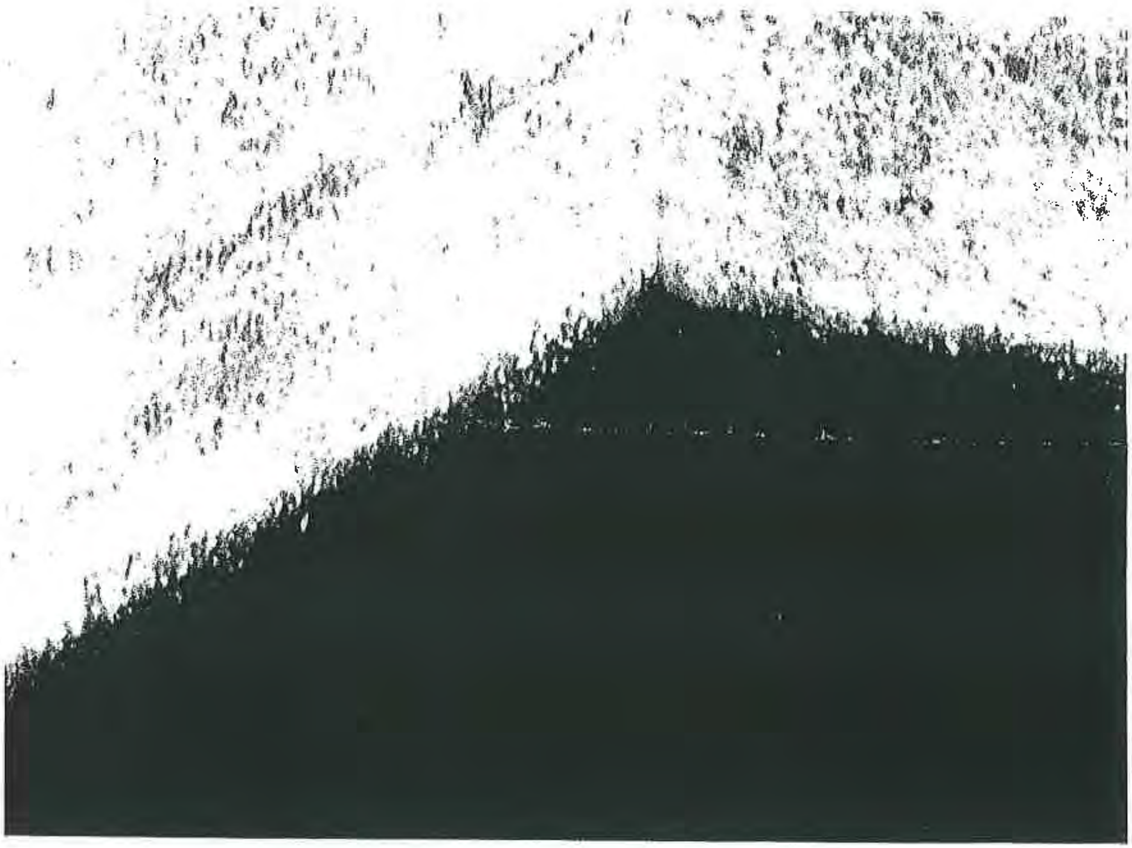


Figure 5 – Chemical Surface Attack

BSK

567 W. Shaw Ave., Ste. B
Fresno, CA 93704
(559) 497-2880
FAX (559) 497-2886

May 14, 2008

BSK Job No. G0811911F

File: 150.205414
630.2042
630.2049
170.721

Peter Sanchez
Fresno Metropolitan Flood Control District
5469 E. Olive
Fresno, CA 93727

Peter:

In response to your memo of May 2, 2008, I have reviewed the memorandum submitted by the Corps of Engineers, dated December 6, 2007, concerning structure settlement and cracking at the Redbank Detention Basin gate structure and seepage at the Big Dry Creek Dam.

RED BANK DETENTION BASIN

The field review was conducted on May 8, 2008. At the time of the review, approximately 18 to 24 inches of water was present in the upstream channel. The gate structure central support concrete block which had been reported to contain large longitudinal cracks was submerged and covered with a protective frame made of plywood and wood studs. The frame was secured with chain and padlocks. Accordingly, examination of the central support block could not be made. Longitudinal cracks are present along the tops of wing walls and retaining walls. The cracks run the lengths of the walls and are typically 1/8 to 1/16 inch wide and situated at the center of the walls.

I believe that these longitudinal cracks are the product of concrete shrinkage and potentially tensile stresses induced in the concrete during the time of its initial setting. In the case of the central support, the top of the concrete and crack area would have been periodically submerged. Water had the opportunity to enter the crack and cause corrosion of the reinforcing steel. This corrosion causes gradual expansion and therefore widening of the crack. This condition could explain the reported conditions observed in the central support.

I examined the wing walls and retaining walls below submerged levels. They did not exhibit indications of Alkali-Silica-Reaction (ASR). This leads me to think that ASR may not be the problem. Just the same, it would be prudent to perform a test on at least the most distressed areas to assess ASR potential.

On the matter concerning settlement of the structure, I believe that it is not a factor at this time. A small amount of differential settlement has occurred between the main gate structure and the wing walls. This settlement likely occurred in the first year following soil saturation. I would not expect that significant additional settlement would occur 18 years following construction.

At this time, I recommend that a core be extracted from the central support concrete pedestal and the core submitted for petrographic analyses, including ASR. Following the analyses, a report would be prepared to address the necessary repairs based on the findings. For the above, I recommend a budget of $12,000.

BIG DRY CREEK DAM
My comments and conclusions are based on preliminary sites review and design data for the raising of Big Dry Creek Dam from maximum water elevation 425.0 to 433.2 feet (February 1986). The scope of additional study proposed by the Corps of Engineers appears appropriate for seepage and stability evaluations. The February 1986 U.S. Army Corps of Engineers "General Design Memorandum" Section for the Big Dry Creek Dam alterations contain adequate field exploration and soils laboratory testing data to support preliminary seepage and stability modeling analyses. This data would be supplemented by the "As Built" drawings for the dam alteration project completed about 1993.

An important aspect of these analyses includes the construction of piezometers through the embankment section for the purpose of eventually establishing actual flow line characteristics and hydrostatic pressure through areas of the embankment and toe exhibiting surface seepage and sand boils and to calibrate the seepage model. These piezometers would be supplemented with a few shallow monitoring wells in the toe areas.

The drilling and installation of piezometers would provide an opportunity to collect and test undisturbed and bulk soil samples in the toe areas where this information is lacking.

The following estimates of fees represent our approach to the seepage and stability study for budget-setting purposes:

Installation of 30 piezometers 30 to 60 feet deep and 5 observation wells 20 feet deep. Soil sampling and field logs of borings:	$105,000.00
Laboratory testing:	$16,000.00
Seepage and stability modeling:	$45,000.00
Consultations	$7,000.00
Design-level analyses of remediation alternatives (in support of civil engineer's preparation of plans and specifications):	$20,000.00
TOTAL:	**$193,000.00**
Contingencies (15%):	*$29,000.00*
Recommended Budget:	**$222,000.00**

These estimates are submitted for your review and evaluation and to facilitate further discussions.

Respectfully submitted
BSK Associates

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BSK Associates
Engineers & Laboratories

PRELIMINARY SEEPAGE STUDY

BIG DRY CREEK DAM
FRESNO METROPOLITAN FLOOD CONTROL DISTRICT
BDR-18

BSK G08-119-11F

PREPARED FOR:

FRESNO METROPOLITAN FLOOD CONTROL DISTRICT
5469 EAST OLIVE AVENUE
FRESNO, CALIFORNIA 93727

JANUARY 22, 2013

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January 22, 2013

BSK G08-119-11F

Mr. Jerry Lakeman, P.E., District Engineer
Fresno Metropolitan Flood Control District
5469 East Olive Avenue
Fresno, California 93727

SUBJECT: Preliminary Seepage Study
Big Dry Creek Dam
Fresno Metropolitan Flood Control District BDR-18

Dear Jerry:

Submitted is our preliminary study for the reported occurrence of seepage along the toe of embankment for Big Dry Creek Dam between Stations 63+00 and 121+85. This report is submitted for your review and will serve to identify areas of interest and the scopes of recommended additional studies for the investigation of seepage and the formulation of mitigation measures.

The opportunity to be of service on this project is appreciated. We are prepared to meet with you and your staff to discuss our findings.

Respectfully submitted,
BSK ASSOCIATES

Hugo Kevorkian
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CE16350, GE462, REAII 20080

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Enclosures

Distribution: Mr. Jerry Lakeman, P.E., FMFCD (3 originals + eMail)
BSK (1 original + eCopy)

TABLE OF CONTENTS

FIGURES

APPENDIX

BSK

PRELIMINARY SEEPAGE STUDY
BIG DRY CREEK DAM
FRESNO METROPOLITAN FLOOD CONTROL DISTRICT
CONTRACT NO. BDR-18

1.0 INTRODUCTION

This report presents the results of our preliminary study for seepage observed along the toe drain for segments of the Big Dry Creek Dam between Stations 63+00 and 121+85. Notice to proceed was issued to BSK Associates on July 28, 2008 by electronic mail from Dan Gilbert, Fresno Metropolitan Flood Control District (FMFCD). Our proposal G0811911F dated May 14, 2008 describes our original objectives for the study. Prior to the start of the study, a meeting was arranged with FMFCD staff to further discuss the scope of this preliminary study.

1.1 Background

Big Dry Creek Dam is situated on Dry Creek at the northeasterly fringe of the Clovis City limits, Fresno County, California. The dam was constructed by the Corps of Engineers (USACE) in 1948. Prior to modification, the main embankment consisted of an earth fill with a maximum height of 37-eet (elevation 435.9) and length of 21,000-feet. The reservoir provided flood detention for a gross pool of 16,250 acre-feet. The reservoir was designed for a 60-year level of protection to the cities of Clovis and Fresno and suburban areas, from floods originating above the Friant-Kern Canal, by temporarily storing the flows of Dog and Dry Creek and diverting them to Little Dry Creek Diversion Channel. The Dry Creek Diversion Channel empties into the San Joaquin River.

Modifications to the main section of Big Dry Creek Dam in 1992 raised the crest elevation to a maximum of 445.0-feet. Typically, the dam embankment now includes a 25-foot crest, 3.0-feet of freeboard above Standard Protection Flood (SPF) Pool, upstream slopes of 3 horizontal to 1 vertical and downstream slopes of 2 horizontal to 1 vertical. The embankment consists of homogeneous random fill, comprising clayey sand and fine silty sand and sandy silt with notable fraction of clay. Figure 5 illustrates typical dam section as modified during the 1991 construction.

Seepage control measures incorporated in the 1992 modifications include an inclined drain on the downstream slope of the dam embankment and a drainage blanket beneath the downstream berm.

Six (6) pressure relief wells were constructed and tested by USACE in October 1995. The wells were located between Stations 121+00 and 123+50 at intervals of 50-feet near the alignment of the old Dry Creek stream bed (Figure 4).

1.2 Seepage

Sustained seepage and small sand boils were observed during the storm event of April 7, 2006. Present at the site during the storm were staff members from FMFCD, California Division of Safety of Dams (DSOD) and USA Corps of Engineers (USACE). Embankment toe areas generally affected by seepage and sand boils extended from Station 30+00 to 122+00. Sand boil concentration points included areas around Stations 30+38, 65+70, 80+50, 82+82, 89+80, 92+50, 115+90, 121+00 to 121+85. Photographs taken during the storm suggest that dam heights necessary to stabilize sand boils were generally less than 18 inches (see Appendix A).

1.3 USACE Mitigation

A letter issued by the Sacramento office of USACE dated April 29, 2008, addressed the necessity for additional studies to respond to the seepage and sand boil occurrences observed during the site visit of April 7, 2006. Initial steps and potential interim actions recommended by USACE included the following:

> "As built" records for the original structure and rehabilitation/raise project should be reviewed.
>
> Geology and subsurface information should be assembled for the areas/reaches that seepage and boils were observed.
>
> Preliminary seepage and stability modeling should be performed based on the existing information.
>
> Additional subsurface information based on new explorations, drilling and sampling and laboratory testing should be obtained.
>
> Based on the Dam's performance history, reservoir pool elevation threshold values should be established that trigger elevated surveillance and monitoring. Based on the information provided by FMFCD it appears the threshold values correspond to roughly pool elevation 410, depending on storm/pool duration. The Emergency Action Plan should be updated to include the pool elevations at which increased surveillance is required, new inundation mapping, and dam break scenarios.
>
> The Emergency Action Plan should be exercised, particularly for a potential seepage and piping failure mode.
>
> The addition of instrumentation, piezometers and observation wells, should be considered.
>
> An emergency fix should be "designed" and sufficient construction materials obtained and stockpiled for an initial flood fight implementation. The emergency materials should include a geotextile filter fabric, drain rock, sand and sand bags."

2.0 SCOPE OF PRELIMINARY STUDY

The scope of services provided to date and reflected in this preliminary study includes the following:

Site review of embankment conditions and identification of features of interest.

Review of available "As Constructed" records for the original construction and modifications for the raising of the dam (the USACOE "Final Foundation Report" has not been available to date).

Available subsurface soils, laboratory analyses and geologic data have been reviewed and correlated to the areas of seepage and sand boils.

Preliminary seepage modeling has been performed based on available field and laboratory data. The computer program SEEP2D was used for seepage analyses.

Preliminary findings for the occurrence and modes of seepage. Recommendations for future investigations, instrumentation and monitoring.

Implementation of other recommendations concerning surveyance and action plans, presented by USACE and listed above are beyond the scope of this study.

3.0 REPORTS AND DOCUMENTS REVIEWED

The following reports and documents were reviewed in conjunction with the preliminary study.

FMFCD field data for the monitoring and observations of seepage and sand boils. Storm event of April 7, 2006 (see Appendix "A").

"General Design Memorandum" Design Memorandum No. 1, Redbank and Fancher Creeks, California" U.S. Army Corps of Engineers Sacramento District February 1986 (inclusive of drawings File No. SJ-11-29-11, Sheets B9 through B41, dated 1-20-86).

"As Built, Contract No. DACW05-92-C-0052 Redbank and Fancher Creeks Big Dry Creek Dam, File SJ-11-9-39 Drawings C1 through C41" U.S. Army Corps of Engineers Sacramento District December 10, 1991.

"Photographs – Storm Event of April 7, 2006" Fresno Metropolitan Flood Control District (see Appendix "A").

"Big Dry Creek Dam, Fresno, California Embankment Criteria Performance Report" Department of the Army Sacramento District, Corps of Engineers Sacramento, California November 21, 1995.

"Redbank and Fancher Creeks California Big Dry Creek Dam Site Geology Design Memorandum No. 5" U.S. Army Crops of Engineers Sacramento District, September 1986.

4.0 SEEPAGE MODES AND OCCURENCES

The occurrence of seepage in earth dams includes: 1) confined seepage through the saturated pervious soil mass in the interior of the dam; 2) unconfined seepage exit over the downstream lower section face of the dam and, when provided, into drainage blankets and aprons designed to intercept, collect and channel seepage water; 3) piping caused by dispersive soils and the presence of animal burrow channels; 4) piping in granular soils with low fines content and; 5) in association with piping, sand boils manifestation at or beyond the dam downstream toe. For the latter, gradual enlargement of piping channels from past flood events can eventually create enlarged zones of lower density/high permeability and produce sand boils even at moderate to low water impoundment head.

For this report, preliminary analyses of seepage modes and occurrences for Big Dry Creek Dam were performed for an area of the embankment which had been entirely removed and reconstructed with broader and deeper sections and below which reports of seepage and sand boils were made during the storm event of April 2006. The study area is bound by Stations 116+00 and 122+00 (The Embankment) Figures 4 and 5 illustrate the embankment configuration and section.

4.1 Seepage

The embankment consists of a "Random I" homogeneous earth section comprising clayey sand and lesser amounts of silty sand with notable clay fraction. An average compaction of 98 percent, based on ASTM Test Method D698, was reported by the USACE. Embankment soil permeability was 0.2-feet per day ($1x10^{-4}$ cm/sec). The material is described as providing high strength and a relatively impervious embankment. Foundation materials, are described as randomly distributed clayey sand with lesser amounts of silty sand (SM) sandy clay (CL) sandy silt (ML) and relatively clean sand (SP/SW). The reported coefficient of permeability is also 0.2-feet per day ($1x10^{-6}$ cm/sec).[1]

For the embankment and foundation sections described above, including the cut-off trench extension to elevation 280 or some 28-feet below toe elevation into undisturbed and impervious clayey sand, maximum impounded water surface elevations of 5 to 23-feet (elevation 421.0-feet) an estimated exit gradients of 0.22 to 0.40, and seepage rates of 3.25 to 6.56 cubic feet per day per foot (CF/Day/Foot) were derived from the computer model. Unconfined seepage discharge into the drainage blanket and apron and subsequent discharge into the shallow drainage ditch is estimated to represent the bulk of the seepage with confined seepage, in the lesser amounts.

[1] "Embankment Criteria and Performance Report Big Dry Creek Dam Fresno California" USACE November 21, 1995.

4.2 Dispersive Soils

Dispersive soils contain fine particles of clay and some silt which are prone to erode by a process of deflocculation in the presence of water (rain water in particular). This condition is the product of imbalance between soil interparticle forces of repulsion and attraction. The clay and fine silt particles go into suspension and pass with water to create progressive piping and eventual discharge through embankments. Starter cavities such as animal burrows and shrinkage cracks are often the beginning points for piping channels.

Tests performed on foundation soils sampled from beneath the Little Dry Creek Levee near the intersection of Copper Avenue produced dispersivity potential of 64 percent. Soils with this percentage are considered highly dispersive. Other test areas for the Little Dry Creek Levee and the Big Dry Creek and Dog Creek Levees produced negligible dispersivity potential.

While the presence of isolated zones of dispersive soils is noted for the general vicinity of the Big Dry Creek Dam, sand boils observed during the storm event of April 2008 reportedly, did not show evidence of fine soil particle discharge. Dispersive soil piping typically produces cloudy water and eventual deposits of silt, clay and fine sand.

Visual indication of deep and narrow gullying erosion features characteristic of dispersive soils over the face of embankment, were not found during our field review.

4.3 Granular Soils

Fine uniform sand and gravel-sand-silt mixtures which are prone to piping were typically removed from materials set-aside for embankment construction. The cut-off trench for the embankment was extended an additional 10-feet from design depth to further eliminate pervious zones. Continuity of soils with piping potential through the 180 foot width of embankment is improbable.

4.4 Sand Boils

Small diameter (1/4 to 1 inch) sand boils were observed at a distance of 48-feet from the embankment toe during April 7 to April 12, 2006. The boils were occasionally controlled by ringing them with sand bag dikes to heights of 18 inches or less. Seepage rates were reported to approximately ¼ gallon per minutes over the initial five (5) days of observation. On the sixth day, most of the boils were no longer flowing. Retained water behind the embankment for the six-day observation period ranged from elevation 419.6 to 420.1 with the higher elevation occurring on the fifth and sixth days of observation.

Sand boils reported at a distance of 48-feet from the embankment toe would have been slightly beyond (down gradient) the relief wells (Figure 4). Water level in relief well RW6, near the sand boils was reported to be at a depth of 10-feet below the concrete pad (April 11, 2006).

Sand boils occur when soil pore water pressure at the base of an impervious layer down stream from the toe exceeds the total downward overburden stress created by the weight of the overlying saturated soils. The exit pressure gradient beyond the embankment toe must be high enough to exceed the critical gradient. This critical gradient is a function of the saturated soil unit weight. For the embankment, the saturated unit weight was estimated to be 130 pounds per cubic foot (pcf) and the critical gradient: 1.08. The exit gradients derived from our computer model for the storm event of April 2006 are 0.22 and 0.40. These values are too small to promote embankment piping associated with sand boils. The presence of static water elevation at a depth of 10-feet in pressure relief wells adjoining the sand boils further negates lateral and upward flows from beneath the embankment. Finally, the general indication of sand boil water flow reduction on the fifth and sixth day of observation, even though the reservoir pool elevation remained steady, conflicts with the typical and predominant gradually increasing flow rates associated with sand boils.

Sand boils are known to have occurred in cases of low level water impoundments by a process of progressive enlargement and porosity increases of piping channels with succeeding storm events. In the case of the embankment studied for these analyses, the entire existing embankment was removed, the base width substantially enlarged and the depth of the foundation increased from the original ground surface to 28-feet below ground surface. Under these conditions, old piping channels would have been eliminated.

The small diameter (1/4 to ½ inch) sand boils are suspected to represent purging of air contained within the soil mass and the attendant transport of soil pore water present in shallow zones near the ground surface.

5.0 COMPUTER MODELING

Models for seepage analyses were developed for the embankment. The computer program SEEP2D developed by the USACE and commercially available to consulting engineers was used for the analyses. Soil profile and soil design parameter for the analyses were obtained from USACE reports listed in Section 3.0 of this report.

The following three sets of conditions were developed for seepage analyses:

1. Pool elevation 421.0 soil profile and soil design parameters based on test data (Figure 1).
2. Pool elevation 439.2 at Standard Design Flood (SPF) peak flow soil profile and soil design parameters based on test data (Figure 2).
3. Pool elevation 439.2 soil profile and soil design parameters based on arbitrary amplified embankment and foundation soils high permeability characteristics (Figure 3).

Computed exit gradient are provided for a discharge point 50-feet away from the toe. This parameter is intended to address the high incidence of sand boils reported at 48-feet from the toe. Pool elevation 421.0 is intended to duplicate water levels during the storm event of April 2006. Pool elevation 439.2 is designed to address reservoir design capacity at the Standard Design Flood (SDF) maximum flow.

Based on the computed exit gradients (ɩ exit) of 0.22 and 0.40 for pool elevations 421.0 and 439.2, respectively and the calculated critical gradient (ɩ critical) of 1.08 derived from soil saturated weight of 130 pcf, the following safety factors (SF) against quick conditions or piping were derived.

$$SF_{(421')} = \frac{\text{ɩ critical}}{\text{ɩ exit}} = \frac{1.08}{0.22} = 4.91$$

$$SF_{439.2} = \frac{\text{ɩ critical}}{\text{ɩ exit}} = \frac{1.08}{0.40} = 2.70$$

6.0 FUTURE INVESTIGATIONS AND MONITORING

Observations made during the storm event of April 2006 reflect embankment performance for a relatively low pool elevation (421.0-feet). The gross pool elevation for the dam is 432.7-feet and the Standard Design Flood (SDF) maximum flow elevation, 439.2. These additional 12 to 18-feet of head can significantly alter seepage modes and increase intensities over those observed in April 2006. Instrumentation of embankment in upstream and downstream areas is recommended to gain information for checking and verifying assumptions made in the analyses. This data will provide a basis for assessing embankment and foundation performance and safety during actual operations.

A variety of instruments are available for the monitoring program. Commonly used geotechnical instrumentation includes open pipe piezometers, vibrating wire piezometers and pneumatic piezometers. The open pipe type of piezometer is the simplest and least expensive. However, it is limited to use in areas with maximum piezometric heads a few feet above ground level and for embankments crest and downgradient of embankments. Vibrating wire piezometers are versatile. They can be buried upgradient and down gradient of embankments. Long length cables leading to a receptor box placed in a convenient location can be provided. Pneumatic piezometers require pressured gas availability. Gas inlet and outlet tubes are necessary for measurements. The selection of piezometer type and development of piezometer network and configuration is not included in this preliminary seepage study.

7.0 SURVEYANCE PROGRAM

The pool elevation threshold value at which elevated surveyance and monitoring has been recommended by the USACE is 410.0-feet. Toe drain seepage was first reported at this pool elevation during the storm event of April 2008. The upgradient toe elevation for the embankment lies above elevation 410 except for the area between Stations 60+00 and 105+00 where toe elevation varies from 401.0 to 406.0. For this limited pool depth and length of embankment, toe drain seepage would be expected to be nominal.

As a component of the surveyance program, drainage flow volume monitoring with corresponding pool elevation increases would be beneficial at several locations along the toe drain. This monitoring program could potentially identify areas of excessive seepage.

8.0 LIMITATIONS

This preliminary seepage study is based on published geotechnical engineering design data and subsurface soil data contained in references listed in Section 3 of this report. No field exploration, drilling, testing or laboratory analyses were performed by BSK Associates.

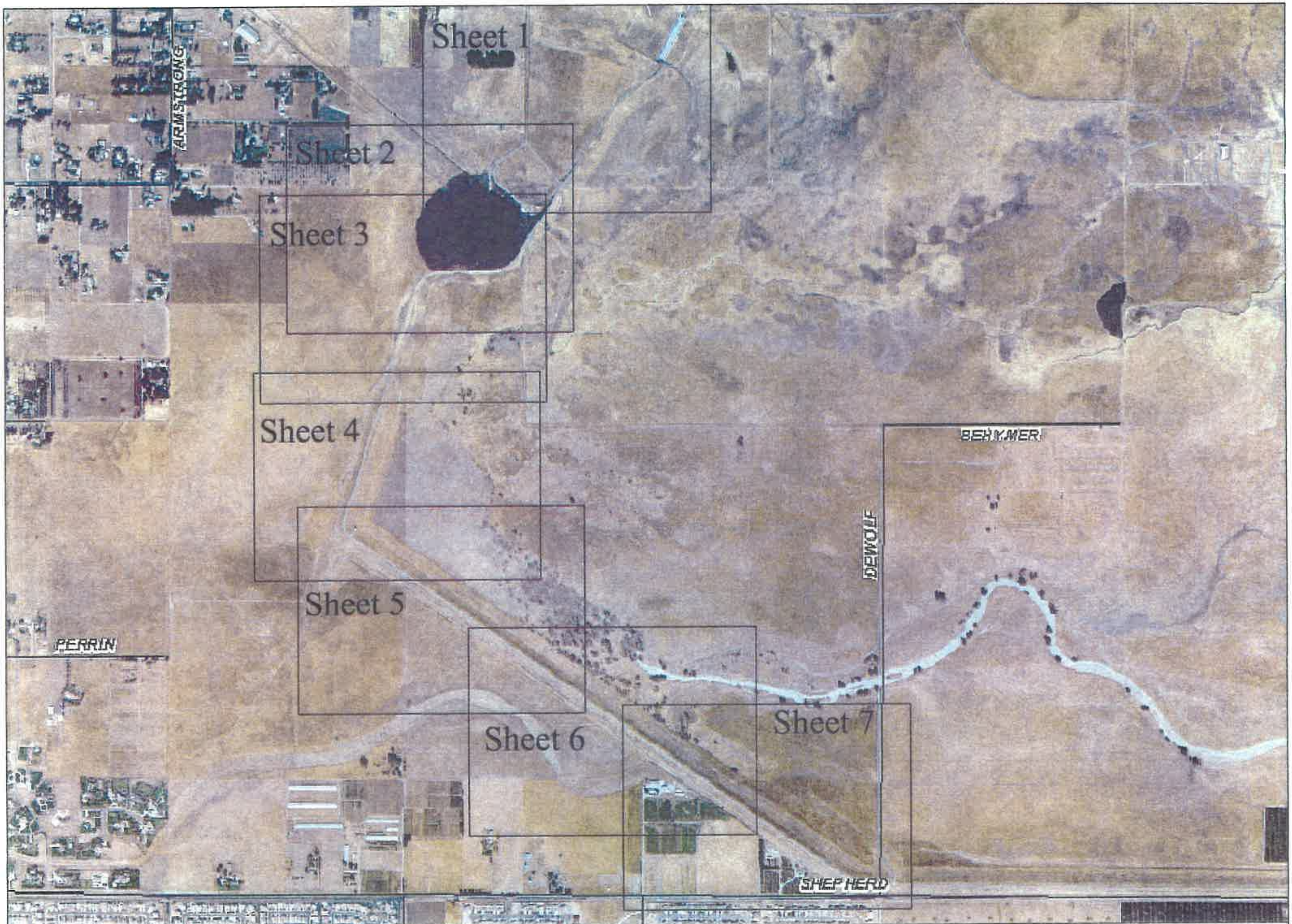
BSK has prepared this report for the exclusive use of the Fresno Metropolitan Flood Control District. The report has been prepared in accordance with generally accepted geotechnical engineering practices for the project area at the time of the report preparation. No other warranty express or implied, is made as to the professional advice provided in this report under the terms of BSK's agreement and with Client.

BSK ASSOCIATES

APPENDIX A

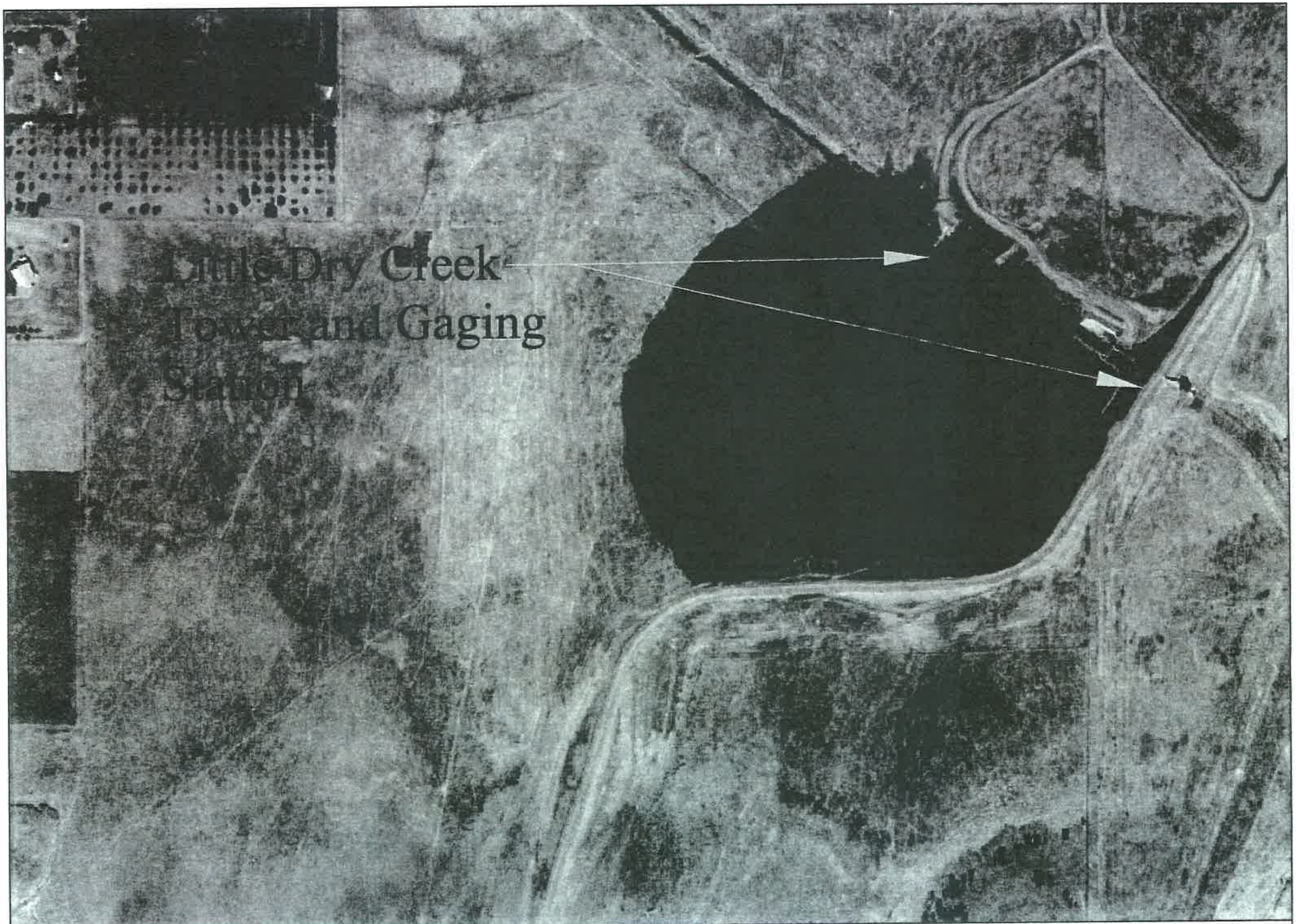
Photographs and Seepage Monitoring Data
Storm Event of April 2006

BSK



Big Dry Creek Dam
Index Sheet

Sheet 1



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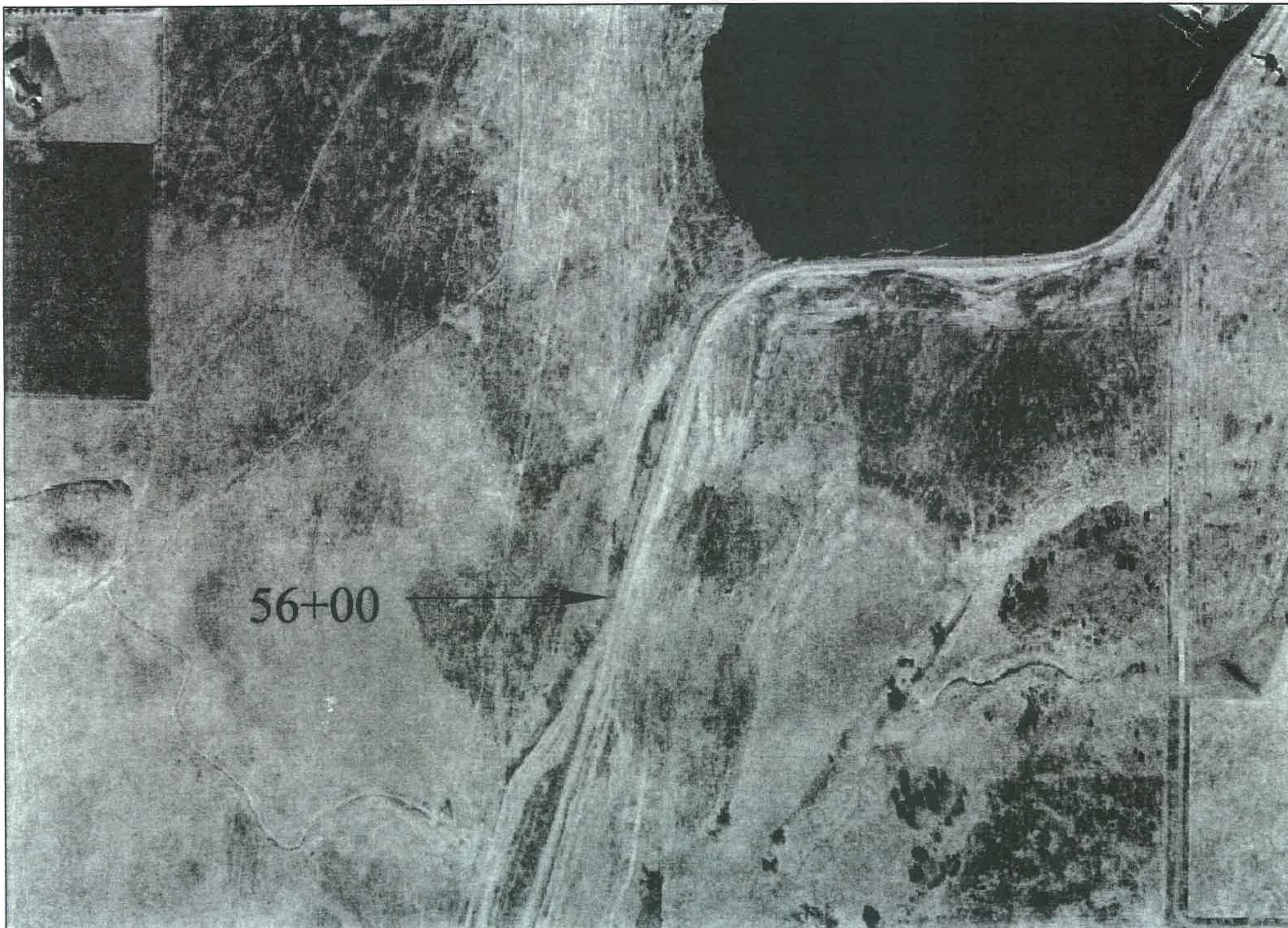

Sheet 3
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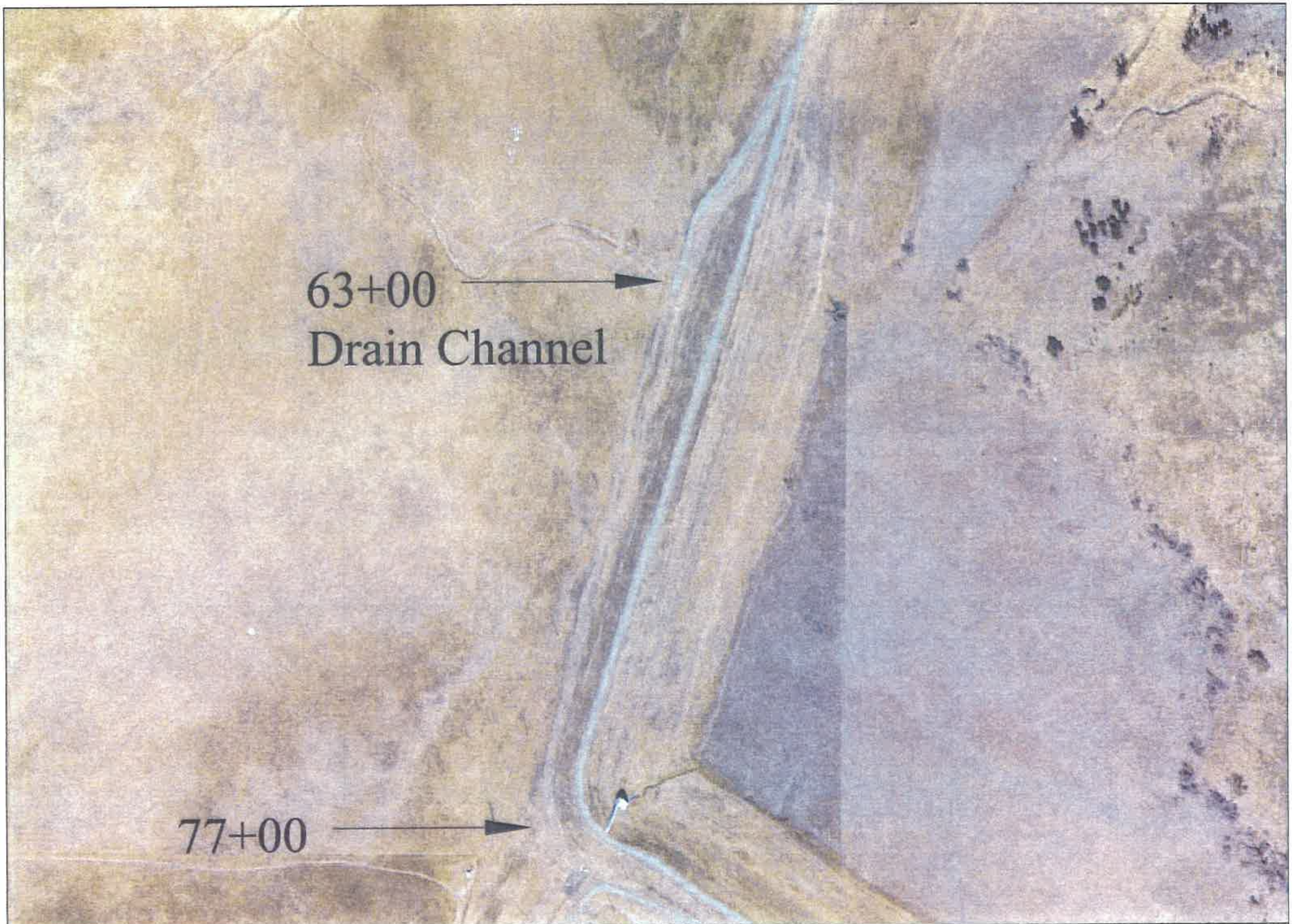

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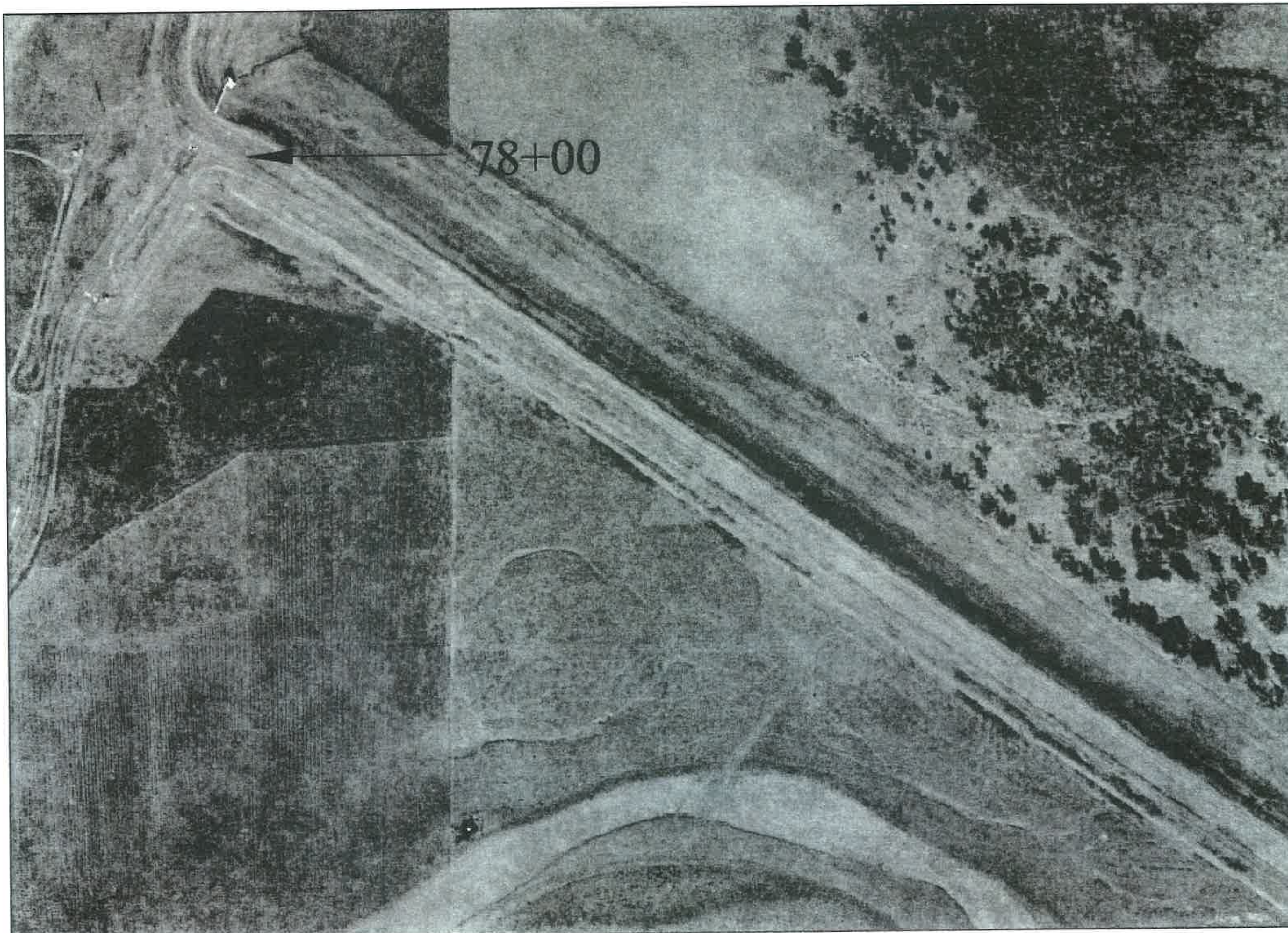
Approximate Stationing



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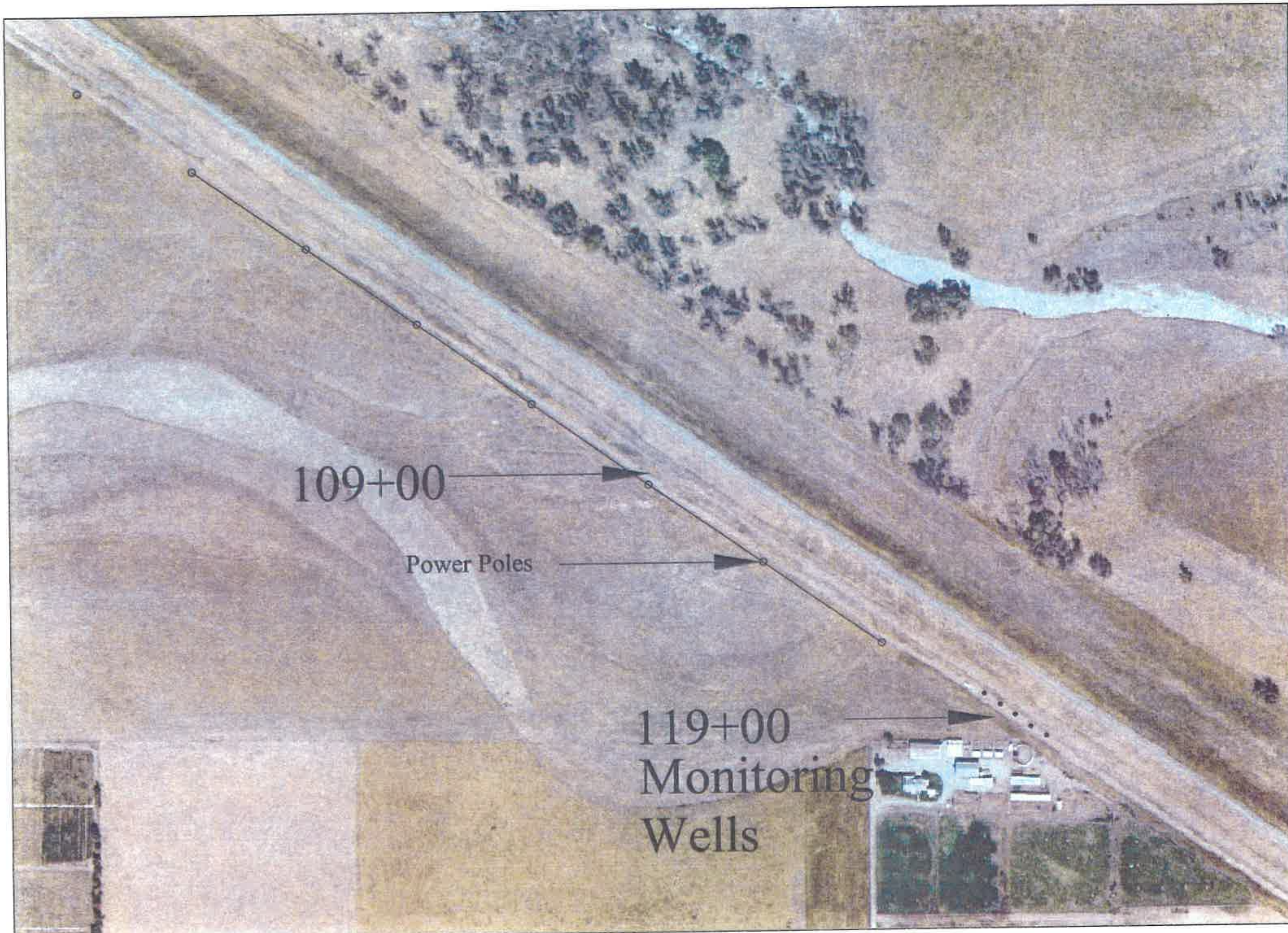


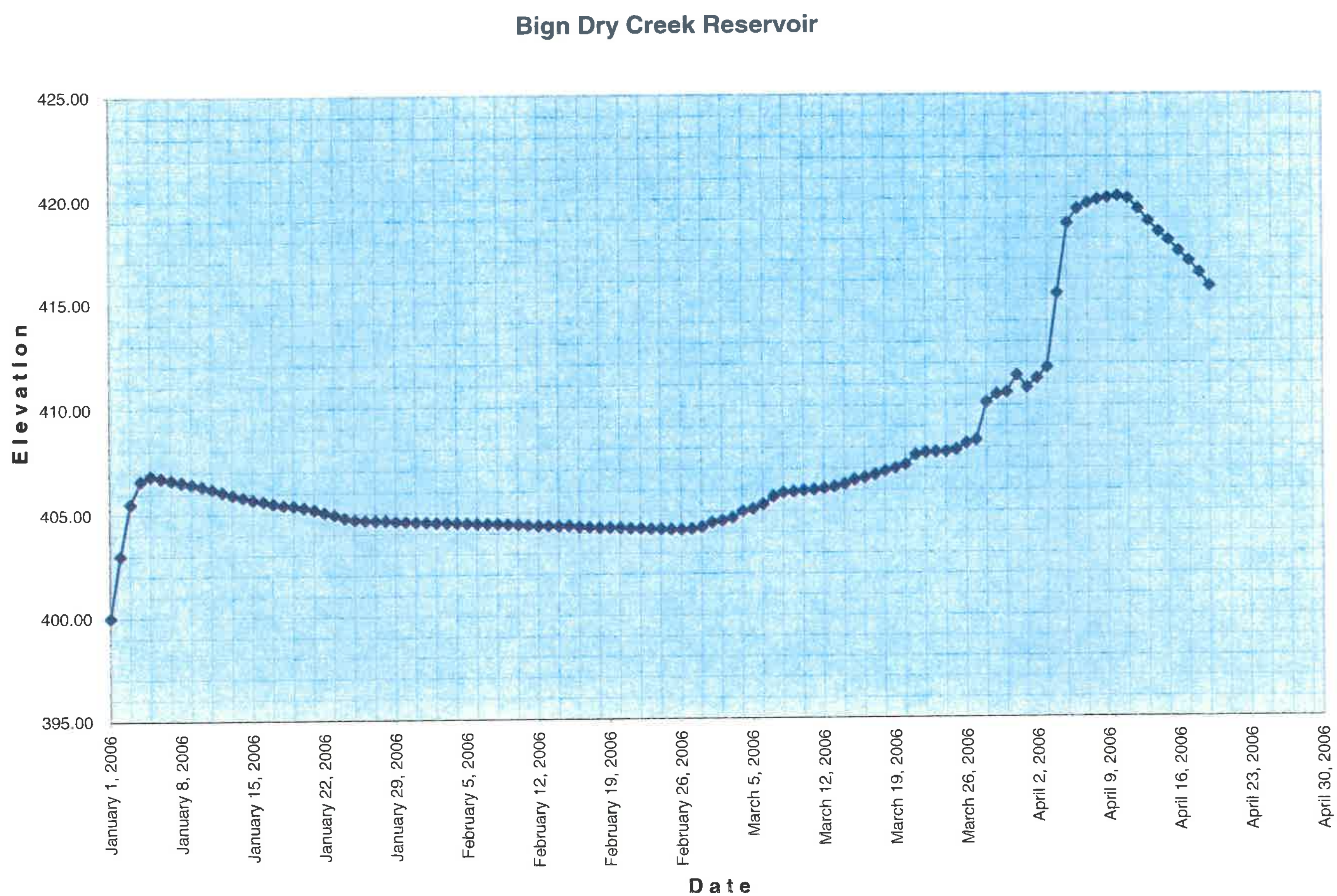
Sheet 6
Approximate Stationing

Sheet 7
Approximate Stationing

Big Dry Creek Reservoir Stage Data

Gross Pool Elevation: 432.70
Gross Pool Storage: 30,300.00

DATE	RESERVOIR ELEVATION MIDNIGHT (FT)	DATE	RESERVOIR ELEVATION MIDNIGHT (FT)	DATE	RESERVOIR ELEVATION MIDNIGHT (FT)	DATE	RESERVOIR ELEVATION MIDNIGHT (FT)
January 1, 2006	400.00	February 1, 2006	404.54	March 1, 2006	404.47	April 1, 2006	410.81
January 2, 2006	403.00	February 2, 2006	404.52	March 2, 2006	404.55	April 2, 2006	411.26
January 3, 2006	405.50	February 3, 2006	404.51	March 3, 2006	404.68	April 3, 2006	411.78
January 4, 2006	406.60	February 4, 2006	404.50	March 4, 2006	404.99	April 4, 2006	415.32
January 5, 2006	406.83	February 5, 2006	404.48	March 5, 2006	405.11	April 5, 2006	418.72
January 6, 2006	406.72	February 6, 2006	404.46	March 6, 2006	405.32	April 6, 2006	419.45
January 7, 2006	406.62	February 7, 2006	404.46	March 7, 2006	405.70	April 7, 2006	419.71
January 8, 2006	406.52	February 8, 2006	404.45	March 8, 2006	405.87	April 8, 2006	419.89
January 9, 2006	406.42	February 9, 2006	404.42	March 9, 2006	405.92	April 9, 2006	419.98
January 10, 2006	406.32	February 10, 2006	404.40	March 10, 2006	405.97	April 10, 2006	420.06
January 11, 2006	406.20	February 11, 2006	404.37	March 11, 2006	406.01	April 11, 2006	419.95
January 12, 2006	406.05	February 12, 2006	404.35	March 12, 2006	406.07	April 12, 2006	419.43
January 13, 2006	405.91	February 13, 2006	404.34	March 13, 2006	406.14	April 13, 2006	418.82
January 14, 2006	405.79	February 14, 2006	404.33	March 14, 2006	406.26	April 14, 2006	418.30
January 15, 2006	405.67	February 15, 2006	404.33	March 15, 2006	406.46	April 15, 2006	417.89
January 16, 2006	405.60	February 16, 2006	404.29	March 16, 2006	406.56	April 16, 2006	417.36
January 17, 2006	405.49	February 17, 2006	404.26	March 17, 2006	406.70	April 17, 2006	416.88
January 18, 2006	405.41	February 18, 2006	404.24	March 18, 2006	406.86	April 18, 2006	416.30
January 19, 2006	405.37	February 19, 2006	404.24	March 19, 2006	407.00	April 19, 2006	415.64
January 20, 2006	405.28	February 20, 2006	404.23	March 20, 2006	407.16	April 20, 2006	
January 21, 2006	405.18	February 21, 2006	404.20	March 21, 2006	407.63	April 21, 2006	
January 22, 2006	405.04	February 22, 2006	404.19	March 22, 2006	407.74	April 22, 2006	
January 23, 2006	404.92	February 23, 2006	404.17	March 23, 2006	407.77	April 23, 2006	
January 24, 2006	404.77	February 24, 2006	404.16	March 24, 2006	407.78	April 24, 2006	
January 25, 2006	404.68	February 25, 2006	404.14	March 25, 2006	407.87	April 25, 2006	
January 26, 2006	404.65	February 26, 2006	404.13	March 26, 2006	408.18	April 26, 2006	
January 27, 2006	404.64	February 27, 2006	404.16	March 27, 2006	408.32	April 27, 2006	
January 28, 2006	404.63	February 28, 2006	404.24	March 28, 2006	410.11	April 28, 2006	
January 29, 2006	404.59			March 29, 2006	410.50	April 29, 2006	
January 30, 2006	404.57			March 30, 2006	410.60	April 30, 2006	
January 31, 2006	404.55			March 31, 2006	411.40		


Bign Dry Creek Reservoir
Elevation
425.00
420.00
415.00
410.00
405.00
400.00
395.00
January 1, 2006
January 8, 2006
January 15, 2006
January 22, 2006
January 29, 2006
February 5, 2006
February 12, 2006
February 19, 2006
February 26, 2006
March 5, 2006
March 12, 2006
March 19, 2006
March 26, 2006
April 2, 2006
April 9, 2006
April 16, 2006
April 23, 2006
April 30, 2006
Date

Location: Big Dry Creek Dam
Date: 4-11-06
Subject: Boils and Seepage
Attendance:
Tom Snyder
Kurt Hupp
Lakhbir Singh (DSOD)
Jerry Lakeman
Bil Garcia
Verlyn Neufeld
Brent Sunamoto
David (USACE)
Paul Allen
Peter Sanchez
Jerry Isler

Kurt and I arrived at Big Dry Creek Dam at approximately 9:30. Went up ramp at Shepherd and 168 (Video 1). Ran into Paul Allen. He said that Lakhbir has shown up. They did not start talking yet because waiting for everyone else. We stopped and talked to Lakhbir just East of control gate for Big Dry Creek (video 2). He said he was not concerned with the boils unless fine material was coming out. If the water is clear, then it is not bringing fines with it.

Paul then joins us again, and heads past the Big Dry Creek outlet and drives down to bottom of dam between Big Dry Creek outlet and Diversion Channel to Little Dry Creek outlet. We are at station 60+365 (video 3). There is seepage coming out from toe drain. We walk to station 60+375 (video 4 & 5). There are sandbags surrounding station 30+375. Paul hands Lakhbir the bottom of a plastic bottle. Lakhbir tests water to see if there are any fines. He does not see any fines. Thinks it is just seepage from toe drain. Dave shows up along with Verlyn, Jerry L., Peter, and Brent. Paul says that about 20 gallons a minute of water is coming out of toe drain. It has climbed to 20 gallons per minute and held steady. They use a shallow pan to measure the water flow (video 6). When the elevation of the water in the dam gets above 410 feet, then seepage from toe drains starts to happen. The current water elevation is 420.5 feet. Everything appears to be flowing clear water. All the gravel at the toe is the toe drain. There is some discussion about whether there is perforated pipe in the toe drain. Lakhbir says that he is certain there is not perforated pipe, just gravel.

Videos 7 & 8 are of stations just south of station 60+375. There was a small amount of seepage coming out. I did not record the exact location.

We then headed up to the top of the dam and drove north, past the outlet to the diversion to Little Dry Creek and over to the Spillway (video 9). Jerry L. asked Dave who we should contact to have the Redbank Detention Basin checked out, because the concrete on the structure was starting to fall apart. Dave said he would pass the information on.

Most likely he would talk to a person named Charles Jang Young. The water at the spillway is due to rainwater and ground water. It is almost always there.

We then drove back to where Kurt, Lakhbir and I first met in the morning. We drove down the ramp to the outlet to Big Dry Creek. Paul said that 25 cfs was being let out to Big Dry Creek (Video 10). The seepage was averaging 1 gallon every 3 to 4 minutes (Video 11 & 12). The seepage was measured on the far side of the gage house. Videos 13 & 14 are miss-~~fires~~ files of station 70+840. The batteries died and I had to change them.

Videos 15 thru 18 are of station 60+262. There is a small boil, possibly from a rodent. We estimated that the flow was 1/10 of a gallon per minute. There was a question on the location of the boil to the excavation and compaction from 1991.

89+00 – (Video 18) Small boil.

Station 89+70 – (Videos 19 through 24, Picture 1) There was a worse boil. There is still air bubbling out. At about this time, Bil joins us. Lakhbir wants to dig out the hole. Bil offers to get the shovel. While Bil gets the shovel, we continue east at the toe of the dam and look around. There are a couple of more seepage points, but very minor. We walk back to station 89+70. Lakhbir and Verlyn dig out hole. Jerry and Lakhbir agree that the air is from the soil. They guestimate that the flow is ¼1 gallon per minute. The all time elevation of the water in the dam is 422.5 feet. About this time, Jerry Isler joins us.

We then return to our trucks and drive back to the place where we entered on Shepherd Ave (Video 25). We then drive at the toe of the dam. At station 121+35 (Video 26, Pictures 2 through 5) there are four boils surrounded by sandbags. They are about 50 feet from the toe of the levee. It is estimated that ¼ gallon per minute is coming from each boil. I went about ¾ up the dam to get approximate location to original Dry Creek (Video 27). The current volume of water in the dam is 9500 ac-ft. Total capacity is 32000 ac-ft. At 2:00 pm we are allowed to increase flow to 300 cfs. First increase to 100 cfs, then call County to block off Shepherd, then increase to 300 cfs to flood street.

Kurt, Dave and myself check monitoring well RW6. The depth from concrete pad to water depth is approximately 10 feet.

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	CULVERT Description and Comments
Bill G.	4-7-06	419.6	63.00	4 SEC. PER GAL
Bill G.	4-8-06	419.75		" " " "
Bill G.	4-9-06	419.89		" " " "
Bill G.	4-10-06	420.0		3 SEC. PER. GAL.
Bill G.	4-11-06	420.1		3 SEC. PER GAL.
Bill G.	4-12-06	419.7		3 SEC. PER. GAL

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	62+70	VERY LITTLE FLOW - UNMEASUREABLE
Bil G.	4-8-06	419.75		" " " "
Bil G.	4-9-06	419.89		" " " "
Bil G.	4-10-06	420.0		" " " "
Bil G.	4-11-06	420.1		WET, CAN'T SEE FLOW
Bil G.	4-12-06	419.7		" " " "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	63+10	WET AREA, CANT SEE FLOW
Bil G.	4-8-06	419.75		" " " " "
Bil G.	4-9-06	419.89		" " " " "
Bil G.	4-10-06	420.0		" " " " "
Bil G.	4-11-06	420.1		" " " " "
Bil G.	4-12-06	419.7		" " " " "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	63+40	VERY LITTLE FLOW APPROX. 1 QT. PER MIN.
Bil G.	4-8-06	419.75		″
Bil G.	4-9-06	419.89		″
Bil G.	4-10-06	420.0		″
Bil G.	4-11-06	420.1		″
Bil G.	4-12-06	419.7		″

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	63 + 55	WET AREA LEADING TO PONDED WATER APPROX 1 PT. PER MIN.
Bil G.	4-8-06	419.75		"
Bil G.	4-9-06	419.89		"
Bil G.	4-10-06	420.0		"
Bil G.	4-11-06	420.1		NO LONGER SEE FLOW
Bil G.	4-12-06	419.7		" " " "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	Description and Comments
Bil G.	4-7-06	419.6	63+75	1" IN DIA. APPROX. 45 SEC. PER. GAL
Bil G.	4-8-06	419.75		" " " " " "
Bil G.	4-9-06	419.89		" " " " " "
Bil G.	4-10-06	420.0		SECOND BOIL APPEARED APPROX. 1/4" DIA
Bil G.	4-11-06	420.1		THIRD BOIL APPEARED APPROX 1/2" DIA
Bil G.	4-12-06	419.7		3 TOTAL APPROX 35 SEC. PER GAL

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	63 + 95	CONTINUOUS FLOW – UNMEASUREABLE
Bil G.	4-8-06	419.75		" " "
Bil G.	4-9-06	419.89		" " "
Bil G.	4-10-06	420.0		" " "
Bil G.	4-11-06	420.1		" " "
Bil G.	4-12-06	419.7		WET, BUT CAN'T SEE FLOW

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	BOH 15' FROM TOE Description and Comments
Bil G.	4-7-06	419.6	65+70	1/4 DIA VERY LITTLE CONTINUOUS FLOW
Bil G.	4-8-06	419.75		UNMEASUREABLE.
Bil G.	4-9-06	419.89		"
Bil G.	4-10-06	420.0		"
Bil G.	4-11-06	420.1		"
Bil G.	4-12-06	419.7		"

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	66+40	WIDE, WET AREA CAN'T SEE FLOW
Bil G.	4-8-06	419.75		" " " " " "
Bil G.	4-9-06	419.89		" " " "
Bil G.	4-10-06	420.0		" " " "
Bil G.	4-11-06	420.1		" " " "
Bil G.	4-12-06	419.7		" " " "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	67+70	CONTINUOUS WET, NO FLOW
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-06	420.0		" "
Bil G.	4-11-06	420.1		" "
Bil G.	4-12-06	419.7		" "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	68 + 40	CONTINUALLY WET, NO FLOW
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-06	420.0		" "
Bil G.	4-11-06	420.1		" "
Bil G.	4-12-06	419.7		" "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	STANDING RAIN WATER Description and Comments
Bil G.	4-7-06	419.6	78+40—82+00	RAIN WATER STANDING
Bil G.	4-8-06	419.75		"
Bil G.	4-9-06	419.89		"
Bil G.	4-10-06	420.0		"
Bil G.	4-11-06	420.1		"
Bil G.	4-12-06	419.7		"
				"

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	BOIL Description and Comments
Bil G.	4-7-06	419.6	80+20	1/4 DIA SMALL CONTINUOUS FLOW
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-06	420.0		" "
Bil G.	4-11-06	420.1		NO LONGER VISABLE
Bil G.	4-12-06	419.7		" " "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	BOIL Description and Comments
Bil G.	4-7-06	419.6	80 + 50	1/4 DIAM. INTER. FLOW
Bil G.	4-8-06	419.75		" " "
Bil G.	4-9-06	419.89		" " "
Bil G.	4-10-06	420.0		" " "
Bil G.	4-11-06	420.1		NO LONGER VISABLE
Bil G.	4-12-06	419.7		" " "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	BOIL Description and Comments
Bil G.	4-7-06	419.6	80+52	1/4 DIA INTER. FLOW
Bil G.	4-8-06	419.75		" " "
Bil G.	4-9-06	419.89		" " "
Bil G.	4-10-06	420.0		NO LONGER VISIBLE
Bil G.	4-11-06	420.1		" " "
Bil G.	4-12-06	419.7		" " "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	80+80	CONTINUALLY WET, NO FLOW
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-06	420.0		" "
Bil G.	4-11-06	420.1		" "
Bil G.	4-12-06	419.7		" "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	BOIL Description and Comments
Bil G.	4-7-06	419.6	81 + 00	3/8 DIAM. VERY LITTLE FLOW
Bil G.	4-8-06	419.75		" " " "
Bil G.	4-9-06	419.89		" " " "
Bil G.	4-10-06	420.0		NO LONGER VISABLE, JUST WET
Bil G.	4-11-06	420.1		" " "
Bil G.	4-12-06	419.7		" " "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bill G.	4-7-06	419.6	82+60	WET CONTINUALLY - NO FLOW
Bill G.	4-8-06	419.75		"
Bill G.	4-9-06	419.89		"
Bill G.	4-10-06	420.0		"
Bill G.	4-11-06	420.1		"
Bill G.	4-12-06	419.7		"

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	BOIL IN TOE DRAIN Description and Comments
Bil G.	4-7-06	419.6	82+82	1" DIAM. CLEAR FLOW, 1 MIN PER (
Bil G.	4-8-06	419.75		" " "
Bil G.	4-9-06	419.89		" " "
Bil G.	4-10-06	420.0		" " "
Bil G.	4-11-06	420.1		LESS FLOW 2 MIN. PER QT
Bil G.	4-12-06	419.7		NON CONTINUOUS FLOW

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	84+84	CONTINUALLY WET, NO FLOW
Bil G.	4-8-06	419.75		"
Bil G.	4-9-06	419.89		"
Bil G.	4-10-06	420.0		"
Bil G.	4-11-06	420.1		"
Bil G.	4-12-06	419.7		"

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	BOIL Description and Comments
Bil G.	4-7-06	419.6	89+00	3/4" DIAM. CLEAR flow 1 min. per.
Bil G.	4-8-06	419.75		"
Bil G.	4-9-06	419.89		"
Bil G.	4-10-06	420.0		"
Bil G.	4-11-06	420.1		LESS flow APPROX. 2 MIN. PER
Bil G.	4-12-06	419.7		" " "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	Boil Description and Comments
Bil G.	4-7-06	419.6	89+80	1/4" DIAM NON-CONTINUOUS FLOW
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-06	420.0		NO FLOW
Bil G.	4-11-06	420.1		" "
Bil G.	4-12-06	419.7		" "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	BOIL - 34' FROM TOE [illegible] Description and Comments
Bil G.	4-7-06	419.6	89+70	3-4 BOILS 1/4" DIAM. NON-CONTINUOUS [illegible]
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-66	420.0		ONE LAMGER 1" DIAM. OTHERS NOT FLO[illegible]
Bil G.	4-11-66	420.1		APPROX 1 MIN. PER QT.
Bil G.	4-12-06	419.7		SANDBAGGED TO MONITOR SEEPAGE

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

BOIL 40' TO TOE DRAIN

Inspector	Date	Reservoir Elevation	Station	Description and Comments
Bill G.	4-7-06	419.6	89+85	1/4" DIA - CONTINUOUS FLOW, UNMEASURABLE
Bill G.	4-8-06	419.75		"
Bill G.	4-9-06	419.89		"
Bill G.	4-10-06	420.0		NO LONGER FLOWING
Bill G.	4-11-06	420.1		" " "
Bill G.	4-12-06	419.7		" " "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	B012 Description and Comments
Bil G.	4-7-06	419.6	92 + 50	3-4, 1/4 DIA. CONTINUOUS FLOW
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-06	420.0		NO LONGER VISABLE
Bil G.	4-11-06	420.1		" " "
Bil G.	4-12-06	419.7		" " "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	92+65	WET AREA – CAN'T SEE FLOW
Bil G.	4-8-06	419.75		"
Bil G.	4-9-06	419.89		"
Bil G.	4-10-06	420.0		"
Bil G.	4-11-06	420.1		"
Bil G.	4-12-06	419.7		"

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	94+35	WET AREA - NO FLOW
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-06	420.0		" "
Bil G.	4-11-06	420.1		" "
Bil G.	4-12-06	419.7		" "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	STANDING RAIN WATER Description and Comments
Bil G.	4-7-06	419.6	95+55	STANDING RAIN WATER
Bil G.	4-8-06	419.75		
Bil G.	4-9-06	419.89		
Bil G.	4-10-06	420.0		
Bil G.	4-11-06	420.1		
Bil G.	4-12-06	419.7		

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	110 + 40	WET AREA – NO FLOW
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-06	420.0		" "
Bil G.	4-11-06	420.1		" "
Bil G.	4-12-06	419.7		" "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	114+00	WET AREA TO PUDDLED WATER - NO Flo
Bil G.	4-8-06	419.75		"
Bil G.	4-9-06	419.89		"
Bil G.	4-10-06	420.0		"
Bil G.	4-11-06	420.1		"
Bil G.	4-12-06	419.7		"

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	BOIL Description and Comments
Bil G.	4-7-06	419.6	115 + 90	3/4" DIAM. - CONTINUOUS CLEAR FLOW
Bil G.	4-8-06	419.75		APPROX 1 MIN. PER QT.
Bil G.	4-9-06	419.89		"
Bil G.	4-10-06	420.0		"
Bil G.	4-11-06	420.1		"
Bil G.	4-12-06	419.7		"

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	116 + 66	LITTLE CONTINUOUS FLOW - UNMEASUREABLE
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-06	420.0		" "
Bil G.	4-11-06	420.1		" "
Bil G.	4-12-06	419.7		NO MORE FLOW

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	SEEPAGE Description and Comments
Bil G.	4-7-06	419.6	120+80	WET AREA - NO FLOW
Bil G.	4-8-06	419.75		"
Bil G.	4-9-06	419.89		"
Bil G.	4-10-06	420.0		"
Bil G.	4-11-06	420.1		"
Bil G.	4-12-06	419.7		"

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	BOIL Description and Comments
Bil G.	4-7-06	419.6	120+92	1/4" DIA. INTER. FLOW
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-06	420.0		" "
Bil G.	4-11-06	420.1		" "
Bil G.	4-12-06	419.7		NO FLOW

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

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Inspector	Date	Reservoir Elevation	Station	BOIL Description and Comments
Bil G.	4-7-06	419.6	121+00	1' DIA. CLEAR FLOW 1 MIN. PER P
Bil Ø.	4-8-06	419.75		"
Bi G.	4-9-06	419.89		"
Bi G.	4-10-06	420.0		"
Bi G.	4-11-06	420.1		"
Bi G.	4-12-06	419.7		"

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	Boil Description and Comments
Bil G.	4-7-06	419.6	121+15	1/2" DIA. 2 MIN. PER. PT.
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-06	420.0		" "
Bil G.	4-11-06	420.1		" "
Bil G.	4-12-06	419.7		NON-CONTINUOUS FLOW

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

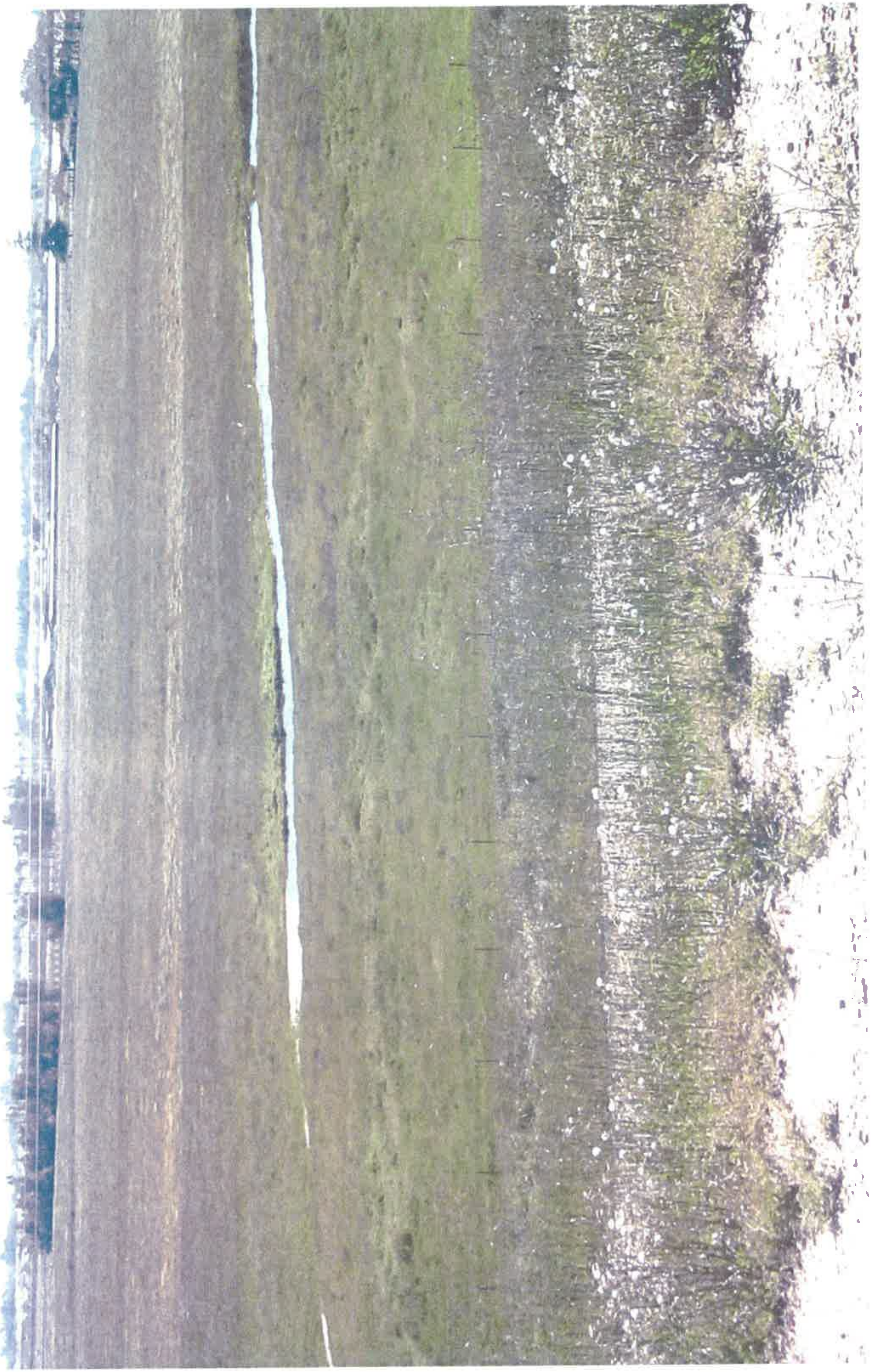
Inspector	Date	Reservoir Elevation	Station	Description and Comments (BOIL – 48' from TOE)
Bil G.	4-7-06	419.6	121 + 35	3-4, 1" DIA. APPROX 1 MIN. PER QT.
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-06	420.0		" "
Bil G.	4-11-06	420.1		SAND BAGGED TO MONITOR
Bil G.	4-12-06	419.7		FLOW NOT VISABLE

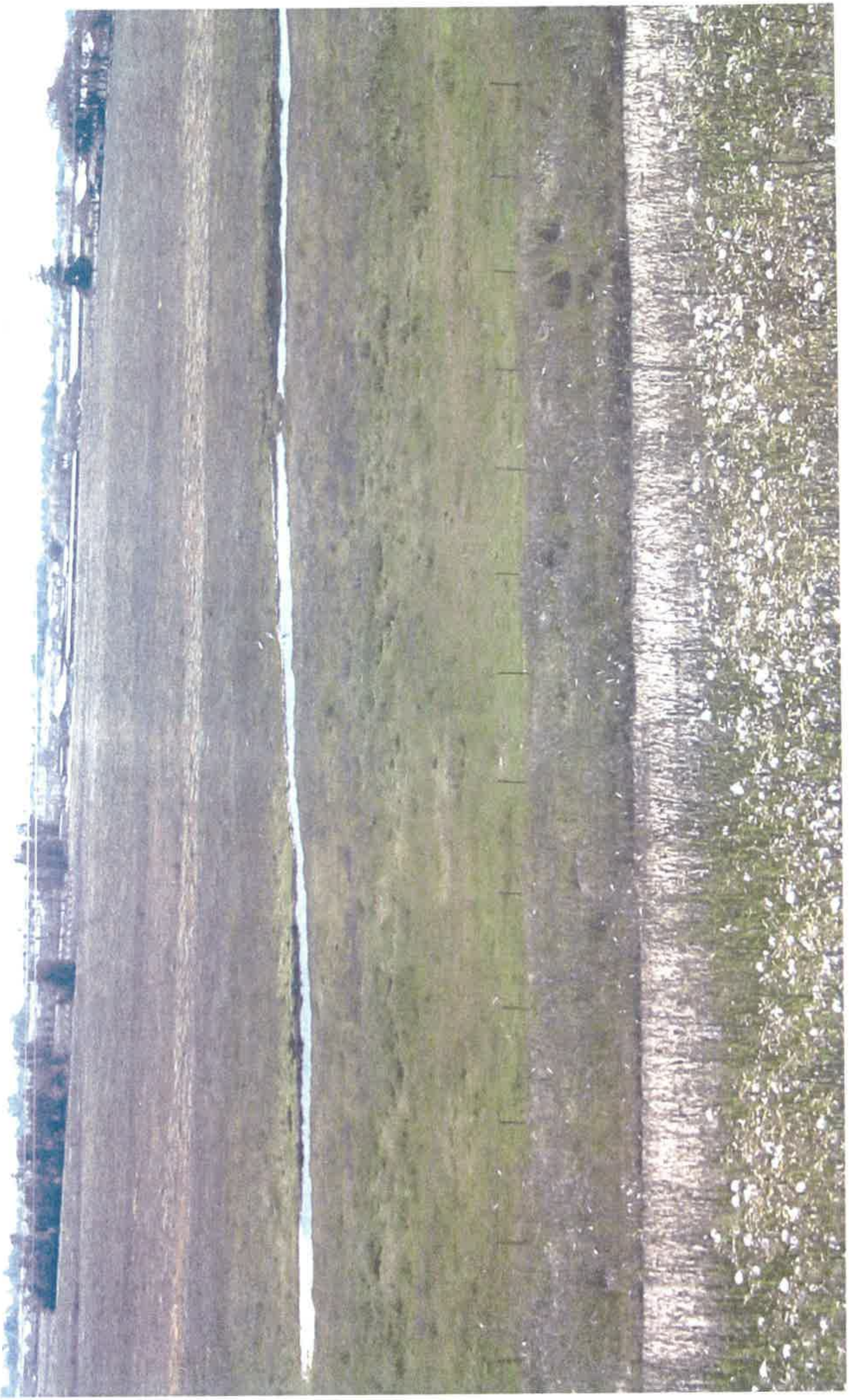
BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

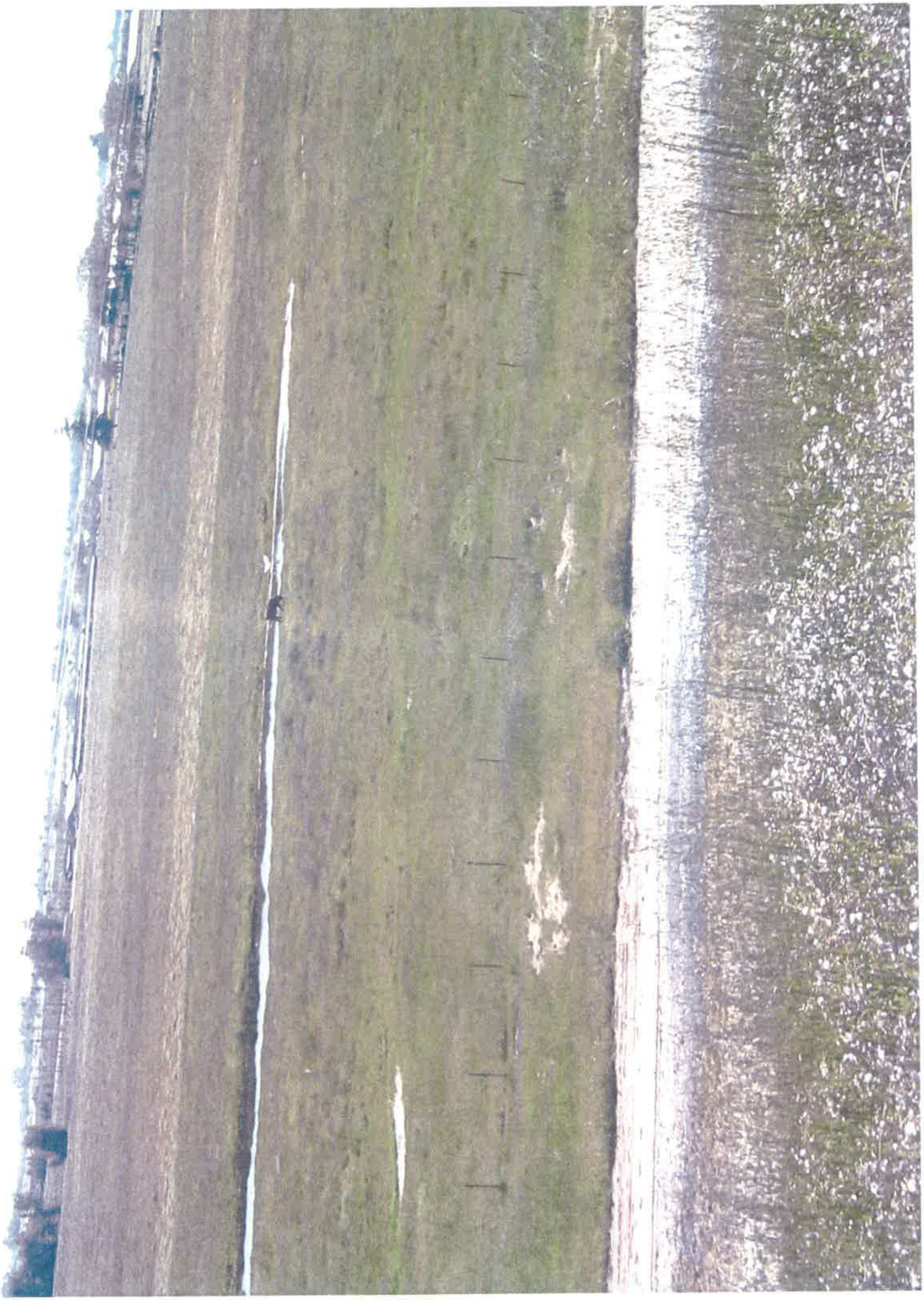
Inspector	Date	Reservoir Elevation	Station	BOIL 48' TO TOE DRAIN Description and Comments
Bil G.	4-7-06	419.6	121+75	1/4" DIA INTER FLOW
Bil G.	4-8-06	419.75		" "
Bil G.	4-9-06	419.89		" "
Bil G.	4-10-06	420.0		FLOW NO LONGER VISIBLE
Bil G.	4-11-06	420.1		" " "
Bil G.	4-12-06	419.7		" " "

BIG DRY CREEK DAM
TOE DRAIN SEEPAGE LOG

Inspector	Date	Reservoir Elevation	Station	Description and Comments (BOIL 46' TO TOE DRAIN)
Bill G.	4-7-06	419.6	121 + 85	3-4, 1/4" DIA. INTER. FLOW
Bill G.	4-8-06	419.75		" "
Bill G.	4-9-06	419.89		" "
Bill G.	4-10-06	420.0		" "
Bill G.	4-11-06	420.1		NO LONGER VISIBLE
Bill G.	4-12-06	419.7		" " "

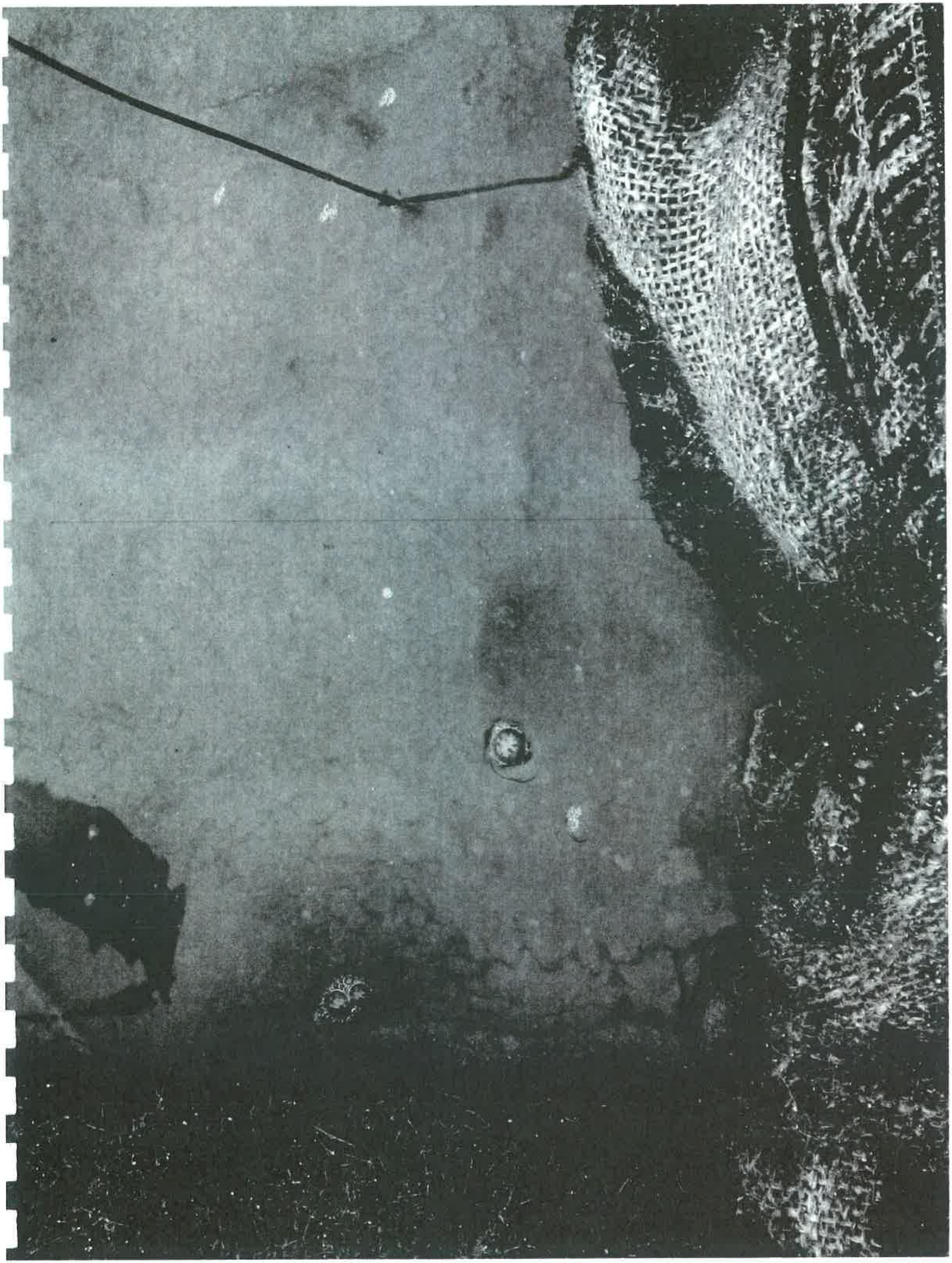







MOVIE


MOVIE



Workplan Piezometer
Installations
Big Dry Creek Dam
Fresno Metropolitan Flood
Control District
Project BDR-18

BSK Job No. G0811911F

November 18, 2008

Prepared for:

Jerry Lakeman, P.E.
District Engineer
Fresno Metropolitan Flood Control District
5469 E. Olive
Fresno, California 93727

BSK

BSK Associates
Engineers & Laboratories

567 West Shaw Avenue, Suite B
Fresno, CA 93704
(559) 497-2880
(559) 497-2886 Fax

November 18, 2008

BSK Job No. G0811911F

Jerry Lakeman, P.E.
District Engineer
Fresno Metropolitan Flood Control District
5469 E. Olive
Fresno, CA 93727

SUBJECT: Workplan Piezometer Installations
Big Dry Creek Dam
Fresno Metropolitan Flood Control District
Project BDR-18

Dear Jerry:

Submitted at your request is our workplan for the installation of piezometers for the monitoring of seepage along a specific length of Big Dry Creek Dam.

Our preliminary seepage study for Big Dry Creek Dam, dated November 5, 2008 recommends a monitoring program of the dam embankment between Stations 63+00 and 121+85 where seepage and sand boils were reported during the storm event of April 7, 2006. Open pipe piezometers are proposed.

PIEZOMETER INSTALLATION

We propose the installation of piezometer clusters at seven locations along the designated length of embankment. The piezometer clusters are situated in areas of reported seepage and sand boil occurrence. Also, they are spaced in an attempt to provide uniform cluster spacing. Each cluster will consist of four (4) piezometer. Piezometers "A" and "B" will be installed at the embankment crest in a common 10-inch diameter boring. Piezometer "A" will extent through the embankment and terminate at the foundation contact. Piezometer "B" will extend to a maximum depth of 20 feet below foundation contact or to weathered rock surface. Piezometers "C" and "D" will be installed into individual 8-inch borings at a depth of 20 feet and distances of 10 and 50 feet from the embankment toe. This network of piezometers will serve to monitor seepage and groundwater elevation rise during storm water impoundments.

Figures 2, 3 and 4 provide typical construction details for the various piezometers. Figures 5 through 8 provide general profiles and embankment configuration for the proposed piezometer locations. Projected depths of piezometers are approximate and will be determined in the field based on the embankment and underlying foundation soil profile established during drilling.

Drilling for the installation of piezometers will be performed by BSK. A BK-81 truck-mounted drill rig equipped with 8 and 10-inch diameter hollow-stem augers will be used.

ELEVATION SURVEY AND STAKING
Staking for piezometer installation will be necessary in accordance with the current USACE stationing system. At completion of piezometer installations, the top rim of each piezometer pipe will be surveyed to establish elevations in reference to the USACE benchmark for the dam. The survey work will be subcontracted.

FEE ESTIMATES
We have estimated that the fee for the construction of the piezometer network described in this workplan will comprise the following elements:

Piezometers "A" and "B". 7 sets of 2 piezometers at $8,250 per set:	$57,750
Piezometers "C" and "D". 7 sets of 2 piezometers at $7,200 per set:	$50,400
Elevation surveys (Subcontract Blair Church & Flynn) Lump Sum:	$5,600
ESTIMATED TOTAL	**$113,750**

***Reporting and engineering evaluation charges are not included in this estimate.*

SCHEDULE
The following schedule is anticipated for the installation of the piezometer network:

Staking for piezometer locations, mobilization of drill rig	5 working days
Piezometers "A" and "B"	16 working days
Piezometers "C" and "D"	16 working days
ESTIMATED TOTAL	**37 working days**

Piezometers "C" and "D" will first be installed to avoid access difficulties along the embankment toe resulting from reported soft and saturated soil conditions following major storms. Access for the installation of piezometers "A" and "B" is expected to remain available a few days following major storms.

This workplan is presented for your review and evaluation. We are prepared to meet with you and discuss the various elements of the plan.

The opportunity to be of service on this project is appreciated.

Respectfully submitted
BSK Associates

Hugo Kevorkian
Senior Principal Geotechnical Engineer
CE16350
GE462
REAII 20080

REGISTERED PROFESSIONAL ENGINEER
HUGO KEVORKIAN
No. 462
Exp. 06.30.09
GEOTECHNICAL
STATE OF CALIFORNIA

HK:jam

G08-119-11F
NOVEMBER 2008
FIGURE 1

284	568402.97	1808583.93	424.62	5+00.00
285	568358.42	1808561.23	424.62	5+50.00
286	568313.87	1808538.53	424.66	6+00.00
287	568269.32	1808515.83	424.64	6+50.00
288	568224.77	1808493.13	424.70	7+00.00
289	568180.22	1808470.43	424.67	7+50.00
290	568164.63	1808462.48	424.67	7+67.50
291	568135.67	1808447.73	434.3	8+00.00
292	568091.12	1808425.02	434.3	8+50.00
293	568046.57	1808402.32	435.1	9+00.00

PROFILE OF CARSON AVE.

265	566584.79	1807214.48	435.37	0+00
266	566604.86	1807226.70	435.50	0+23.5
267	566625.08	1807237.71	435.70	0+46.52
268	566666.32	1807259.28	436.78	0+93.06
269	566718.92	1807274.10	438.50	1+48.60
270	566764.89	1807259.42	436.86	1+97.46
271	566809.07	1807225.18	432.98	2+53.35
272	566844.18	1807196.04	430.26	2+98.98
273	566878.[illegible]	1807166.88	427.92	3+44.24
274	5669[illegible]	1807134.01	425.08	3+95.22
275	5669[illegible]2	1807100.53	422.02	4+46.97
276	56699[illegible]3	1807070.40	419.30	4+93.77

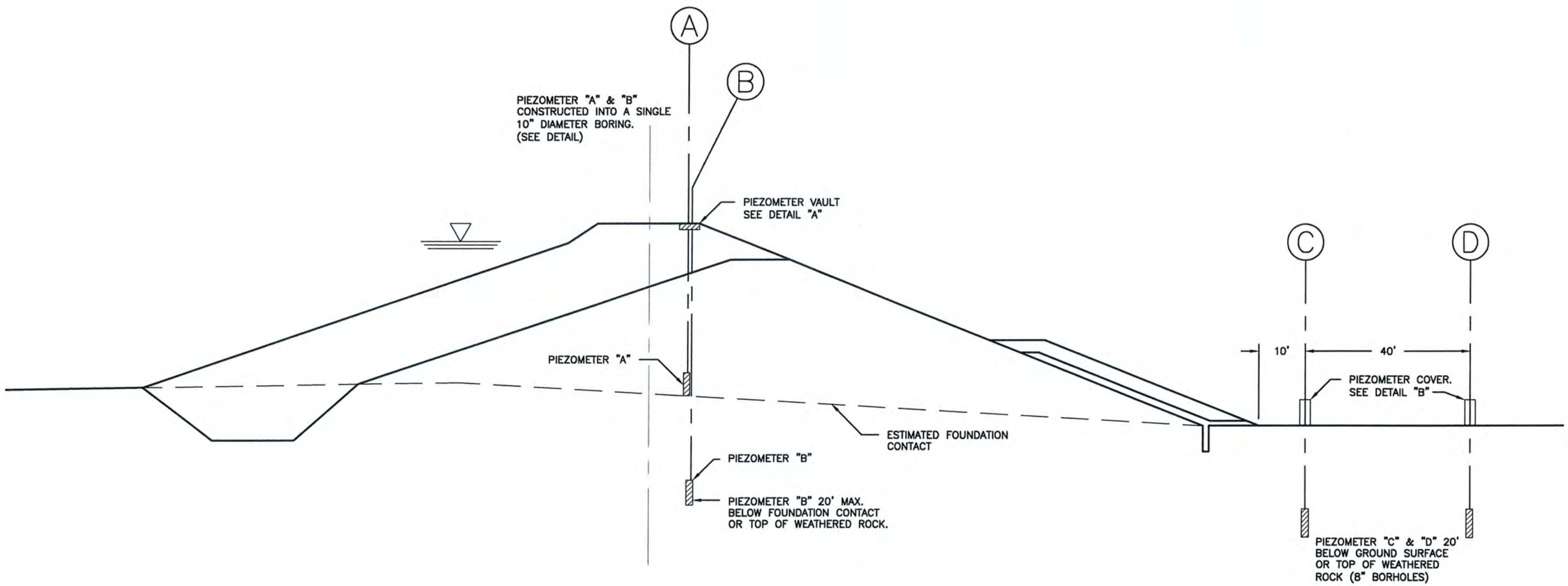
CURVE	RADIUS	LENGTH	TANGENT	CHORD	DELTA
C1	100.00'	159.26'	102.20'	142.96'	91°14'41"
C2	100.00'	156.91'	99.83'	141.30'	89°54'00"
C3	100.00'	157.32'	100.24'	141.59'	90°08'00"
C4	100.00'	156.50'	99.42'	141.01'	89°39'51"
C5	250.01'	142.50'	73.24'	140.58'	32°39'25"
C6	200.01'	253.97'	147.34'	237.25'	72°45'17"
C7	300.01'	364.42'	208.50'	342.43'	69°35'45"
C8	300.01'	286.73'	155.37'	275.94'	54°45'29"
C9	325.02'	123.26'	62.38'	122.52'	21°43'45"
C10	140.01'	66.79'	34.04'	66.16'	27°19'56"
C11	140.01'	113.10'	59.84'	110.05'	46°17'03"

LINE	DIRECTION	DISTANCE
L1	N 88°45'19" E	757.70'
L2	S 00°00'00" E	487.02'
L3	S 89°54'00" E	359.90'
L4	N 00°02'00" W	504.12'
L5	N 89°37'51" E	276.06'
L6	S 87°32'15" E	682.67'
L7	S 87°27'58" W	633.13'
L8	S 32°42'29" W	382.31'
L9	S 33°44'4[illegible]" W	361.58'
L10	S 54°20'00" W	492.62'
L11	S 27°00'04" W	757.56'
L12	S 19°16'59" E	47.17'

BSK

SITE MAP
Big Dry Creek Red Bank Dams
Fresno County, California

G08-119-11F
NOVEMBER 2008
FIGURE 2



DETAIL DRAWINGS
OPEN TUBE-TYPE PIEZOMETERS

Big Dry Creek Red Bank Dams
Fresno County, California

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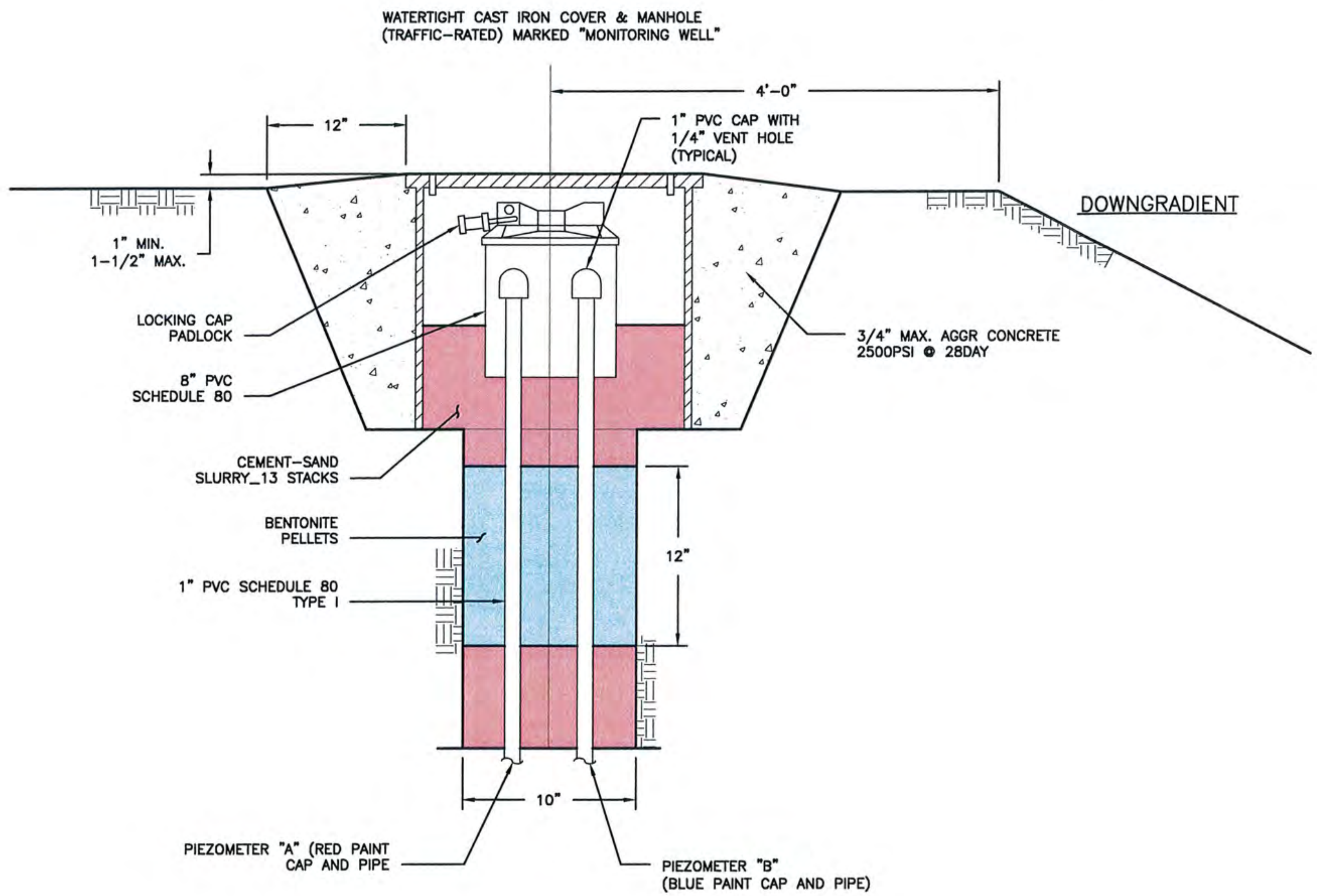
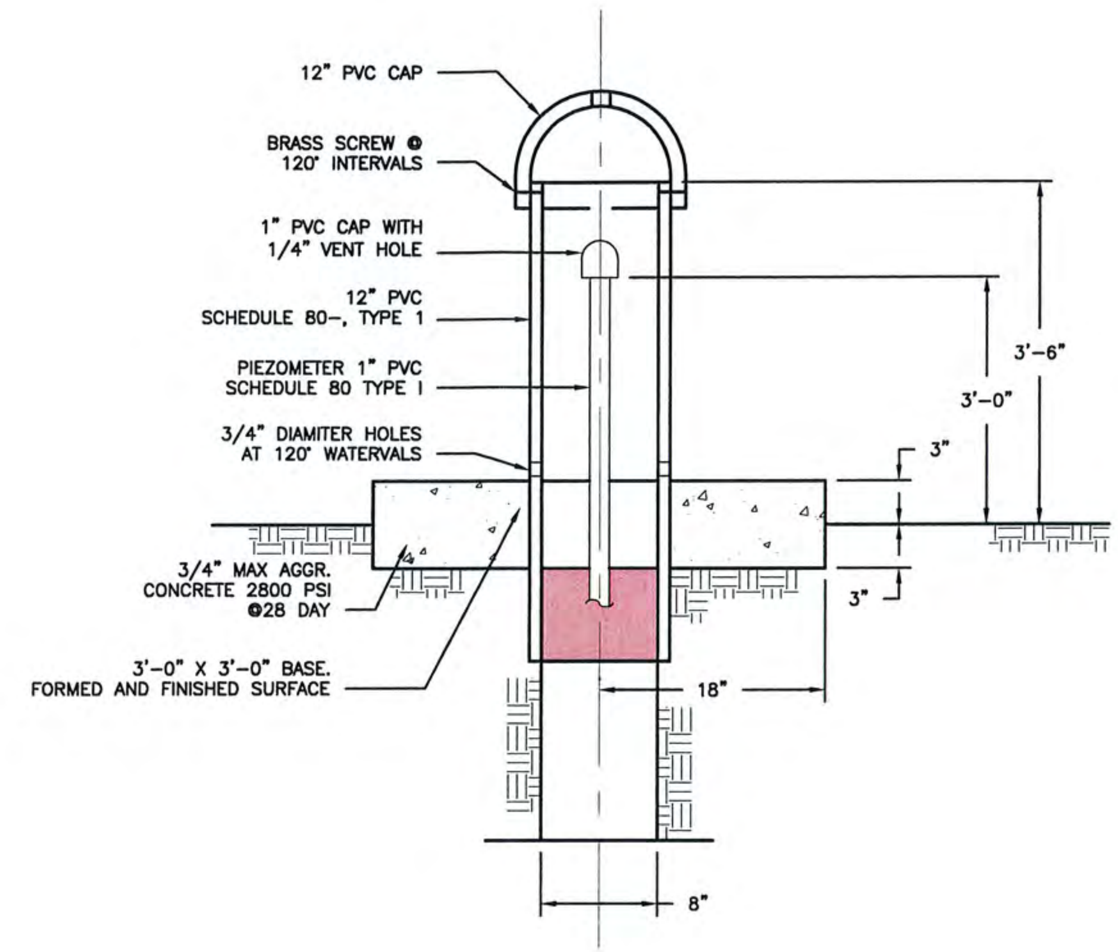
K:\Projects\2008\Fresno\G081191 1F Big Dry Creek Red Bank Dams\Figures\Details.dwg User:kanderson Plotted:Nov 18, 2008 - 9:36am Last Save:Nov 18, 2008 - 9:18am

G08-119-11F
NOVEMBER 2008
FIGURE 3



DETAIL "A"
PIEZOMETER VAULT
AT EMBANKMENT CREST
PIEZOMETER "A" & "B"



DETAIL "B"
PIEZOMETER PROTECTIVE COVER
PIEZOMETERS "C" & "D"
AT EMBANKMENT TOE AREA

LEGEND:

- BENTONITE PELLETS
- 13. SACK CEMENT-SAND GROUT (TREMIED)
- PERMEABLE MATERIAL. CALTRANS CLASS I, TYPE 'A' (SECTION 6B-1.025)

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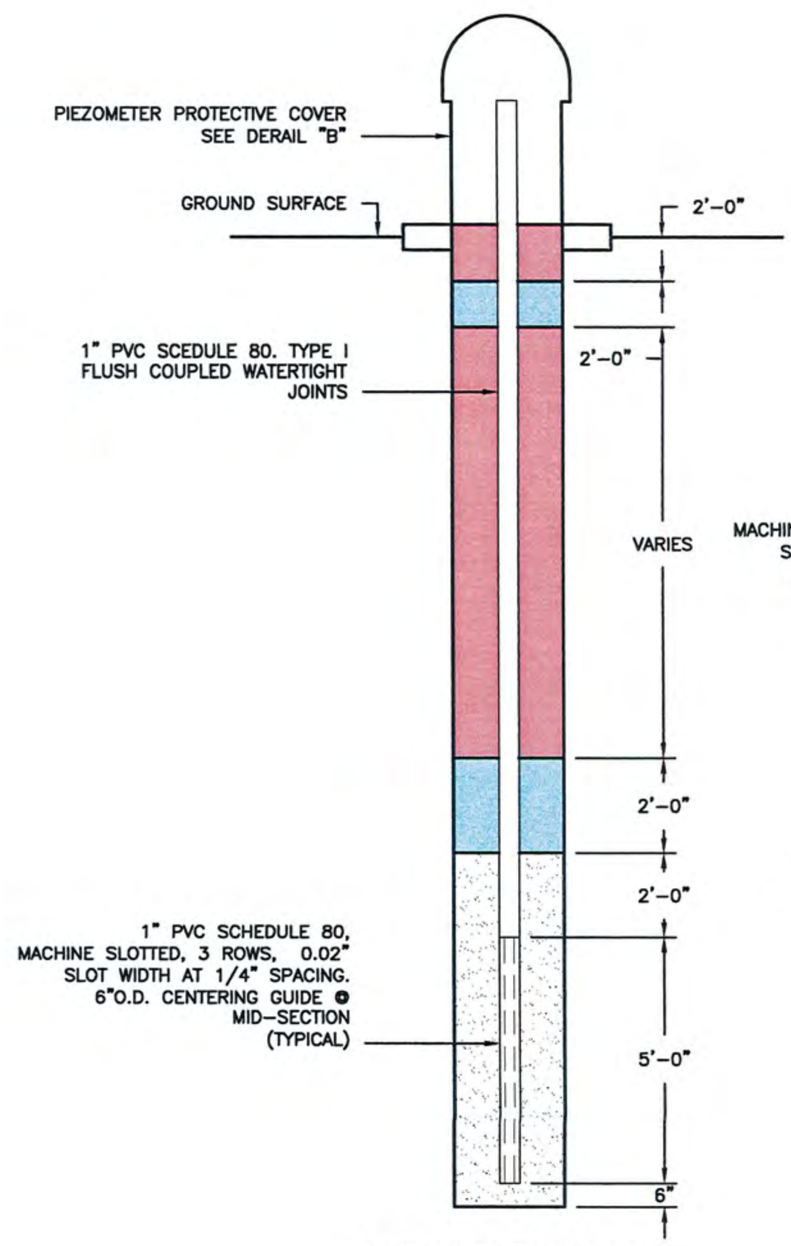
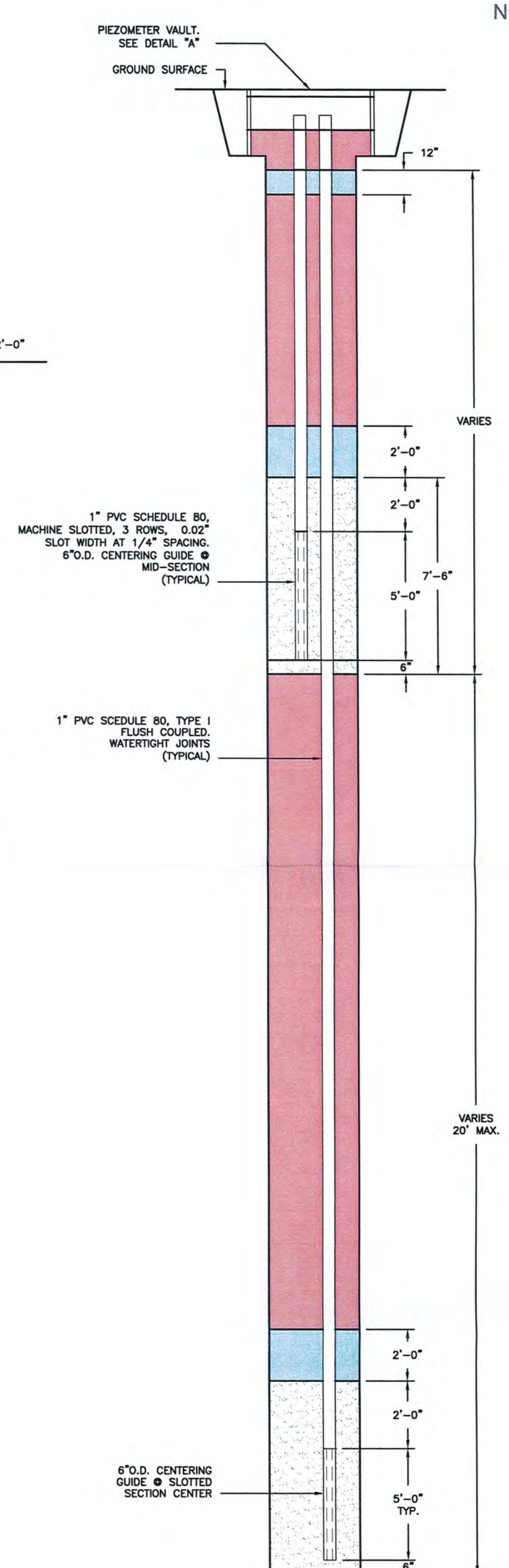
DETAIL DRAWINGS OPEN TUBE-TYPE PIEZOMETERS

Big Dry Creek Red Bank Dams
Fresno County, California

G08-119-11F
NOVEMBER 2008
FIGURE 4



PIEZOMETERS "C" & "D"



DOUBLE PIEZOMETER
INSTALLATION
PIEZOMETERS "A" & "B"

LEGEND:

- BENTONITE PELLETS
- 13. SACK CEMENT-SAND GROUT (TREMIED)
- PERMEABLE MATERIAL. CALTRANS CLASS I, TYPE 'A' (SECTION 6B-1.025)

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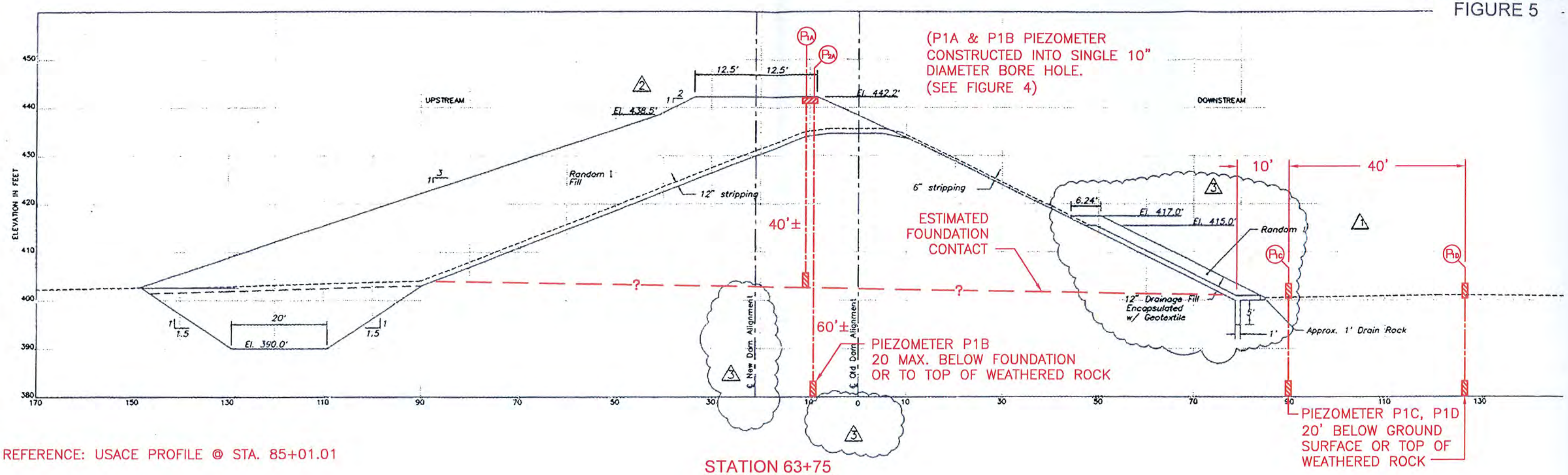
DETAIL DRAWINGS
OPEN TUBE-TYPE
PIEZOMETERS

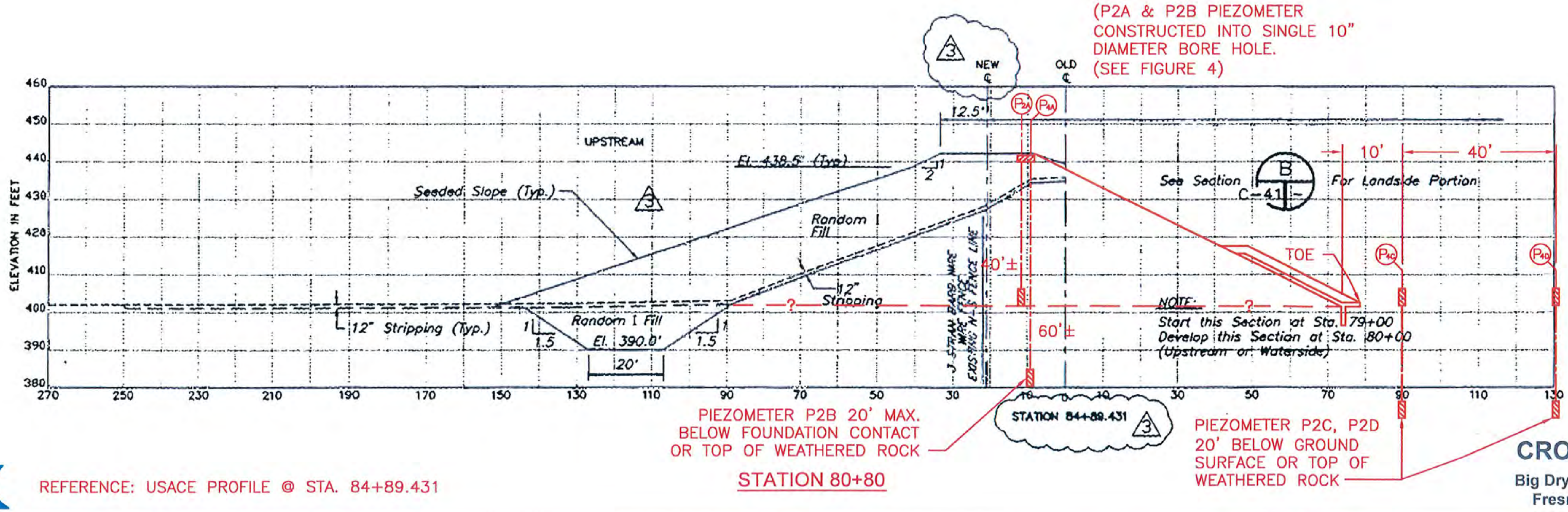
Big Dry Creek Red Bank Dams
Fresno County, California

G08-119-11F
NOVEMBER 2008
FIGURE 5



REFERENCE: USACE PROFILE @ STA. 85+01.01

STATION 63+75



REFERENCE: USACE PROFILE @ STA. 84+89.431

STATION 80+80

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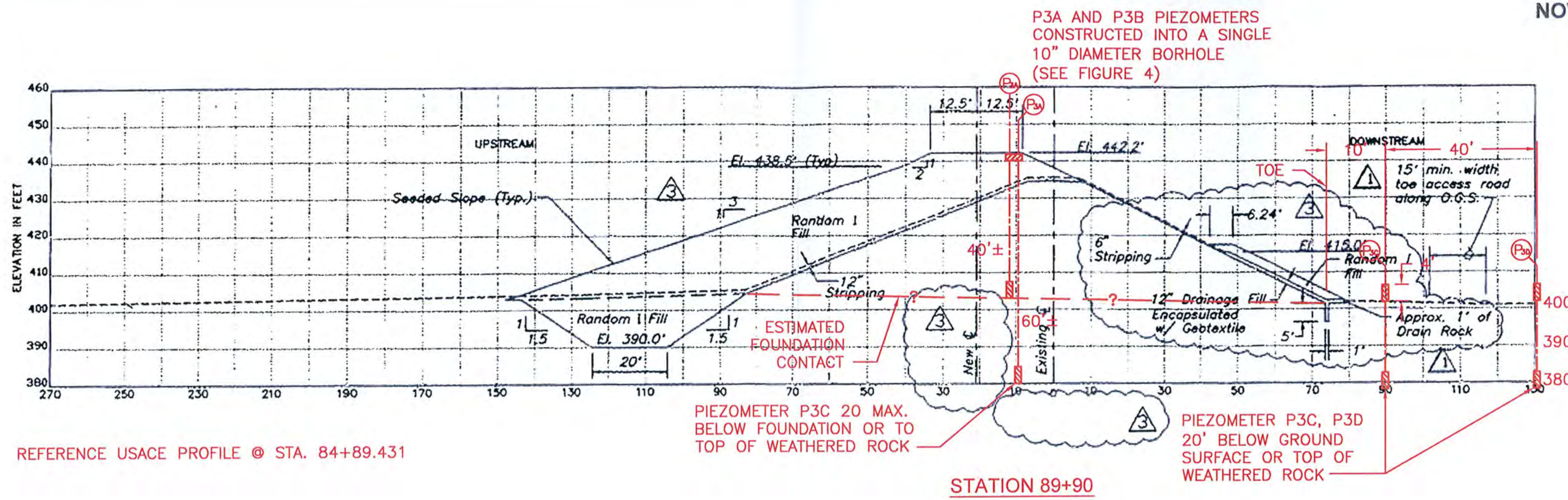
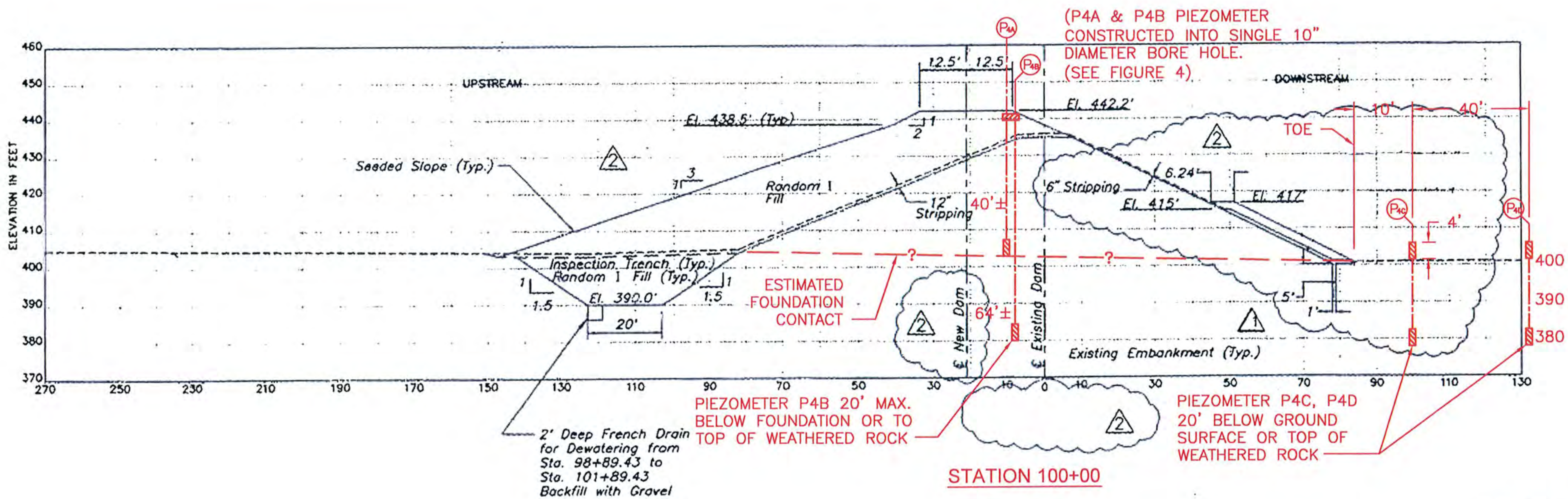
CROSS SECTIONS
Big Dry Creek Red Bank Dams
Fresno County, California

G08-119-11F
NOVEMBER 2008
FIGURE 6



REFERENCE USACE PROFILE @ STA. 84+89.431



REFERENCE USACE PROFILE @ STA. 99+89.431

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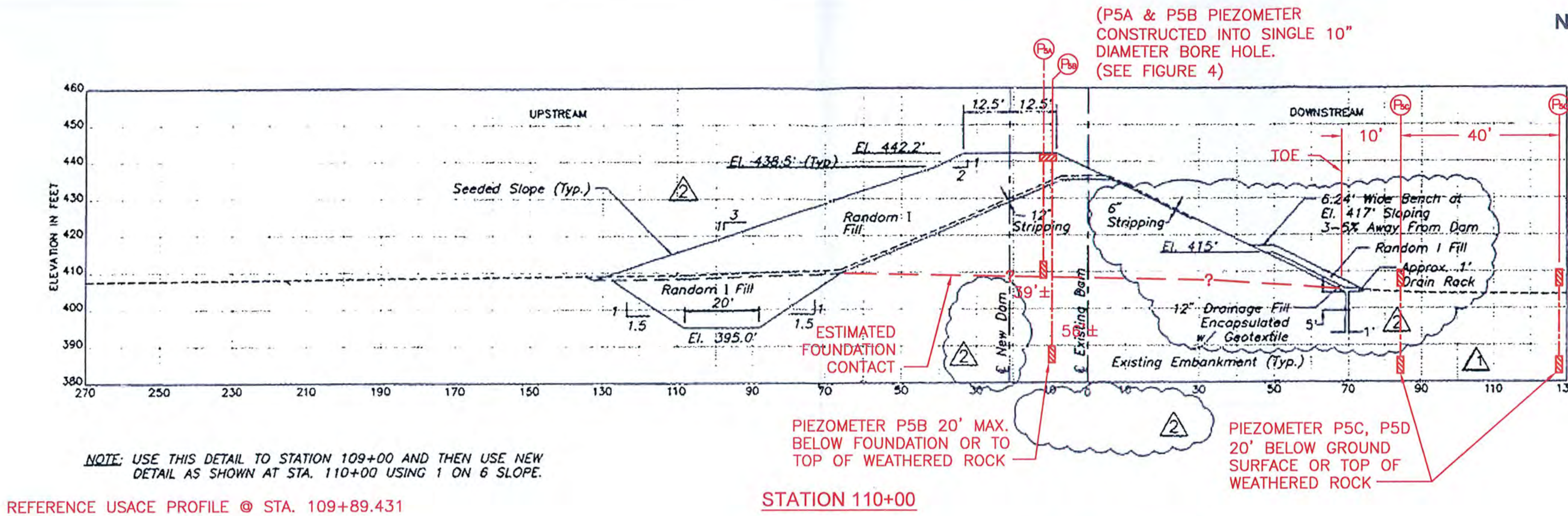
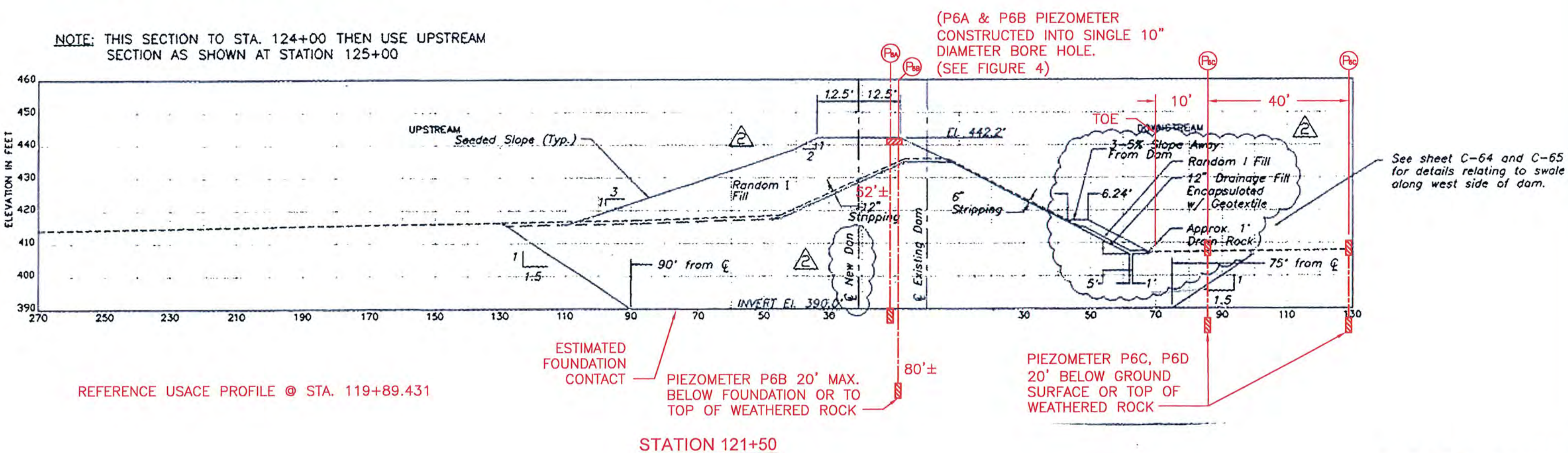
CROSS SECTIONS

Big Dry Creek Red Bank Dams
Fresno County, California





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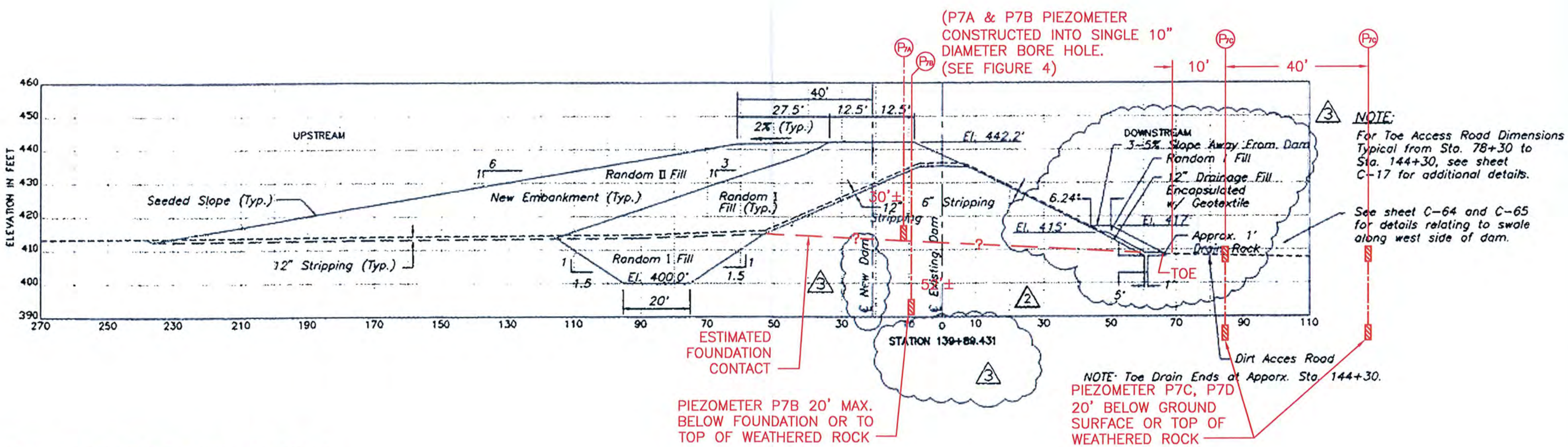
CROSS SECTIONS

Big Dry Creek Red Bank Dams
Fresno County, California

G08-119-11F
NOVEMBER 2008
FIGURE 8



REFERENCE USACE PROFILE @ STA. 139+89.431

STATION 135+00

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CROSS SECTIONS
Big Dry Creek Red Bank Dams
Fresno County, California

BSK
Associates
Engineers & Laboratories

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May 20, 2009

BSK Job No. G0811911F

Jerry Lakeman, P.E.
District Engineer
Fresno Metropolitan Flood Control District
5469 E. Olive
Fresno, CA 93727

SUBJECT: Piezometer Installations
Big Dry Creek Dam
Fresno Metropolitan Flood Control District
Project BDR-18

Dear Jerry:

This report describes the installation of piezometers in Big Dry Creek Dam, Fresno California. Field activities were carried out from late January to early March 2009. The installation of piezometers served the objectives of providing a means of monitoring seepage through a specific segment of the embankment. This particular segment (Stations 63+00 to 121+85) has produced seepage and sand boils during the storm event of April 7, 2006. The installation was performed in substantial conformance to our Workplan of November 18, 2008.

Piezometer locations and post-construction piezometer elevations were surveyed by Blair Church and Flynn. Minor deviations of locations were made for some of piezometers "C" and "D" located at the base of the embankment. These deviations were necessary to avoid existing features and to accommodate drill rig access. "As Constructed" embankment section drawings, Figure 1 through 8, document field modifications for piezometer locations and field adjustments in the depths of piezometers. The latter was designed to adjust for depths to the embankment fill-to-native soil interface based on USACE records and actual determinations during drilling.

The filter materials used for the piezometers was tested prior to use for particle size distribution compliance with our design (our report of December 12, 2008). As an added protection against accumulation of fines in the piezometer, the screened area was fitted with a geotextile filter fabric.

Intact and bulk soil samples were obtained in the borings. Boring logs and piezometer construction configurations are appended to this report.

Groundwater was encountered in piezometer sets P1, P2, P3, P4, and P6. Depth to groundwater ranged from approximately 6 to 20 feet below natural ground surface. Fresno Irrigation District Groundwater Maps indicate a general groundwater elevation of 380 feet near Shepherd and DeWolf Avenues or approximately 20 feet below ground surface.

The opportunity to be of service is appreciated.

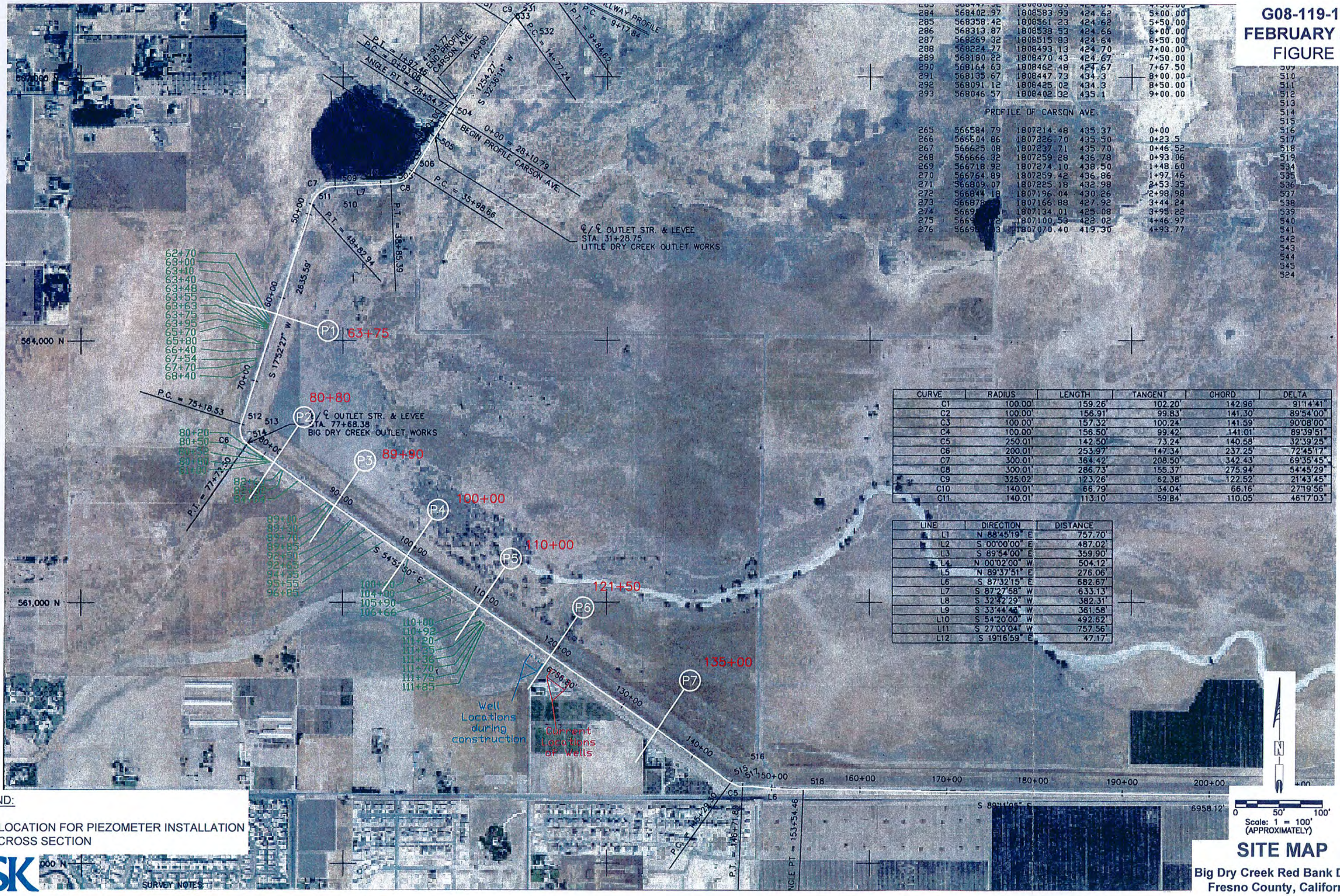
Respectfully submitted
BSK Associates

Hugo Keyorkian
Principal Geotechnical Engineer
CE16350
GE462
REAII 20080

HK:jam

Distribution: Client (3 originals)
BSK File (1 original)

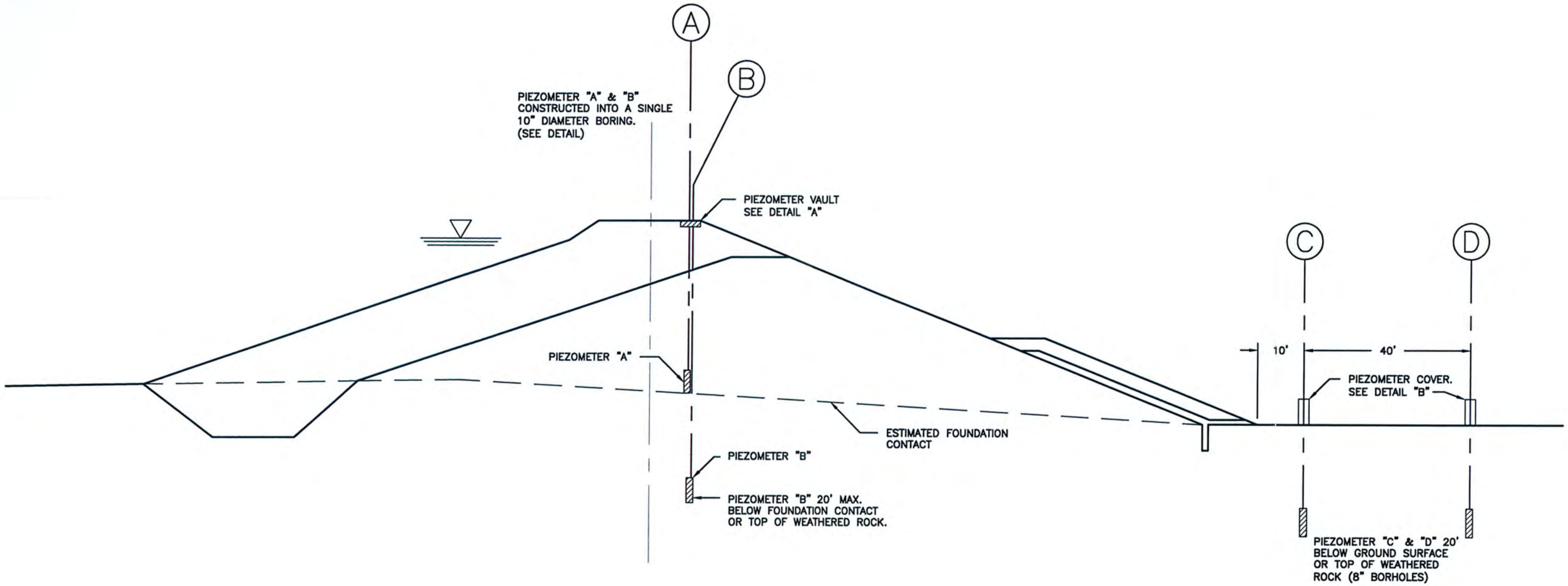
Enclosures: Piezometers "As Constructed"
Figures 1 through 8
Logs of Borings/Well Construction Configurations
Figures 9 through 29
Filter Design, Open Pipe Piezometers, Figures 30 through 32



CURVE	RADIUS	LENGTH	TANGENT	CHORD	DELTA
C1	100.00'	159.26'	102.20'	142.96'	91°14'41"
C2	100.00'	156.91'	99.83'	141.30'	89°54'00"
C3	100.00'	157.32'	100.24'	141.59'	90°08'00"
C4	100.00'	156.50'	99.42'	141.01'	89°39'51"
C5	250.01'	142.50'	73.24'	140.58'	32°39'25"
C6	200.01'	253.97'	147.34'	237.25'	72°45'17"
C7	300.01'	364.42'	208.50'	342.43'	69°35'45"
C8	300.01'	286.73'	155.37'	275.94'	54°45'29"
C9	325.02'	123.26'	62.38'	122.52'	21°43'45"
C10	140.01'	66.79'	34.04'	66.16'	27°19'56"
C11	140.01'	113.10'	59.84'	110.05'	46°17'03"

LINE	DIRECTION	DISTANCE
L1	N 88°45'19" E	757.70'
L2	S 00°00'00" E	487.02'
L3	S 89°54'00" E	359.90'
L4	N 00°02'00" W	504.12'
L5	N 89°37'51" E	276.06'
L6	S 87°32'15" E	682.67'
L7	S 87°27'58" W	633.13'
L8	S 32°42'29" W	382.31'
L9	S 33°44'43" W	361.58'
L10	S 54°20'00" W	492.62'
L11	S 27°00'04" W	757.56'
L12	S 19°16'59" E	47.17'

G08-119-11F
FEBRUARY 2009
FIGURE 2



DETAIL DRAWINGS
OPEN TUBE-TYPE
PIEZOMETERS

Big Dry Creek Red Bank Dams
Fresno County, California

BSK

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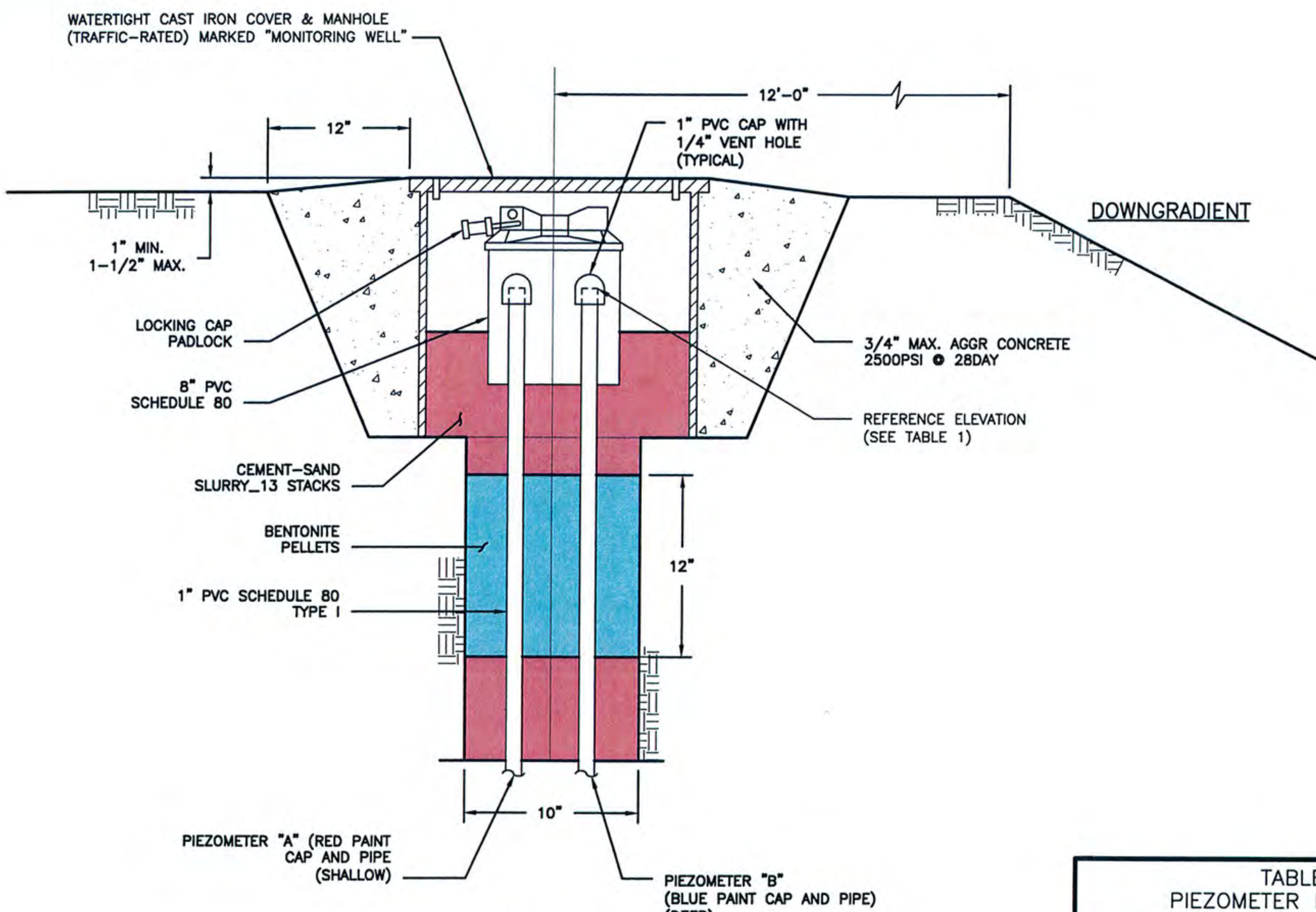
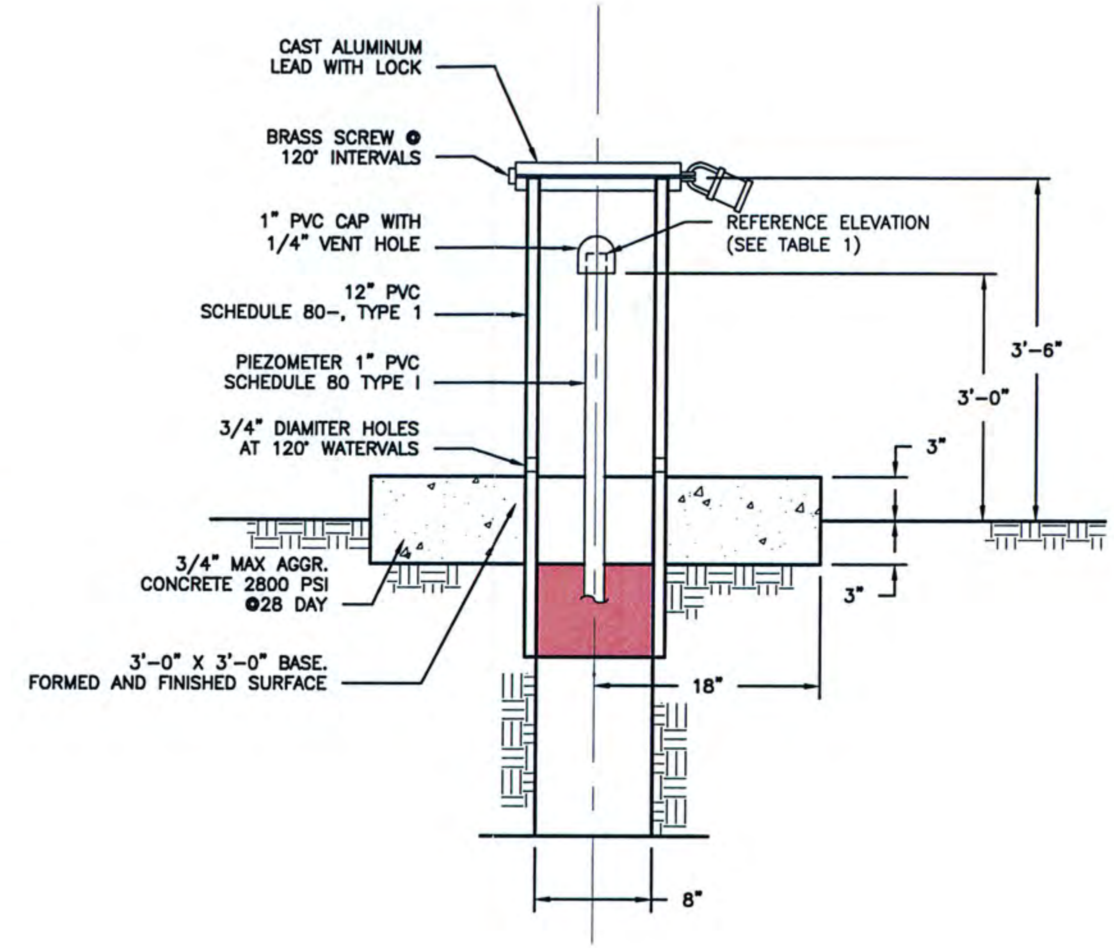
G08-119-11F
FEBRUARY 2009
FIGURE 3



DETAIL "A"
PIEZOMETER VAULT
AT EMBANKMENT CREST
PIEZOMETER "A" & "B"



DETAIL "B"
PIEZOMETER PROTECTIVE COVER
PIEZOMETERS "C" & "D"
AT EMBANKMENT TOE AREA

LEGEND:

- BENTONITE PELLETS
- 13. SACK CEMENT-SAND GROUT (TREMIED)
- PERMEABLE MATERIAL. CALTRANS CLASS I, TYPE 'A' (SECTION 6B-1.025)

TABLE 1
PIEZOMETER ELEVATIONS

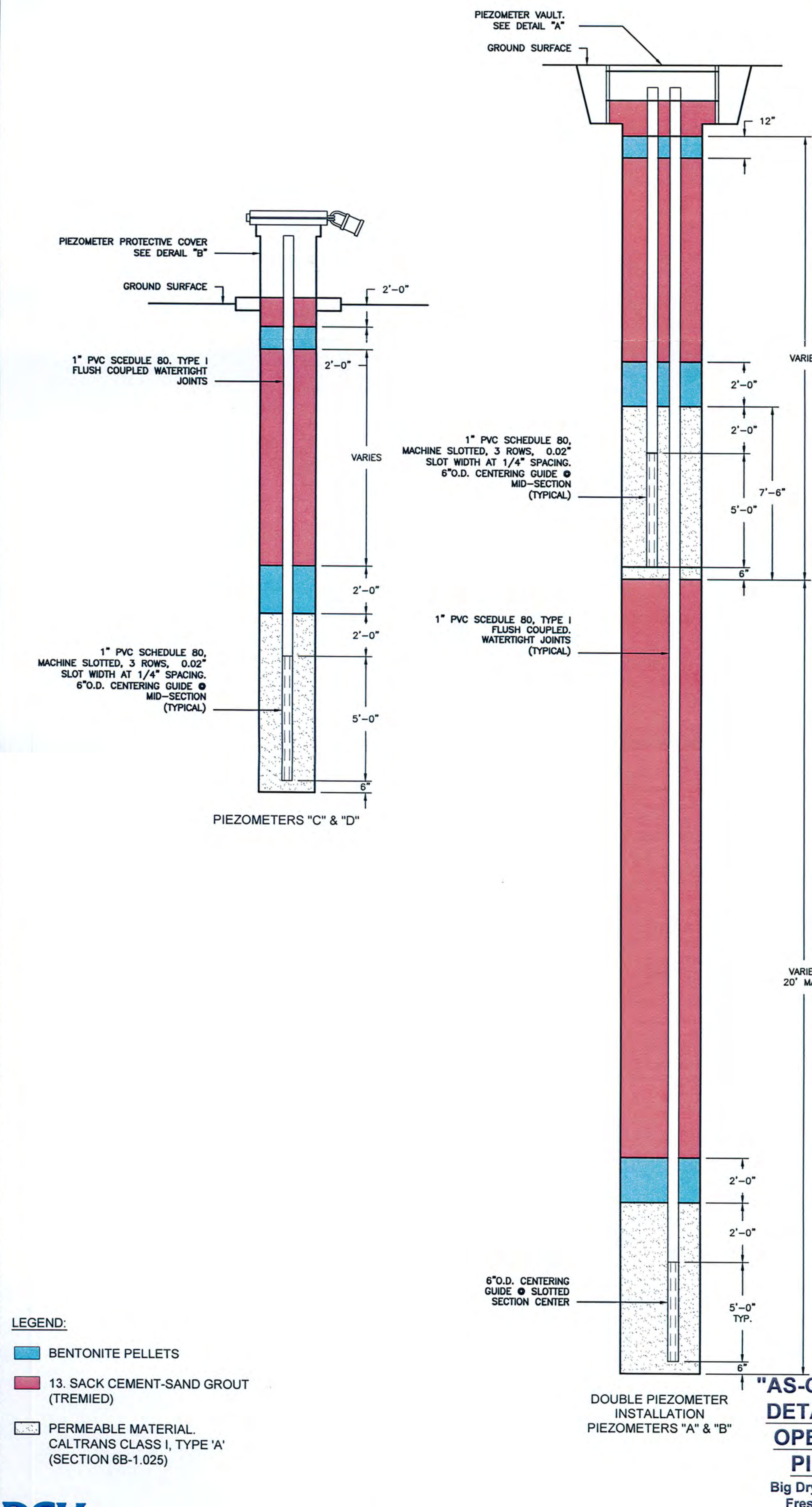
PIEZOMETER STATION	PIEZOMETER ELEVATIONS			
	Ⓐ	Ⓑ	Ⓒ	Ⓓ
P1	441.87	441.92	400.14	402.54
P2	442.18	442.00	399.97	401.01
P3	442.43	442.18	405.08	405.33
P4	442.54	442.56	405.45	405.63
P5	442.36	442.42	409.12	407.87
P6	442.72	442.87	410.86	414.27
P7	442.42	442.49	412.14	412.92

"AS-CONSTRUCTED" DETAIL DRAWINGS OPEN TUBE-TYPE PIEZOMETERS

Big Dry Creek Red Bank Dams
Fresno County, California

BSK

G08-119-11F
FEBRUARY 2009
FIGURE 4

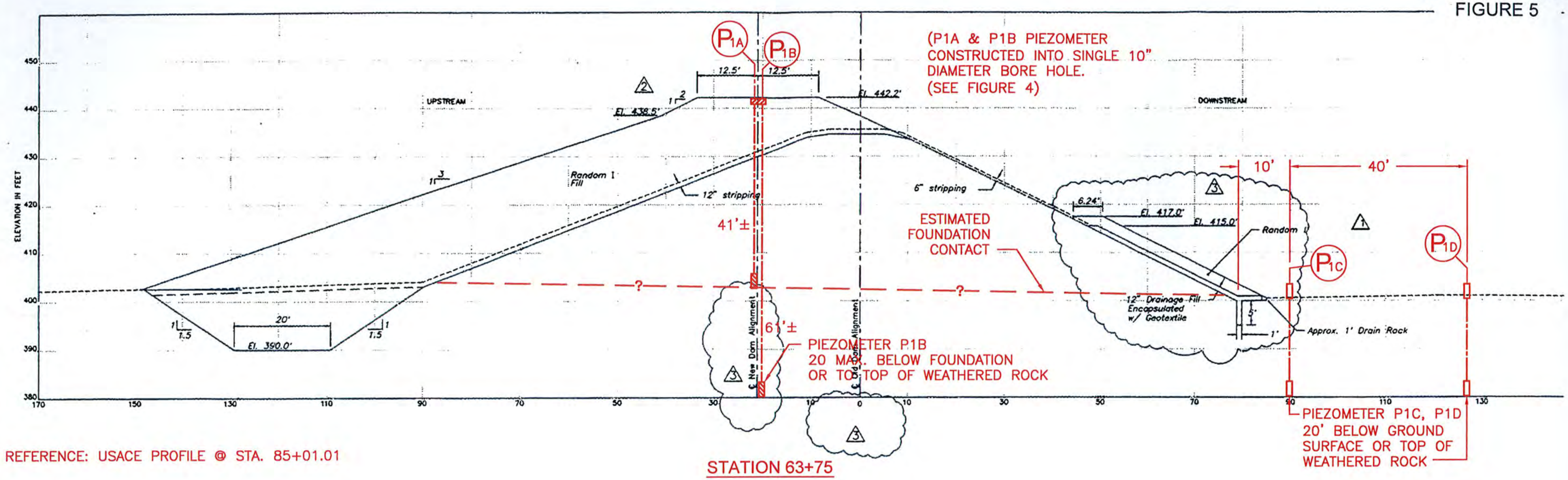


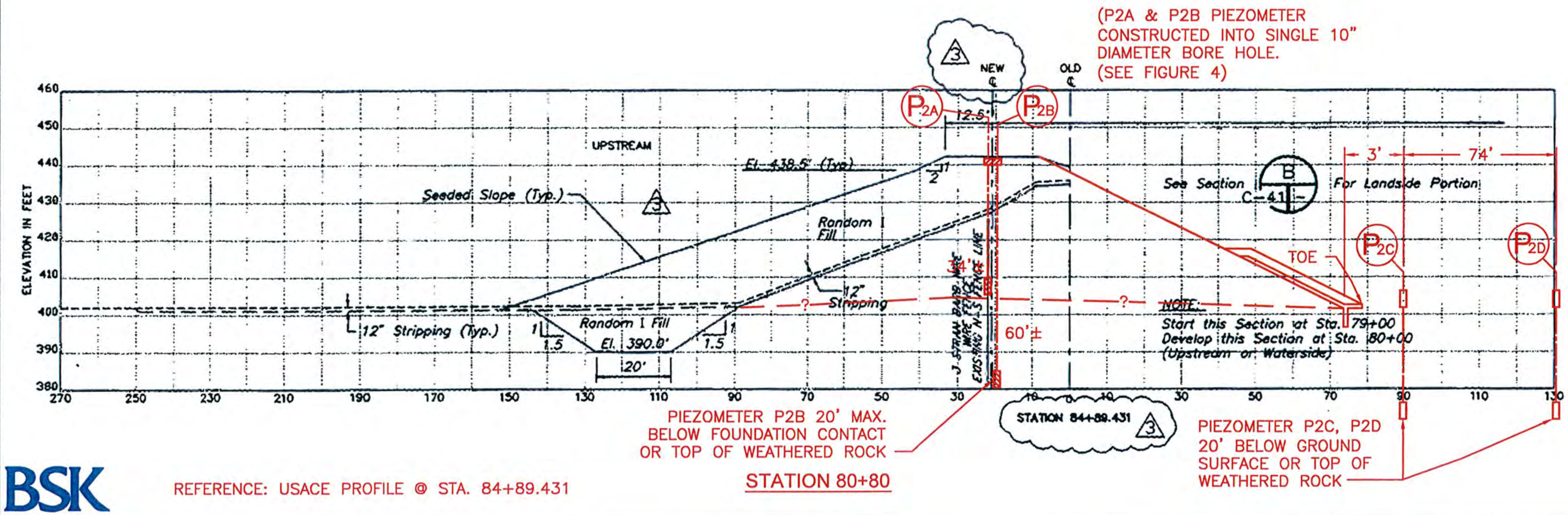
"AS-CONSTRUCTED" DETAIL DRAWINGS OPEN TUBE-TYPE PIEZOMETERS

Big Dry Creek Red Bank Dams
Fresno County, California

BSK

G08-119-11F
FEBRUARY 2009
FIGURE 5





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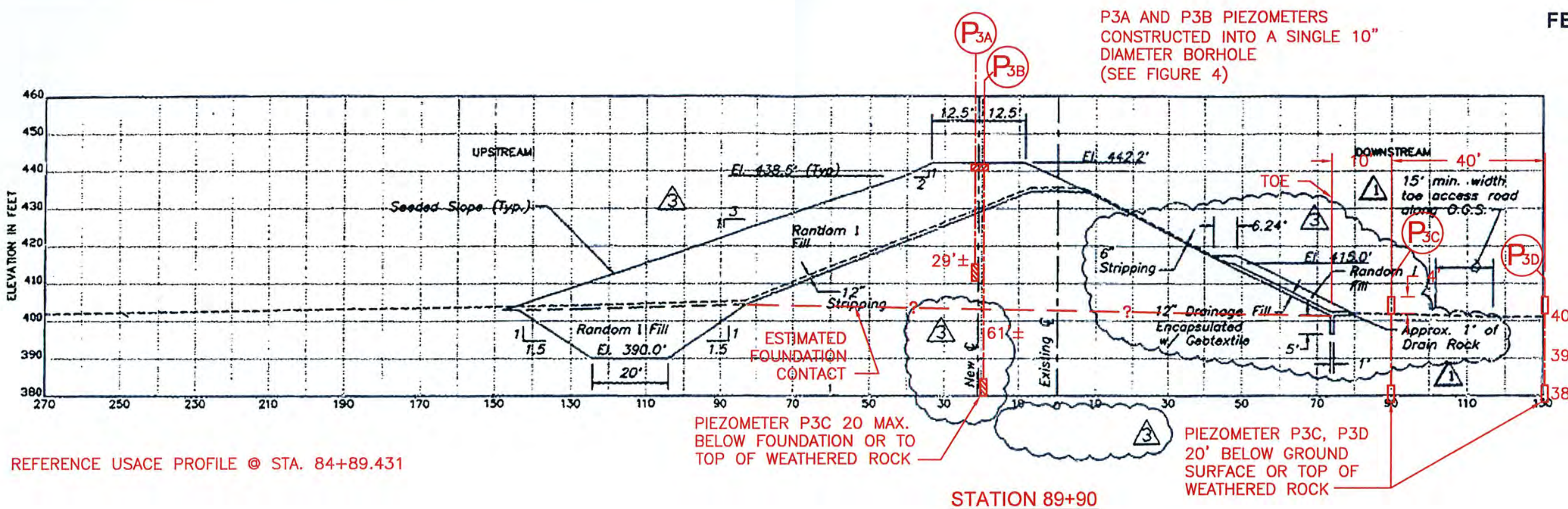
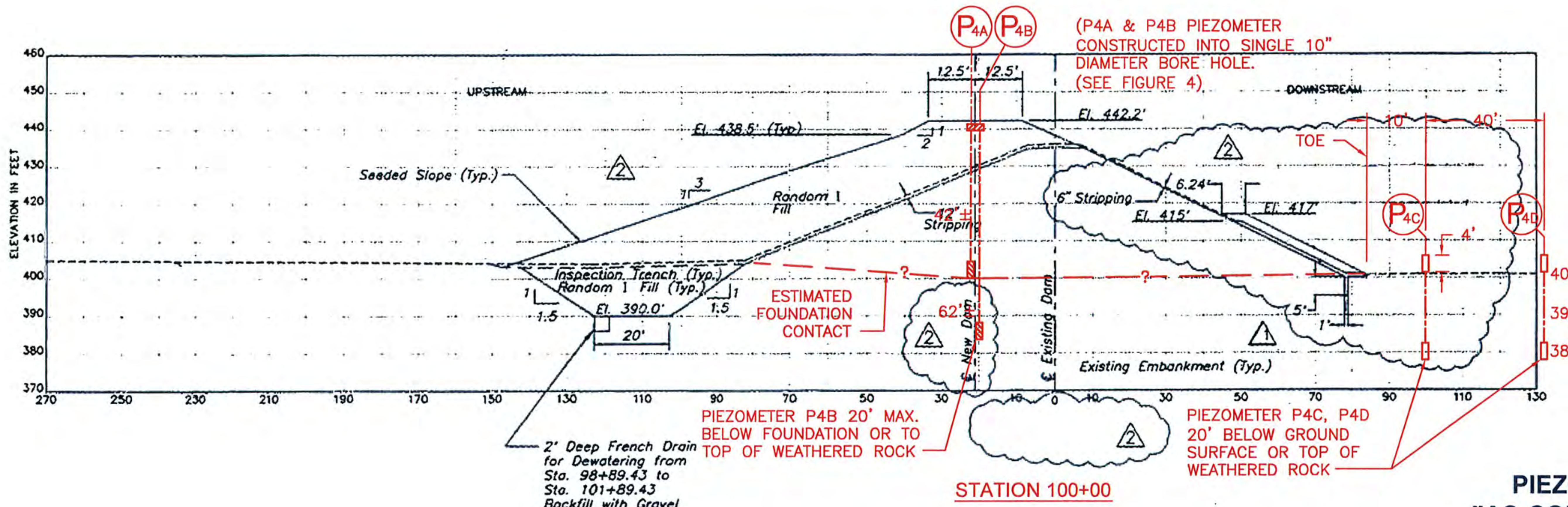
PIEZOMETERS "AS-CONSTRUCTED" CROSS SECTIONS

Big Dry Creek Red Bank Dams
Fresno County, California

G08-119-11F
FEBRUARY 2009
FIGURE 6





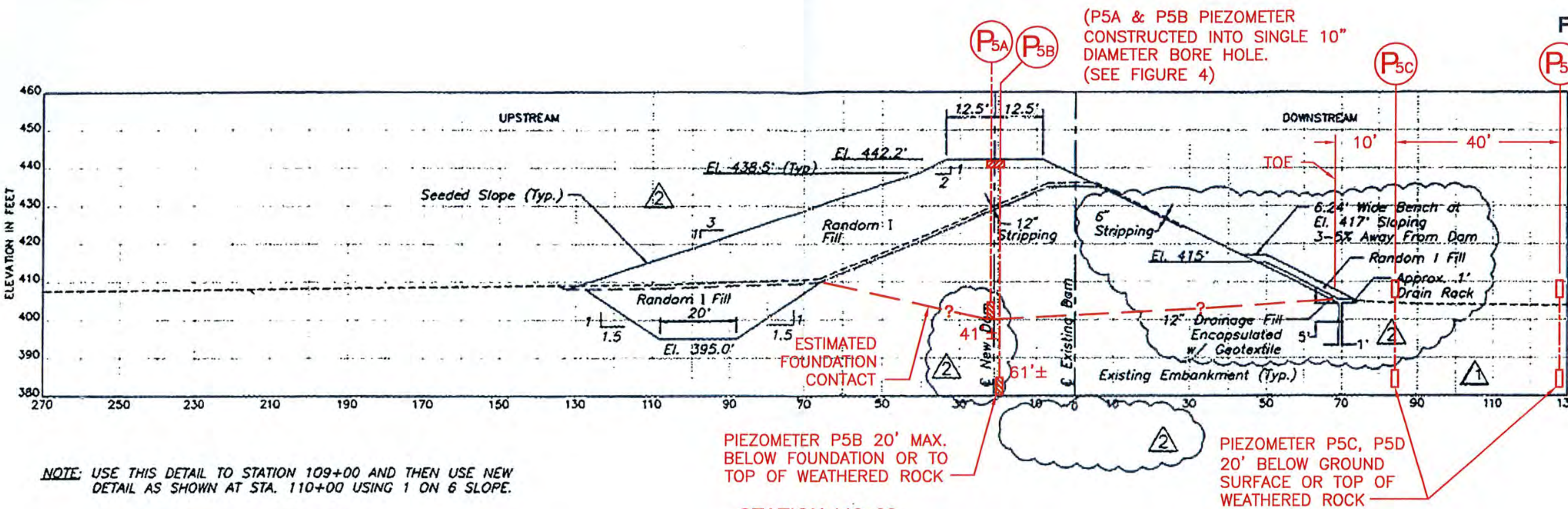
REFERENCE USACE PROFILE @ STA. 99+89.431

BSK

PIEZOMETERS "AS-CONSTRUCTED" CROSS SECTIONS

Big Dry Creek Red Bank Dams
Fresno County, California

G08-119-11F
FEBRUARY 2009
FIGURE 7

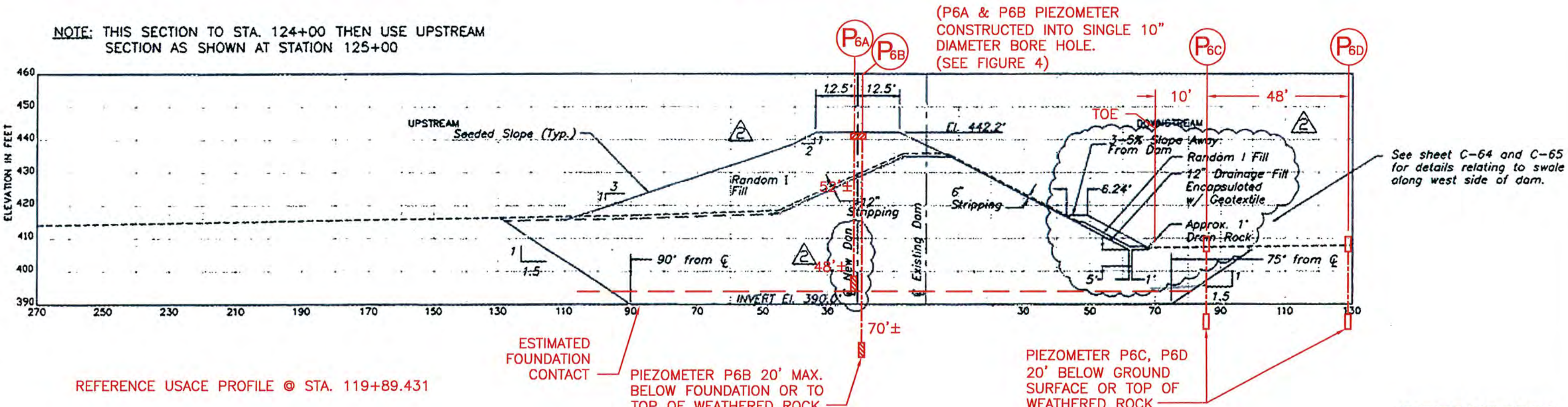


NOTE: USE THIS DETAIL TO STATION 109+00 AND THEN USE NEW DETAIL AS SHOWN AT STA. 110+00 USING 1 ON 6 SLOPE.

REFERENCE USACE PROFILE @ STA. 109+89.431

STATION 110+00

NOTE: THIS SECTION TO STA. 124+00 THEN USE UPSTREAM SECTION AS SHOWN AT STATION 125+00



REFERENCE USACE PROFILE @ STA. 119+89.431

STATION 121+50

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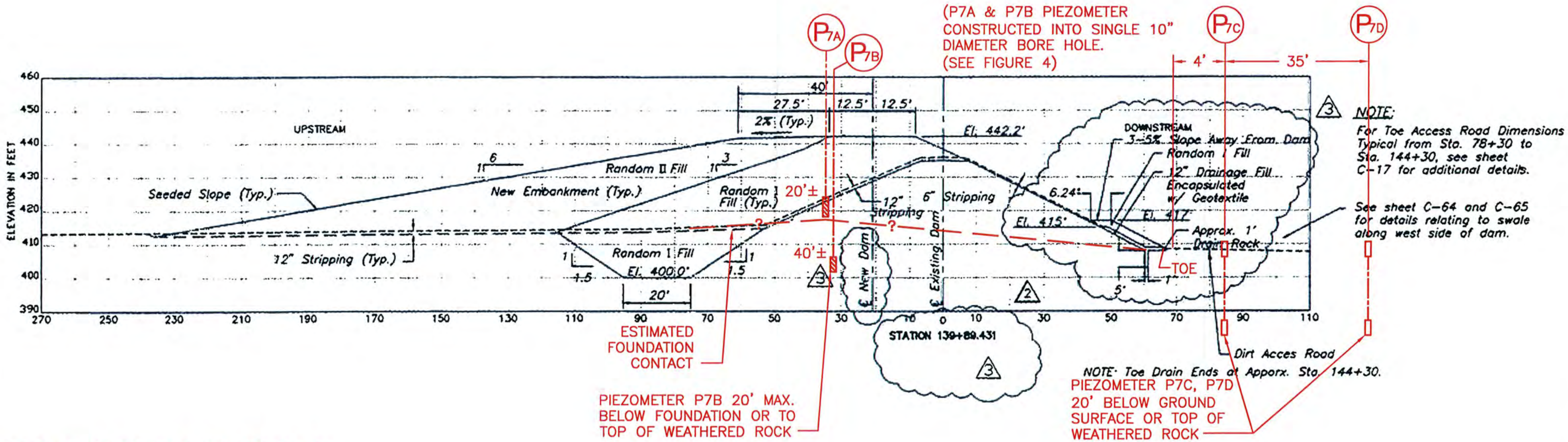
PIEZOMETERS "AS-CONSTRUCTED" CROSS SECTIONS

Big Dry Creek Red Bank Dams
Fresno County, California

G08-119-11F
FEBRUARY 2009
FIGURE 8



REFERENCE USACE PROFILE @ STA. 139+89.431

STATION 135+00

PIEZOMETERS "AS-CONSTRUCTED" CROSS SECTIONS

Big Dry Creek Red Bank Dams
Fresno County, California

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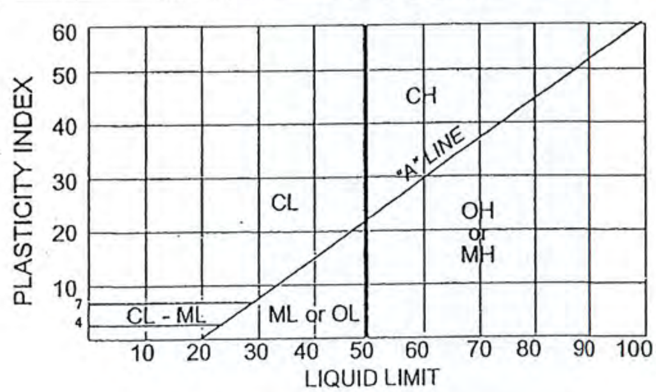
METHOD OF SOIL CLASSIFICATION
(Unified Soil Classification System)

MAJOR DIVISIONS		SYMBOLS		TYPICAL NAMES
COARSE GRAINED SOILS (More than ½ of soil >No. 200 sieve size)	**GRAVELS** (More than ½ of coarse fraction > No. 4 sieve size)	GW		Well graded gravels or gravel-sand mixtures, little or no fines
		GP		Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM		Silty gravels, gravel-sand mixtures, little or no fines
		GC		Clayey Gravels, gravel-sand-silt mixtures
	SANDS (More than ½ of coarse fraction < No. 4 sieve size)	SW		Well graded sands or gravelly sands, little or no fines
		SP		Poorly graded sands or gravelly sands, little or no fines
		SM		Silty sands, sand-silt mixtures
		SC		Clayey sands, sand-clay mixtures
FINE GRAINED SOILS (More than ½ of soil < No. 200 sieve size)	**SILTS & CLAYS** **LL < 50**	ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL		Organic silts and organic silty clays of low plasticity
	SILTS & CLAYS **LL > 50**	MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH		Inorganic clays of high plasticity, fat clays
		OH		Organic clays of medium to high plasticity, organic silty clays, organic silts



PLASTICITY CHART

3 1/4" O.D. California Modified Sampler

2.0" O.D. Standard Penetration Sampler

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Log of Well P-1 - A/B

Red Bank Dam
Figure 9

Job Number: G0811911F

Elevation: 442.77

Driller: BSK Associates	**Start Date:** February 24, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 24, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** 53'	**Reviewed By:** H. Kevorkian

Depth (feet)	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)
5	56	129	6.5
10	57	133	7.4
15	44	123	8.5
20	39	119	13.5
25	62	119	9.6
30	47	116	15.7

Depth (feet)	Materials Description	Remarks
0	Gravel road surface	10" Well Vault
0	**Silty SAND w/trace of Clay (SM)** Red brown, fine to medium grained, moist, dense (FILL)	
6	. . .increasing fines	
7	**Sandy SILT w/Clay (ML)** Brown with intermixed red brown, fine grained, moist, very stiff to hard (FILL)	Bag sample @ 7' - 10'
12		Bentonite Grout
14	. . .trace of medium rounded gravel	
16		1" Schedule 80 PVC
19	. . .yellow brown, less clay, stiff	
22		Bag sample @ 22' - 25'
24	. . .fractured aggregate	
29	. . .red brown w/intermixed dark gray sandy clay, fine, moist	
31	. . .decreased fines	Hydrated Bentonite Chips
32	**Silty SAND (SM)** Yellow brown with intermixed dark brown, fine to medium grained, moist, dense (FILL)	Bag sample @ 32' - 35'

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Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)
~35	Sample	46	119	10.5
~37	Sample	53	119	14.7
~39.5	Sample	79	128	9.0
~44.5	Sample	31	113	15.1
~49.5	Sample	16	--	--
~54.5	Sample	86	117	13.5
~60	Sample	50-3"	125	10.6

Depth scale (feet): 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66, 68

Materials Description
Silty SAND (SM) Yellow brown with intermixed dark brown, fine to medium grained, moist, dense (FILL)
. . .fine, trace of clay
Silty SAND (SM) Dark brown, fine grained, moist, dense, weakly cemented (NATIVE)
. . .orange brown, fine to medium grained with trace of coarse and trace of clay, medium dense, increased fines
. . .dark brown, medium dense, fine grained moist to wet
Clayey SAND (SC) Orange brown, fine grained, moist to wet, hard (NATIVE)
. . .trace of coarse sand and fine gravel
Boring terminated at 60.5 feet
Groundwater encountered at 53 feet

Elevation (feet) scale: -35, -36, -37, -38, -39, -40, -41, -42, -43, -44, -45, -46, -47, -48, -49, -50, -51, -52, -53, -54, -55, -56, -57, -58, -59, -60, -61, -62, -63, -64, -65, -66, -67, -68

Remarks
___Caltrans Concrete Sand
___0.02" Slotted Pipe Schedule 80,Geotextile Wrap
Bag sample @ 40' - 43'
___End Cap P1-A
___Bentonite Grout
___1" Schedule 80 PVC
Sample Disturbed
___Hydrated Bentonite Chips
53' ▼
___Caltrans Concrete Sand
___0.02" Slotted Pipe Schedule 80,Geotextile Wrap
___End Cap P1-B

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Log of Well P-1-C

Red Bank Dam
Figure 10

Sheet: 1 of 1	
Job Number: G0811911F	
Elevation: 397.29	
Driller: BSK Associates	**Start Date:** February 5, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 5, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** 8.5'	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						**Silty SAND w/trace of Clay (SM)** Dark brown, fine grained, moist, medium dense	0		___10" Schedule 80 PVC Standpipe
2							-2		
							-3		___Bentonite Grout
4		25					-4		___1" Schedule 80 PVC
6						**SAND w/trace Silt (SP/SM)** Red brown, fine to medium grained, moist to wet	-6		
8							-8		8.5' ▼
10		36	116			. . .medium dense	-10		
							-11		___Hydrated Bentonite Chips
12						. . .saturated cuttings	-12		
14							-14		___Caltrans Concrete Sand
16							-16		
18							-17		____0.02" Slotted Schedule 40 PVC Geotextile Wrap
20							-20		___End Cap
21						Boring terminated at 20.5 feet	-21		
22						Groundwater encountered at 8.5 feet	-22		
24							-24		
26							-26		
28							-28		
30							-30		
32							-32		
34							-34		
							-35		

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Log of Well P-1-D

Red Bank Dam
Figure 11

Job Number: G0811911F
Elevation: 39.71 (Pad)

Driller: BSK Associates	**Start Date:** February 9, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 9, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** 9.2'	**Reviewed By:** H. Kevorkian

Depth (feet)	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Materials Description	Elevation (feet)	Remarks
0				**Silty SAND w/trace Clay (SM)** Dark brown, fine to coarse grained, weak scattered cementation	0	10" Schedule 80 PVC Standpipe
2					-2	___Bentonite Grout
4–5	38			. . .red brown, fine grained, medium dense	-4	___1" Schedule 80 PVC
6				**SAND w/trace of Silt (SP)** Red brown, fine to medium grained, moist, medium dense	-6	
9–10	29	113	18.3	. . .wet at 9 feet	-9	9.2' ▼
10				**Sandy SILT w/trace Clay (ML)** Red brown, fine grained, stiff	-10	
12					-12	___Hydrated Bentonite Chips
13					-13	___Caltrans Concrete Sand
14–15	90				-15	No Sample Retrieval
17					-17	___0.02" Slotted Schedule 80 PVC Geotextile Wrap
18				**Sandy CLAY (CL)** Olive yellow brown, fine to coarse grained, hard	-18	
19–20	32				-20	___End Cap
20.5				Boring terminated at 20.5 feet Groundwater encountered at 9.2 feet		

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Log of Well P-2 - A/B

Red Bank Dam
Figure 12

Sheet: 1 of 2
Job Number: G0811911F
Elevation: 443.26

Driller: BSK Associates	**Start Date:** February 23, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 23, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** Not encountered	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
						Gravel road surface	0		
0						**Sandy SILT w/Clay (ML)** Red brown, fine to medium grain (FILL)			___10" Well Vault; ___Ready Mix Cement
2						. . .olive brown increasing fines and clay content	-2, -3		Bag sample at 2' - 5'
4		55	125	9.5		. . .blue gray, less clay, fine, dense, moist	-4, -5		
6							-6, -7		Bag sample at 6' - 9'
8						**Clayey SAND w/ Silt (SC)** Red brown, fine to coarse, moist, medium dense (FILL)	-8, -9		
10		30	125	9.9			-10, -11		___Bentonite Grout
12						. . .blue gray brown, fine to medium grained	-12, -13		___1" Schedule 80 PVC
14		44	123	10.8		**Sandy SILT w/Clay (ML)** Red brown, fine to medium grained, moist, medium stiff to medium dense (FILL)	-14, -15		
16							-16, -17		Bag sample at 17' - 20
18						**Silty SAND w/trace of Clay (SM)** Light red brown, fine to medium grained with trace of coarse, moist, dense (FILL)	-18, -19		
20		46	126	9.6			-20, -21		
22							-22, -23		Bag sample at 22' - 25
24		38	118	7.0		. . .red brown, increased medium and coarse sand fraction, less fines	-24, -25		___Hydrated Bentonite Chips
26							-26, -27		___Caltrans Concrete Sand
28							-28, -29		___0.02" Slotted Schedule 80 PVC Geotextile Wrap
30		27	123	7.0		. . .color change to dark brown, fine grained, moist, medium dense	-30, -31		

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Log of Well P-2 - A/B

Red Bank Dam
Figure 12

Job Number: G0811911F

Elevation 443.26

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
33						**Silty SAND w/trace Clay (SM)** Red brown, fine to medium grained, dry, weak to moderate cementation, dense, pinhole voids (NATIVE)	-32, -33, -34		___End Cap P2-A
35		51	121	9.4			-35, -36, -37, -38		
39		61	124	8.7		. . .brown, moist, very dense	-39, -40		
41							-41, -42		Bag sample at 41' - 45
43							-43		___1" Schedule 80 PVC
45		40	127	10.2		. . .fine to coarse, dense	-44, -45, -46		
47						**Sandy SILT w/trace Clay (ML)** Red yellow brown, moist, stiff (NATIVE)	-47, -48, -49		
49		84-11"	114	16.6		. . .cemented at 50 feet	-50, -51, -52		___Hydrated Bentonite Chips
53							-53		___Caltrans Concrete Sand
55		84-11"	121	11.5		. . .fine to coarse grained, increased clay, micaceous	-54, -55, -56, -57, -58		___0.02" Slotted Schedule 80 PVC Geotextile Wrap
59		50-6"	109	19.2		. . .red brown, moist	-59, -60		___End Cap P2-B
61						Boring terminated at 60.5 feet	-61, -62		

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Log of Well P-2-C

Red Bank Dam
Figure 13

Sheet: 1 of 1	**Job Number:** G0811911F
Elevation: 396.94 (Pad)	
Driller: BSK Associates	**Start Date:** February 5, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 5, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** 19.8'	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						**Silty SAND w/some Clay (SM)** Brown, fine to medium grained with fine to medium gravel, moist	0		___10" Schedule 80 Standpipe
2							-2		Bag smple at 0' - 3'
4		15				**Sandy CLAY (CL)** Blue gray, fine grained with trace gravel, moist, stiff	-4		___Bentonite Grout
7							-7		Bag sample at 7' - 10'
8						. . .yellow olive brown, fine to coarse, increasing sand content, micaceous, hard	-8		
9		38					-9		___1" Schedule 80 PVC
11							-11		___Hydrated Bentonite Chips
13						. . .decreasing clay	-13		___Caltrans Concrete Sand
14		55				**Sandy SILT w/Clay (ML)** Yellow brown with red brown and blue gray, fine grained, moist, very stiff to hard, micaceous	-14		____0.02" Slotted Schedule 80 PVC Geotextile Wrap
18.5		50-5"				**WEATHERED SCHIST** Excavates as SAND, blue gray with red black streaks, fine to medium grained, high mica content	-19		19.8' ▼
20							-20		___End Cap
22						Boring terminated at 20 feet			
						Groundwater not encountered			

Depth scale: 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34
Elevation scale: 0, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23, -24, -25, -26, -27, -28, -29, -30, -31, -32, -33, -34, -35

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		Job Number: G0811911F
		Elevation: 397.86 (Pad)

Driller: BSK Associates		**Start Date:** February 9, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger		**Finish Date:** February 9, 2009
Sample Method: 2.4" I.D. California Sampler		**Logged By:** N. Shwiyhat
Borehole Diameter: 8"	**Water Level:** Not encountered	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						**Silty SAND w/trace Clay (SM)** Brown, fine to medium, trace of fine to coarse gravel, sporatic cobble	0		10" Schedule 80 Standpipe
4		15				**Sandy SILT w/Clay (ML)** Gray brown, fine to medium grained, moist, medium stiff	-4		Bentonite Grout
7							-7		1" Schedule 80 PVC
10		33				. . .yellow gray, some clay, fine, stiff to hard	-10		
11							-11		Hydrated Bentonite Chips
13						. . .silty sand layers	-13		Caltrans Concrete Sand
15		57				. . .red gray brown, fine, trace of clay, hard	-15		0.02" Slotted Schedule 80 PVC Geotextile Wrap
18.5		50-6"				**WEATHERED SCHIST** Excavates as fine silty sand, gray, high mica content	-19		End Cap
22						Boring terminated at 19 feet Groundwater not encountered	-22		

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Log of Well P-3 A/B

Red Bank Dam
Figure 15

Job Number: G0811911F	**Elevation:** 442.90
Driller: BSK Associates	**Start Date:** February 19, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 19, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** 57'	**Reviewed By:** H. Kevorkian

Depth (feet)	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Materials Description	Remarks
0				Gravel Road Surface	___10" Well Vault ___Ready Mix Cement
0				**Silty SAND w/Clay (SM)** Red brown, fine to medium, moist (FILL)	
3				. . .dark brown, fine to coarse, moist, medium dense, less clay	
4-5	36	126	9.4		Bag sample at 4' - 8'
7					___Bentonite Grout
9-10	45	124	9.9	. . .yellow brown w/intermixed olive brown, fine to medium with trace of coarse, dense	
12					Bag sample at 12' - 15
14-15	38	120	10.0	. . .scattered cemented pieces, medium dense	___1" Schedule 80 PVC
19-20	53	125	10.7	. . .brown, fine to medium, moist, dense, trace of clay	
21-22					___Hydrated Bentonite Chips
23					___Caltrans Concrete Sand
24-25	28	129	7.3	. . .medium dense	___0.02" Slotted Schedule 80 PVC Geotextile Wrap
29					___End Cap P3-A
29-30	33	121	7.8		
32				**Silty SAND (SM)** Yellow brown, damp to moist, dense, scattered cementation (FILL)	
34-35	43	123	9.1		

Elevation (feet): 0, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23, -24, -25, -26, -27, -28, -29, -30, -31, -32, -33, -34, -35

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Log of Well P-3 A/B

Red bank Dam
Figure 15

Job Number: G0811911F

Elevation 442.90

Depth (feet)	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Materials Description	Elevation (feet)	Remarks
	43	123	9.1	**Silty SAND (SM)** Yellow brown, damp to moist, dense, scattered cementation (FILL)	-36	
37	44	120	14.3	. . .trace of clay, trace of mica	-37, -38	
39	70	131	7.6	**Silty SAND (SM)** Dark brown, fine, moist, weakly cemented, very dense (NATIVE)	-39, -40	___Bentonite Grout
41					-41, -42	
43	50-6"	115	7.1	. . .trace of clay, moderate cementation	-43, -44	
45					-45, -46	
47					-47, -48	
49	25	109	18.8	**Sandy SILT (ML)** Yellow brown, fine grained, moist, medium stiff, very micaceous (NATIVE)	-49, -50	
51					-51, -52	___Hydrated Bentonite Chips
53				. . .yellow dark brown, trace clay, moist to wet	-53, -54	
55	27	102	21.2		-55, -56	___0.02" Slotted Schedule 80 PVC Geotextile Wrap
57					-57, -58	57' ▼
59	94	120	12.3	. . .increased clay content, very stiff	-59, -60	___Caltrans Concrete Sand ___End Cap P3-B
61				Boring terminated at 61.5 feet Groundwater encountered at 57 feet	-61, -62	
63					-63, -64	
65					-65, -66	
67					-67, -68	
69					-69, -70	

BSK 567 W. Shaw Ave. Fresno, CA 93704 (559) 497-2880 (559) 497-2886 FAX	***Log of Well P-3-C*** Red Bank Dam Figure 16	**Sheet:** 1 of 1
		Job Number: G0811911F
		Elevation: 401.36 (Pad)

Driller: BSK Associates	**Start Date:** February 4, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 4, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** 19.5'	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						**Silty SAND w/Clay (SM)** Orange brown, fine to medium grained	0		___10" Schedule 80 PVC Standpipe
4		85-9"				. . .very dense, some cementation, moist	-4 to -5		___Bentonite Grout
7							-7		___1" Schedule 80 PVC
9–10		37				. . .increased moisture content, medium dense at 9 feet	-9 to -10		
10.2						**Sandy SILT w/Clay (ML)** Red brown, fine with trace medium, moist, stiff	-11		
12.6						**Silty SAND/Sandy SILT w/Clay (SM/ML)** Light orange brown, fine to coarse, micaceous, stiff to very stiff	-12 to -13		___Hydrated Bentonite Chips
14–15		44					-14 to -15		___Caltrans Concrete Sand
15–18						. . .decreasing fines	-15 to -18		___0.02" Slotted Schedule 80 PVC Geotextile Wrap
19.5							-19.5		19.5' ▼
19.5–20.5		58				**Silty SAND w/trace Clay (SM)** Brown, fine to medium, moist to wet, micaceous, dense	-20		___End Cap

Boring terminated at 20.5 feet

Groundwater encountered at 19.5 feet

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		Job Number: G0811911F
		Elevation: 401.20 (Pad)

Driller: BSK Associates	**Start Date:** February 10, 2009
Drill Method: B-61 Mobile Drill	**Finish Date:** February 10, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** 19.4'	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						**Silty SAND w/trace Clay (SM)** Red brown, fine to medium, moist	0		___10: Schedule 80 PVC Standpipe
2							-2		
							-3		Bag sample at 3' - 5'
4						. . .drills firm	-4		
							-5		___Bentonite Grout
6						. . .increasing clay content	-6		
						Sandy SILT/Sandy Clay (ML/CL) Red brown, fine to medium grained, moist	-7		Bag sample at 7' - 10'
8							-8		
							-9		___1" Schedule 80 PVC
10							-10		
							-11		___Hydrated Bentonite Chips
12							-12		
							-13		___Caltrans Concrete Sand
14						. . .yellow olive brown, fine, moist	-14		
							-15		Bag sample at 12'-15'
16							-16		____0.02" Slotted Schedule 80 PVC
							-17		Geotextile Wrap
18							-18		19.4'
							-19		▼
20							-20		___End Cap
							-21		
22						Boring terminated at 21 feet	-22		
						Groundwater encountered at 19.4 feet	-23		
24							-24		
							-25		
26							-26		
							-27		
28							-28		
							-29		
30							-30		
							-31		
32							-32		
							-33		
34							-34		
							-35		

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Log of Well P-4 A/B

Red Bank Dam
Figure 18

Job Number: G0811911F

Elevation: 442.99

Driller: BSK Associates	**Start Date:** February 18, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 18, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** 59.5'	**Reviewed By:** H. Kevorkian

Depth (feet)	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Materials Description	Remarks
0				Gravel road surface	___10" Well Vault
0				**Silty SAND w/Clay (SM)** Red brown, fine to medium grained, moist, dense to very dense (FILL)	___Ready Mix Concrete
4–5	59	122	10.0		___Bentonite Grout
9–10	47	123	10.9	. . .brown, dense	
12					Bag sample at 12' - 15
14–15	33	116	11.0	. . .yellow red brown, trace fine gravel, moist, more clay, medium dense	
16					___1" Schedule 80 PVC
17				**Sandy SILT w/Clay (ML)** Yellow olive brown, fine grained, moist, very stiff (FILL)	
19–20	50	121	11.5		
24–25	41	121	12.5		Bag sample at 25' - 30
29–30	51	127	8.9	. . .increased sand content	
32				**Silty SAND w/trace Clay (SM)** Dark brown, fine grained, moist, dense (FILL)	___Hydrated Bentonite Chips
34–35	48	125	11.2		___Caltrans Concrete Sand

Elevation (feet): 0 to -36

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		Job Number: G0811911F
		Elevation 442.99

Depth (feet)	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Materials Description
37				**Silty SAND w/trace Clay (SM)** Dark brown, fine grained, moist, dense (FILL)
	52	122	12.8	. . .yellow brown, fine to medium grained
39				
	64	126	9.1	. . .intermixed cemented pieces, very dense
41				**Silty Clay w/fine Sand (CL)** Dark brown, moist, stiff (NATIVE)
43	27	121	13.5	
45	71-9"	109	12.2	**Silty SAND w/trace Clay (SM)** Light red brown, fine to medium grained, dry to moist, very dense, strongly cemented hardpan (NATIVE)
47				
49				
	38	118	10.1	. . .red brown, dense, no cementation
51				
53				**Sandy SILT w/trace of Clay (ML)** Yellow brown, fine grained, moist, very stiff, micaceous (NATIVE)
55	68	112	20.3	
57				
59				
	82-9"	113	12.0	. . .increased clay and silt content, hard, moist to wet
61				
63				Boring terminated at 62.5 feet Groundwater encountered at 59.5 feet
65				
67				
69				
71				

Elevation (feet): -37, -38, -39, -40, -41, -42, -43, -44, -45, -46, -47, -48, -49, -50, -51, -52, -53, -54, -55, -56, -57, -58, -59, -60, -61, -62, -63, -64, -65, -66, -67, -68, -69, -70, -71, -72

Remarks

- Bag sample at 35' - 38
- ___0.02" Slotted Schedule 80 PVC Geotextile Wrap
- ___End Cap P4-A
- ___Bentonite Grout
- Bag sample at 47' - 50
- ___1" Schedule 80 PVC
- ___Hydrated Bentonite Chips
- ___Caltrans Concrete Sand
- 59.5' ▼
- ___0.02" Slotted Schedule 80 PVC Geotextile Wrap
- ___End Cap P4-B

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Log of Well P-4-C

Red Bank Dam
Figure 19

Job Number: G0811911F	**Elevation:** 402.28 (Pad)
Driller: BSK Associates	**Start Date:** February 4, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 4, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" — **Water Level:** 18.8'	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)
4–5	■	12		
9–10	■	61		
14–15	■	44		
19–20	■	44		

Materials Description

Depth (feet)	Description
0–3	**Silty SAND w/trace Clay (SM)** Orange brown, trace of coarse, moist
3–8	**Sandy SILT w/Clay (ML)** Olive brown, fine grained, moist, medium stiff . . .increasing sand
8–17	**Silty SAND w/trace Clay (SM)** Orange brown, dense to very dense . . .brown, fine to medium, micaceous, medium dense to dense
17–20.5	**Sandy SILT w/Clay (ML)** Olive gray, fine grained, moist to wet . . .orange brown, increased sand content fine to medium grained
20.5	Boring terminated at 20.5 feet Groundwater encountered at 18.8 feet

Depth scale: 0 to 34 feet. Elevation (feet) scale: 0 to -35.

Remarks

- ___10" Schedule 80 PVC Standpipe
- Bag sample at 0' - 2'
- Bag sample at 3' - 5'
- ___Bentonite Grout
- ___1" Schedule 80 PVC
- ___Hydrated Bentonite Chips
- ___Caltrans Concrete Sand
- ___0.02" Slotted Schedule 80 PVC Geotextile Wrap
- 18.8' ▼
- ___End Cap

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Log of Well P-4-D

Red Bank Dam
Figure 20

Sheet: 1 of 1
Job Number: G0811911F
Elevation: 402.67 (Pad)

Driller: BSK Associates
Start Date: February 10, 2009
Drill Method: B-61 Mobile Drill
Finish Date: February 10, 2009
Sample Method: 2.4" I.D. California Sampler
Logged By: N. Shwiyhat
Borehole Diameter: 8"
Water Level: 20.0'
Reviewed By: H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						**Silty SAND w/Clay (SM)** Brown, fine to medium grained, moist	0		___10" Schedule 80 PVC Standpipe
2						**Sandy SILT w/Clay (ML)** Dark olive brown, fine grained, moist	-2		Bag sample at 2' - 4'
4							-4, -5		___Bentonite Grout
6							-6, -7		___1" Schedule 80 PVC
8						. . .brown, increased clay, moist	-8, -9		
10							-10, -11		Bag sample at 10' - 12'
12							-12, -13		___Hydrated Bentonite Chips
14							-14, -15		___Caltrans Concrete Sand
16						. . .increased clay, moist to wet cuttings	-16, -17		___0.02" Slotted Schedule 80 PVC Geotextile Wrap
18							-18, -19		20.0' ▼
20							-20, -21		___End Cap
22						Boring terminated at 21 feet Groundwater encountered at 20.0 feet	-22, -23		
24							-24, -25		
26							-26, -27		
28							-28, -29		
30							-30, -31		
32							-32, -33		
34							-34, -35		

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Log of Well P-5 - A/B

Red Bank Dam
Figure 21

Sheet: 1 of 2
Job Number: G0811911F
Elevation: 442.97

Driller: BSK Associates	Start Date: February 17, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	Finish Date: February 17, 2009
Sample Method: 2.4" I.D. California Sampler	Logged By: N. Shwiyhat
Borehole Diameter: 8" / Water Level: Not encountered	Reviewed By: H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						Gravel road surface	0		___10" Well Vault
						Silty SAND w/Clay (SM) Brown, fine to medium grained, moist (FILL)			___Ready Mix Concrete
2						**Sandy CLAY (CL)** Red orange brown, fine to medium grained with trace of coarse, moist, very dense, hard (FILL)	-2, -3, -4		
4		74	123	12.6			-5, -6, -7		
8						. . .more clay, very stiff	-8, -9		___1"Schedule 80 PVC
10		44	123	11.7			-10, -11		
12						**Sandy SILT w/Clay (ML)** Brown, fine to medium grained, moist, hard	-12, -13, -14		
14		53	126	11.7			-15, -16		Bag sample at 15' - 20
16							-17, -18, -19		___Bentonite Grout
20		47	122	13.4		. . .yellow brown	-20, -21, -22, -23		
24						. . .intermixed red and dark brown	-24		
24		52	122	12.8			-25, -26		Bag sample at 25' - 30
26						. . .decreasing fines	-27		
28						**Silty SAND w/trace Clay (SM)** Brown, fine to medium grained with trace of coarse, dense (FILL)	-28, -29		
30		55	121	10.4			-30, -31, -32, -33		___Hydrated Bentonite Chips
34		45	128	10.8		. . .olive brown, fine to coarse, moist	-34, -35		___Caltrans Concrete Sand

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Log of Well P-5 - A/B

Red Bank Dam
Figure 21

Job Number: G0811911F

Elevation 442.97

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description
35–36		45	128	10.8		
38–60.5						**Sandy CLAY w/Silt (CL)** Olive brown, fine grained, moist, very stiff (NATIVE)
39–40.5		49	127	13.7		
41.5–43		83-11"	126	12.4		. . .fine to medium w/trace coarse, hard
44–45.5		58	128	10.9		
49–50.5		56	119	14.9		. . .red brown, moist, increased sand content, dense
53						**Clayey SILT w/fine Sand (ML)** Yellow brown, medium stiff, moist to wet (NATIVE)
54–55.5		17	101	27.5		
59–60.5		72	118	16.4		. . .sandy silt, yellow brown, fine to medium, moist, micaceous
60.5						Boring terminated at 60.5 feet Groundwater not encountered

Depth scale: 37, 39, 41, 43, 45, 47, 49, 51, 53, 55, 57, 59, 61, 63, 65, 67, 69

Elevation (feet) scale: -36, -37, -38, -39, -40, -41, -42, -43, -44, -45, -46, -47, -48, -49, -50, -51, -52, -53, -54, -55, -56, -57, -58, -59, -60, -61, -62, -63, -64, -65, -66, -67, -68, -69, -70

Well Completion — Remarks

- ___0.02" Slotted Schedule 80 PVC Geotextile Wrap
- ___End Cap P5-A
- ___Bentonite Grout
- ___1" Schedule 80 PVC
- ___Hydrated Bentonite Chips
- ___Caltrans Concrete Sand
- ___0.02" Slotted Schedule 80 PVC Geotextile Wrap
- ___End Cap P5-B

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Log of Well P-5-C

Red Bank Dam
Figure 22

Job Number: G0811911F	**Elevation:** 406.00 (Pad)
Driller: BSK Associates	**Start Date:** February 4, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 4, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** Not encountered	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0							0		___10" Schedule 80 PVC Standpipe
						Silty SAND w/Clay (SM) Brown to dark olive brown, fine to medium grained, moist			
2							-2		Bag sample at 1' - 4'
							-3		
4						. . .medium dense	-4		
	■	13					-5		___Bentonite Grout
6							-6		
							-7		___1" Schedule 80 PVC
8							-8		
						. . .red brown, trace of coarse, dense, less silt	-9		
10	■	52					-10		
							-11		___Hydrated Bentonite Chips
12							-12		
							-13		___Caltrans Concrete Sand
14	■	85-11"				. . .fine to medium, some cementation, very dense	-14		
							-15		Bag sample at 12' - 15
16							-16		
							-17		___0.02" Slotted Schedule 80 PVC Geotextile Wrap
18						**Sandy SILT w/Clay (ML)** Red brown, fine grained, moist, stiff	-18		
							-19		
20	■	30					-20		___End Cap
						Boring terminated at 20.5 feet	-21		
22						Groundwater not encountered	-22		
							-23		
24							-24		
							-25		
26							-26		
							-27		
28							-28		
							-29		
30							-30		
							-31		
32							-32		
							-33		
34							-34		
							-35		

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		Job Number: G0811911F
		Elevation: 405.49 (Pad)

Driller: BSK Associates	**Start Date:** February 11, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 11, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** Not encountered	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						**Silty SAND w/trace of Clay (SM)** Brown, fine to medium grained with trace of cobble up to 6 inches, moist	0		___10" Schedule 80 PVC Standpipe
2							-2		Bag sample at 1 ft.-3 ft.
4							-4		___Bentonite Grout
6						. . .dark brown, fine to medium grained with trace of coarse, less fines	-6		Bag sample at 6 ft.-8 ft.
8							-8		___1" Schedule 80 PVC
10						**Sandy SILT w/Clay (ML)** Red brown, moist, drills firm	-10		
12							-12		___Hydrated Bentonite Chips
14							-14		___Caltrans Concrete Sand
16							-16		___0.02" Slotted Schedule 80 PVC Geotextile Wrap
18						. . .more clay, increased moisture content	-18		Bag sample at 17 ft.-19 ft.
20							-20		___End Cap
22						Boring terminated at 21 feet Groundwater not encountered	-22		
24							-24		
26							-26		
28							-28		
30							-30		
32							-32		
34							-34		

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Log of Well P-6 - A/B

Red Bank Dam
Figure 24

Job Number: G0811911F
Elevation: 443.08

Driller: BSK Associates
Start Date: February 11, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger
Finish Date: February 11, 2009
Sample Method: 2.4" I.D. California Sampler
Logged By: N. Shwiyhat
Borehole Diameter: 8"
Water Level: 61'
Reviewed By: H. Kevorkian

Depth (feet)	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Materials Description	Elevation (feet)	Remarks
0				Gravel road surface	0	10" Well Vault
0				**Sandy Silt w/Clay (ML)** Red brown, fine to medium grained, dry to moist, dense (FILL)		Ready Mix Concrete
2					-2	Bag sample at 2' - 5'
4	39	125	11.5		-5	
7				. . .drills hard	-7	
9				. . .yellow brown dry to moist	-9	
10	37	121	10.6		-10	
13					-13	Bentonite Grout
14	59	130	9.6	. . .brown, moist, very dense, less fines	-14	
18				**Sandy CLAY (CL)** Dark olive gray, fine to medium grained with trace coarse, hard, intermixed silty sand (FILL)	-18	Bag sample at 18' - 22
20	49				-20	
22					-22	1" Schedule 80 PVC
25	59	130	8.0		-25	
28				**Sandy SILT w/Clay (ML)** Red brown with yellow brown and gray, fine to coarse, very dense (FILL)	-28	
30	68	130	9.8		-30	Bag sample at 30' - 35
32				. . .intermixed silty sand	-32	
34				. . .intermixed silty sand and sandy silt, fine to medium, dense, hard, moist	-34	
35	75	129	9.7		-35	
38					-38	

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Depth (feet)	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Materials Description
-40	52	135	6.7	. . .more sand, fine to coarse
-42	49	123	11.5	. . .grades to silty sand
-44	46	120	5.7	**Silty SAND w/trace Clay (SM)** Red brown, fine to coarse, trace of fine gravel, dense (FILL)
-47	47	122	11.4	. . .more clay, fine to medium, moist
-49	49	123	8.1	**Silty SAND w/trace Clay (SM)** Red brown, fine to coarse, moist, dense (NATIVE)
-54	73-11"	116	6.9	. . .trace of gravel, fine to coarse
-57				. . .sandy silt layer
-59	86-10"	117	17.0	. . .yellow brown, fine, micaceous
-62				. . .decreasing fines
-64				. . .red brown, fine to coarse, wet, very dense
-65	73	123	12.8	
-69	30	107	19.9	**Silty CLAY w/trace of fine sand (CL)** Light red brown with black speckles, moist to wet, stiff
-71				Boring terminated at 70.5 feet Groundwater encountered at 61 feet

Elevation (feet): -39 to -76

Remarks

- ___Hydrated Bentonite Chips
- ___Caltrans Concrete Sand
- ___0.02" Slotted Schedule 80 PVC Geotextile Wrap
- Bag sample at 45' - 50
- ___End Cap P6-A
- ___Bentonite Grout
- ___1" Schedule 80 PVC
- 61' ▼
- ___Hydrated Bentonite Chips
- ___Caltrans Concrete Sand
- ___0.02" Slotted Schedule 80 PVC Geotextile Wrap
- ___End Cap P6-B

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Log of Well P-6-C

Red Bank Dam
Figure 25

Sheet: 1 of 1	
Job Number: G0811911F	
Elevation: 407.91 (Pad)	
Driller: BSK Associates	**Start Date:** February 3, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 3, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** Not encountered	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						**Clayey SAND (SC)** Red olive brown, fine to medium with trace of coarse, moist	0		___10" Schedule 80 PVC Standpipe; Bag sample at 0' - 4'
2							-2		
							-3		___Bentonite Grout
4		31				. . .red brown, moist, medium dense	-4		
							-5		
6							-6		___1" Schedule 80 PVC
							-7		
8							-8		
							-9		
10		17				. . .less fines, trace of fine gravel	-10		
							-11		
12							-12		___Hydrated Bentonite Chips
						. . .decreasing fines	-13		___Caltrans Concrete Sand
14		25					-14		
						. . .red brown, fine to coarse, increasing gravel content	-15		
16							-16		
							-17		___0.02" Slotted Schedule 80 PVC Geotextile Wrap
18							-18		
		50-3"				. . .very dense	-19		___End Cap
20						Boring terminated at 20 feet	-20		
							-21		
22							-22		
							-23		
24							-24		
							-25		
26							-26		
							-27		
28							-28		
							-29		
30							-30		
							-31		
32							-32		
							-33		
34							-34		
							-35		

BSK	Log of Well P-6-D	Sheet: 1 of 1
567 W. Shaw Ave. Fresno, CA 93704 (559) 497-2880 (559) 497-2886 FAX	Red Bank Dam Figure 26	Job Number: G0811911F Elevation: 411.43 (Pad)

Driller: BSK Associates		**Start Date:** February 3, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger		**Finish Date:** February 3, 2009
Sample Method: 2.4" I.D. California Sampler		**Logged By:** N. Shwiyhat
Borehole Diameter: 8"	**Water Level:** Not encountered	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						**Silty SAND (SM)** Brown, fine to medium grained, moist	0		___10" Schedule 80 PVC Standpipe Bag sample at 1' - 5'
2							-2		
4	■	23				. . .orange brown, slight decrease in fines, medium dense	-4		___Bentonite Grout
6							-6		___1" Schedule 80 PVC
8						. . .red brown, fine to coarse, trace of clay	-8		
10	■	26					-10		Bag sample at 10' - 15
12							-12		___Hydrated Bentonite Chips
14	■	22				. . .less fines, trace of fine gravel, fine to coarse	-14		___Caltrans Concrete Sand
16							-16		___0.02" Slotted Schedule 80 PVC Geotextile Wrap
18						. . .medium dense to dense, more clay, sporadic fine to medium gravel	-18		
20	■	40					-20		___End Cap
22						Boring terminated at 20.5 feet Groundwater not encountered	-22		
24							-24		
26							-26		
28							-28		
30							-30		
32							-32		
34							-34		
							-35		

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Log of Well P-7-C

Red Bank Dam
Figure 28

Sheet: 1 of 1	
Job Number: G0811911F	
Elevation: 409.50 (Pad)	
Driller: BSK Associates	**Start Date:** January 29, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** January 29, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** Not encountered	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						**Silty SAND (SM)** Brown, fine grained with trace of medium, moist, loose	0		10" Schedule 80 PVC Standpipe
4–5	■	7					-4		Bentonite Grout
7						**Sandy SILT w/trace Clay (ML)** Red brown, fine grained, moist, hard cemented	-7		1" Schedule 80 PVC
9–10	■	50-3"							
12							-12		Hydrated Bentonite Chips
13						**SAND/Silty SAND (SP/SM)** Red brown, fine to medium grained, medium dense	-13		
14							-14		Caltrans Concrete Sand
14–15	■	20							
16							-16		0.02" Slotted Schedule 80 PVC Geotextile Wrap
19						. . .fine to coarse, trace clay	-19		
19–20	■	72					-20		End Cap
20.5						Boring terminated at 20.5 feet			

Depth scale: 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34

Elevation scale: 0, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23, -24, -25, -26, -27, -28, -29, -30, -31, -32, -33, -34, -35

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Log of Well P-7-D

Red Bank Dam
Figure 29

Sheet: 1 of 1	
Job Number: G0811911F	
Elevation: 409.86 (Pad)	
Driller: BSK Associates	**Start Date:** January 30, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** January 30, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" — **Water Level:** Not encountered	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						**Silty SAND w/trace Clay (SM)** Red brown, fine with a trace of medium grained, moist	0		___10" Schedule 80 PVC Standpipe Bag sample at 0' - 4'
4		16				. . .medium dense, less clay	-4		___Bentonite Grout
6							-6		___1" Schedule 80 PVC
7						**Sandy SILT (ML)** Olive brown, fine with trace of clay, moist, drills very firm	-7		
10		74-11"					-10		Bag sample at 10' - 14 ___Hydrated Bentonite Chips
12						**SAND w/trace Silt (SP)** Orange brown, fine grained, moist, micaceous	-12		
14		27					-14		___Caltrans Concrete Sand
16							-16		Bag sample at 16' - 20
17						. . .grades to fine to medium grained	-17		___0.02" Slotted Schedule 80 PVC Geotextile Wrap
19		41				. . .fine to coarse, trace clay	-19		
20							-20		___End Cap
20.5						Boring terminated at 20.5 feet	-21		

FILTER DESIGN OPEN PIPE PIEZOMETERS

FILTER SAND GRADATION (CALTRANS SECTION 90-3.03)*

	mm	Percent Passing
3/8"	(9.5)	100
#4	(4.75)	95-100
#8	(2.36)	65-95
#100	(0.15)	2-12
#200	(0.075)	0-8

*Concrete Sand

Screen Slot Width: *0.02" = 0.50 mm*

FILTER/SLOT WIDTH CRITERION

$$\frac{D_{85}\text{ Filter}}{\text{Slot Width}} > 2 = \frac{2.40}{0.50} = 4.8\text{, OK}$$

PIPING RATIO

$$\frac{D_{15}\text{ Filter}}{D_{85}\text{ Soil}} < 5 = \frac{0.26}{0.65} = 0.40\text{, OK}$$

PERMEABILITY CRITERION

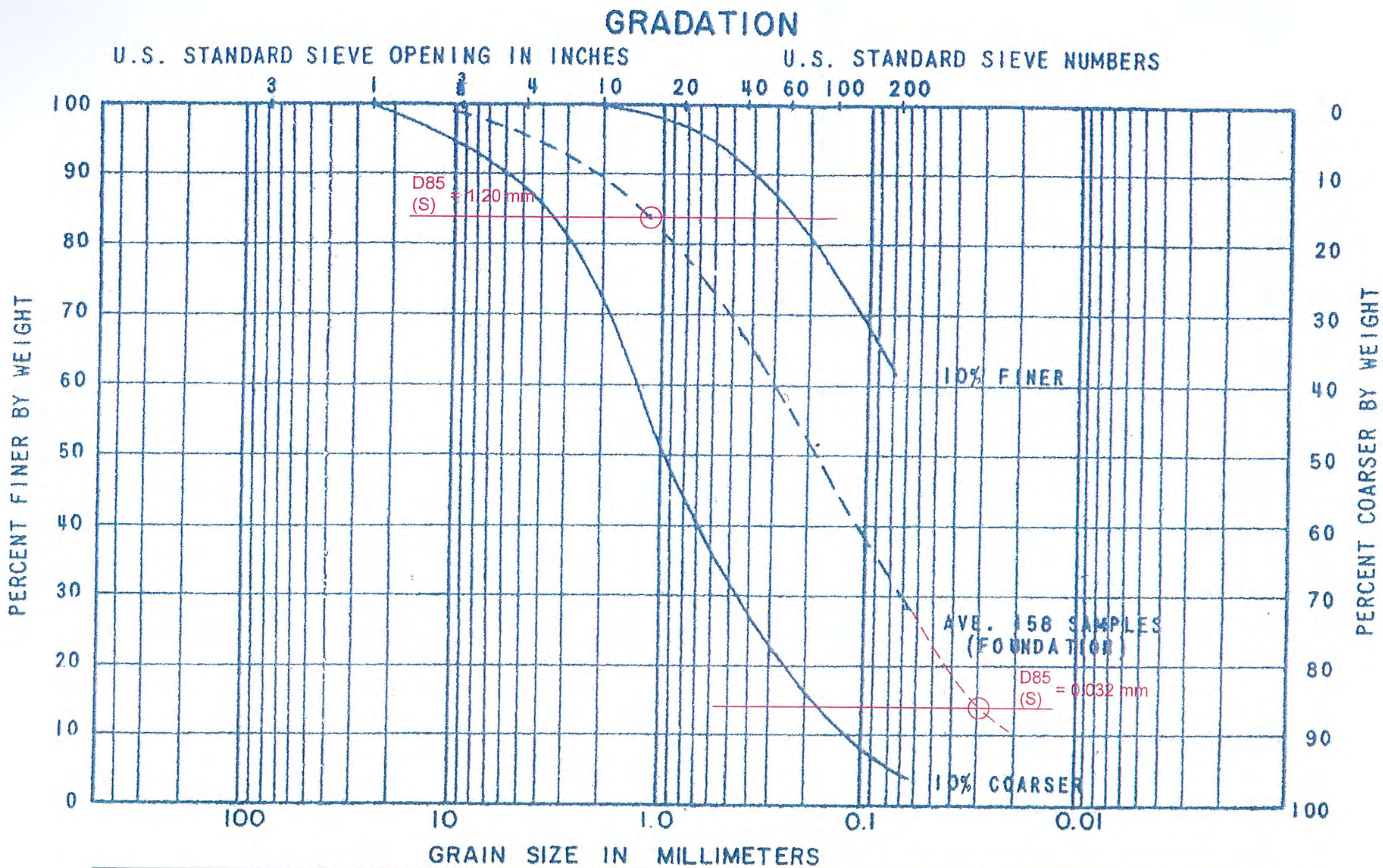
$$\frac{D_{15}\text{ Filter}}{D_{15}\text{ Soil}} > 4 = \frac{0.28}{0.032} = 8.8\text{, OK}$$

$$\frac{D_{15}\text{ Filter}}{D_{15}\text{ Soil (Finer)}} = \frac{0.28}{0.07} = 4.0\text{, OK}$$

COEFFICIENT OF FILTER UNIFORMITY

$$C_U = \frac{D_{60}}{D_{10}} > 2.5 \quad \frac{1.2}{0.2} = 6\text{, OK}$$

G08-119-11F
DECEMBER 2008
FIGURE 31



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SOIL

D_{85} (S) = 1.20 mm

D_{15} (S) = 0.032 mm

REFERENCE: SUMMARY OF TEST RESULTS
BIG DRY CREEK DAM
REDBANK AND FANCHER CREEKS, CA.
FILE NO. SJ-11-20-11, SHEET B35

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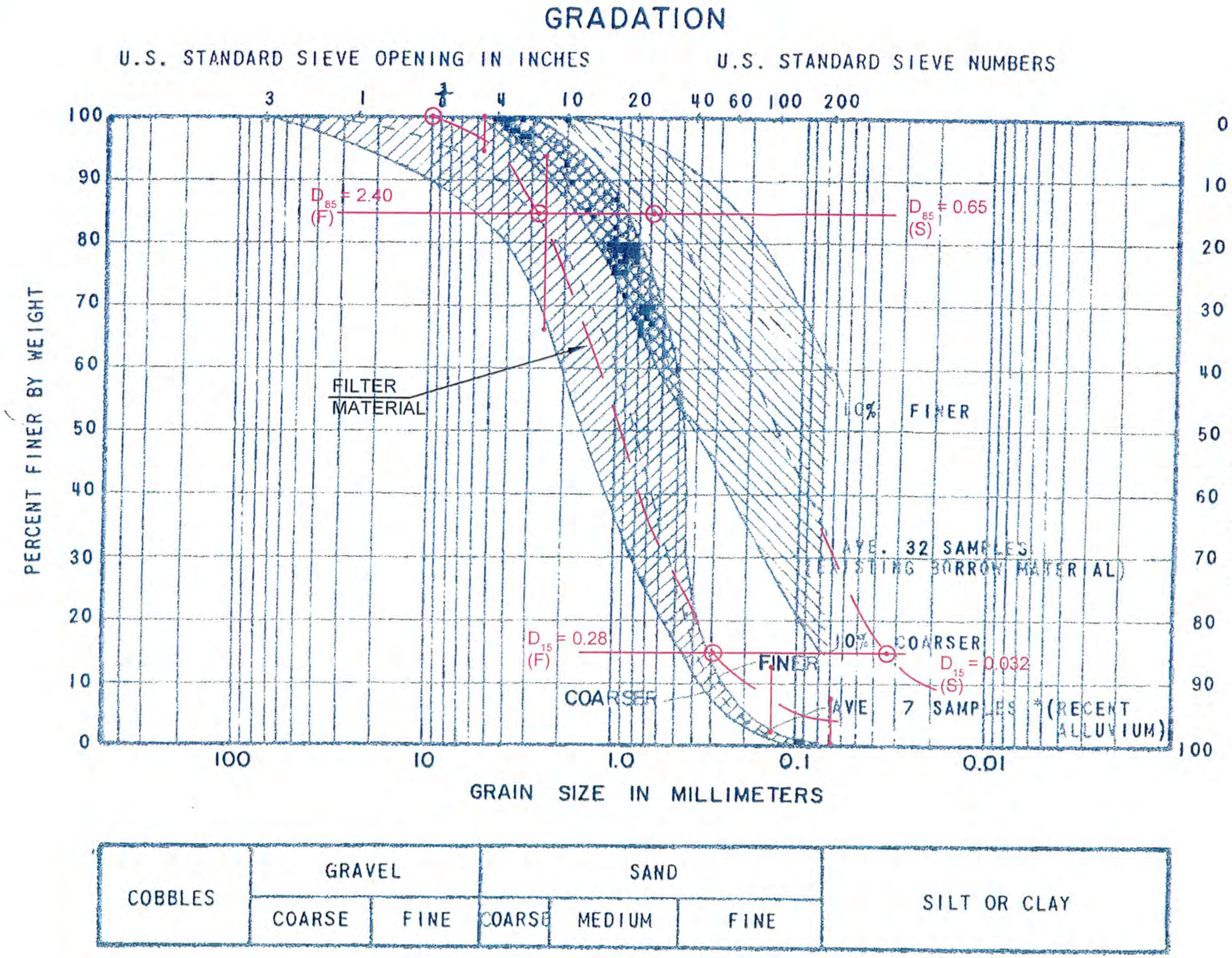
FILTER MATERIALS
PIEZOMETER INSTALLATIONS

BIG DRY CREEK DAM
Fresno Metropolitan Flood Control District
Fresno, California



FILTER

D_{85} = 2.40 mm (F)

D_{15} = 0.28 mm (F)

SOIL

D_{85} = 0.65 mm (S)

D_{15} = 0.032 mm (S)

REFERENCE: SUMMARY OF TEST RESULTS
BIG DRY CREEK DAM
REDBANK AND FANCHER CREEKS, CA.
FILE NO. SJ-11-20-11, SHEET B35

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FILTER MATERIALS PIEZOMETER INSTALLATIONS

BIG DRY CREEK DAM
Fresno Metropolitan Flood Control District
Fresno, California

BSK Associates
Engineers & Laboratories

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June 24, 2009

BSK Job No. G0811911F

Jerry Lakeman, P.E.
District Engineer
Fresno Metropolitan Flood Control District
5469 E. Olive
Fresno, California 93727

SUBJECT: **Supplement Preliminary Seepage Study**
Big Dry Creek Dam
Fresno Metropolitan Flood Control District
Contract No. BDR-18

Dear Jerry:

Submitted is a Supplement to our Preliminary Study of the Big Dry Creek Dam embankment toe seepage for the area of Station 125+50 at Piezometer Profile P6.

This supplement provides more detailed analyses based on site-specific subsurface profiles developed with a group of five (5) borings and with additional laboratory tests performed on soil specimens derived from the borings. Station 125+50 is in an area of reported notable seepage and sand boils (storm event of April 7, 2006). This site-specific study confirms the analyses presented in the Preliminary Seepage Study for Big Dry Creek submitted on November 5, 2008.

The opportunity to be of service on this project is appreciated. We are prepared to meet with you and your staff to discuss our findings.

Respectfully submitted
BSK Associates

Hugo Kevorkian
Principal Geotechnical Engineer
CE16350, GE462, REAII 20080

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K:\Projects\2008\Fresno\G0811911F Big Dry Creek Red Bank Dams\SupplmtPrelimSeepgeStdy(June24.09).doc

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

SUPPLEMENT PRELIMINARY SEEPAGE STUDY
BIG DRY CREEK DAM
FRESNO METROPOLITAN FLOOD CONTROL DISTRICT
CONTRACT NO. BDR-18

1.0 INTRODUCTION

This report presents the results of our supplementary study for seepage observed along the toe drain for the Big Dry Creek Dam near Station 125+50. Recommendations for this supplemental study were presented in our proposal of April 16, 2009. Notice to proceed was issued by electronic mail on April 20, 2009 (FMFCD – Kurt Hupp).

A Preliminary Seepage Study Report [1] dated November 5, 2008 was prepared by BSK for the Big Dry Creek Dam segment extending from Stations 63+00 to 121+85. This supplement provides more detailed analyses in the area of Station 125+50 based on a site-specific subsurface profile of five (5) borings and additional laboratory analyses of soil densities and permeability.

2.0 FIELD EXPLORATION

Field exploration data for the development of the subsurface profile was obtained in two stages. At Station 121+50, borings P6A, P6B and P6C were advanced through the center axis and downgradient of the main embankment in conjunction with the installation of piezometers.[2] Borings P6D and P6E were drilled on June 3, 2009 upgradient of the embankment at distances of 10 and 100 feet away from the embankment toe respectively. Figures 1 through 4 illustrate boring locations and depths. Boring logs are provided in Appendix A of this report.

3.0 LABORATORY TESTING

In situ moisture and dry density, permeability, particle size mechanical gradation analyses and hydrometer analyses were performed on soil specimens selected from the various intact and bulk soil samples obtained during the field exploration. The test data are presented in tabular and graphical format in Appendix B of this report.

4.0 REPORTS AND DOCUMENTS REVIEWED

The following reports and documents were reviewed in conjunction with the preparation of this supplement.

---

[1] "Preliminary Seepage Study Big Dry Creek Dam, Fresno Metropolitan Flood Control District Contract No. BRD-18 Job No. G0811911F" BSK Associates, November 5, 2008.

[2] "Piezometer Installations Big Dry Creek Dam FMFCD Project BDR-18 Job No. G0811911F" BSK Associates, May 20, 2009

FMFCD field data for the monitoring and observations of seepage and sand boils. Storm event of April 7, 2006 (see Appendix "A").

"General Design Memorandum" Design Memorandum No. 1, Redbank and Fancher Creeks, California" U.S. Army Corps of Engineers Sacramento District February 1986 (inclusive of drawings File No. SJ-11-29-11, Sheets B9 through B41, dated 1-20-86).

"As Built, Contract No. DACW05-92-C-0052 Redbank and Fancher Creeks Big Dry Creek Dam, File SJ-11-9-39 Drawings C1 through C41" U.S. Army Corps of Engineers Sacramento District December 10, 1991.

"Photographs – Storm Event of April 7, 2006" Fresno Metropolitan Flood Control District (see Appendix "A").

"Big Dry Creek Dam, Fresno, California Embankment Criteria Performance Report" Department of the Army Sacramento District, Corps of Engineers Sacramento, California November 21, 1995.

"Piezometer Installations Big Dry Creek Dam FMFCD Project BDR-18 Job G0811911F" BSK Associates, May 20, 2009.

"Redbank and Fancher Creeks California Big Dry Creek Dam Site Geology Design Memorandum No. 5" U.S. Army Crops of Engineers Sacramento District, September 1986.

5.0 COMPUTER MODELING

Models for seepage analyses were developed for the embankment. The computer program SEEP2D developed by the USACE and commercially available to consulting engineers was used for the analyses. Soil profile and soil design parameter for the analyses were obtained from the field exploration and laboratory test data described in Section 2.0 and 3.0. The embankment profile was obtained from USACE reports listed in Section 4.0.

The following sets of conditions were developed for seepage analyses:

1. Pool elevation 421.0 soil profile and soil design parameters based on test data (Figure 1).
2. Pool elevation 439.2 at Standard Design Flood (SDF) peak flow soil profile and soil design parameters based on test data (Figure 2

Computed exit gradient and seepage flow volumes are provided at the downgradient toe and for a discharge point 50 feet away from the toe. The latter parameter is intended to address the high incidence of sand boils reported at 48 feet from the toe (April 7, 2006). Pool elevation 421.0 is intended to duplicate water levels during the storm event of April 2006. Pool elevation 439.2 is designed to address reservoir design capacity at the Standard Design Flood (SDF) maximum flow.

Based on the computed exit gradients (i exit) of 0.13 and 0.44 for pool elevations 421.0 and 439.2, respectively and the calculated critical gradient (i critical) of 1.08 derived from soil saturated weight of 130 pcf, safety factors (SF) against quick conditions or piping were derived. The results are listed in Table 1 below:

TABLE 1
SAFETY FACTORS – EXIT GRADIENTS

$$SF_{(421')} = \frac{i\ \text{critical}}{i\ \text{exit}} = \frac{1.08}{0.13} = 8.30$$

$$SF_{439.2} = \frac{i\ \text{critical}}{i\ \text{exit}} = \frac{1.08}{0.44} = 2.45$$

These safety factors depart from the values of 4.91 and 2.70 previously obtained during our preliminary study at Station 119+89 for the lower and maximum water elevations respectively. Lower flow volumes are derived based on this specific supplementary study as compared to the original preliminary study. Table 2 below provides a comparison of seepage flow volume estimates.

TABLE 2
SEEPAGE FLOW VOLUME ESTIMATES
(Cubic Feet/Day/Foot)

Water Elevation	General Preliminary Study (Nov. 5, 2008)	Site-Specific Supplementary Study (May 2009)
421.0	3.25	0.20
439.2	6.56	0.40

The lower flow volumes indicated in the supplementary study reflect the site-specific higher incidence of lower permeability soil fill placed upgradient of the embankment and natural deposits beneath the embankment as opposed to the more general profile used for the preliminary study.

6.0 CONCLUSIONS

Site-specific seepage analyses were performed for the dam embankment at Station 121+50. Greater details of subsurface profile were obtained from the piezometer installations and additional borings advanced upgradient of the embankment. Additional laboratory testing was also performed.

Station 121+50 was selected for the study on the bases of reported concentrations of sand boils and seepage (April 7, 2006).

The resulting seepage rates and exit gradients developed from the site-specific analyses differ from those derived from the earlier general seepage analyses. As listed in Table 1, the safety factor for seepage exit gradients increased for the low impoundment (pool elevation, 421.0) and decreased slightly for the maximum impoundment (pool elevation 439.2). For the seepage flow rates, as listed in Table 2, a marked decrease is noted.[3]

We conclude that at this time, the calculated safety factors for the site-specific analyses at Station 121+50 do not justify taking additional mitigating measures. Rather, future monitoring of recently installed piezometers should be performed to acquire actual seepage data and to formulate reassessments of seepage criteria. Seepage analyses at Station 121+50 were performed to provide a more specific approach to assessing the significance of reported seepage and sand boil occurrences during the storm event of April 7, 2006. Embankment conditions and configurations at Station 121+50 are specific. Other areas of the Big Dry Creeks Dam previously studied differ, although the occurrence of sand boils and seepage was reported in several locations in particular, the area of piezometer profile P1 at Station 63+75.

Figures 3 and 4 provide illustrations of the influence of modifying the existing toe drain by deepening it from the existing 5 foot to 12 to 15 feet below surface. The resulting exist gradients at 50 feet from the toe are 0.08 and 0.33 for the lower and maximum pool elevations, respectively. This approach would be available in the event remedial measures to increase seepage factors of safety became necessary.

7.0 LIMITATIONS

This site-specific seepage study is based on published geotechnical engineering design data and subsurface soil data contained in references listed in Sections 2 and 3 of this report. Findings and conclusions presented in this report may not apply to other areas of the Big Dry Creek Dam embankment.

BSK has prepared this report for the exclusive use of the Fresno Metropolitan Flood Control District. The report has been prepared in accordance with generally accepted geotechnical engineering practices for the project area at the time of the report preparation. No other warranty express or implied, is made as to the professional advice provided in this report under the terms of BSK's agreement and with Client.

BSK Associates

---

[3] The USACE Sacramento District Levee Design Criteria call for exit gradients of 0.3 and 0.5 for new and existing levees, respectively (SF.=2.8, 1.7). The definition of "New" levee includes existing levees if they are being designed to a higher water surface or to a higher level of performance. However, a lower factor of safety could be used if there was sufficient soil data and past performance information to justify (ETL 110-2-555).

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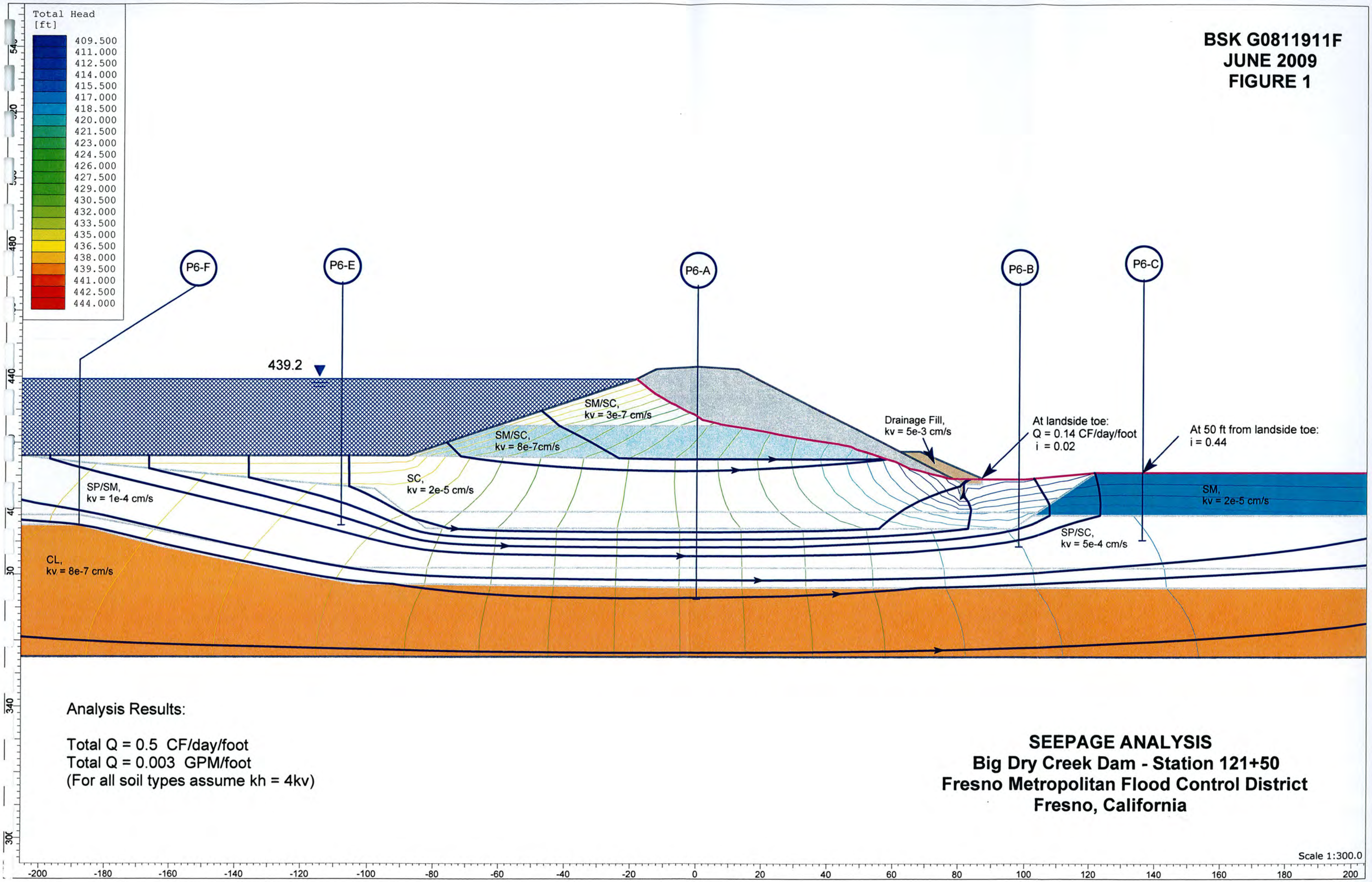
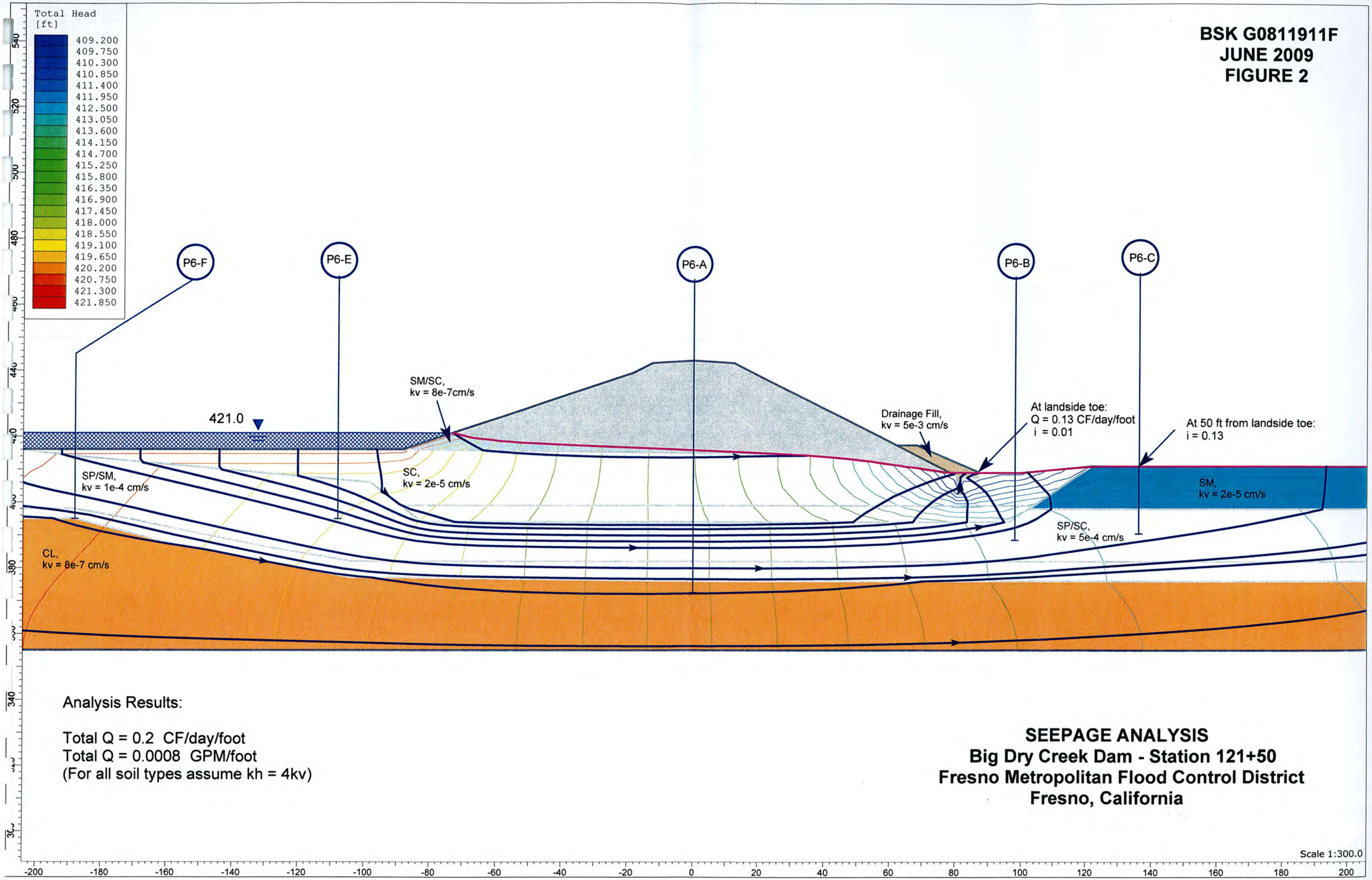
JUNE 2009
FIGURE 1



Analysis Results:

Total Q = 0.5 CF/day/foot
Total Q = 0.003 GPM/foot
(For all soil types assume kh = 4kv)

SEEPAGE ANALYSIS
Big Dry Creek Dam - Station 121+50
Fresno Metropolitan Flood Control District
Fresno, California



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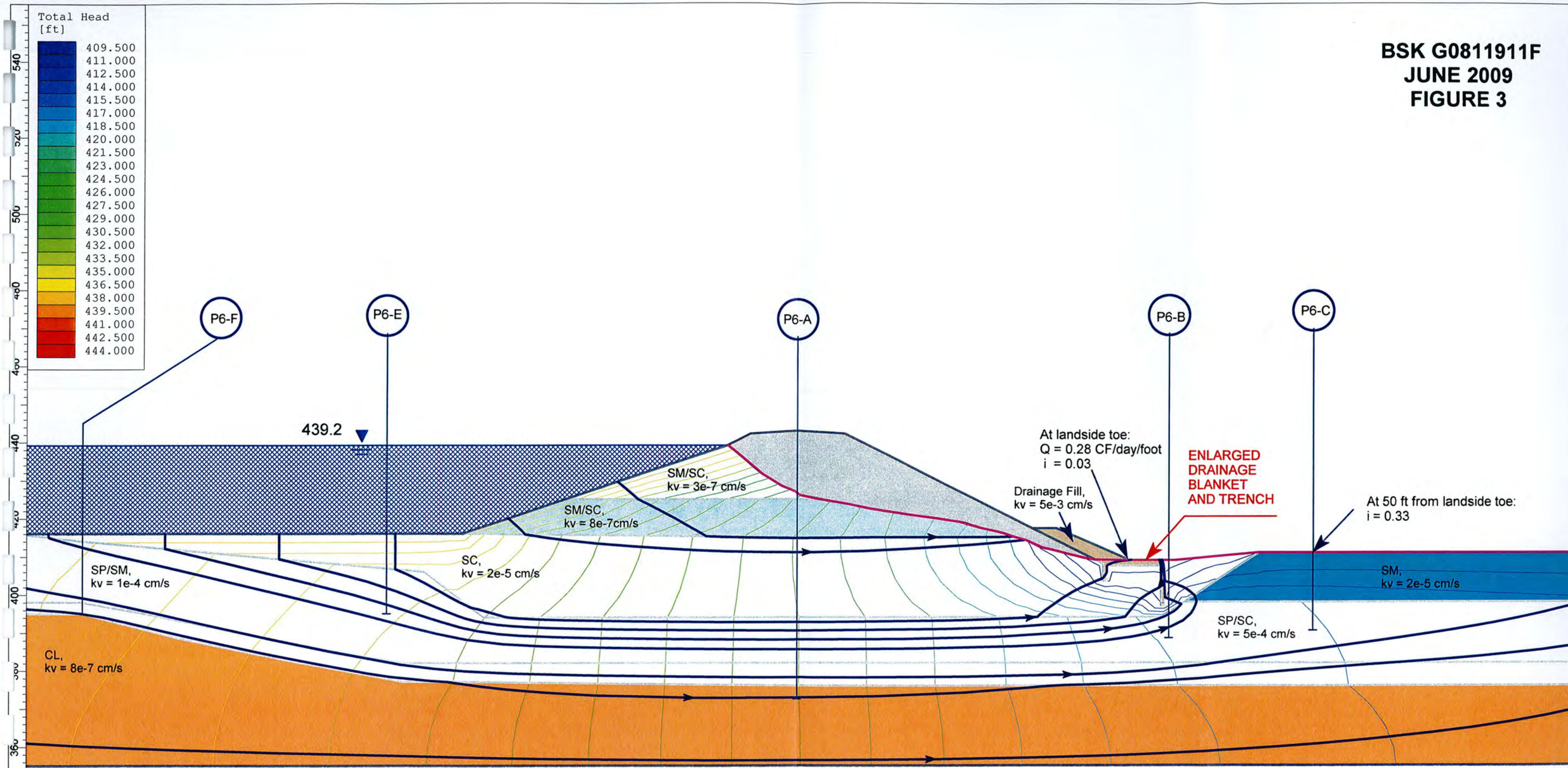
JUNE 2009
FIGURE 2

Analysis Results:

Total Q = 0.2 CF/day/foot
Total Q = 0.0008 GPM/foot
(For all soil types assume kh = 4kv)

SEEPAGE ANALYSIS
Big Dry Creek Dam - Station 121+50
Fresno Metropolitan Flood Control District
Fresno, California

BSK G0811911F
JUNE 2009
FIGURE 3

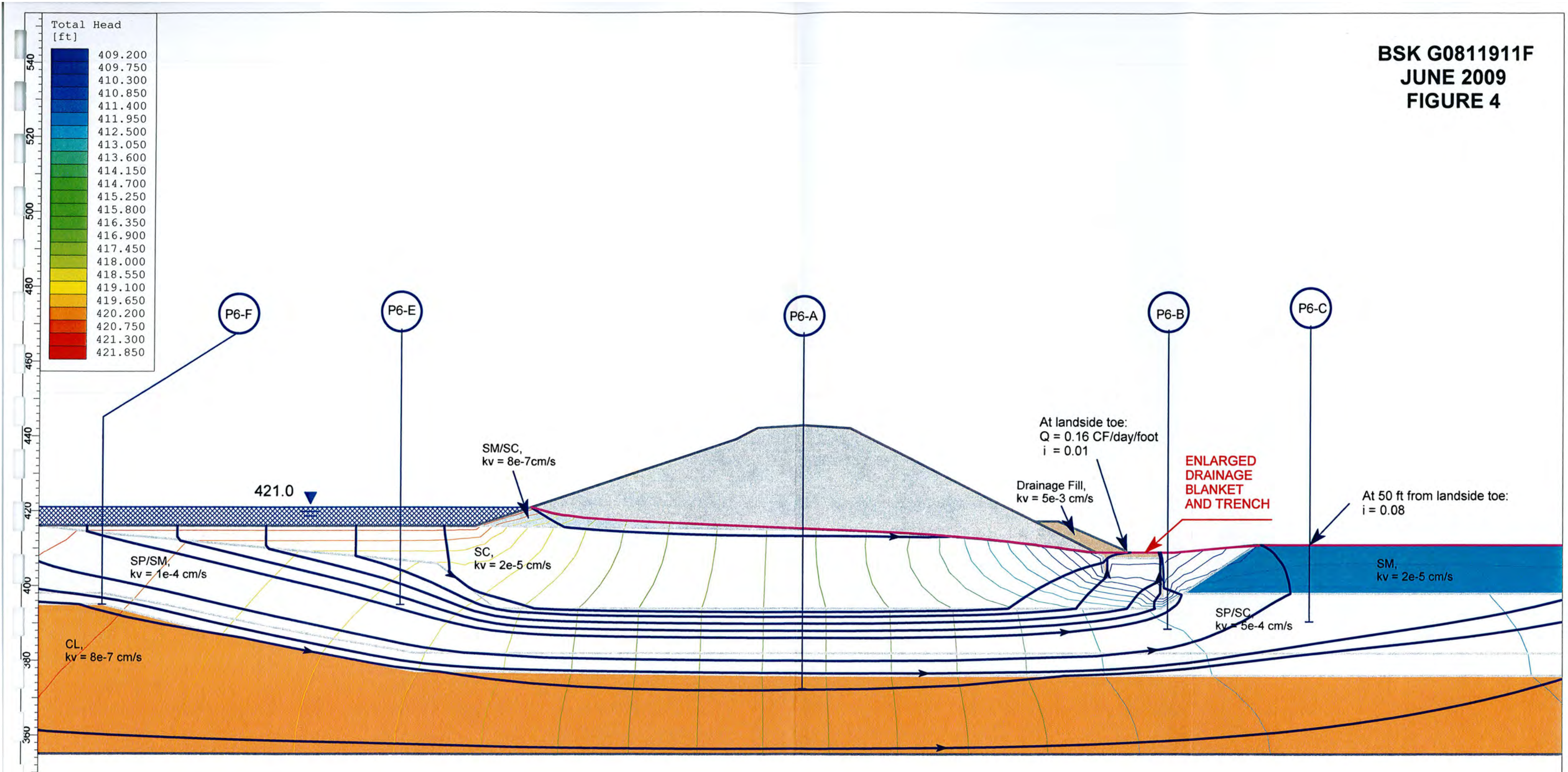


Analysis Results:

Total Q = 0.5 CF/day/foot
Total Q = 0.003 GPM/foot
(For all soil types assume kh = 4kv)

SEEPAGE ANALYSIS
Big Dry Creek Dam - Station 121+50
Fresno Metropolitan Flood Control District
Fresno, California

BSK G0811911F
JUNE 2009
FIGURE 4



Analysis Results:

Total Q = 0.2 CF/day/foot
Total Q = 0.0009 GPM/foot
(For all soil types assume kh = 4kv)

SEEPAGE ANALYSIS
Big Dry Creek Dam - Station 121+50
Fresno Metropolitan Flood Control District
Fresno, California

Scale 1:300.0

APPENDIX A
Field Exploration

MAJOR DIVISIONS				TYPICAL NAMES
COARSE GRAINED SOILS More than Half >#200	GRAVELS MORE THAN HALF COURSE FRACTION IS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES
			GP	POORLY GRADED GRAVELS, GRAVEL- SAND MIXTURES
		GRAVELS WITH OVER 15% FINES	GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES
	SANDS MORE THAN HALF COURSE FRACTION IS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS WITH LITTLE OR NO FINES	SW	WELL GRADED SANDS, GRAVELLY SANDS
			SP	POORLY GRADED SANDS, GRAVELLY SANDS
		SANDS WITH OVER 15% FINES	SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES
			SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES
FINE GRAIN SOILS More than Half <#200 sieve	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC CLAYS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS , MICACEOUS OR DIATOMACIOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS

Notes:
Dual symbols are used to indicate borderline soil classifications. Blow counts represent the number of blows a 140-pound hammer falling 30 inches required to drive a sampler through the last 12 inches of an 18 inch penetration, unless otherwise noted. The lines separating strata on the logs represent approximate boundaries only. The actual transition may be gradual. No warranty is provided as to the continuity of soil strata between borings. Logs represent the soil section observed at the boring location on the date of drilling only.

	Modified California	RV	R-Value
	Standard Penetration Test (SPT)	SA	Sieve Analysis
	Split spoon	SW	Swell Test
	Pushed Shelby Tube	TC	Cyclic Triaxial
	Auger Cuttings	TX	Unconsolidated Undrained Triaxial
	Grab Sample	TV	Torvane Shear
	Sample Attempt with No Recovery	UC	Unconfined Compression
CA	Chemical Analysis	(1.2)	(Shear Strength, ksf)
CN	Consolidation	WA	Wash Analysis
CP	Compaction	(20)	(with % Passing No. 200 Sieve)
DS	Direct Shear	▽	Water Level at Time of Drilling
PM	Permeability	▼	Water Level after Drilling (with date measured)
PP	Pocket Penetrometer		

SOIL CLASSIFICATION CHART AND KEY TO TEST DATA **Unified Soil Classification System**	PLATE:

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LOG OF BORING NO. P6-E

Project Name: **Big Dry Creek & Red Bank Dams**
Location: **Fresno and Clovis, CA**
Job Number: **G0811911F**

Figure A1

Surface El.: **419.0**
Location: **See Figures 1 through 4 Borehole Location Map**
Surface Description:

Depth, feet	Samples	Penetration Blows / Foot	In-Situ Dry Weight (pcf)	In-Situ Moisture Content (%)	% Passing No. 200 Sieve	Graphic Log	MATERIAL DESCRIPTION	REMARKS
0						CL	**Sandy CLAY (CL)** Orange brown, fine to medium grained with trace of 0.5-inch gravel, moist. Fill? Bulk Sample at 0.5 - 4 feet	
5	■	39	120	9				
							Bulk Sample at 7 - 9 feet	
							. . .fine to coarse grained	
10	■	85	112	7		SP	**SAND (SP)** Brown, fine to medium grained, moist	
							Bulk Sample at 12 - 14 feet	
15	■	64	119	5			. . .increase in silt, fine to coarse grained	
20	■	23	111	4			. . .orange brown, medium to coarse grained	
25								
30								

Completion Depth: **21.0**
Date Started: **6/3/09**
Date Completed: **6/3/09**
Logged By: **Ashleigh Love**
Checked By: **Hugo Kevorkian**

Drilling Equipment and Method: Mobile 61 with 8 inch Hollow Stem Auger Auto Hammer, California Modified
Remarks: 1) Boring terminated at 21 feet 2) Groundwater not encountered 3) Boring backfilled with soil cuttings

BSK Associates Engineers & Laboratories

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LOG OF BORING NO. P6-F

Project Name: **Big Dry Creek & Red Bank Dams**
Location: **Fresno and Clovis, CA**
Job Number: **G0811911F**

Figure A2

Surface El.: **418.0**
Location: **See Figures 1 through 4 Borehole Location Map**
Surface Description:

Depth, feet	Samples	Penetration Blows / Foot	In-Situ Dry Weight (pcf)	In-Situ Moisture Content (%)	% Passing No. 200 Sieve	Graphic Log	MATERIAL DESCRIPTION	REMARKS
0 - 2						CL	**Sandy CLAY (CL)** Orange brown, fine to medium grained. Fill? Bulk Sample at 0.5 - 4 feet	
2 - 8						SP	**SAND (SP)** Dark brown, fine grained, moist	
5	Sample	13	113	8				
8 - 10						CL	**Sandy CLAY (CL)** Orange brown, fine grained, moist	
10 - 18	Sample	52	116	11		SM	**Silty SAND (SM)** Brown, fine to medium grained, moist	
15	Sample	11	110	11			Bulk Sample at 15 - 16 feet . . .with trace of clay	
18 - 21						CL	**Sandy CLAY with Silt (CL)** Orange brown, fine grained, moist	
20	Sample	29	118	14				

Completion Depth: **21.0**
Date Started: **6/3/09**
Date Completed: **6/3/09**
Logged By: **Ashleigh Love**
Checked By: **Hugo Kevorkian**

Drilling Equipment and Method: Mobile 61 with 8 inch Hollow Stem Auger Auto Hammer, California Modified

Remarks: 1) Boring terminated at 21 feet 2) Groundwater not encountered 3) Boring backfilled with soil cuttings

BSK 567 W. Shaw Ave. Fresno, CA 93704 (559) 497-2880 (559) 497-2886 FAX	***Log of Well P-6 - A/B*** Red Bank Dam Figure A3	Sheet: 1 of 2
		Job Number: G0811911F
		Elevation: 443.08

Driller: BSK Associates	**Start Date:** February 11, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 11, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** 61'	**Reviewed By:** H. Kevorkian

Depth (feet)	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Materials Description	Elevation (feet)	Remarks
0				Gravel road surface	0	10" Well Vault
0				**Sandy Silt w/Clay (ML)** Red brown, fine to medium grained, dry to moist, dense (FILL)		Ready Mix Concrete
2					-2	Bag sample at 2' - 5'
4	39	125	11.5		-5	
6				. . .drills hard	-7	
8				. . .yellow brown dry to moist	-9	
10	37	121	10.6		-10	
12					-13	Bentonite Grout
14	59	130	9.6	. . .brown, moist, very dense, less fines	-14	
18				**Sandy CLAY (CL)** Dark olive gray, fine to medium grained with trace coarse, hard, intermixed silty sand (FILL)	-18	Bag sample at 18' - 22
20	49				-20	
22					-22	1" Schedule 80 PVC
24	59	130	8.0		-25	
28				**Sandy SILT w/Clay (ML)** Red brown with yellow brown and gray, fine to coarse, very dense (FILL)	-28	
30	68	130	9.8		-30	Bag sample at 30' - 35
32				. . .intermixed silty sand	-32	
34	75	129	9.7	. . .intermixed silty sand and sandy silt, fine to medium, dense, hard, moist	-34	
36					-36	
38					-38	

BSK

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Fresno, CA 93704
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(559) 497-2886 FAX

Log of Well P-6 - A/B

Red Bank Dam
Figure A3

Sheet: 2 of 2
Job Number: G0811911F
Elevation 443.08

Depth (feet)	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Materials Description	Elevation (feet)	Remarks
40	52	135	6.7	. . .more sand, fine to coarse	-39 / -40	___Hydrated Bentonite Chips
41					-41	___Caltrans Concrete Sand
42	49	123	11.5		-42	
43				. . .grades to silty sand	-43	___0.02" Slotted Schedule 80 PVC Geotextile Wrap
44	46	120	5.7	**Silty SAND w/trace Clay (SM)** Red brown, fine to coarse, trace of fine gravel, dense (FILL)	-44 / -45	
46					-46	Bag sample at 45' - 50
48	47	122	11.4	. . .more clay, fine to medium, moist	-47 / -48	___End Cap P6-A
50	49	123	8.1	**Silty SAND w/trace Clay (SM)** Red brown, fine to coarse, moist, dense (NATIVE)	-49 / -50	
52					-51 / -52 / -53	
54	73-11"	116	6.9	. . .trace of gravel, fine to coarse	-54 / -55	___Bentonite Grout
56					-56	___1" Schedule 80 PVC
57				. . .sandy silt layer	-57 / -58	
60	86-10"	117	17.0	. . .yellow brown, fine, micaceous	-59 / -60	61' ▼
62				. . .decreasing fines	-61 / -62 / -63	___Hydrated Bentonite Chips
64	73	123	12.8	. . .red brown, fine to coarse, wet, very dense	-64 / -65	___Caltrans Concrete Sand
66					-66 / -67 / -68	___0.02" Slotted Schedule 80 PVC Geotextile Wrap
70	30	107	19.9	**Silty CLAY w/trace of fine sand (CL)** Light red brown with black speckles, moist to wet, stiff	-69 / -70	___End Cap P6-B
72				Boring terminated at 70.5 feet Groundwater encountered at 61 feet	-71 / -72 / -73	
74					-74 / -75	
76					-76	

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Log of Well P-6-C

Red Bank Dam
Figure A4

Sheet: 1 of 1	
Job Number: G0811911F	
Elevation: 407.91 (Pad)	
Driller: BSK Associates	**Start Date:** February 3, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 3, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** Not encountered	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						**Clayey SAND (SC)** Red olive brown, fine to medium with trace of coarse, moist	0		10" Schedule 80 PVC Standpipe; Bag sample at 0' - 4'
3							-3		Bentonite Grout
4	■	31				. . .red brown, moist, medium dense	-4		
6							-6		1" Schedule 80 PVC
10	■	17				. . .less fines, trace of fine gravel	-10		
12							-12		Hydrated Bentonite Chips
13						. . .decreasing fines	-13		Caltrans Concrete Sand
15	■	25				. . .red brown, fine to coarse, increasing gravel content	-15		
17							-17		0.02" Slotted Schedule 80 PVC Geotextile Wrap
19	■	50-3"				. . .very dense	-19		End Cap
20						Boring terminated at 20 feet	-20		

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Log of Well P-6-D

Red Bank Dam
Figure A5

Sheet: 1 of 1
Job Number: G0811911F
Elevation: 411.43 (Pad)

Driller: BSK Associates	**Start Date:** February 3, 2009
Drill Method: BK-81 w/8" Hollow Stem Auger	**Finish Date:** February 3, 2009
Sample Method: 2.4" I.D. California Sampler	**Logged By:** N. Shwiyhat
Borehole Diameter: 8" / **Water Level:** Not encountered	**Reviewed By:** H. Kevorkian

Depth (feet)	Sample Type	Blow Count (blows/ft.)	Dry Density (pcf)	Moisture (%)	Graphic Log	Materials Description	Elevation (feet)	Well Completion	Remarks
0						**Silty SAND (SM)** Brown, fine to medium grained, moist	0		10" Schedule 80 PVC Standpipe; Bag sample at 1' - 5'
2							-2		
4		23				. . .orange brown, slight decrease in fines, medium dense	-4, -5		Bentonite Grout
6							-6, -7		1" Schedule 80 PVC
8						. . .red brown, fine to coarse, trace of clay	-8, -9		
10		26					-10		Bag sample at 10' - 15
12							-11, -12, -13		Hydrated Bentonite Chips
14		22				. . .less fines, trace of fine gravel, fine to coarse	-14, -15		Caltrans Concrete Sand
16							-16, -17, -18		0.02" Slotted Schedule 80 PVC Geotextile Wrap
18									
20		40				. . .medium dense to dense, more clay, sporadic fine to medium gravel	-19, -20		End Cap
						Boring terminated at 20.5 feet	-21		
22						Groundwater not encountered	-22, -23		
24							-24, -25		
26							-26, -27		
28							-28, -29		
30							-30, -31		
32							-32, -33		
34							-34, -35		

APPENDIX B
Laboratory Testing

BSK

Associates: 1415 Tuolumne Street. Fresno, CA. 93706- PH: (559) 497-2868 Fax: (559) 485-1863

HYDAULIC CONDUCTIVITY TEST
CONSTANT HEAD METHOD- ASTM D-2434

REPORT DATE: 6/9/2009

BSK PROJECT NAME: Big Dry Creek Dam
BSK PROJECT NO.: G0811911F

Sample I.D.: P6-F @ 5.5'
Visual Classification: Sand / Silty Sand (SP/SM), Fine to Medium Grained, Brown

Sampled By: A. Love
Sample Date: 6/3/2009
Tested By: N. Shwiyhat
Test Date: 6/8/2009

Density Determination:

Diameter, cm:	**6.12**
Tube & Soil Gross wt., gm	1091.0
Tube wt., gm	216.5
Wet Soil wt., gm	**874.5**
Tube Length, cm	15.24
Tare Length,cm	0.00
Sample Length,cm	15.24
Dry Density, g/cm^3	**1.80**

Moisture Detrmination:

Pan + Wet Soil wt., gm	**186.9**
Pan wt., gm	**0.0**
Pan + dry wt., gm	**172.7**
% moisture Content:	8.2

Dry Density, pcf **112.4**

Hyraulic Conductivity Specimen:

Diameter, cm	**6.12**
Tube Length, cm	**15.24**
Tare Length, cm	**3.40**
Specimen Length (L), cm	11.84

Area (A), cm^2: 29.43

Trial Number	Constant Head, h, cm	Elapsed Time, t (s)	Outflow Volume Q, cm^3	Water Temp., T, °C	K_T	K_{20}
1	40.64	4020	57.0	23.0	1.40E-04	1.31E-04
2	40.64	4020	48.0	23.0	1.18E-04	1.10E-04
3	40.64	4020	47.0	23.0	1.16E-04	1.05E-04
4	40.64	4020	44.0	23.0	1.08E-04	9.85E-05
Average Hydraulic Conductivity, cm/sec					**1.11E-04**	

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CONSTANT VOLUME FLEXIBLE-WALL PERMEABILITY TEST (ASTM D-5084)		
PROJECT NAME :	**Big Dry Creek Dam**	
BSK JOB NO. :	**G0811911F**	
Report Date:	**5/20/2009**	
Sample Date:	**2/11/2009**	
Sample I.D.:	**P6-A/B @ 10'**	
Soil Description:	**Clayey Sand w/ Silt (SC), Red Brown, Fine to Coarse w/ a Trace of Fine Gravel**	
STAGE	INITIAL	FINAL
WET WEIGHT (GM)	186.7	190.0
DRY WEIGHT (GM)	168.8	168.8
MOISTURE CONTENT (%)	10.6	12.6
AVE. LENGTH (IN)	1.177	1.161
AVE DIAMETER (IN)	2.393	2.370
Vt (CU. FT)	3.07E-03	2.96E-03
Vw (CU. FT)	6.31E-04	7.48E-04
Vs (CU. FT)	2.21E-03	2.21E-03
Va (CU. FT)	2.25E-04	6.36E-06
Vv (CU.FT)	8.56E-04	7.54E-04
s Degree of saturation %	73.7	99.2
DRY DENSITY (PCF)	121.3	125.4
e (VOID RAITO)	0.39	0.34
n (POROSITY)	27.9	25.5
"B" PARAMETER	0.95	
BACK PRESSURE (PSI)	21.5	
EFFECTIVE PRESSURE (PSI)	13.5	
PERMEABILITY (cm/sec)	**2.75E-07**	

NOTES :

1) A 0.005N SOLUTION OF $CaSO_4$ WAS USED AS PERMEANT

2) POROSITY WAS BASED ON A SPECIFIC GRAVITY OF 2.7

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CONSTANT VOLUME FLEXIBLE-WALL PERMEABILITY TEST (ASTM D-5084)		
PROJECT NAME :	**Big Dry Creek Dam**	
BSK JOB NO. :	**G0811911F**	
Report Date:	**5/20/2009**	
Sample Date:	**2/11/2009**	
Sample I.D.:	**P6-A/B @ 20'**	
Soil Description:	**Silty Sand / Clayey Sand (SM/SC), Olive Brown, Fine to Medium Grained w/ a Trace of Coarse**	
STAGE	INITIAL	FINAL
WET WEIGHT (GM)	212.7	215.7
DRY WEIGHT (GM)	195.7	195.7
MOISTURE CONTENT (%)	8.7	10.2
AVE. LENGTH (IN)	1.252	1.247
AVE DIAMETER (IN)	2.416	2.402
Vt (CU. FT)	3.32E-03	3.27E-03
Vw (CU. FT)	6.01E-04	7.07E-04
Vs (CU. FT)	2.56E-03	2.56E-03
Va (CU. FT)	1.59E-04	3.00E-06
Vv (CU.FT)	7.60E-04	7.10E-04
s Degree of saturation %	79.0	99.6
DRY DENSITY (PCF)	129.8	131.8
e (VOID RAITO)	0.30	0.28
n (POROSITY)	22.9	21.7
"B" PARAMETER	0.95	
BACK PRESSURE (PSI)	18	
EFFECTIVE PRESSURE (PSI)	27	
PERMEABILITY (cm/sec)	**7.73E-07**	

NOTES :

1) A 0.005N SOLUTION OF $CaSO_4$ WAS USED AS PERMEANT
2) POROSITY WAS BASED ON A SPECIFIC GRAVITY OF 2.7

BSK
ASSOCIATES

CONSTANT VOLUME FLEXIBLE-WALL PERMEABILITY TEST (ASTM D-5084)		
PROJECT NAME :	**Big Dry Creek Dam**	
BSK JOB NO. :	**G0811911F**	
Report Date:	**5/20/2009**	
Sample Date:	**2/11/2009**	
Sample I.D.:	**P6-A/B @ 45'**	
Soil Description:	**Clayey Sand w/ Silt (SC), Red Brown, Fine to Coarse w/ a Trace of Fine Gravel**	
STAGE	INITIAL	FINAL
WET WEIGHT (GM)	162.6	172.7
DRY WEIGHT (GM)	153.8	153.8
MOISTURE CONTENT (%)	5.7	12.3
AVE. LENGTH (IN)	1.092	1.057
AVE DIAMETER (IN)	2.390	2.375
Vt (CU. FT)	2.83E-03	2.71E-03
Vw (CU. FT)	3.09E-04	6.66E-04
Vs (CU. FT)	2.01E-03	2.01E-03
Va (CU. FT)	5.12E-04	3.10E-05
Vv (CU.FT)	8.21E-04	6.97E-04
s Degree of saturation %	37.7	95.6
DRY DENSITY (PCF)	119.5	125.0
e (VOID RAITO)	0.41	0.35
n (POROSITY)	29.0	25.7
"B" PARAMETER	0.95	
BACK PRESSURE (PSI)	20	
EFFECTIVE PRESSURE (PSI)	30	
PERMEABILITY (cm/sec)	**2.46E-05**	

NOTES :

1) A 0.005N SOLUTION OF CaSO4 WAS USED AS PERMEANT
2) POROSITY WAS BASED ON A SPECIFIC GRAVITY OF 2.7

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CONSTANT VOLUME FLEXIBLE-WALL PERMEABILITY TEST (ASTM D-5084)		
PROJECT NAME :	**Big Dry Creek Dam**	
BSK JOB NO. :	**G0811911F**	
Report Date:	**5/20/2009**	
Sample Date:	**2/11/2009**	
Sample I.D.:	**P6-A/B @ 54.5'**	
Soil Description:	**Sand w/ a Trace of Clay (SP/SC), Red Brown, Fine to Coarse Grained**	
STAGE	INITIAL	FINAL
WET WEIGHT (GM)	187.2	200.1
DRY WEIGHT (GM)	175.1	175.1
MOISTURE CONTENT (%)	6.9	14.3
AVE. LENGTH (IN)	1.278	1.222
AVE DIAMETER (IN)	2.419	2.400
Vt (CU. FT)	3.40E-03	3.20E-03
Vw (CU. FT)	4.26E-04	8.82E-04
Vs (CU. FT)	2.29E-03	2.29E-03
Va (CU. FT)	6.81E-04	2.70E-05
Vv (CU.FT)	1.11E-03	9.09E-04
s Degree of saturation %	38.5	97.0
DRY DENSITY (PCF)	113.4	120.5
e (VOID RAITO)	0.48	0.40
n (POROSITY)	32.6	28.4
"B" PARAMETER	0.95	
BACK PRESSURE (PSI)	20	
EFFECTIVE PRESSURE (PSI)	30	
PERMEABILITY (cm/sec)	**3.06E-04**	

NOTES :

1) A 0.005N SOLUTION OF CaSO4 WAS USED AS PERMEANT

2) POROSITY WAS BASED ON A SPECIFIC GRAVITY OF 2.7

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CONSTANT VOLUME FLEXIBLE-WALL PERMEABILITY TEST (ASTM D-5084)		
PROJECT NAME :	Big Dry Creek Dam	
BSK JOB NO. :	G0811911F	
Report Date:	5/22/2009	
Sample Date:	2/3/2009	
Sample I.D.:	P6-D @ 15'	
Soil Description:	Sand w/ a Trace of Silt Clay (SP/SM), Red Brown,	
	Fine to Coarse Grained	
STAGE	INITIAL	FINAL
WET WEIGHT (GM)	236.0	259.0
DRY WEIGHT (GM)	225.8	225.8
MOISTURE CONTENT (%)	4.5	14.7
AVE. LENGTH (IN)	1.732	1.715
AVE DIAMETER (IN)	2.378	2.314
Vt (CU. FT)	4.45E-03	4.17E-03
Vw (CU. FT)	3.59E-04	1.17E-03
Vs (CU. FT)	2.96E-03	2.96E-03
Va (CU. FT)	1.14E-03	4.64E-05
Vv (CU.FT)	1.50E-03	1.22E-03
s Degree of saturation %	24.0	96.2
DRY DENSITY (PCF)	111.7	119.2
e (VOID RAITO)	0.51	0.41
n (POROSITY)	33.6	29.2
"B" PARAMETER	0.95	
BACK PRESSURE (PSI)	29	
EFFECTIVE PRESSURE (PSI)	20.3	
PERMEABILITY (cm/sec)	4.67E-04	

NOTES :

1) A 0.005N SOLUTION OF $CaSO_4$ WAS USED AS PERMEANT
2) POROSITY WAS BASED ON A SPECIFIC GRAVITY OF 2.7

BSK
Associates: 1415 Tuolumne Street. Fresno, CA. 93706- PH: (559) 497-2868 Fax: (559) 485-1863

HYDAULIC CONDUCTIVITY TEST
CONSTANT HEAD METHOD- ASTM D-2434

REPORT DATE: 5/20/2009

BSK PROJECT NAME: Big Dry Creek Dam
BSK PROJECT NO.: G0811911F

Sample I.D.: P1-C @ 10'
Visual Classification: Sand w/ a Trace of Silt and Clay (SP/SM), Orange Brown, Fine to Coarse Grained Trace of Fine Gravel
Sampled By: N. Shwiyhat
Sample Date: 2/5/2009
Tested By: N. Shwiyhat
Test Date: 5/6/2009

Density Determination:

Diameter, cm:	**6.12**
Tube & Soil Gross wt., gm	1029.6
Tube wt., gm	258.8
Wet Soil wt., gm	**770.8**
Tube Length, cm	15.24
Tare Length,cm	2.69
Sample Length,cm	12.55
Dry Density, g/cm^3	**1.86**

Moisture Detrmination:

Pan + Wet Soil wt., gm	**127.0**
Pan wt., gm	**0.0**
Pan + dry wt., gm	**113.2**
% moisture Content:	12.2

Dry Density, pcf **116.1**

Hyraulic Conductivity Specimen:

Diameter, cm	**6.12**
Tube Length, cm	**15.24**
Tare Length, cm	**2.69**
Specimen Length (L), cm	12.55

Area (A), cm^2: 29.43

Trial Number	Constant Head, h, cm	Elapsed Time, t (s)	Outflow Volume Q, cm^3	Water Temp., T, °C	K_T	K_{20}
1	40.64	300	62.0	23.0	2.17E-03	2.02E-03
2	40.64	300	59.0	23.0	2.06E-03	1.92E-03
3	40.64	300	63.0	23.0	2.20E-03	2.00E-03
4	40.64	300	54.0	23.0	1.89E-03	1.72E-03
Average Hydraulic Conductivity, cm/sec					**1.92E-03**	

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HYDAULIC CONDUCTIVITY TEST
CONSTANT HEAD METHOD- ASTM D-2434

REPORT DATE: 5/20/2009

BSK PROJECT NAME: Big Dry Creek Dam
BSK PROJECT NO.: G0811911F

Sample I.D.: P1-D @ 9.5'
Visual Classification: Sand w/ a Trace of Silt and Clay (SP/SM), Red Brown, Fine to Medium Grained Trace of Fine Gravel
Sampled By: N. Shwiyhat — Tested By: N. Shwiyhat
Sample Date: 2/9/2009 — Test Date: 5/18/2009

Density Determination:

Diameter, cm:	**6.12**
Tube & Soil Gross wt., gm	629.7
Tube wt., gm	246.7
Wet Soil wt., gm	**383.0**
Tube Length, cm	15.24
Tare Length,cm	9.02
Sample Length,cm	6.22
Dry Density, g/cm^3	**1.78**

Moisture Detrmination:

Pan + Wet Soil wt., gm	**94.5**
Pan wt., gm	**0.0**
Pan + dry wt., gm	**80.3**
% moisture Content:	17.6

Dry Density, pcf **110.9**

Hyraulic Conductivity Specimen:

Diameter, cm	**6.12**
Tube Length, cm	**15.24**
Tare Length, cm	**10.41**
Specimen Length (L), cm	4.83

Area (A), cm^2: 29.43

Trial Number	Constant Head, h, cm	Elapsed Time, t (s)	Outflow Volume Q, cm^3	Water Temp., T, °C	K_T	K_{20}
1	40.64	90	77.5	23.0	3.47E-03	3.24E-03
2	40.64	90	75.0	23.0	3.36E-03	3.13E-03
3	40.64	90	75.0	23.0	3.36E-03	3.06E-03
4	40.64	90	72.0	23.0	3.23E-03	2.94E-03
Average Hydraulic Conductivity, cm/sec					**3.09E-03**	

BSK Associates
Engineers & Laboratories
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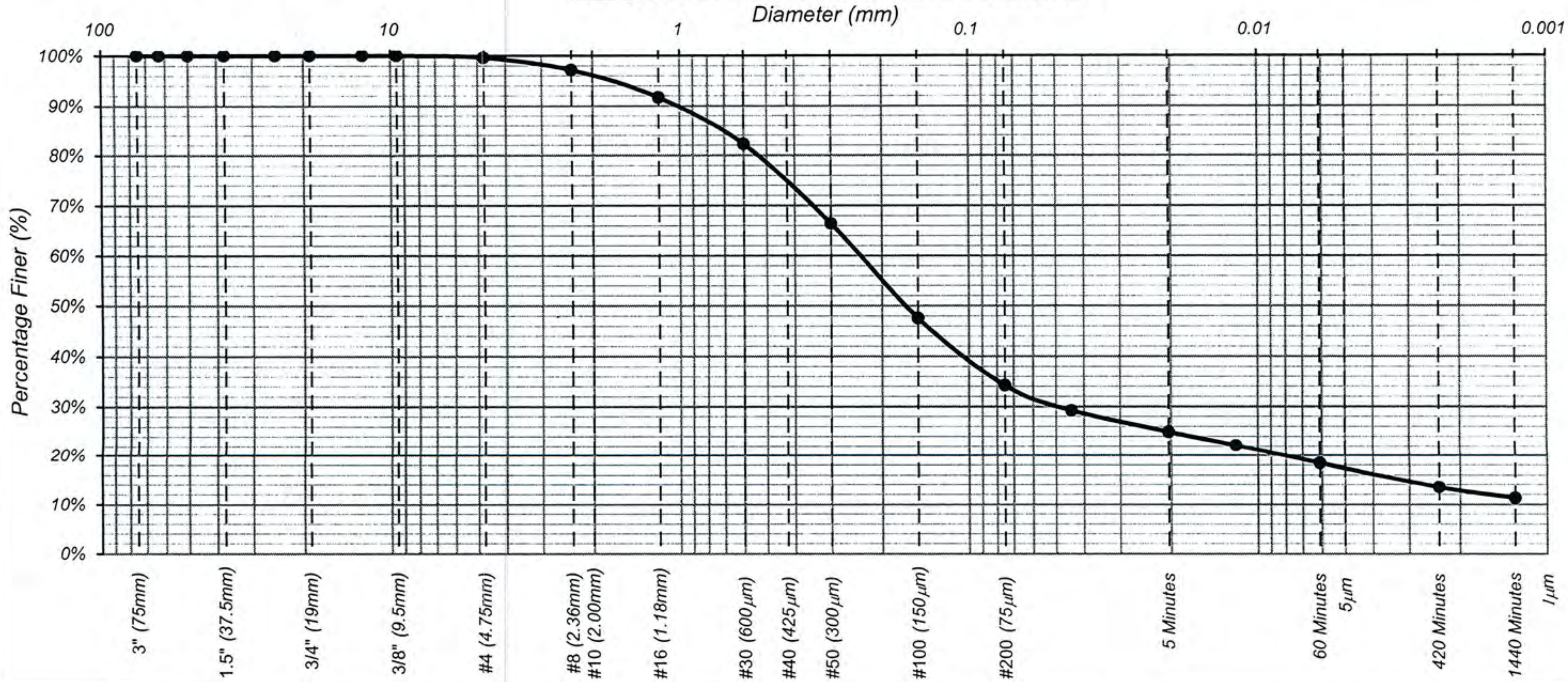
FIGURE #

Gradation Analysis Report
ASTM D-422 / ASTM C-136

Project Name:	Big Dry Creek Dam	**Project Number:**	G0811911F	**Report Date:**	05/20/09
Sample Location:	P6-A/B @ 10'	**Sample Lab ID:**	F09-185	**Sample Date:**	02/11/09
Sample Description:	Silty Sand / Clayey Sand (SM/SC), Yellow Brown, Fine to Medium w/ Trace of Coarse Grained			**Test Date:**	05/13/09

Particle Size Distribution Diagram



Clear Square Openings (ASTM C-136)			US Standard Series (ASTM D-422)			Hydrometer Readings (ASTM D-422)
Cobble	Gravel		Sand			Silt (Non-Plastic) to Clay (Plastic)
	Coarse	Fine	Coarse	Medium	Fine	

% Gravel = 0% **% Sand = 65%** **% Silt = 17%** **% Clay = 17%**

Reviewed By:______________

Approved By:______________

BSK Associates Engineers & Laboratories

Gradation Analysis Report
ASTM D-422 / ASTM C-136

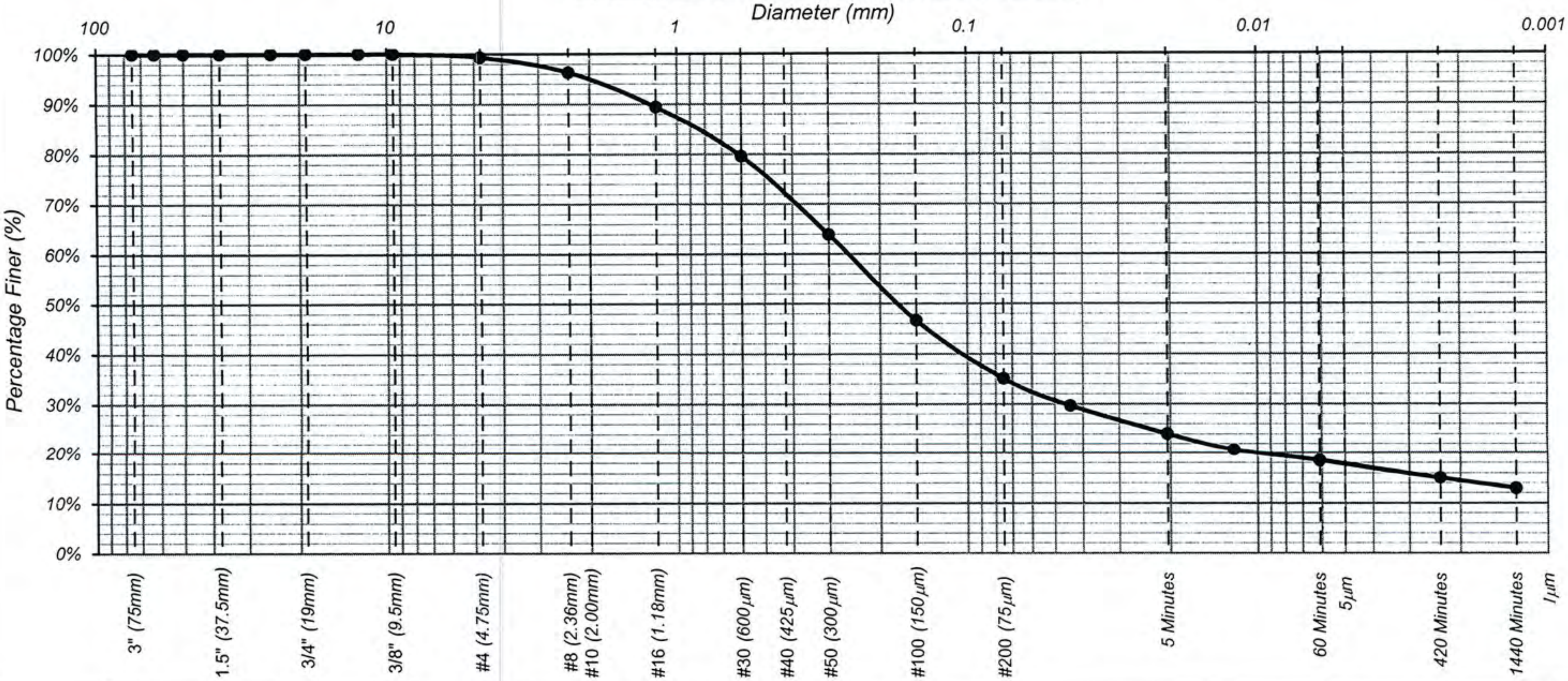
FIGURE #
1415 Tuolumne St.
Fresno, CA 93706
Ph: (559) 497-2868
Fax: (559) 485-6140

Project Name: Big Dry Creek Dam
Project Number: G0811911F
Report Date: 05/20/09

Sample Location: P6-A/B @ 20'
Sample Lab ID: F09-185
Sample Date: 02/11/09

Sample Description: Silty Sand / Clayey Sand (SM/SC), Olive Brown, Fine to Medium w/ Trace of Coarse Grained
Test Date: 05/11/09

Particle Size Distribution Diagram



Clear Square Openings (ASTM C-136)			US Standard Series (ASTM D-422)			Hydrometer Readings (ASTM D-422)
Cobble	Gravel		Sand			Silt (Non-Plastic) to Clay (Plastic)
	Coarse	Fine	Coarse	Medium	Fine	

% Gravel = 1% **% Sand = 64%** **% Silt = 18%** **% Clay = 17%**

Reviewed By:__________

Approved By:__________

BSK Associates
Engineers & Laboratories

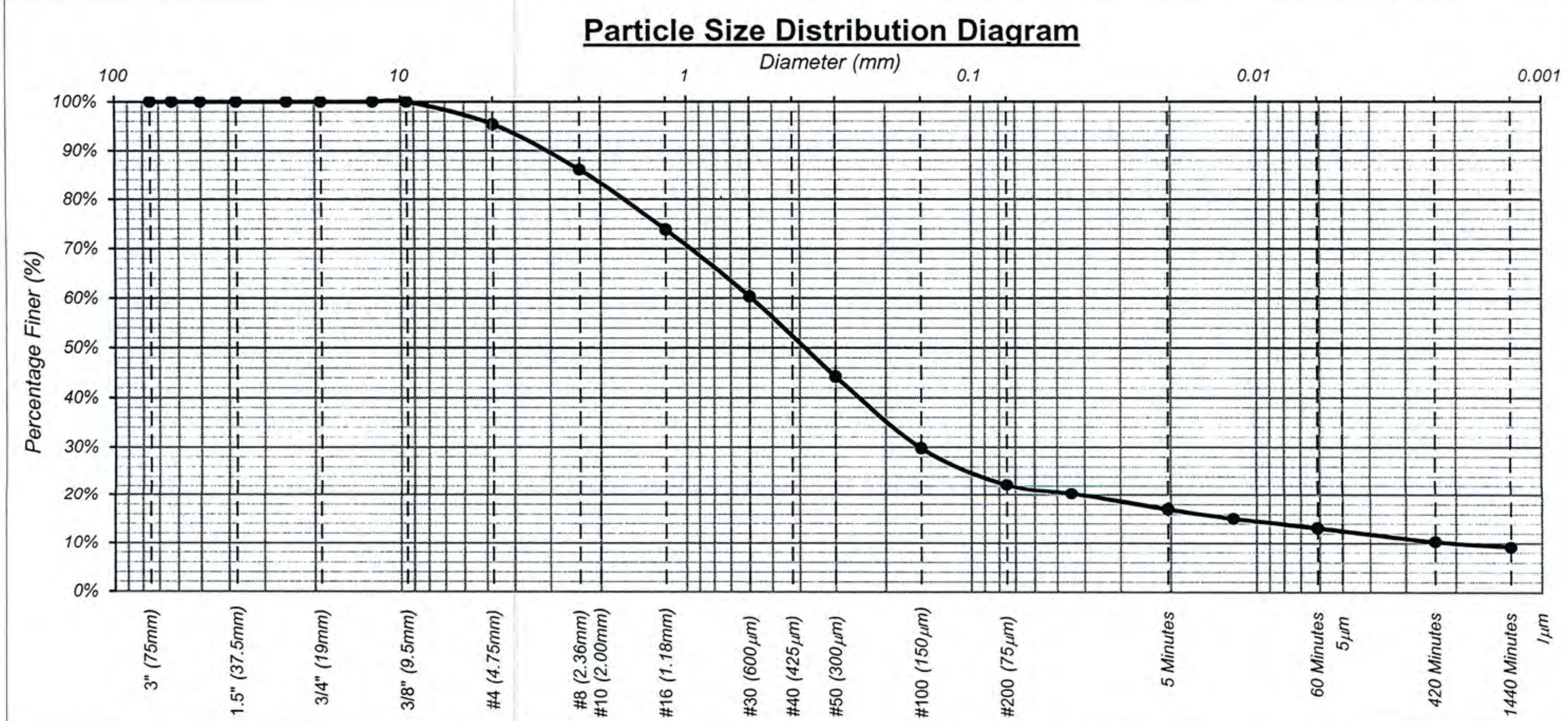
Gradation Analysis Report
ASTM D-422 / ASTM C-136

FIGURE #
1415 Tuolumne St.
Fresno, CA 93706
Ph: (559) 497-2868
Fax: (559) 485-6140

Project Name: Big Dry Creek Dam
Project Number: G0811911F
Report Date: 05/20/09

Sample Location: P6-A/B @ 45'
Sample Lab ID: F09-185
Sample Date: 02/11/09

Sample Description: Clayey Sand (SC), Red Brown, Fine to Coarse w/ a Trace of Fine Gravel
Test Date: 05/13/09



Clear Square Openings (ASTM C-136)			US Standard Series (ASTM D-422)			Hydrometer Readings (ASTM D-422)
Cobble	Gravel		Sand			Silt (Non-Plastic) to Clay (Plastic)
	Coarse	Fine	Coarse	Medium	Fine	

% Gravel = 5% **% Sand = 73%** **% Silt = 10%** **% Clay = 12%**

Reviewed By:____________

Approved By:____________

BSK Associates
Engineers & Laboratories

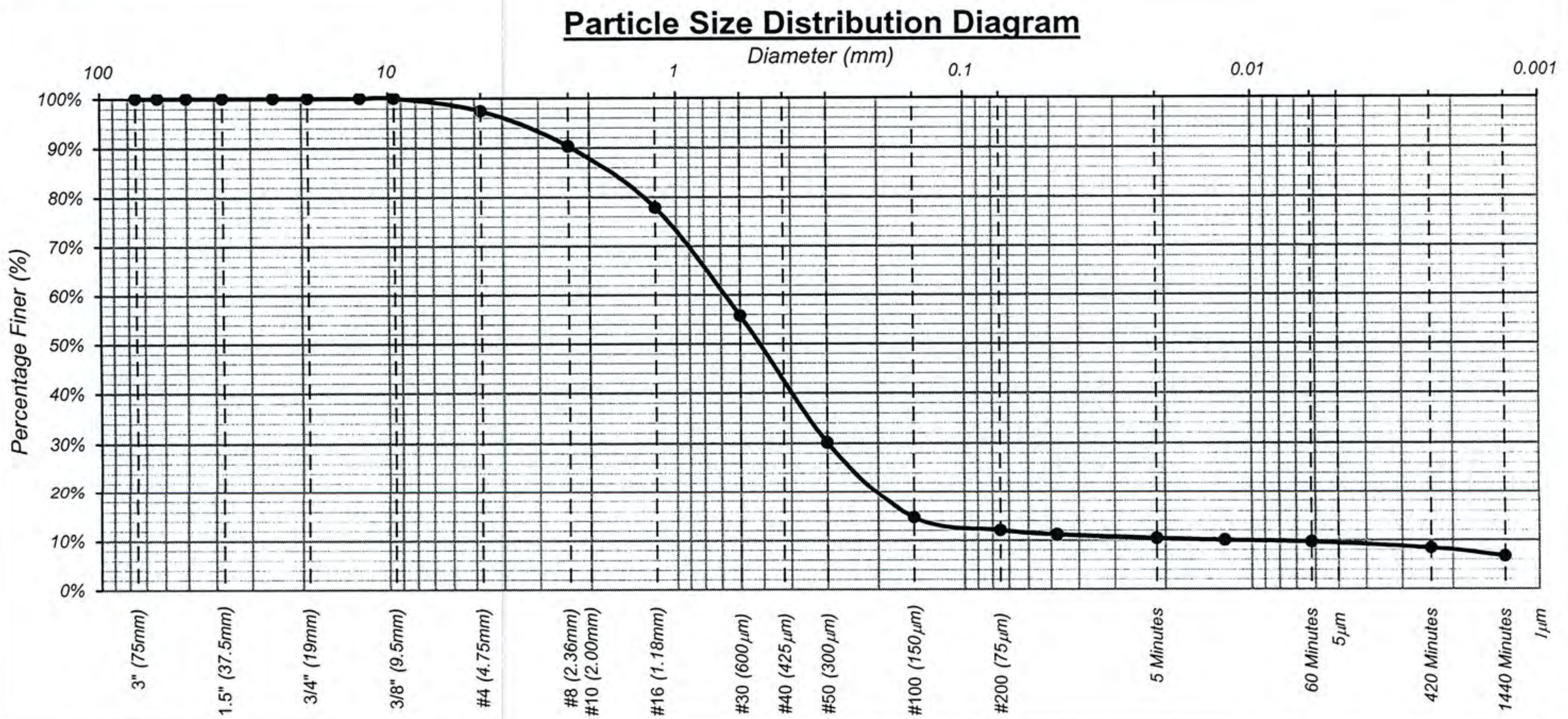
Gradation Analysis Report
ASTM D-422 / ASTM C-136

FIGURE #
1415 Tuolumne St.
Fresno, CA 93706
Ph: (559) 497-2868
Fax: (559) 485-6140

Project Name: Big Dry Creek Dam
Project Number: G0811911F
Report Date: 05/20/09

Sample Location: P6-A/B @ 54.5'
Sample Lab ID: F09-185
Sample Date: 02/11/09

Sample Description: Sand w/ a Trace of Clay (SP/SC), Red Brown, Fine to Coarse w/ a Trace of Fine Gravel
Test Date: 05/13/09



Clear Square Openings (ASTM C-136)			US Standard Series (ASTM D-422)			Hydrometer Readings (ASTM D-422)
Cobble	Gravel		Sand			Silt (Non-Plastic) to Clay (Plastic)
	Coarse	Fine	Coarse	Medium	Fine	

% Gravel = 3% **% Sand = 85%** **% Silt = 3%** **% Clay = 9%**

Reviewed By:______________

Approved By:______________

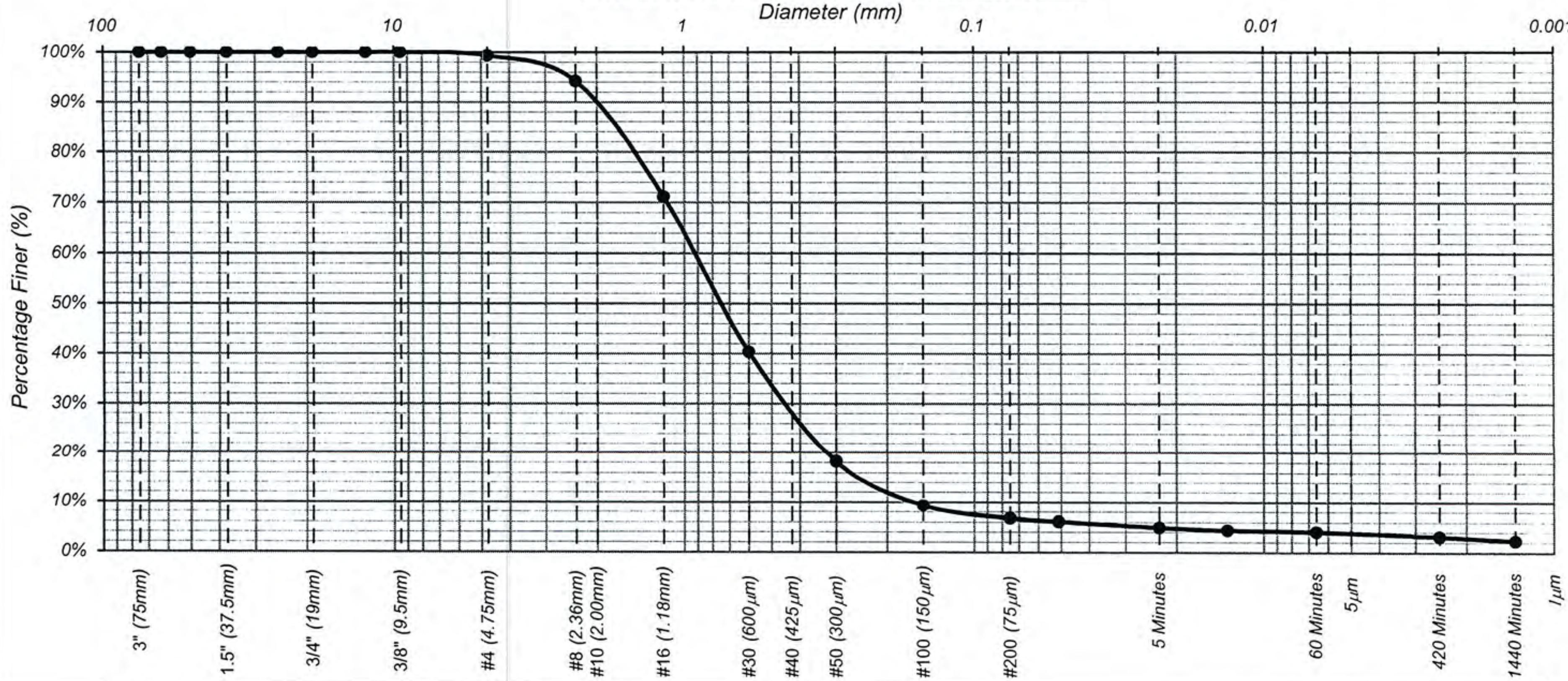
BSK Associates
Engineers & Laboratories

Gradation Analysis Report
ASTM D-422 / ASTM C-136

FIGURE #
1415 Tuolumne St.
Fresno, CA 93706
Ph: (559) 497-2868
Fax: (559) 485-6140

Project Name:	Big Dry Creek Dam	**Project Number:**	G0811911F	**Report Date:**	05/22/09
Sample Location:	P6-D @ 15'	**Sample Lab ID:**	F09-185	**Sample Date:**	02/03/09
Sample Description:	Sand w/ Trace of Silt and Clay (SP/SM), Red Brown, Fine to Coarse Grained			**Test Date:**	05/21/09

Particle Size Distribution Diagram



Clear Square Openings (ASTM C-136)			US Standard Series (ASTM D-422)			Hydrometer Readings (ASTM D-422)
Cobble	Gravel		Sand			Silt (Non-Plastic) to Clay (Plastic)
	Coarse	Fine	Coarse	Medium	Fine	

% Gravel = 1%	**% Sand = 93%**	**% Silt = 3%**	**% Clay = 4%**

Reviewed By:_______________ Approved By:_______________

Workplan Piezometer
Installations
Big Dry Creek Dam
Fresno Metropolitan Flood
Control District

BSK Job No. G0811911F

November 10, 2010

Prepared for:

Jerry Lakeman, P.E.
District Engineer
Fresno Metropolitan Flood Control District
5469 E. Olive
Fresno, California 93727

BSK

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November 10, 2010

BSK No. G0811911F

Jerry Lakeman, P.E.
District Engineer
Fresno Metropolitan Flood Control District
5469 E. Olive
Fresno, CA 93727

SUBJECT: Workplan Piezometer Installations
Big Dry Creek Dam
Fresno Metropolitan Flood Control District

Dear Jerry:

In response to our meeting of October 5, 2010, we are submitting at your request, our workplan for the installation of piezometers for the monitoring of seepage along the south embankment of Big Dry Creek Dam.

PIEZOMETER INSTALLATION

We propose the installation of piezometer clusters at four locations along the designated south embankment. The piezometer stations are proposed in the areas of higher embankment depths in the westerly 7,000 feet, from Station 140+00 to Station 214+00. Cluster will consist of either two or four piezometer. Piezometers "A" and "B" will be installed at the embankment crest in a common 10-inch diameter boring. Piezometer "A" will extend through the embankment and terminate at the foundation contact. Piezometer "B" will extend to a maximum depth of 20 feet below foundation contact or to weathered rock surface. Where applicable, piezometers "C" and "D" will be installed into individual 8-inch diameter borings at a depth of 20 feet. This network of piezometers will serve to monitor seepage and groundwater elevation rise during storm water impoundments.

Figures 2, 3 and 4 provide typical construction details for the various piezometers. Figures 5 through 7 provide general profiles and embankment configurations for the proposed piezometer locations. Projected depths of piezometers are approximate and will be determined in the field based on the depth of embankment and underlying foundation soil profile established during drilling.

Drilling for the installation of piezometers will be performed by BSK. A BK-81 truck-mounted drill rig equipped with 8 and 10-inch diameter hollow-stem augers will be used.

ELEVATION SURVEY AND STAKING
Staking for piezometer installation will be necessary in accordance with the current USACE stationing system. At completion of piezometer installations, the top rim of each piezometer pipe will be surveyed to establish elevations in reference to the USACE benchmark for the dam. The survey work will be subcontracted.

FEE ESTIMATES
We have estimated that the fee for the construction of the piezometer network described in this workplan will comprise the following elements:

Piezometers "A" and "B". 3 sets of 2 piezometers at $8,800.00 per set:	$26,400.00
Piezometers "C" and "D". 2 sets of 2 piezometers at $7,800.00 per set:	$15,600.00
Elevation surveys (Subcontract Blair Church & Flynn) Lump Sum:	$5,600.00
ESTIMATED TOTAL	***$47,600.00**

**Reporting and engineering evaluation charges are not included in this estimate. Services will be provided on a time and materials basis in accordance with our 2010 Fee Schedule.*

SCHEDULE
The following schedule is anticipated for the installation of the piezometer network:

Staking for piezometer locations, mobilization of drill rig	5 working days
Piezometers "A" and "B"	7 working days
Piezometers "C" and "D"	4 working days
ESTIMATED TOTAL	**16 working days**

This workplan is presented for your review and evaluation. We are prepared to meet with you and discuss the various elements of the plan.

The opportunity to be of service on this project is appreciated.

Respectfully submitted
BSK Associates

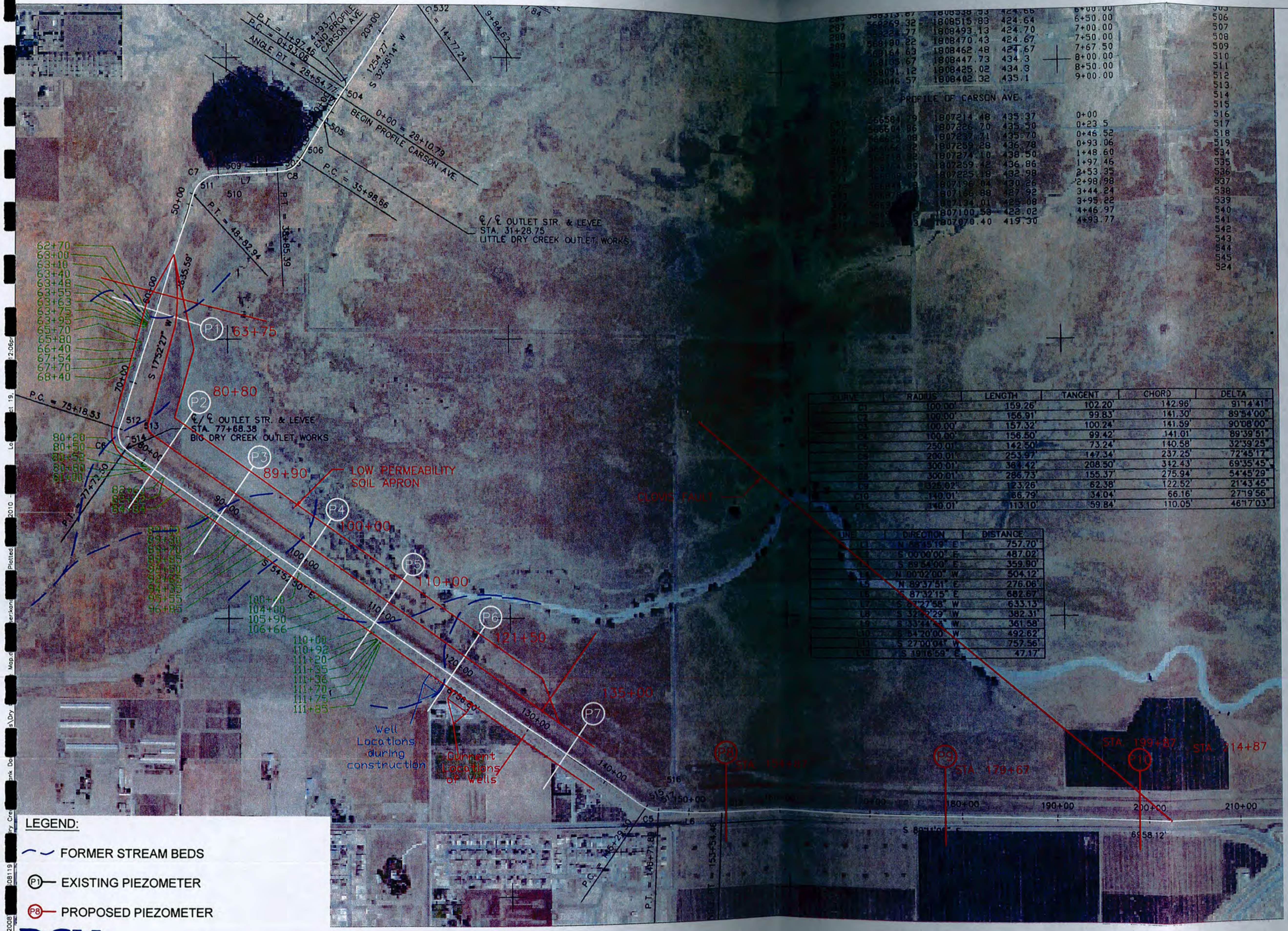
Hugo Kevorkian
Senior Principal Geotechnical Engineer
CE16350
GE462
REAII 20080

REGISTERED PROFESSIONAL ENGINEER
HUGO KEVORKIAN
No. 462
Exp. 06.30.11
GEOTECHNICAL
STATE OF CALIFORNIA

HK:jam

Distribution: Client (3 originals)
BSK File (1 original)

Cc: Bob Van Wyk

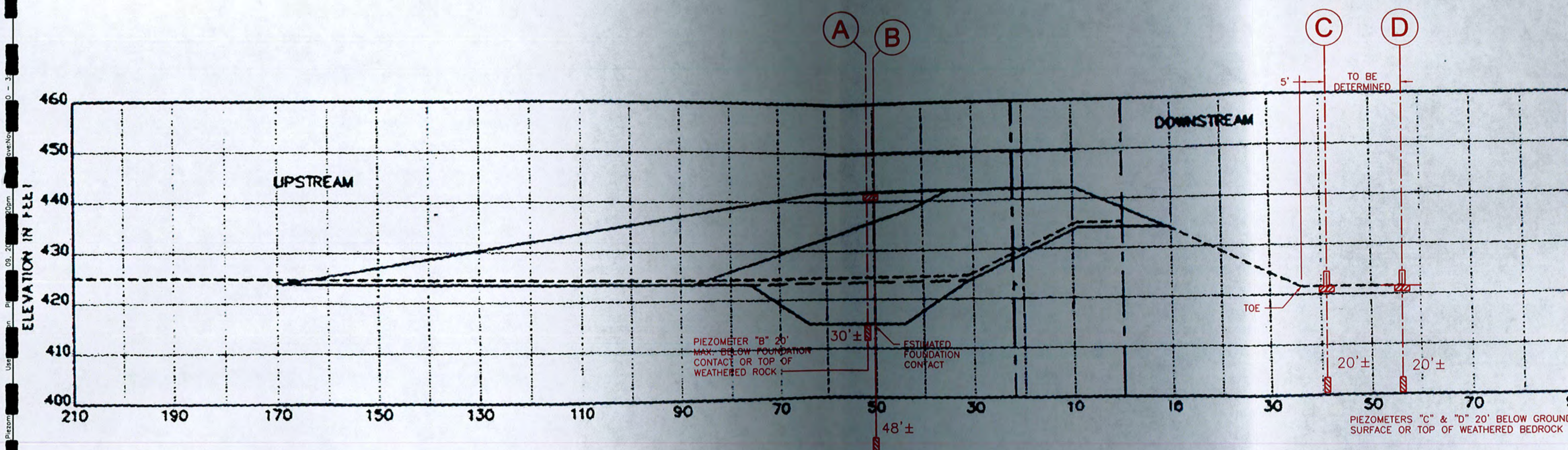


G08-119-11F
JUNE 2010
FIGURE 1

SITE MAP
Big Dry Creek Dam
Fresno County, California

BSK

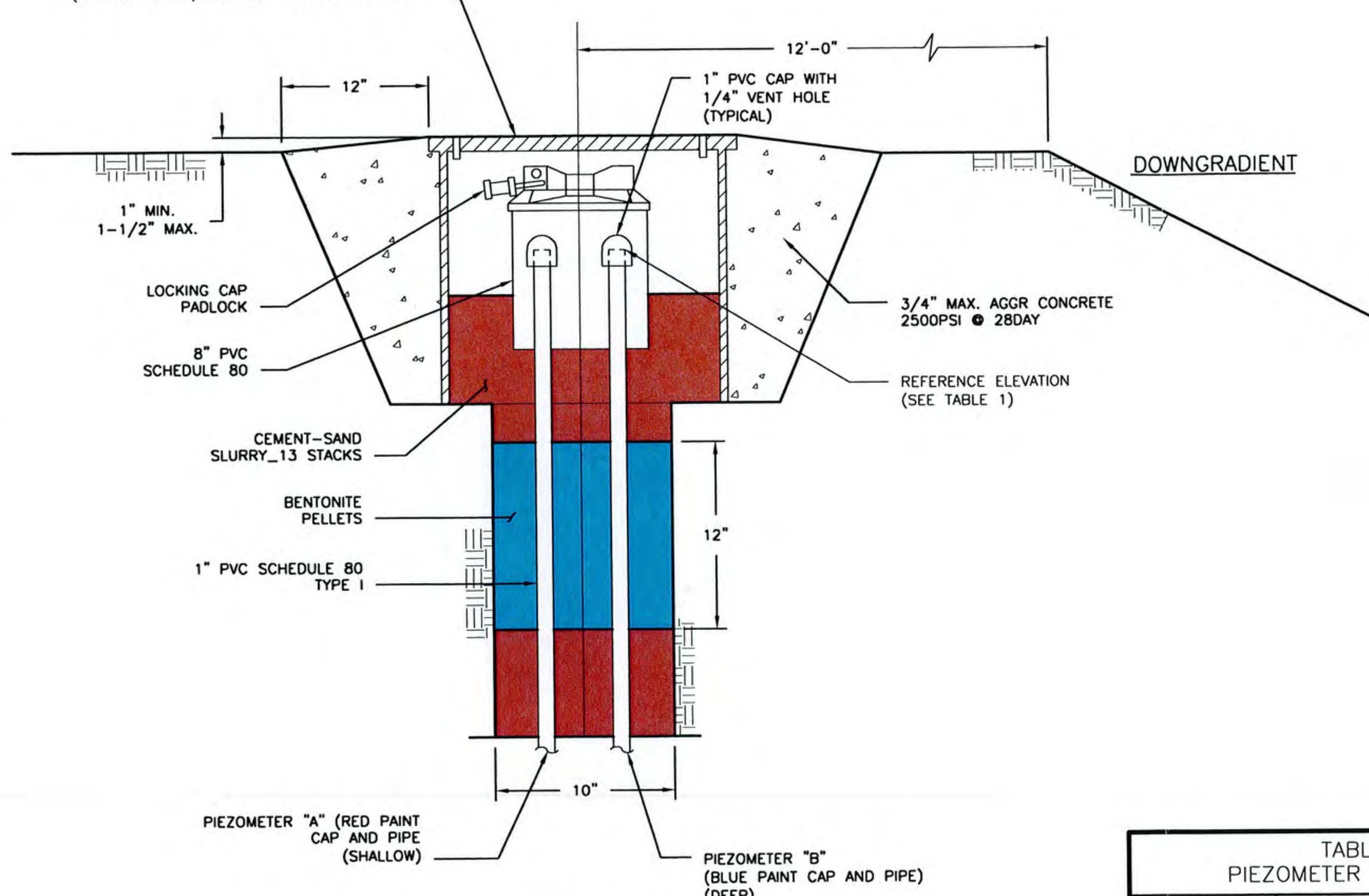
G08-119-11F
OCTOBER 2010
FIGURE 2



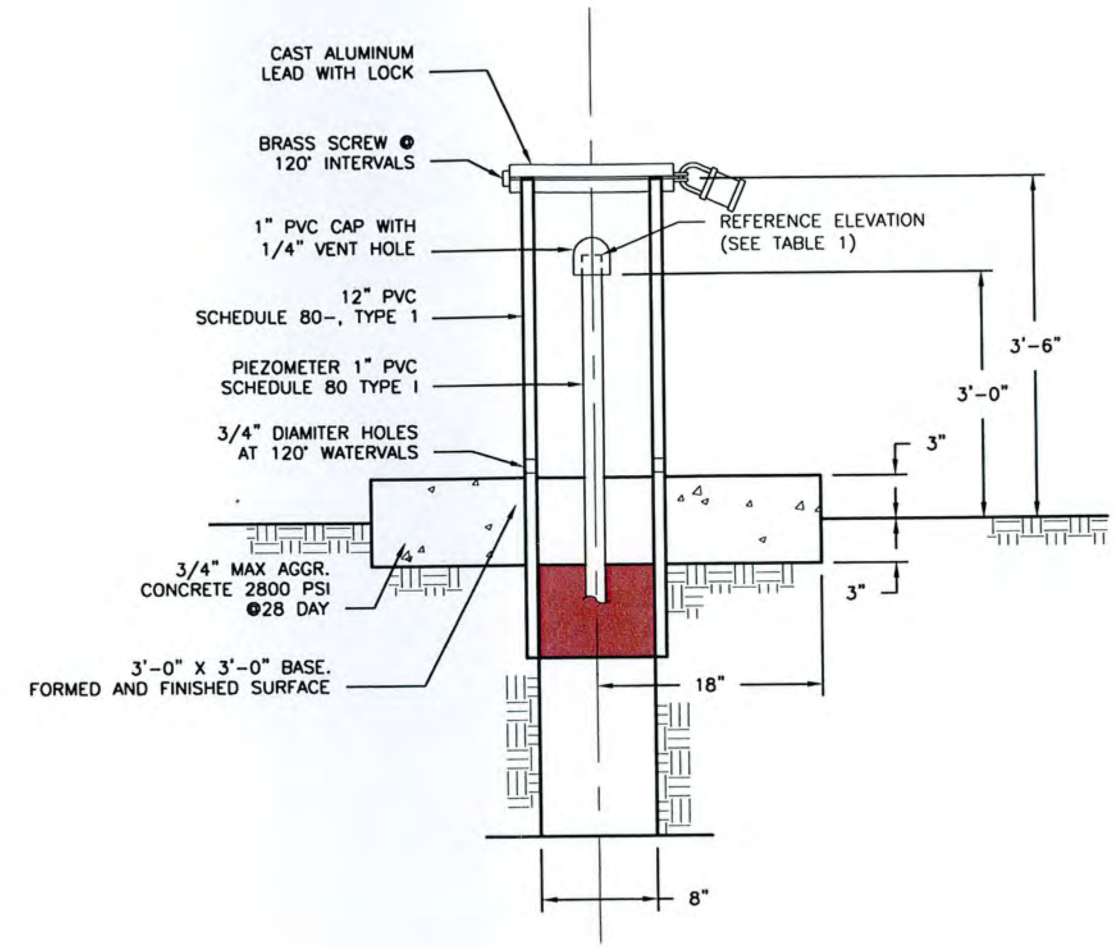
BSK

DETAIL DRAWING OPEN TUBE-TYPE PIEZOMETER

Big Dry Creek Dam
Fresno County, California



DETAIL "A"
PIEZOMETER VAULT
AT EMBANKMENT CREST
PIEZOMETER "A" & "B"



DETAIL "B"
PIEZOMETER PROTECTIVE COVER
PIEZOMETERS "C" & "D"
AT EMBANKMENT TOE AREA

LEGEND:

- BENTONITE PELLETS
- 13. SACK CEMENT-SAND GROUT (TREMIED)
- PERMEABLE MATERIAL. CALTRANS CLASS I, TYPE 'A' (SECTION 6B-1.025)

TABLE 1
PIEZOMETER ELEVATIONS

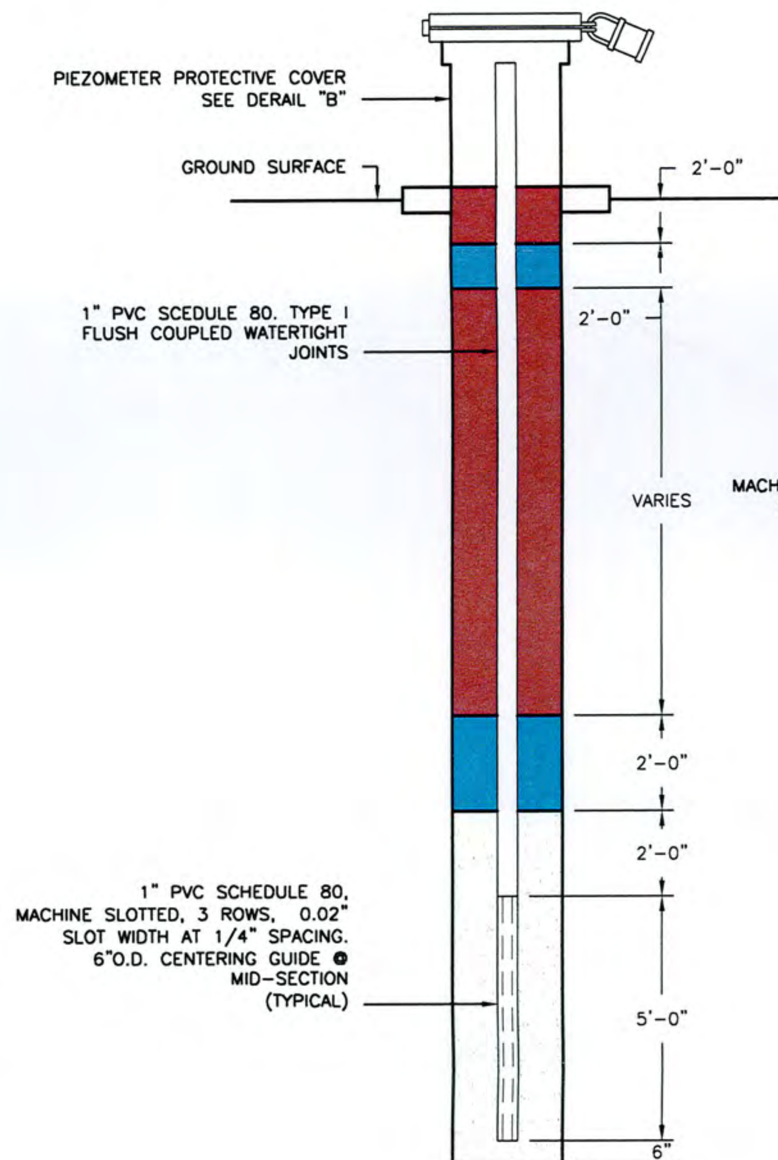
PIEZOMETER STATION	PIEZOMETER ELEVATIONS Ⓐ	Ⓑ	Ⓒ	Ⓓ
P8				
P9				
P10				

BSK

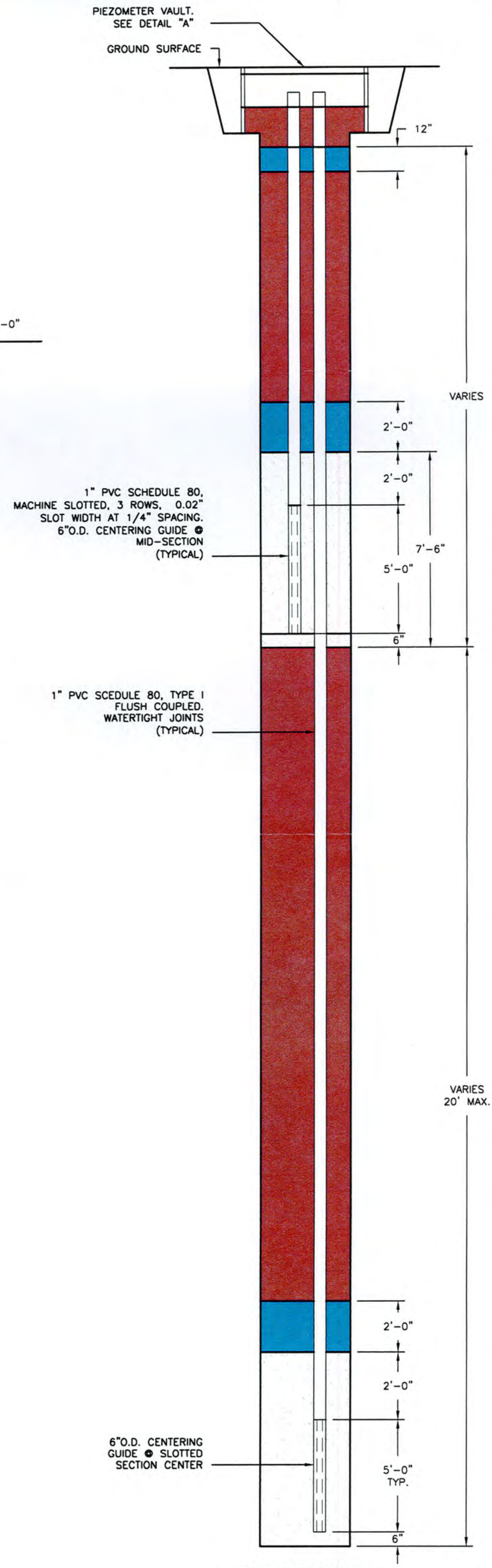
DETAIL DRAWINGS OPEN TUBE-TYPE PIEZOMETERS

Big Dry Creek Dam
Fresno County, California

G08-119-11F
OCTOBER 2010
FIGURE 4



PIEZOMETERS "C" & "D"



DOUBLE PIEZOMETER INSTALLATION
PIEZOMETERS "A" & "B"

LEGEND:

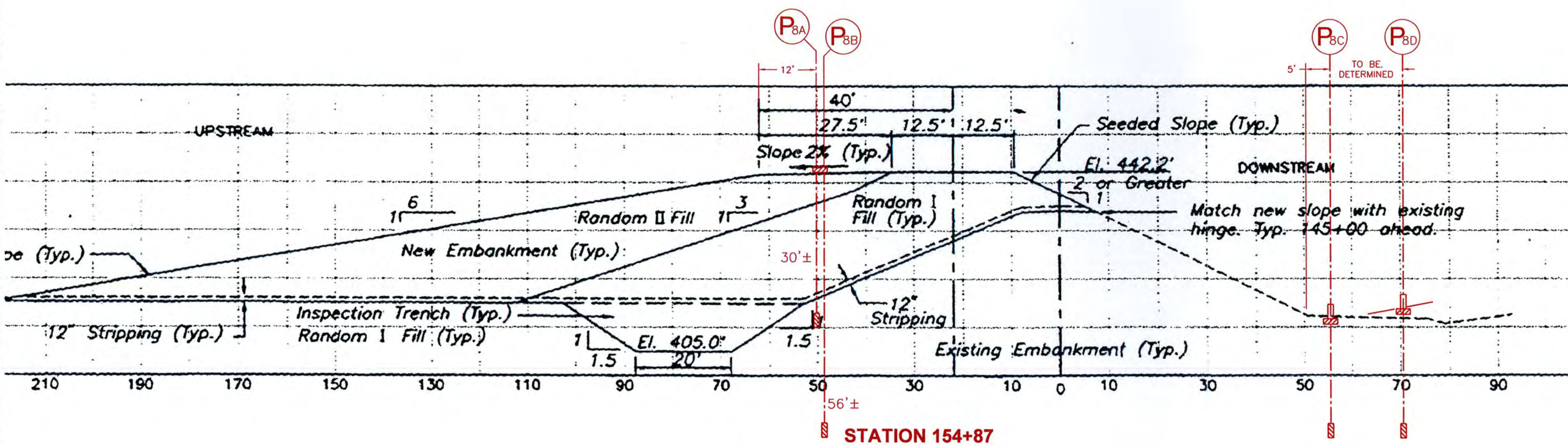
- BENTONITE PELLETS
- 13. SACK CEMENT-SAND GROUT (TREMIED)
- PERMEABLE MATERIAL. CALTRANS CLASS I, TYPE 'A' (SECTION 6B-1.025)

DETAIL DRAWINGS
OPEN TUBE-TYPE PIEZOMETERS

Big Dry Creek Dam
Fresno County, California

BSK

G08-119-11F
OCTOBER 2010
FIGURE 5



REFERANCE:

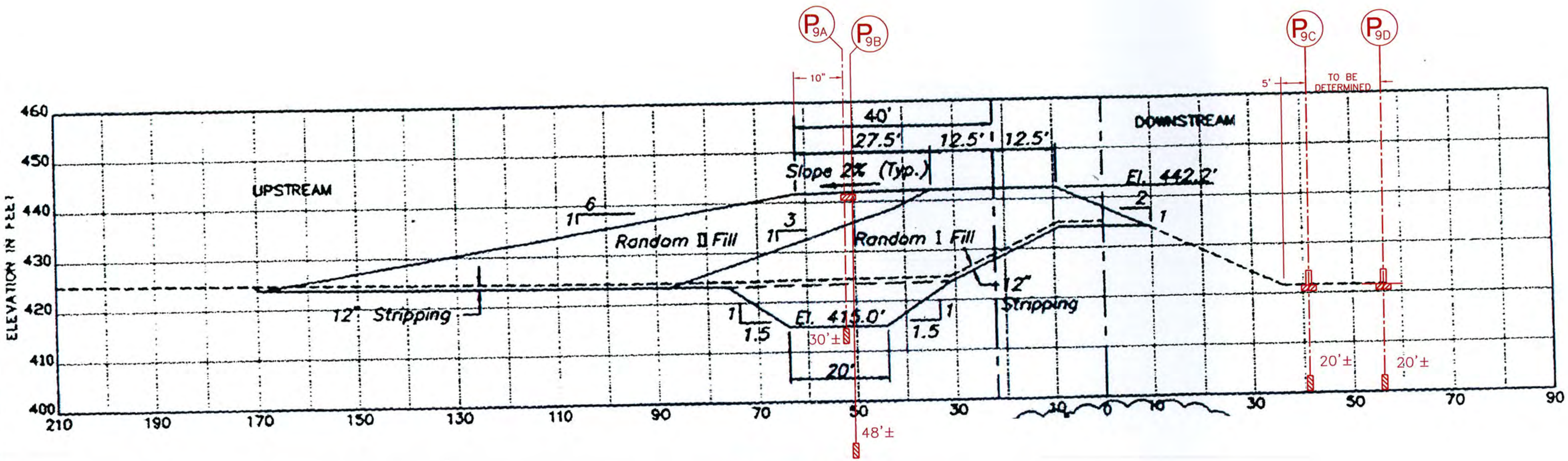
USCE PROFILE 154+87.076 "AS-BUILT"

BSK

CROSS SECTIONS PIEZOMETER INSTALLATIONS

Big Dry Creek Dam
Fresno County, California

G08-119-11F
OCTOBER 2010
FIGURE 6



STATION 179+67

REFERANCE:

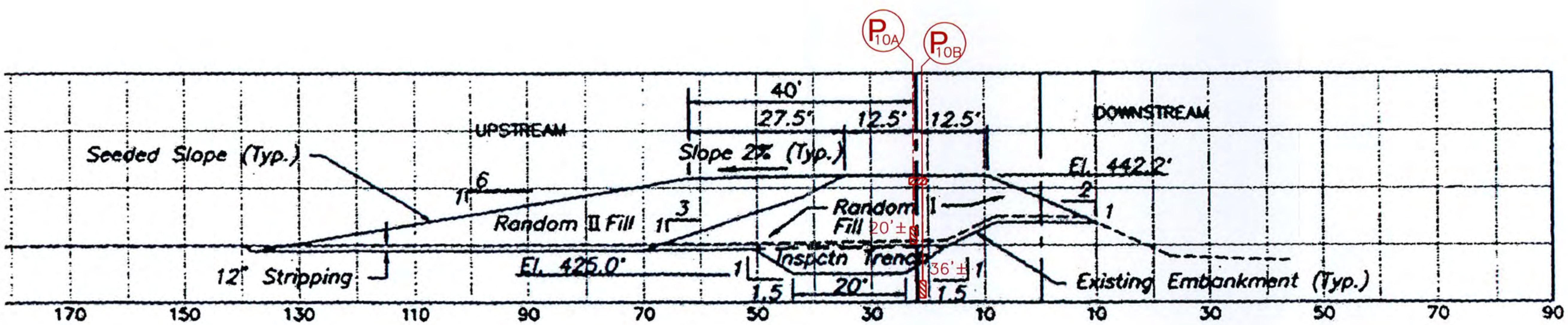
USCE PROFILE 479+67.076 "AS-BUILT"

BSK

CROSS SECTIONS PIEZOMETER INSTALLATIONS

Big Dry Creek Dam
Fresno County, California

G08-119-11F
OCTOBER 2010
FIGURE 7



STATION 199+87

REFERANCE:

USCE PROFILE 214+87.076 "AS-BUILT"

BSK

CROSS SECTIONS PIEZOMETER INSTALLATIONS

Big Dry Creek Dam
Fresno County, California

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VIA U.S. MAIL & EMAIL
jerryl@fresnofloodcontrol.org

November 10, 2010

BSK No. G0811911F

Jerry Lakeman, P.E.
District Engineer
Fresno Metropolitan Flood Control District
5469 E. Olive
Fresno, California 93727

SUBJECT: Seepage Control Alternatives
Big Dry Creek Dam
Fresno Metropolitan Flood Control District
Contract No. BDR-18

Dear Jerry:

In response to our meeting of October 5, 2010, we are submitting our evaluations of alternatives for seepage control along the northwesterly segment of Big Dry Creek Dam, specifically from Station 60+00 to Station 130+00. These evaluations consist of a more detailed presentation of evaluations contained in our June 10, 2010 letter for the same and include schematic illustrations of the seepage control features. As previously stated, the estimates associated with the various alternatives are "order-of-magnitude" costs for construction. More detailed estimates will require field exploration, topographic surveying and civil engineering layout and design of the selected option.

Two cases are considered for the reservoir usage. Case 1 would allow customary flood control impoundment and temporary storage. Case 2 would provide for extended storage for water resources management in favorable water years. The following alternatives are considered:

SEEPAGE MITIGATION ALTERNATIVES
BIG DRY CREEK DAM
STATIONS 60+00 TO 130+00

Case 1	**No Water Impoundment/Storage**	
Alternative 1	Landside (downgradient) toe drain extension 12 to 15 feet deep, Stations 60+00 to 130+00 (see Figure 1)	$1,000,000
Alternative 2	300 feet wide waterside (upgradient) soil apron, soil obtained from within reservoir Stations 60+00 to 130+00 (see Figure 2)	$1,200,000
Alternative 3	300 feet wide waterside (upgradient) soil apron, soil obtained from basin BX, Stations 60+00 to 130+00 (see Figure 2)	$2,000,000

Case 2	**Sustained Water Impoundment/Storage**	
Alternative 4	Landside (downgradient) toe drain extension 12 to 15 feet deep, Stations 60+00 to 130+00 and 300 feet wide water side soil apron (upgradient), soils obtained from Basin "BX" (see Figure 3)	$3,000,000
Alternative 5	Landside (downgradient) toe drain extension 12 to 15 feet deep, Stations 60+00 to 130+00 and 300 feet wide water side soil apron (upgradient), soil obtained from reservoir (see Figure 3)	$2,200,000
Alternative 6	Deep waterside (upgradient) slurry trench cut-off extension to bedrock (bentonite slurry or concrete), Station 60+00 to 130+00 (see Figure 4)	$13,000,000
Alternative 7	Landside (Downgradient) toe drain extension 12 to 15 feet deep, 150 feet waterside (downgradient) and landside (upgradient) soil apron (see Figure 5)	$2,400,000

For Case 1, the alternative of constructing a landside (downgradient) apron has not been included at this time because of the interference the five foot thick apron would create with the existing toe drain. Acquisition of additional property would also be necessary. For Case 2, adjustments in the construction of the toe drain extension can be made to accommodate the apron.

For Case 2, Alternatives 4, 5 and 7, the combined utilization of soil aprons and toe drain extension is recommended to provide a more effective control of seepage. The placement of a perforated drain and pump sumps in the toe drain extension is intended to provide an added level of control should it become necessary. Portable pumps and generators would be used to meet short term needs. Permanent installations could be provided for extended needs.

Case 2, Alternative 6, the waterside (upgradient) slurry trench offers the more positive seepage control, providing the cutoff extends to bedrock. Partial depth cutoff is inefficient and serves to little benefit. Exploratory drilling along the cutoff alignment will be necessary to establish depth to bedrock. For these "order-of-magnitude" estimates, an average depth of 25 feet was used.

The implementation of a chosen alternative will require a geotechnical engineering investigation comprising mainly 1) subsurface exploratory drilling and some laboratory analyses and 2) a more detailed development of design parameters for the civil engineer's use in the preparation of construction plans and specifications.

Aside from Case 2, Alternative 6 (Slurry Trench), from a seepage mitigation efficiency perspective, Case 1, Alternative 1 and Case 2, Alternatives 4 and 5 are the more effective choices based on seepage exit gradient magnitudes and extent beyond the toe of the dam.

We are prepared to meet with you and answer questions to assist you in formulating the choice of alternative. Following the above, we will submit a proposal with estimates of charges and a more detail scope of services. Our standard agreement for geotechnical engineering design services will be submitted for approval and signature.

Respectfully submitted
BSK Associates

Hugo Kevorkian
Principal Geotechnical Engineer
CE16350
GE462
REAII 20080

HK:jam

Distribution: Client (3 originals)
BSK File (1 original)

Cc: Bob Van Wyk

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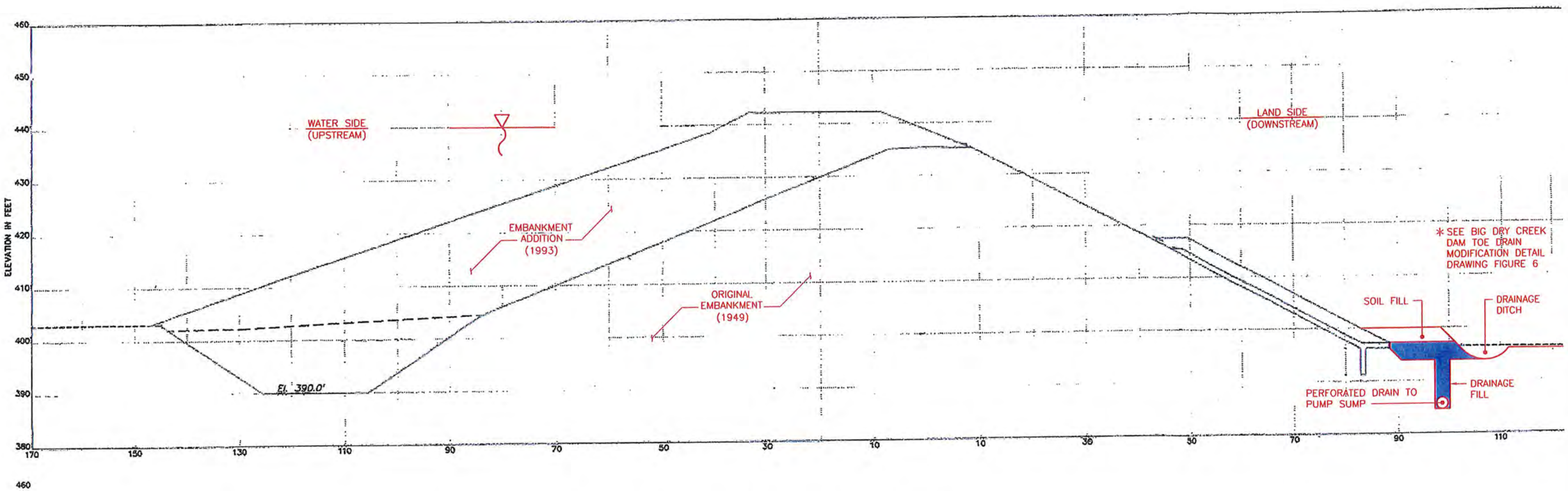
G08-119-11F
OCTOBER 2010
FIGURE 1



LANDSIDE (DOWNGRADIENT) TOE DRAIN 12 TO 15 FEET DEEP (1)

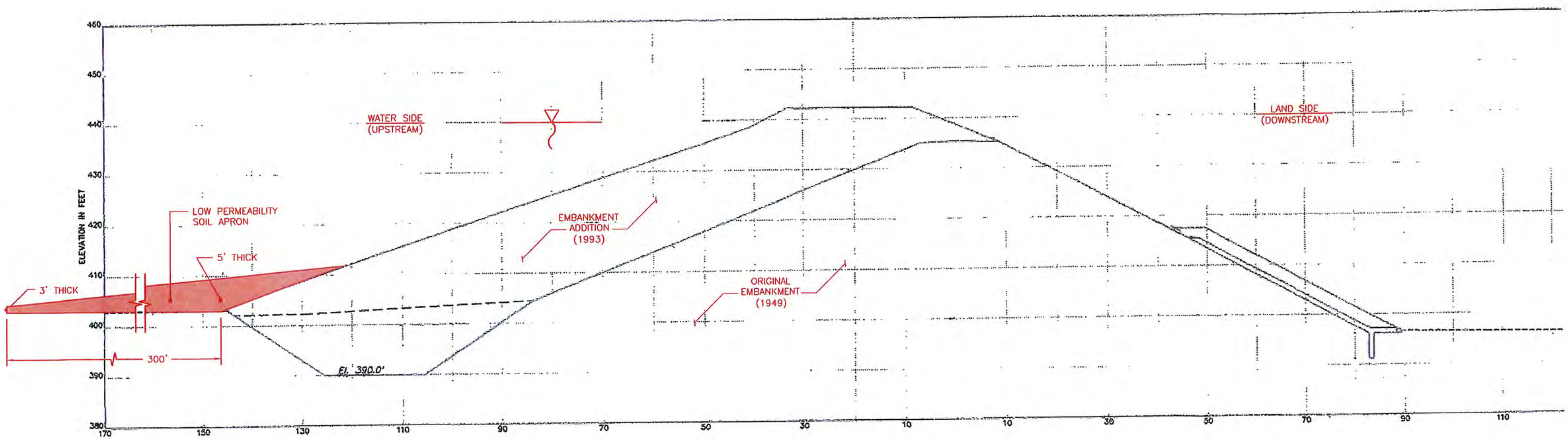
NOTE:

(1) SUBJECT TO SOILS EXPLORATION FOR TRENCH AREA PROFILING

BSK

ALTERNATIVE 1
SEEPAGE CONTROL ALTERNATIVES
Big Dry Creek Dam
(STATION 60+00 TO 130+00)
Fresno County, California

G08-119-11F
OCTOBER 2010
FIGURE 2



460

300 FEET WATERSIDE (UPGRADIENT) APRON WITH COMPACTED LOW PERMEADILITY SOILS.

ALTERNATIVE 2: SOILS OBTAINED FROM WITHIN RESERVOIR (1)

ALTERNATIVE 3: SOILS OBTAINED FROM BASIN "BX" (1)

NOTE:

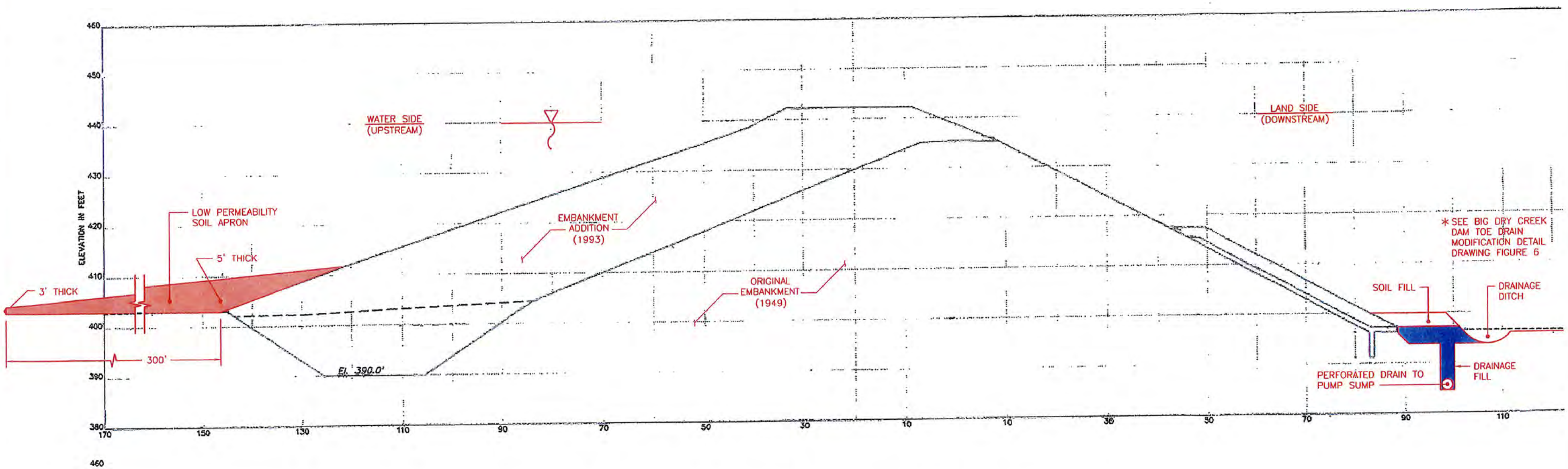
(1) SUBJECT TO SOILS EXPLORATION FOR DETERMINATION OF SUFFICIENT QUANTITIES OF SUITABLE SOILS.

BSK

ALTERNATIVE 2
ALTERNATIVE 3
SEEPAGE CONTROL ALTERNATIVES

Big Dry Creek Dam
(STATION 60+00 TO 130+00)
Fresno County, California

G08-119-11F
OCTOBER 2010
FIGURE 3



LANDSIDE (DOWNGRADIENT) TOE DRAIN EXTENTION, 12 TO 15 FEET DEEP AND 300 FEET WATERSIDE (UPGRADIENT) SOIL APRON.

ALTERNATIVE 4: SOILS OBTAINED FROM BASIN "BX" (1)

ALTERNATIVE 5: SOILS OBTAINED FROM WITHIN RESERVOIR (1)

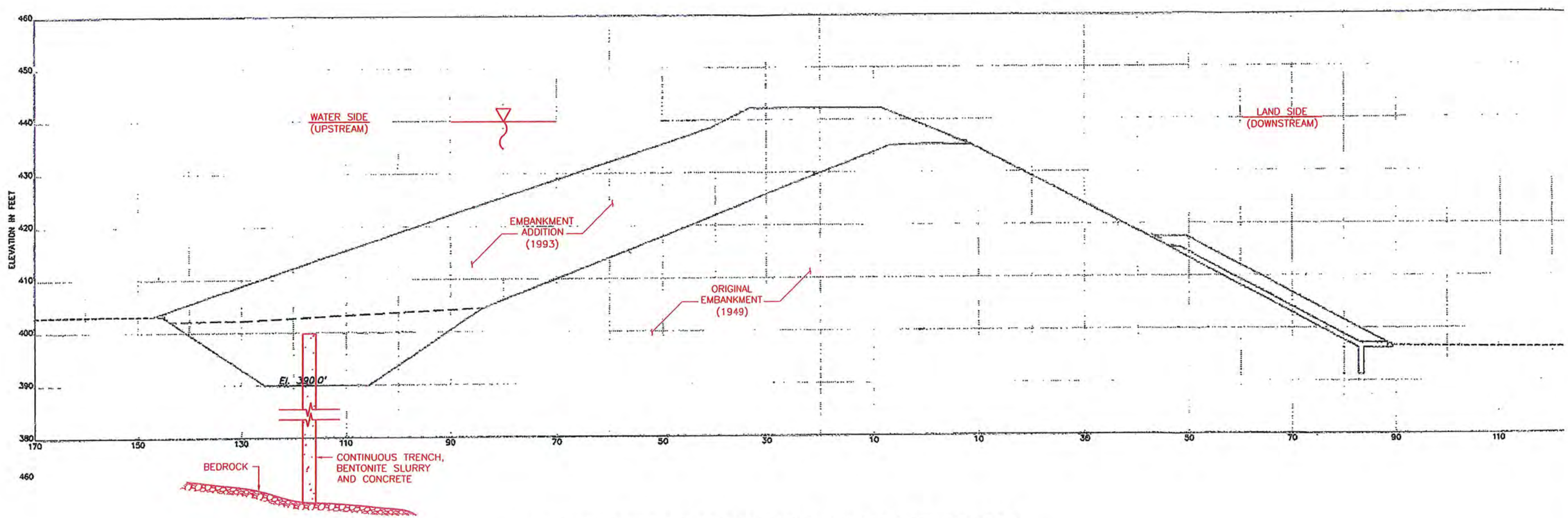
NOTE:

(1) SUBJECT TO SOILS EXPLORATION FOR DETERMINATION OF SUFFICIENT QUANTITIES OF SUITABLE SOILS.

BSK

ALTERNATIVE 4
ALTERNATIVE 5
SEEPAGE CONTROL ALTERNATIVES
Big Dry Creek Dam
(STATION 60+00 TO 130+00)
Fresno County, California

G08-119-11F
OCTOBER 2010
FIGURE 4



WATERSIDE (UPGRADIENT) SLURRY TRENCH CUT-OFF TO BEDROCK

NOTE:

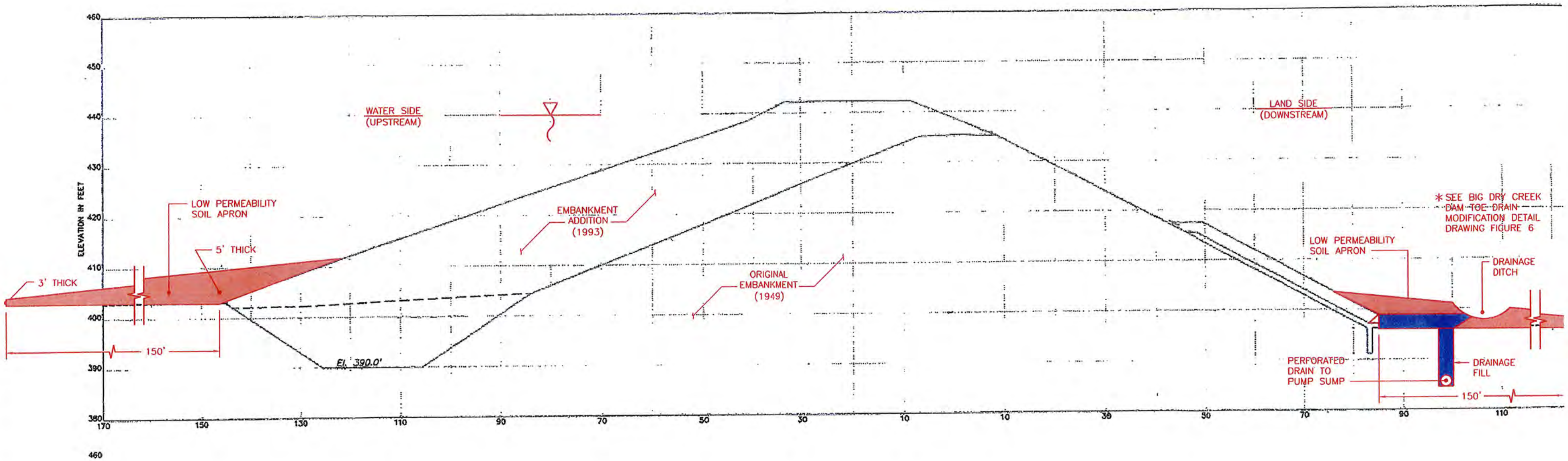
(1) SUBJECT TO SUBURFACE EXPLORATION FOR DETERMINATION OF DEPTH TO BEDROCK

BSK

ALTERNATIVE 6
SEEPAGE CONTROL ALTERNATIVES

Big Dry Creek Dam
(STATION 60+00 TO 130+00)
Fresno County, California

G08-119-11F
OCTOBER 2010
FIGURE 5

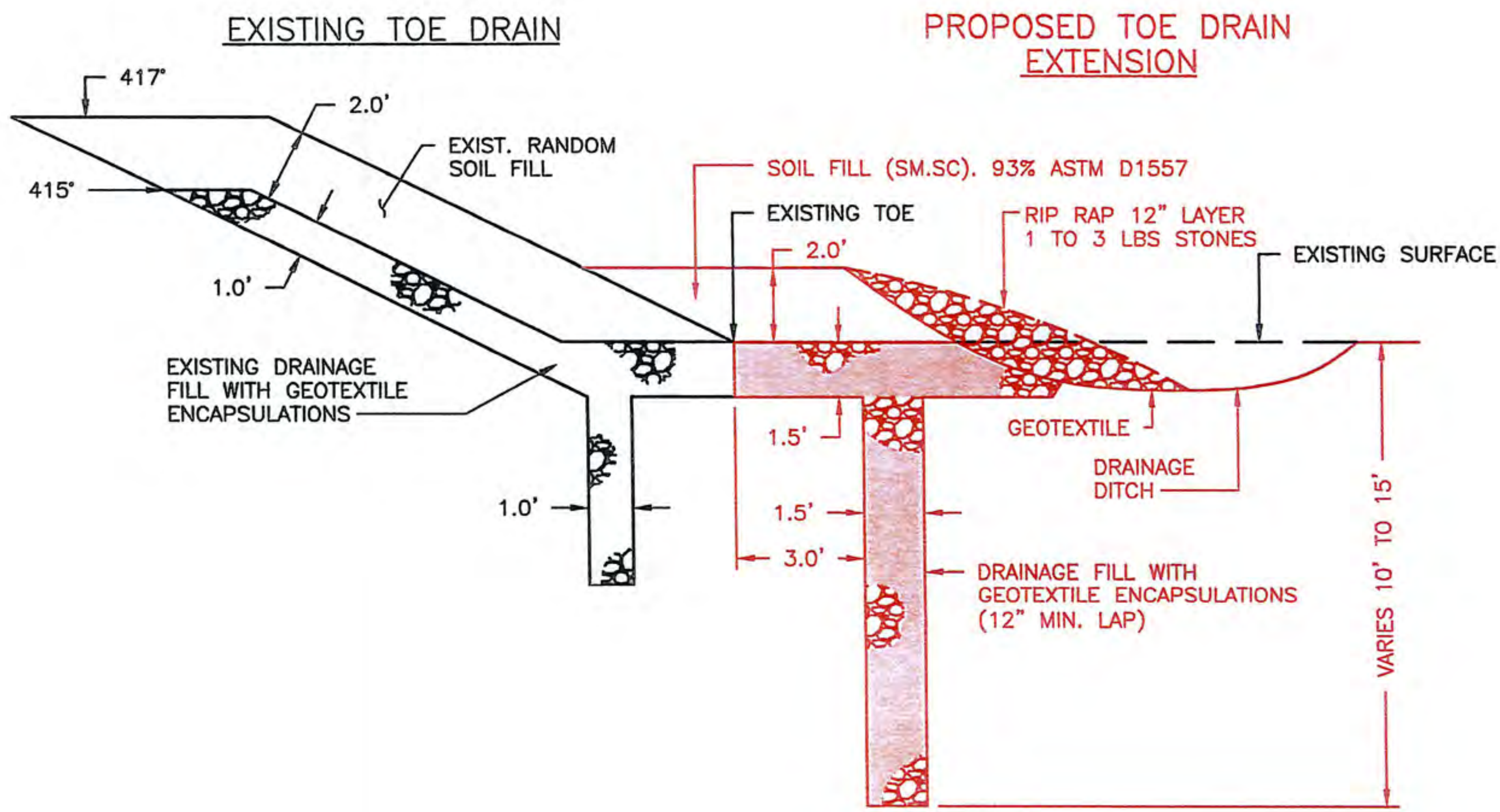


LANDSIDE (DOWNGRADIENT) TOE DRAIN EXTENSION, 12 TO 15 FEET DEEP, 150 FEET WATERSIDE (UPGRADIENT) SOIL APRON, 150 FEET LANDSIDE (DOWNGRADIENT) SOIL APRON (LANDSIDE APRON SOILS OPTAINED FROM BASIN "BX." WATERSIDE APRON SOILS OBTAINED FROM RESERVOIR AREA).

BSK

ALTERNATIVE 7
SEEPAGE CONTROL ALTERNATIVES
Big Dry Creek Dam
(STATION 60+00 TO 130+00)
Fresno County, California

G08.119.11F
FEBRUARY 2010
FIGURE 6



BIG DRY CREEK DAM
TOE DRAIN MODIFICATION

BIG DRY CREEK DAM
Fresno Metropolitan Flood Control District
Fresno, California

BSK

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BSK Associates Engineers & Laboratories

PIEZOMETRIC DATA EVALUATION

BIG DRY CREEK DAM
FRESNO METROPOLITAN FLOOD CONTROL DISTRICT
PROJECT BDR-18

BSK G08-119-11F

PREPARED FOR:

FRESNO METROPOLITAN FLOOD CONTROL DISTRICT
5469 EAST OLIVE AVENUE
FRESNO, CALIFORNIA 93727

JANUARY 22, 2013

Engineers, Geologists, Inspectors and Scientists

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Engineers & Laboratories

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January 22, 2013 BSK G08-119-11F

Mr. Jerry Lakeman, P.E., District Engineer
Fresno Metropolitan Flood Control District
5469 East Olive Avenue
Fresno, California 93727

SUBJECT: Piezometric Data Evaluation
Big Dry Creek Dam
Fresno Metropolitan Flood Control District
Project BDR-18

Dear Jerry:

This report presents our evaluations of the piezometric data collected during the recent storm event of December 2110 - February 2011. Also incorporated with the evaluation are the piezometric data collected in March and April 2010.

Based on these evaluations, earlier mitigation alternatives for the control of under seepage were reviewed and minor adjustments made to account for the information gained from the piezometer monitoring program. Maximum pool elevation limits were also identified in terms of permissible underseepage exit gradients and levels of seepage mitigation work provided for the embankment.

This report is presented for your review. We are prepared to meet with you and address questions.

Respectfully submitted,
BSK ASSOCIATES

Hugo Kevorkian
Principal Geotechnical Engineer
CE16350, GE462, REAII 20080

REGISTERED PROFESSIONAL ENGINEER
HUGO KEVORKIAN
No. 462
Exp.
GEOTECHNICAL
STATE OF CALIFORNIA

Enclosures

Distribution: Mr. Jerry Lakeman, P.E., FMFCD (3 originals + eMail)
BSK (1 original + eCopy)

TABLE OF CONTENTS

FIGURES

APPENDIX

PIEZOMETRIC DATA EVALUATION
BIG DRY CREEK DAM
FRESNO METROPOLITAN FLOOD CONTROL DISTRICT
PROJECT BDR - 18

1.0 INTRODUCTION

This report presents the results of our evaluations of piezometric data recorded by the Fresno Metropolitan Flood Control District at Big Dry Creek Dam. Piezometric data evaluations for this report include primarily records for the storm period of December 1, 2010 to February 28, 2011. Piezometric data previously recorded over the period of March 1, 2010 to April 29, 2010 were also reviewed and incorporated as additional data in applicable sections of these evaluations.

Maximum pool elevation for the December 1, 2010 to February 28, 2011 period was 419.00-feet. Elevations ranging from 419.00 to 418.05-feet were maintained over a four-day period.

Maximum pool elevation for the March 1, 2010 to April 29, 2010 period was 410.68-feet. Elevations ranging from 410.68-feet to 410.50 were maintained over a four-day period.

In the preparation of this report, the following reports were reviewed:

> "Seepage Control Alternatives Big Dry Creek Dam, Fresno Metropolitan Flood Control District Contract BDR-18" BSK Associates November 9, 2010.
>
> "Piezometer Installations, Big Dry Creek Dam, Fresno Metropolitan Flood Control District, Project BDR-18" BSK Associates, May 20, 2009.
>
> "Preliminary Seepage Study Big Dry Creek Dam, Fresno Metropolitan Flood Control District BDR-18" BSK Associates, November 5, 2008.

2.0 REPORT EVALUATIONS

The following evaluations were made based on data derived from open piezometer readings.

- Lag Periods – Peak Reservoir Pool Level vs. Peak Groundwater Levels in Downgradient Piezometers.
- Embankment Underseepage and Exit Gradients.
- Seepage Criteria: Sacramento District, U.S. Army Corps of Engineers, Central Valley Flood Management Planning Program (Flood Safe, California).
- Sand Boil Observations: Storm Events of April 2006, March 2010 and December/January 2010-2011.
- Seepage Mitigation alternatives and Construction Cost Estimates.
- Additional Exploration and Data Development and Design of Seepage Mitigation Systems.

2.1 Lag Periods

Date comparisons were made for the times of maximum pool elevations (419.0) versus maximum averaged water elevations in piezometers "C" and "D" at the toe of the embankment. The following lag times were derived:

Piezometer Stations	Lag Time (Days)	Water Depth at Upgradient Toe (feet)	Length of Embankment (feet)
(P_1) 63+75	3	17±	235±
(P_2) 80+80	4	17±	160±
(P_3) 89+90	7	17±	220±
(P_4) 100+00	4	16±	155±
(P_5) 110+00	4	10±	135±
(P_6) 121+50	10	2±	110±
(P_7) 135+00	21	6±	200±

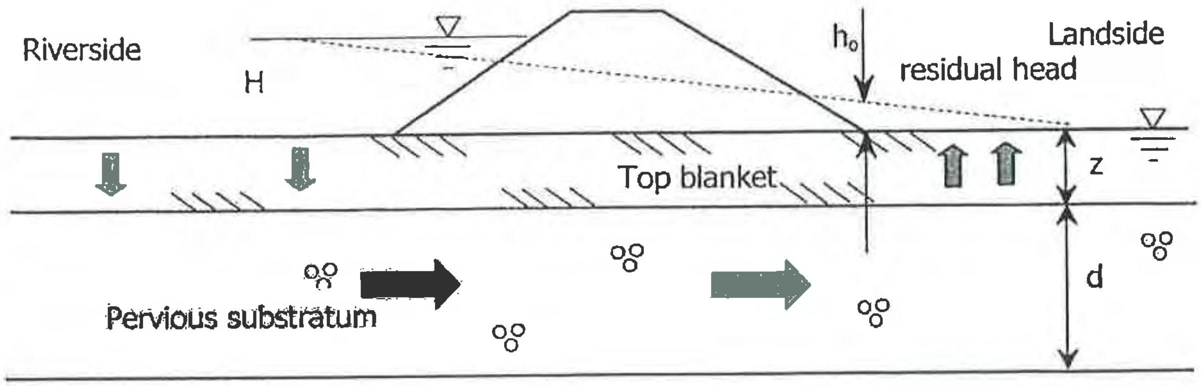
Lag times are affected by the depth of pooled water behind the embankment, the permeability of embankment soils and underlying native soils, and the length of embankment.

The predominant lag period for water depths of approximately 17-feet and embankment lengths of some 155 to 235-feet is four days. Absent significant variations in soil permeability, these values provide general indications of the lag period for which exit gradients (i_o) reach peak values at the embankment toe and beyond the toe. Pool elevation increases above 419.0-feet are expected to produce commensurate reductions in the lag periods.

2.2 Embankment Underseepage

The magnitude of seepage impact on embankment stability is measured by the height of the residual head (Piezometric Surface) "h_o" above the landside toe and at various distances from the toe. The magnitude of the exit gradient "i_o" at the embankment toe is used to define the level of embankment safety and corresponds to the residual head "h_o" divided by the top stratum low permeability layer thickness "Z":

$$i_o = \frac{h_o}{Z}$$



Further, when the residual head rises to the point where "i_o" exceeds the "Critical Gradient" $i_{crit.}$, the pore pressure on the base of the low permeability layer "Z" will equal or exceed the downward overburden stress and "Quick" conditions will develop leading to the potential for the top layer "Z" to heave or experience sand boils. $i_{crit.}$ is the product of the difference between the saturated unit weights of the top layer soils less the unit weight of water, divided by the unit weight of water.

$$i_{crit.} = \frac{W_{sat} - W_w}{W_w}$$

The calculated average saturated unit weight of soils in the low permeability top layer is 135 pounds per cubic foot (PCF). Correspondingly, the calculated critical gradient, $i_{crit.}$ is 1.16.

In establishing the effective thickness of the low permeability top layer "Z", an averaging transformation must be performed to account for the variations of permeability in the various layers comprising the thickness "Z". Judgment must be exercised in the final determination.

The following exit gradients "i_o" were estimated for the respective profiles P_1 through P_7. The piezometric data obtained from the monitoring program for the storm event of December 2010 – February 2011 were used for these determinations. The exit gradients reflect maximum pool elevation 419.0 and the resulting peak piezometer levels following response lag times.

EXIT GRADIENTS
(Pool Elevation 419.0 ft.)

Profile Designation	h_o (feet)		Z	Exit Gradient	
	Toe	40 ft.-77 ft. from Toe	(feet)	i_o	i 40 ft.-77 ft. from Toe
P_1	1.13	0.33	6	0.19	0.06
P_2	6.86	6.82	14	0.49	0.36
P_3	1.48	1.77	19	0.08	0.09
P_4	1.93	0.34	18	0.11	0.02
P_5	0.99	0.26	18	0.06	0.01
P_6	-3.82	-8.81	13	0.0	0.0
P_7	-14.32	-14.62	13	0.0	0.0

Embankment profiles P_1 through P_7 illustrated on Figure 1 through 5 provide the relative piezometric levels measured at the embankment toe and varying distances from the toe.

3.0 SEEPAGE DESIGN CRITERIA

Seepage design criteria presented in this section include 1) Recommendations for Seepage Control Design Criteria developed by the Sacramento District of the U.S. Army Corps of Engineers (2000) and 2) Interim Levee Design Criteria for Urban and Urbanizing Areas in the Sacramento-San Joaquin Valley developed by the Central Valley Flood Management Planning Program. Version 4 (2010). The Design Criteria are expressed in terms of exit gradient i_e at the levee/embankment toe and when present, at the toe of an impervious apron extending downgradient from the levee toe.

3.1 Sacramento COE

$i_e = 0.3$ New construction (Levee Toe)
$i_e = 0.5$ Existing levees with no history of seepage problems (Levee Toe)
$i_e = 0.8$ At apron toe

Frequently Loaded Levees (EM-1110-2-1913)*: Frequently loaded levees should include seepage control and crack-stopping features, like those commonly included in earthen dams of similar height, whenever such levees protect urban or urbanizing areas. In general, seepage exiting the landside slope of the levee without being controlled by filter drains is not acceptable.

* Defined as a levee that experiences a water surface elevation of one foot or higher above the elevation of the levee toe at least once a day for more than 36 days per year on average.

3.2 Central Valley Flood Management

$i_e \leq 0.5$ (Levee Toe)
$i_e \leq 0.8$ (Berm Toe)

Frequently Loaded Levees: Same as COE Definition and Requirements

For the flood event of December 2010-February 2011, embankment seepage in the vicinity of Profile P_2, by the criteria stated above, reached the recommended $i_e = 0.5$ maximum exit gradient at the toe (0.49). This is for a pool elevation 419.0-feet. Higher water impoundments would be expected to produce exit gradients in excess of the recommended maximum values unless embankment improvements are made to reduce underseepage.

Underseepage for embankments in the area of Profile P_2 and to a lesser extent, Profile P_1, Stations 62+00 to 85+00 more or less, currently control the maximum pool levels which can be accommodated during a prolonged storm water impoundment period.

3.3 Sand Boil Observations

Low level seepage with order magnitudes of less than 10 cubic feet/day/foot have been estimated for the storm events of April 2006 and December 2010. Seepage occurred along the embankment toe drain but also permeated the area beyond the toe drain, thus creating soft, spongy ground conditions over widths of 50 to 80-feet and perhaps greater. Small diameter sand boils have been observed in association with these seepage activities. Small diameter (1/3 to 1-inch) sand boils were observed at a distance of 48-feet from the embankment toe during April 7 to April 12, 2006 (BSK 2008). The boils were occasionally controlled by ringing them with sand bag dikes to heights of 18 inches or less. Seepage rates were reported to approximately ¼ gallon per minutes over the initial five days of observation. On the sixth day, most of the boils were no longer flowing. Retained water behind the embankment for the six-day observation period ranged from elevation 419.6 to 420.1 with the higher elevation occurring on the fifth and sixth days. Clear water was discharging from the boils in every instance.

Sand boils are known to have occurred in cases of low level water impoundments by a process of progressive enlargement and porosity increases of piping channels with succeeding storm events. In the case of the embankment studied for these analyses, the entire existing embankment was removed by the COE in 1992, the base width substantially enlarged and the depth of the foundation increased from the original ground surface to 28-feet below ground surface. Under these conditions, old piping channels would have been eliminated.

The small diameter (1/4 to ½ inch) sand boils were suspected to represent purging of air contained within the soil mass and the attendant transport of soil pore water present in shallow zones near the ground surface.

For the storm event of December 2010 – February 2011, sporadic small diameter (1/4 – ½ inch) sand boils were occurring along the toe drain. Discharge water was clear. Sand boils were no longer observed away from the embankment toe. The only sand boil of significance was at Station 63+00 near a shallow 18-inch diameter drain line. A single layer of sand bag was used to contain the discharge. These recent observations support the notion that the sand boils are substantially associated with air purging.

Computer analyses of slope stability and seepage for Profile P_2 (Station 80+80) for the maximum Design Pool Level elevation 439.2 under extended storage conditions, produced marginal stability and toe exit gradients magnitudes with the potential for sand boils in the drainage fill at the embankment toe (Figure 6 through 9).

4.0 SEEPAGE MITIGATION ALTERNATIVES

Seepage conditions in the area of Stations 62+00 to 85+00, as observed in 2006 and again in 2010-2011, place limitations on the pool level retained behind the dam. A maximum pool elevation of 419.0-feet produces a toe exit gradient of approximately 0.50.

Toe exit gradients in excess of 0.50, by COE standards, call for the construction of a low permeability apron. Seepage control along the toe and downgradient from the toe would also be necessary to mitigate the soft-spongy conditions and overland runoff.

For the long term and in keeping with the objective of providing higher elevation impoundment and potential extended storage, an upgradient apron with a width of 300-feet and downgradient toe drain extension approximately 15.0-feet deep, combined, would be necessary. At a minimum, the blanket would extend from Stations 60+00 to 125+00. The toe drain modification would extend from Station 60+00 to near Station 130+00.

A schematic drawing of the toe drain modification is provided in Figure 10. A perforated drain pipe would be installed at the base of the drain in the event excessive drain discharge made it necessary for pumping and discharge into the drainage ditch. (Dry sumps would be constructed in conjunction with the pipe drain installation in which temporary lift pumps could be installed).

The upgradient apron would be constructed of low permeability soils excavated at shallow depths from within the reservoir at a minimum set back distance of 500-feet from the embankment upgradient toe.

With the combined implementation of the apron and toe drain modifications, design, maximum pool water elevations would be expected feasible. However, gradual water elevation increases would be imperative with attendant close monitoring of piezometers and toe area seepage to establish actual practical limits of maximum impoundments. Figure 11 illustrates toe drain and blanket configurations.

For the short term, the lowest level of improvements necessary to increase pool elevation from 419.0-feet to an estimated maximum of 425.0-feet would be the construction of an upgradient apron from Stations 60+00 to 85+00, again subject to verification by seepage monitoring.

The following "Order of Magnitude" costs are estimated for the mitigation alternatives discussed above:

LONG TERM: Toe Drain Modification Station 60+00 to 130+00	$1,100,000.00
300-feet Wide Upgradient Blanket Stations 60+00 to 125+00*	$1,300,000.00
TOTAL	**$2,400,000.00**
SHORT TERM: 300-feet Wide Upgradient Blanket Stations 60+00 to 85+00*	$500,000.00
TOTAL	**$500,000.00**

***Soils obtained from within reservoir area.**

5.0 ADDITIONAL EXPLORATION AND DATA DEVELOPMENT-DESIGN

Additional exploration and data development will be necessary to support the preparation of construction drawings and specifications by the Project Civil Engineer. The following scopes of services are proposed.

5.1 Toe Drain Modification

- Additional subsurface exploration for the characterization of trenching conditions (stability) 8 borings to 25-feet.

- Laboratory testing for the determination of trench soils particle size gradation for purposes of geotextile fabric selection.
- Geotextile fabric soil tests for permeation, clogging and binding evaluations.
- Evaluations, graphics and report preparation.
- Meetings and coordination with FMFCD Staff and Project Civil Engineer.

5.2 Upgradient Low Permeability Blanket

- Subsurface exploration for the assessment of suitable low permeability materials 40 acre area, 24 test pits to 6.0-feet.
- Laboratory testing for particle size gradation analyses, maximum dry density, remolded soil coefficient of permeability.
- Delineation of borrow area limits for suitable fill soils, berm configuration, report preparation.
- Meetings and coordination with FMFC Staff and Project Civil Engineer.

5.3 Project Schedule

Schedules for the toe drain and upgradient blanket investigation, testing and reporting are the following:

Mobilization:	1 week
Field Exploration:	1 week
Laboratory Testing:	3 weeks
Report Preparation	2 weeks
TOTAL	**7 weeks**

6.0 LIMITATIONS

The findings, observations and conclusions presented in this report are based substantially on the results of piezometric data evaluations at piezometer Stations P_1 through P_7 for the storm events in 2010 and 2011 and a maximum water storage elevation of 419.0-feet. Water impoundment at higher elevation may produce conditions which may vary from those identified in this report. If variations are then observed, a re-evaluation of these findings and conclusions will be necessary. Findings and conclusions presented in this report may not apply to other areas of Big Creek Dam Embankment for which no exploration and testing was performed.

BSK has prepared this report for the exclusive use of the Fresno Metropolitan Flood Control District. The report has been prepared in accordance with generally accepted geotechnical engineering practices for the project area at the time of the report preparation. No other warranty express or implied, is made as to the professional advice provided in this report under the terms of BSK's agreement and with Client.

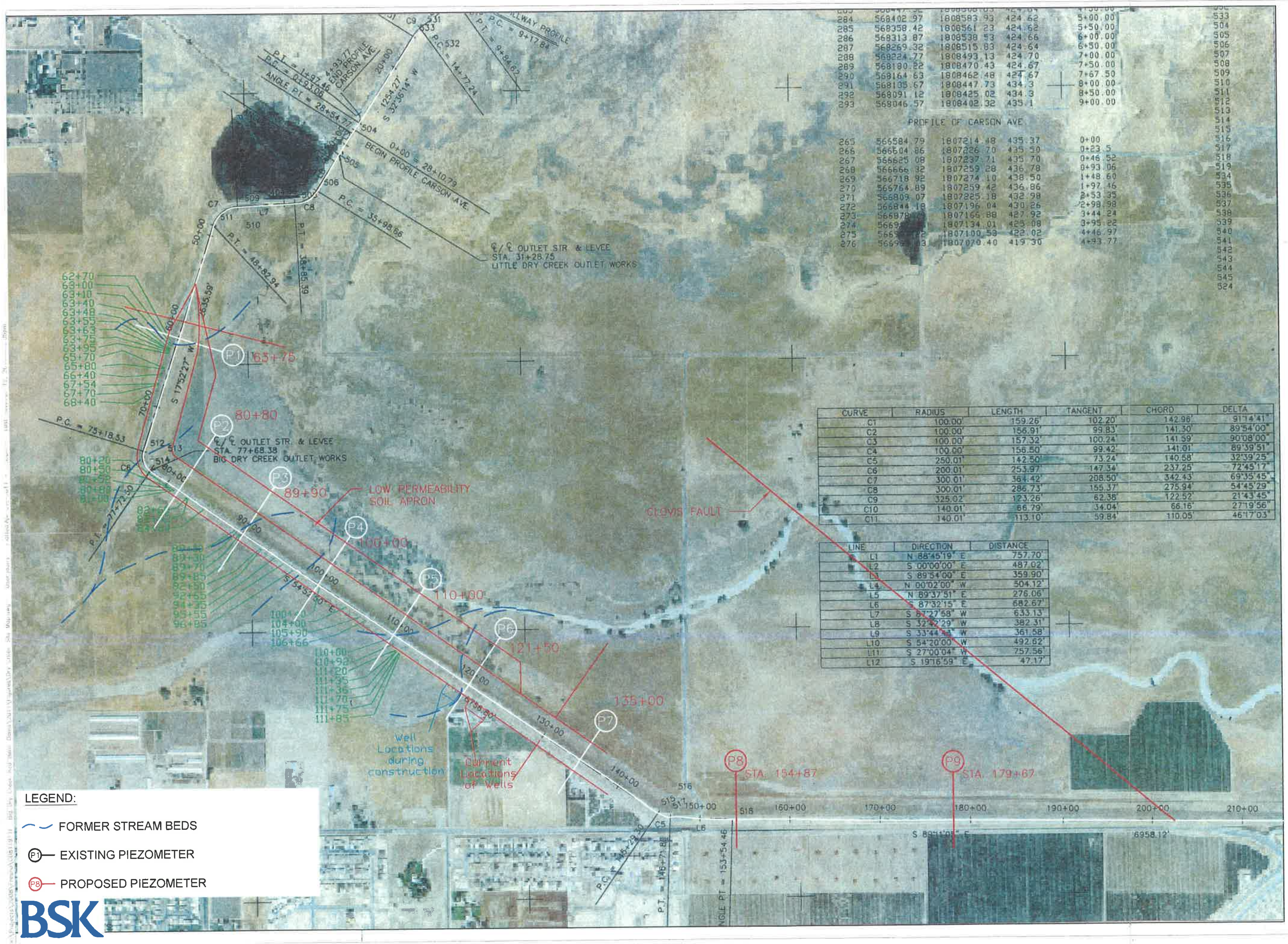
BSK ASSOCIATES

FIGURES

1 through 11

BSK

G08-119-11F
APRIL 2011
FIGURE 1



CURVE	RADIUS	LENGTH	TANGENT	CHORD	DELTA
C1	100.00'	159.26'	102.20'	142.96'	91°14'41"
C2	100.00'	156.91'	99.83'	141.30'	89°54'00"
C3	100.00'	157.32'	100.24'	141.59'	90°08'00"
C4	100.00'	156.50'	99.42'	141.01'	89°39'51"
C5	250.01'	142.50'	73.24'	140.58'	32°39'25"
C6	200.01'	253.97'	147.34'	237.25'	72°45'17"
C7	300.01'	364.42'	208.50'	342.43'	69°35'45"
C8	300.01'	286.73'	155.37'	275.94'	54°45'29"
C9	325.02'	123.26'	62.38'	122.52'	21°43'45"
C10	140.01'	66.79'	34.04'	66.16'	27°19'56"
C11	140.01'	113.10'	59.84'	110.05'	46°17'03"

LINE	DIRECTION	DISTANCE
L1	N 88°45'19" E	757.70'
L2	S 00°00'00" E	487.02'
L3	S 89°54'00" E	359.90'
L4	N 00°02'00" W	504.12'
L5	N 89°37'51" E	276.06'
L6	S 87°32'15" E	682.67'
L7	S 87°27'58" W	633.13'
L8	S 32°42'29" W	382.31'
L9	S 33°44'4[illegible]" W	361.58'
L10	S 54°20'00" W	492.62'
L11	S 27°00'04" W	757.56'
L12	S 19°16'59" E	47.17'

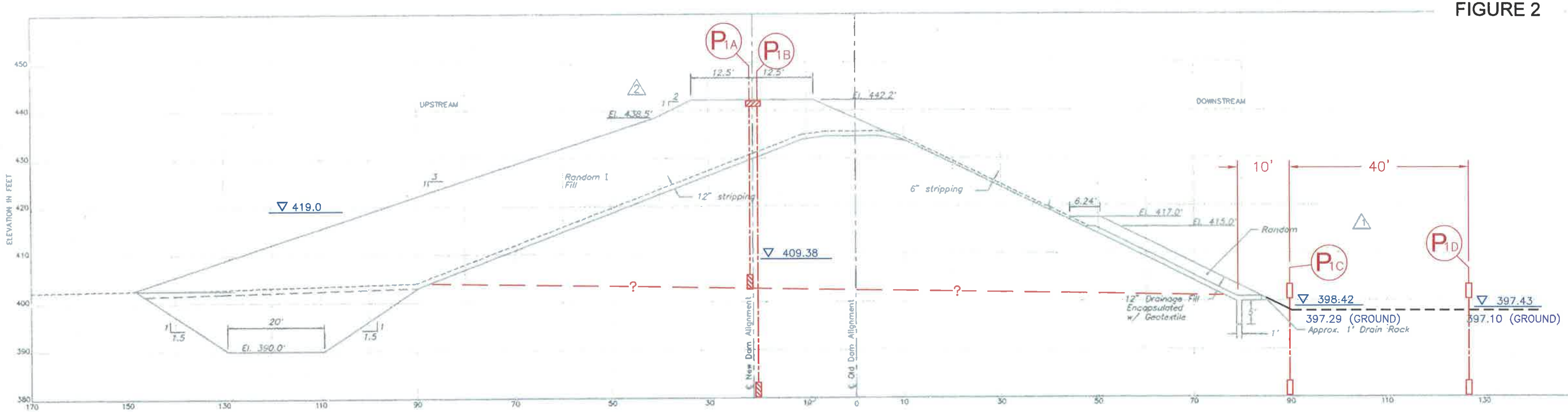
Scale: 1" = 100' (APPROXIMATELY)

0 50' 100'

SITE MAP

Big Dry Creek Dam
Fresno County, California

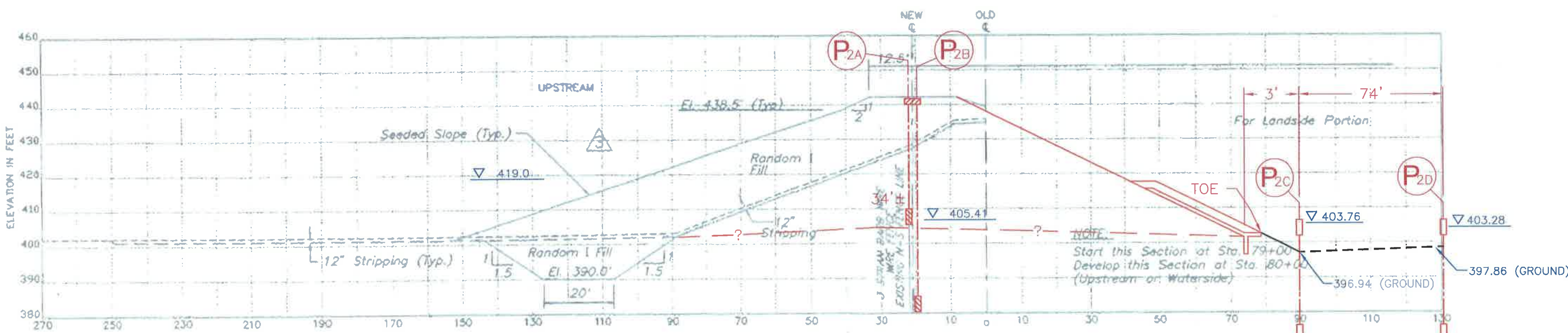
G08-119-11F
APRIL 2011
FIGURE 2



REFERENCE: USACE PROFILE @ STA. 85+01.01

STATION 63+75

MAXIMUM WATER LEVELS (419.0) STORM EVENT OF DECEMBER 2010 - FEBRUARY 2011



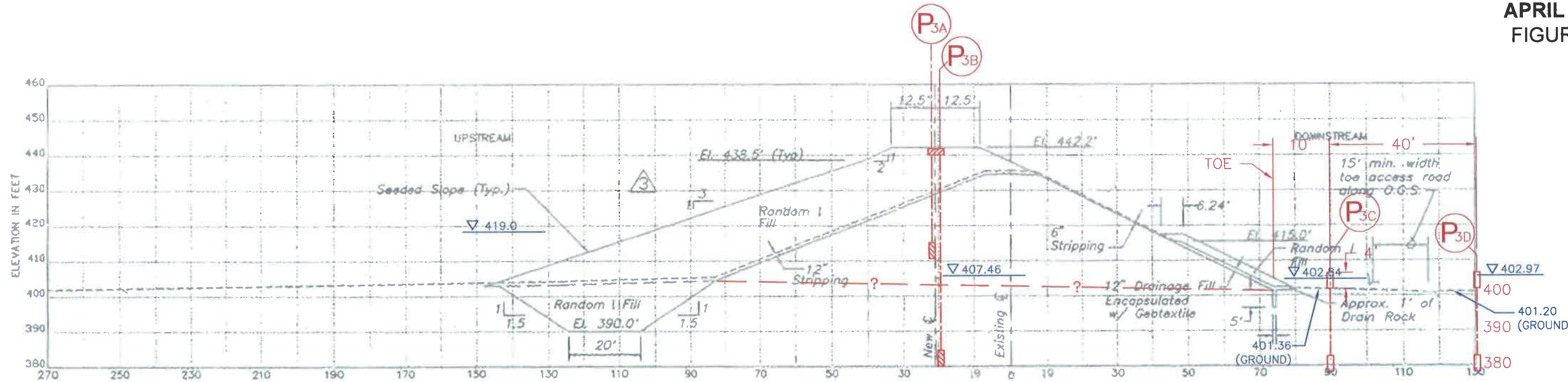
REFERENCE: USACE PROFILE @ STA. 84+89.431

STATION 80+80

BSK

PIEZOMETRIC DATA EVALUATIONS
Big Dry Creek Red Bank Dams
Fresno County, California

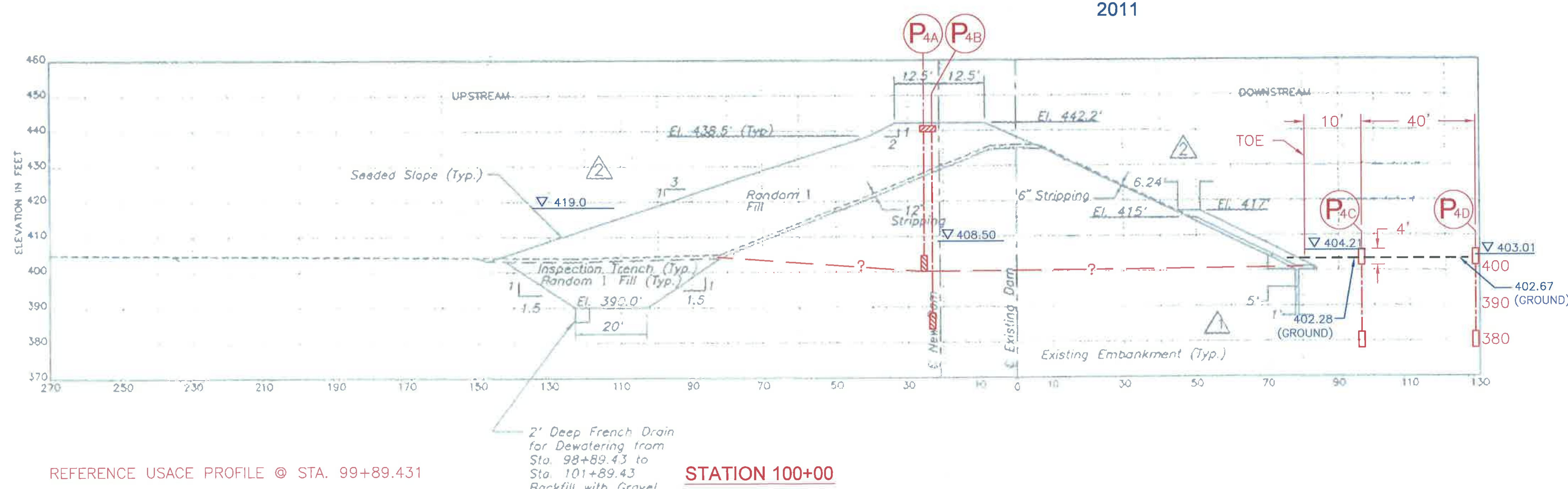
G08-119-11F
APRIL 2011
FIGURE 3



REFERENCE USACE PROFILE @ STA. 84+89.431

STATION 89+90

MAXIMUM WATER LEVELS (419.0) STORM EVENT OF DECEMBER 2010 - FEBRUARY 2011



REFERENCE USACE PROFILE @ STA. 99+89.431

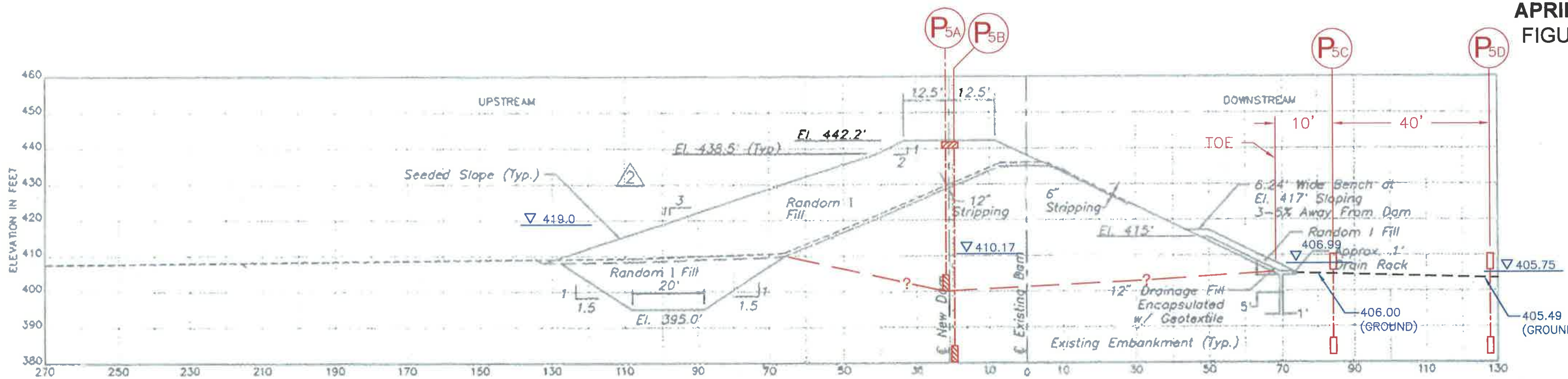
STATION 100+00

BSK

PIEZOMETRIC DATA EVALUATIONS

Big Dry Creek Red Bank Dams
Fresno County, California

G08-119-11F
APRIL 2011
FIGURE 4



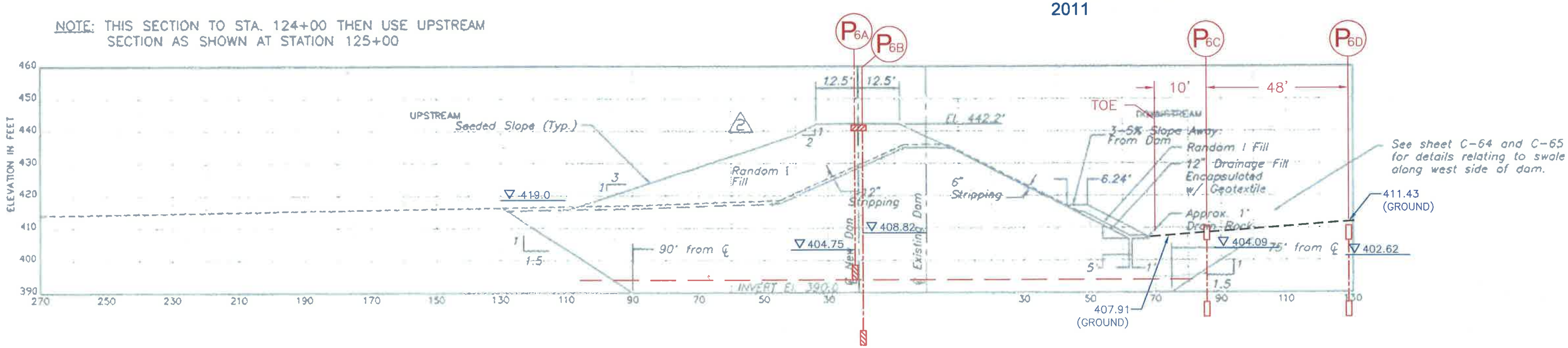
NOTE: USE THIS DETAIL TO STATION 109+00 AND THEN USE NEW DETAIL AS SHOWN AT STA. 110+00 USING 1 ON 6 SLOPE.

REFERENCE USACE PROFILE @ STA. 109+89.431

STATION 110+00

MAXIMUM WATER LEVELS (419.0) STORM EVENT OF DECEMBER 2010 - FEBRUARY 2011

NOTE: THIS SECTION TO STA. 124+00 THEN USE UPSTREAM SECTION AS SHOWN AT STATION 125+00



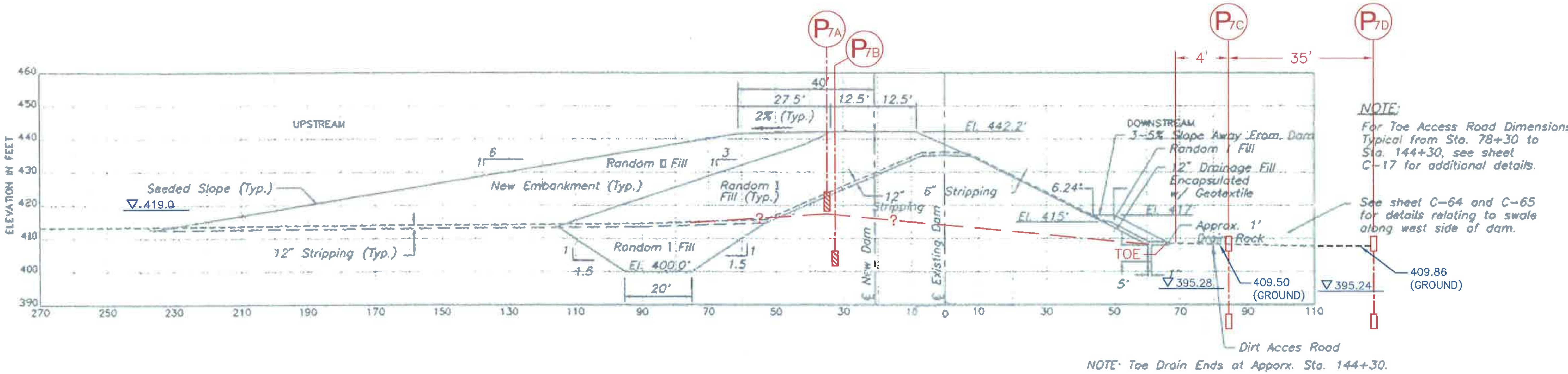
REFERENCE USACE PROFILE @ STA. 119+89.431

STATION 121+50

BSK

PIEZOMETRIC DATA EVALUATIONS
Big Dry Creek Red Bank Dams
Fresno County, California

G08-119-11F
APRIL 2011
FIGURE 5



REFERENCE USACE PROFILE @ STA. 139+89.431

STATION 135+00

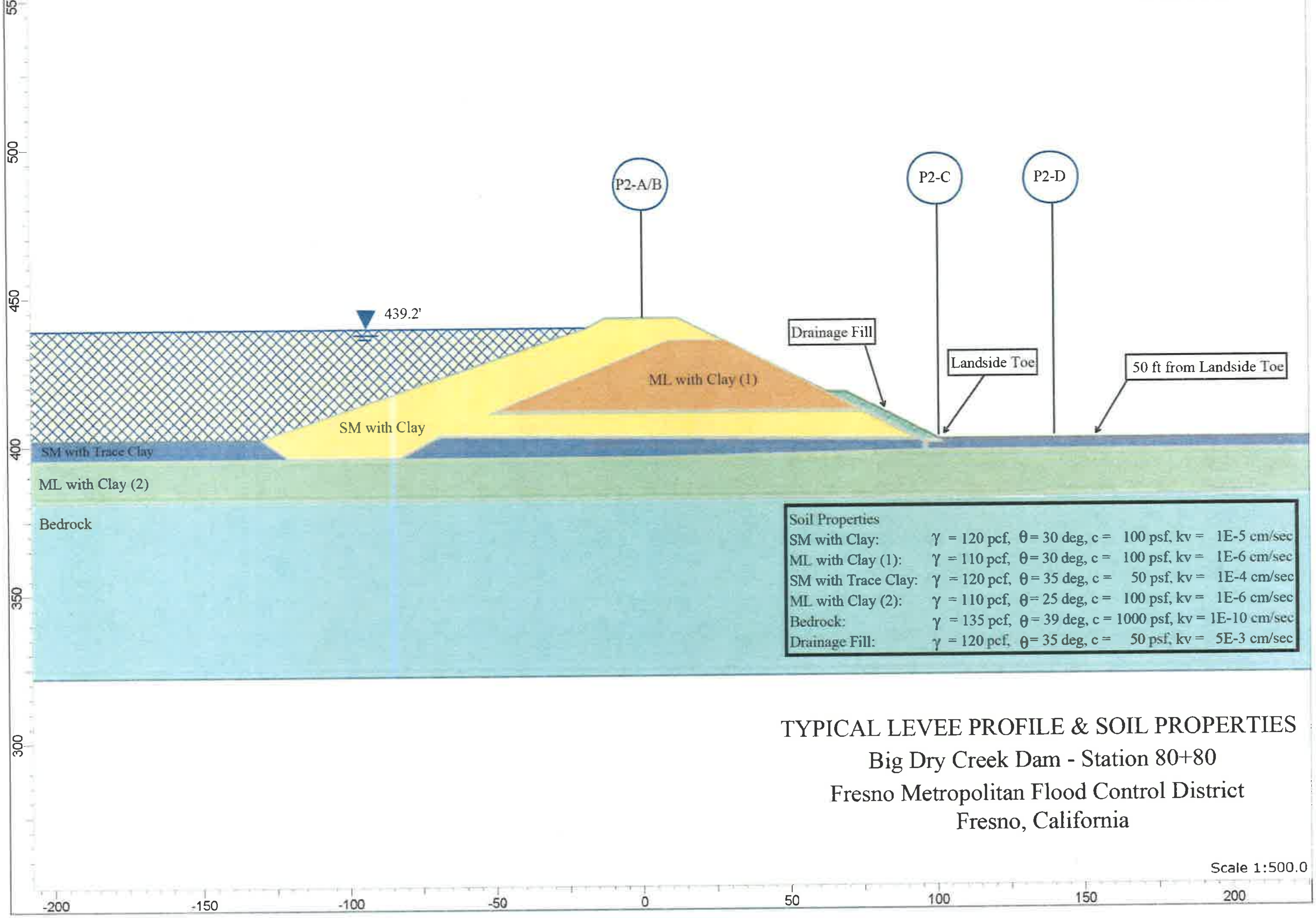
MAXIMUM WATER LEVELS (419.0) STORM EVENT OF DECEMBER 2010 - FEBRUARY 2011

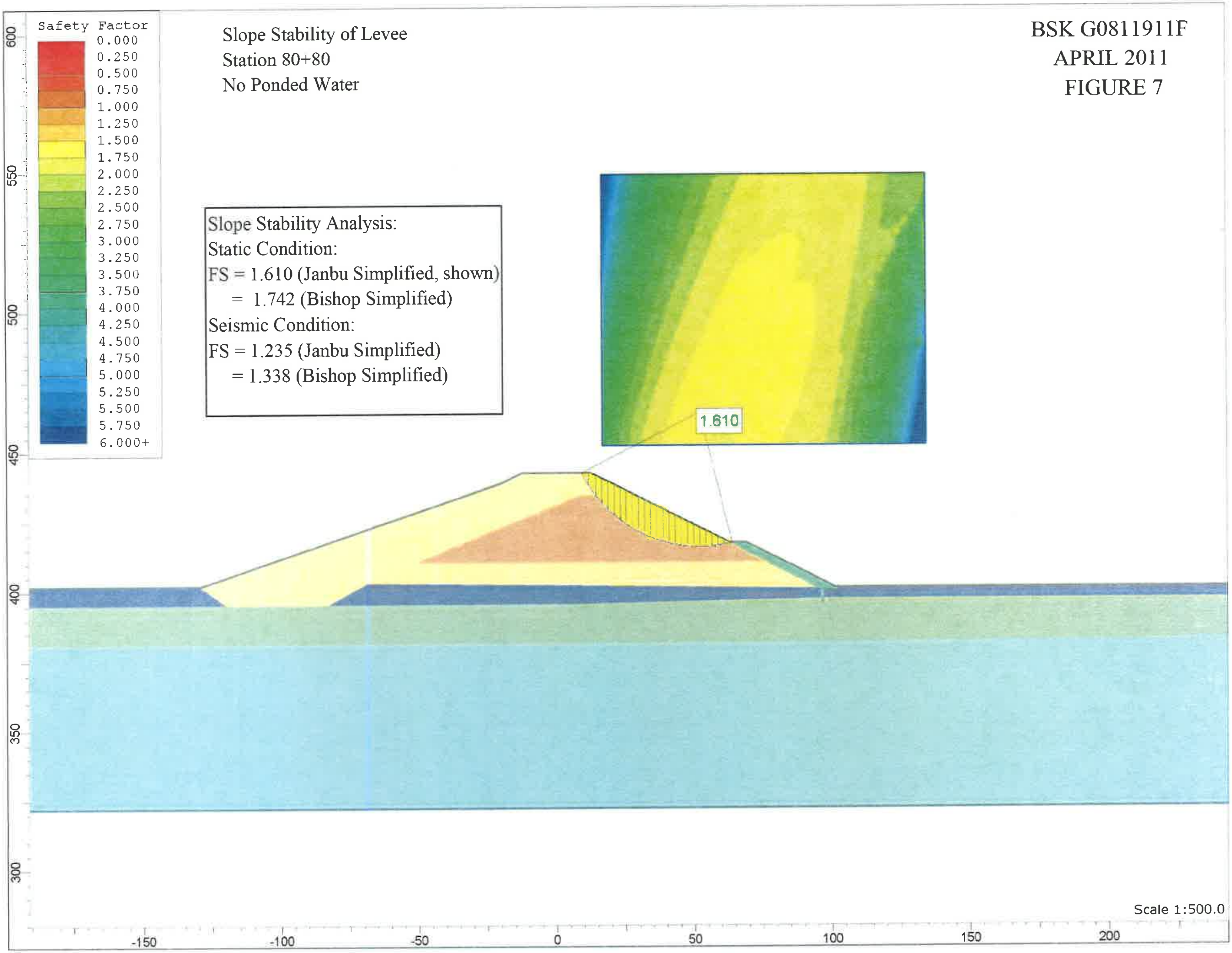
BSK

PIEZOMETRIC DATA EVALUATIONS
Big Dry Creek Red Bank Dams
Fresno County, California

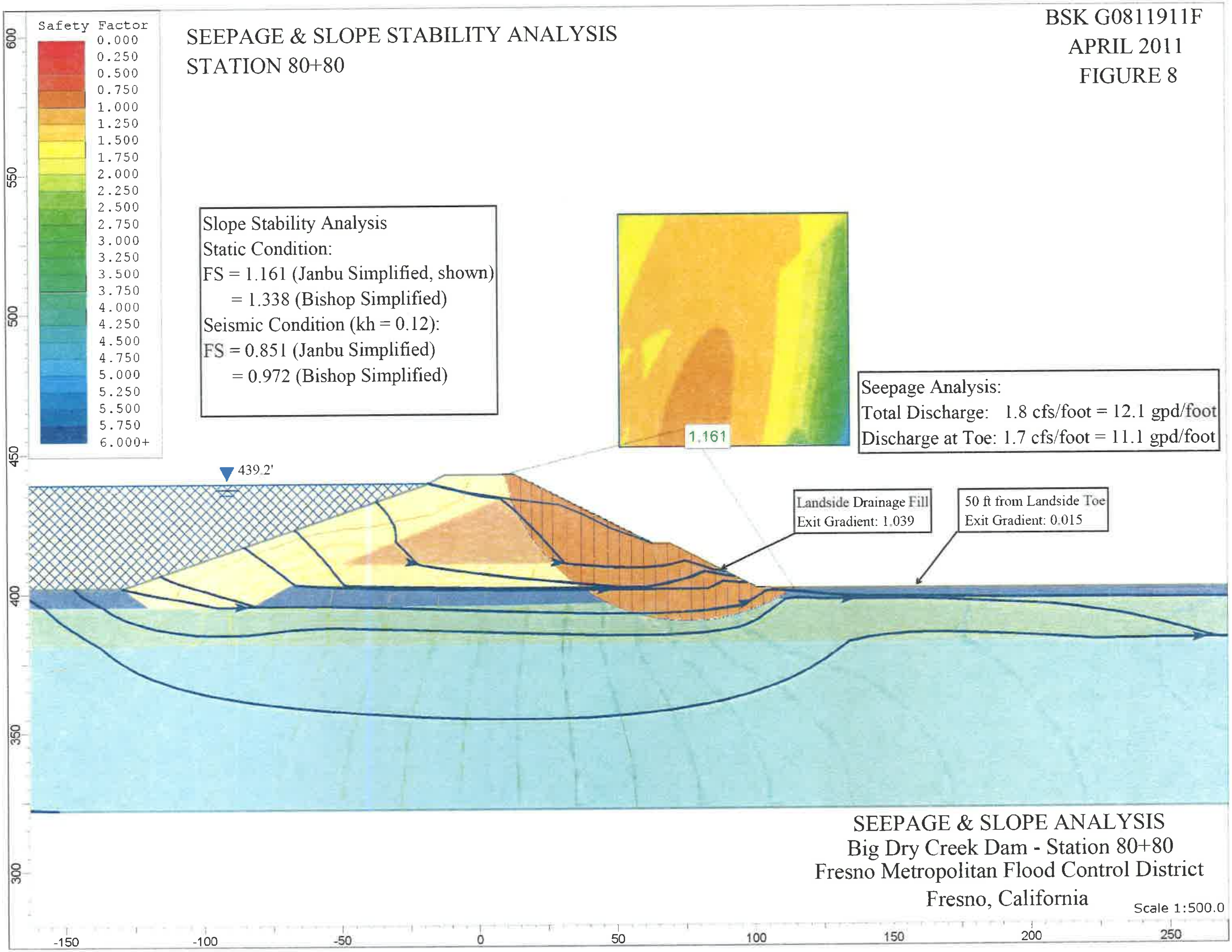
TYPICAL LEVEE PROFILE & SOIL PROPERTIES
STATION 80+80

BSK G0811911F
APRIL 2011
FIGURE 6



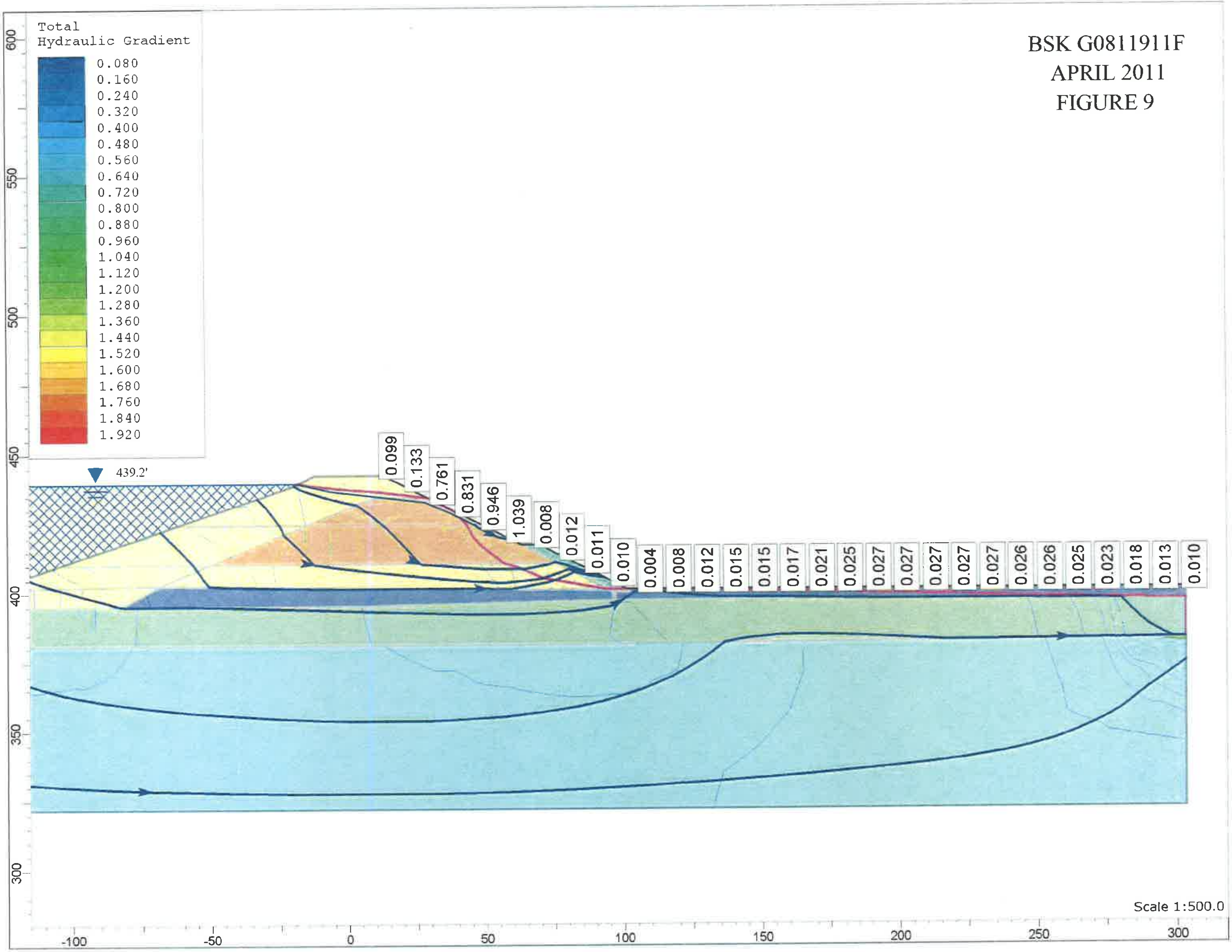


Slope Stability of Levee
Station 80+80
No Ponded Water
BSK G0811911F
APRIL 2011
FIGURE 7
Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
Slope Stability Analysis:
Static Condition:
FS = 1.610 (Janbu Simplified, shown)
= 1.742 (Bishop Simplified)
Seismic Condition:
FS = 1.235 (Janbu Simplified)
= 1.338 (Bishop Simplified)
1.610
600
550
500
450
400
350
300
-150
-100
-50
0
50
100
150
200
Scale 1:500.0

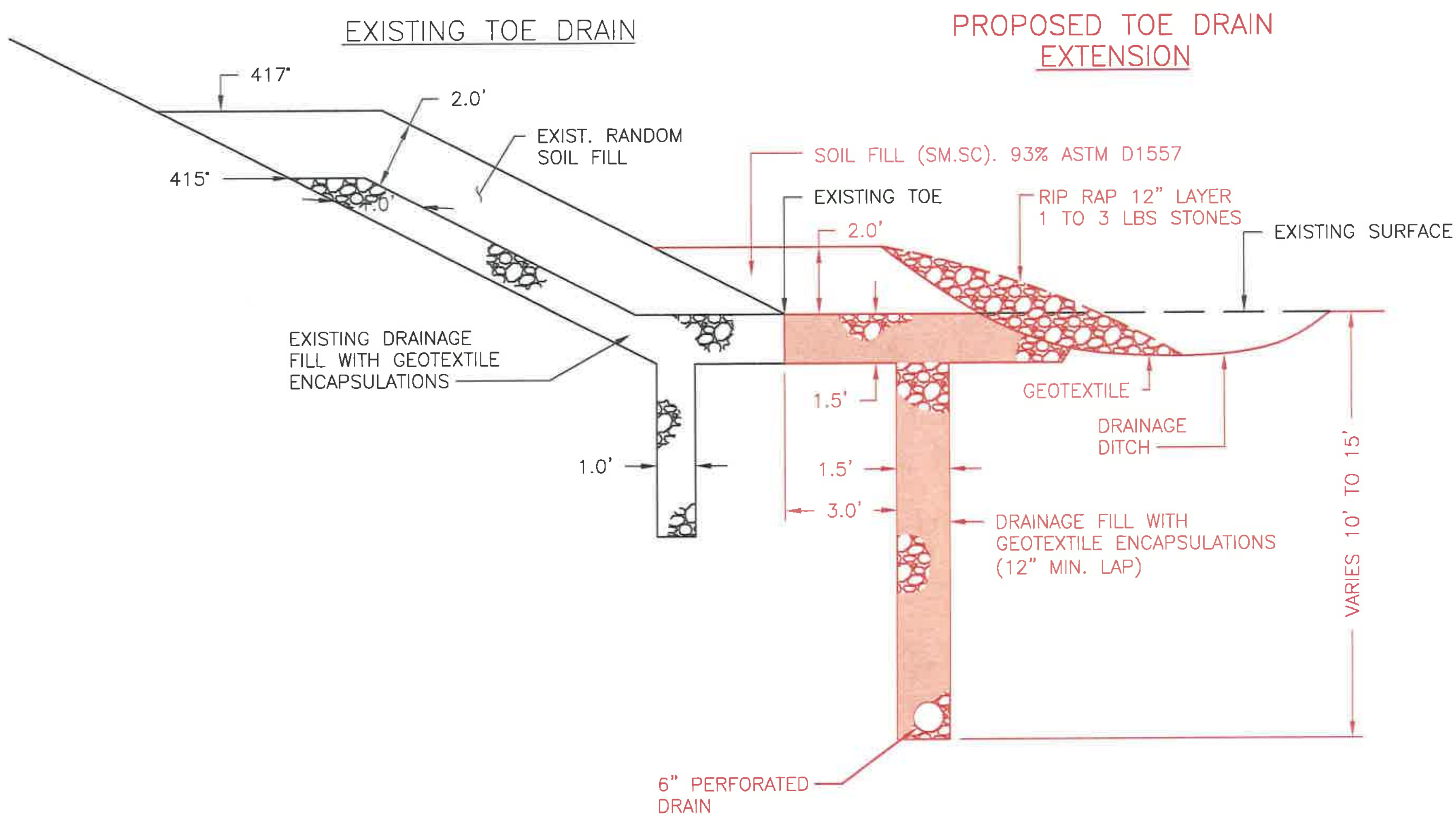


Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
SEEPAGE & SLOPE STABILITY ANALYSIS
STATION 80+80
BSK G0811911F
APRIL 2011
FIGURE 8
Slope Stability Analysis
Static Condition:
FS = 1.161 (Janbu Simplified, shown)
= 1.338 (Bishop Simplified)
Seismic Condition (kh = 0.12):
FS = 0.851 (Janbu Simplified)
= 0.972 (Bishop Simplified)
1.161
Seepage Analysis:
Total Discharge: 1.8 cfs/foot = 12.1 gpd/foot
Discharge at Toe: 1.7 cfs/foot = 11.1 gpd/foot
439.2'
Landside Drainage Fill
Exit Gradient: 1.039
50 ft from Landside Toe
Exit Gradient: 0.015
SEEPAGE & SLOPE ANALYSIS
Big Dry Creek Dam - Station 80+80
Fresno Metropolitan Flood Control District
Fresno, California
Scale 1:500.0
600
550
500
450
400
350
300
-150
-100
-50
0
50
100
150
200
250

BSK G0811911F
APRIL 2011
FIGURE 9



G08.119.11F
APRIL 2011
FIGURE 10

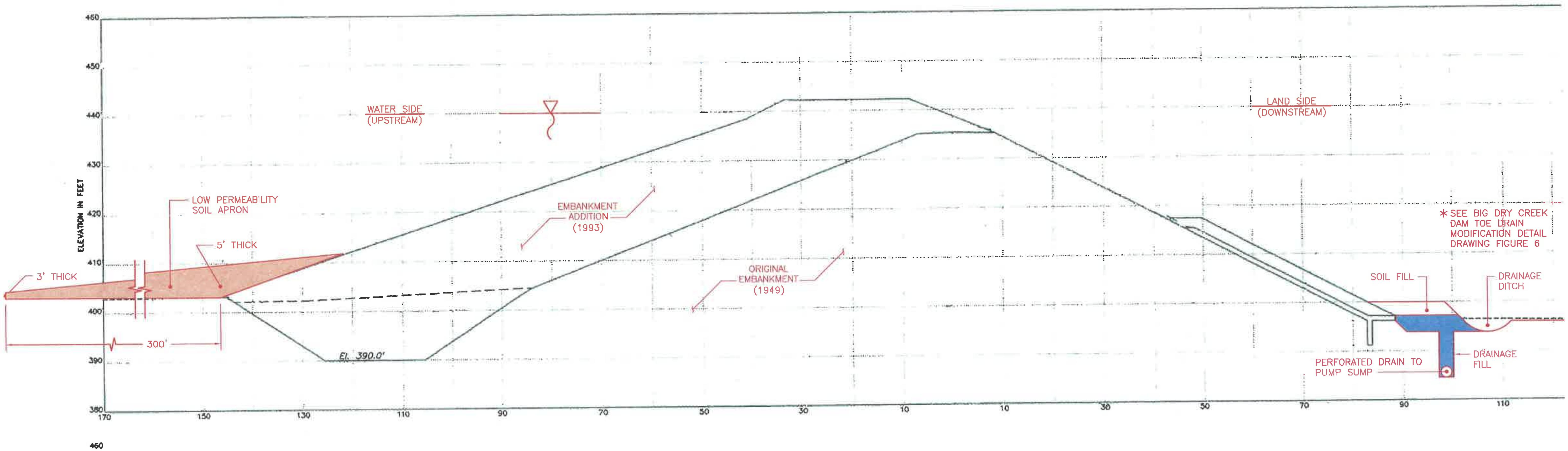


BSK

BIG DRY CREEK DAM
TOE DRAIN MODIFICATION

BIG DRY CREEK DAM
Fresno Metropolitan Flood Control District
Fresno, California

G08-119-11F
APRIL 2011
FIGURE 11



LANDSIDE (DOWNGRADIENT) TOE DRAIN EXTENTION, 12 TO 15 FEET DEEP AND 300 FEET WATERSIDE (UPGRADIENT) SOIL APRON. (SOIL OBTAINED FROM WITHIN RESERVOIR).(1)

NOTE:

(1) SUBJECT TO SOILS EXPLORATION FOR DETERMINATION OF SUFFICIENT QUANTITIES OF SUITABLE SOILS.

BSK

SEEPAGE CONTROL

Big Dry Creek Dam
(STATION 60+00 TO 130+00)
Fresno County, California

APPENDIX A

Piezometric Data
(December 1, 2010 – February 28, 2011)

BSK

Section P1 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
12/1/2010		401.51	393.70	391.82	391.65
12/21/2010	409.10	401.92	398.15	392.46	392.12
12/23/2010	410.50	401.74	400.91	393.58	392.91
12/24/2010	410.75	401.70	402.23	394.44	393.64
12/25/2010	410.80	401.67	403.21	395.24	394.27
12/26/2010	411.49	401.68	403.23	395.67	394.80
12/27/2010	411.82	401.67	403.92	396.15	395.31
12/28/2010	411.95	401.69	404.66	396.72	395.86
12/29/2010	414.10	401.71	405.15	397.36	396.65
12/30/2010	416.20	401.70	406.69	397.63	397.00
12/31/2010					

Section P2 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
12/1/2010		-	390.83	390.78	390.67
12/21/2010	409.10	-	391.00	391.56	391.66
12/23/2010	410.50	-	393.15	393.54	393.58
12/24/2010	410.75	-	394.49	394.95	394.84
12/25/2010	410.80	-	395.76	396.17	396.01
12/26/2010	411.49	-	396.00	396.28	396.12
12/27/2010	411.82	-	396.77	396.91	396.70
12/28/2010	411.95	-	397.93	397.87	397.61
12/29/2010	414.10	-	398.77	398.58	398.33
12/30/2010	416.20	-	399.95	399.64	399.37
12/31/2010					

DATA SHOWN FOR 12/1/10 ARE READINGS FROM 9/30/10

Section P3 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
12/1/2010		-	390.63	389.39	390.10
12/21/2010	409.10	-	392.23	390.08	390.47
12/23/2010	410.50	-	395.73	391.68	392.08
12/24/2010	410.75	-	397.43	392.78	393.11
12/25/2010	410.80	-	398.71	394.28	394.12
12/26/2010	411.49	-	398.96	394.93	394.47
12/27/2010	411.82	-	399.69	395.64	395.18
12/28/2010	411.95	-	400.60	396.69	396.22
12/29/2010	414.10	-	401.23	397.73	397.21
12/30/2010	416.20	-	402.79	398.54	398.15
12/31/2010					

Section P4 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
12/1/2010		-	389.89	389.03	388.65
12/21/2010	409.10	-	393.38	390.75	389.88
12/23/2010	410.50	-	396.45	393.20	392.18
12/24/2010	410.75	-	397.99	394.51	393.37
12/25/2010	410.80	-	399.22	395.75	394.55
12/26/2010	411.49	-	399.62	396.16	394.94
12/27/2010	411.82	-	400.41	396.85	395.65
12/28/2010	411.95	-	401.35	397.74	396.64
12/29/2010	414.10	-	402.11	398.57	397.36
12/30/2010	416.20	-	404.08	399.98	398.63
12/31/2010					

DATA SHOWN FOR 12/1/10 ARE READINGS FROM 9/30/10

Section P5 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
12/1/2010		-	389.64	389.04	388.84
12/21/2010	409.10	-	392.32	390.02	388.56
12/23/2010	410.50	-	396.70	394.34	393.06
12/24/2010	410.75	-	398.81	396.32	395.27
12/25/2010	410.80	-	400.26	397.82	396.82
12/26/2010	411.49	-	400.76	398.24	397.17
12/27/2010	411.82	-	401.74	399.05	397.92
12/28/2010	411.95	-	402.69	400.00	398.87
12/29/2010	414.10	-	403.42	400.72	399.49
12/30/2010	416.20	-	405.69	402.41	400.94
12/31/2010					

Section P6 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
12/1/2010		-	386.95	388.49	391.48
12/21/2010	409.10	-	385.33	388.54	391.53
12/23/2010	410.50	-	387.11	388.52	391.49
12/24/2010	410.75	-	388.66	388.51	391.48
12/25/2010	410.80	-	390.58	388.51	391.48
12/26/2010	411.49	-	391.97	388.52	391.50
12/27/2010	411.82	-	393.53	389.21	391.48
12/28/2010	411.95	-	395.40	390.21	391.51
12/29/2010	414.10	-	396.52	391.34	391.52
12/30/2010	416.20	-	398.53	392.96	391.55
12/31/2010					

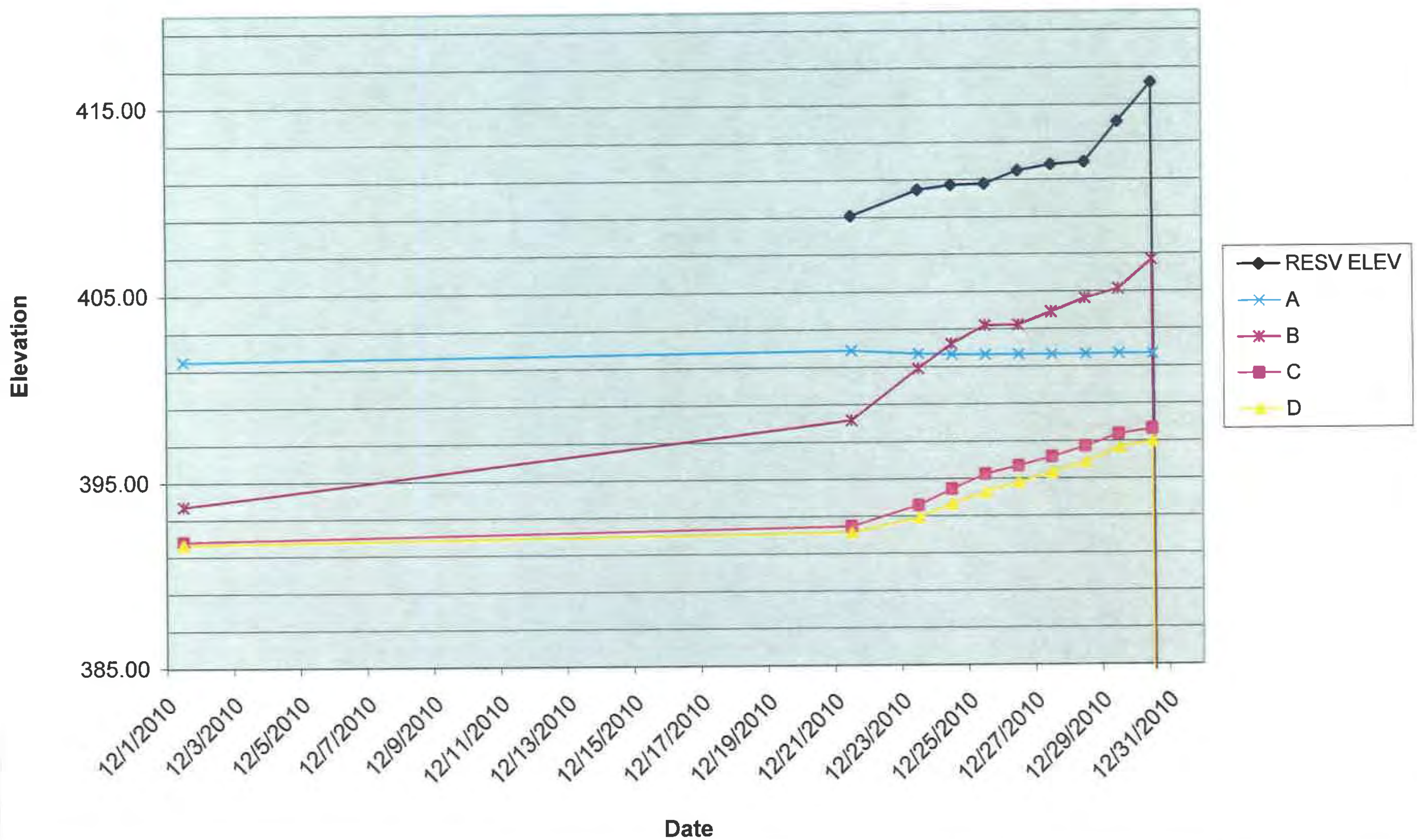
DATA SHOWN FOR 12/1/10 ARE READINGS FROM 9/30/10

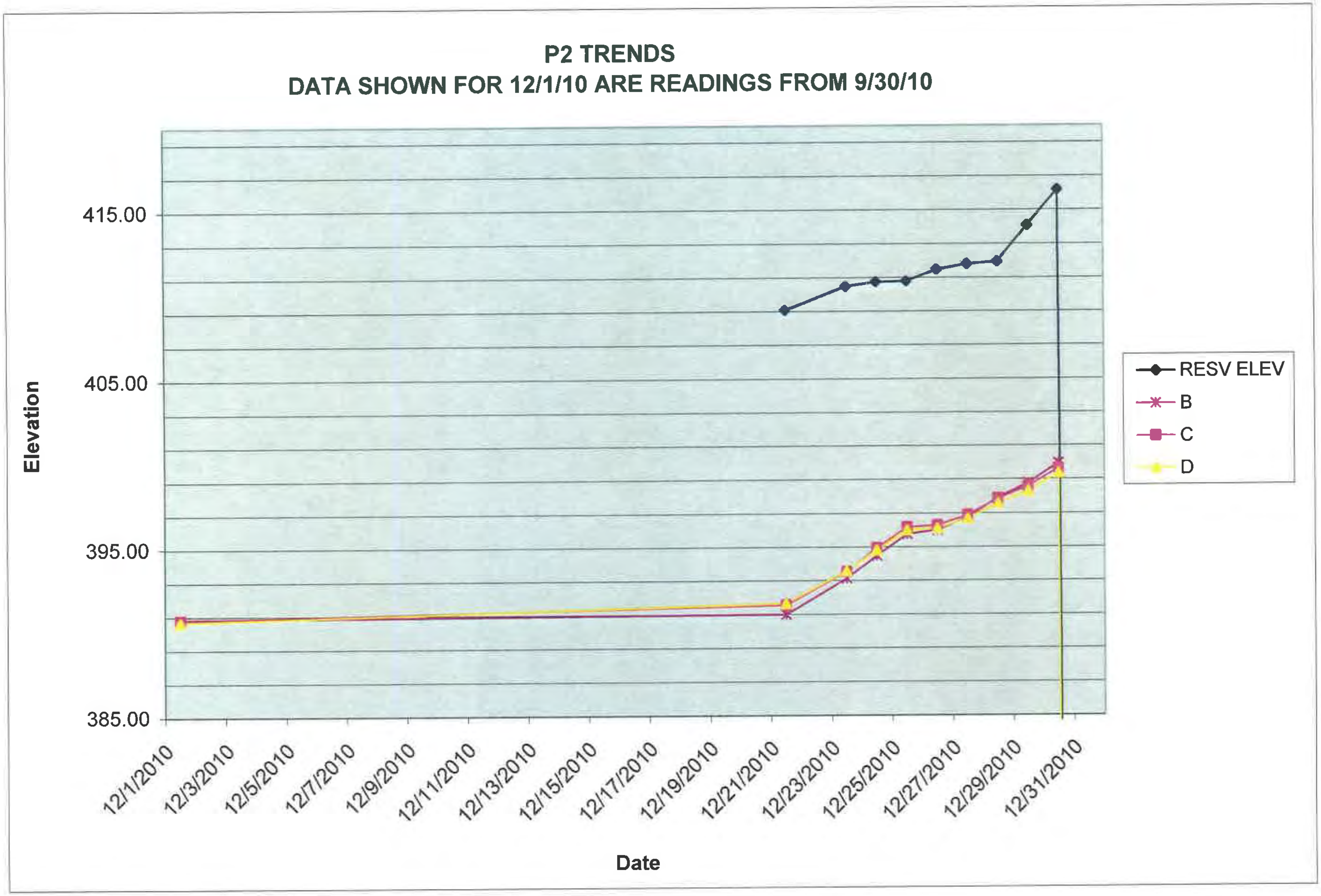
Section P7 Trends

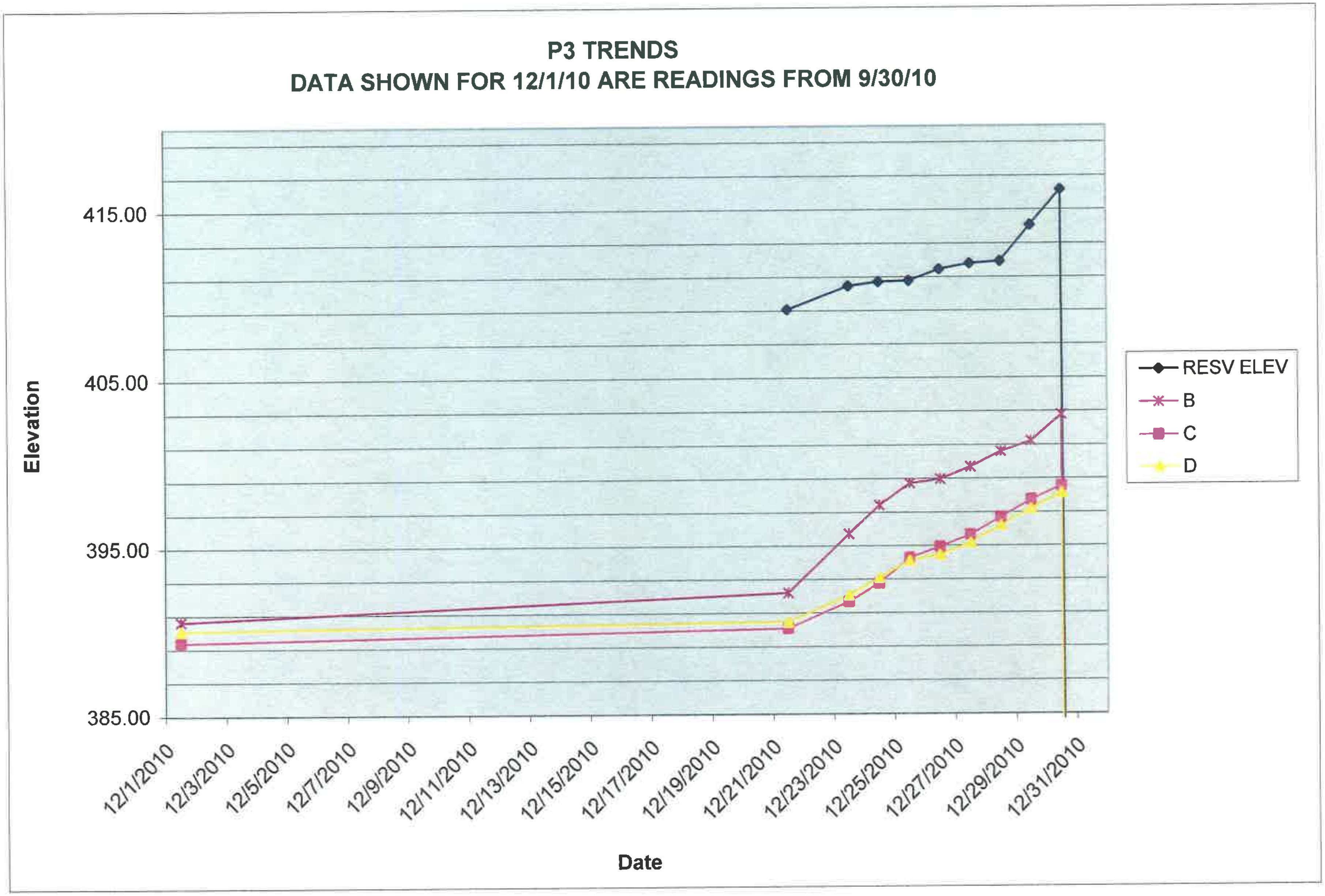
DATA SHOWN FOR 12/1/10 ARE READINGS FROM 9/30/10

	RESV	GROUND WATER ELEVATION			
DATE	ELEV	A	B	C	D
12/1/2010		-	-	389.39	389.92
12/21/2010	409.10	-	-	389.44	389.97
12/23/2010	410.50	-	-	389.40	389.92
12/24/2010	410.75	-	-	389.39	389.92
12/25/2010	410.80	-	-	389.40	390.02
12/26/2010	411.49	-	-	389.40	389.99
12/27/2010	411.82	-	-	389.42	389.99
12/28/2010	411.95	-	-	389.42	390.00
12/29/2010	414.10	-	-	389.43	390.07
12/30/2010	416.20	-	-	389.45	390.10
12/31/2010					

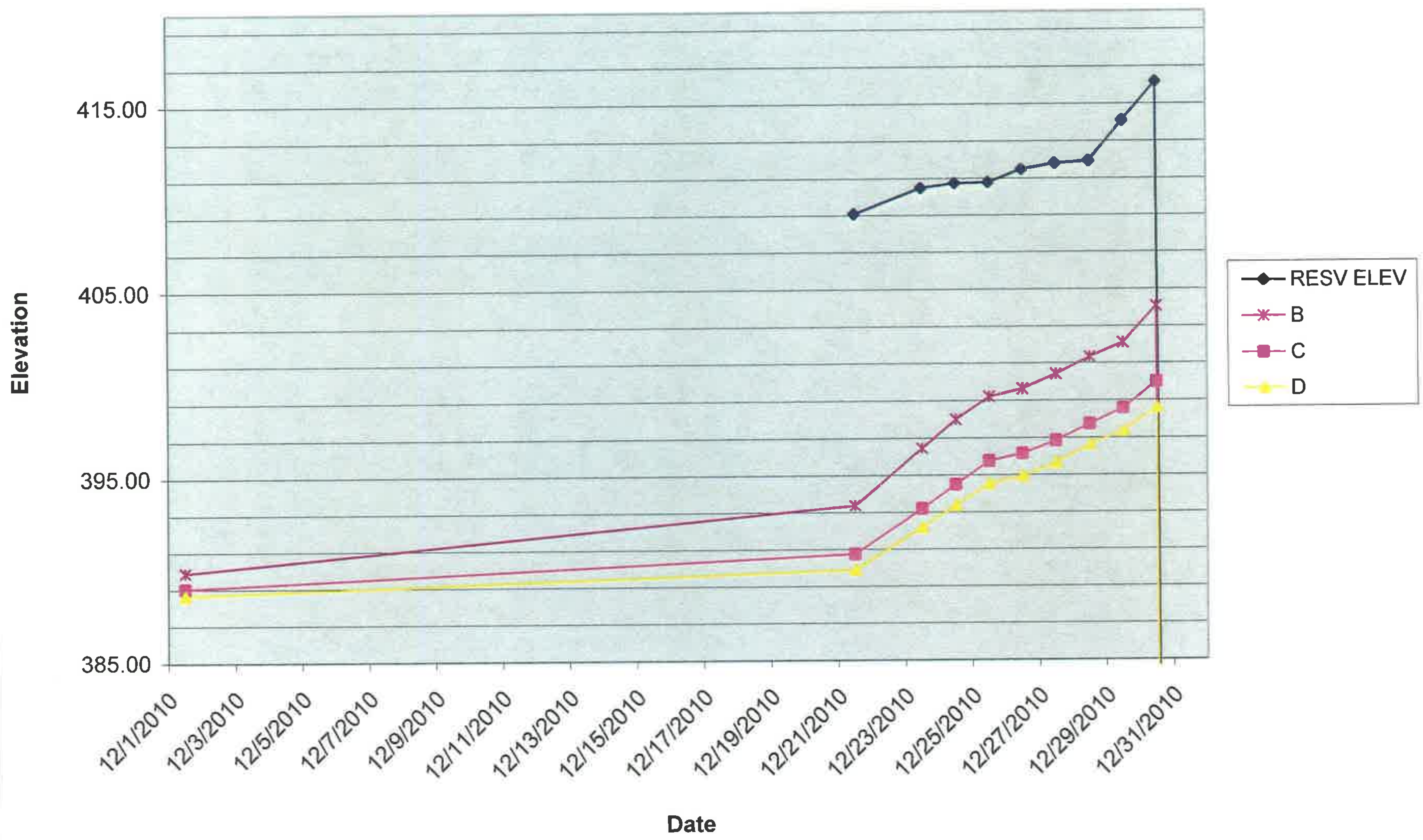
P1 TRENDS
DATA SHOWN FOR 12/1/10 ARE READINGS FROM 9/30/10

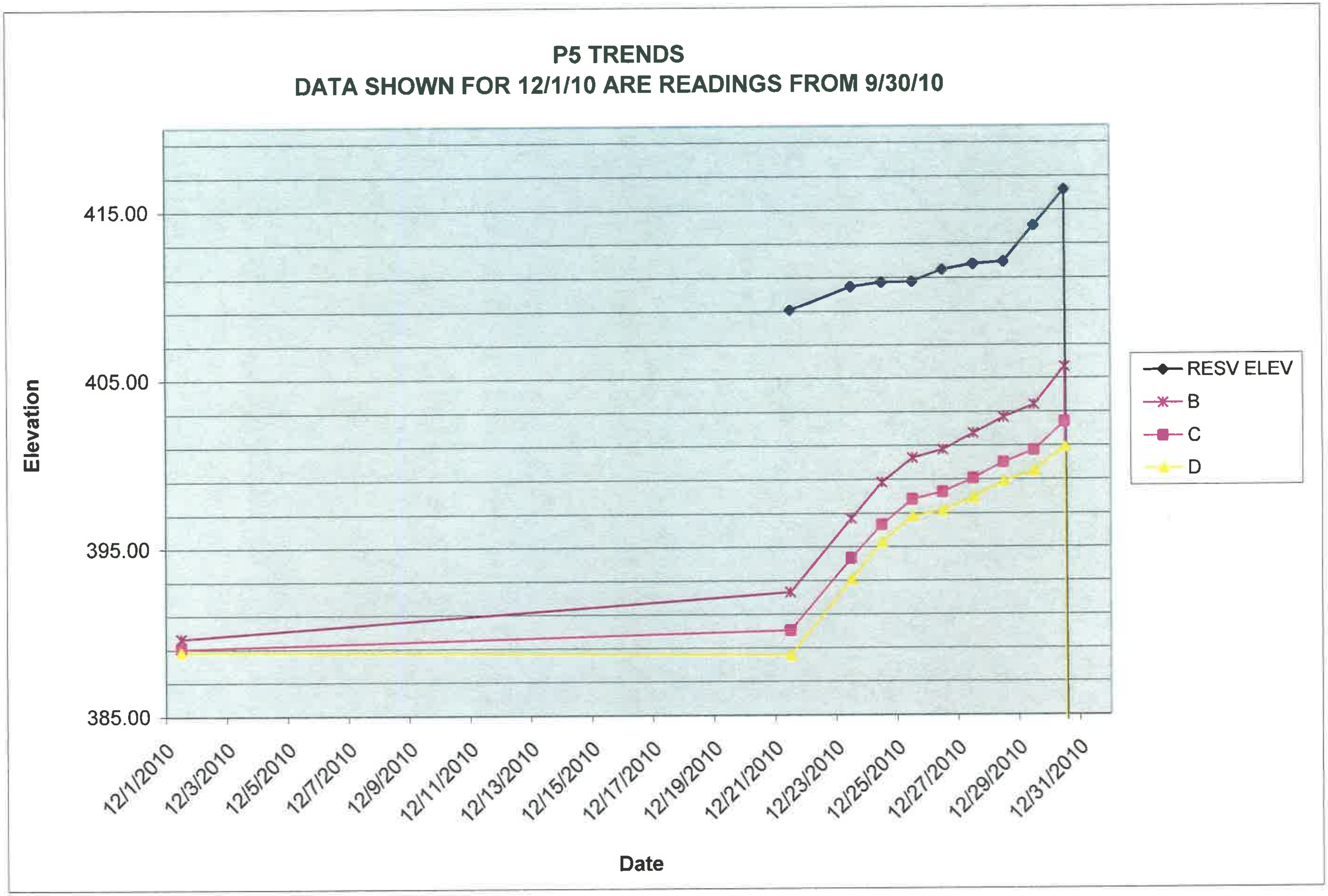



P2 TRENDS
DATA SHOWN FOR 12/1/10 ARE READINGS FROM 9/30/10
Elevation
415.00
405.00
395.00
385.00
12/1/2010
12/3/2010
12/5/2010
12/7/2010
12/9/2010
12/11/2010
12/13/2010
12/15/2010
12/17/2010
12/19/2010
12/21/2010
12/23/2010
12/25/2010
12/27/2010
12/29/2010
12/31/2010
Date
RESV ELEV
B
C
D

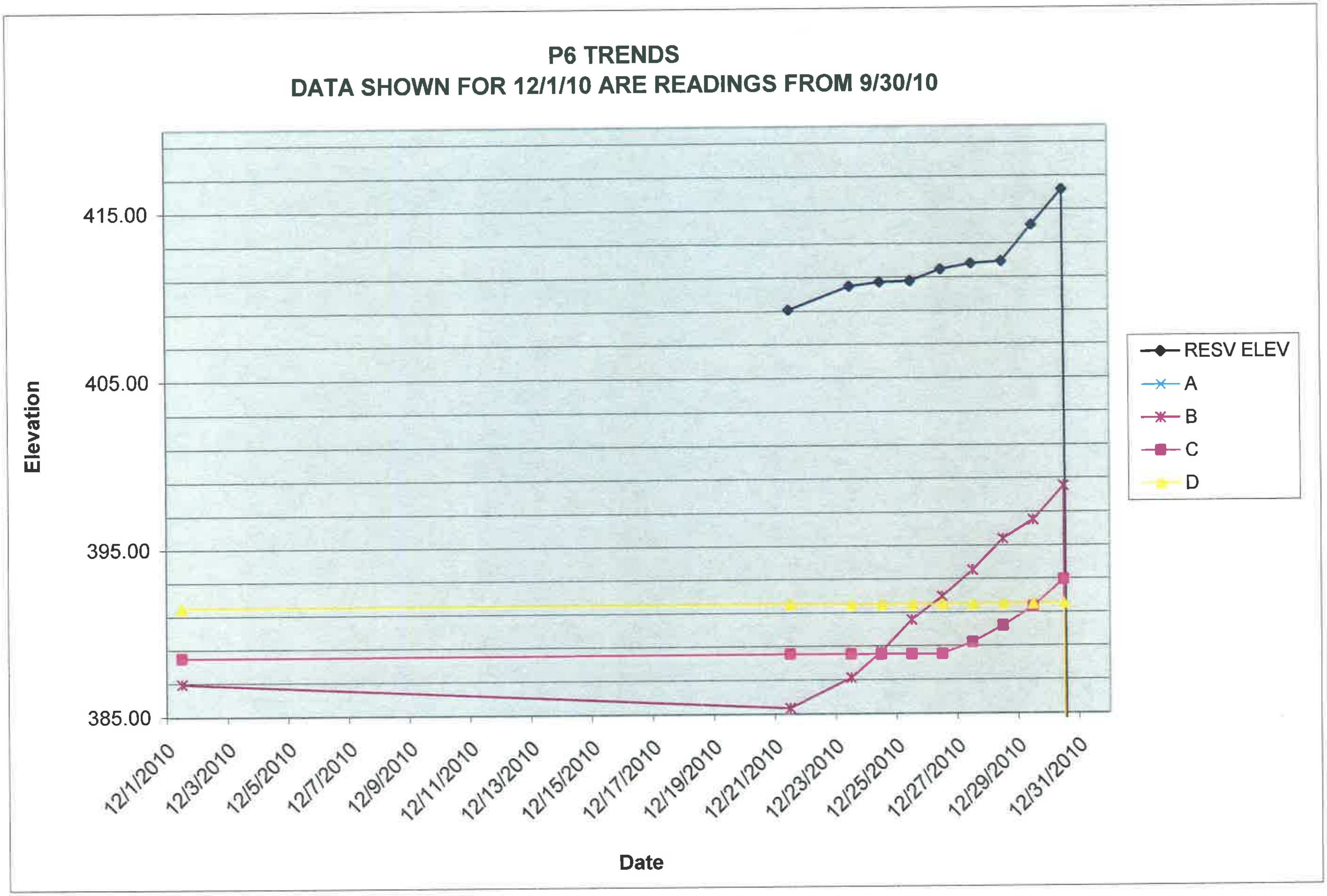

P3 TRENDS
DATA SHOWN FOR 12/1/10 ARE READINGS FROM 9/30/10
Elevation
415.00
405.00
395.00
385.00
12/1/2010
12/3/2010
12/5/2010
12/7/2010
12/9/2010
12/11/2010
12/13/2010
12/15/2010
12/17/2010
12/19/2010
12/21/2010
12/23/2010
12/25/2010
12/27/2010
12/29/2010
12/31/2010
Date
RESV ELEV
B
C
D

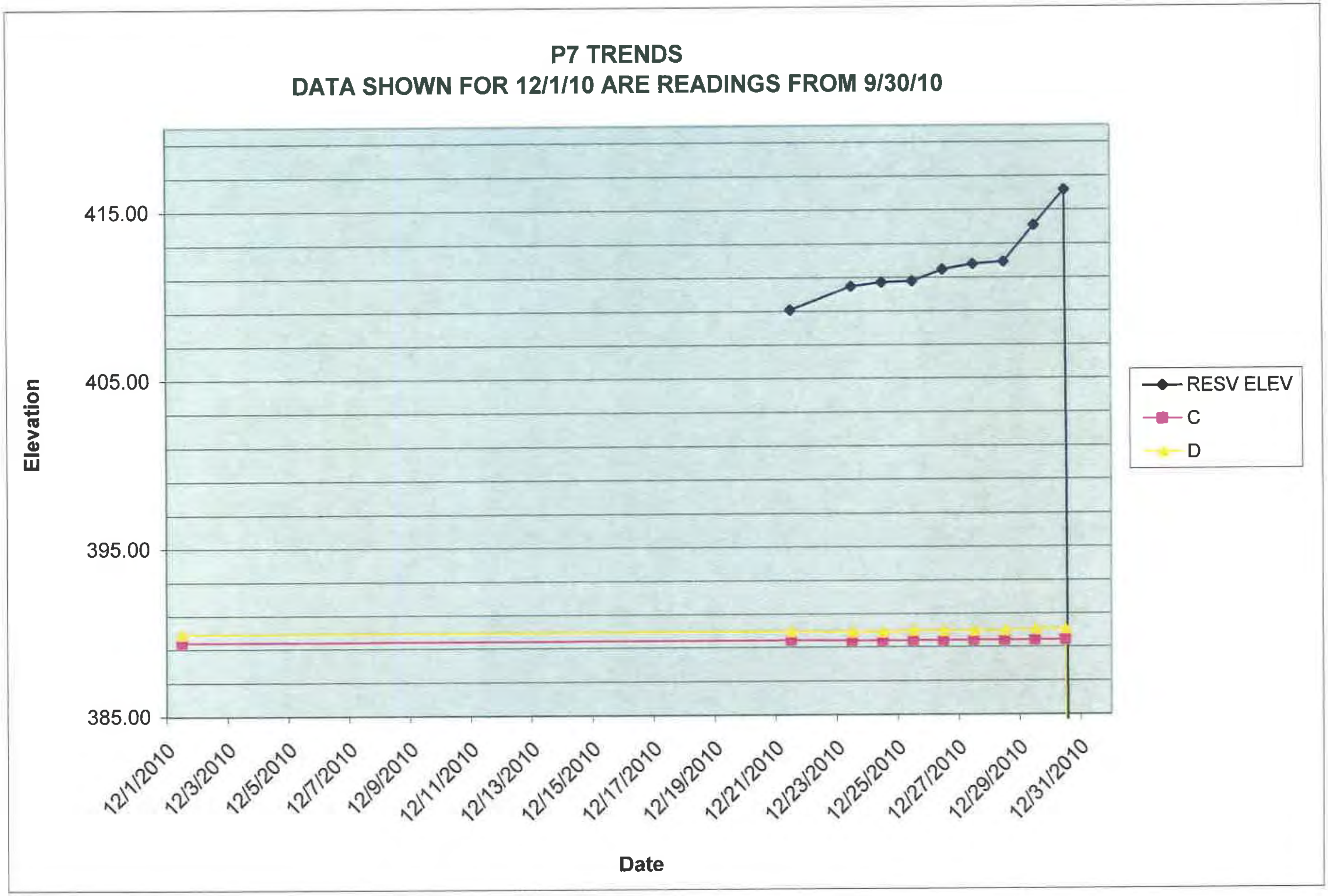
P4 TRENDS
DATA SHOWN FOR 12/1/10 ARE READINGS FROM 9/30/10





P5 TRENDS
DATA SHOWN FOR 12/1/10 ARE READINGS FROM 9/30/10
Elevation
415.00
405.00
395.00
385.00
12/1/2010
12/3/2010
12/5/2010
12/7/2010
12/9/2010
12/11/2010
12/13/2010
12/15/2010
12/17/2010
12/19/2010
12/21/2010
12/23/2010
12/25/2010
12/27/2010
12/29/2010
12/31/2010
Date
RESV ELEV
B
C
D


P6 TRENDS
DATA SHOWN FOR 12/1/10 ARE READINGS FROM 9/30/10
Elevation
415.00
405.00
395.00
385.00
12/1/2010
12/3/2010
12/5/2010
12/7/2010
12/9/2010
12/11/2010
12/13/2010
12/15/2010
12/17/2010
12/19/2010
12/21/2010
12/23/2010
12/25/2010
12/27/2010
12/29/2010
12/31/2010
Date
RESV ELEV
A
B
C
D



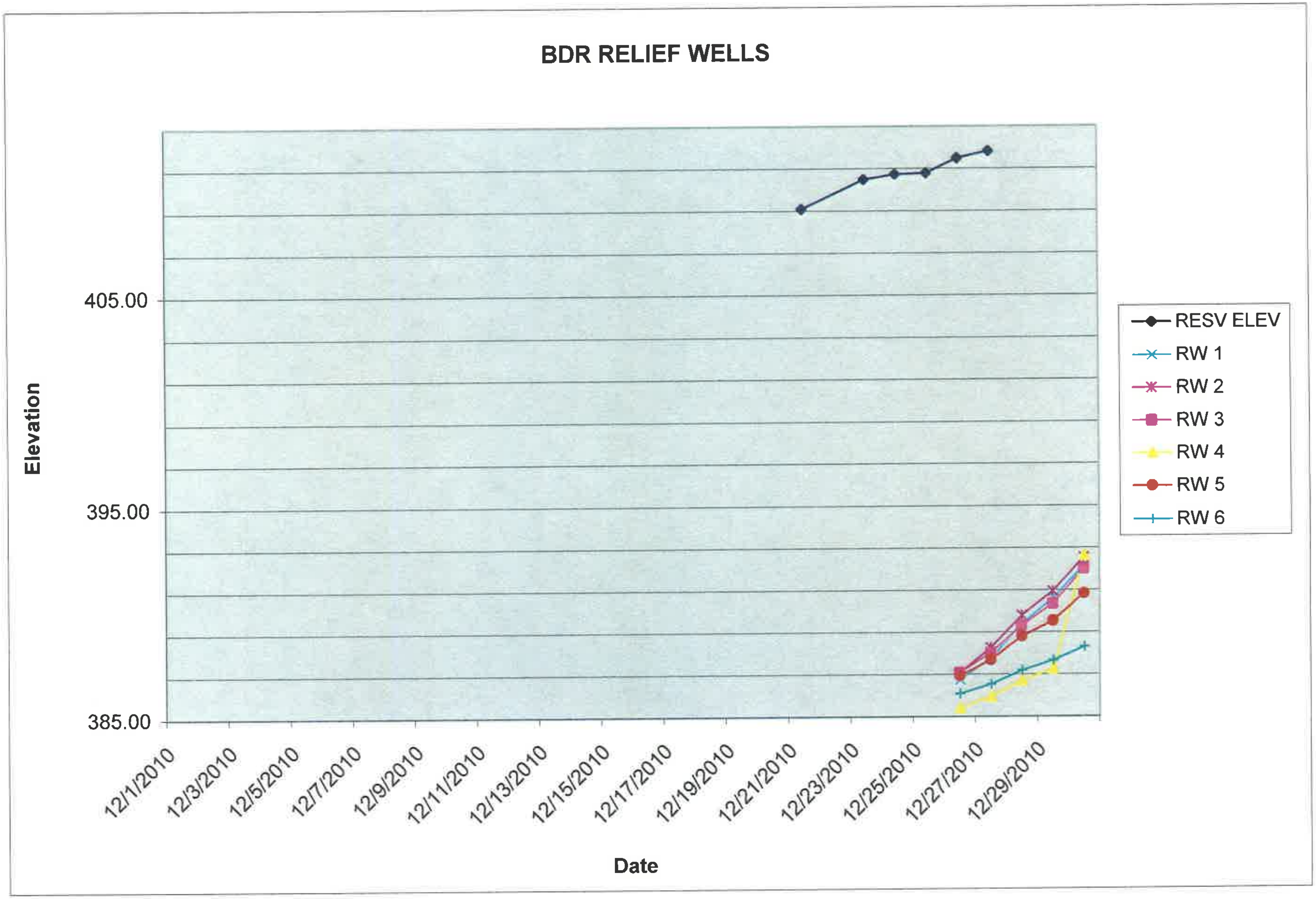
P7 TRENDS
DATA SHOWN FOR 12/1/10 ARE READINGS FROM 9/30/10
Elevation
415.00
405.00
395.00
385.00
12/1/2010
12/3/2010
12/5/2010
12/7/2010
12/9/2010
12/11/2010
12/13/2010
12/15/2010
12/17/2010
12/19/2010
12/21/2010
12/23/2010
12/25/2010
12/27/2010
12/29/2010
12/31/2010
Date
RESV ELEV
C
D

NOTE: For the trend graphs to show correctly, you must go to each row of data for each date not collected and deleted the cell contents of the date cell for that row - DO NOT DELETE THE CELL OR ROW, JUST THE DATE CELL CONTENTS THAT SHOW

RELIEF WELL MONITORING

December-10

DATE	RESV ELEV	GROUND WATER ELEVATION RW 1	RW 2	RW 3	RW 4	RW 5	RW 6
12/1/2010							
12/21/2010	409.10						
12/23/2010	410.50						
12/24/2010	410.75						
12/25/2010	410.80						
12/26/2010	411.49	386.77	387.06	387.07	385.38	386.93	386.11
12/27/2010	411.82	387.78	388.26	388.01	385.95	387.68	386.56
12/28/2010		389.41	389.79	389.31	386.69	388.80	387.21
12/29/2010		390.64	390.94	390.35	387.25	389.53	387.68
12/30/2010		392.20	392.54	392.01	392.64	390.83	388.31



BDR RELIEF WELLS
Elevation
405.00
395.00
385.00
12/1/2010
12/3/2010
12/5/2010
12/7/2010
12/9/2010
12/11/2010
12/13/2010
12/15/2010
12/17/2010
12/19/2010
12/21/2010
12/23/2010
12/25/2010
12/27/2010
12/29/2010
Date
RESV ELEV
RW 1
RW 2
RW 3
RW 4
RW 5
RW 6

Section P1 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
1/1/2011	416.50	401.70	407.51	397.82	397.24
1/2/2011	417.00	401.71	407.90	398.20	397.69
1/3/2011	419.00	401.70	408.92	398.36	397.89
1/4/2011	418.95	401.70	409.20	398.35	397.89
1/5/2011	418.80	401.70	409.34	398.39	397.93
1/6/2011	418.42	401.70	409.38	398.42	397.93
1/7/2011	418.05	401.69	409.30	398.41	397.93
1/8/2011	417.80	401.70	409.11	398.35	397.88
1/9/2011	417.40	401.69	408.90	398.30	397.81
1/10/2011	416.91	401.69	408.68	398.31	397.83
1/12/2011	415.99	401.71	408.23	398.26	397.77
1/13/2011	415.52	401.70	407.97	398.18	397.69
1/14/2011	414.82	401.67	407.75	398.21	397.70
1/16/2011	413.65	401.69	407.17	398.19	397.69
1/18/2011	412.30	401.68	406.45	398.07	397.63
1/19/2011	411.45	401.68	406.09	398.07	397.65
1/21/2011	409.49	401.66	405.00	397.89	397.48
1/24/2011	404.49	401.69	402.71	397.67	397.32
1/26/2011	404.49	401.64	401.79	397.47	397.16
1/28/2011	404.42	401.68	401.80	397.51	397.20
1/31/2011	404.77	401.63	401.54	397.46	397.14

Section P2 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
1/1/2011	416.50	-	401.67	400.82	400.51
1/2/2011	417.00	-	402.52	401.50	401.18
1/3/2011	419.00	-	403.62	402.40	402.09
1/4/2011	418.95	-	404.18	402.81	402.44
1/5/2011	418.80	-	404.80	403.29	402.86
1/6/2011	418.42	-	405.20	403.46	403.21
1/7/2011	418.05	-	405.41	403.46	403.28
1/8/2011	417.80	-	405.36	403.46	403.24
1/9/2011	417.40	-	405.23	403.46	403.15
1/10/2011	416.91	-	405.10	403.46	403.08
1/12/2011	415.99	-	404.73	403.29	402.88
1/13/2011	415.52	-	404.53	403.08	402.71
1/14/2011	414.82	-	404.19	403.04	402.70
1/16/2011	413.65	-	404.11	402.79	402.46
1/18/2011	412.30	-	403.62	402.46	402.13
1/19/2011	411.45	-	403.37	402.29	401.97
1/21/2011	409.49	-	402.50	401.59	401.31
1/24/2011	404.49	-	401.13	400.44	400.19
1/26/2011	404.49	-	400.13	399.66	399.47
1/28/2011	404.42	-	399.75	399.40	399.26
1/31/2011	404.77	-	399.22	399.01	398.88

Section P3 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
1/1/2011	416.50	-	404.04	399.61	399.21
1/2/2011	417.00	-	404.74	400.57	400.02
1/3/2011	419.00	-	406.07	401.45	401.23
1/4/2011	418.95	-	406.59	401.84	401.66
1/5/2011	418.80	-	407.03	402.26	402.18
1/6/2011	418.42	-	407.30	402.62	402.56
1/7/2011	418.05	-	407.46	402.82	402.85
1/8/2011	417.80	-	407.39	402.83	402.89
1/9/2011	417.40	-	407.29	402.83	402.92
1/10/2011	416.91	-	407.24	402.84	402.97
1/12/2011	415.99	-	406.89	402.76	402.94
1/13/2011	415.52	-	406.67	402.62	402.83
1/14/2011	414.82	-	406.48	402.63	402.89
1/16/2011	413.65	-	406.08	402.46	402.79
1/18/2011	412.30	-	405.48	402.20	402.55
1/19/2011	411.45	-	405.15	402.05	402.44
1/21/2011	409.49	-	404.09	401.47	401.86
1/24/2011	404.49	-	401.95	400.13	400.72
1/26/2011	404.49	-	400.94	399.23	399.90
1/28/2011	404.42	-	400.69	398.95	399.60
1/31/2011	404.77	-	400.28	398.51	399.15

Section P4 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
1/1/2011	416.50	-	405.53	401.35	399.92
1/2/2011	417.00	-	406.18	402.15	400.74
1/3/2011	419.00	-	407.65	403.40	402.05
1/4/2011	418.95	-	408.06	403.72	402.36
1/5/2011	418.80	-	408.36	403.98	402.68
1/6/2011	418.42	-	408.50	404.14	402.88
1/7/2011	418.05	-	408.48	404.21	403.01
1/8/2011	417.80	-	408.35	404.16	402.97
1/9/2011	417.40	-	408.15	404.10	402.91
1/10/2011	416.91	-	408.02	404.10	402.93
1/12/2011	415.99	-	407.62	403.93	402.85
1/13/2011	415.52	-	407.38	403.81	402.74
1/14/2011	414.82	-	407.15	403.75	402.71
1/16/2011	413.65	-	406.62	403.50	402.52
1/18/2011	412.30	-	405.96	403.15	402.25
1/19/2011	411.45	-	405.63	402.98	402.07
1/21/2011	409.49	-	404.53	402.28	401.47
1/24/2011	404.49	-	402.26	400.73	400.18
1/26/2011	404.49	-	401.16	399.76	399.26
1/28/2011	404.42	-	400.81	399.38	398.88
1/31/2011	404.77	-	400.40	398.98	398.48

Section P5 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
1/1/2011	416.50	-	407.01	403.71	402.29
1/2/2011	417.00	-	407.66	404.38	403.01
1/3/2011	419.00	-	409.37	405.85	404.30
1/4/2011	418.95	-	409.84	406.34	404.82
1/5/2011	418.80	-	410.07	406.71	405.31
1/6/2011	418.42		410.17	406.90	405.57
1/7/2011	418.05	403.14	410.11	406.99	405.75
1/8/2011	417.80	403.32	409.92	406.89	405.72
1/9/2011	417.40	403.56	409.74	406.77	405.67
1/10/2011	416.91	403.81	409.56	406.70	405.63
1/12/2011	415.99	404.30	409.06	406.40	405.40
1/13/2011	415.52	404.35	408.77	406.19	405.25
1/14/2011	414.82	404.46	408.44	406.00	405.14
1/16/2011	413.65	404.64	407.80	405.53	404.70
1/18/2011	412.30	404.84	406.94	404.87	404.18
1/19/2011	411.45	404.89	406.45	404.52	403.87
1/21/2011	409.49	404.93	405.11	403.43	402.87
1/24/2011	404.49	404.88	402.92	401.59	401.18
1/26/2011	404.49	404.67	402.04	400.77	400.35
1/28/2011	404.42	404.54	401.75	400.53	400.07
1/31/2011	404.77	404.26	401.34	400.07	399.61

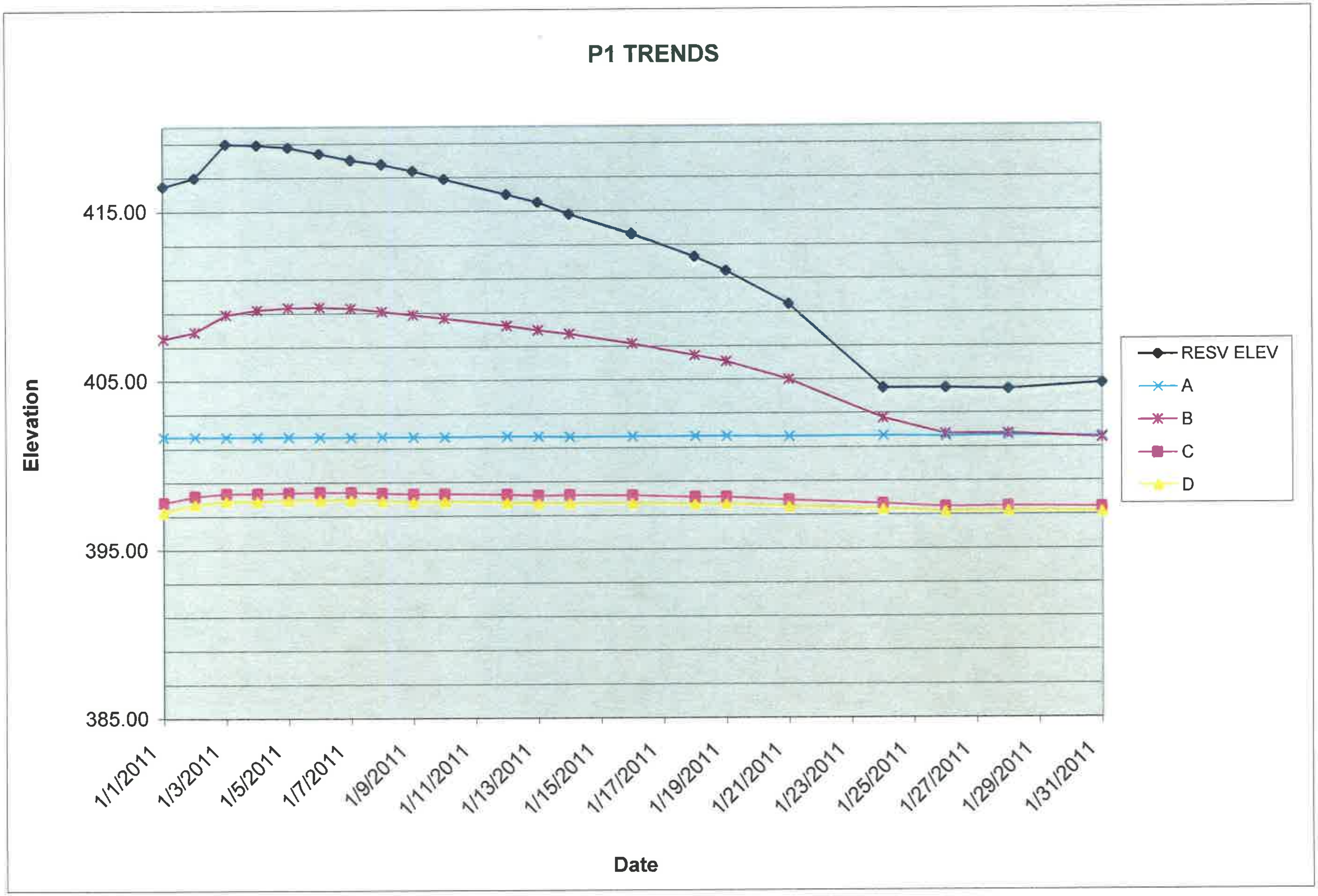
Section P6 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
1/1/2011	416.50	395.61	401.72	395.62	393.72
1/2/2011	417.00	396.43	403.06	396.84	395.04
1/3/2011	419.00	397.79	405.60	398.76	396.73
1/4/2011	418.95	398.35	406.74	399.99	397.92
1/5/2011	418.80	399.88	407.69	401.28	399.23
1/6/2011	418.42	400.57	408.29	402.20	400.23
1/7/2011	418.05	401.39	408.56	402.88	400.98
1/8/2011	417.80	401.81	408.65	403.20	401.36
1/9/2011	417.40	402.42	408.73	403.49	401.77
1/10/2011	416.91	403.87	408.82	403.84	402.17
1/12/2011	415.99	404.49	408.59	404.09	402.55
1/13/2011	415.52	404.50	408.36	404.02	402.55
1/14/2011	414.82	404.59	408.15	404.07	402.62
1/16/2011	413.65	404.75	407.62	403.87	402.58
1/18/2011	412.30	404.62	407.01	403.56	402.37
1/19/2011	411.45	404.56	406.71	403.43	402.28
1/21/2011	409.49	404.04	405.82	402.92	401.85
1/24/2011	404.49	403.42	404.56	402.11	401.24
1/26/2011	404.49	402.89	403.77	401.56	400.78
1/28/2011	404.42	402.58	403.32	401.25	400.50
1/31/2011	404.77	402.01	402.60	400.62	399.95

Jan-11

Section P7 Trends

	RESV	GROUND WATER ELEVATION			
DATE	ELEV	A	B	C	D
1/1/2011	416.50	-	-	389.44	390.09
1/2/2011	417.00	-	-	389.43	390.10
1/3/2011	419.00	-	-	389.43	390.09
1/4/2011	418.95	-	-	389.43	390.10
1/5/2011	418.80	-	-	389.43	390.10
1/6/2011	418.42	-	-	389.76	390.10
1/7/2011	418.05	-	-	390.51	390.70
1/8/2011	417.80	-	-	391.02	391.15
1/9/2011	417.40	-	-	391.57	391.70
1/10/2011	416.91	-	-	392.19	392.31
1/12/2011	415.99	-	-	392.99	393.12
1/13/2011	415.52	-	-	393.34	393.42
1/14/2011	414.82	-	-	393.73	393.81
1/16/2011	413.65	-	-	394.25	394.32
1/18/2011	412.30	-	-	394.73	394.76
1/19/2011	411.45	-	-	394.91	394.93
1/21/2011	409.49	-	-	395.10	395.14
1/24/2011	404.49	-	-	395.28	395.24
1/26/2011	404.49	-	-	395.22	395.18
1/28/2011	404.42	-	-	395.27	395.24
1/31/2011	404.77	-	-	395.11	395.05


P1 TRENDS
Elevation
415.00
405.00
395.00
385.00
1/1/2011
1/3/2011
1/5/2011
1/7/2011
1/9/2011
1/11/2011
1/13/2011
1/15/2011
1/17/2011
1/19/2011
1/21/2011
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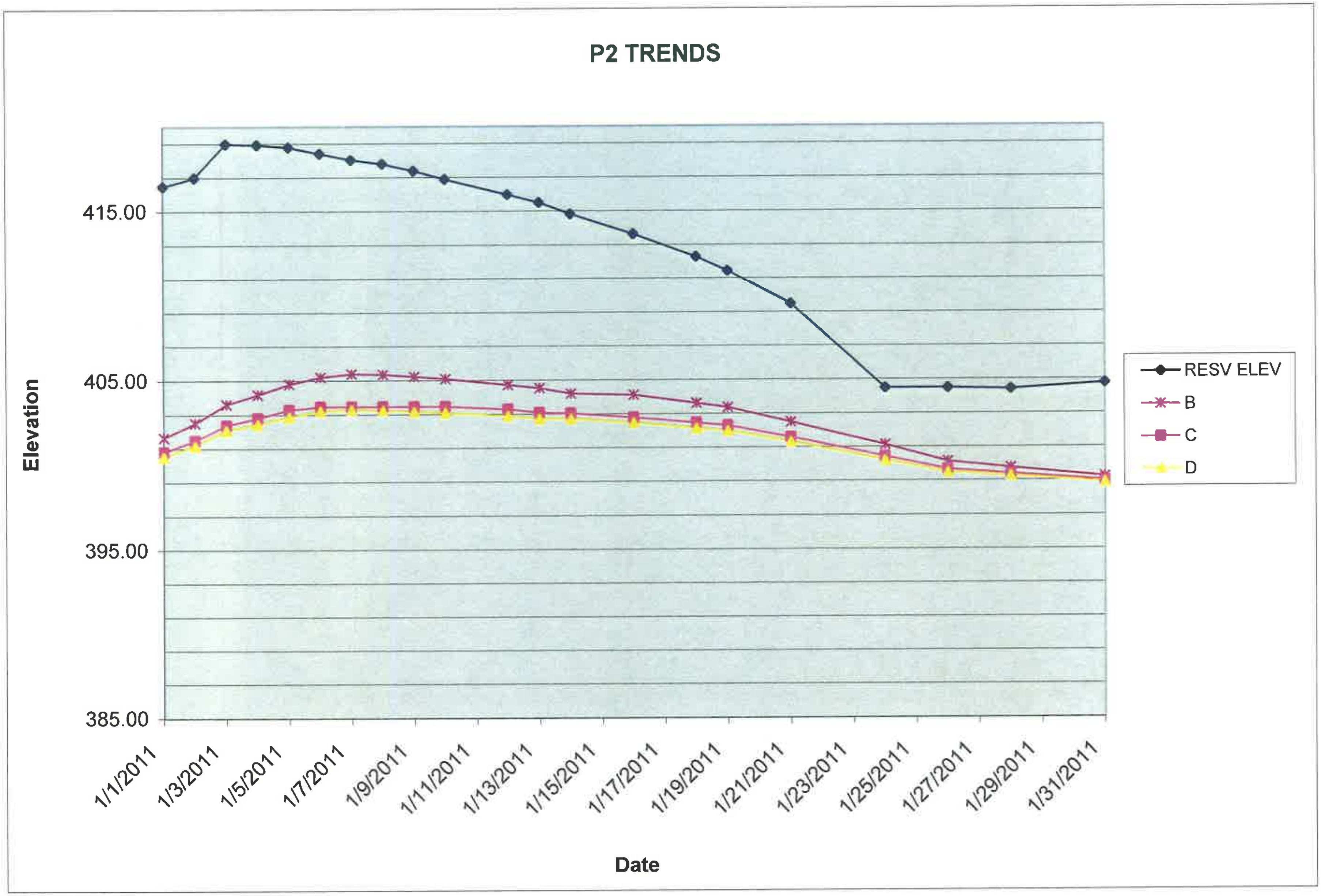
1/25/2011
1/27/2011
1/29/2011
1/31/2011
Date
RESV ELEV
A
B
C
D


P2 TRENDS
Elevation
415.00
405.00
395.00
385.00
1/1/2011
1/3/2011
1/5/2011
1/7/2011
1/9/2011
1/11/2011
1/13/2011
1/15/2011
1/17/2011
1/19/2011
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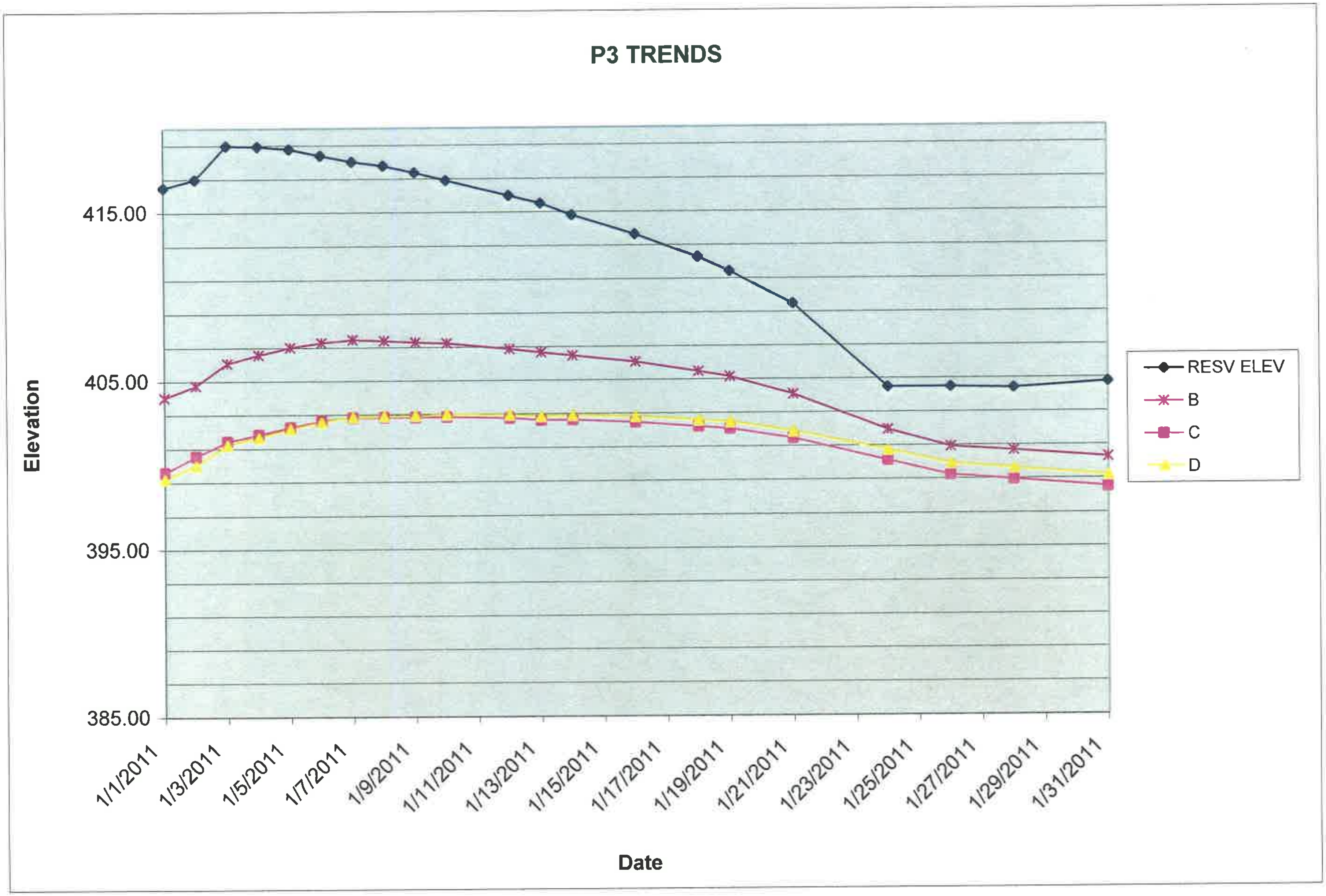
1/29/2011
1/31/2011
Date
RESV ELEV
B
C
D


P3 TRENDS
Elevation
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405.00
395.00
385.00
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1/3/2011
1/5/2011
1/7/2011
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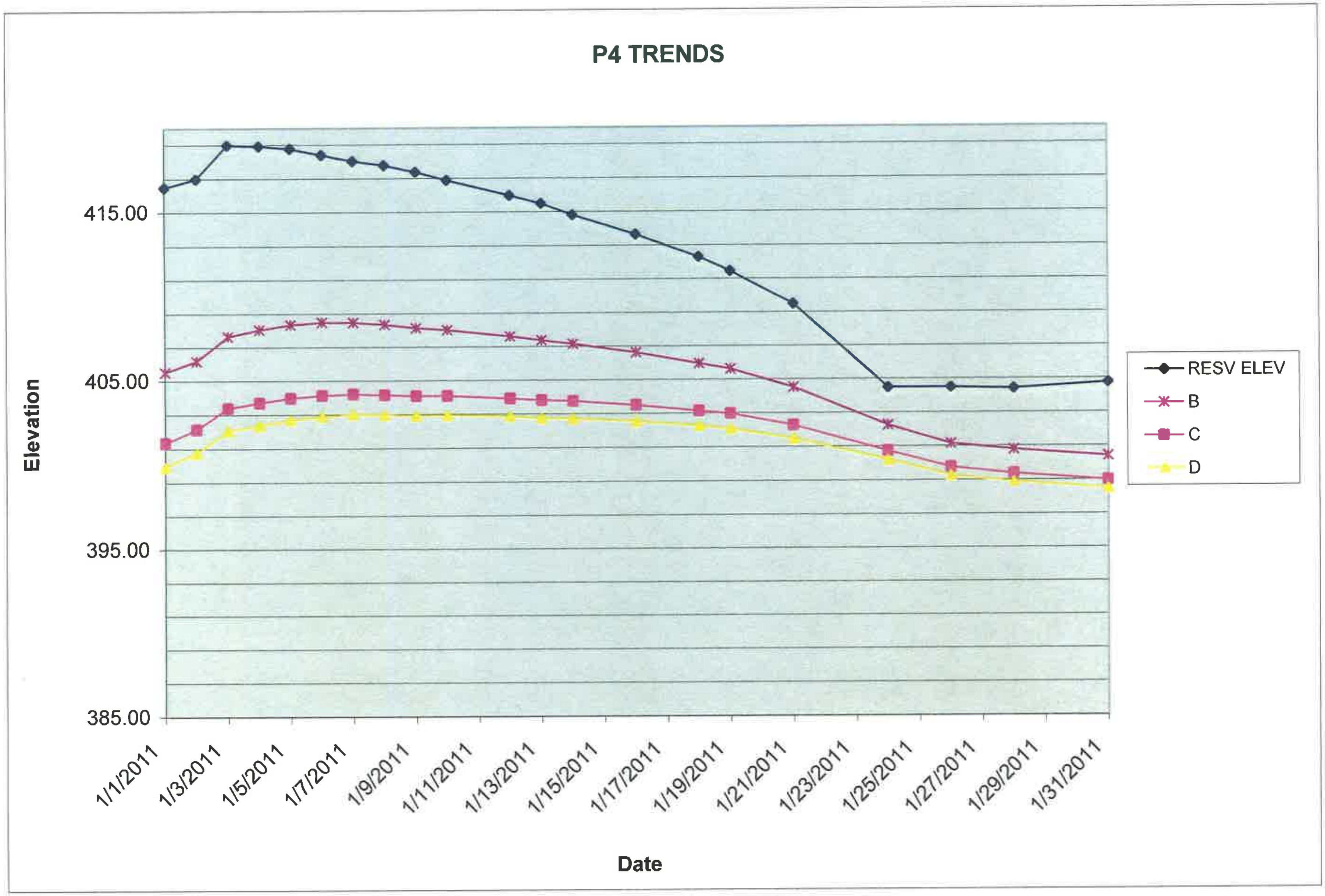
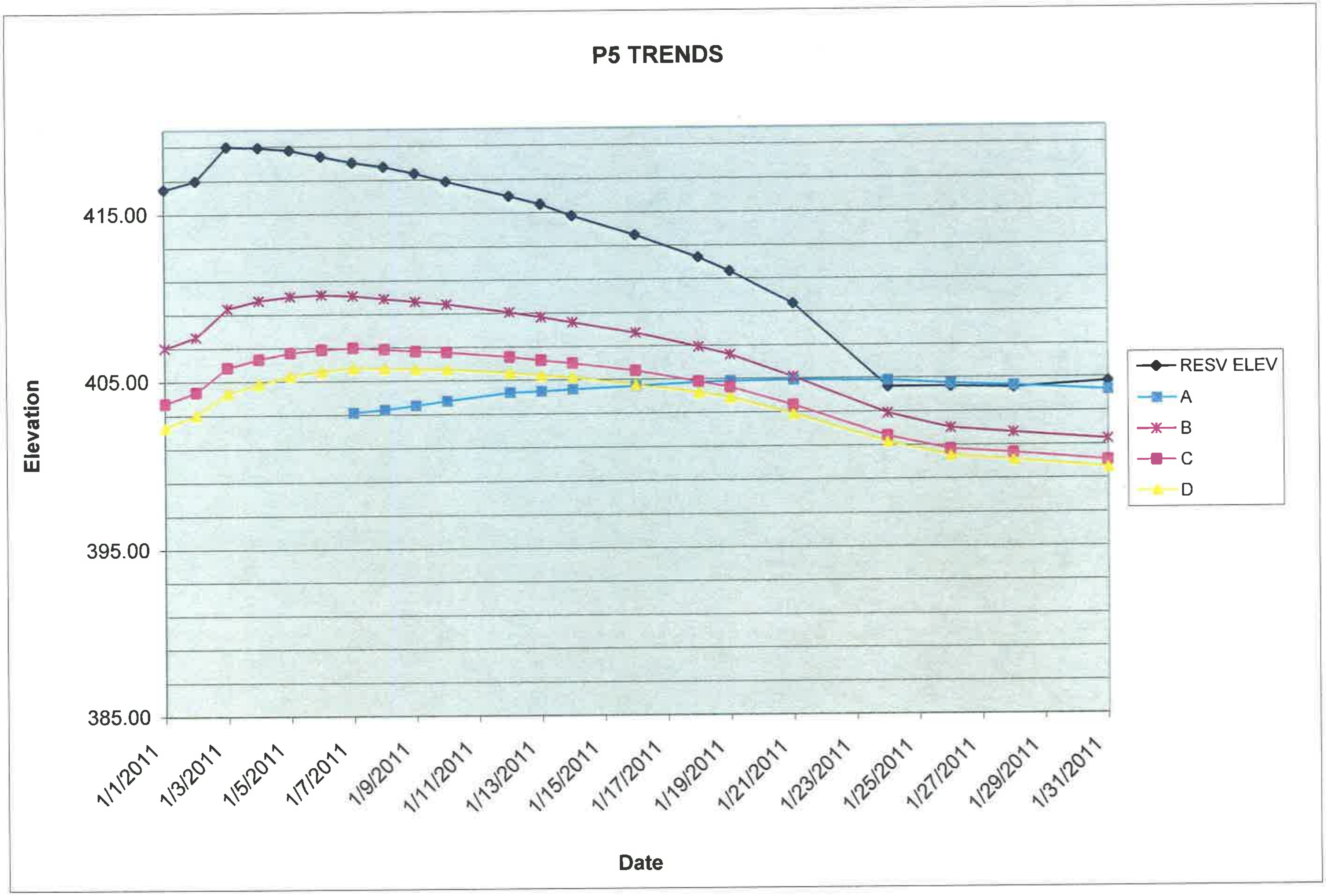
1/11/2011
1/13/2011
1/15/2011
1/17/2011
1/19/2011
1/21/2011
1/23/2011
1/25/2011
1/27/2011
1/29/2011
1/31/2011
Date
RESV ELEV
B
C
D


P4 TRENDS
Elevation
415.00
405.00
395.00
385.00
1/1/2011
1/3/2011
1/5/2011
1/7/2011
1/9/2011
1/11/2011
1/13/2011
1/15/2011
1/17/2011
1/19/2011
1/21/2011
1/23/2011
1/25/2011
1/27/2011
1/29/2011
1/31/2011
Date
RESV ELEV
B
C
D


P5 TRENDS
Elevation
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405.00
395.00
385.00
1/1/2011
1/3/2011
1/5/2011
1/7/2011
1/9/2011
1/11/2011
1/13/2011
1/15/2011
1/17/2011
1/19/2011
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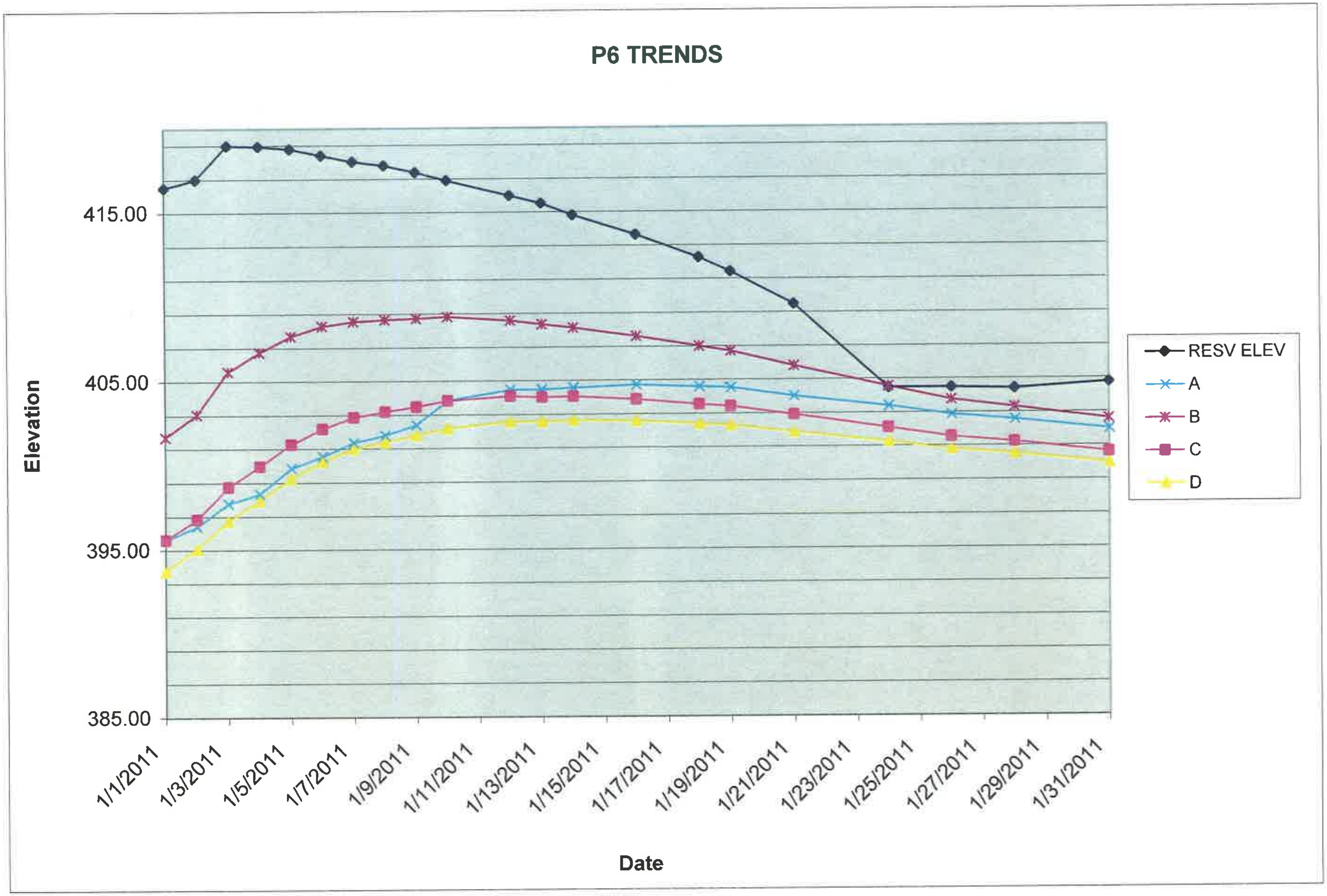
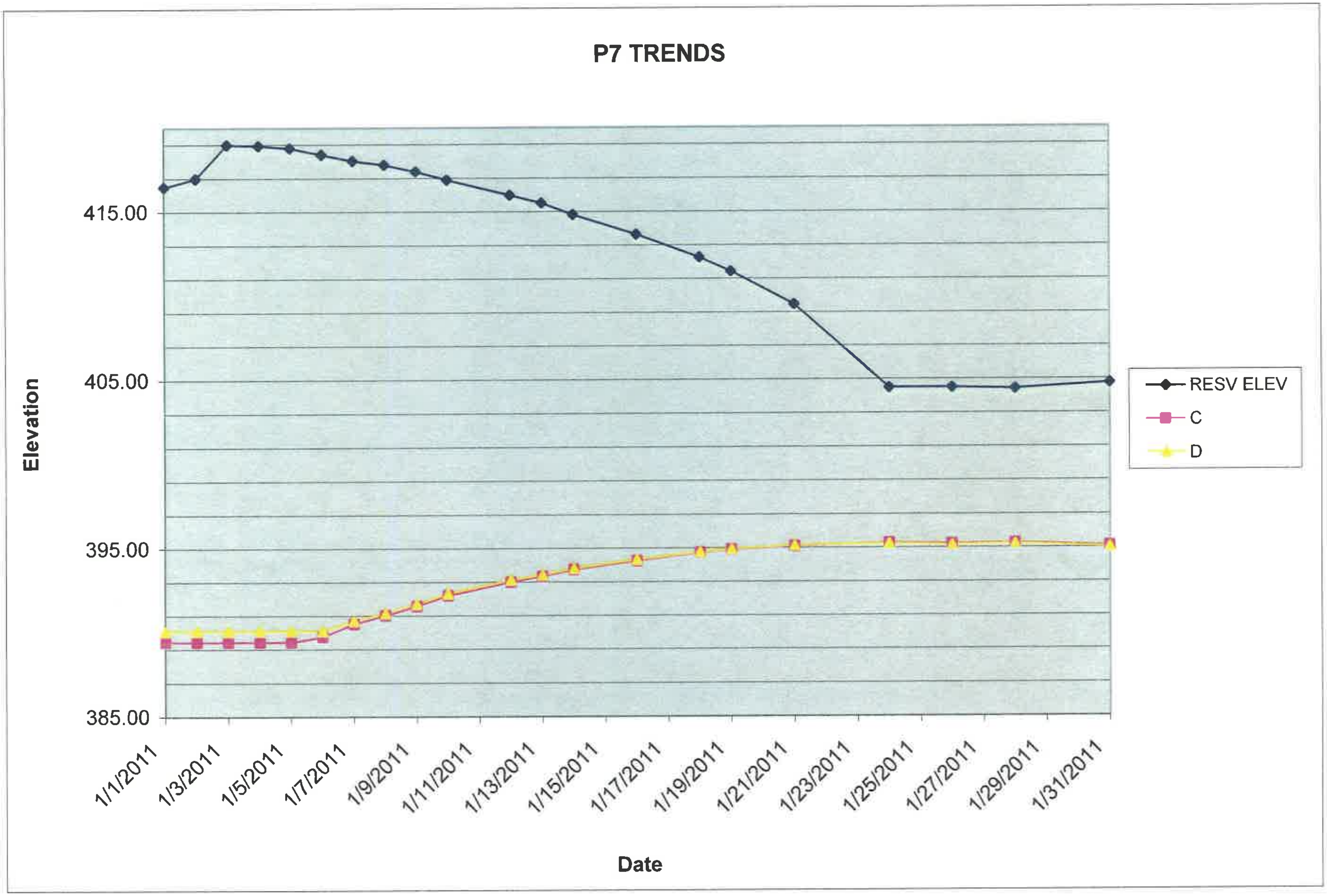
1/27/2011
1/29/2011
1/31/2011
Date
RESV ELEV
A
B
C
D


P6 TRENDS
Elevation
415.00
405.00
395.00
385.00
1/1/2011
1/3/2011
1/5/2011
1/7/2011
1/9/2011
1/11/2011
1/13/2011
1/15/2011
1/17/2011
1/19/2011
1/21/2011
1/23/2011
1/25/2011
1/27/2011
1/29/2011
1/31/2011
Date
RESV ELEV
A
B
C
D

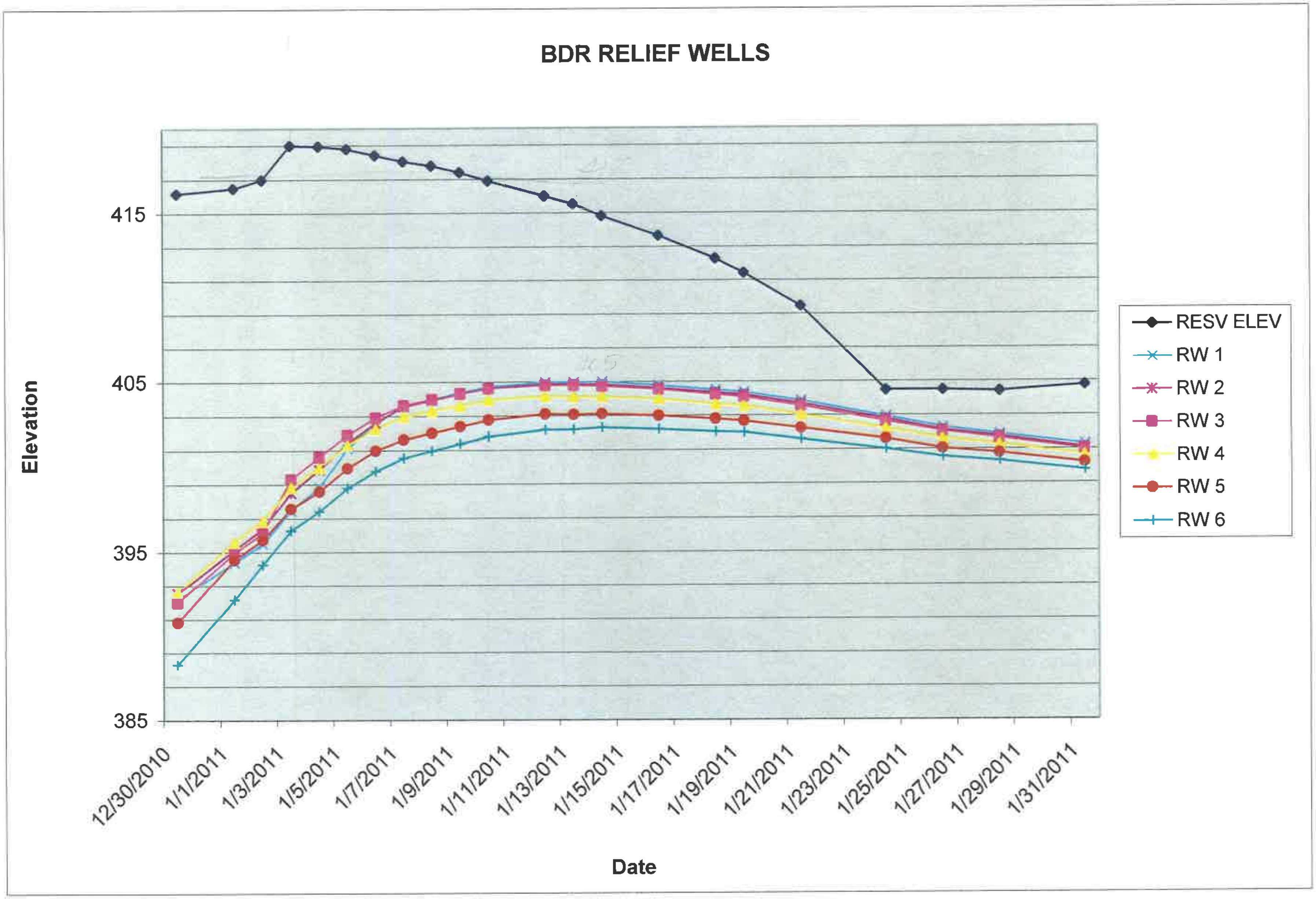


P7 TRENDS
Elevation
415.00
405.00
395.00
385.00
1/1/2011
1/3/2011
1/5/2011
1/7/2011
1/9/2011
1/11/2011
1/13/2011
1/15/2011
1/17/2011
1/19/2011
1/21/2011
1/23/2011
1/25/2011
1/27/2011
1/29/2011
1/31/2011
Date
RESV ELEV
C
D

NOTE: For the trend graphs to show correctly, you must go to each row of data for each date not collected and deleted the cell contents of the date cell for that row - DO NOT DELETE THE CELL OR ROW, JUST THE DATE CELL CONTENTS THAT SHOW

RELIEF WELL MONITORING

DATE	RESV ELEV	GROUND WATER ELEVATION					
		RW 1	RW 2	RW 3	RW 4	RW 5	RW 6
12/30/2010	**416.2**	392.20	392.54	392.01	392.64	390.83	388.31
1/1/2011	416.50	394.39	395.14	394.94	395.59	394.54	392.18
1/2/2011	417.00	395.50	396.39	396.15	396.83	395.73	394.26
1/3/2011	419.00	397.47	398.49	399.31	398.82	397.56	396.29
1/4/2011	418.95	398.84	399.89	400.62	399.99	398.58	397.42
1/5/2011	418.80	401.13	401.41	401.90	401.33	399.96	398.79
1/6/2011	418.42	402.63	402.62	402.91	402.26	400.98	399.78
1/7/2011	418.05	403.57	403.56	403.64	402.96	401.63	400.56
1/8/2011	417.80	404.02	403.94	403.99	403.28	402.02	400.99
1/9/2011	417.40	404.39	404.33	404.32	403.58	402.40	401.40
1/10/2011	416.91	404.73	404.64	404.64	403.93	402.78	401.81
1/12/2011	415.99	405.00	404.86	404.81	404.16	403.11	402.21
1/13/2011	415.52	405.00	404.86	404.81	404.12	403.09	402.23
1/14/2011	414.82	405.03	404.84	404.75	404.12	403.12	402.34
1/16/2011	413.65	404.81	404.62	404.57	403.98	403.00	402.22
1/18/2011	412.30	404.52	404.35	404.26	403.65	402.81	402.07
1/19/2011	411.45	404.40	404.22	404.10	403.55	402.68	402.03
1/21/2011	409.49	403.89	403.71	403.56	403.02	402.25	401.62
1/24/2011	404.49	402.95	402.79	402.65	402.19	401.62	401.03
1/26/2011	404.49	402.29	402.13	402.06	401.61	401.04	400.56
1/28/2011	404.42	401.89	401.74	401.65	401.27	400.78	400.31
1/31/2011	404.77	401.29	401.10	401.01	400.64	400.21	399.76



BDR RELIEF WELLS
Elevation
415
405
395
385
12/30/2010
1/1/2011
1/3/2011
1/5/2011
1/7/2011
1/9/2011
1/11/2011
1/13/2011
1/15/2011
1/17/2011
1/19/2011
1/21/2011
1/23/2011
1/25/2011
1/27/2011
1/29/2011
1/31/2011
Date
RESV ELEV
RW 1
RW 2
RW 3
RW 4
RW 5
RW 6

Section P1 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
2/2/2011	404.88	401.63	401.72	397.45	397.11
2/4/2011	404.79	401.60	401.83	397.49	397.15
2/7/2011	404.58	401.63	401.77	397.51	397.18
2/9/2011	404.43	401.63	401.42	397.37	397.01
2/11/2011	404.21	401.63	401.36	397.35	397.01
2/14/2011	403.69	401.66	401.10	397.34	397.07
2/16/2011	403.46	401.62	401.14	397.36	397.02
2/18/2011	403.85	401.63	401.25	397.52	397.21
2/22/2011	406.75	401.63	402.50	397.55	397.19
2/23/2011	406.87	401.64	402.78	397.64	397.27
2/25/2011	407.02	401.65	403.03	397.70	397.35
2/28/2011	408.89	401.60	403.61	397.67	397.27

Section P2 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
2/2/2011	404.88	-	399.16	398.95	398.83
2/4/2011	404.79	-	399.25	399.07	398.97
2/7/2011	404.58	-	399.31	399.08	399.00
2/9/2011	404.43	-	399.06	398.83	398.73
2/11/2011	404.21	-	398.95	398.72	398.62
2/14/2011	403.69	-	398.80	398.60	398.51
2/16/2011	403.46	-	398.96	398.73	398.61
2/18/2011	403.85	-	398.95	398.82	398.74
2/22/2011	406.75	-	399.42	399.25	398.94
2/23/2011	406.87	-	399.75	399.53	399.42
2/25/2011	407.02	-	400.13	399.62	399.71
2/28/2011	408.89	-	400.47	400.13	400.02

Section P3 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
2/2/2011	404.88	-	400.37	398.52	399.11
2/4/2011	404.79	-	400.47	398.59	399.18
2/7/2011	404.58	-	400.40	398.59	399.19
2/9/2011	404.43	-	400.10	398.32	398.94
2/11/2011	404.21	-	399.96	398.21	398.83
2/14/2011	403.69	-	399.72	398.03	398.68
2/16/2011	403.46	-	399.75	398.10	398.77
2/18/2011	403.85	-	399.83	398.08	398.80
2/22/2011	406.75	-	401.05	398.85	399.32
2/23/2011	406.87	-	401.41	399.16	399.61
2/25/2011	407.02	-	401.75	399.45	399.95
2/28/2011	408.89	-	402.44	399.93	400.37

Section P4 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
2/2/2011	404.88	-	400.52	398.95	398.41
2/4/2011	404.79	-	400.61	398.99	398.42
2/7/2011	404.58	-	400.41	398.85	398.27
2/9/2011	404.43	-	400.06	398.54	397.98
2/11/2011	404.21	-	399.88	398.38	397.81
2/14/2011	403.69	-	399.56	398.15	397.62
2/16/2011	403.46	-	399.58	398.12	397.56
2/18/2011	403.85	-	399.59	398.14	397.58
2/22/2011	406.75	-	401.34	399.21	398.49
2/23/2011	406.87	-	401.73	399.56	398.81
2/25/2011	407.02	-	402.09	399.90	399.13
2/28/2011	408.89	-	402.84	400.53	399.72

Section P5 Trends

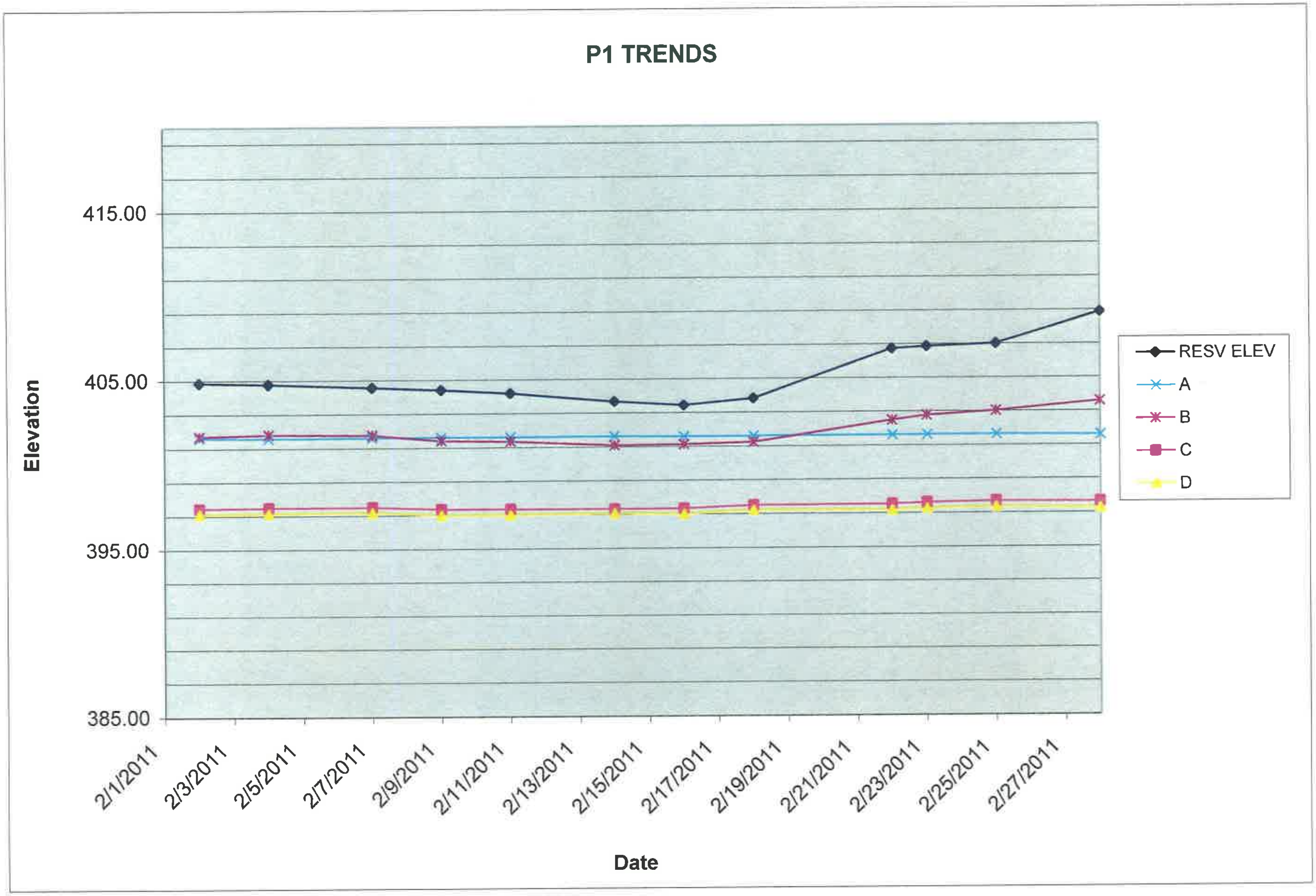
DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
2/2/2011	404.88	404.03	401.23	399.96	399.51
2/4/2011	404.79	403.79	401.25	400.01	399.55
2/7/2011	404.58	403.49	401.08	399.87	399.40
2/9/2011	404.43	403.35	400.80	399.57	399.11
2/11/2011	404.21	403.20	400.73	399.47	399.01
2/14/2011	403.69	402.96	400.58	399.37	398.90
2/16/2011	403.46	402.81	400.71	399.42	398.96
2/18/2011	403.85	402.70	400.80	399.53	399.05
2/22/2011	406.75	402.69	401.42	400.11	399.48
2/23/2011	406.87	402.70	401.69	400.36	399.83
2/25/2011	407.02	402.71	402.05	400.63	400.09
2/28/2011	408.89	402.67	403.41	401.67	400.97

Section P6 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
2/2/2011	404.88	401.66	402.29	400.33	399.64
2/4/2011	404.79	401.54	402.15	400.17	399.45
2/7/2011	404.58	401.38	401.84	399.92	399.19
2/9/2011	404.43	401.14	401.58	399.67	398.99
2/11/2011	404.21	401.03	401.45	399.49	398.82
2/14/2011	403.69	400.90	401.30	399.37	398.66
2/16/2011	403.46	401.14	401.32	399.28	398.58
2/18/2011	403.85	401.01	401.33	399.25	398.54
2/22/2011	406.75	400.53	401.03	399.03	398.33
2/23/2011	406.87	400.59	401.13	399.07	398.34
2/25/2011	407.02	400.68	401.35	399.14	398.38
2/28/2011	408.89	400.56	401.76	399.28	398.46

Section P7 Trends

DATE	RESV ELEV	GROUND WATER ELEVATION A	B	C	D
2/2/2011	404.88	-	-	395.04	394.99
2/4/2011	404.79	-	-	395.01	394.96
2/7/2011	404.58	-	-	395.01	394.98
2/9/2011	404.43	-	-	394.94	394.89
2/11/2011	404.21	-	-	394.90	394.84
2/14/2011	403.69	-	-	394.87	394.83
2/16/2011	403.46	-	-	394.91	394.87
2/18/2011	403.85	-	-	394.93	394.88
2/22/2011	406.75	-	-	394.77	394.72
2/23/2011	406.87	-	-	394.81	394.74
2/25/2011	407.02	-	-	394.85	394.79
2/28/2011	408.89	-	-	394.83	394.80



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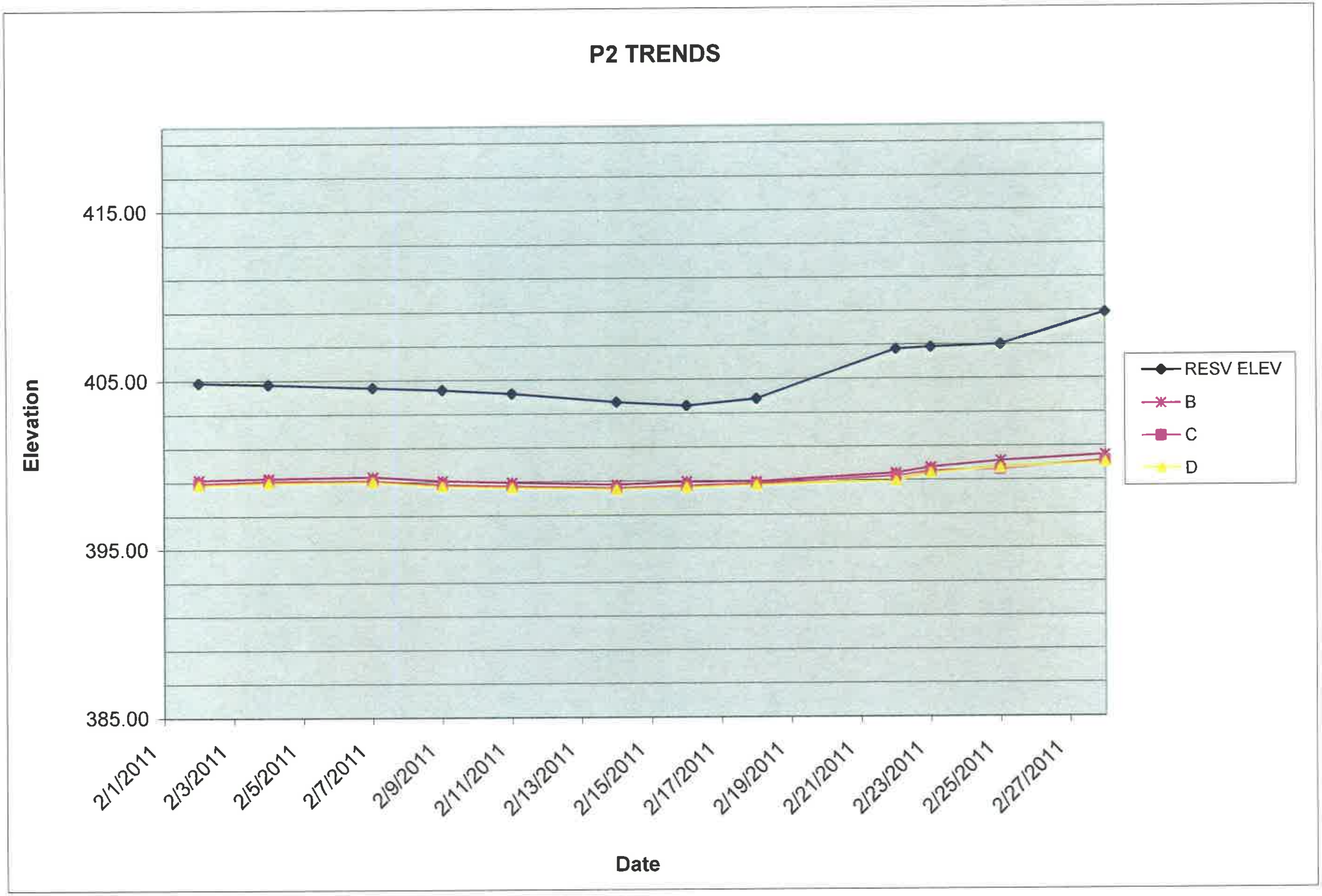
405.00
395.00
385.00
2/1/2011
2/3/2011
2/5/2011
2/7/2011
2/9/2011
2/11/2011
2/13/2011
2/15/2011
2/17/2011
2/19/2011
2/21/2011
2/23/2011
2/25/2011
2/27/2011
Date
RESV ELEV
A
B
C
D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395.00
385.00
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2/3/2011
2/5/2011
2/7/2011
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2/11/2011
2/13/2011
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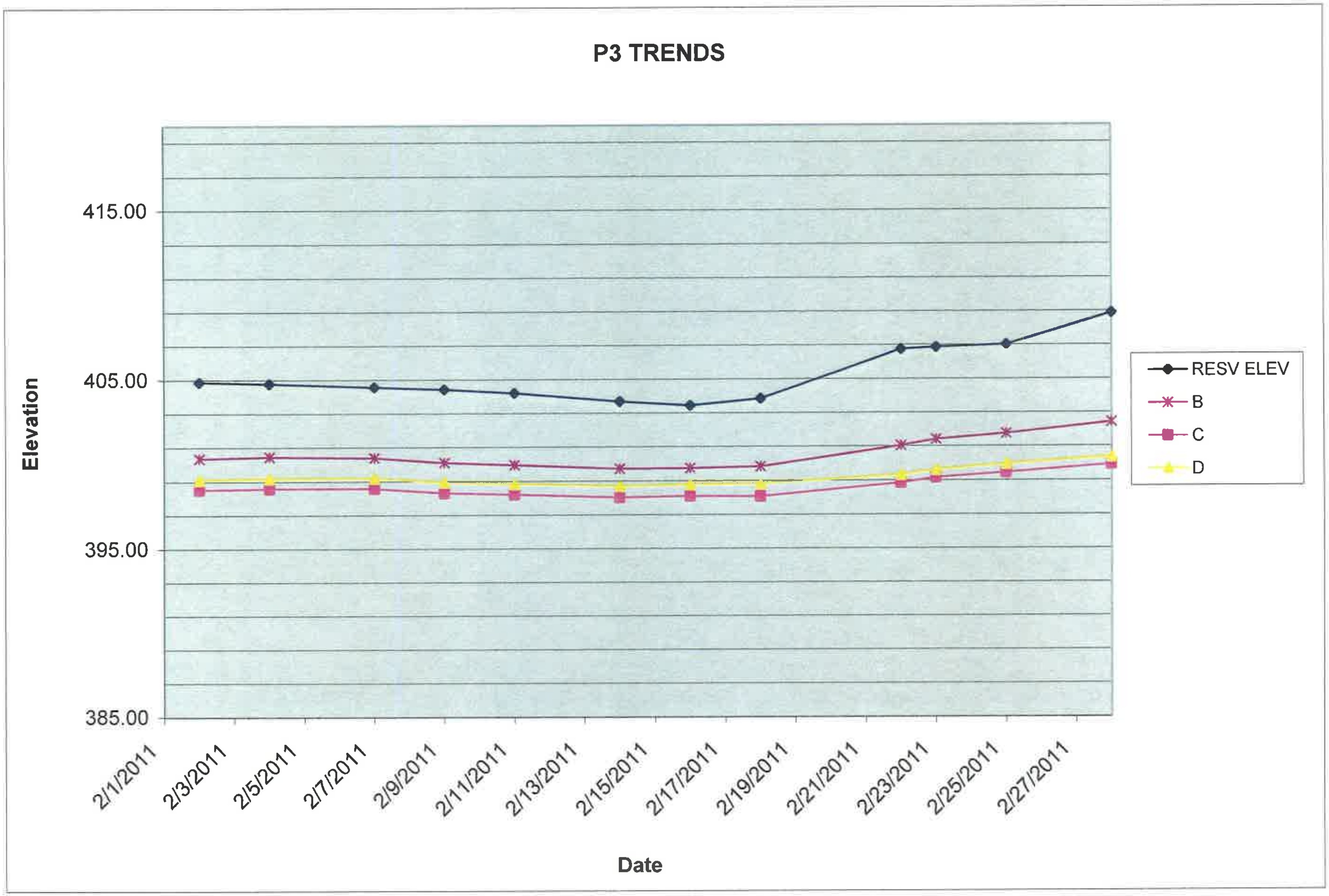
2/27/2011
Date
RESV ELEV
B
C
D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2/11/2011
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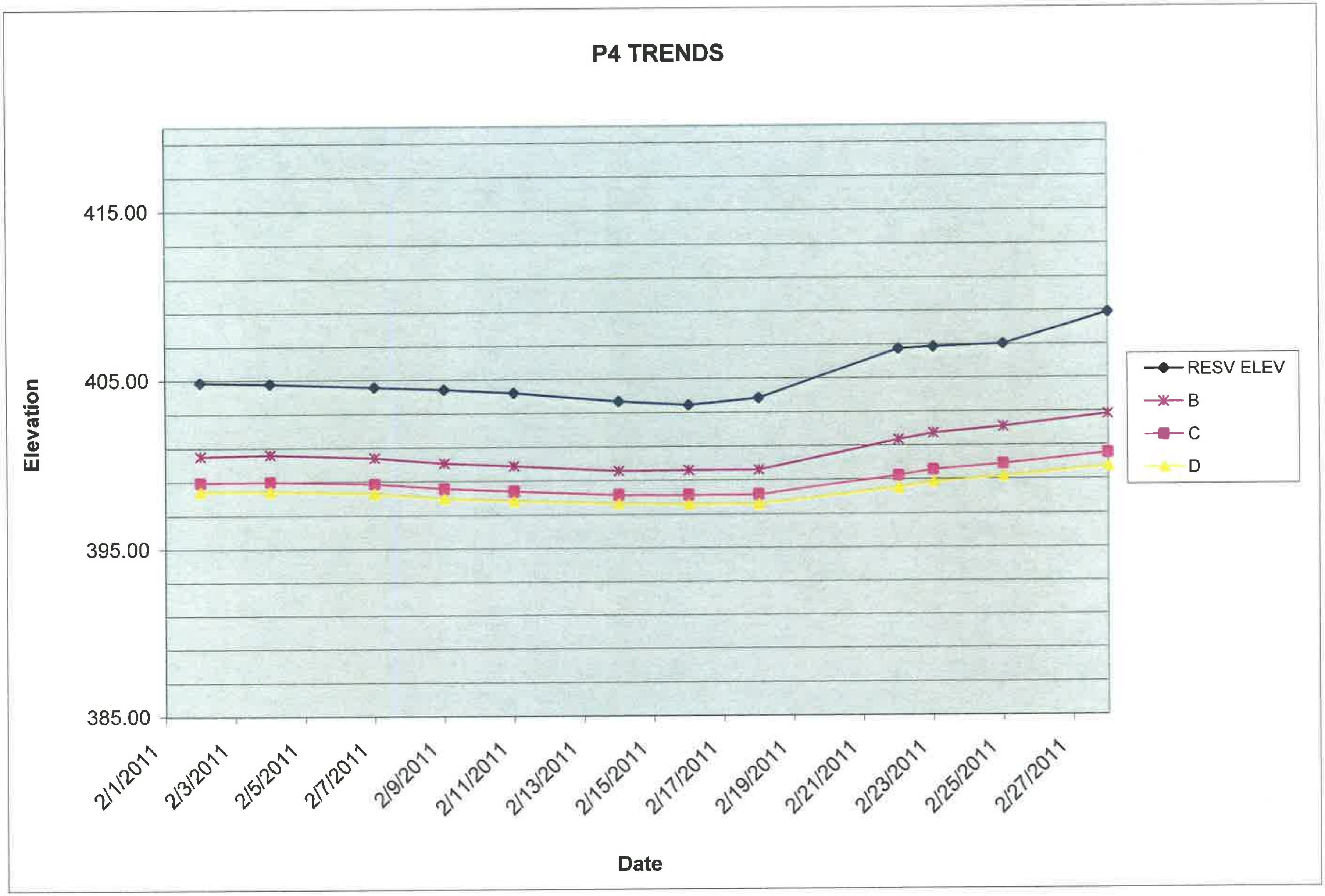
Date
RESV ELEV
B
C
D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Elevation
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405.00
395.00
385.00
2/1/2011
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2/13/2011
2/15/2011
2/17/2011
2/19/2011
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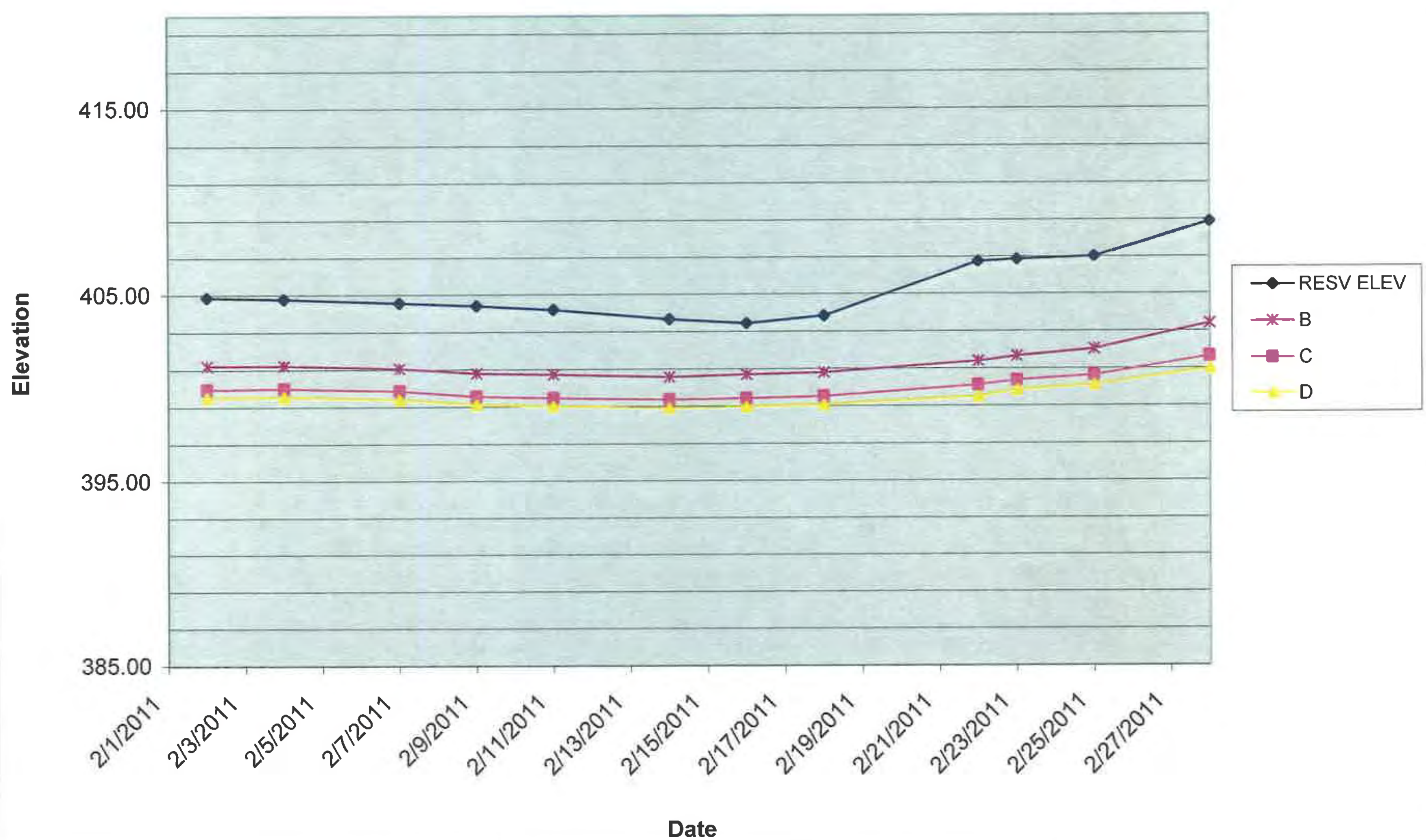
2/23/2011
2/25/2011
2/27/2011
Date
RESV ELEV
B
C
D

P5 TRENDS



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405.00
395.00
385.00
2/1/2011
2/3/2011
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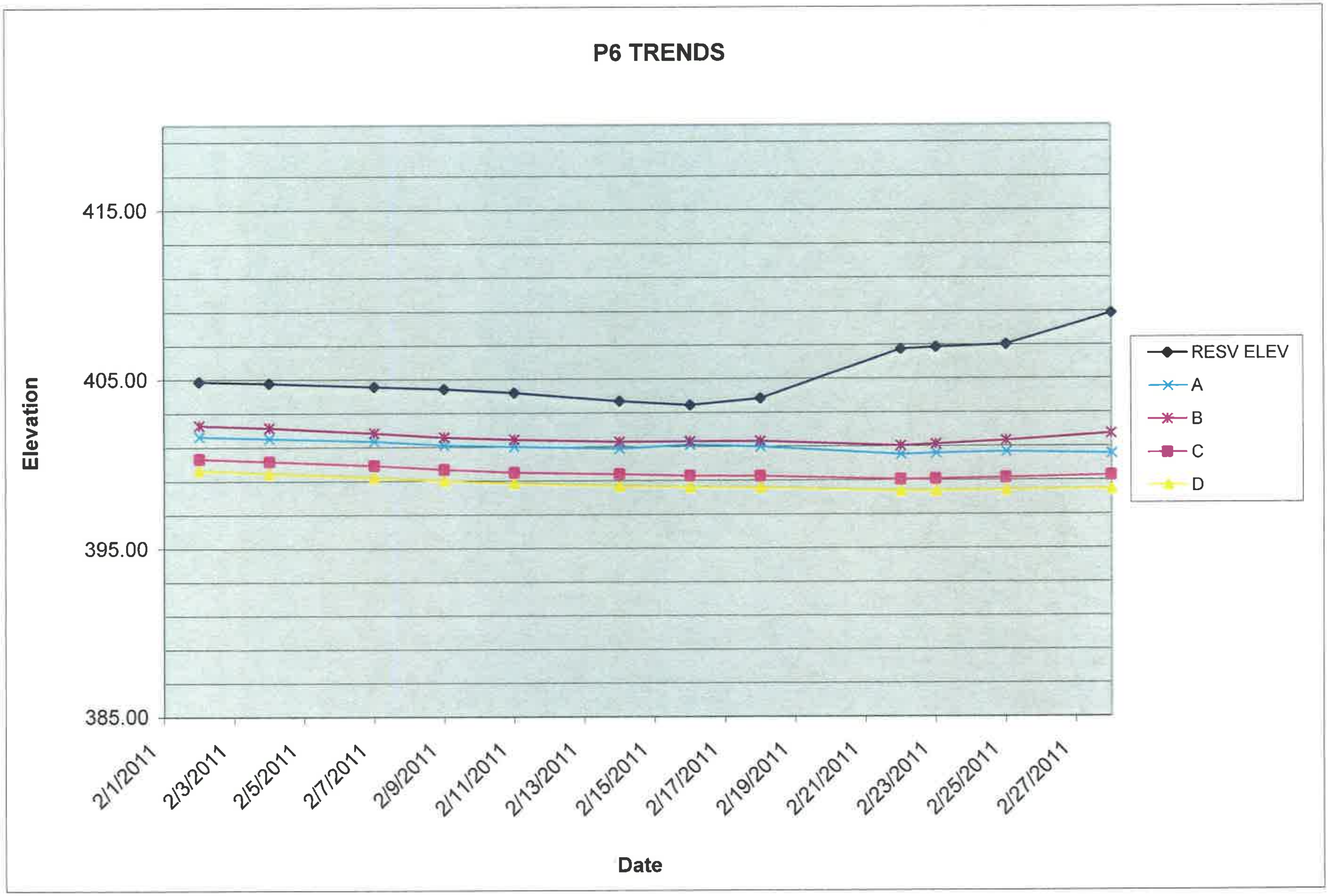
RESV ELEV
B
C
D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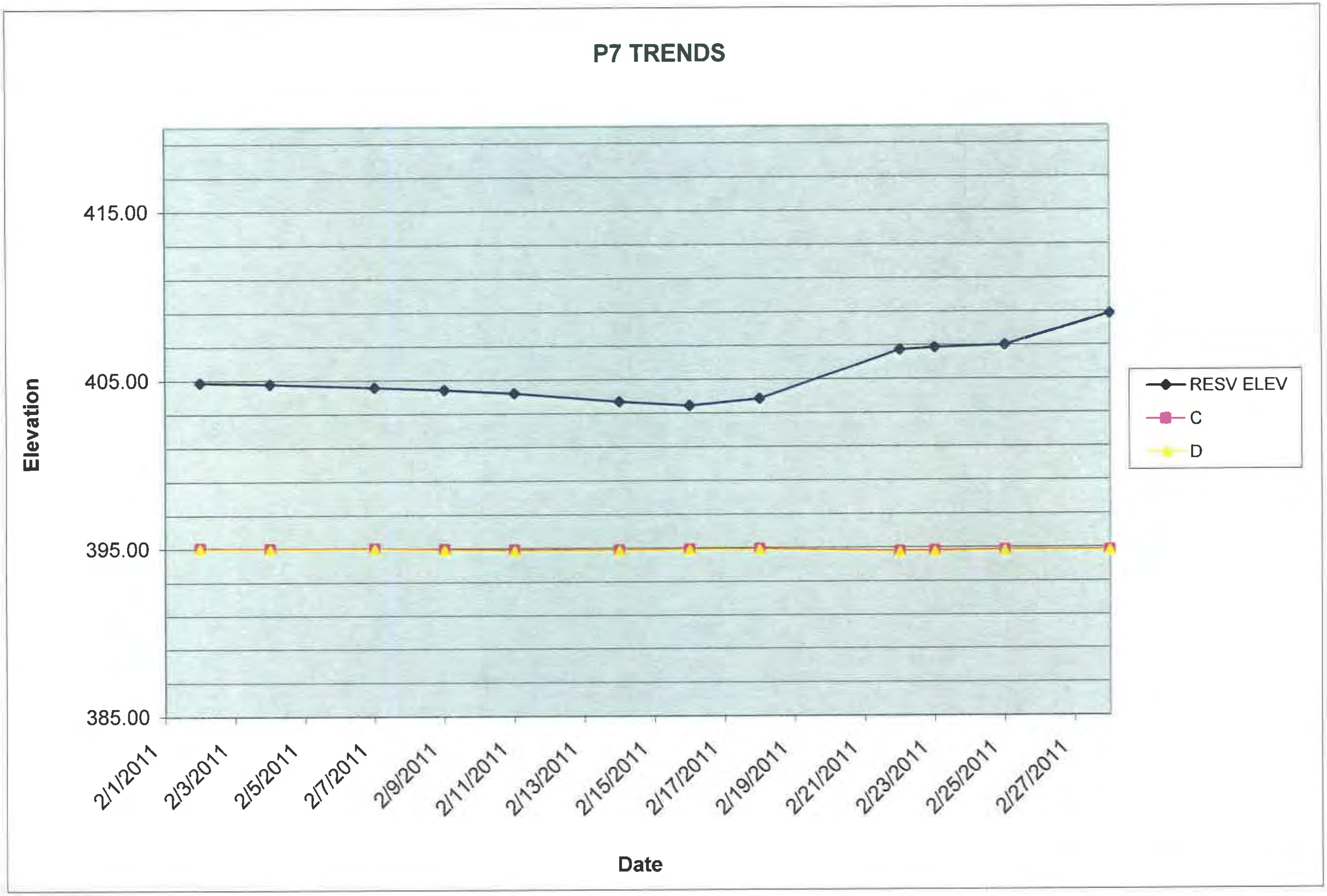
A
B
C
D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385.00
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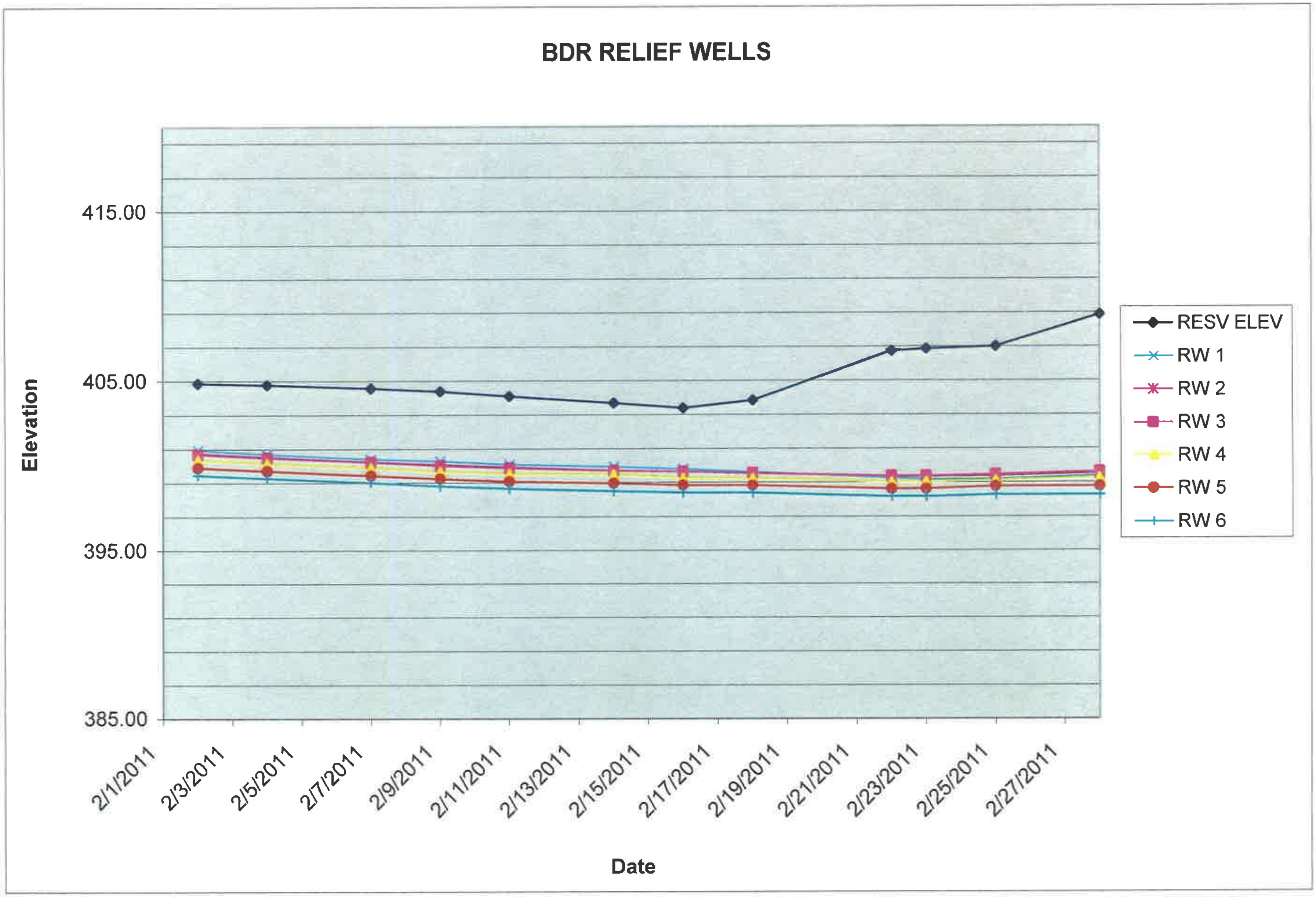
2/15/2011
2/17/2011
2/19/2011
2/21/2011
2/23/2011
2/25/2011
2/27/2011
Date
RESV ELEV
C
D

NOTE: For the trend graphs to show correctly, you must go to each row of data for each date not collected and deleted the cell contents of the date cell for that row - DO NOT DELETE THE CELL OR ROW, JUST THE DATE CELL CONTENTS THAT SHOW

RELIEF WELL MONITORING

Feb-11

DATE	RESV ELEV	RW 1	RW 2	GROUND WATER ELEVATION RW 3	RW 4	RW 5	RW 6
2/2/2011	404.88	400.95	400.75	400.69	400.35	399.92	399.48
2/4/2011	404.79	400.70	400.52	400.49	400.15	399.72	399.29
2/7/2011	404.58	400.42	400.24	400.22	399.89	399.44	399.03
2/9/2011	404.39	400.29	400.07	400.01	399.66	399.23	398.80
2/11/2011	404.10	400.09	399.92	399.87	399.52	399.07	398.65
2/14/2011	403.69	399.96	399.72	399.70	399.47	398.95	398.49
2/16/2011	403.39	399.82	399.64	399.65	399.26	398.83	398.41
2/18/2011	403.85	399.63	399.55	399.56	399.24	398.81	398.39
2/22/2011	406.75	399.27	399.36	399.38	399.01	398.59	398.16
2/23/2011	406.87	399.20	399.35	399.38	399.03	398.59	398.17
2/25/2011	407.02	399.18	399.39	399.46	399.13	398.74	398.26
2/28/2011	408.89	399.40	399.54	399.63	399.26	398.76	398.25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395.00
385.00
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2/23/2011
2/25/2011
2/27/2011
Date
RESV ELEV
RW 1
RW 2
RW 3
RW 4
RW 5
RW 6

8/8

BSK Associates Engineers & Laboratories

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June 28, 2011

BSK G08.119.11F

Mr. Jerry Lakeman, P.E., District Engineer
Fresno Metropolitan Flood Control District
5469 East Olive Avenue
Fresno, California 93727

SUBJECT: Piezometer Installations
Big Dry Creek Dam
Fresno Metropolitan Flood Control District
Project BDR-18

Dear Jerry:

This report describes the installation of piezometers in Big Dry Creek Dam, Fresno California. Field activities were carried out from late April to early June 2011. The installation was performed in substantial conformance to our Workplan of November 10, 2010.

Piezometer locations and post-construction piezometer elevations were surveyed by Blair Church and Flynn. "As Constructed" embankment section drawings, Figure 1 through 8, document field locations and field adjustments in the depths of piezometers.

The filter materials used for the piezometers was tested for particle size distribution compliance with our design (our report of December 12, 2008). As an added protection against accumulation of fines in the piezometer, the screened area was fitted with a geotextile filter fabric.

Intact and bulk soil samples were obtained in the borings. Boring logs and piezometer construction configurations are appended to this report.

Groundwater was encountered in piezometer sets P-8C. Depth to groundwater at the time of drilling was 16.1 feet below natural ground surface.

The opportunity to be of service is appreciated.

Respectfully submitted,
BSK ASSOCIATES

Hugo Kevorkian
Principal Geotechnical Engineer
CE16350
GE462
REAII 20080

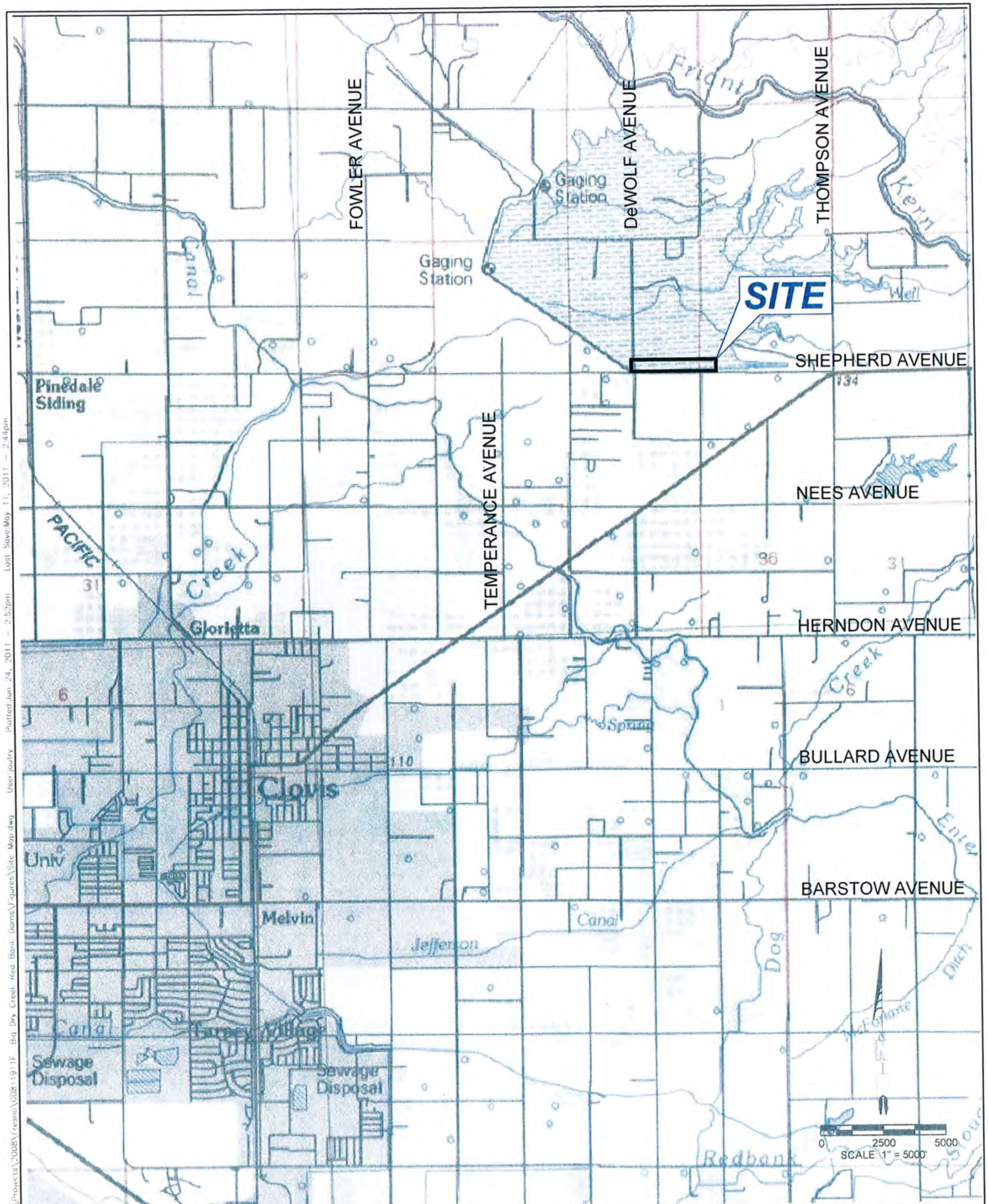
REGISTERED PROFESSIONAL ENGINEER
HUGO KEVORKIAN
No. 462
Exp. 06.30.13
GEOTECHNICAL
STATE OF CALIFORNIA

DISTRIBUTION LIST

Mr. Jerry Lakeman, P.E., FMFCD (3 originals)
BSK (1 original + E-copy)

LIST OF ENCLOSURES

Figure 1	Site Vicinicty Map
Figure 2	Site Map
Figure 3	Piezometer Location Plan
Figure 4-5	Detail Drawings – open tube-type Piezometer
Figure 6-8	Piezometer Cross Sections
Figure 9	Methods of Soil Classification-Log Borings



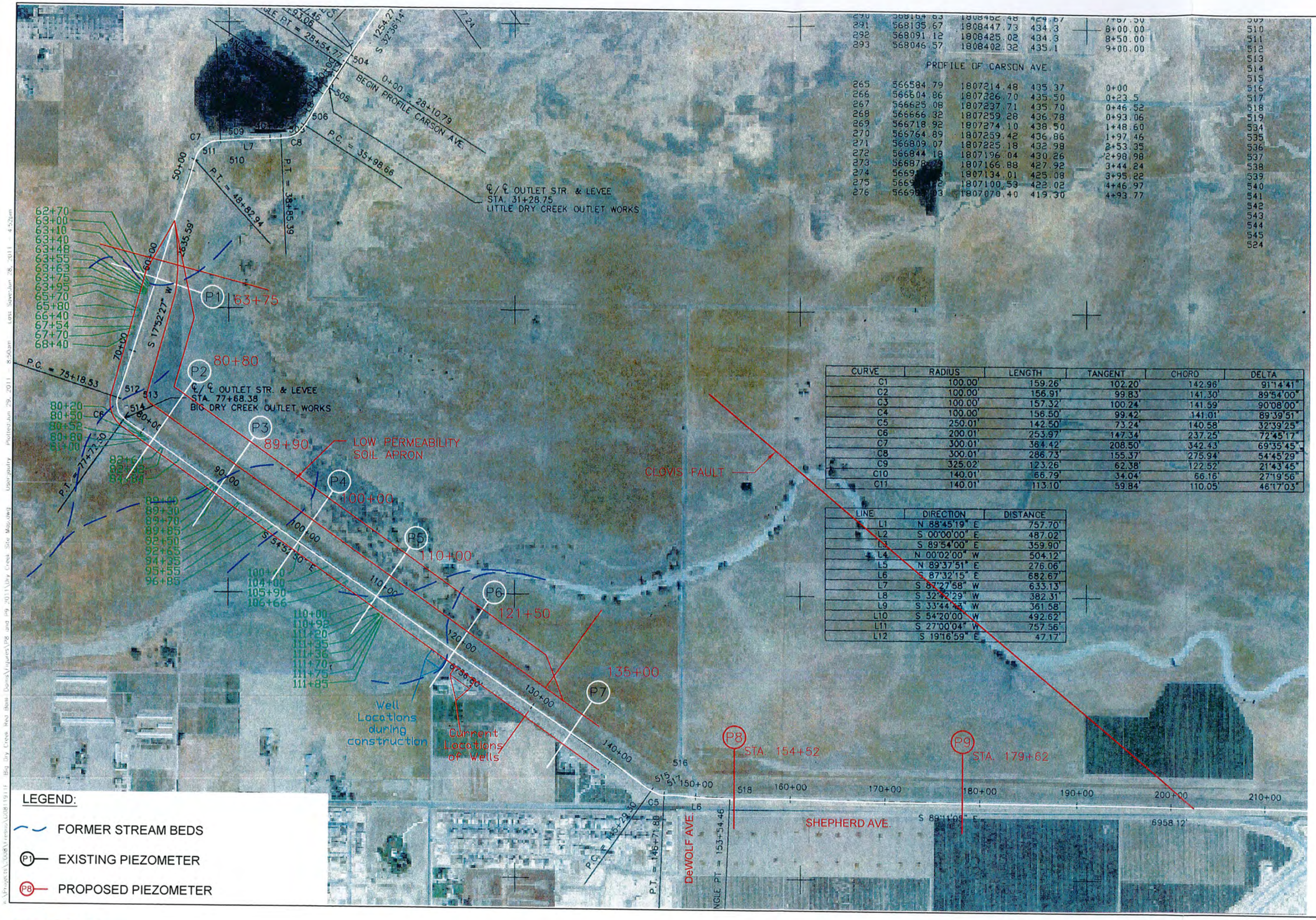
REFERENCE IMAGE: NATIONAL GEOGRAPHIC; TOPO!

BSK

SITE VICINITY MAP

Big Dry Creek Dam
Fresno Metropolitan Flood Control District
Fresno County, California

G08.119.11F | JRA | Site Map.dwg | 06/24/11 | FIGURE 1



CURVE	RADIUS	LENGTH	TANGENT	CHORD	DELTA
C1	100.00'	159.26'	102.20'	142.96'	91°14'41"
C2	100.00'	156.91'	99.83'	141.30'	89°54'00"
C3	100.00'	157.32'	100.24'	141.59'	90°08'00"
C4	100.00'	156.50'	99.42'	141.01'	89°39'51"
C5	250.01'	142.50'	73.24'	140.58'	32°39'25"
C6	200.01'	253.97'	147.34'	237.25'	72°45'17"
C7	300.01'	364.42'	208.50'	342.43'	69°35'45"
C8	300.01'	286.73'	155.37'	275.94'	54°45'29"
C9	325.02'	123.26'	62.38'	122.52'	21°43'45"
C10	140.01'	66.79'	34.04'	66.16'	27°19'56"
C11	140.01'	113.10'	59.84'	110.05'	46°17'03"

LINE	DIRECTION	DISTANCE
L1	N 88°45'19" E	757.70'
L2	S 00°00'00" E	487.02'
L3	S 89°54'00" E	359.90'
L4	N 00°02'00" W	504.12'
L5	N 89°37'51" E	276.06'
L6	S 87°32'15" E	682.67'
L7	S 87°27'58" W	633.13'
L8	S 32°42'29" W	382.31'
L9	S 33°44'43" W	361.58'
L10	S 54°20'00" W	492.62'
L11	S 27°00'04" W	757.56'
L12	S 19°16'59" E	47.17'

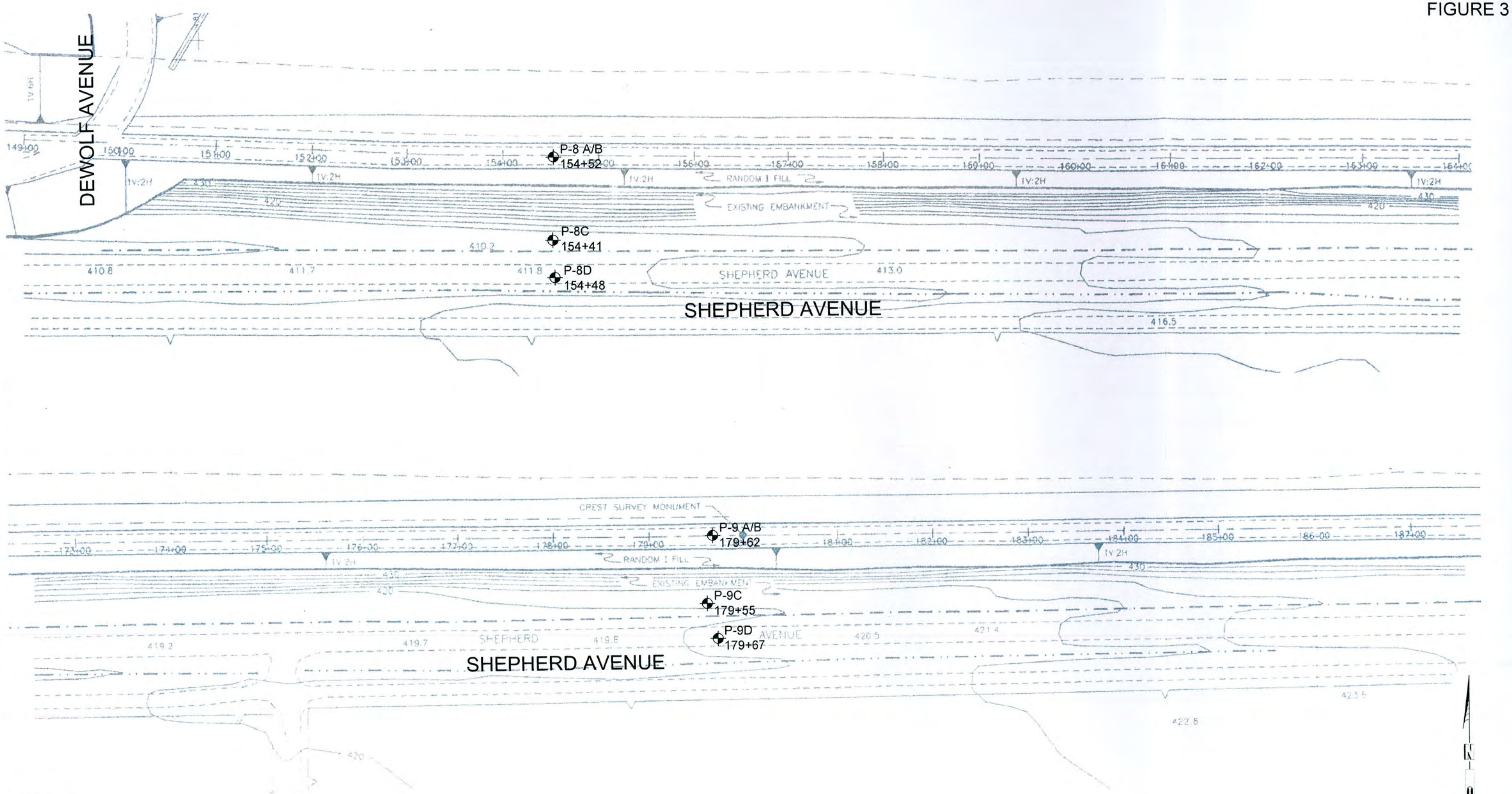
BSK

SITE PLAN

Big Dry Creek Dam
Fresno Metropolitan Flood Control District
Fresno County, California

G11.025.11F | JRA | Dry Creek Site Map.dwg | 06/29/11

G08-119-11F
JUNE 2011
FIGURE 3



LEGEND:

⊕ APPROXIMATE PIEZOMETER LOCATION

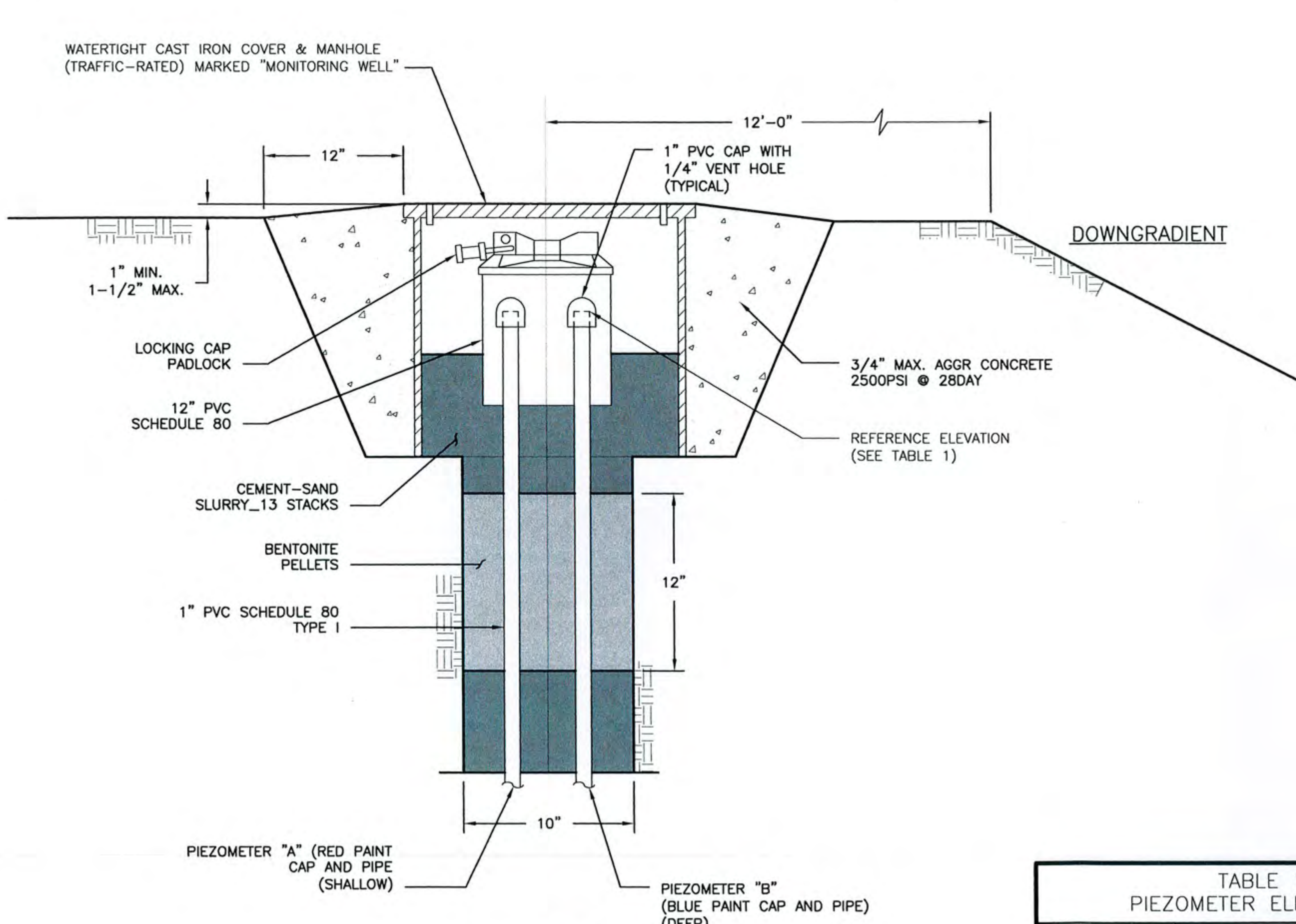
BSK

PIEZOMETER LOCATION PLAN

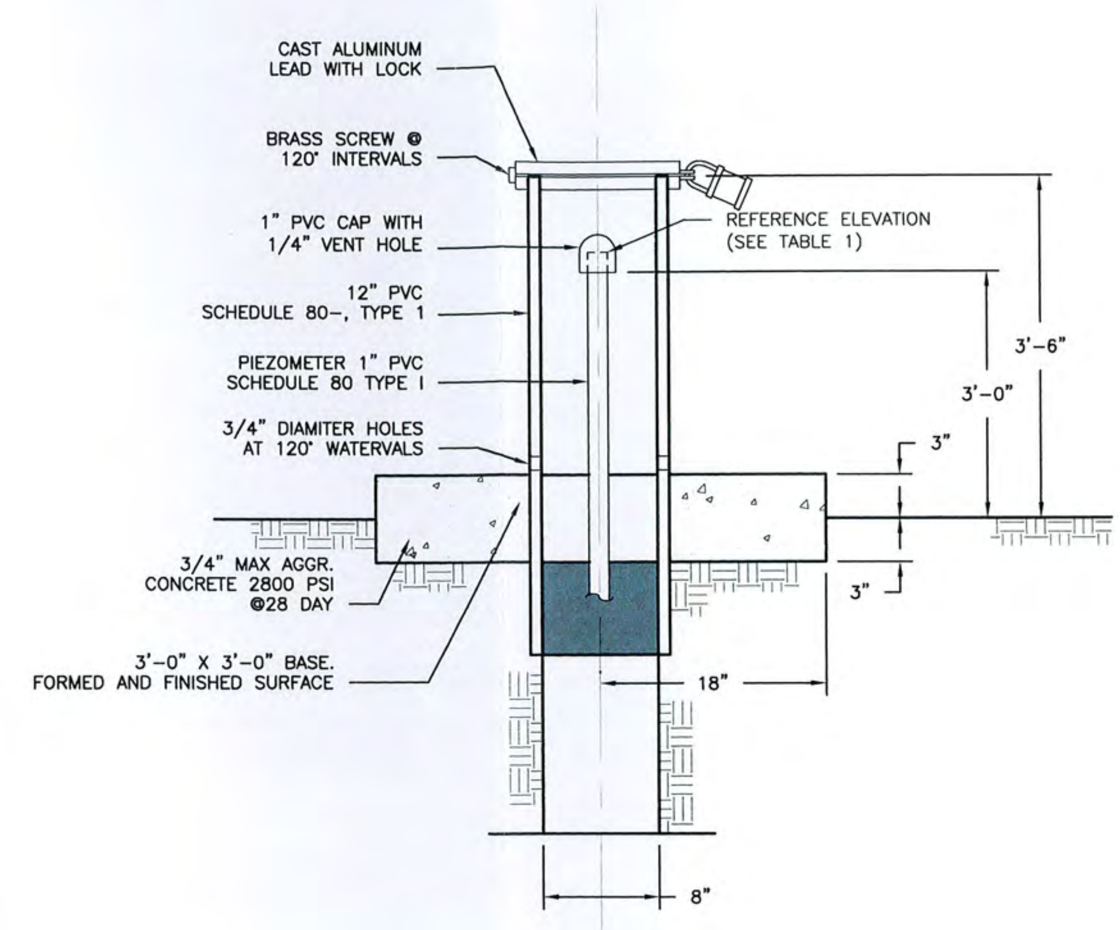
Big Dry Creek Dam, Piezometers P-8 and P-9
Fresno Metropolitan Flood Control District
Fresno County, California

G08.119.11F	JRA	Piezometer Location Plan.dwg	06/29/11	FIGURE 3

G08-119-11F
JUNE 2011
FIGURE 4



DETAIL "A"
PIEZOMETER VAULT
AT EMBANKMENT CREST
PIEZOMETER "A" & "B"



DETAIL "B"
PIEZOMETER PROTECTIVE COVER
PIEZOMETERS "C" & "D"
AT EMBANKMENT TOE AREA

TABLE 1
PIEZOMETER ELEVATIONS

PIEZOMETER STATION	PIEZOMETER ELEVATIONS			
	Ⓐ	Ⓑ	Ⓒ	Ⓓ
P8	442.04	442.02	415.62	417.76
P9	442.25	442.24	423.66	424.61

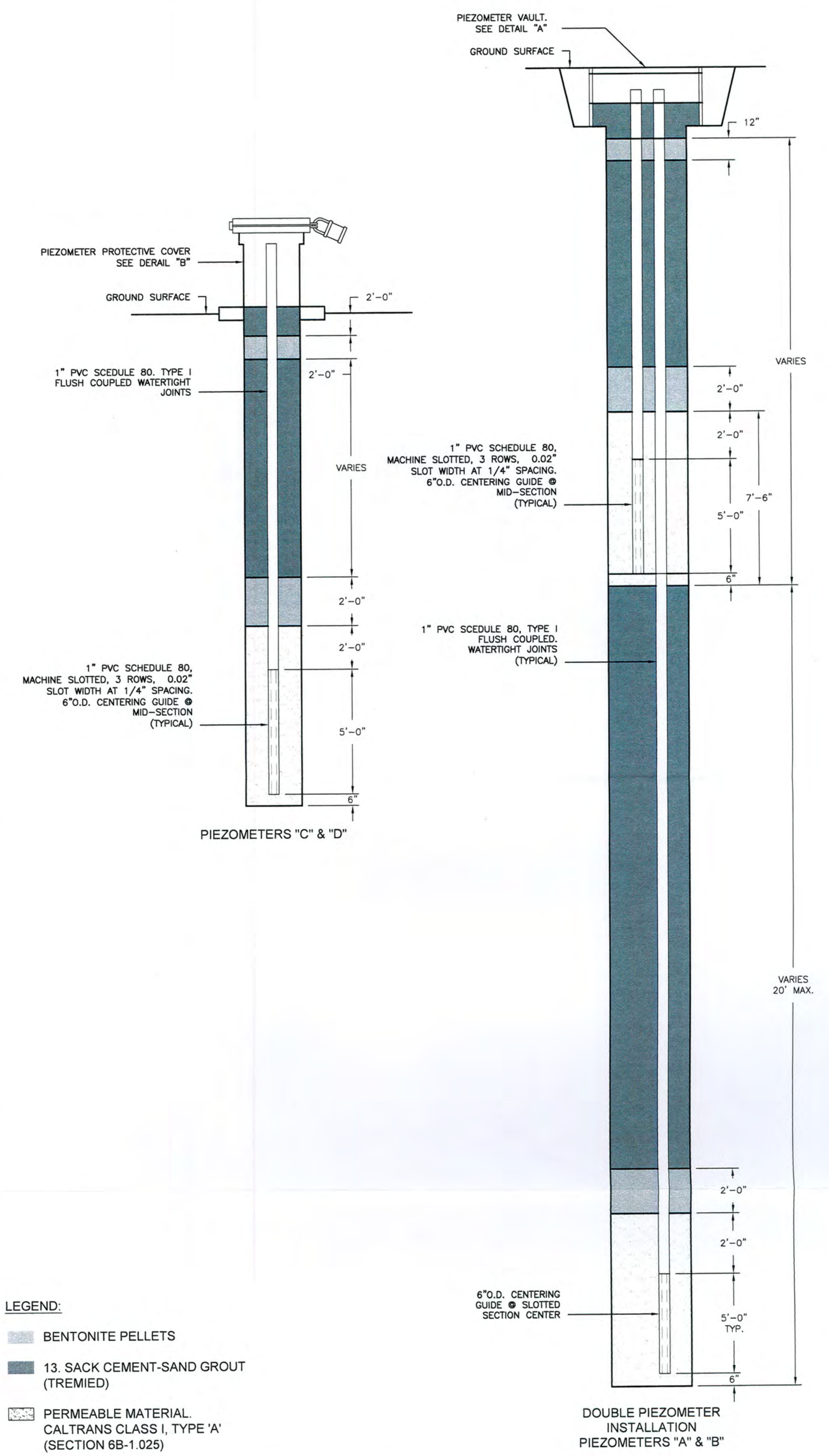
BSK

DETAIL DRAWINGS OPEN TUBE-TYPE PIEZOMETERS

Big Dry Creek Dam, Piezometers P-8 and P-9
Fresno Metropolitan Flood Control District
Fresno County, California

G08.119.11F JRA

G08-119-11F
JUNE 2011
FIGURE 5



DETAIL DRAWINGS OPNEN TUBE-TYPE PIEZOMETERS

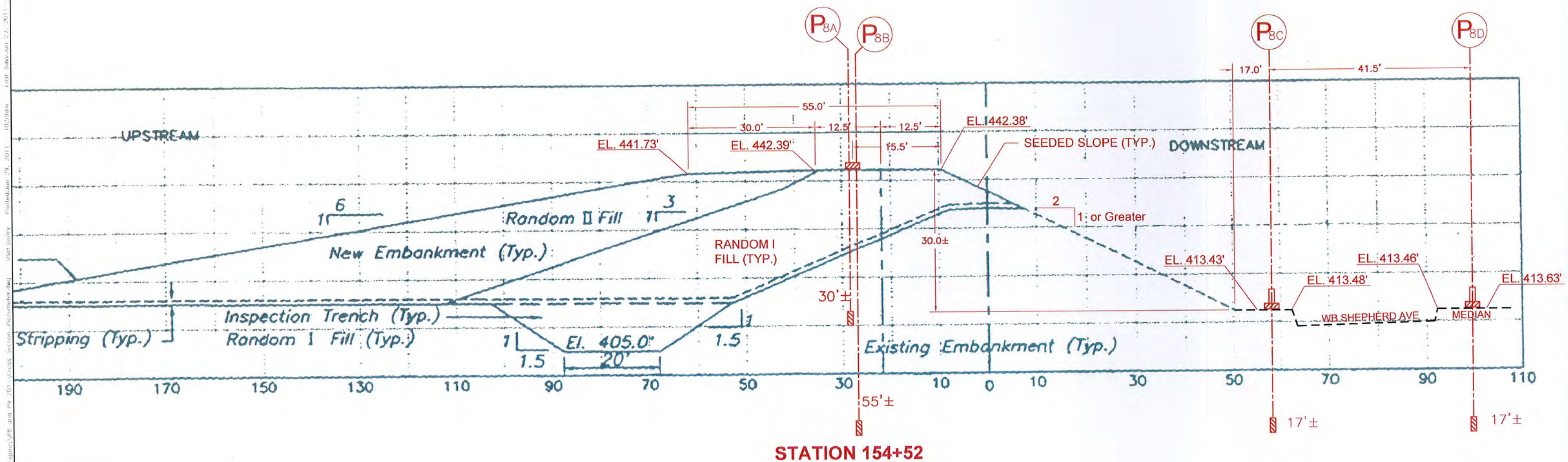
Big Dry Creek Dam
Fresno Metropolitan Flood Control District
Fresno County, California

BSK

G08.119.11F JRA

FIGURE 5

G08-119-11F
JUNE 2011
FIGURE 6



REFERENCE:

USCE PROFILE 154+87.076 "AS-BUILT"

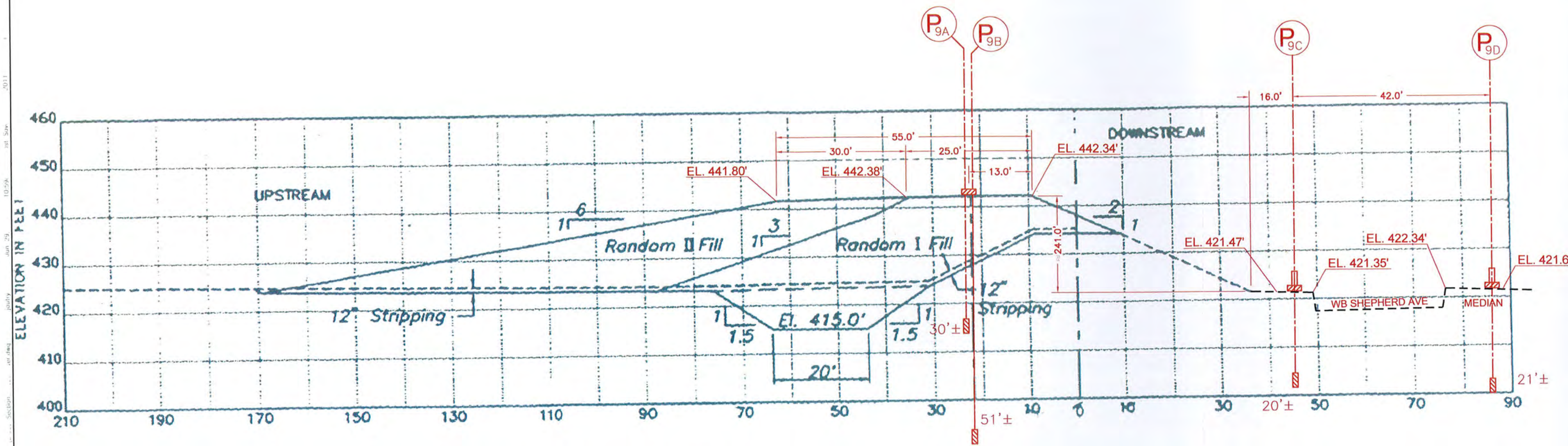
BSK

CROSS SECTIONS PIEZOMETER INSTALLATIONS

Big Dry Creek Dam, Piezometers P-8 and P-9
Fresno Metropolitan Flood Control District
Fresno County, California

G08.119.11F JRA Cross Section_Piezometer.dwg 06/29/11 FIGURE 6

G08-119-11F
JUNE 2011
FIGURE 7



STATION 179+62

REFERENCE:

USCE PROFILE 479+67.076 "AS-BUILT"

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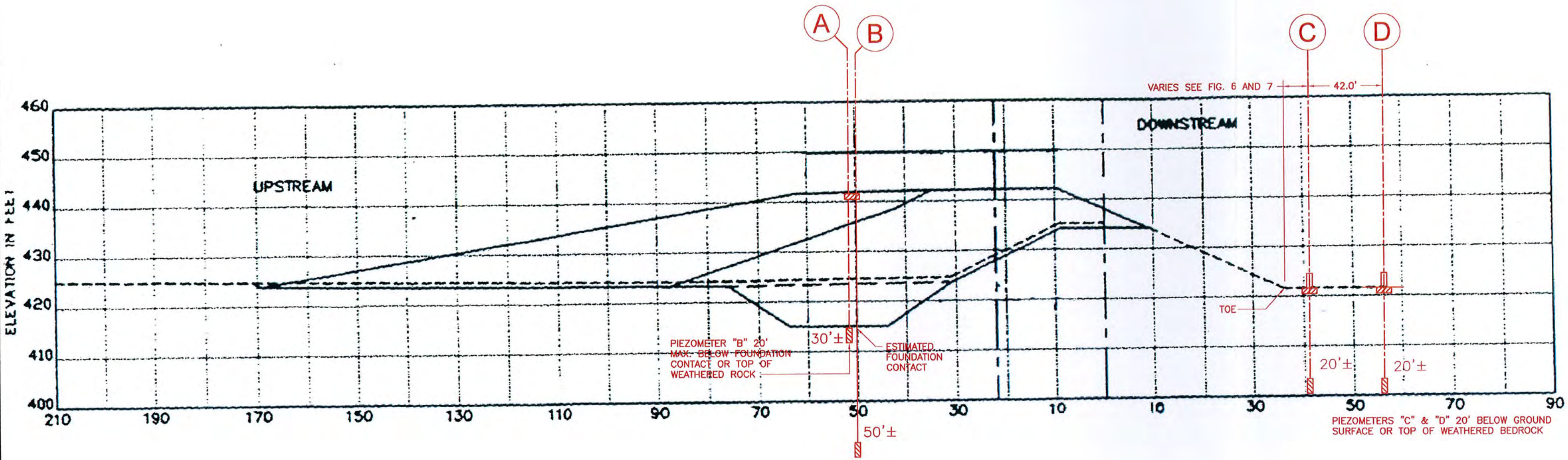
CROSS SECTIONS PIEZOMETER INSTALLATIONS

Big Dry Creek Dam, Piezometers P-8 and P-9
Fresno Metropolitan Flood Control District
Fresno County, California

G08.119.11F | JRA | Cross Section_Piezometer.dwg | 06/29/11 | FIGURE 7

G08-119-11F
JUNE 2011
FIGURE 8



BSK

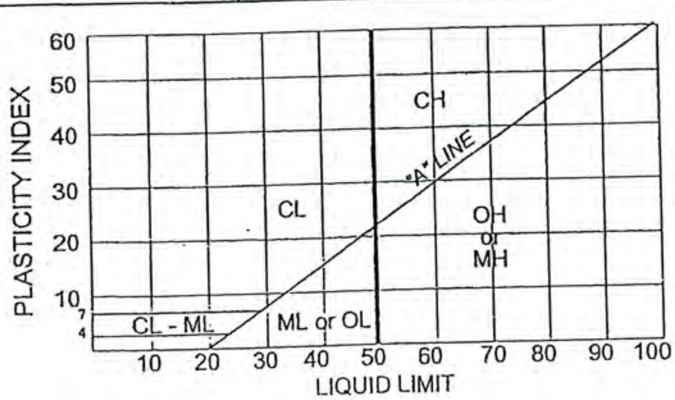
DETAIL DRAWING OPEN TUBE-TYPE PIEZOMETER

Big Dry Creek Dam, Piezometers P-8 and P-9
Fresno Metropolitan Flood Control District
Fresno County, California

G08.119.11F | JRA | Cross Section_Piezometer.dwg | 06/29/11 | FIGURE 8

METHOD OF SOIL CLASSIFICATION
(Unified Soil Classification System)

MAJOR DIVISIONS		SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS (More than ½ of soil >No. 200 sieve size)	**GRAVELS** (More than ½ of coarse fraction > No. 4 sieve size)	GW	Well graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand mixtures, little or no fines
		GC	Clayey Gravels, gravel-sand-silt mixtures
	SANDS (More than ½ of coarse fraction < No. 4 sieve size)	SW	Well graded sands or gravelly sands, little or no fines
		SP	Poorly graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS (More than ½ of soil < No. 200 sieve size)	**SILTS & CLAYS** **LL < 50**	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
	SILTS & CLAYS **LL > 50**	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silty clays, organic silts



3 1/4" O.D. California Modified Sampler

2.0" O.D. Standard Penetration Sampler

PLASTICITY CHART

BSK Associates Engineers & Laboratories

BSK & Associates
567 W Shaw ave
Fresno Ca 93704
Telephone: 559-497-2880
Fax: 559-497-2886

Project: Big Dry Creek Piezometers
Location: Fresno, CA
Project No.: G08.119.11F
Logged By: A. Love
Checked By: H. Kevorkian

Well ID: P-8 A/B

Depth (Feet)	Penetration Blows / Foot	In-Situ Dry Density (pcf)	In-Situ Moisture Content (%)	% Passing No. 200 Sieve	MATERIAL DESCRIPTION
0					**Clayey SAND (SC) Fill** Red brown, fine to coarse grained sand, moist, very dense
5	50-5"	133	7.6		
7					...encountered gravel bed
10	100	135	8.0		
11					...trace 1/2 inch gravel, increasing in fine to coarse grained sand
15	50-3"	131	10		...orange brown, no visible gravel, fine to medium grained sand
18					**Silty SAND (SM)** Dark red brown, fine to medium grained sand, moist, very dense, with trace clay
20	50-5"	107	17.9		
25	36	123	16.2		
30	24	128	9.1		...dark red brown, decreasing clay

WELL CONSTRUCTION DETAILS

- 12 inch Well Vault
- 13 Sack Cement-Sand Grout
- 1 inch Schedule 80 PVC
- Hydrated Bentonite Pellets
- Caltrans Class 1, Type "A" Sand
- 0.02 inch Slotted Schedule 80 PVC Screen. Geotextile Wrap
- PVC Cap Schedule 80
- Depth of approximate fill/native interface

Drilling Contractor: Dave's Drilling
Drilling Method: Hollow Stem Auger
Drilling Equipment: Mobile 61
Date Started: 4/20/11
Date Completed: 4/20/11

Surface Elevation: Station: 154+52, El. 442.0'
Groundwater Depth: Not Encountered
Completion Depth: 55 Feet
Sample Method: 2.4-inch ID CA Mod & 1.4-inch ID Split Spoon
Borehole Diameter: 8 inches

* See key sheet for symbols and abbreviations used above.

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Telephone: 559-497-2880
Fax: 559-497-2886

Project: Big Dry Creek Piezometers
Location: Fresno, CA
Project No.: G08.119.11F
Logged By: A. Love
Checked By: H. Kevorkian

Well ID: P-8 A/B

Depth (Feet)	Samples	Bulk Samples	Penetration Blows / Foot	In-Situ Dry Density (pcf)	In-Situ Moisture Content (%)	% Passing No. 200 Sieve	Graphic Log	MATERIAL DESCRIPTION	WELL CONSTRUCTION DETAILS
32								**Silty SAND (SM)** Dark red brown, fine to medium grained sand, moist, very dense, with trace clay *(continued)*	
33								**Sandy CLAY (CL)** Dark red brown, fine to medium grained sand, moist, hard	13 Sack Cement-Sand Grout
34									
35	X		50-5"	130	11.2				
36–39									1 inch Schedule 80 PVC
40	X		47	131	16.6			...orange brown, fine grained sand	
41–42									
43								**Clayey SAND (SC)** Brown, fine to medium grained sand, moist, very dense	
44									
45	X		50-5"	131	13.3				
46–47									Hydrated Bentonite Pellets
48–49									Caltrans Class 1, Type "A" Sand
50	X		50-5"	130	11.2				
51	X		50-5"	130	10.4				0.02 inch Slotted Schedule 80 PVC Screen. Geotextile Wrap
52–54									PVC Cap Schedule 80
55								Boring terminated at 55 feet bgs Groundwater Not Encountered	
56–67									

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Fax: 559-497-2886

Project: Big Dry Creek Piezometers

Location: Fresno, CA

Project No.: G08.119.11F

Logged By: A. Love

Checked By: H. Kevorkian

Well ID: P-8C

Depth (Feet)	Samples	Bulk Samples	Penetration Blows / Foot	In-Situ Dry Density (pcf)	In-Situ Moisture Content (%)	% Passing No. 200 Sieve	Graphic Log	MATERIAL DESCRIPTION	WELL CONSTRUCTION DETAILS
0–5								**Sandy CLAY (CL)** Red brown, fine to medium grained sand, moist	Well casing extends approx. 3 feet above ground surface; 13 Sack Cement-Sand Grout
5–18								**Clayey SAND (SC)** Brown, fine to medium grained sand, moist	Hydrated Bentonite Pellets; Caltrans Class 1, Type "A" Sand; 0.02 inch Slotted Schedule 80 PVC Screen, Geotextile Wrap; PVC Cap Schedule 80
18								Boring terminated at 18 feet bgs Groundwater encountered at 16.1 feet bgs Installed Piezometer	

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31

Drilling Contractor: Dave's Drilling
Drilling Method: Hollow Stem Auger
Drilling Equipment: Mobile 61
Date Started: 6/9/11
Date Completed: 6/9/11

Surface Elevation: Station: 154+41, El. 415.6'
Groundwater Depth: 16.1 Feet
Completion Depth: 18 Feet
Sample Method: 2.4-inch ID CA Mod & 1.4-inch ID Split Spoon
Borehole Diameter: 8 inches

* See key sheet for symbols and abbreviations used above.

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Fax: 559-497-2886

Project: Big Dry Creek Piezometers
Location: Fresno, CA
Project No.: G08.119.11F
Logged By: A. Love
Checked By: H. Kevorkian

Well ID: P-8D

Depth (Feet)	Samples	Bulk Samples	Penetration Blows / Foot	In-Situ Dry Density (pcf)	In-Situ Moisture Content (%)	% Passing No. 200 Sieve	Graphic Log	MATERIAL DESCRIPTION	WELL CONSTRUCTION DETAILS
0–8		1–6						**Silty SAND with Clay (SM)** Red brown, fine to medium grained sand, moist, weak to moderate cementation, very dense	Well casing extends approx. 3 feet above ground surface; 13 Sack Cement-Sand Grout
5–6	5–6		50-3"	121.3	10.4				
8–17								**SAND (SP)** Red brown, fine to coarse grained, moist, dense	Hydrated Bentonite Pellets
10–11.5	10–11.5		37	109.4	12.5				Caltrans Class 1, Type "A" Sand; 0.02 inch Slotted Schedule 80 PVC Screen, Geotextile Wrap
15–16.5	15–16.5		13		15.4			...medium dense	PVC Cap Schedule 80
17–21.5								**Sandy SILT with trace Clay (ML)** Brown, fine grained sand, moist, hard	
20–21.5	20–21.5		42		17.4				
21.5								Boring terminated at 21.5 feet bgs Groundwater Not Encountered Installed Piezometer	

Drilling Contractor: Dave's Drilling
Drilling Method: Hollow Stem Auger
Drilling Equipment: Mobile 61
Date Started: 6/8/11
Date Completed: 6/8/11

Surface Elevation: Station: 154+48, El. 417.8'
Groundwater Depth: Not Encountered
Completion Depth: 21.5 Feet
Sample Method: 2.4-inch ID CA Mod & 1.4-inch ID Split Spoon
Borehole Diameter: 8 inches

* See key sheet for symbols and abbreviations used above.

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Fax: 559-497-2886

Project: Big Dry Creek Piezometers
Location: Fresno, CA
Project No.: G08.119.11F
Logged By: A. Love
Checked By: H. Kevorkian

Well ID: P-9 A/B

Depth (Feet)	Samples	Bulk Samples	Penetration Blows / Foot	In-Situ Dry Density (pcf)	In-Situ Moisture Content (%)	% Passing No. 200 Sieve	Graphic Log	MATERIAL DESCRIPTION
0–4		■					SC	**Clayey SAND (SC) Fill** Red brown, fine to coarse grained sand, moist, very dense
5	■		100	131	8.3			
10	☒		33	128	10.6			
15	■		96-8"	128	7.9			
20	☒		50-4"	122	18.2		SM	**Silty SAND (SM)** Red brown, fine to coarse grained sand, moist, trace weak cementation, very dense
25	■		50-4"					
30	☒		50-5"	125	12.5			

WELL CONSTRUCTION DETAILS

- 12 inch Well Vault
- 13 Sack Cement-Sand Grout
- 1 inch Schedule 80 PVC
- Hydrated Bentonite Pellets
- Caltrans Class 1, Type "A" Sand
- 0.02 inch Slotted Schedule 80 PVC Screen. Geotextile Wrap
- Depth of approximate fill/native interface
- PVC Cap Schedule 80

Drilling Contractor: Dave's Drilling
Drilling Method: Hollow Stem Auger
Drilling Equipment: Mobile 61
Date Started: 4/19/11
Date Completed: 4/19/11

Surface Elevation: Station: 179+62, El. 442.2'
Groundwater Depth: Not Encountered
Completion Depth: 51 Feet
Sample Method: 2.4-inch ID CA Mod & 1.4-inch ID Split Spoon
Borehole Diameter: 8 inches

* See key sheet for symbols and abbreviations used above.

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Fresno Ca 93704
Telephone: 559-497-2880
Fax: 559-497-2886

Project: Big Dry Creek Piezometers
Location: Fresno, CA
Project No.: G08.119.11F
Logged By: A. Love
Checked By: H. Kevorkian

Well ID: P-9 A/B

Depth (Feet)	Samples	Bulk Samples	Penetration Blows / Foot	In-Situ Dry Density (pcf)	In-Situ Moisture Content (%)	% Passing No. 200 Sieve	Graphic Log	MATERIAL DESCRIPTION	WELL CONSTRUCTION DETAILS
32								**Clayey SAND (SC)** Red brown, fine to medium grained, moist, very dense *(continued)*	
33									13 Sack Cement-Sand Grout
34									
35	X		50-5"	129	7.7				
36									1 inch Schedule 80 PVC
37									
38									
39									
40	X		50-5"	128	9.5			...decrease in clay fines	
41									
42									Hydrated Bentonite Pellets
43									
44									Caltrans Class 1, Type "A" Sand
45	X		50-5"	133	124			...increase in clay fines	
46									0.02 inch Slotted Schedule 80 PVC Screen. Geotextile Wrap
47								**Sandy SILT (SM)** Brown, fine grained sand, moist, stiff	
48									
49									
50	X		20	121	21.1				PVC Cap Schedule 80
51									
52								Boring terminated at 51 feet bgs Groundwater Not Encountered	
53									
54									
55									
56									
57									
58									
59									
60									
61									
62									
63									
64									
65									
66									
67									

BSK Associates Engineers & Laboratories

BSK & Associates
567 W Shaw ave
Fresno Ca 93704
Telephone: 559-497-2880
Fax: 559-497-2886

Project: Big Dry Creek Piezometers

Location: Fresno, CA

Project No.: G08.119.11F

Logged By: A. Love

Checked By: H. Kevorkian

Well ID: P-9C

Depth (Feet)	Samples	Bulk Samples	Penetration Blows / Foot	In-Situ Dry Density (pcf)	In-Situ Moisture Content (%)	% Passing No. 200 Sieve	Graphic Log	MATERIAL DESCRIPTION	WELL CONSTRUCTION DETAILS
0–20								**Clayey SAND (SC)** Fine to coarse grained, moist, trace fine to coarse gravel at approx. 5 feet	Well casing extends approx. 3 feet above ground surface; 13 Sack Cement-Sand Grout; Hydrated Bentonite Pellets; Caltrans Class 1, Type "A" Sand; 0.2 inch Slotted Schedule 80 PVC Screen Geotextile Wrap; Depth of approx. fill/native interface; PVC Cap Schedule 80
20								Boring terminated at 20 feet bgs Groundwater Not Encountered Installed Piezometer	

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31

Drilling Contractor: Dave's Drilling
Drilling Method: Hollow Stem Auger
Drilling Equipment: Mobile 61
Date Started: 6/9/11
Date Completed: 6/9/11

Surface Elevation: Station: 179+55, El. 423.7'
Groundwater Depth: Not Encountered
Completion Depth: 20 Feet
Sample Method: 2.4-inch ID CA Mod & 1.4-inch ID Split Spoon
Borehole Diameter: 8 inches

* See key sheet for symbols and abbreviations used above.

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Engineers & Laboratories

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567 W Shaw ave
Fresno Ca 93704
Telephone: 559-497-2880
Fax: 559-497-2886

Project: Big Dry Creek Piezometers
Location: Fresno, CA
Project No.: G08.119.11F
Logged By: A. Love
Checked By: H. Kevorkian

Well ID: P-9D

Depth (Feet)	Samples	Bulk Samples	Penetration Blows / Foot	In-Situ Dry Density (pcf)	In-Situ Moisture Content (%)	% Passing No. 200 Sieve	Graphic Log	MATERIAL DESCRIPTION	WELL CONSTRUCTION DETAILS
0–3								**Clayey SAND (SC)** Dark red brown, fine to medium grained sand, moist, very dense	Well casing extends approx. 3 feet above ground surface
3–8								**Silty SAND with trace of Clay (SM)** Light brown, fine to coarse grained sand, moist, very dense	
5			50-4"	110.3	10.2				
6								...decrasting fines, silt and clay, weak to moderate cementation	
8–13								**Clayey SAND (SC)** Dark red brown, fine to coarse grained sand, moist, very dense, weak to moderate cementation	13 Sack Cement-Sand Grout
10			50-4"	121.5	13.0				
12–14									Hydrated Bentonite Pellets
13–18								**Silty SAND (SM)** Dark brown, fine to medium grained, moist, very dense	
14–21.5									Caltrans Class 1, Type "A" Sand
15			65		12.3				
16.5–21.5									0.2 inch Slotted Schedule 80 PVC Screen Geotextile Wrap
18–21.5								**SAND/Silty SAND (SP/SM)** Red brown, fine to coarse grained, moist, very dense	
20			80-10"	114.2	10.5				Depth of approx. fill/native interface
21.5									PVC Cap Schedule 80
22								Boring terminated at 21.5 feet bgs Groundwater Not Encountered Installed Piezometer	

Drilling Contractor: Dave's Drilling
Drilling Method: Hollow Stem Auger
Drilling Equipment: Mobile 61
Date Started: 6/8/11
Date Completed: 6/8/11

Surface Elevation: Station: 179+67, El. 424.6'
Groundwater Depth: Not Encountered
Completion Depth: 21.5 Feet
Sample Method: 2.4-inch ID CA Mod & 1.4-inch ID Split Spoon
Borehole Diameter: 8 inches

* See key sheet for symbols and abbreviations used above.

E & J EXCAVATION

4974 North Fresno Street #569
Fresno, California 93726-0387
Off: 1-559-447-3280
Fax: 1-559-447-3285

160.8378
630.2064

January 8, 2012

Jerry Lakeman
District Engineer
Fresno Metropolitan Flood Control District
5469 E. Olive Avenue
Fresno, CA 93727

Dear Jerry,

Subject: Parcel Easterly of Dry Creek Extension Basin

As you are aware, I am the owner of the 24 acre parcel adjoining and easterly of the Dry Creek Extension Basin. I am a willing seller of the 24 acres, provided you pay me fair market value compensation for the property. I recognize the public benefit that would be accomplished with the expansion of the Dry Creek Extension Basin and I can assure you that the basin soil is sandy and it will percolate water rapidly. I also recognize the efficiency of expanding the current basin onto my property rather than onto other property that would not be a continuous excavation and storage area.

I also understand you are seeking a grant to assist you with the funding for the acquisition of my property and I will await approval of the grant within the next 6 months.

Sincerely,

Eugene Qualls

Eugene Qualls

SEMI-MONTHLY RECHARGE BASIN SUMMARY

Inspected June 28 - July 2, 2012

Basin	Location	Date Authorized	Maximum June Authorized Recharge Level	Maximum July Authorized Recharge Level	Observed Water Elevation	Intertie Position	Comments
		June 2012					
A	Florence Avenue west of Chestnut Avenue						Off recharge to dewater and maintain upstream basin.
D	Forkner Avenue & Barstow Avenue	June 6, 2012	15' BRB	15' BRB	15' BRB	Closed	**** FMFCD to control recharge valve from Basin "J". ****Do not exceed 15' BRB to prevent water from spilling to upper floor.
J	Bullard Avenue and Forkner Avenue	June 6, 2012	3' BRB	3' BRB	4' BRB	Open	
K	Santa Fe Avenue north of Shaw Avenue	May 1, 2012	3' BRB	3' BRB	4' 3" BRB	Open	Please increase water delivery.
L	San Jose Avenue east of Blackstone Avenue						Off recharge to maintain basin.
N	Escalon Avenue west of Fresno Street	March 28, 2012	3' BRB	3' BRB	3' 5" BRB	Open	
O	First Street south of Bullard Avenue						Basin elevation at maximum recharge elevation due to nuisance flow.
P	Bullard Avenue and Cedar Avenue	May 1, 2012					Off recharge to repair sewer relief valve. ****Cannot recharge Basin "P" until Basin "CM" is 7.5' BRB.
R	Shepherd Avenue and Chestnut Avenue						Off recharge for basin maintenance.
S	Ashlan Avenue east of Peach Avenue	May 1, 2012	4' BRB	4' BRB	4' 1" BRB	Closed	Recharge valve closed for canal weed maintenance. ****Do not recharge above 4' BRB due to trees in basin.
T	Airways Avenue and Leyte Avenue						
U	Dakota Avenue and Chestnut Avenue	May 1, 2012	4' BRB	4' BRB	4' 4" BRB	Closed	Recharge valve closed for canal weed maintenance. ****Do recharge above 4' BRB due to habitat control.
W	Minnewawa Avenue south of Olive Avenue	May 9, 2012	3' BRB	3' BRB	4' 9" BRB	Open	Please increase water delivery.
X	Willow Avenue and Belmont Avenue	May 9, 2012	3' BRB	3' BRB	3' 3" BRB	Open	****Cannot recharge Basin "X" until Basin "W" is 7.5' BRB. FMFCD to control recharge valve from Basin "W".
Y	Adler Avenue north of Kings Canyon Road	May 1, 2012	16' BRB	16' BRB	15' 6" BRB	Closed	Please keep recharge water terminated until basin elevation drops below maximum authorized level. ****Do not exceed 16' BRB to prevent water from spilling to upper floor.
Z	Kings Canyon Road and Maple Avenue (Fairgrounds)						Off recharge for basin maintenance. ****Do not exceed 12' BRB to prevent water from spilling to upper floor.
CC	Floradora Avenue west of Clark Street	June 12, 2012	11' BRB	8' BRB	13' BRB	Open	Please increase water delivery. Recharge elevation limited to 8' BRB due to construction of storm drain. ****Do not recharge before June due to limited basin capacity.
DD2	Palm Avenue and Dakota Avenue	May 1, 2012	4' BRB	3' BRB	5' 6" BRB	Open	Please increase water delivery.
EE	McKinley Avenue west of West Avenue	May 1, 2012	5' BRB	3' BRB	4' 11" BRB	Open	
FF	West Avenue south of Kearney Blvd.	May 17. 2012	14' BRB	14' BRB	14' 9" BRB	Closed	****Do not exceed 14' BRB to prevent spilling water to the floor on east side of West Avenue.
GG	Florence Avenue east of Cedar Avenue	May 1, 2012	9' BRB	9' BRB	10' BRB	Closed	Recharge elevation limited to 9' BRB due to construction of storm drain.
HH	Maple Avenue & Annadale Avenue	June 21, 2012	3' BRB	3' BRB	4' BRB	Open	

* BRB: Below Red Band ** BCL: Below Chalk Line *** ACL: Above Chalk Line ****Note for future reference

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SEMI-MONTHLY RECHARGE BASIN SUMMARY

Inspected June 28 - July 2, 2012

		June 2012					
Basin	Location	Date Authorized	Maximum June Authorized Recharge Level	Maximum July Authorized Recharge Level	Observed Water Elevation	Intertie Position	Comments
II1	Church Avenue and Elm Avenue						Off recharge to expand basin. ****Cannot recharge before May due to limited basin capacity. Do not exceed 8' BRB to prevent water from spilling to upper floor.
II2	Orange Avenue and Belgravia Avenue	May 1, 2012	4' BRB	3' BRB	4' 3" BRB	Open	
JJ	Tenth Street south of McKinley Avenue	May 1, 2012	3' BRB	3' BRB	3' 1" BRB	Open	
KK	Elm Avenue south of Jensen Avenue	May 1, 2012	3' BRB	3' BRB	6' BRB	Open	Maximum recharge elevation not achieved due to canal capacity limitations during current agricultural water delivery.
LL	Annadale Avenue and Cherry Avenue	March 28, 2012	7' BRB	7' BRB	8' 9" BRB	Open	Please increase water delivery. Recharge elevation limited to 7' BRB due to construction of storm drain.
MM	Ashlan Avenue west of Hughes Avenue	May 29, 2012	3' BRB	3' BRB	2' 7" BRB	Open	Please terminate recharge delivery until basin drops below authorized elevation.
OO	West Avenue and Florence Avenue	May 21, 2012	3' BRB	3' BRB	7' BRB	Open	Maximum recharge elevation not achieved due to canal capacity limitations during current agricultural water delivery.
RR1	Nielson Avenue and Freeway 99	May 1, 2012	6' BRB	6' BRB	8' BRB	Open	Please increase water delivery. ****Do not recharge above 6' BRB due to trees in basin.
RR2	Belmont Avenue and Thorne Avenue						Off recharge to maintain basin. ****Cannot recharge until June and do not recharge above 5' BRB in July and August due to limited capacity.
RR3	Whitesbridge Avenue and West Avenue	May 1, 2012	5' BRB	5' BRB	6' 7" BRB	open	Please increase water delivery. ****Do not to exceed 5' BRB due to Chandler Airport inlets and trees in basin.
TT1	West Avenue south of Church Avenue	March 28, 2012	3' BRB	3' BRB	10' BRB	Open	Maximum recharge elevation not achieved due to canal capacity limitations during current agricultural water delivery.
UU2	Freeway 99 & Olive Avenue	April 5, 2012	10' BRB	10' BRB	15' BRB	Open	Please increase water delivery. ****Can no longer discharge into Cole Ditch because line is severed south of Belmont west of Hughes.
UU3	Belmont Avenue and Marks Avenue	May 23, 2012	7' BRB	7' BRB	8' 1" BRB	Open	Please increase water delivery. Recharge elevation limited to 7' BRB due to construction of storm drain.
XX	Mckinley Avenue and Hughes Avenue	As Needed For Reclaimed Irr. System					Basin "EE" authorized level is below the recharge valve to Basin "XX". ****FMFCD to control recharge valve from Basin EE and do not exceed 15' BRB to prevent water from spilling to upper floor.
ZZ	Crystal Avenue south of Whitesbridge Avenue						Off recharge for construction of outfall structure.
AB	Palo Alto Avenue West of Marks Avenue	May 1, 2012	3' BRB	3' BRB	3' 10" BRB	Closed	
AC	Escalon north of Bullard						Basin is now a recreational facility and recharged primarily for reclaimed irrigation water .
AD	Valentine Avenue and Escalon Avenue	June 6, 2012	3' BRB	3' BRB	3' 3" BRB	Open	
AE	Barstow Avenue west of Valentine Avenue	May 1, 2012	3' BRB	3' BRB	3' BRB	Open	
AF	Shaw Avenue east of Valentine Avenue	May 1, 2012	3' BRB	3' BRB	3' 3" BRB	Open	
AG	Valentine Avenue south of Ashlan Avenue	May 29, 2012	3' BRB	3' BRB	3' BRB	Open	

* BRB: Below Red Band ** BCL: Below Chalk Line *** ACL: Above Chalk Line ****Note for future reference

Figure 3-18

SEMI-MONTHLY RECHARGE BASIN SUMMARY

Inspected June 28 - July 2, 2012

Basin	Location	June 2012						
		Date Authorized	Maximum June Authorized Recharge Level	Maximum July Authorized Recharge Level	Observed Water Elevation	Intertie Position	Comments
AH2	Cornelia and Gettysburg Avenue Alignment	May 1, 2012	3' BRB	3' BRB	3' BRB	Open	
AJ	Ashlan Avenue west of Cornelia Avenue	May 1, 2012	3' BRB	3' BRB	4' BRB	Open	Please increase water delivery to raise basin elevation to increase delivery to Basin "AJ".
AK	Dakota Avenue and Polk Avenue	May 1, 2012	3' BRB	3' BRB	8' 6" BRB	Open	Basin "AJ" to low to maximize water delivery. ****Basin "AJ" must be 4.5' BRB to recharge Basin "AK". FMFCD to control recharge valve from Basin "AJ".
AL	Brawley Avenue and Clinton Avenue	May 1, 2012	3' BRB	3' BRB	11' BRB	Open	Maximum recharge elevation not achieved due to canal capacity limitations during current agricultural water delivery.
AO	Blythe Avenue and Belmont Avenue	March 28, 2012	3' BRB	3' BRB	6' 2" BRB	Open	Please increase water delivery. ****Recharge level remains at 3' BRB due to minimum storm drain lines are connected to the basin.
AW2	North Avenue east of Cherry Avenue	May 1, 2012	3' BRB	3' BRB	6' BRB	Open	Please increase water delivery.
AZ	Muscat Avenue and Chestnut Avenue	May 1, 2012	3' BRB	3' BRB	4' BRB	Open	
BE	Helm Avenue north of Church Avenue	March 28, 2012	3' BRB	3' BRB	3' 10" BRB	Open	
BF	Chestnut Avenue south of Church Avenue	March 28, 2012	3' BRB	3' BRB	3' 3" BRB	Open	
BH	Church Avenue east of Clovis Avenue	April 5, 2012	3' BRB	3' BRB	3' 6" BRB	Open	
BM	Fowler Avenue and California Avenue	March 28, 2012	3' BRB	3' BRB	7' 3" BRB	Closed	Recharge valve closed for canal weed maintenance.
BO	Sunnyside Avenue south Belmont Avenue						Off recharge due to excavation.
BQ	Belmont and Fowler	April 2, 2012	5' BRB	3' BRB	8' 3" BRB	Open	Please increase water delivery.
BT	Marion Avenue south of Nees Avenue						Off recharge for dewatering of Basin "BX" for excavation.
BU	Clovis Avenue south of Clinton Avenue	May 1, 2012	4' BRB	4' BRB	3' 11" BRB	Open	Please terminate recharge delivery until basin drops below authorized elevation. ****Do not recharge above 4' BRB due to habitat control.
BV	` Fowler Avenue north of Shields Avenue	May 1, 2012	3' BRB	3' BRB	3' 2" BRB	Closed	Recharge valve closed for canal weed maintenance.
BW	Dakota Avenue east of Clovis Avenue	May 1, 2012	3' BRB	3' BRB	3' 6" BRB	Closed	Recharge valve closed for canal weed maintenance.
BZ	Copper Avenue and Cedar Avenue	May 1, 2012	3' BRB	3' BRB	5' BRB	Open	Please increase water delivery.
CL	Willow Avenue and Sierra Avenue	May 1, 2012	3' BRB	3' BRB	5' BRB	Open	Please increase water delivery.
CM	Cedar Avenue north of Sierra Avenue	May 1, 2012	3' BRB	3' BRB	3' 3" BRB	Open	
CN	Angus Avenue and Fir Avenue	May 1, 2012	9' BRB	9' BRB	10' BRB	Closed	****Do not exceed 9' BRB to prevent water from spilling onto baseball fields.
CO2	Maroa Avenue and Herndon Avenue	March 28, 2012	3' BRB	3' BRB	5' 6" BRB	Open	Please increase water delivery.

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SEMI-MONTHLY RECHARGE BASIN SUMMARY

Inspected June 28 - July 2, 2012

Basin	Location	Date Authorized	Maximum June Authorized Recharge Level	Maximum July Authorized Recharge Level	Observed Water Elevation	Intertie Position	Comments
		June 2012					
CS	Minnewawa Avenue south of North Avenue	March 28, 2012	1' BRB	1' BRB	10' 6" BRB	Closed	Basin elevation reduced due to terminating recharge delivery during recent canal weed maintenance. ****Recharge level remains at 1' BRB due to no storm drain lines are connected to the basin.
CW	Fresno Street and Nees Avenue						Off recharge for construction of pump station.
CX	Ninth Street and Nees Avenue	May 1, 2012	3' BRB	3' BRB	3' 6" BRB	open	
CY	Alluvial Avenue and Cedar Avenue	May 1, 2012	3' BRB	3' BRB	3' 3" BRB	Open	
CZ	Alluvial Avenue and Chestnut Avenue	May 1, 2012	8' BRB	8' BRB	8' 4" BRB	Open	Recharge elevation limited to 8' BRB due to construction of storm drain. ***Do not recharge above 4' BRB due to trees in basin.
DE	Copper Avenue and Cedar Avenue						Cannot recharge due to pipeline easement.
DH	Maroa Avenue and Cromwell Avenue						Cannot recharge due to chemical plume.
EF	Bullard Avenue and Cornelia Avenue	May 1, 2012	3' BRB	3' BRB	7' BRB	Open	Please increase water delivery.
EG	Sandrini Avenue and Spruce Avenue	May 1, 2012	Top of Weir	Top of Weir	1' Below Top of Weir	Open	
EL	Freeway 99 and Barstow Avenue	May 1, 2012	3' BRB	3' BRB	3' 1" BRB	Open	
EM	Barstow and Grantland	April 5, 2012	3' BRB	3' BRB	3' 2" BRB	Open	
1E	Ashlan Avenue and Fordham Avenue	May 1, 2012	3' BRB	3' BRB	3' 9" BRB	Closed	Recharge valve closed for canal weed maintenance.
1G	Temperance Avenue south of Ashlan Avenue	May 1, 2012	3' BRB	3' BRB	3' 2" BRB	Closed	Recharge valve closed for canal weed maintenance.
2D	Ashlan Avenue and Clovis Avenue	May 1, 2012	3' BRB	3' BRB	4' BRB	Closed	Recharge valve closed for canal weed maintenance.
3A	Shaw Avenue and Helm Avenue	May 1, 2012	3' BRB	3' BRB	3' 5" BRB	Closed	
3D	Hoblitt Avenue and Sunnyside Avenue	June 18, 2012	3' BRB	3' BRB	16' 5" BRB	Closed	Recharge valve closed for canal weed maintenance.
3F	Shaw Avenue and Laverne Avenue	May 1, 2012	3' BRB	3' BRB	3' 2" BRB	Closed	Recharge valve closed for canal weed maintenance.
4E	Bullard Avenue and Fowler Avenue	May 1, 2012	3' BRB	3' BRB	3' 10" BRB	Closed	Recharge valve closed for canal weed maintenance.
5B/5C	Sierra Avenue and Minnewawa Avenue	May 1, 2012	18' BRB	18' BRB	16' BRB	Closed	Please keep recharge delivery terminated until basin elevation drops below maximum authorized level. Recharge elevation limited to 18' BRB due to leakage in 168 embankment.
5F	Fowler Avenue and Vartikian Avenue	May 1, 2012	3' BRB	3' BRB	3' 5" BRB	Closed	Recharge valve closed for canal weed maintenance.
6D	Sierra Avenue and Clovis Avenue	May 1, 2012	3' BRB	3' BRB	3' 1" BRB	Closed	Recharge valve closed for canal weed maintenance.
7C	Clovis Avenue and Alluvial Avenue	May 1, 2012	3' BRB	3' BRB	4' 7" BRB	Open	Please increase water delivery.
7D	Alluvial Avenue and Fowler Avenue	May 1, 2012	3' BRB	3' BRB	3' 7" BRB	Open	Recharge valve closed for canal weed maintenance.

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Figure 3-18