

**Annual Surveillance Report**  
**January 2018 through December 2018**  
**Sand Canyon Dam**  
**DSOD Dam No. 1029-002**  
**Irvine, CA**  
**June 14, 2019**



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**Prepared For:**

**Irvine Ranch Water District**  
**Field Operations Department**  
**P. O. Box 57000**  
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**GENTERRA**  
**CONSULTANTS, INC.**  
ENGINEERING & GEOTECHNICAL SERVICES

**ANNUAL SURVEILLANCE REPORT  
JANUARY 2018 THROUGH DECEMBER 2018  
FOR  
SAND CANYON DAM  
DSOD DAM NO. 1029-002  
IRVINE, CALIFORNIA**

**Submitted To:**

**Irvine Ranch Water District  
Field Operations Department  
P. O. Box 57000  
Irvine, CA 92619-7000**

**Prepared By:**

**GENTERRA Consultants, Inc.  
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**Project No. 397B-IRW**

**June 14, 2019**



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Project No. 397B-IRW

Irvine Ranch Water District  
P. O. Box 57000  
Irvine, CA 92619-7000

Attention: Mr. Malcolm A. Cortez, P.E.

Subject: Sand Canyon Dam, DSOD Dam No. 1029-002  
Annual Surveillance Report from January 2018 through December 2018

Dear Mr. Cortez:

GENTERRA Consultants, Inc. (GENTERRA) is pleased to submit this Annual Surveillance Report for Sand Canyon Dam covering the period from January 2018 through December 2018. This report is part of the scope of work described in our proposal dated October 14, 2015, and as authorized by the Irvine Ranch Water District (District) in Purchase Order No. 527854 dated December 22, 2015.

We appreciate this opportunity to provide the District with our services during this annual surveillance program. Please contact either of the undersigned with any questions.

Sincerely,  
**GENTERRA CONSULTANTS, INC.**

Douglas A. Harriman, P.E.  
Principal Engineer  
P.E. 55620

Joseph J. Kulikowski, P.E., G.E.  
President and Senior Principal Engineer  
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Enclosure

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**SECTION 1: INTRODUCTION AND BACKGROUND**

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**1.1 GENERAL**

This report presents the results of the dam safety monitoring and surveillance program for Sand Canyon Dam conducted by the Irvine Ranch Water District (District) and GENTERRA Consultants, Inc. (GENTERRA) for the 12-month period from January 2018 through December 2018. It includes a compilation of the field measurements, observations, and conclusions related to the general condition and safety of the dam. In addition, recommendations are provided for continued operation, surveillance, and monitoring of the dam. This report is submitted as part of the jurisdictional requirements of the State of California, Department of Water Resources, Division of Safety of Dams (DSOD).

The tables provided in this report present field measurements of piezometer water levels, reservoir water surface elevations, seepage flow rates, and net horizontal and net vertical movement based on survey data collected at Sand Canyon Dam. Graphs illustrating piezometer water levels and seepage flow rates, each with corresponding reservoir water surface elevations are provided for the two-year period (January 2017 through December 2018), as well as for the 10-year period (January 2009 through December 2018). The 10-year plots are included to show longer-term trends, to facilitate evaluation of the performance of the dam and reservoir, and to more easily identify any adverse trends or significant deviations in the data. Tables 2 through 5 present the results of horizontal and vertical movement surveys from 1975 through 2018. Graphs of the net horizontal displacement and net vertical movement for the 24-year period from 1995 through 2018 are shown on Figures 8 and 9, respectively.

**1.2 DAM AND RESERVOIR**

Sand Canyon Dam is a compacted earthfill embankment dam located on Sand Canyon Wash in Irvine, California. The dam was completed in 1942. The District took over operation of the Sand Canyon Dam and Reservoir in 1967 from The Irvine Company.

The vertical datum used for the dam safety monitoring program is the National Geodetic Vertical Datum of 1929 (NGVD29).

Modifications to the dam have occurred over the years. The current configuration of the dam consists of the following: the crest of the dam is at Elevation 202 feet, and there is a one-foot-high concrete parapet wall along the upstream edge of the crest of the dam (Figure 1). The downstream edge of the crest of the dam has a small curb. The height of the dam is 58 feet with a crest length of 861 feet and a crest width of 10 feet. Asphalt Concrete (AC) covers the crest of the dam.

The upstream face of the dam is lined with 3-inch-thick AC extending approximately 19 feet down from the upstream edge of the crest of the dam and has a slope gradient of 2.5H:1V (Horizontal: Vertical). The downstream face of the dam is covered with grass and has a slope gradient of 2H:1V. No benches were constructed on either face of the dam.

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The dam was designed as a zoned embankment with an upstream zone consisting of “selected impervious” material, a central zone of “random” material, and a downstream zone of “unselected pervious” material (Figures 2 and 3). During construction of the dam, test results indicated that the embankment is fairly homogeneous and consists, for the most part, of medium dense sandy clay and clayey sand (DSOD, 1984). The dam is reported as being founded on alluvium across the original broad stream channel, and on the sandstone of the Santiago Formation near the abutments.

A cutoff trench was constructed under portions of the upstream and central zones of embankment material (see Figure 2). The trench typically penetrates 2 to 4 feet into the sandstone bedrock but does not extend across the full width of the broad alluvial channel.

The reservoir has a drainage area of about 6.8 square miles. Per the document titled “*Dams within the Jurisdiction of the State of California*” (DSOD, 2000) the reservoir has a storage capacity of 960 acre-feet. However, because of modifications and many years of sediment accumulation, the storage capacity has been reduced to approximately 768 acre-feet (AECOM, 2016).

### **1.3 SPILLWAY**

Located on the right abutment, the spillway consists of an approach channel, an ungated ogee weir, and a rectangular-shaped spillway channel. The spillway channel has reinforced concrete retaining walls on both sides, with a maximum height of 18 feet. The bottom of the channel is mostly unlined and consists of sandstone bedrock with filled-in areas of dental concrete. The channel conveys the water to an energy dissipation structure that outlets to Sand Canyon Wash. The spillway crest is at Elevation 193.5 feet, which provides 8.5 feet of freeboard (not counting the one-foot high parapet wall along the upstream edge of the dam crest).

### **1.4 OUTLET WORKS**

The outlet works have been modified over the years and are currently controlled by four upstream gates and three downstream valves. The outlet works consist of a 36-inch-diameter ungated corrugated metal pipe (CMP) with an inlet at Elevation 187.0 feet. The 36-inch-diameter pipe has three 24-inch-diameter inlet slide gates at Elevations 169.9, 177.1, and 185.0 feet, and one 20-inch-diameter main gate located near the upstream toe. The inlet gates are manually operated from the controls located at the upstream edge of the crest of the dam. Per the operating procedures posted on the controls, at least one of the 24-inch-diameter inlet gates is to remain fully open at all times when it is below the reservoir level. The main gate is to remain fully open at all reservoir levels except during temporary periods for maintenance shutdown.

The 20-inch-diameter steel outlet pipe is 260 feet in length and transitions to a 24-inch-diameter distribution line near the toe of the dam. A 16-inch-diameter gate valve is located between the 20-inch and 24-inch lines. The 24-inch-diameter distribution line has a 24-inch-diameter gate valve about 100 feet downstream of the toe of the dam. Just upstream of the 24-inch gate valve, the 24-inch line splits to a 20-inch-diameter outfall line. At approximately 330 feet downstream of the toe of the dam, the 24-inch line has a 24-inch-diameter butterfly blow off valve and nearby splits again



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to a 24-inch-diameter outfall line. The 20-inch outfall line connects to the 24-inch outfall line and transitions to a 30-inch-diameter outfall line that discharges to Sand Canyon Wash (Figure 1).

## **1.5 SUBDRAINS**

No internal drains were installed during the construction of the dam. However, two seepage subdrains referred to as the Left Subdrain and Right Subdrain, were installed at the downstream toe near the left groin (Figure 1). The Left Subdrain consists of a 6-inch pipe with two 4-inch branches, and the Right Subdrain is a 6-inch pipe extending approximately 100 feet parallel to the toe (DSOD, 1984). The two subdrains discharge into a Drain Junction Vault.

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## **SECTION 2: FIELD MEASUREMENTS**

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### **2.1 GENERAL**

There are 18 open-well piezometers, two seepage subdrains, and six survey monuments being monitored at Sand Canyon Dam. District personnel measure the water levels in the piezometers and reservoir, and seepage flow rates from the two drains monthly and immediately following significant seismic events. The survey monuments are surveyed annually by a licensed surveyor under contract with the District. Precipitation is measured at an on-site rain gage.

Figure 1 is a site and instrumentation plan showing the layout of the dam and appurtenances, as well as the locations of the piezometers, seepage collection subdrains, and survey monuments. Figures 2 and 3 show Sections A-A' and B-B', respectively. Section A-A' is at the approximate location of the deepest portion of the alluvium in the foundation. Section B-B' is at approximate the location of the maximum section of the dam. As used in this report, the left and right designations are as viewed looking downstream.

During the 12-month review period, the reservoir water surface elevation varied from a minimum elevation of 177.3 feet to a maximum elevation of 184.3 feet (about 18 feet below the dam crest). The reservoir elevations that were read on the same dates as the instrumentation are shown in Table 1.

An abandoned weir is located downstream of the dam on the left abutment adjacent to the golf cart path. Intermittent flow from this weir is occasionally observed but is not measured by the District.

### **2.2 PIEZOMETERS**

A piezometer is a small diameter well used mainly to measure water levels. It is typically installed as a casing in a vertical borehole and has a discrete perforated zone near its bottom to enable monitoring of changes in groundwater levels within that zone. More than one piezometer can be installed within a single, larger-diameter outer well casing. These groups of piezometers are often referred to as multi-stage or nested piezometers. The tip of each piezometer is generally placed at its own discrete depth range within the outer well casing. The outer well casing is perforated along the vertical zones corresponding to the depths of the piezometer tips.

There are 18 piezometers currently being monitored at Sand Canyon Dam. At this facility, there are five nested piezometers, Piezometers P-1, P-2, P-8, P-9, and P-10, each having two piezometers in them, designated as A and B.

The water levels in the piezometers are measured monthly by the District. The reservoir water surface elevation is also noted at the time of the field measurements. The location of each piezometer is shown on Figure 1. Thirteen of the 18 piezometers are located either at or near the maximum depth of foundation alluvium (Section A-A' on Figure 2), or at the section near the maximum section of the dam (Section B-B' on Figure 3). Three of the remaining five piezometers are in the right portion of the dam and two are in the left portion. On Sections A-A' and B-B'

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(Figures 2 and 3), for the selected piezometers, the maximum historical water levels since 1984 are shown along with the maximum and minimum piezometer water levels recorded during the 12-month review period (January 2018 through December 2018).

Table 1 provides the reservoir water surface elevation and piezometer water levels for the 10-year period from January 2009 through December 2018. Figures 4A through 4E are graphical plots of piezometer water levels and reservoir water surface elevations during the two-year period from January 2017 through December 2018. Figures 5A through 5E are graphical plots that cover a 10-year period from January 2009 through December 2018.

In December 2015, the District converted Piezometers P-9A, P-9B, P-10A, P-10B, P-11, P-12, and P-13 to vibrating wire piezometers. A vibrating wire piezometer contains a high tensile steel wire attached at one end to a diaphragm. The wire is electronically plucked to make it vibrate, and its resonant frequency is proportional to the tension in the wire. The frequency of vibration in the wire induces an alternating electrical current in a coil. The magnitude of the current is detected, and the reading is then converted to a pressure. The pressure fluctuates with changes in water levels in the immediate vicinity of the piezometer tip.

The following is a summary of the water level measurements taken during the 12-month review period for each piezometer and a discussion of the historical trends and any questionable or erroneous measurements that were noted.

Piezometers P-1A, P-1B, and P-6 are located in the right portion of the dam. Piezometer P-1A is nested in the same well as Piezometer P-1B on the crest of the dam, while Piezometer P-6 is near the toe. The tip of Piezometer P-1A is located within the dam embankment downstream from the cutoff trench, while Piezometers P-1B and P-6 have tips within the foundation alluvium. Graphs of the water levels during the two-year period from January 2017 through December 2018 are shown on Figure 4A, and those for a 10-year historical period from January 2009 through December 2018 are shown on Figure 5A. Piezometer P-1A has historically shown little to no response to reservoir water surface fluctuations and the water levels tend to stay within a small range. A reading taken on June 28, 2016 is below the reported bottom of the piezometer and is therefore considered as erroneous. During the 12-month review period, the water levels in P-1A remained fairly consistent. Piezometers P-1B and P-6 respond to reservoir water surface fluctuations and the range during the 12-month review period was within the historical water levels. Fluctuations in these two piezometers appear to indicate that water levels within the alluvium do show some response to changes in reservoir water levels.

Piezometers P-2A, P-2B, P-5, P-10A, and P-10B are located at or near the section of the dam overlying the maximum depth of the foundation alluvium (Section A-A' on Figure 2). Piezometer P-2A is nested in the same well as Piezometer P-2B and they are situated on the crest of the dam. During July through September 2017 period, water level in P-2A was temporarily higher than the water surface elevation of the reservoir. This temporary condition occurred because, during the period starting from April to July 2017, the elevation of the reservoir water surface had been lowered

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by 30 feet. This is a significant drawdown over a three-month period and this time period did not allow the high pore pressure that had been developed during high reservoir water level to dissipate quickly enough to stay below the reservoir water level. That is nothing unusual for an earth embankment dam during a significant drawdown period. Readings taken on September 27 and October 24, 2018 are reported below the bottom of Piezometer 2A and are therefore considered as erroneous. Piezometer P-5 is situated near the toe of the dam. Piezometer P-10A is nested in the same well as Piezometer P-10B and they are situated along the downstream face of the dam. Graphs of the water levels measured during the two-year period from January 2017 through December 2018 are shown on Figure 4B, and those for a 10-year historical period from January 2009 through December 2018 are shown on Figure 5B.

Piezometers P-2A and P-10A are installed in the dam embankment, and generally respond to reservoir water surface fluctuations. A reading of the water level in Piezometer P-2A taken on April 4, 2010 showed a sudden increase, followed by the water level readings returning to below Elevation 173 feet. This single measurement is likely erroneous. A reading taken on May 23, 2017 in Piezometer P-10A showed a sudden decrease, followed by higher water level readings. This single measurement is likely erroneous. The water levels observed in these piezometers during this 12-month review period were consistent with historical levels.

Piezometers P-2B, P-5, and P-10B are installed in the foundation alluvium. Piezometers P-2B and P-10B show little response to reservoir water surface fluctuations, while Piezometer P-5 shows very little if any correlation. Readings taken on October 29, 2013, August 26, 2014, March 26, 2015, April 29, 2015, August 26, 2015, and November 24, 2015 in Piezometer P-10B indicated sudden increases in the water level in that piezometer. Following those high readings however, the water level returned to below Elevation 140 feet. Therefore, those measurements were likely erroneous. The water levels observed in these piezometers during this 12-month review period were generally consistent with historical levels.

Piezometers P-4, P-8A, P-8B, P-9A, P-9B, and P-11 are located at the maximum section of the dam (see Section B-B' on Figure 3). Piezometer P-8A is nested in the same well as Piezometer P-8B and they are situated on the crest of the dam. Piezometer P-4 is situated near the toe of the dam. Piezometer P-9A is nested in the same well as Piezometer P-9B and they are situated along the downstream face of the dam approximately in-line with Piezometer P-11. Graphs of the water levels during the two-year period from January 2017 through December 2018 are shown on Figure 4C, and those for a 10-year historical period from January 2009 through December 2018 are shown on Figure 5C.

Piezometers P-8A, P-9A, and P-11 are installed in the dam embankment. Piezometers P-8A and P-9A generally respond to reservoir water surface fluctuations, while Piezometer P-11 shows very little response. A reading taken on October 26, 2017 was approximately 27 feet below the reported bottom of Piezometer P-11, and a reading taken on June 28, 2018 was approximately 16 feet below the reported bottom of the piezometer. Therefore, those readings were considered as erroneous. The

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water levels observed in these piezometers during this 12-month review period were generally consistent with historical levels.

Piezometers P-4 and P-8B are installed in foundation bedrock, and P-9B is installed in foundation alluvium. Piezometers P-8B and P-9B generally respond to reservoir water surface fluctuations, while increases and decreases in Piezometer P-4 may be related to rainwater. On August 26, 2014, a sudden decrease to a dry reading was reported in Piezometer P-9B, followed by water level readings returning to Elevation 155 feet. This single measurement is likely erroneous. The water levels observed in these piezometers during this 12-month review period were consistent with historical levels.

Piezometers P-3 and P-7 are located in the left portion of the dam. Piezometer P-3 is situated on the crest of the dam while Piezometer P-7 is on the downstream face near the left groin. Graphs of the water levels during the two-year period from January 2017 through December 2018 are shown on Figure 4D, and those for a 10-year historical period from January 2009 through December 2018 are shown on Figure 5D. The tips of these piezometers are believed to be set below the base of the embankment, and possibly into bedrock. During the July through August 2017 period, water level in P-3 was temporarily higher than the water surface elevation of the reservoir. This temporary condition occurred because during the period starting from April to July 2017, the elevation of the reservoir water surface had been lowered by 30 feet. This is a significant drawdown over a three-month period and this time period did not allow the high pore pressure that was developed during high reservoir water level to dissipate quick enough to stay below the reservoir water level, this is nothing unusual for an earth embankment dam during significant drawdown period. During the 12-month review period and historically, Piezometer P-7 has shown relatively high water levels considering that it is located near the downstream toe of the dam. Since the cutoff trench and the alluvium in the foundation are not believed to extend this far to the left, it is likely that a semi-pervious zone on top of the bedrock remains in place beneath this portion of the dam. If present, such a zone would account for much of the seepage that is intercepted by the Left Subdrain (see Section 2.3). Based on historical data, these two piezometers generally respond to reservoir water surface fluctuations, but Piezometer P-7 generally becomes dry when the reservoir water surface remains below an elevation of approximately 170 feet. A questionable reading taken on September 28, 2011 in Piezometer P-3 indicated a sudden increase in the water level. Following the high reading however, the water level returned to below Elevation 170 feet. This single measurement was likely erroneous. The water levels observed in these piezometers during this 12-month review period were generally consistent with historical levels.

Piezometers P-12 and P-13 are located on the downstream face of the dam near the toe between Sections A-A' and B-B'. Graphs of the water levels during the two-year period from January 2017 through December 2018 are shown on Figure 4E, and those for a 10-year historical period from January 2009 through December 2018 are shown on Figure 5E. The tip elevation of these two piezometers is believed to be in the dam embankment. Water levels observed in these piezometers show some response to reservoir water surface fluctuations, and they are at about the same elevation (approximately 153 feet) as that of the invert of the Right Subdrain. On October 26, 2010, a dry

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reading was reported in Piezometer P-12 that corresponds to a water level approximately 2 feet above the reported bottom of the piezometer. This reading is considered as erroneous. A reading taken on August 29, 2012 was below the reported bottom elevation of the piezometer and was therefore considered as erroneous. The water levels observed in these piezometers during this 12-month review period were consistent with historical levels.

Based on GENTERRA's review of the piezometer data, there are no indications of any adverse conditions in the dam embankment, abutments, or foundation. The District should have the elevations of tops of casings surveyed and should measure the depth to the bottom of each piezometer periodically to verify that the casings are not blocked to their entire as-built depth, and to confirm the elevation of the bottom of the piezometer. The District should continue to closely monitor the water levels in each piezometer.

### **2.3 SUBDRAIN FLOWS**

No internal drains were installed during construction of the dam. Because of seepage appearing at the downstream toe soon after the reservoir first began to be filled with water, a seepage collection drain (Left Subdrain) was installed in the left groin near the downstream toe. Modifications occurred over the years and in 1976, a second seepage collection subdrain (Right Subdrain) was added. The Left Subdrain consists of a 6-inch-diameter pipe with two 4-inch-diameter branches, and the Right Subdrain is a 6-inch-diameter pipe extending approximately 100 feet parallel to the toe (DSOD, 1984). The two subdrains discharge into the Drain Junction Vault, which is located at the downstream toe of the dam near the left abutment (Figure 1). An outlet pipe from the Drain Junction Vault then discharges the seepage flow to a drop inlet structure. The flow rates of the two subdrains discharging into the Drain Junction Vault are measured by District personnel on a monthly basis.

A graph on Figure 6 presents the seepage flow rates from the Left and Right Subdrains versus the reservoir water surface elevations for the two-year period from January 2017 through December 2018. The graph on Figure 7 covers a 10-year period from January 2009 through December 2018. Tabulated data for the 10-year period are presented in Table 1.

On March 24, 2016, GENTERRA was called to inspect an area of seepage observed upstream of the seepage collection vault located at the downstream toe, near the left side of the dam. Observations and a summary of concerns were sent to the District by GENTERRA. Using suggestions by GENTERRA, an investigation was then performed by the District to determine the cause for this seepage. It was determined that the pipe for the seepage collection drain had become blocked by roots and soil, and several portions of the pipe had been damaged. The roots and soil were then removed from the pipe by the District and the pipe was repaired, a cap was installed on the upstream end, and a liner was placed along the portions that had cracked. GENTERRA reviewed a copy of the District's video recording showing the repaired areas in the seepage drain.

Repairs of the Left Subdrain were performed at two different times in the past. One of the repairs was made in 1999 following the discovery of a sinkhole near the left abutment in October 1999, and the other was the repair in 2016 after the discovery of a broken pipe (described above). The graph



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on Figure 7 shows that the seepage flow rate through the Left Subdrain tends to increase when the reservoir water surface is above an elevation of approximately 180 feet. The flow rate then decreases to less than 0.5 gallons per minute (gpm) when the reservoir water surface remains below Elevation 180 feet. As noted in Section 2.2 of this report, it is likely that a semi-pervious zone on top of the bedrock remains in place beneath the left portion of the dam. If present, such a zone would account for much of the seepage that is intercepted by the Left Subdrain. The flows should continue to be observed for clarity to check for the presence of any suspended solids that might indicate a potential piping condition.

During this 12-month review period, the Right Subdrain was dry, and the Left Subdrain flow rate ranged from no flow from August through November 2018, to a maximum flow rate of 0.29 gpm on April 27, 2018. Based on historical data, the maximum flow rate of 3.96 gpm was measured from the Left Subdrain on June 28, 2000. Based on GENTERRA's review of the subdrain data, the flow rates appear to be consistent with historical flow rates and there are no indications of any adverse conditions.

## **2.4 MOVEMENT SURVEYS**

A total of six survey monuments (S-1 through S-6) are being surveyed at Sand Canyon Dam. All six survey monuments are located on the crest of the dam spanning from left abutment to right abutment (Figure 1). Survey Monuments S-1 through S-5 were initially read on September 15, 1975, while S-6 was initially read on October 20, 1987. According to AECOM (2016), historical survey data was located for the years 1975, 1981, and 1982 in a DSOD *Safety Review Report* dated April 1984. It should be noted that there is a data gap of about 33 years from the date the dam was constructed in 1942 to the initial survey beginning in 1975.

The survey monuments are usually surveyed annually by a licensed surveyor under contract with the District. Bush & Associates, Inc. performed the last survey of the survey monuments on May 31, 2018. No survey was performed during the year 2017.

Table 2 presents the horizontal Offset of Survey Monuments relative to their original baseline alignment, whereas Table 3 presents the net horizontal displacement of the survey monuments. Table 4 presents the actual elevations of the survey monuments, whereas Table 5 presents the net vertical movement of the survey monuments. Tables 2 through 5 cover a date range from 1975 through 2018. Figures 8 and 9 are graphical plots of the net horizontal displacement and net vertical movement of survey monuments from January 1995 through December 2018, respectively. Since no survey was performed in 2017, there is no data entered for 2017 in the tables or graphs for horizontal or vertical movement.

A comparison of the most recent survey data (2018) with the 2016 data indicates that the largest horizontal movement was 0.01 foot (0.12 inch) in the downstream direction at Survey Monument S-5 (Table 2). Survey Monuments S-1, S-3, and S-6 did not exhibit any change in horizontal movement during the same two-year period.

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As illustrated on Figure 8, the net horizontal displacement data indicate minor fluctuations in the movement in both the upstream and downstream direction since 1995. As of 2018, the maximum net horizontal displacement in the downstream direction was 0.065 foot (0.78 inch) at Survey Monuments S-3 and S-4, and 0.025 foot (0.30 inch) in the upstream direction at Survey Monument S-6 (Table 3).

The data indicate a maximum uplift/heave of 0.27 foot (3.24 inches) recorded at Survey Monument S-4 on May 28, 1997. Comparison of the most recent survey data (2018) with the previous (2016) data indicate that the largest vertical change was an uplift/heave of 0.015 foot (0.18 inch) at Survey Monuments S-5 and S-6 (Table 5). As of 2018, the maximum cumulative vertical movement was an uplift/heave of 0.252 foot (3.024 inches) at Survey Monument S-4 (Table 5).

Based on GENTERRA's review of the survey data, the horizontal and vertical displacements of survey monuments appear to be minimal and consistent with historical surveys. There are no indications of any adverse conditions as determined from data obtained through 2018.

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**SECTION 3: FIELD EVALUATIONS**

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**3.1 FIELD EVALUATION OF MAY 2, 2018**

A field evaluation of Sand Canyon Dam on May 2, 2018 was performed by Douglas A. Harriman, P.E. and J. Will Kulikowski of GENTERRA; Steve Habiger and Tyler Dillman of the District; Philip Lee of DSOD was also present. The reservoir water surface was at an elevation of 184.1 feet at the time of the field evaluation. Photographs were taken and are in the project files at GENTERRA for comparison with previous and future inspections.

**3.1.1 DAM**

The crest of the dam is surfaced with asphalt concrete (AC) pavement and was in satisfactory condition at the time of this field evaluation, with no signs of settlement, instability, or significant cracking. Minor surficial longitudinal cracking was observed in the AC along the downstream portion of the crest of the dam, but it is not considered to be significant. The parapet wall along the upstream edge of the crest of the dam was in good condition at the time of this field evaluation.

The upper portion of the upstream face of the dam is paved with AC and was in satisfactory condition. The lower portion of the upstream slope is not paved and was not visible due to the reservoir level. During the previous field evaluation dated December 28, 2017, minor cracking was observed throughout the AC on the upstream face of the dam. Repairs had been made but it was observed during the field evaluation that some cracks were still present. This minor cracking should continue to be monitored in the future and plans for patching and repair should be made if the cracking worsens. There were no signs of settlement or instability.

The downstream face of the dam is covered with grass and was in satisfactory condition. The vegetation on the downstream slope was trimmed and was at a satisfactory height. DSOD noted in January 1984 that the downstream slope has an uneven appearance and concluded that it was not a dam safety hazard (AECOM, 2016). There were no significant signs of cracking or instability on the slope.

The rodent abatement program for the dam is ongoing and appears to be working satisfactorily.

**3.1.2 SPILLWAY**

The spillway approach, ogee weir, channel, and energy dissipator were in satisfactory condition. The reservoir water surface was more than nine feet below the spillway crest elevation. Minor seepage was observed at the left edge, central portion, and right edge just downstream of the spillway crest. Vegetation is growing in the natural channel (Sand Canyon Wash) just downstream of the energy dissipator. Note that any vegetation in the natural channel downstream of the energy dissipator may impact the performance of the spillway.

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### **3.1.3 OUTLET WORKS**

DSOD recommends that the outlet and the emergency blow-off valves be exercised and documented in a log at least once per year to confirm operability. DSOD requires the valves be exercised once every three years in the presence of a DSOD representative.

The outlet works are currently controlled by four upstream gates and three downstream valves. The 36-inch-diameter CMP inlet, the three 24-inch-diameter outlet gates (Nos. 1, 2, and 3), and the 20-inch-diameter main gate were under water at the time of this field evaluation. The controls for the outlet valves are located at the upstream edge of the crest of the dam and appeared to be in satisfactory condition. The three upstream outlet gates were exercised through a full cycle and in the presence of the DSOD representative on May 2, 2018. On May 26, 2016, the main gate was attempted to be cycled, but broke as it was being closed. At the time of this field evaluation on May 2, 2018, the District had completed the repair of the main gate.

In 2016, exploratory excavation work was performed by the District to uncover the 30-inch-diameter blowoff valve. GENTERRA estimated the locations of the outlet works (valves and lines) as shown on Figure 1. GENTERRA recommends an updated survey to create a site plan that will show current layout of features at the project site as well as the locations of all lines and valves of the outlet works.

There are two 24-inch-diameter emergency blow-off valves located downstream of the dam. These two valves are located in-line so that one can be kept close while the other one is exercised, which minimizes the release of water. Both valves were exercised through a full cycle in the presence of the DSOD representative during this field evaluation.

On the date of a previous field evaluation on December 28, 2017, the District had completed the in-kind replacement of the main gate valve and no problems have been reported or were observed.

### **3.1.4 SEEPAGE**

Seepage flow rates are measured monthly by District personnel in the Drain Junction Vault located at the downstream toe of the dam near the left groin. A small amount of seepage flow was observed from the Left Subdrain. The Right Subdrain was dry.

A small amount of seepage was observed at the abandoned weir located downstream of the dam on the left abutment adjacent to the golf cart path. The District observes but does not measure the seepage flow rate from this weir. The history, purpose, and significance of this weir are not known.

The area of seepage observed during the previous field evaluation around the abandoned weir located downstream of the dam on the left abutment adjacent to the golf cart path, had dried up.

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### **3.2 FIELD EVALUATION OF DECEMBER 20, 2018**

A field evaluation of Sand Canyon Dam on December 20, 2018 was performed by Soma Balachandran, Ph.D., G.E., P.E. and J. Will Kulikowski of GENTERRA; and Bill Wesson of the District. The reservoir water surface was at an elevation of 176.2 feet at the time of the field evaluation. Photographs were taken and are in the project files at GENTERRA for comparison with previous and future inspections.

#### **3.2.1 DAM**

The crest of the dam is surfaced with asphalt concrete (AC) pavement and was in satisfactory condition, with no signs of settlement, instability, or significant cracking. Previous field evaluations noted minor cracking on the crest of the dam. During this field evaluation, it was observed that a slurry seal had been placed on the entire paved portion of the crest. Minor cracking is still present. The parapet wall along the upstream edge of the crest of the dam appeared to be in good condition, but minor vegetation growth was observed along the base of the parapet wall.

The upper portion of the upstream face of the dam is paved with AC and was in satisfactory condition, but minor vegetation growth was observed along existing cracks. The lower portion of the upstream slope is not paved, and the visible portion appeared to be in good condition. Previous field evaluations noted minor cracking on the upstream slope. During this field evaluation, it was observed that a slurry seal had been placed on the entire paved portion of the upstream slope. Minor cracking is still present. This minor cracking should continue to be monitored in the future and plans for patching and repair should be made if the cracking worsens. There were no signs of settlement or instability. Vegetation growth along the existing cracks should be controlled.

The downstream face of the dam has some uneven slope at some locations and is covered with grass and was in satisfactory condition, but a few erosion gullies were observed near the left abutment. The vegetation on the downstream slope was at a satisfactory height. DSOD noted in January 1984 that the downstream slope has an uneven appearance and concluded that it was not a dam safety hazard (AECOM, 2016). There were no significant signs of cracking or instability on the slope. There was a minor amount of recent rodent activity observed on the downstream face near the downstream toe area, left abutment area, and near downstream edge of dam crest in the form of fresh burrows. GENTERRA recommends the District continue to improve their rodent abatement program. Some maintenance repair is needed for the access ramp located in the left abutment. Also, vegetation control should be improved near the left abutment. All erosion gullies should be repaired.

#### **3.2.2 SPILLWAY**

The spillway approach, ogee weir, channel, and energy dissipator were in satisfactory condition. The spillway approach was dry. Vegetation was observed in the energy dissipator structure at its downstream end. GENTERRA recommends periodic removal of vegetation from the energy dissipator so that the energy dissipator can perform as intended during the design. Heavy vegetation is growing in the natural channel (Sand Canyon Wash) just downstream of the energy dissipator.

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Note that any vegetation in the natural channel downstream of the energy dissipator may impact the performance of the spillway.

### **3.2.3 OUTLET WORKS**

The outlet works are currently controlled by four upstream gates and three downstream valves. The 36-inch-diameter CMP and one of the three 24-inch-diameter outlet gates (No. 3) was above the water surface and appeared to be in good condition. The controls for the outlet valves are located at the upstream edge of the crest of the dam and appeared to be in satisfactory condition. During this field evaluation, none of the outlet valves or blowoff valves were exercised.

### **3.2.4 SEEPAGE**

Seepage flow rates are measured monthly by District personnel in the Drain Junction Vault located at the downstream toe of the dam near the left groin. There was no flow observed from either the Left or Right Subdrains.



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**SECTION 4: CONCLUSIONS AND RECOMMENDATIONS**

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**4.1 CONCLUSIONS**

- 4.1.1** Based on the available data, the dam appears to be performing satisfactorily.
- 4.1.2** The piezometers exhibited water levels that are generally consistent with historical values and trends. Piezometer P-12 (on October 26, 2010) had a dry reading at an elevation above the reported tip elevation at the bottom of the piezometer. Piezometers P-1A (on June 28, 2016), P-2A (on September 27 and October 24, 2018), P-9A (on July 26, 2018), P-11 (on October 26, 2017 and June 28, 2018), and P-12 (on August 29, 2012) had readings reported below their reported tip elevations. The reported tip elevations of Piezometers P-1A, P-2A, P-9A, P-11, and P-12 are 159.3 feet, 153.9 feet, 160.4 feet, 155.4 feet, and 151.5 feet, respectively.
- 4.1.3** Horizontal and vertical movement of the survey monuments appears to be normal and consistent with historical values and trends, as determined by survey data through 2018.
- 4.1.4** Minor cracking was observed on the dam crest and upstream face of the dam. A slurry seal had recently been placed on both of these surfaces. Vegetation along existing cracks should be controlled.
- 4.1.5** Minor rodent activity was observed on the downstream face of the dam at several locations, such as downstream toe area, area near the left abutment, and area near the downstream edge of the dam crest.
- 4.1.6** Vegetation was observed in the energy dissipator structure at its downstream end. Heavy vegetation is growing in the natural channel just downstream of the energy dissipator.
- 4.1.7** The three outlet gates (Nos. 1, 2, and 3) were exercised through a full cycle in the presence of a DSOD representative on May 2, 2018. On May 26, 2016, the main gate was attempted to be cycled, but it broke as it was being closed. The two blow-off valves located downstream of the dam were last exercised through a full cycle in the presence of a DSOD representative on May 2, 2018.
- 4.1.8** GENTERRA had estimated the locations of the outlet works (valves and lines) as shown on Figure 1.

**4.2 RECOMMENDATIONS**

- 4.2.1** The District should have the elevations of the top of piezometer casings surveyed and the depth to bottom of each piezometer is measured at the same time as surveying to determine the tip elevation of each piezometer. Also, the District should measure the

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depth to the bottom of each piezometer periodically to verify that the casings are not blocked to their entire as-built depth, and to confirm the elevation of the bottom of the piezometer. It is also beneficial to physically mark the depth of each piezometer tip on the piezometer cover to check the validity of water level readings or dry readings immediately after the measurements are taken.

- 4.2.2** The District should monitor the areas where cracks are present. Any increase in cracking of the AC surfaces should be reported to a District supervisor and the District's Dam Safety Consultant.
- 4.2.3** The District should continue the on going program for controlling rodent activity.
- 4.2.4** The District should repair the existing erosion gullies that were observed on the downstream face near the left abutment of the dam as well as any other erosion gullies that may have developed recently. Also, it is beneficial to regrade the downstream slope to get rid of uneven spots and to provide a condition that will allow easy and timely detection of any developing issue on the downstream slope.
- 4.2.5** The District should remove vegetation that is growing in the natural channel just downstream of the energy dissipator.
- 4.2.6** During the daily, weekly, and monthly operations at the dam, District personnel should always be observing the condition of the dam, appurtenances, and other features in the immediate area around the dam, looking for signs of distress or movement, increased seepage, or other unusual conditions, and verifying that the critical facilities are functional. Any unusual observations should be reported immediately to a District supervisor and the District's Dam Safety Consultant under contract at the time.
- 4.2.7** GENTERRA recommends the District should continue to perform a special evaluation of the dam immediately after any earthquake with a Magnitude of 4.5 or greater within a 50-mile radius of the dam, and/or any seismic event that would cause heavy furniture overturning in areas in the vicinity of the dam and reservoir.

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**SECTION 5: LIMITATIONS**

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This report represents the results of our surveillance program for Sand Canyon Dam, covering the period from January 2018 through December 2018. Professional services were provided to evaluate the performance of the existing dam based upon review of previous data, field inspections, instrumentation readings, and surveys.

The conclusions and professional opinions presented herein were developed by GENTERRA Consultants, Inc. for the Irvine Ranch Water District in accordance with generally accepted engineering principles and practices. We make no other warranty, either express or implied.

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**SECTION 6: REFERENCES**

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6. GENTERRA Consultants, Inc., 2018, *Annual Surveillance Report, January 2017 through December 2017 for Sand Canyon Dam and Reservoir, DSOD Dam No. 1029-002, Irvine, California*; by GENTERRA; dated November 26, 2018
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**TABLES**

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-1A			P-1B			P-2A			P-2B		
Top Elevation (ft) →			201.9			201.8			201.9			202.0		
Tip Elevation (ft) →			159.3			132.9			153.9			123.8		
Depth (ft) →			42.6			68.9			48.0			78.2		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
1/29/2009	182.20	0.39	42.4	159.5		57.5	144.3		34.8	167.1		61.3	140.7	
2/25/2009	185.70	3.10	42.0	159.9		57.0	144.8		34.1	167.8		59.9	142.1	
3/26/2009	188.40	0.10	42.4	159.5		56.9	144.9		33.2	168.7		61.0	141.0	
4/28/2009	189.30	0.00	42.4	159.5		56.7	145.1		32.0	169.9		61.3	140.7	
5/18/2009	188.50	0.00	41.3	160.6		56.6	145.2		31.4	170.5		61.0	141.0	
5/27/2009	188.10	0.00	42.2	159.7		56.7	145.1		31.2	170.7		61.0	141.0	
6/30/2009	188.60	0.10	42.4	159.5		56.7	145.1		31.2	170.7		61.3	140.7	
7/30/2009	184.80	0.00	42.3	159.6		56.9	144.9		30.9	171.0		61.3	140.7	
8/26/2009	176.60	0.00	41.5	160.4		57.8	144.0		31.6	170.3		61.8	140.2	
9/30/2009	174.50	0.00	42.2	159.7		59.0	142.8		33.3	168.6		62.8	139.2	
10/28/2009	175.30	0.29	42.6	159.3		59.2	142.6		34.2	167.7		63.0	139.0	
12/1/2009	176.40	0.00	42.0	159.9		59.4	142.4		35.2	166.7		63.3	138.7	
12/28/2009	178.80	2.75	42.5	159.5		58.6	143.3		35.5	166.5		62.2	139.8	
1/26/2010	191.30	4.15	42.4	159.5		57.3	144.5		34.9	167.0		60.6	141.4	
2/24/2010	193.60	2.29	42.4	159.5		55.4	146.4		32.5	169.4		59.8	142.2	
3/29/2010	193.50	1.18	42.2	159.7		55.4	146.4		29.9	172.0		60.0	142.0	
4/4/2010	193.50		41.5	160.4		55.5	146.3		25.5	176.4	Erroneous	60.0	142.0	
4/27/2010	193.90	1.66	42.3	159.6		55.4	146.4		29.2	172.7		59.9	142.1	
5/27/2010	192.90	0.03	41.4	160.5		55.4	146.4		28.7	173.2		59.9	142.1	
6/29/2010	191.60	0.00	41.4	160.5		55.4	146.4		28.7	173.2		59.7	142.3	
7/28/2010	187.50	0.00	42.3	159.6		55.9	145.9		29.1	172.8		60.4	141.6	
8/31/2010	179.20	0.00	41.5	160.4		57.3	144.5		30.8	171.1		61.4	140.6	
9/29/2010	175.60	0.00	41.2	160.7		58.5	143.3		31.7	170.2		62.0	140.0	
10/26/2010	178.20	2.93	41.4	160.5		58.6	143.2		33.0	168.9		61.9	140.1	
11/30/2010	178.80	1.14	42.6	159.3		58.8	143.0		34.4	167.5		62.4	139.6	
12/30/2010	193.90	9.95	42.4	159.5		55.4	146.4		33.8	168.1		59.5	142.5	
1/27/2011	194.00	0.86	41.5	160.4		55.4	146.4		30.4	171.5		60.0	142.0	
2/23/2011	193.80	1.02	42.4	159.5		55.5	146.4		28.9	173.0		59.7	142.3	
3/29/2011	193.90	2.38	41.3	160.6		54.9	146.9		28.1	173.8		59.5	142.5	
4/27/2011	193.60	0.56	42.3	159.6		55.3	146.5		27.6	174.3		59.8	142.2	
5/25/2011	193.10	0.51	41.4	160.5		55.2	146.6		27.9	174.0		59.8	142.2	
6/28/2011	192.00	0.00	42.3	159.6		55.3	146.5		28.2	173.7		59.7	142.3	

## Notes:

Elevations are in feet relative to NGVD29 datum;

Elev. = Elevation; ft = feet; in. = inches



**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-1A			P-1B			P-2A			P-2B		
Top Elevation (ft) →			201.9			201.8			201.9			202.0		
Tip Elevation (ft) →			159.3			132.9			153.9			123.8		
Depth (ft) →			42.6			68.9			48.0			78.2		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
7/27/2011	186.75	0.00	41.5	160.5		55.8	146.0		28.9	173.1		60.0	142.0	
8/25/2011	176.30	0.00	42.4	159.5		57.2	144.6		30.3	171.6		61.0	141.0	
9/28/2011	176.00	0.06	42.4	159.5		58.6	143.3		32.5	169.5		62.1	139.9	
10/25/2011	176.50	0.89	42.2	159.7		59.1	142.7		33.5	168.4		62.3	139.7	
11/22/2011	177.20	1.31	42.4	159.5		58.9	143.0		34.4	167.5		62.2	139.8	
12/22/2011	176.70	0.20	41.6	160.3		59.0	142.8		34.5	167.4		62.5	139.5	
1/25/2012	178.60	0.84	41.4	160.5		58.6	143.2		35.0	166.9		61.9	140.1	
2/28/2012	179.20	0.68	41.5	160.4		58.6	143.2		35.5	166.4		61.1	140.9	
3/27/2012	180.60	1.73	41.5	160.4		58.4	143.5		35.1	166.8		61.6	140.4	
6/27/2012	180.70	0.00	42.5	159.4		58.6	143.2		33.8	168.1		61.9	140.1	
7/26/2012	179.20	0.10	42.3	159.6		58.7	143.1		34.3	167.6		62.1	139.9	
8/8/2012	178.50	0.10	42.2	159.7		58.9	142.9		34.3	167.6		62.7	139.3	
8/28/2012	177.10	0.00	42.4	159.5		59.3	142.5		34.6	167.3		62.9	139.1	
8/29/2012	177.10	0.00	42.0	159.9		59.1	142.7		34.3	167.6		62.7	139.3	
9/25/2012	175.30	0.00	42.3	159.6		59.8	142.0		35.0	166.9		63.5	138.5	
10/30/2012	176.00	0.19	42.3	159.6		60.0	141.8		35.6	166.3		63.8	138.2	
11/27/2012	175.80	0.69	42.4	159.5		59.7	142.1		35.8	166.2		63.4	138.6	
12/12/2012	176.10	0.70	42.5	159.4		59.7	142.1		35.7	166.2		62.9	139.1	
1/22/2013	177.20	1.40	42.4	159.5		58.8	143.0		36.0	165.9		62.1	139.9	
2/27/2013	178.20	1.20	42.3	159.6		58.4	143.4		35.8	166.1		61.8	140.2	
3/28/2013	178.20	0.31	42.4	159.5		58.4	143.4		35.8	166.1		61.7	140.3	
4/25/2013	177.30	0.71	42.5	159.4		58.4	143.4		35.9	166.0		62.4	139.7	
5/22/2013	177.60	0.03	42.5	159.4		59.0	142.8		35.9	166.0		62.3	139.7	
6/25/2013	177.50	0.00	42.3	159.6		59.2	142.7		36.0	165.9		62.5	139.5	
7/23/2013	175.70	0.00	42.5	159.4		59.6	142.2		36.0	165.9		63.1	138.9	
8/21/2013	174.50	0.00	42.5	159.4		59.9	141.9		36.2	165.7		63.7	138.3	
9/25/2013	175.70	0.00	42.6	159.3		60.2	141.6		36.3	165.6		63.8	138.2	
10/29/2013	176.00	0.00	42.6	159.3		59.9	141.9		36.5	165.4		63.6	138.4	
11/27/2013	176.50	0.44	42.3	159.6		59.5	142.3		36.4	165.5		63.3	138.7	
12/19/2013	176.80	0.53	42.5	159.4		59.5	142.3		36.4	165.5		63.1	138.9	

## Notes:

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Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-1A			P-1B			P-2A			P-2B		
Top Elevation (ft) →			201.9			201.8			201.9			202.0		
Tip Elevation (ft) →			159.3			132.9			153.9			123.8		
Depth (ft) →			42.6			68.9			48.0			78.2		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
1/28/2014	176.80	0.00	42.5	159.4		59.1	142.7		36.5	165.4		62.7	139.3	
2/25/2014	176.70	0.72	42.3	159.6		59.0	142.8		36.6	165.3		62.5	139.5	
3/25/2014	178.50		42.5	159.4		58.5	143.3		36.5	165.4		62.0	140.0	
3/29/2014	178.40	1.44	42.5	159.4		58.6	143.2		36.6	165.3		62.0	140.0	
4/25/2014	177.40	0.74	42.4	159.5		58.8	143.0		36.3	165.6		62.2	139.8	
5/28/2014	176.40	0.00	42.5	159.4		59.4	142.4		36.3	165.6		62.9	139.1	
6/25/2014	176.10	0.00	42.5	159.4		60.0	141.8		36.5	165.4		63.6	138.4	
7/30/2014	177.30	0.00	42.5	159.4		60.1	141.7		36.4	165.5		63.7	138.4	
8/26/2014	176.10	0.03	42.5	159.4		60.2	141.6		36.3	165.6		63.8	138.2	
9/23/2014	175.90	0.00	42.3	159.6		60.3	141.5		36.5	165.4		64.2	137.9	
10/30/2014	176.30	0.00	42.2	159.7		60.1	141.7		36.6	165.3		64.0	138.0	
11/21/2014	176.20	0.25	42.2	159.7		59.9	141.9		36.7	165.2		63.9	138.1	
12/30/2014	178.90	3.37	42.3	159.6		58.8	143.0		36.7	165.2		62.5	139.5	
1/27/2015	179.60	0.89	42.3	159.6		58.3	143.5		36.2	165.7		62.2	139.9	
2/27/2015	180.00	0.46	42.3	159.6		58.3	143.5		35.8	166.1		62.0	140.0	
3/26/2015	179.60	0.45	42.3	159.6		58.2	143.6		35.7	166.2		62.1	139.9	
4/29/2015	178.20	0.24	42.2	159.7		58.7	143.1		35.5	166.4		62.7	139.3	
5/27/2015	179.00	1.04	42.2	159.7		58.6	143.2		35.8	166.1		62.6	139.4	
6/25/2015	179.60	0.00	42.2	159.7		58.5	143.3		35.6	166.3		62.3	139.7	
7/29/2015	178.10	0.00	42.3	159.6		58.9	142.9		35.5	166.4		63.1	138.9	
8/26/2015	176.20	0.00	42.2	159.7		59.2	142.6		35.4	166.5		63.3	138.7	
9/22/2015	178.20	1.64	42.2	159.7		58.9	142.9		35.8	166.1		62.8	139.2	
10/27/2015	176.90	0.10	42.3	159.6		59.0	142.8		35.8	166.1		63.0	139.0	
11/24/2015	176.30	0.17	42.2	159.7		59.2	142.6		36.0	165.9		63.1	138.9	
12/22/2015	177.60	0.72	42.3	159.7		58.9	143.0		36.1	165.8		62.9	139.1	
1/27/2016	180.10	2.86	42.6	159.3		58.2	143.6		36.5	165.4		61.9	140.1	
2/25/2016	181.60	0.20	42.2	159.7		57.8	144.0		35.6	166.3		61.8	140.2	
3/24/2016	184.80	1.48	42.3	159.6		57.7	144.1		34.1	167.8		61.3	140.7	
3/31/2016	184.50	1.51	42.2	159.7		57.7	144.1		35.0	166.9		61.8	140.2	
4/28/2016	183.60	0.04	42.2	159.7		57.8	144.0		34.3	167.7		62.1	139.9	
5/25/2016	182.50	0.13	42.2	159.7		58.0	143.8		34.2	167.7		62.2	139.8	
6/28/2016	180.70	0.00	42.9	159.0	Erroneous	59.2	142.6		33.3	168.6		63.3	138.7	

## Notes:

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Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-1A			P-1B			P-2A			P-2B		
Top Elevation (ft) →			201.9			201.8			201.9			202.0		
Tip Elevation (ft) →			159.3			132.9			153.9			123.8		
Depth (ft) →			42.6			68.9			48.0			78.2		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
7/27/2016	178.40	0.00	42.4	159.5		59.1	142.7		34.2	167.7		63.1	138.9	
8/24/2016	176.40	0.00	42.3	159.6		59.6	142.3		34.8	167.1		63.5	138.5	
9/27/2016	175.80	0.00	42.3	159.6		60.0	141.8		35.3	166.6		63.9	138.1	
10/26/2016	178.60	0.64	42.3	159.6		59.8	142.0		35.6	166.3		63.7	138.3	
11/22/2016	178.30	1.11	42.4	159.5		59.7	142.1		35.5	166.4		63.5	138.5	
12/28/2016	184.80	4.01	42.3	159.6		59.0	142.8		35.6	166.3		62.6	139.4	
1/25/2017	193.30	6.33	42.4	159.5		56.1	145.7		34.6	167.3		59.0	143.0	
2/28/2017	193.90	3.27	42.3	159.6		54.5	147.3		31.2	170.7		58.8	143.2	
3/29/2017	193.70	0.08	42.4	159.5		54.7	147.1		29.6	172.3		59.2	142.8	
4/27/2017	192.90	0.04	42.2	159.7		54.7	147.1		28.8	173.1		59.5	142.5	
5/23/2017	187.90	0.33	42.2	159.7		55.2	146.6		29.1	172.8		59.5	142.5	
6/21/2017	182.50	0.00	42.2	159.7		56.1	145.7		29.9	172.0		60.1	141.9	
7/26/2017	163.60	0.00	42.2	159.7		58.2	143.6		32.0	169.9		61.6	140.4	
8/30/2017	163.60	0.00	42.2	159.7		59.7	142.1		34.1	167.8		62.9	139.1	
9/28/2017	163.60	0.00	42.3	159.6		60.8	141.0		35.5	166.4		63.7	138.3	
10/26/2017	171.80	0.00	42.1	159.8		61.4	140.4		36.2	165.7		64.2	137.8	
11/29/2017	177.20	0.08	42.2	159.7		60.7	141.1		36.8	165.1		64.4	137.6	
12/27/2017	176.70	0.00	42.3	159.6	Dry	60.9	140.9		36.4	165.5		64.5	137.5	
1/24/2018	178.10	1.67	42.3	159.6	Dry	60.3	141.5		36.0	165.9		63.9	138.1	
2/21/2018	177.80	0.27	42.2	159.7		60.2	141.6		35.9	166.0		63.9	138.1	
3/28/2018	183.50	1.23	42.3	159.6	Wet	59.7	142.1		35.6	166.3		63.5	138.5	
4/27/2018	184.30	0.05	42.2	159.7		59.5	142.3		35.0	166.9		63.5	138.5	
5/30/2018	183.10	0.13	42.2	159.7		59.1	142.7		34.0	167.9		63.4	138.6	
6/28/2018	181.70	0.00	42.4	159.5		59.3	142.5		33.8	168.1		63.6	138.4	
7/26/2018	180.00	0.00	42.4	159.5		59.8	142.0		34.2	167.7		63.6	138.4	
8/28/2018	177.30	0.00	42.3	159.6		60.2	141.6		34.3	167.6		64.2	137.8	
9/27/2018	178.10	0.00	42.3	159.6		60.3	141.5		64.4	137.5	Erroneous	64.7	137.3	
10/24/2018	178.00	0.66	42.4	159.5		60.3	141.5		64.4	137.5	Erroneous	64.3	137.7	
11/29/2018	177.50	1.60	42.3	159.6		60.3	141.5		35.0	166.9		64.3	137.7	
12/20/2018	181.40	2.39	42.2	159.7		59.1	142.7		35.0	166.9		62.9	139.1	

## Notes:

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**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-3			P-4			P-5			P-6		
Top Elevation (ft) →			201.2			150.7			151.5			167.4		
Tip Elevation (ft) →			155.8			129.1			129.6			127.7		
Depth (ft) →			45.4			21.6			21.9			39.7		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
1/29/2009	182.20	0.39	27.1	174.1		10.9	139.8		9.1	142.4		24.0	143.4	
2/25/2009	185.70	3.10	25.1	176.1		10.8	139.9		9.1	142.4		23.5	143.9	
3/26/2009	188.40	0.10	23.3	177.9		10.8	139.9		9.2	142.3		23.4	144.0	
4/28/2009	189.30	0.00	22.4	178.8		10.9	139.8		9.1	142.4		23.1	144.3	
5/18/2009	188.50	0.00	22.8	178.4		10.9	139.8		9.2	142.3		23.2	144.2	
5/27/2009	188.10	0.00	23.0	178.2		10.9	139.8		9.2	142.3		23.2	144.2	
6/30/2009	188.60	0.10	22.8	178.4		11.0	139.7		9.0	142.5		23.7	143.7	
7/30/2009	184.80	0.00	24.7	176.5		11.0	139.7		9.1	142.4		23.4	144.0	
8/26/2009	176.60	0.00	29.2	172.0		11.1	139.6		9.1	142.4		24.2	143.2	
9/30/2009	174.50	0.00	32.1	169.1		11.3	139.4		9.2	142.3		25.3	142.1	
10/28/2009	175.30	0.29	31.8	169.4		11.5	139.2		8.3	143.2		25.6	141.8	
12/1/2009	176.40	0.00	31.5	169.7		11.9	138.8		9.5	142.0		25.7	141.7	
12/28/2009	178.80	2.75	29.9	171.3		11.3	139.4		9.5	142.0		24.9	142.5	
1/26/2010	191.30	4.15	22.8	178.4		9.9	140.8		9.2	142.3		23.8	143.6	
2/24/2010	193.60	2.29	20.3	180.9		9.8	140.9		7.9	143.6		22.0	145.4	
3/29/2010	193.50	1.18	19.7	181.5		8.5	142.2		8.2	143.3		22.0	145.4	
4/4/2010	193.50		19.8	181.4		8.7	142.0		8.2	143.3		22.1	145.3	
4/27/2010	193.90	1.66	19.5	181.7		8.9	141.8		7.8	143.7		22.0	145.4	
5/27/2010	192.90	0.03	19.9	181.3		9.2	141.5		7.8	143.7		22.0	145.4	
6/29/2010	191.60	0.00	20.6	180.6		9.5	141.2		7.7	143.8		22.0	145.4	
7/28/2010	187.50	0.00	22.6	178.6		9.8	140.9		7.8	143.7		22.4	145.0	
8/31/2010	179.20	0.00	27.9	173.3		10.2	140.5		8.0	143.5		23.6	143.8	
9/29/2010	175.60	0.00	31.2	170.0		10.6	140.1		8.1	143.4		24.9	142.5	
10/26/2010	178.20	2.93	30.5	170.7		10.8	139.9		9.7	141.8		24.9	142.5	
11/30/2010	178.80	1.14	30.2	171.0		11.6	139.1		8.3	143.2		25.0	142.4	
12/30/2010	193.90	9.95	20.4	180.8		8.6	142.1		5.9	145.6		22.0	145.4	
1/27/2011	194.00	0.86	20.0	181.2		9.3	141.4		6.2	145.4		22.0	145.4	
2/23/2011	193.80	1.02	20.0	181.3		9.5	141.2		5.9	145.6		22.0	145.4	
3/29/2011	193.90	2.38	19.6	181.6		8.9	141.8		6.7	144.8		21.7	145.7	
4/27/2011	193.60	0.56	19.7	181.5		9.0	141.7		7.0	144.5		22.0	145.4	
5/25/2011	193.10	0.51	20.2	181.0		9.2	141.5		7.0	144.5		21.9	145.5	
6/28/2011	192.00	0.00	20.7	180.5		9.3	141.4		7.2	144.3		22.0	145.4	

## Notes:

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Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-3			P-4			P-5			P-6		
Top Elevation (ft) →			201.2			150.7			151.5			167.4		
Tip Elevation (ft) →			155.8			129.1			129.6			127.7		
Depth (ft) →			45.4			21.6			21.9			39.7		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
7/27/2011	186.75	0.00	23.5	177.8		9.4	141.4		7.1	144.4		22.4	145.0	
8/25/2011	176.30	0.00	29.7	171.5		9.7	141.0		7.2	144.3		23.6	143.8	
9/28/2011	176.00	0.06	24.7	176.5	Erroneous	10.5	140.3		7.6	143.9		24.9	142.5	
10/25/2011	176.50	0.89	31.7	169.5		11.0	139.7		8.1	143.4		25.2	142.2	
11/22/2011	177.20	1.31	31.7	169.6		11.1	139.7		8.2	143.4		25.2	142.2	
12/22/2011	176.70	0.20	31.7	169.5		11.5	139.2		8.2	143.3		25.4	142.0	
1/25/2012	178.60	0.84	30.8	170.4		11.7	139.0		8.3	143.2		25.0	142.4	
2/28/2012	179.20	0.68	30.5	170.7		11.7	139.0		8.5	143.0		25.0	142.4	
3/27/2012	180.60	1.73	29.7	171.5		11.5	139.2		8.4	143.1		24.8	142.7	
6/27/2012	180.70	0.00	28.0	173.2		10.3	140.4		8.8	142.7		24.9	142.5	
7/26/2012	179.20	0.10	29.8	171.5		10.9	139.8		8.8	142.7		25.1	142.3	
8/8/2012	178.50	0.10	30.1	171.1		10.8	139.9		8.6	142.9		25.3	142.1	
8/28/2012	177.10	0.00	31.0	170.2		11.2	139.5		8.7	142.8		26.6	140.8	
8/29/2012	177.10	0.00	30.8	170.4		11.0	139.7		8.5	143.0		25.5	141.9	
9/25/2012	175.30	0.00	32.2	169.0		11.6	139.1		8.8	142.7		26.1	141.3	
10/30/2012	176.00	0.19	32.0	169.2		12.1	138.6		8.9	142.6		26.3	141.1	
11/27/2012	175.80	0.69	32.2	169.0		12.4	138.3		9.4	142.1		26.0	141.4	
12/12/2012	176.10	0.70	31.9	169.3		12.5	138.2		9.5	142.0		25.8	141.6	
1/22/2013	177.20	1.40	31.3	169.9		12.5	138.2		9.6	141.9		25.1	142.3	
2/27/2013	178.20	1.20	30.7	170.5		12.2	138.5		9.3	142.2		24.7	142.7	
3/28/2013	178.20	0.31	31.0	170.2		12.1	138.6		9.5	142.0		24.7	142.7	
4/25/2013	177.30	0.71	31.6	169.6		12.2	138.6		9.6	141.9		25.1	142.3	
5/22/2013	177.60	0.03	31.4	169.8		12.1	138.6		9.6	141.9		25.3	142.1	
6/25/2013	177.50	0.00	31.4	169.9		12.2	138.6		9.6	141.9		25.5	142.0	
7/23/2013	175.70	0.00	32.4	168.8		12.3	138.4		9.7	141.8		25.9	141.5	
8/21/2013	174.50	0.00	32.8	168.4		12.5	138.2		9.7	141.8		26.3	141.1	
9/25/2013	175.70	0.00	32.4	168.8		12.9	137.8		10.2	141.3		26.5	140.9	
10/29/2013	176.00	0.00	32.2	169.0		13.0	137.7		10.2	141.3		26.3	141.2	
11/27/2013	176.50	0.44	31.8	169.4		12.9	137.8		10.0	141.5		25.9	141.5	
12/19/2013	176.80	0.53	31.7	169.5		13.1	137.6		10.2	141.3		25.8	141.6	

## Notes:

Elevations are in feet relative to NGVD29 datum;

Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-3			P-4			P-5			P-6		
Top Elevation (ft) →			201.2			150.7			151.5			167.4		
Tip Elevation (ft) →			155.8			129.1			129.6			127.7		
Depth (ft) →			45.4			21.6			21.9			39.7		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
1/28/2014	176.80	0.00	32.0	169.2		13.0	137.7		10.3	141.2		25.5	141.9	
2/25/2014	176.70	0.72	32.2	169.0		12.8	137.9		10.3	141.2		25.4	142.1	
3/25/2014	178.50		30.9	170.3		8.1	142.6		10.2	141.3		24.9	142.5	
3/29/2014	178.40	1.44	31.1	170.1		8.2	142.5		10.3	141.2		24.9	142.5	
4/25/2014	177.40	0.74	31.5	169.7		8.9	141.8		10.2	141.3		25.0	142.4	
5/28/2014	176.40	0.00	32.4	168.8		9.7	141.0		10.3	141.3		25.7	141.7	
6/25/2014	176.10	0.00	32.2	169.0		10.3	140.4		10.2	141.3		26.3	141.1	
7/30/2014	177.30	0.00	31.6	169.6		10.7	140.1		10.2	141.3		26.4	141.0	
8/26/2014	176.10	0.03	32.1	169.1		11.0	139.7		10.2	141.3		26.4	141.0	
9/23/2014	175.90	0.00	32.0	169.2		11.4	139.3		10.3	141.2		26.7	140.8	
10/30/2014	176.30	0.00	32.1	169.1		11.9	138.8		10.5	141.0		26.5	140.9	
11/21/2014	176.20	0.25	31.8	169.4		12.1	138.6		10.5	141.0		26.2	141.2	
12/30/2014	178.90	3.37	30.3	170.9		11.9	138.8		10.5	141.0		25.2	142.2	
1/27/2015	179.60	0.89	29.9	171.3		11.9	138.8		10.5	141.1		24.8	142.6	
2/27/2015	180.00	0.46	29.7	171.5		11.9	138.8		10.5	141.0		24.6	142.8	
3/26/2015	179.60	0.45	30.0	171.2		11.9	138.8		10.4	141.1		24.5	142.9	
4/29/2015	178.20	0.24	30.8	170.4		11.9	138.8		10.6	140.9		24.9	142.5	
5/27/2015	179.00	1.04	30.8	170.4		12.0	138.7		10.4	141.1		24.9	142.5	
6/25/2015	179.60	0.00	29.8	171.4		12.0	138.7		10.3	141.2		25.0	142.4	
7/29/2015	178.10	0.00	30.8	170.4		12.3	138.4		10.4	141.1		25.3	142.1	
8/26/2015	176.20	0.00	31.9	169.3		12.3	138.4		10.4	141.1		25.6	141.8	
9/22/2015	178.20	1.64	31.0	170.2		9.3	141.4		10.5	141.0		25.3	142.1	
10/27/2015	176.90	0.10	31.4	169.8		9.9	140.8		10.5	141.0		25.3	142.1	
11/24/2015	176.30	0.17	32.5	168.7		10.4	140.3		10.6	140.9		25.7	141.7	
12/22/2015	177.60	0.72	31.2	170.0		10.7	140.0		10.5	141.0		25.2	142.2	
1/27/2016	180.10	2.86	30.2	171.0		10.2	140.5		10.5	141.0		24.5	142.9	
2/25/2016	181.60	0.20	29.2	172.0		10.6	140.1		9.9	141.6		24.2	143.2	
3/24/2016	184.80	1.48	27.6	173.6		10.1	140.6		9.8	141.7		24.0	143.4	
3/31/2016	184.50	1.51	27.6	173.6		10.2	140.5		9.8	141.7		24.1	143.3	
4/28/2016	183.60	0.04	27.8	173.4		10.4	140.3		9.8	141.7		24.3	143.1	
5/25/2016	182.50	0.13	28.4	172.8		10.6	140.1		9.8	141.7		24.4	143.0	
6/28/2016	180.70	0.00	29.3	171.9		11.0	139.7		9.9	141.6		24.9	142.5	

## Notes:

Elevations are in feet relative to NGVD29 datum;

Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-3			P-4			P-5			P-6		
Top Elevation (ft) →			201.2			150.7			151.5			167.4		
Tip Elevation (ft) →			155.8			129.1			129.6			127.7		
Depth (ft) →			45.4			21.6			21.9			39.7		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
7/27/2016	178.40	0.00	30.7	170.5		11.1	139.6		9.9	141.6		25.5	141.9	
8/24/2016	176.40	0.00	32.1	169.2		11.4	139.3		10.0	141.5		25.6	141.8	
9/27/2016	175.80	0.00	32.7	168.5		11.8	138.9		10.1	141.4		26.4	141.0	
10/26/2016	178.60	0.64	31.0	170.2		11.2	139.5		10.2	141.3		25.4	142.0	
11/22/2016	178.30	1.11	31.2	170.0		12.2	138.5		10.3	141.3		26.1	141.3	
12/28/2016	184.80	4.01	29.3	172.0		12.3	138.4		10.3	141.2		25.5	142.0	
1/25/2017	193.30	6.33	22.5	178.7		11.0	139.7		7.1	144.4		22.6	144.8	
2/28/2017	193.90	3.27	21.4	179.8		9.3	141.4		6.7	144.8		21.1	146.3	
3/29/2017	193.70	0.08	21.2	180.0		9.1	141.6		7.2	144.3		21.4	146.0	
4/27/2017	192.90	0.04	21.5	179.7		9.0	141.7		7.2	144.3		21.4	146.0	
5/23/2017	187.90	0.33	23.8	177.4		9.1	141.6		7.3	144.2		21.9	145.5	
6/21/2017	182.50	0.00	27.0	174.2		9.3	141.4		7.3	144.2		22.6	144.8	
7/26/2017	163.60	0.00	34.6	166.6		9.7	141.0		8.3	143.3		24.4	143.0	
8/30/2017	163.60	0.00	37.8	163.4		10.5	140.2		7.2	144.3		25.9	141.5	
9/28/2017	163.60	0.00	40.2	161.0		11.4	139.3		10.5	141.0		26.9	140.5	
10/26/2017	171.80	0.00	41.4	159.8		11.7	139.0		10.6	140.9		27.3	140.1	
11/29/2017	177.20	0.08	33.1	168.1		12.3	138.4		10.9	140.6		27.1	140.3	
12/27/2017	176.70	0.00	32.6	168.6		12.7	138.0		11.1	140.4		27.1	140.3	
1/24/2018	178.10	1.67	31.8	169.4		13.0	137.7		11.1	140.4		27.1	140.3	
2/21/2018	177.80	0.27	31.8	169.4		13.2	137.5		11.1	140.4		26.6	140.8	
3/28/2018	183.50	1.23	28.8	172.4		13.3	137.4		1.2	150.3	Erroneous	26.1	141.3	
4/27/2018	184.30	0.05	27.9	173.3		13.4	137.3		11.3	140.2		25.9	141.5	
5/30/2018	183.10	0.13	28.2	173.0		13.5	137.2		11.7	139.8		25.7	141.7	
6/28/2018	181.70	0.00	29.2	172.0		13.4	137.3		11.2	140.3		25.7	141.7	
7/26/2018	180.00	0.00	30.4	170.8		13.4	137.3		11.2	140.3		24.7	142.7	
8/28/2018	177.30	0.00	31.8	169.4		13.7	137.0		11.2	140.3		26.6	140.8	
9/27/2018	178.10	0.00	32.0	169.2		13.8	136.9		11.3	140.2		26.7	140.7	
10/24/2018	178.00	0.66	31.7	169.5		14.0	136.7		11.3	140.2		26.6	140.8	
11/29/2018	177.50	1.60	31.8	169.4		14.5	136.2		11.4	140.1		26.6	140.8	
12/20/2018	181.40	2.39	29.3	171.9		13.7	137.0		11.4	140.1		25.5	141.9	

## Notes:

Elevations are in feet relative to NGVD29 datum;

Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-7			P-8A			P-8B			P-9A		
Top Elevation (ft) →			169.2			202.3			202.2			184.0		
Tip Elevation (ft) →			152.7			164.3			144.5			160.4		
Depth (ft) →			16.5			38.0			57.7			23.6		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
1/29/2009	182.20	0.39	6.0	163.2		34.9	167.4		44.7	157.5		22.7	161.3	
2/25/2009	185.70	3.10	5.8	163.4		34.6	167.7		43.9	158.3		22.4	161.6	
3/26/2009	188.40	0.10	5.0	164.2		33.0	169.3		43.1	159.1		21.9	162.1	
4/28/2009	189.30	0.00	3.7	165.5		31.9	170.4		42.7	159.5		21.4	162.6	
5/18/2009	188.50	0.00	4.5	164.7		31.9	170.4		42.7	159.5		21.0	163.0	
5/27/2009	188.10	0.00	4.6	164.6		31.9	170.4		42.9	159.3		21.0	163.0	
6/30/2009	188.60	0.10	4.3	164.9		31.7	170.6		42.6	159.6		21.0	163.0	
7/30/2009	184.80	0.00	4.5	164.7		32.0	170.3		43.2	159.0		20.9	163.1	
8/26/2009	176.60	0.00	5.8	163.4		33.3	169.0		45.1	157.1		21.4	162.6	
9/30/2009	174.50	0.00	7.7	161.5		35.1	167.2		46.6	155.6		22.2	161.8	
10/28/2009	175.30	0.29	7.8	161.4		35.6	166.7		46.7	155.5		22.5	161.5	
12/1/2009	176.40	0.00	7.7	161.5		36.1	166.2		46.9	155.3		22.8	161.2	
12/28/2009	178.80	2.75	6.8	162.4		36.0	166.3		46.0	156.2		23.0	161.1	
1/26/2010	191.30	4.15	5.5	163.7		35.4	166.9		43.2	159.0		22.9	161.1	
2/24/2010	193.60	2.29	3.2	166.0		31.8	170.5		41.5	160.7		21.6	162.4	
3/29/2010	193.50	1.18	3.4	165.8		31.3	171.0		41.2	161.0		20.2	163.8	
4/4/2010	193.50		3.6	165.6		30.2	172.1		41.1	161.1		20.3	163.7	
4/27/2010	193.90	1.66	3.4	165.8		29.8	172.5		41.0	161.2		19.5	164.5	
5/27/2010	192.90	0.03	3.4	165.8		29.8	172.5		41.0	161.2		19.4	164.6	
6/29/2010	191.60	0.00	3.1	166.1		29.9	172.4		41.2	161.0		19.4	164.6	
7/28/2010	187.50	0.00	3.3	165.9		30.6	171.7		42.6	159.6		19.8	164.2	
8/31/2010	179.20	0.00	4.6	164.6		32.6	169.7		44.4	157.8		21.0	163.0	
9/29/2010	175.60	0.00	6.3	162.9		34.2	168.1		45.8	156.4		21.5	162.5	
10/26/2010	178.20	2.93	6.8	162.4		35.2	167.1		45.8	156.4		22.3	161.7	
11/30/2010	178.80	1.14	6.4	162.8		35.7	166.6		45.8	156.4		22.8	161.2	
12/30/2010	193.90	9.95	4.1	165.1		33.8	168.5		41.3	160.9		19.6	164.4	
1/27/2011	194.00	0.86	2.9	166.3		30.3	172.0		41.0	161.2		19.2	164.8	
2/23/2011	193.80	1.02	2.8	166.4		29.5	172.9		40.7	161.5		18.7	165.4	
3/29/2011	193.90	2.38	2.7	166.5		28.8	173.5		40.4	161.8		16.3	167.7	
4/27/2011	193.60	0.56	2.8	166.5		29.0	173.3		40.5	161.7		18.2	165.9	
5/25/2011	193.10	0.51	2.5	166.7		29.4	172.9		40.6	161.6		18.8	165.2	
6/28/2011	192.00	0.00	2.5	166.7		29.6	172.7		40.9	161.3		19.2	164.8	

## Notes:

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Elev. = Elevation; ft = feet; in. = inches



**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-7			P-8A			P-8B			P-9A		
Top Elevation (ft) →			169.2			202.3			202.2			184.0		
Tip Elevation (ft) →			152.7			164.3			144.5			160.4		
Depth (ft) →			16.5			38.0			57.7			23.6		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
7/27/2011	186.75	0.00	2.9	166.3		30.7	171.6		42.1	160.1		19.7	164.3	
8/25/2011	176.30	0.00	4.7	164.5		32.7	169.6		44.8	157.4		20.9	163.1	
9/28/2011	176.00	0.06	6.6	162.6		34.9	167.4		46.0	156.2		22.1	161.9	
10/25/2011	176.50	0.89	6.7	162.5		35.8	166.5		46.1	156.1		22.5	161.5	
11/22/2011	177.20	1.31	6.7	162.6		36.0	166.4		46.2	156.0		22.8	161.2	
12/22/2011	176.70	0.20	6.3	162.9		35.9	166.4		45.9	156.3		22.9	161.1	
1/25/2012	178.60	0.84	6.5	162.7		35.7	166.6		45.5	156.7		22.8	161.2	
2/28/2012	179.20	0.68	6.4	162.8		35.9	166.4		45.6	156.6		22.8	161.2	
3/27/2012	180.60	1.73	6.3	162.9		35.6	166.7		45.0	157.2		23.0	161.1	
6/27/2012	180.70	0.00	5.9	163.3		34.4	167.9		44.6	157.6		22.4	161.6	
7/26/2012	179.20	0.10	6.3	162.9		35.0	167.3		45.1	157.1		22.5	161.5	
8/8/2012	178.50	0.10	6.2	163.0		34.8	167.5		45.2	157.0		22.4	161.6	
8/28/2012	177.10	0.00	6.5	162.7		35.3	167.0		45.6	156.6		22.6	161.4	
8/29/2012	177.10	0.00	6.4	162.8		35.0	167.3		45.5	156.7		22.3	161.7	
9/25/2012	175.30	0.00	7.0	162.2		35.7	166.6		46.3	155.9		22.8	161.2	
10/30/2012	176.00	0.19	7.0	162.2		36.3	166.0		46.4	155.8		23.2	160.8	
11/27/2012	175.80	0.69	7.0	162.2		36.4	165.9		46.5	155.7		23.3	160.7	
12/12/2012	176.10	0.70	6.9	162.3		36.3	166.0		46.3	155.9		23.1	160.9	
1/22/2013	177.20	1.40	6.4	162.8		36.4	165.9		45.8	156.4		23.3	160.7	
2/27/2013	178.20	1.20	6.1	163.1		36.0	166.3		45.4	156.8		23.1	160.9	
3/28/2013	178.20	0.31	6.4	162.8		36.0	166.3		45.5	156.7		23.3	160.7	
4/25/2013	177.30	0.71	6.6	162.6		36.1	166.2		45.8	156.4		23.3	160.8	
5/22/2013	177.60	0.03	6.6	162.6		36.1	166.2		45.7	156.5		23.2	160.8	
6/25/2013	177.50	0.00	6.5	162.7		36.2	166.1		45.7	156.5		23.3	160.7	
7/23/2013	175.70	0.00	6.8	162.4		36.3	166.0		46.3	156.0		23.3	160.7	
8/21/2013	174.50	0.00	7.0	162.2		38.0	164.3	Wet	46.5	155.7		23.3	160.7	
9/25/2013	175.70	0.00	6.8	162.4		36.2	166.1		46.3	155.9		23.4	160.6	
10/29/2013	176.00	0.00	6.5	162.7		36.6	165.7		46.2	156.0		23.5	160.6	
11/27/2013	176.50	0.44	6.1	163.1		36.4	165.9		45.9	156.3		23.3	160.7	
12/19/2013	176.80	0.53	6.2	163.0		36.3	166.0		45.8	156.4		23.2	160.8	

## Notes:

Elevations are in feet relative to NGVD29 datum;

Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-7			P-8A			P-8B			P-9A		
Top Elevation (ft) →			169.2			202.3			202.2			184.0		
Tip Elevation (ft) →			152.7			164.3			144.5			160.4		
Depth (ft) →			16.5			38.0			57.7			23.6		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
1/28/2014	176.80	0.00	6.2	163.0		36.5	165.8		45.9	156.3		23.5	160.5	
2/25/2014	176.70	0.72	6.3	163.0		36.5	165.8		45.9	156.3		23.5	160.5	
3/25/2014	178.50		6.0	163.3		36.2	166.1		45.4	156.9		23.4	160.6	
3/29/2014	178.40	1.44	5.9	163.3		36.4	165.9		45.5	156.7		23.5	160.5	
4/25/2014	177.40	0.74	6.1	163.1		36.1	166.2		45.5	156.7		23.3	160.7	
5/28/2014	176.40	0.00	6.6	162.6		36.3	166.0		46.0	156.2		23.3	160.7	
6/25/2014	176.10	0.00	6.4	162.8		36.4	165.9		44.9	157.3		23.3	160.7	
7/30/2014	177.30	0.00	6.2	163.0		36.3	166.0		45.6	156.7		23.2	160.9	
8/26/2014	176.10	0.03	6.1	163.1		36.2	166.1		45.6	156.6		23.6	160.4	Dry
9/23/2014	175.90	0.00	6.0	163.2		36.4	166.0		45.7	156.5		23.3	160.8	
10/30/2014	176.30	0.00	5.9	163.3		36.3	166.0		45.8	156.4		23.3	160.7	
11/21/2014	176.20	0.25	5.8	163.4		36.3	166.0		45.5	156.7		23.2	160.8	
12/30/2014	178.90	3.37	5.3	163.9		36.0	166.3		44.9	157.3		23.1	160.9	
1/27/2015	179.60	0.89	5.2	164.0		35.8	166.5		44.6	157.6		23.2	160.9	
2/27/2015	180.00	0.46	5.2	164.0		35.2	167.1		44.3	157.9		22.8	161.2	
3/26/2015	179.60	0.45	5.3	163.9		35.3	167.0		44.4	157.8		22.8	161.2	
4/29/2015	178.20	0.24	5.6	163.6		35.3	167.0		44.8	157.4		22.6	161.4	
5/27/2015	179.00	1.04	5.8	163.4		35.7	166.6		45.0	157.2		22.9	161.1	
6/25/2015	179.60	0.00	5.2	164.0		35.2	167.1		44.5	157.7		23.0	161.0	
7/29/2015	178.10	0.00	5.4	163.8		35.3	167.0		44.8	157.4		22.6	161.4	
8/26/2015	176.20	0.00	5.6	163.6		35.6	166.7		45.2	157.0		22.7	161.3	
9/22/2015	178.20	1.64	5.6	163.6		35.8	166.5		44.9	157.3		22.9	161.1	
10/27/2015	176.90	0.10	5.4	163.8		35.8	166.5		45.0	157.2		22.5	161.5	
11/24/2015	176.30	0.17	5.6	163.6		35.8	166.5		45.3	156.9		23.2	160.8	
12/22/2015	177.60	0.72	5.5	163.7		35.8	166.5		44.9	157.3		22.9	161.1	VW installed
1/27/2016	180.10	2.86	5.3	163.9		36.0	166.3		44.7	157.5		23.5	160.5	
2/25/2016	181.60	0.20	5.0	164.2		34.9	167.4		43.8	158.4		23.5	160.5	
3/24/2016	184.80	1.48	4.8	164.4		34.5	167.8		43.3	158.9		23.4	160.6	
3/31/2016	184.50	1.51	4.7	164.5		34.4	167.9		43.1	159.1		23.3	160.7	
4/28/2016	183.60	0.04	4.8	164.4		33.8	168.5		43.2	159.0		23.2	160.8	
5/25/2016	182.50	0.13	4.7	164.5		34.1	168.2		43.6	158.6		22.9	161.1	
6/28/2016	180.70	0.00	4.8	164.4		34.3	168.0		43.9	158.3		23.1	160.9	

## Notes:

Elevations are in feet relative to NGVD29 datum;

Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-7			P-8A			P-8B			P-9A		
Top Elevation (ft) →			169.2			202.3			202.2			184.0		
Tip Elevation (ft) →			152.7			164.3			144.5			160.4		
Depth (ft) →			16.5			38.0			57.7			23.6		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
7/27/2016	178.40	0.00	5.1	164.1		34.6	167.7		44.6	157.6		23.2	160.8	
8/24/2016	176.40	0.00	5.7	163.5		35.3	167.0		45.1	157.1		23.4	160.6	
9/27/2016	175.80	0.00	6.1	163.1		35.8	166.5		45.5	156.7		23.5	160.5	
10/26/2016	178.60	0.64	5.3	163.9		35.8	166.5		44.8	157.4		23.6	160.4	
11/22/2016	178.30	1.11	5.6	163.7		35.7	166.6		44.8	157.4				VW not logging
12/28/2016	184.80	4.01	5.2	164.0		35.5	166.8		44.0	158.2		23.4	160.6	
1/25/2017	193.30	6.33	3.9	165.3		33.9	168.4		41.1	161.1		22.3	161.7	
2/28/2017	193.90	3.27	3.2	166.0		30.7	171.6		40.5	161.7		21.2	162.8	
3/29/2017	193.70	0.08	3.0	166.2		30.0	172.3		40.3	161.9		20.5	163.5	
4/27/2017	192.90	0.04	2.7	166.5		29.7	172.6		40.0	162.2		20.4	163.6	
5/23/2017	187.90	0.33	3.0	166.2		30.5	171.8		41.2	161.0		23.4	160.6	
6/21/2017	182.50	0.00	3.5	165.7		31.9	170.4		42.6	159.6		21.3	162.7	
7/26/2017	163.60	0.00	5.8	163.4		34.5	167.8		46.7	155.5		22.8	161.3	
8/30/2017	163.60	0.00	8.7	160.5		36.4	165.9		48.6	153.6		23.5	160.5	
9/28/2017	163.60	0.00	12.6	156.6		37.5	164.8		49.7	152.5		23.6	160.4	
10/26/2017	171.80	0.00	14.5	154.7		37.7	164.6		48.8	153.4		23.6	160.4	
11/29/2017	177.20	0.08	9.7	159.5		37.2	165.1		46.3	155.9		23.6	160.4	
12/27/2017	176.70	0.00	7.6	161.6		36.7	165.6		46.1	156.1		23.6	160.4	
1/24/2018	178.10	1.67	7.7	161.5		36.3	166.0		45.4	156.8		23.6	160.4	
2/21/2018	177.80	0.27	6.8	162.4		36.1	166.2		45.3	156.9		23.6	160.4	
3/28/2018	183.50	1.23	5.9	163.3		35.6	166.7		44.0	158.2		23.3	160.7	
4/27/2018	184.30	0.05	5.2	164.0		34.8	167.5		43.5	158.7		23.6	160.4	
5/30/2018	183.10	0.13	5.3	163.9		34.2	168.1		43.6	158.6		0.25	183.8	Erroneous
6/28/2018	181.70	0.00	5.7	163.5		34.2	168.1		44.0	158.2		23.3	160.7	
7/26/2018	180.00	0.00	6.0	163.2		34.5	167.8		44.4	157.8		23.9	160.1	Erroneous
8/28/2018	177.30	0.00	6.7	162.5		35.2	167.2		45.3	156.9		23.4	160.6	
9/27/2018	178.10	0.00	7.0	162.2		35.5	166.8		45.5	156.7		23.6	160.4	
10/24/2018	178.00	0.66	6.2	163.0		35.6	166.7		45.3	156.9		23.6	160.4	
11/29/2018	177.50	1.60	6.9	162.3		35.5	166.8		45.5	156.7		23.6	160.4	
12/20/2018	181.40	2.39	6.6	162.6		35.3	167.0		44.4	157.8		23.6	160.4	

## Notes:

Elevations are in feet relative to NGVD29 datum;

Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-9B			P-10A			P-10B			P-11		
Top Elevation (ft) →			184.2			183.4			183.7			165.6		
Tip Elevation (ft) →			151.7			148.0			136.1			155.4		
Depth (ft) →			32.5			35.4			47.6			10.2		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
1/29/2009	182.20	0.39	28.2	156.0		21.5	161.9		43.9	139.8		9.1	156.5	
2/25/2009	185.70	3.10	28.0	156.2		21.4	162.0		43.0	140.7		8.9	156.7	
3/26/2009	188.40	0.10	27.5	156.7		20.9	162.5		43.6	140.1		8.8	156.8	
4/28/2009	189.30	0.00	27.1	157.1		20.2	163.2		43.7	140.0		8.5	157.1	
5/18/2009	188.50	0.00	26.8	157.4		19.6	163.8		43.4	140.3		8.4	157.2	
5/27/2009	188.10	0.00	26.8	157.4		19.4	164.0		43.6	140.1		8.4	157.2	
6/30/2009	188.60	0.10	26.7	157.5		19.2	164.2		43.7	140.0		8.4	157.2	
7/30/2009	184.80	0.00	26.7	157.5		19.2	164.2		43.9	139.8		8.3	157.3	
8/26/2009	176.60	0.00	27.0	157.2		19.5	163.9		44.1	139.6		8.3	157.3	
9/30/2009	174.50	0.00	27.7	156.5		20.4	163.0		45.1	138.6		8.7	156.9	
10/28/2009	175.30	0.29	28.0	156.2		20.8	162.6		44.4	139.3		8.9	156.7	
12/1/2009	176.40	0.00	28.4	155.8		21.0	162.4		45.0	138.7		9.0	156.6	
12/28/2009	178.80	2.75	28.5	155.8		21.8	161.6		44.5	139.2		9.2	156.5	
1/26/2010	191.30	4.15	28.3	155.9		21.5	161.9		43.0	140.7		8.1	157.5	
2/24/2010	193.60	2.29	27.2	157.0		20.5	162.9		42.4	141.3		8.3	157.3	
3/29/2010	193.50	1.18	26.1	158.1		19.1	164.3		42.4	141.3		8.1	157.5	
4/4/2010	193.50		26.0	158.2		18.7	164.7		42.6	141.1		8.2	157.4	
4/27/2010	193.90	1.66	25.8	158.4		18.4	165.0		42.5	141.2		8.0	157.6	
5/27/2010	192.90	0.03	25.7	158.5		18.2	165.2		42.4	141.3		7.8	157.8	
6/29/2010	191.60	0.00	25.8	158.4		18.1	165.3		42.2	141.5		7.9	157.7	
7/28/2010	187.50	0.00	26.1	158.1		18.3	165.1		42.9	140.8		8.0	157.6	
8/31/2010	179.20	0.00	26.8	157.4		18.9	164.5		42.9	140.8		7.9	157.7	
9/29/2010	175.60	0.00	27.2	157.0		19.3	164.1		44.0	139.7		8.0	157.6	
10/26/2010	178.20	2.93	27.8	156.4		20.3	163.1		44.3	139.4		8.6	157.0	
11/30/2010	178.80	1.14	28.4	155.8		21.3	162.1		44.6	139.1		8.9	156.7	
12/30/2010	193.90	9.95	27.0	157.2		19.5	163.9		42.1	141.6		7.5	158.1	
1/27/2011	194.00	0.86	26.0	158.2		18.8	164.6		42.7	141.1		7.8	157.8	
2/23/2011	193.80	1.02	25.6	158.7		18.2	165.2		42.4	141.3		7.9	157.8	
3/29/2011	193.90	2.38	24.6	159.6		16.8	166.6		41.9	141.8		7.6	158.0	
4/27/2011	193.60	0.56	25.0	159.2		17.0	166.4		42.4	141.3		7.8	157.8	
5/25/2011	193.10	0.51	25.5	158.7		17.6	165.8		42.3	141.4		7.9	157.7	
6/28/2011	192.00	0.00	25.8	158.4		18.3	165.1		42.4	141.3		8.0	157.6	

## Notes:

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Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-9B			P-10A			P-10B			P-11		
Top Elevation (ft) →			184.2			183.4			183.7			165.6		
Tip Elevation (ft) →			151.7			148.0			136.1			155.4		
Depth (ft) →			32.5			35.4			47.6			10.2		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
7/27/2011	186.75	0.00	26.1	158.1		18.4	165.1		42.6	141.1		8.2	157.4	
8/25/2011	176.30	0.00	26.9	157.3		18.5	164.9		43.4	140.3		8.5	157.1	
9/28/2011	176.00	0.06	27.7	156.5		20.0	163.5		44.5	139.2		8.7	156.9	
10/25/2011	176.50	0.89	28.1	156.1		20.6	162.8		44.8	138.9		8.9	156.7	
11/22/2011	177.20	1.31	28.4	155.8		21.2	162.2		44.7	139.0		9.0	156.6	
12/22/2011	176.70	0.20	28.5	155.7		21.6	161.8		45.2	138.5		8.9	156.7	
1/25/2012	178.60	0.84	28.3	155.9		21.4	162.0		44.2	139.5		9.2	156.4	
2/28/2012	179.20	0.68	28.6	155.6		21.7	161.7		44.2	139.5		9.4	156.2	
3/27/2012	180.60	1.73	28.4	155.8		21.8	161.7		43.8	139.9		9.2	156.4	
6/27/2012	180.70	0.00	27.9	156.3		20.2	163.2		44.1	139.6		9.6	156.0	
7/26/2012	179.20	0.10	28.2	156.0		21.5	161.9		44.4	139.3		9.2	156.4	
8/8/2012	178.50	0.10	28.0	156.2		21.1	162.3		44.9	138.8		9.0	156.6	
8/28/2012	177.10	0.00	28.2	156.0		21.3	162.1		45.3	138.4		9.1	156.5	
8/29/2012	177.10	0.00	27.8	156.4		20.9	162.5		45.7	138.0		8.9	156.7	
9/25/2012	175.30	0.00	28.3	155.9		21.4	162.0		46.2	137.5		9.1	156.5	
10/30/2012	176.00	0.19	28.6	155.6		21.8	161.6		46.3	137.4		9.2	156.4	
11/27/2012	175.80	0.69	28.8	155.4		22.1	161.3		46.1	137.6		9.3	156.3	
12/12/2012	176.10	0.70	28.6	155.6		22.0	161.5		45.6	138.1		9.3	156.3	
1/22/2013	177.20	1.40	28.8	155.4		22.3	161.1		44.6	139.1		9.2	156.4	
2/27/2013	178.20	1.20	28.6	155.6		22.2	161.2		44.4	139.3		9.4	156.2	
3/28/2013	178.20	0.31	28.7	155.5		22.3	161.1		44.1	139.6		9.5	156.1	
4/25/2013	177.30	0.71	28.7	155.5		22.3	161.1		45.0	138.7		9.5	156.1	
5/22/2013	177.60	0.03	28.5	155.7		22.3	161.1		44.9	138.8		9.5	156.1	
6/25/2013	177.50	0.00	28.7	155.5		22.4	161.1		45.0	138.7		9.6	156.1	
7/23/2013	175.70	0.00	28.7	155.5		22.3	161.1		45.7	138.0		9.5	156.2	
8/21/2013	174.50	0.00	28.6	155.6		22.3	161.1		46.1	137.6		9.4	156.2	
9/25/2013	175.70	0.00	28.7	155.5		22.0	161.4		46.4	137.3		9.4	156.2	
10/29/2013	176.00	0.00	28.8	155.4		22.5	160.9		42.3	141.5	Erroneous	9.4	156.2	
11/27/2013	176.50	0.44	28.6	155.6		22.5	160.9		46.2	137.5		9.3	156.3	
12/19/2013	176.80	0.53	28.6	155.6		22.5	160.9		45.6	138.1		9.5	156.1	

## Notes:

Elevations are in feet relative to NGVD29 datum;

Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-9B			P-10A			P-10B			P-11		
Top Elevation (ft) →			184.2			183.4			183.7			165.6		
Tip Elevation (ft) →			151.7			148.0			136.1			155.4		
Depth (ft) →			32.5			35.4			47.6			10.2		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
1/28/2014	176.80	0.00	28.9	155.3		22.9	160.5		45.4	138.3		9.6	156.0	
2/25/2014	176.70	0.72	28.9	155.3		22.9	160.5		45.2	138.5		9.6	156.0	
3/25/2014	178.50		28.8	155.5		22.9	160.6		44.6	139.1		9.6	156.0	
3/29/2014	178.40	1.44	28.9	155.3		22.9	160.5		44.7	139.0		9.3	156.3	
4/25/2014	177.40	0.74	28.7	155.5		22.7	160.7		44.8	138.9		9.5	156.1	
5/28/2014	176.40	0.00	28.8	155.4		22.7	160.7		43.3	140.4		9.6	156.0	
6/25/2014	176.10	0.00	28.8	155.4		22.7	160.7		46.3	137.4		8.9	156.7	
7/30/2014	177.30	0.00	28.6	155.7		22.6	160.9		46.9	136.8		9.3	156.3	
8/26/2014	176.10	0.03	32.5	151.7	Dry; Erroneous	22.5	160.9		42.5	141.2	Erroneous	9.5	156.1	
9/23/2014	175.90	0.00	28.7	155.5		22.7	160.7		46.6	137.2		9.4	156.3	
10/30/2014	176.30	0.00	28.7	155.5		22.7	160.7		46.6	137.1		9.3	156.3	
11/21/2014	176.20	0.25	28.6	155.6		22.7	160.7		45.0	138.7		9.1	156.5	
12/30/2014	178.90	3.37	28.5	155.7		22.8	160.6		45.1	138.6		9.4	156.2	
1/27/2015	179.60	0.89	28.6	155.6		22.8	160.6		44.8	138.9		9.3	156.3	
2/27/2015	180.00	0.46	28.2	156.0		22.4	161.0		44.3	139.4		9.1	156.5	
3/26/2015	179.60	0.45	28.2	156.0		22.3	161.1		42.5	141.2	Erroneous	9.1	156.5	
4/29/2015	178.20	0.24	28.1	156.1		22.1	161.3		42.4	141.3	Erroneous	9.0	156.6	
5/27/2015	179.00	1.04	28.5	155.7		22.2	161.2		44.0	139.7		9.3	156.3	
6/25/2015	179.60	0.00	28.3	155.9		22.1	161.3		46.9	136.8	Dry	9.0	156.6	
7/29/2015	178.10	0.00	28.0	156.2		22.0	161.4		45.0	138.7		8.9	156.7	
8/26/2015	176.20	0.00	28.0	156.2		21.2	162.2		40.6	143.1	Erroneous	8.9	156.7	
9/22/2015	178.20	1.64	28.2	156.0		22.1	161.3		45.4	138.3		9.0	156.6	
10/27/2015	176.90	0.10	28.3	155.9		22.2	161.2		45.8	137.9		9.2	156.4	
11/24/2015	176.30	0.17	28.5	155.7		22.3	161.1		42.7	141.0	Erroneous	9.3	156.3	
12/22/2015	177.60	0.72	28.7	155.5	VW installed	22.7	160.7	VW installed	45.7	138.0	VW installed	9.3	156.3	VW installed
1/27/2016	180.10	2.86	29.4	154.8		24.7	158.7		45.7	138.0		10.1	155.5	
2/25/2016	181.60	0.20	29.3	154.9		24.6	158.9		46.5	137.2		10.1	155.5	
3/24/2016	184.80	1.48	29.1	155.1		24.3	159.1		46.3	137.4		10.1	155.5	
3/31/2016	184.50	1.51	29.1	155.1		24.3	159.1		46.5	137.2		10.1	155.5	
4/28/2016	183.60	0.04	28.9	155.3		24.0	159.4		46.9	136.8		10.2	155.4	
5/25/2016	182.50	0.13	28.8	155.4		23.7	159.7		46.8	136.9		9.8	155.8	
6/28/2016	180.70	0.00	28.9	155.3		23.6	159.8		47.1	136.6		9.9	155.7	

## Notes:

Elevations are in feet relative to NGVD29 datum;

Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-9B			P-10A			P-10B			P-11		
Top Elevation (ft) →			184.2			183.4			183.7			165.6		
Tip Elevation (ft) →			151.7			148.0			136.1			155.4		
Depth (ft) →			32.5			35.4			47.6			10.2		
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment
7/27/2016	178.40	0.00	29.0	155.2		23.6	159.8		47.5	136.2		9.9	155.7	
8/24/2016	176.40	0.00	29.1	155.1		23.6	159.8		47.6	136.1		9.8	155.8	
9/27/2016	175.80	0.00	29.4	154.8		23.9	159.5		47.6	136.1		10.0	155.6	
10/26/2016	178.60	0.64	29.5	154.7		24.1	159.3		47.6	136.1		10.0	155.6	
11/22/2016	178.30	1.11			VW not logging			VW not logging			VW not logging			VW not logging
12/28/2016	184.80	4.01	29.3	154.9		24.2	159.2		45.5	138.3		10.1	155.5	
1/25/2017	193.30	6.33	28.2	156.0		23.0	160.4		42.9	140.8		9.5	156.1	
2/28/2017	193.90	3.27	27.4	156.8		21.3	162.1		43.1	140.6		9.0	156.6	
3/29/2017	193.70	0.08	27.0	157.2		20.5	162.9		43.7	140.0		9.0	156.6	
4/27/2017	192.90	0.04	27.0	157.2		20.6	162.8		43.9	139.8		9.2	156.4	
5/23/2017	187.90	0.33	27.3	156.9		23.0	160.4	Erroneous	44.0	139.7		9.7	155.9	
6/21/2017	182.50	0.00	27.7	156.5		21.1	162.3		44.8	138.9		9.3	156.3	
7/26/2017	163.60	0.00	28.6	155.6		22.0	161.4		46.6	137.1		9.5	156.1	
8/30/2017	163.60	0.00	29.4	154.8		23.1	160.3		47.6	136.1		9.8	155.8	
9/28/2017	163.60	0.00	29.8	154.4		23.8	159.6		47.6	136.1		9.9	155.7	
10/26/2017	171.80	0.00	29.9	154.3		24.3	159.1		47.6	136.1		37.3	128.3	Erroneous
11/29/2017	177.20	0.08	30.0	154.2		24.7	158.7		47.6	136.1		10.2	155.4	
12/27/2017	176.70	0.00	29.8	154.4		24.7	158.7		47.6	136.1		10.2	155.4	
1/24/2018	178.10	1.67	29.8	154.4		24.7	158.7		47.6	136.1		10.2	155.4	
2/21/2018	177.80	0.27	29.8	154.4		24.7	158.7		47.6	136.1		10.2	155.4	
3/28/2018	183.50	1.23	29.7	154.5		24.6	158.8		47.6	136.1		10.2	155.4	
4/27/2018	184.30	0.05	29.4	154.8		24.4	159.0		47.6	136.1		10.2	155.4	
5/30/2018	183.10	0.13	29.2	155.0		24.4	159.0		47.6	136.1		10.2	155.4	
6/28/2018	181.70	0.00	29.0	155.2		23.6	159.8		47.6	136.1		28.2	137.4	Erroneous
7/26/2018	180.00	0.00	29.1	155.1		23.5	159.9		47.6	136.1		10.0	155.6	
8/28/2018	177.30	0.00	29.2	155.0		23.5	159.9		47.6	136.1		9.9	155.7	
9/27/2018	178.10	0.00	29.4	154.8		23.7	159.7		47.6	136.1		10.0	155.6	
10/24/2018	178.00	0.66	29.4	154.8		23.9	159.5		47.6	136.1		10.1	155.5	
11/29/2018	177.50	1.60	29.6	154.6		24.2	159.2		47.6	136.1		10.2	155.4	
12/20/2018	181.40	2.39	29.5	154.7		24.1	159.3		46.8	136.9		10.1	155.5	

## Notes:

Elevations are in feet relative to NGVD29 datum;

Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-12			P-13			Drain ID	
Top Elevation (ft) →			160.5			160.1				
Tip Elevation (ft) →			151.5			150.6				
Depth (ft) →			9.0			9.5				
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Left Subdrain (Gal/Min)	Right Subdrain (Gal/Min)
1/29/2009	182.20	0.39	8.6	151.9		8.5	151.6		0.68	0.00
2/25/2009	185.70	3.10	7.7	152.8		7.5	152.6		1.06	0.00
3/26/2009	188.40	0.10	8.5	152.0		8.5	151.6		1.59	0.00
4/28/2009	189.30	0.00	8.6	151.9		8.9	151.2		2.26	0.00
5/18/2009	188.50	0.00	7.8	152.7		9.0	151.1		2.18	0.00
5/27/2009	188.10	0.00	8.7	151.8	Dry	9.1	151.0		1.98	0.00
6/30/2009	188.60	0.10	7.8	152.7		8.6	151.5		2.98	0.00
7/30/2009	184.80	0.00	8.1	152.4		8.4	151.7		2.26	0.00
8/26/2009	176.60	0.00	8.0	152.5		8.1	152.0		0.63	0.00
9/30/2009	174.50	0.00	7.9	152.6		8.4	151.7		0.01	0.00
10/28/2009	175.30	0.29	8.0	152.5		8.5	151.6		0.00	0.00
12/1/2009	176.40	0.00	8.0	152.5		8.7	151.4		0.00	0.00
12/28/2009	178.80	2.75	8.2	152.3		8.6	151.5		0.21	0.00
1/26/2010	191.30	4.15	5.6	154.9		4.9	155.2		1.06	0.00
2/24/2010	193.60	2.29	7.1	153.4		6.7	153.4		2.88	0.00
3/29/2010	193.50	1.18	7.3	153.2		6.8	153.3		1.82	0.00
4/4/2010	193.50		7.5	153.0		7.0	153.1		2.54	0.00
4/27/2010	193.90	1.66	7.3	153.2		6.8	153.3		0.75	0.00
5/27/2010	192.90	0.03	7.4	153.1		7.5	152.6		3.17	0.00
6/29/2010	191.60	0.00	7.7	152.8		8.6	151.5		2.38	0.00
7/28/2010	187.50	0.00	7.5	153.0		7.1	153.0		1.59	0.00
8/31/2010	179.20	0.00	7.4	153.1		7.7	152.4		0.98	0.00
9/29/2010	175.60	0.00	7.3	153.2		7.3	152.8		0.13	0.00
10/26/2010	178.20	2.93	7.5	153.0	Dry; Erroneous	7.6	152.5		0.20	0.00
11/30/2010	178.80	1.14	8.0	152.5		8.6	151.5		0.32	0.00
12/30/2010	193.90	9.95	4.6	155.9		3.7	156.4		2.51	0.00
1/27/2011	194.00	0.86	6.4	154.2		5.9	154.2		2.25	0.00
2/23/2011	193.80	1.02	6.5	154.0		6.1	154.0		1.46	0.00
3/29/2011	193.90	2.38	4.8	155.7		3.8	156.3		0.87	0.00
4/27/2011	193.60	0.56	6.0	154.6		5.2	154.9		0.79	0.00
5/25/2011	193.10	0.51	6.8	153.7		6.2	153.9		0.79	0.00
6/28/2011	192.00	0.00	7.8	152.7		7.3	152.8		1.59	0.00

## Notes:

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**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-12			P-13			Drain ID	
Top Elevation (ft) →			160.5			160.1				
Tip Elevation (ft) →			151.5			150.6				
Depth (ft) →			9.0			9.5				
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Left Subdrain (Gal/Min)	Right Subdrain (Gal/Min)
7/27/2011	186.75	0.00	7.7	152.9		7.0	153.1		0.98	0.00
8/25/2011	176.30	0.00	7.7	152.8		7.8	152.3		0.69	0.00
9/28/2011	176.00	0.06	7.8	152.7		7.9	152.3		0.13	0.00
10/25/2011	176.50	0.89	7.9	152.6		8.3	151.8		0.26	0.00
11/22/2011	177.20	1.31	8.4	152.1		8.4	151.8		0.24	0.00
12/22/2011	176.70	0.20	8.7	151.8		8.5	151.6		0.30	0.00
1/25/2012	178.60	0.84	7.8	152.7		8.6	151.5		0.32	0.00
2/28/2012	179.20	0.68	8.0	152.5		8.6	151.5		0.40	0.00
3/27/2012	180.60	1.73	7.9	152.6		8.6	151.5		0.43	0.00
6/27/2012	180.70	0.00	8.9	151.6		9.4	150.7		0.13	0.00
7/26/2012	179.20	0.10	8.8	151.7		9.5	150.6		0.12	0.00
8/8/2012	178.50	0.10	8.9	151.6		8.6	151.5		0.32	0.00
8/28/2012	177.10	0.00	8.9	151.6		9.4	150.7		0.24	0.00
8/29/2012	177.10	0.00	9.2	151.3	Erroneous	8.6	151.5		0.18	0.00
9/25/2012	175.30	0.00	8.9	151.6		9.4	150.7		0.07	0.00
10/30/2012	176.00	0.19	8.9	151.6		9.3	150.8		0.12	0.00
11/27/2012	175.80	0.69	9.0	151.5		9.2	150.9		0.13	0.00
12/12/2012	176.10	0.70	9.0	151.6		9.0	151.1		0.13	0.00
1/22/2013	177.20	1.40	9.0	151.5		9.3	150.8		0.24	0.00
2/27/2013	178.20	1.20	8.9	151.6		9.2	150.9		0.14	0.00
3/28/2013	178.20	0.31	9.0	151.5		9.4	150.7		0.32	0.00
4/25/2013	177.30	0.71	9.0	151.5		9.4	150.7		0.34	0.00
5/22/2013	177.60	0.03	9.0	151.5		9.4	150.7		0.16	0.00
6/25/2013	177.50	0.00	8.9	151.6		9.2	150.9		0.23	0.00
7/23/2013	175.70	0.00	8.9	151.6	Dry	9.3	150.8	Dry	0.12	0.00
8/21/2013	174.50	0.00	9.0	151.5	Dry	9.5	150.6	Dry	0.10	0.00
9/25/2013	175.70	0.00	9.0	151.5	Dry	9.4	150.7	Dry	0.16	0.00
10/29/2013	176.00	0.00	9.0	151.5	Dry	9.4	150.7	Dry	0.22	0.00
11/27/2013	176.50	0.44	8.9	151.6	Wet	9.2	150.9	Wet	0.25	0.00
12/19/2013	176.80	0.53	9.0	151.5	Dry	9.4	150.7	Dry	0.40	0.00

## Notes:

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**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-12			P-13			Drain ID	
Top Elevation (ft) →			160.5			160.1				
Tip Elevation (ft) →			151.5			150.6				
Depth (ft) →			9.0			9.5				
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Left Subdrain (Gal/Min)	Right Subdrain (Gal/Min)
1/28/2014	176.80	0.00	9.0	151.5	Dry	9.4	150.7	Dry	0.37	0.00
2/25/2014	176.70	0.72	9.0	151.5	Dry	9.4	150.7	Dry	0.22	0.00
3/25/2014	178.50		9.0	151.5	Dry	9.4	150.7	Dry	0.25	0.00
3/29/2014	178.40	1.44	9.0	151.5	Dry	9.4	150.7	Dry	0.47	0.00
4/25/2014	177.40	0.74	9.0	151.5	Dry	9.5	150.6	Dry	0.32	0.00
5/28/2014	176.40	0.00	9.0	151.5	Dry	9.3	150.8	Dry	0.04	0.00
6/25/2014	176.10	0.00	9.0	151.5	Dry	9.5	150.6	Dry	0.21	0.00
7/30/2014	177.30	0.00	9.0	151.5	Dry	9.4	150.7	Dry	0.28	0.00
8/26/2014	176.10	0.03	9.0	151.5	Dry	9.4	150.7	Dry	0.29	0.00
9/23/2014	175.90	0.00	8.9	151.7	Dry	9.2	150.9	Dry	0.26	0.00
10/30/2014	176.30	0.00	8.0	152.5	Wet	8.5	151.6	Dry	0.29	0.00
11/21/2014	176.20	0.25	8.9	151.6	Dry	9.2	150.9	Dry	0.32	0.00
12/30/2014	178.90	3.37	8.8	151.7	Dry	9.2	150.9	Dry	0.42	0.00
1/27/2015	179.60	0.89	8.9	151.6	Dry	9.1	151.0	Wet	0.40	0.00
2/27/2015	180.00	0.46	8.9	151.6	Dry	9.1	151.0	Wet	0.52	0.00
3/26/2015	179.60	0.45	9.0	151.5	Dry	8.9	151.2		0.61	0.00
4/29/2015	178.20	0.24	8.9	151.6	Dry	9.2	150.9	Dry	0.55	0.00
5/27/2015	179.00	1.04	8.9	151.6	Dry	9.3	150.8	Dry	0.48	0.00
6/25/2015	179.60	0.00	8.9	151.6	Dry	9.3	150.8	Dry	0.44	0.00
7/29/2015	178.10	0.00	8.9	151.6	Wet	9.3	150.8	Wet	0.55	0.00
8/26/2015	176.20	0.00	8.9	151.6	Dry	9.3	150.8	Dry	0.13	0.00
9/22/2015	178.20	1.64	8.9	151.6	Dry	9.3	150.8	Dry	0.61	0.00
10/27/2015	176.90	0.10	8.9	151.6	Dry	9.3	150.8	Dry	0.42	0.00
11/24/2015	176.30	0.17	9.0	151.5	Dry	9.3	150.8	Dry	0.40	0.00
12/22/2015	177.60	0.72	9.0	151.5	Dry; VW installed	8.4	151.7	VW installed	0.41	0.00
1/27/2016	180.10	2.86	8.9	151.6		9.4	150.7		0.37	0.00
2/25/2016	181.60	0.20	9.0	151.5	Dry	9.5	150.6	Dry	0.57	0.00
3/24/2016	184.80	1.48	8.9	151.6		9.5	150.6		0.60	0.00
3/31/2016	184.50	1.51	8.9	151.6		9.5	150.6		2.03	0.00
4/28/2016	183.60	0.04	9.0	151.5		9.5	150.6		1.76	0.00
5/25/2016	182.50	0.13	9.0	151.5		9.5	150.6		1.61	0.00
6/28/2016	180.70	0.00	9.0	151.5		9.5	150.6		1.11	0.00

## Notes:

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Elev. = Elevation; ft = feet; in. = inches

**TABLE 1**  
**SAND CANYON DAM**  
**PIEZOMETER AND SUBDRAIN MEASUREMENTS**  
**JANUARY 2009 THROUGH DECEMBER 2018**

Piezometer No. →			P-12			P-13			Drain ID	
Top Elevation (ft) →			160.5			160.1				
Tip Elevation (ft) →			151.5			150.6				
Depth (ft) →			9.0			9.5				
Date	Reservoir Elevation (ft)	Rainfall (in.)	Reading (ft)	Elev. (ft)	Comment	Reading (ft)	Elev. (ft)	Comment	Left Subdrain (Gal/Min)	Right Subdrain (Gal/Min)
7/27/2016	178.40	0.00	9.0	151.5		9.5	150.6		1.02	0.00
8/24/2016	176.40	0.00	9.0	151.5		9.5	150.6		0.61	0.00
9/27/2016	175.80	0.00	9.0	151.5		9.5	150.6		0.40	0.00
10/26/2016	178.60	0.64	9.0	151.5		9.5	150.6		0.88	0.00
11/22/2016	178.30	1.11			VW not logging			VW not logging	0.92	0.00
12/28/2016	184.80	4.01	9.0	151.5		9.5	150.6		1.36	0.00
1/25/2017	193.30	6.33	4.7	155.8		7.7	152.4		2.01	0.00
2/28/2017	193.90	3.27	3.8	156.7		6.5	153.6		1.72	0.00
3/29/2017	193.70	0.08	4.9	155.6		7.7	152.4		1.66	0.00
4/27/2017	192.90	0.04	5.5	155.0		8.2	151.9		2.77	0.00
5/23/2017	187.90	0.33	9.0	151.5		9.0	151.1		3.29	0.00
6/21/2017	182.50	0.00	8.9	151.6		8.6	151.5		2.06	0.00
7/26/2017	163.60	0.00	8.8	151.7		8.5	151.6		0.26	0.00
8/30/2017	163.60	0.00	8.4	152.1		9.2	150.9		0.00	0.00
9/28/2017	163.60	0.00	9.0	151.5		9.5	150.6		0.00	0.00
10/26/2017	171.80	0.00	9.0	151.5		9.5	150.6		0.00	0.00
11/29/2017	177.20	0.08	9.0	151.5		9.5	150.6		0.00	0.00
12/27/2017	176.70	0.00	9.0	151.5		9.5	150.6		0.00	0.00
1/24/2018	178.10	1.67	9.0	151.5		9.5	150.6		0.02	0.00
2/21/2018	177.80	0.27	9.0	151.5		9.5	150.6		0.00	0.00
3/28/2018	183.50	1.23	9.0	151.5		9.5	150.6		0.14	0.00
4/27/2018	184.30	0.05	9.0	151.5		9.5	150.6		0.29	0.00
5/30/2018	183.10	0.13	9.0	151.5		9.5	150.6		0.22	0.00
6/28/2018	181.70	0.00	9.0	151.5		9.5	150.6		0.15	0.00
7/26/2018	180.00	0.00	9.0	151.5		9.5	150.6		0.03	0.00
8/28/2018	177.30	0.00	9.0	151.5		9.5	150.6		0.00	0.00
9/27/2018	178.10	0.00	9.0	151.5		9.5	150.6		0.00	0.00
10/24/2018	178.00	0.66	9.0	151.5		9.5	150.6		0.00	0.00
11/29/2018	177.50	1.60	9.0	151.5		9.5	150.6		0.00	0.00
12/20/2018	181.40	2.39	9.0	151.5		9.5	150.6		0.08	0.00

## Notes:

Elevations are in feet relative to NGVD29 datum;

Elev. = Elevation; ft = feet; in. = inches

**TABLE 2**  
**SAND CANYON DAM**  
**HORIZONTAL OFFSET OF SURVEY MONUMENTS RELATIVE TO ORIGINAL BASELINE**  
**1975 THROUGH 2018**

Monument ID →		S-1		S-2		S-3		S-4		S-6		S-5		Comment
Approx. Station →		8+00.234		6+00.212		4+00.125		2+00.191		0+61.430		0+00.079		
Year	Date	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	
1975	9/15/1975	0.050	0.600	0.060	0.720	0.050	0.600	0.040	0.480			0.000	0.000	Initial Reading for S-1 to S-5
1976														Data were not found
1977														Data were not found
1978														Data were not found
1979														Data were not found
1980														Data were not found
1981	12/15/1981	0.070	0.840	0.080	0.960	0.080	0.960	0.040	0.480			0.100	1.200	
1982	6/15/1982	0.030	0.360	0.070	0.840	0.100	1.200	0.080	0.960			0.050	0.600	
1983														Data were not found
1984														Data were not found
1985	10/20/1985	0.070	0.840	0.090	1.080	0.120	1.440	0.130	1.560			0.060	0.720	
1986														Data were not found
1987	10/20/1987	0.080	0.960	0.120	1.440	0.110	1.320	0.110	1.320	0.150	1.800	0.060	0.720	Initial Reading for S-6
1988														Data were not found
1989														Data were not found
1990														Data were not found
1991														Data were not found
1992														Data were not found
1993														Data were not found
1994														Data were not found
1995	5/8/1995	0.060	0.720	0.080	0.960	0.130	1.560	0.120	1.440	0.120	1.440	0.040	0.480	
1996	5/1/1996	0.080	0.960	0.100	1.200	0.120	1.440	0.120	1.440	0.150	1.800	0.050	0.600	
1997	5/28/1997	0.070	0.840	0.080	0.960	0.100	1.200	0.100	1.200	0.130	1.560	0.050	0.600	
1998	5/11/1998	0.070	0.840	0.080	0.960	0.100	1.200	0.100	1.200	0.120	1.440	0.010	0.120	
1999	4/26/1999	0.070	0.840	0.090	1.080	0.100	1.200	0.095	1.140	0.115	1.380	0.015	0.180	
2000	6/29/2000	0.075	0.900	0.090	1.080	0.105	1.260	0.095	1.140	0.120	1.440	0.015	0.180	
2001	5/2/2001	0.075	0.900	0.090	1.080	0.100	1.200	0.095	1.140	0.110	1.320	0.020	0.240	
2002	5/21/2002	0.070	0.840	0.090	1.080	0.120	1.440	0.100	1.200	0.105	1.260	0.020	0.240	
2003	5/21/2003	0.075	0.900	0.095	1.140	0.115	1.380	0.100	1.200	0.110	1.320	0.015	0.180	
2004	5/18/2004	0.070	0.840	0.100	1.200	0.120	1.440	0.100	1.200	0.115	1.380	0.020	0.240	
2005	5/31/2005	0.070	0.840	0.100	1.200	0.105	1.260	0.100	1.200	0.115	1.380	0.020	0.240	
2006	5/31/2006	0.070	0.840	0.095	1.140	0.110	1.320	0.100	1.200	0.115	1.380	0.010	0.120	
2007	5/15/2007	0.080	0.960	0.085	1.020	0.105	1.260	0.090	1.080	0.105	1.260	0.020	0.240	
2008	5/27/2008	0.080	0.960	0.085	1.020	0.105	1.260	0.100	1.200	0.120	1.440	0.020	0.240	
2009	6/9/2009	0.065	0.780	0.085	1.020	0.095	1.140	0.100	1.200	0.120	1.440	0.020	0.240	
2010	5/24/2010	0.060	0.720	0.080	0.960	0.110	1.320	0.090	1.080	0.105	1.260	0.020	0.240	

Note:

(1) Positive values represent downstream offset (North).

**TABLE 2**  
**SAND CANYON DAM**  
**HORIZONTAL OFFSET OF SURVEY MONUMENTS RELATIVE TO ORIGINAL BASELINE**  
**1975 THROUGH 2018**

Monument ID →		S-1		S-2		S-3		S-4		S-6		S-5		Comment
Approx. Station →		8+00.234		6+00.212		4+00.125		2+00.191		0+61.430		0+00.079		
Year	Date	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	
2011	5/18/2011	0.065	0.780	0.080	0.960	0.110	1.320	0.110	1.320	0.120	1.440	0.020	0.240	
2012	5/18/2012	0.065	0.780	0.085	1.020	0.110	1.320	0.105	1.260	0.120	1.440	0.020	0.240	
2013	6/6/2013	0.065	0.780	0.105	1.260	0.100	1.200	0.100	1.200	0.115	1.380	0.015	0.180	
2014	4/25/2014	0.095	1.140	0.100	1.200	0.130	1.560	0.100	1.200	0.120	1.440	0.015	0.180	
2015	6/4/2015	0.080	0.960	0.080	0.960	0.115	1.380	0.105	1.260	0.115	1.380	0.020	0.240	
2016	7/25/2016	0.080	0.960	0.085	1.020	0.115	1.380	0.110	1.320	0.125	1.500	0.015	0.180	
2017														No survey was done in 2017
2018	5/31/2018	0.080	0.960	0.090	1.080	0.115	1.380	0.105	1.260	0.125	1.500	0.025	0.300	

Note:

(1) Positive values represent downstream offset (North).

**TABLE 3**  
**SAND CANYON DAM**  
**NET HORIZONTAL DISPLACEMENT OF SURVEY MONUMENTS**  
**1975 THROUGH 2018**

Monument ID →		S-1		S-2		S-3		S-4		S-6		S-5		Comment
Approx. Station →		8+00.234		6+00.212		4+00.125		2+00.191		0+61.430		0+00.079		
Year	Date	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	
1975	9/15/1975	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			0.000	0.000	Initial Reading for S-1 to S-5
1976														Data were not found
1977														Data were not found
1978														Data were not found
1979														Data were not found
1980														Data were not found
1981	12/15/1981	0.020	0.240	0.020	0.240	0.030	0.360	0.000	0.000			0.100	1.200	
1982	6/15/1982	-0.020	-0.240	0.010	0.120	0.050	0.600	0.040	0.480			0.050	0.600	
1983														Data were not found
1984														Data were not found
1985	10/20/1985	0.020	0.240	0.030	0.360	0.070	0.840	0.090	1.080			0.060	0.720	
1986									0.000					Data were not found
1987	10/20/1987	0.030	0.360	0.060	0.720	0.060	0.720	0.070	0.840	0.000	0.000	0.060	0.720	Initial Reading for S-6
1988														Data were not found
1989														Data were not found
1990														Data were not found
1991														Data were not found
1992														Data were not found
1993														Data were not found
1994														Data were not found
1995	5/8/1995	0.010	0.120	0.020	0.240	0.080	0.960	0.080	0.960	-0.030	-0.360	0.040	0.480	
1996	5/1/1996	0.030	0.360	0.040	0.480	0.070	0.840	0.080	0.960	0.000	0.000	0.050	0.600	
1997	5/28/1997	0.020	0.240	0.020	0.240	0.050	0.600	0.060	0.720	-0.020	-0.240	0.050	0.600	
1998	5/11/1998	0.020	0.240	0.020	0.240	0.050	0.600	0.060	0.720	-0.030	-0.360	0.010	0.120	
1999	4/26/1999	0.020	0.240	0.030	0.360	0.050	0.600	0.055	0.660	-0.035	-0.420	0.015	0.180	
2000	6/29/2000	0.025	0.300	0.030	0.360	0.055	0.660	0.055	0.660	-0.030	-0.360	0.015	0.180	
2001	5/2/2001	0.025	0.300	0.030	0.360	0.050	0.600	0.055	0.660	-0.040	-0.480	0.020	0.240	
2002	5/21/2002	0.020	0.240	0.030	0.360	0.070	0.840	0.060	0.720	-0.045	-0.540	0.020	0.240	
2003	5/21/2003	0.025	0.300	0.035	0.420	0.065	0.780	0.060	0.720	-0.040	-0.480	0.015	0.180	
2004	5/18/2004	0.020	0.240	0.040	0.480	0.070	0.840	0.060	0.720	-0.035	-0.420	0.020	0.240	
2005	5/31/2005	0.020	0.240	0.040	0.480	0.055	0.660	0.060	0.720	-0.035	-0.420	0.020	0.240	
2006	5/31/2006	0.020	0.240	0.035	0.420	0.060	0.720	0.060	0.720	-0.035	-0.420	0.010	0.120	
2007	5/15/2007	0.030	0.360	0.025	0.300	0.055	0.660	0.050	0.600	-0.045	-0.540	0.020	0.240	
2008	5/27/2008	0.030	0.360	0.025	0.300	0.055	0.660	0.060	0.720	-0.030	-0.360	0.020	0.240	
2009	6/9/2009	0.015	0.180	0.025	0.300	0.045	0.540	0.060	0.720	-0.030	-0.360	0.020	0.240	
2010	5/24/2010	0.010	0.120	0.020	0.240	0.060	0.720	0.050	0.600	-0.045	-0.540	0.020	0.240	

Notes:

(1) Positive values represent downstream displacement (North).

(2) Negative values represent upstream displacement (South).

**TABLE 3**  
**SAND CANYON DAM**  
**NET HORIZONTAL DISPLACEMENT OF SURVEY MONUMENTS**  
**1975 THROUGH 2018**

Monument ID →		S-1		S-2		S-3		S-4		S-6		S-5		Comment
Approx. Station →		8+00.234		6+00.212		4+00.125		2+00.191		0+61.430		0+00.079		
Year	Date	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	
2011	5/18/2011	0.015	0.180	0.020	0.240	0.060	0.720	0.070	0.840	-0.030	-0.360	0.020	0.240	
2012	5/18/2012	0.015	0.180	0.025	0.300	0.060	0.720	0.065	0.780	-0.030	-0.360	0.020	0.240	
2013	6/6/2013	0.015	0.180	0.015	0.180	0.055	0.660	0.060	0.720	-0.035	-0.420	0.015	0.180	
2014	4/25/2014	0.045	0.540	0.040	0.480	0.080	0.960	0.060	0.720	-0.030	-0.360	0.015	0.180	
2015	6/4/2015	0.030	0.360	0.020	0.240	0.065	0.780	0.065	0.780	-0.035	-0.420	0.020	0.240	
2016	7/25/2016	0.030	0.360	0.025	0.300	0.065	0.780	0.070	0.840	-0.025	-0.300	0.015	0.180	
2017														No survey was done in 2017
2018	5/31/2018	0.030	0.360	0.030	0.360	0.065	0.780	0.065	0.780	-0.025	-0.300	0.025	0.300	

## Notes:

- (1) Positive values represent downstream displacement (North).  
(2) Negative values represent upstream displacement (South).

**TABLE 4**  
**SAND CANYON DAM**  
**ELEVATIONS OF SURVEY MONUMENTS**  
**1975 THROUGH 2018**

Monument ID →		S-1	S-2	S-3	S-4	S-6	S-5	
Approx. Station →		8+00.234	6+00.212	4+00.125	2+00.191	0+61.430	0+00.079	
Year	Date	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	Comment
1975	9/15/1975	200.727	200.956	200.534	200.430		200.570	Initial Reading for S-1 to S-5
1976								Data were not found
1977								Data were not found
1978								Data were not found
1979								Data were not found
1980								Data were not found
1981	12/15/1981	200.750	201.970	200.540	200.630		200.570	
1982	6/15/1982	200.800	201.010	200.570	200.660		200.610	
1983								Data were not found
1984								Data were not found
1985	10/20/1985	200.740	200.960	200.540	200.600		200.550	
1986								Data were not found
1987	10/20/1987	200.790		200.550	200.630	200.760	200.550	Initial Reading for S-6
1988								Data were not found
1989								Data were not found
1990								Data were not found
1991								Data were not found
1992								Data were not found
1993								Data were not found
1994								Data were not found
1995	5/8/1995	200.840	201.060	200.610	200.680	200.830	200.660	
1996	5/1/1996	200.840	201.060	200.610	200.690	200.840	200.670	
1997	5/28/1997	200.850	201.070	200.610	200.700	200.810	200.680	
1998	5/11/1998	200.850	201.060	200.600	200.680	200.780	200.660	
1999	4/26/1999	200.847	201.057	200.592	200.677	200.772	200.657	
2000	6/29/2000	200.847	201.057	200.597	200.682	200.777	200.667	
2001	5/2/2001	200.847	201.057	200.602	200.692	200.787	200.672	
2002	5/21/2002	200.852	201.057	200.597	200.682	200.782	200.672	
2003	5/21/2003	200.852	201.062	200.602	200.687	200.787	200.677	
2004	5/18/2004	200.852	201.062	200.602	200.687	200.787	200.677	
2005	5/31/2005	200.852	201.062	200.602	200.682	200.782	200.672	
2006	5/31/2006	200.857	201.062	200.597	200.682	200.782	200.672	
2007	5/15/2007	200.847	201.060	200.597	200.680	200.778	200.671	
2008	5/27/2008	200.850	201.054	200.591	200.673	200.774	200.668	
2009	6/9/2009	200.847	201.067	200.607	200.687	200.787	200.682	
2010	5/24/2010	200.847	201.052	200.587	200.672	200.772	200.667	

Note:

(1) Elevations are in feet relative to NGVD29 datum.

IRVINE RANCH WATER DISTRICT



**TABLE 4**  
**SAND CANYON DAM**  
**ELEVATIONS OF SURVEY MONUMENTS**  
**1975 THROUGH 2018**

Monument ID →		S-1	S-2	S-3	S-4	S-6	S-5	
Approx. Station →		8+00.234	6+00.212	4+00.125	2+00.191	0+61.430	0+00.079	
Year	Date	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	Comment
2011	5/18/2011	200.847	201.052	200.592	200.677	200.777	200.672	
2012	5/18/2012	200.847	201.057	200.592	200.677	200.777	200.672	
2013	6/6/2013	200.847	201.057	200.587	200.672	200.777	200.672	
2014	4/25/2014	200.847	201.062	200.597	200.682	200.787	200.682	
2015	6/4/2015	200.847	201.057	200.587	200.677	200.777	200.672	
2016	7/25/2016	200.842	201.047	200.582	200.672	200.772	200.667	
2017								No survey was done in 2017
2018	5/31/2018	200.847	201.057	200.592	200.682	200.787	200.682	

Note:  
(1) Elevations are in feet relative to NGVD29 datum.

**TABLE 5**  
**SAND CANYON DAM**  
**NET VERTICAL MOVEMENT OF SURVEY MONUMENTS**  
**1975 THROUGH 2018**

Monument ID →		S-1		S-2		S-3		S-4		S-6		S-5		Comment
Approx. Station →		8+00.234		6+00.212		4+00.125		2+00.191		0+61.430		0+00.079		
Year	Date	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	
1975	9/15/1975	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			0.000	0.000	Initial Reading for S-1 to S-5
1976														Data were not found
1977														Data were not found
1978														Data were not found
1979														Data were not found
1980														Data were not found
1981	12/15/1981	-0.023	-0.276	-1.014	-12.168	-0.006	-0.072	-0.200	-2.400			0.000	0.000	
1982	6/15/1982	-0.073	-0.876	-0.054	-0.648	-0.036	-0.432	-0.230	-2.760			-0.040	-0.480	
1983														Data were not found
1984														Data were not found
1985	10/20/1985	-0.013	-0.156	-0.004	-0.048	-0.006	-0.072	-0.170	-2.040			0.020	0.240	
1986														Data were not found
1987	10/20/1987	-0.063	-0.756		0.000	-0.016	-0.192	-0.200	-2.400	0.000	0.000	0.020	0.240	Initial Reading for S-6
1988														Data were not found
1989														Data were not found
1990														Data were not found
1991														Data were not found
1992														Data were not found
1993														Data were not found
1994														Data were not found
1995	5/8/1995	-0.113	-1.356	-0.104	-1.248	-0.076	-0.912	-0.250	-3.000	-0.070	-0.840	-0.090	-1.080	
1996	5/1/1996	-0.113	-1.356	-0.104	-1.248	-0.076	-0.912	-0.260	-3.120	-0.080	-0.960	-0.100	-1.200	
1997	5/28/1997	-0.123	-1.476	-0.114	-1.368	-0.076	-0.912	-0.270	-3.240	-0.050	-0.600	-0.110	-1.320	
1998	5/11/1998	-0.123	-1.476	-0.104	-1.248	-0.066	-0.792	-0.250	-3.000	-0.020	-0.240	-0.090	-1.080	
1999	4/26/1999	-0.120	-1.440	-0.101	-1.212	-0.058	-0.696	-0.247	-2.964	-0.012	-0.144	-0.087	-1.044	
2000	6/29/2000	-0.120	-1.440	-0.101	-1.212	-0.063	-0.756	-0.252	-3.024	-0.017	-0.204	-0.097	-1.164	
2001	5/2/2001	-0.120	-1.440	-0.101	-1.212	-0.068	-0.816	-0.262	-3.144	-0.027	-0.324	-0.102	-1.224	
2002	5/21/2002	-0.125	-1.500	-0.101	-1.212	-0.063	-0.756	-0.252	-3.024	-0.022	-0.264	-0.102	-1.224	
2003	5/21/2003	-0.125	-1.500	-0.106	-1.272	-0.068	-0.816	-0.257	-3.084	-0.027	-0.324	-0.107	-1.284	
2004	5/18/2004	-0.125	-1.500	-0.106	-1.272	-0.068	-0.816	-0.257	-3.084	-0.027	-0.324	-0.107	-1.284	
2005	5/31/2005	-0.125	-1.500	-0.106	-1.272	-0.068	-0.816	-0.252	-3.024	-0.022	-0.264	-0.102	-1.224	
2006	5/31/2006	-0.130	-1.560	-0.106	-1.272	-0.063	-0.756	-0.252	-3.024	-0.022	-0.264	-0.102	-1.224	
2007	5/15/2007	-0.120	-1.440	-0.104	-1.248	-0.063	-0.756	-0.250	-3.000	-0.018	-0.216	-0.101	-1.212	
2008	5/27/2008	-0.123	-1.476	-0.098	-1.176	-0.057	-0.684	-0.243	-2.916	-0.014	-0.168	-0.098	-1.176	
2009	6/9/2009	-0.120	-1.440	-0.111	-1.332	-0.073	-0.876	-0.257	-3.084	-0.027	-0.324	-0.112	-1.344	
2010	5/24/2010	-0.120	-1.440	-0.096	-1.152	-0.053	-0.636	-0.242	-2.904	-0.012	-0.144	-0.097	-1.164	

Notes:

(1) Positive values represent downward movement (settlement).

(2) Negative values represent upward movement (uplift).

**TABLE 5**  
**SAND CANYON DAM**  
**NET VERTICAL MOVEMENT OF SURVEY MONUMENTS**  
**1975 THROUGH 2018**

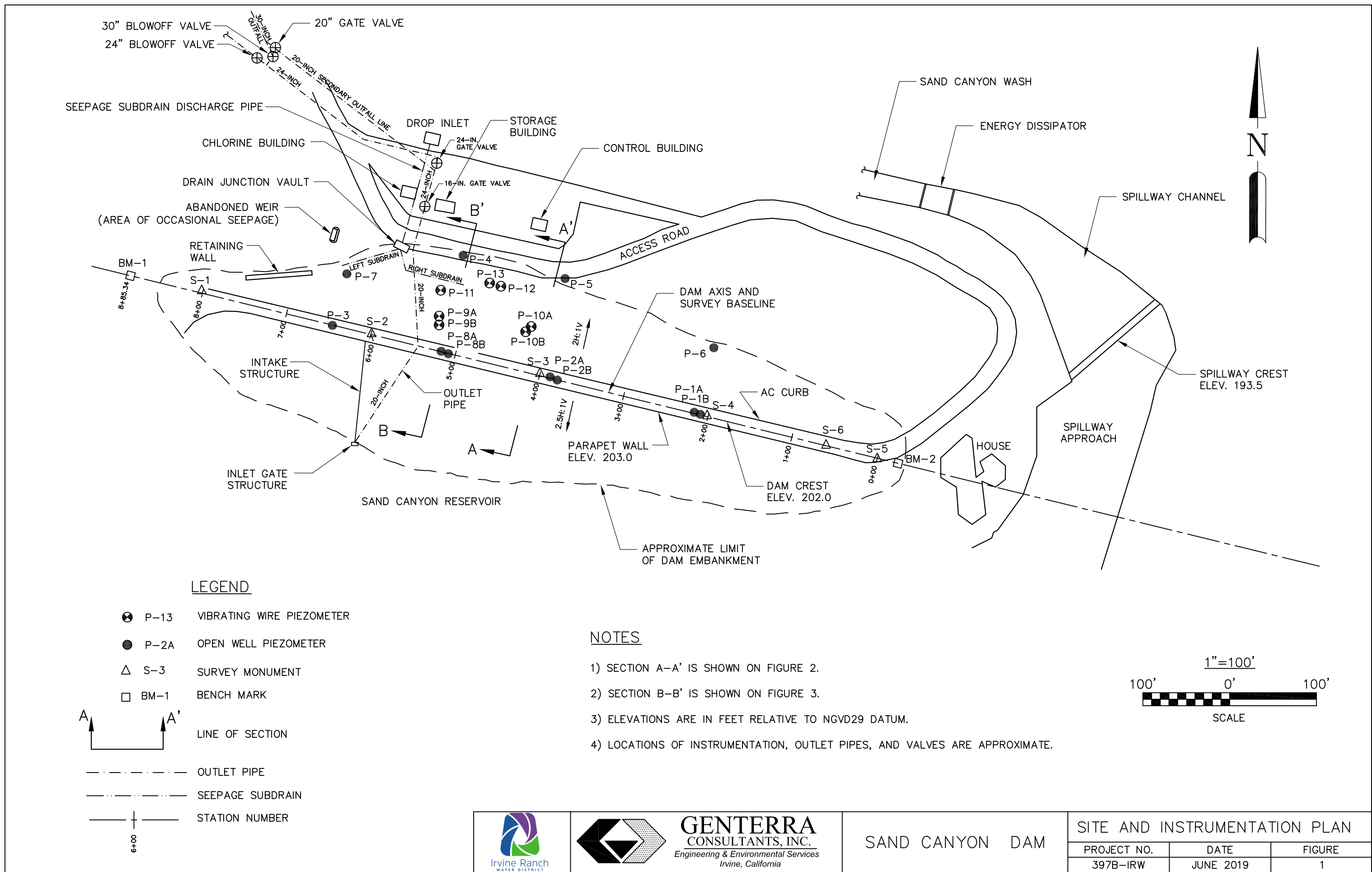
Monument ID →		S-1		S-2		S-3		S-4		S-6		S-5		Comment
Approx. Station →		8+00.234		6+00.212		4+00.125		2+00.191		0+61.430		0+00.079		
Year	Date	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	(feet)	(inches)	
2011	5/18/2011	-0.120	-1.440	-0.096	-1.152	-0.058	-0.696	-0.247	-2.964	-0.017	-0.204	-0.102	-1.224	
2012	5/18/2012	-0.120	-1.440	-0.101	-1.212	-0.058	-0.696	-0.247	-2.964	-0.017	-0.204	-0.102	-1.224	
2013	6/6/2013	-0.120	-1.440	-0.101	-1.212	-0.053	-0.636	-0.242	-2.904	-0.017	-0.204	-0.102	-1.224	
2014	4/25/2014	-0.120	-1.440	-0.106	-1.272	-0.063	-0.756	-0.252	-3.024	-0.027	-0.324	-0.112	-1.344	
2015	6/4/2015	-0.120	-1.440	-0.101	-1.212	-0.053	-0.636	-0.247	-2.964	-0.017	-0.204	-0.102	-1.224	
2016	7/25/2016	-0.115	-1.380	-0.091	-1.092	-0.048	-0.576	-0.242	-2.904	-0.012	-0.144	-0.097	-1.164	
2017														No survey was done in 2017
2018	5/31/2018	-0.120	-1.440	-0.101	-1.212	-0.058	-0.696	-0.252	-3.024	-0.027	-0.324	-0.112	-1.344	

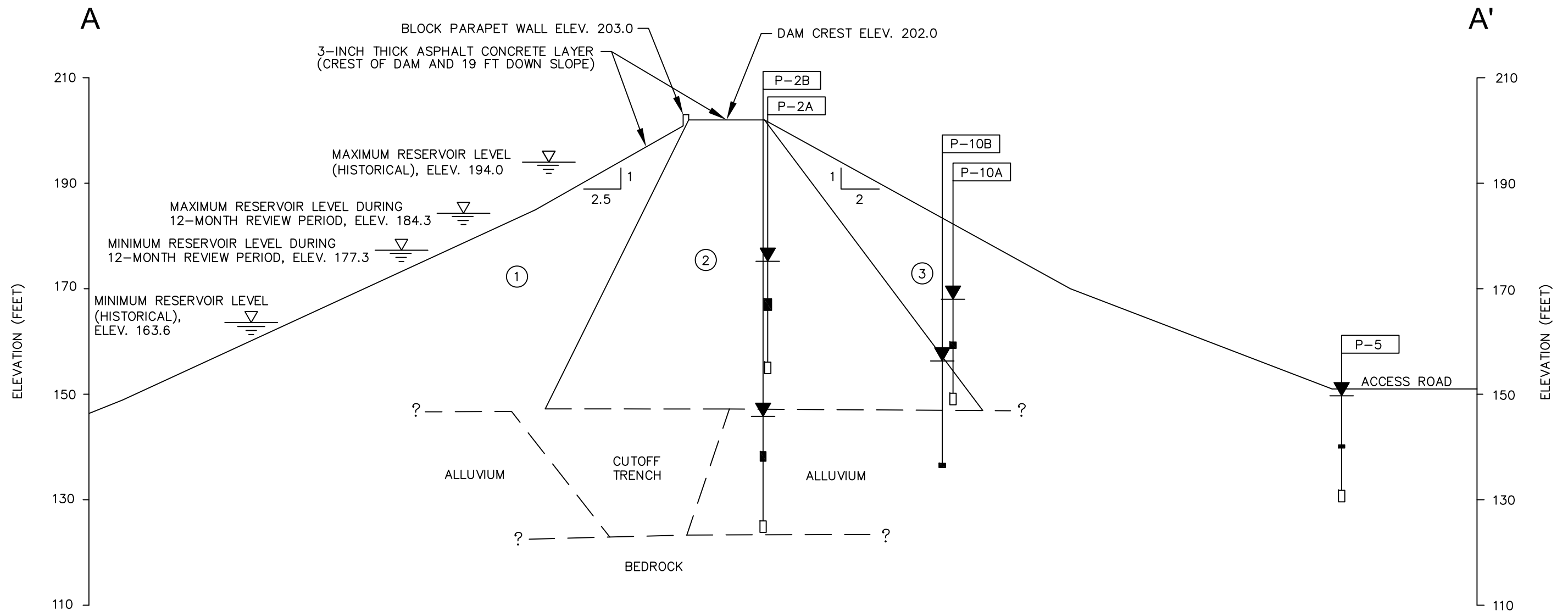
## Notes:

- (1) Positive values represent downward movement (settlement).  
(2) Negative values represent upward movement (uplift).

**ANNUAL SURVEILLANCE REPORT  
JANUARY 2018 THROUGH DECEMBER 2018  
SAND CANYON DAM, DSOD DAM NO. 1029-002**

**FIGURES**

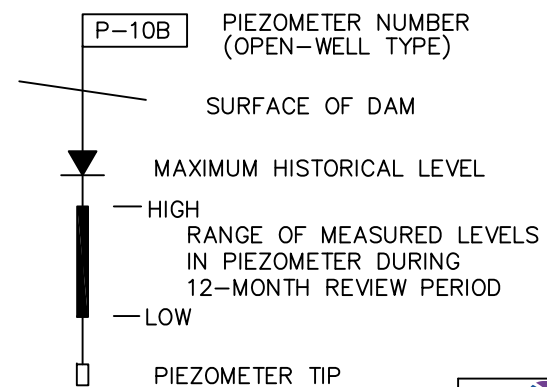




### LEGEND

### MATERIALS

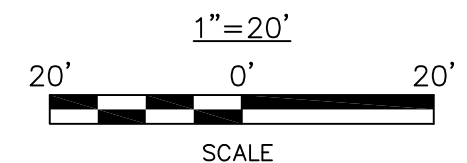
- ① SELECTED IMPERVIOUS
- ② RANDOM
- ③ UNSELECTED PERVIOUS



NOTE: QUESTIONABLE READINGS ARE NOT SHOWN

### NOTES

- 1) SEE FIGURE 1 FOR LOCATION OF SECTION.
- 2) ELEVATIONS ARE IN FEET RELATIVE TO NGVD29 DATUM.
- 3) EVEN THOUGH THE DAM WAS DESIGNED AS A ZONED EMBANKMENT DAM, IT WAS CONSTRUCTED AS A FAIRLY HOMOGENEOUS EMBANKMENT DAM PER DSOD (1984).

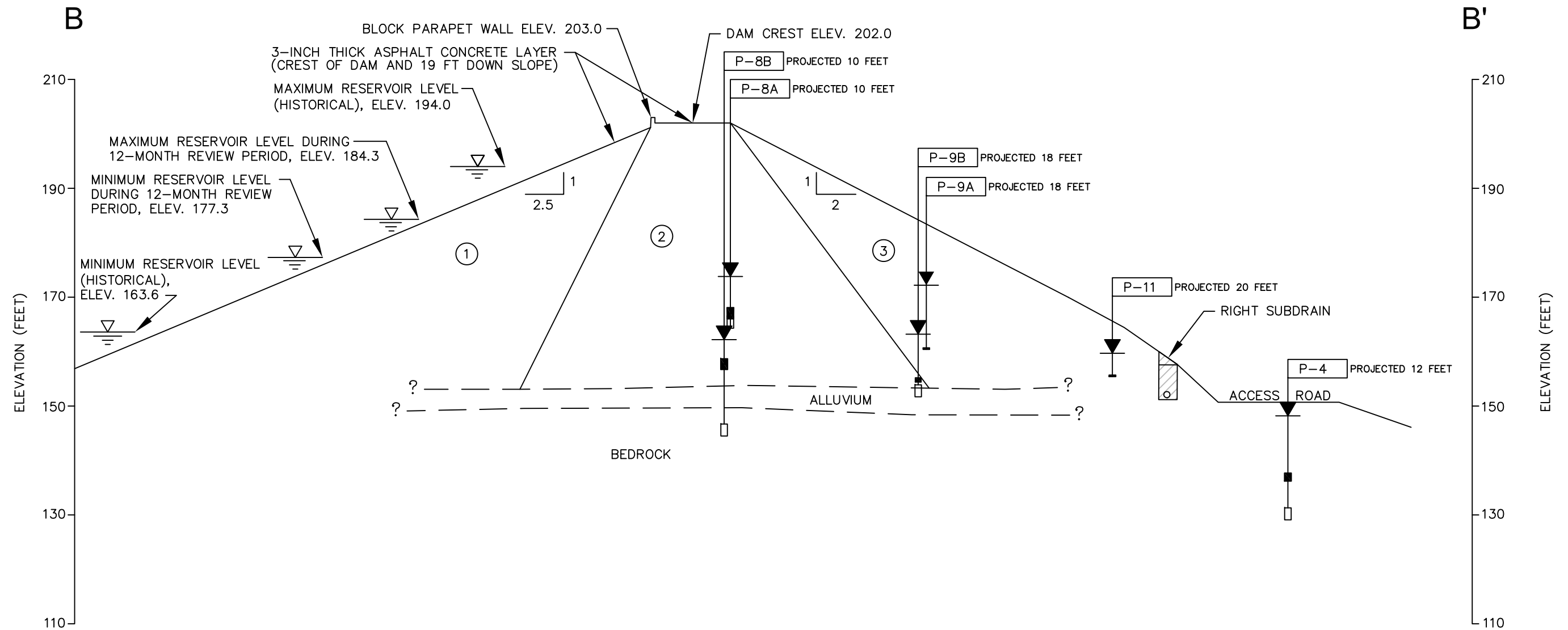


**GENTERRA**  
CONSULTANTS, INC.  
Engineering & Environmental Services  
Irvine, California

SAND CANYON DAM

SECTION A-A'

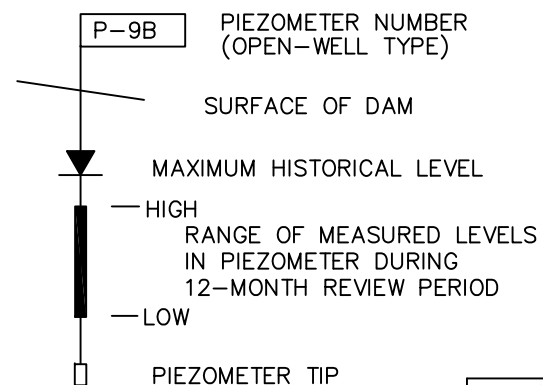
PROJECT NO.	DATE	FIGURE
397B-IRW	JUNE 2019	2



### LEGEND

#### MATERIALS

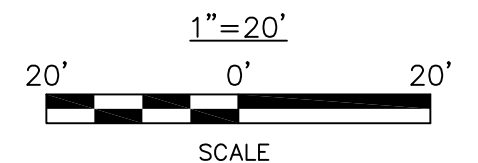
- ① SELECTED IMPERVIOUS
- ② RANDOM
- ③ UNSELECTED PERVIOUS



NOTE: QUESTIONABLE READINGS ARE NOT SHOWN

### NOTES

- 1) SEE FIGURE 1 FOR LOCATION OF SECTION.
- 2) ELEVATIONS ARE IN FEET RELATIVE TO NGVD29 DATUM.
- 3) EVEN THOUGH THE DAM WAS DESIGNED AS A ZONED EMBANKMENT DAM, IT WAS CONSTRUCTED AS A FAIRLY HOMOGENEOUS EMBANKMENT DAM PER DSOD (1984).



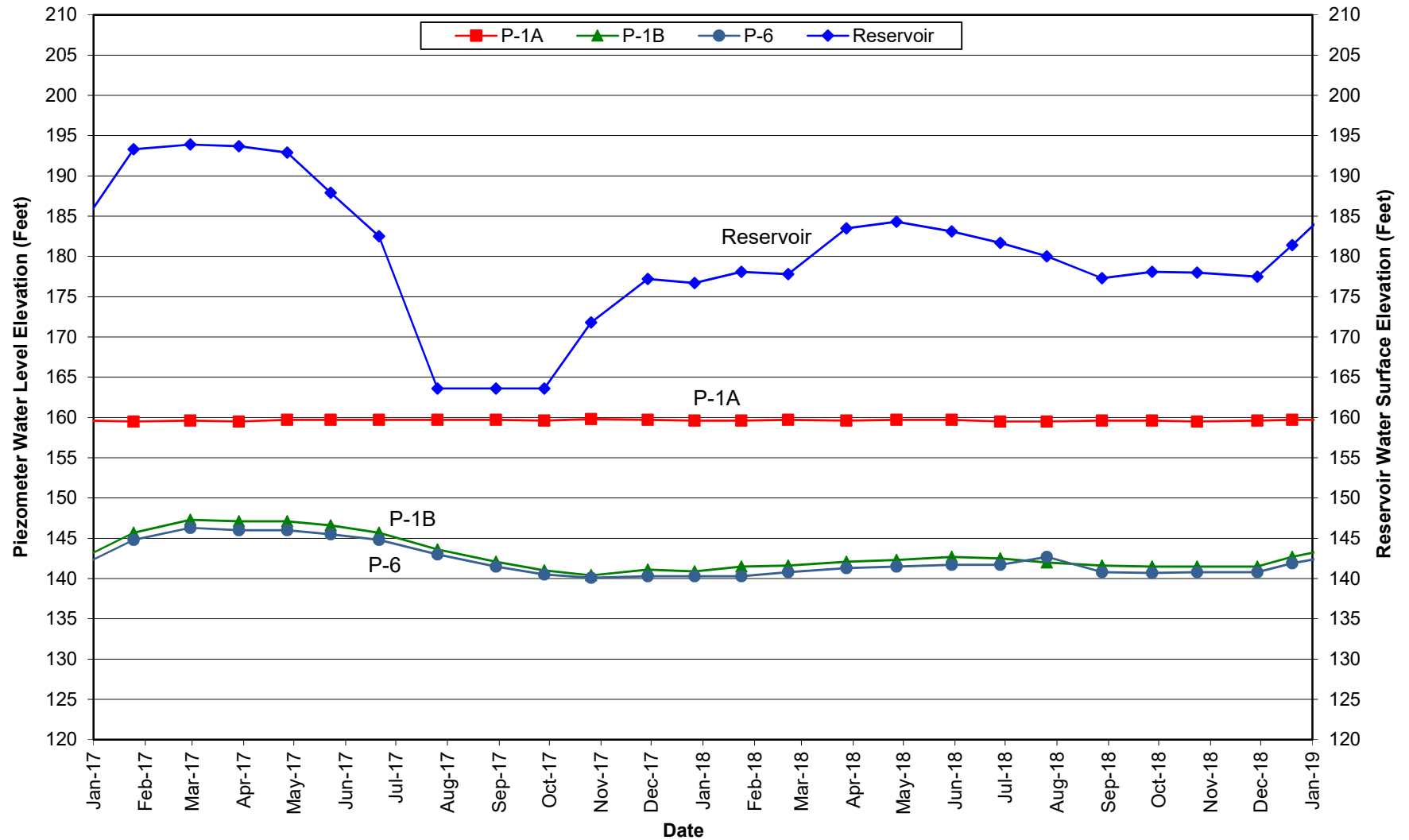
**GENTERRA**  
CONSULTANTS, INC.  
Engineering & Environmental Services  
Irvine, California

SAND CANYON DAM

SECTION B-B'

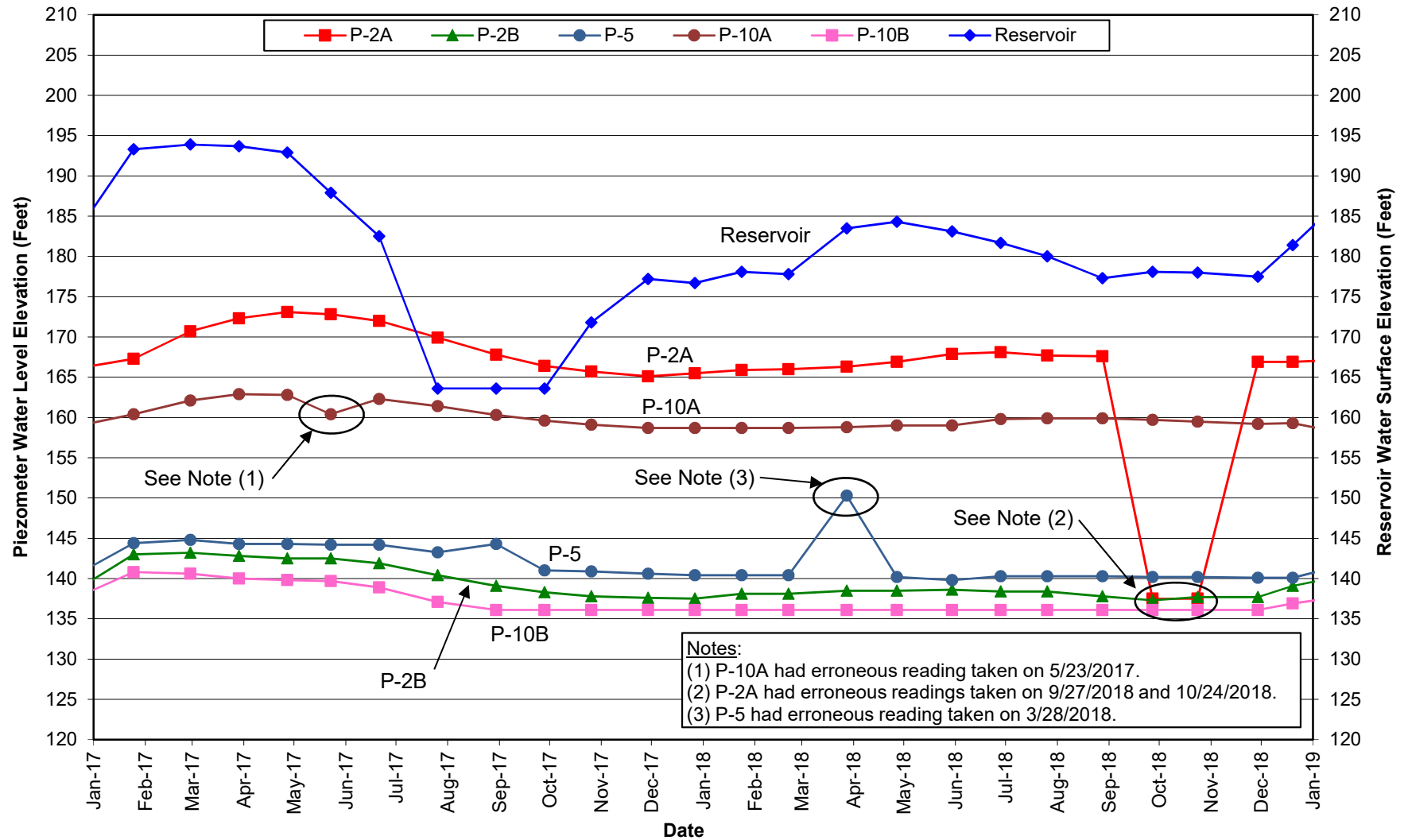
PROJECT NO.	DATE	FIGURE
397B-IRW	JUNE 2019	3

**SAND CANYON DAM  
2-YR PIEZOMETER AND RESERVOIR WATER SURFACE ELEVATIONS  
PIEZOMETERS P-1A, P-1B, AND P-6  
JANUARY 2017 THROUGH DECEMBER 2018**

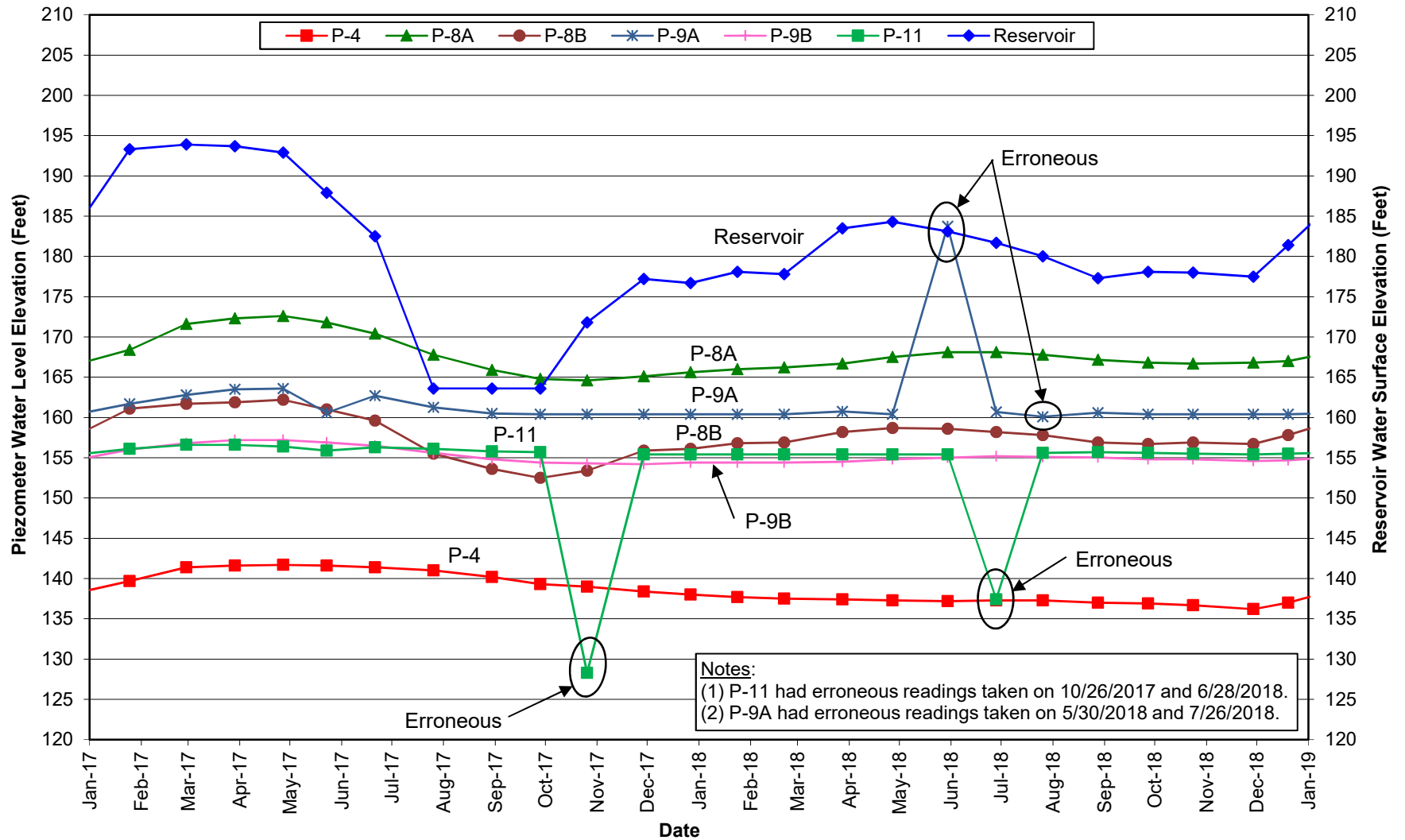




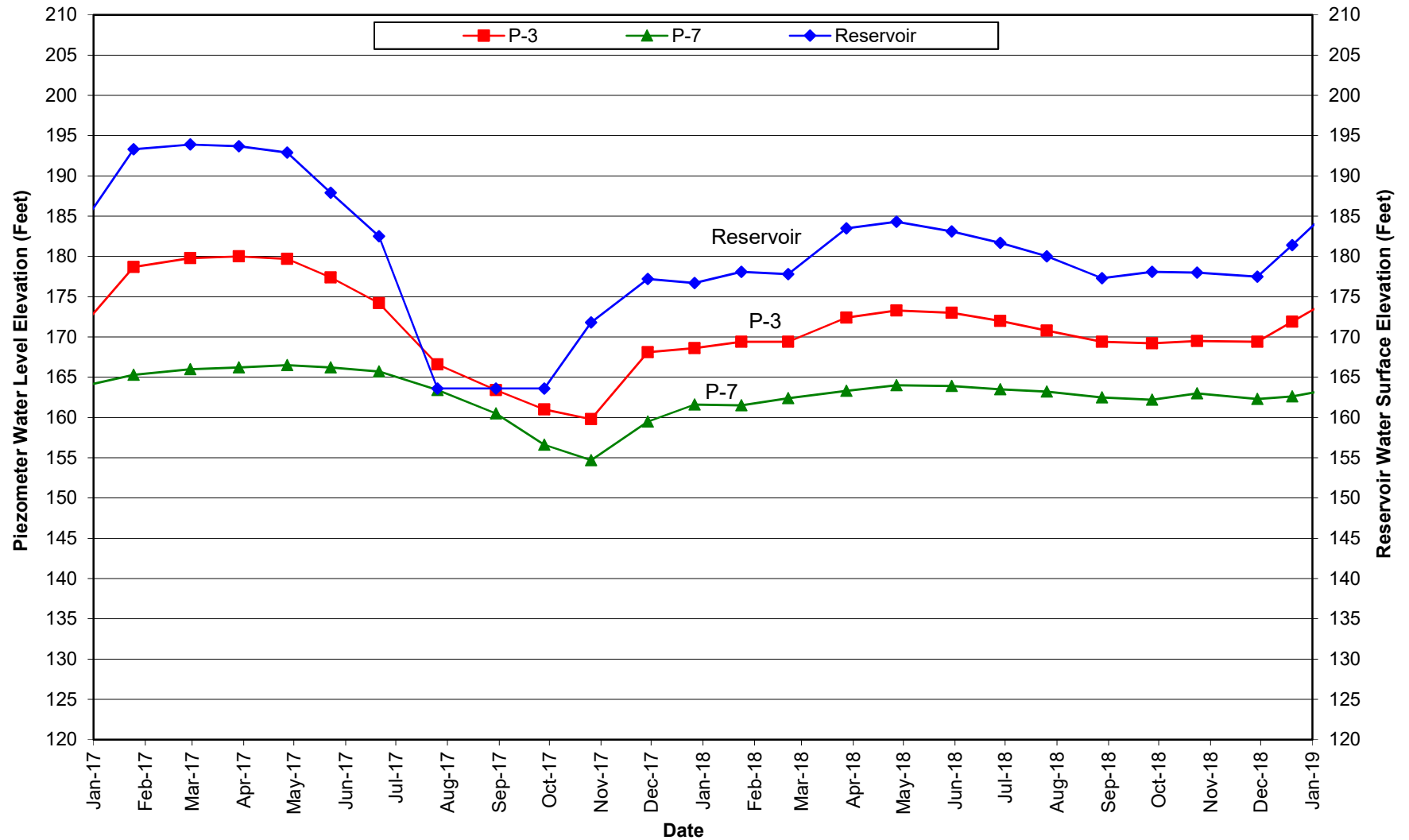
**SAND CANYON DAM  
2-YR PIEZOMETER AND RESERVOIR WATER SURFACE ELEVATIONS  
PIEZOMETERS P-2A, P-2B, P-5, P-10A, AND P-10B  
JANUARY 2017 THROUGH DECEMBER 2018**



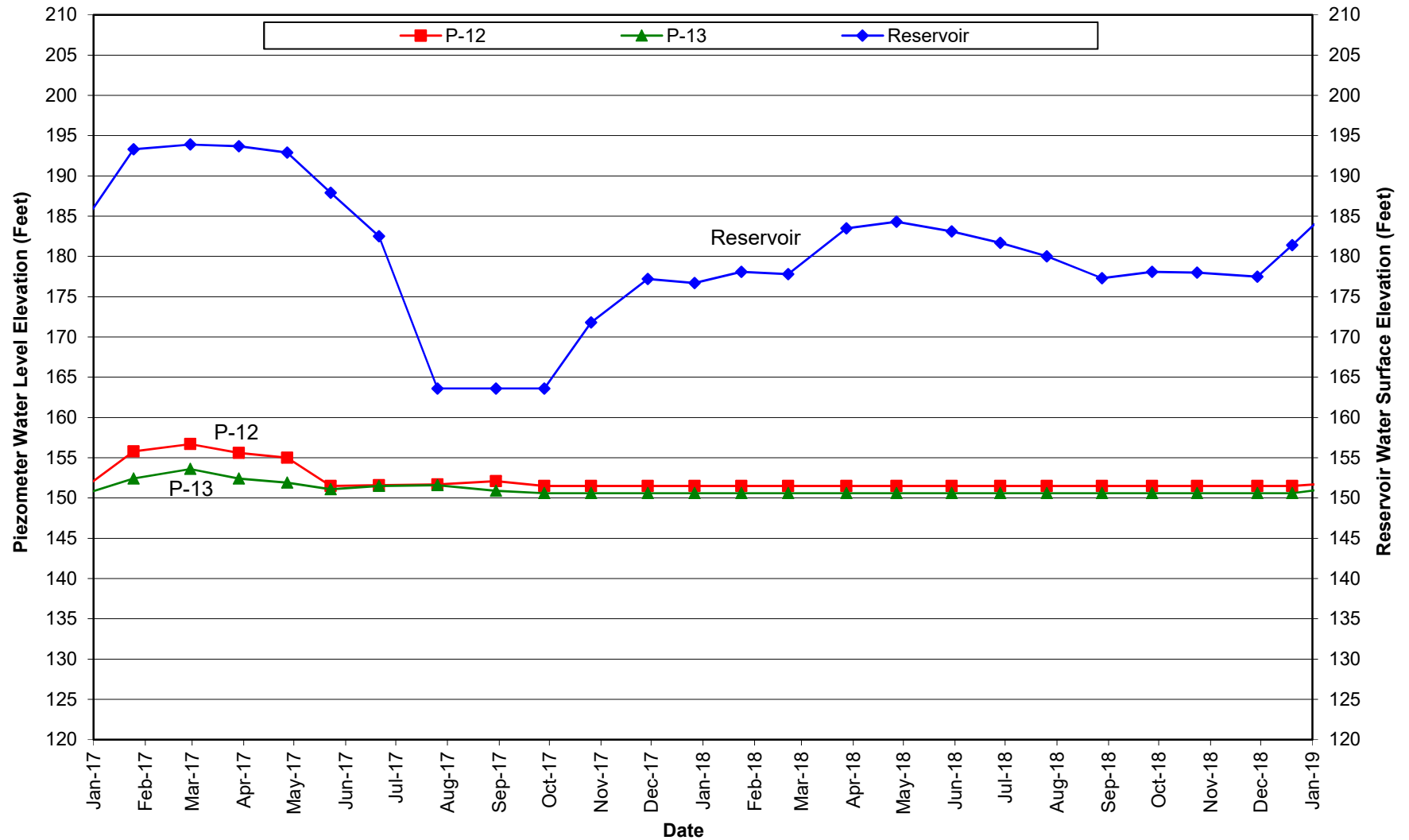
**SAND CANYON DAM  
2-YR PIEZOMETER AND RESERVOIR WATER SURFACE ELEVATIONS  
PIEZOMETERS P-4, P-8A, P-8B, P-9A, P-9B, AND P-11  
JANUARY 2017 THROUGH DECEMBER 2018**



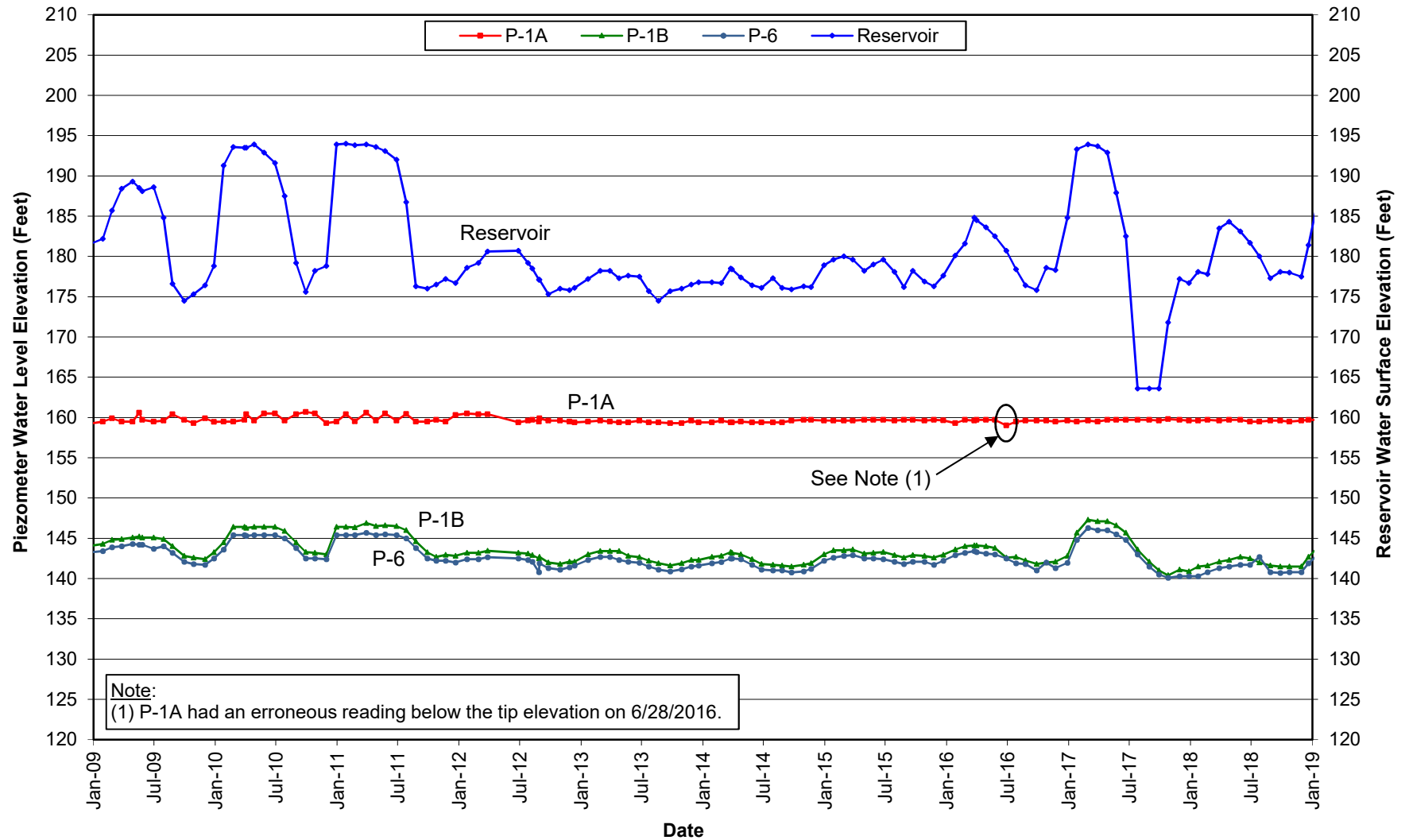
**SAND CANYON DAM  
2-YR PIEZOMETER AND RESERVOIR WATER SURFACE ELEVATIONS  
PIEZOMETERS P-3 AND P-7  
JANUARY 2017 THROUGH DECEMBER 2018**



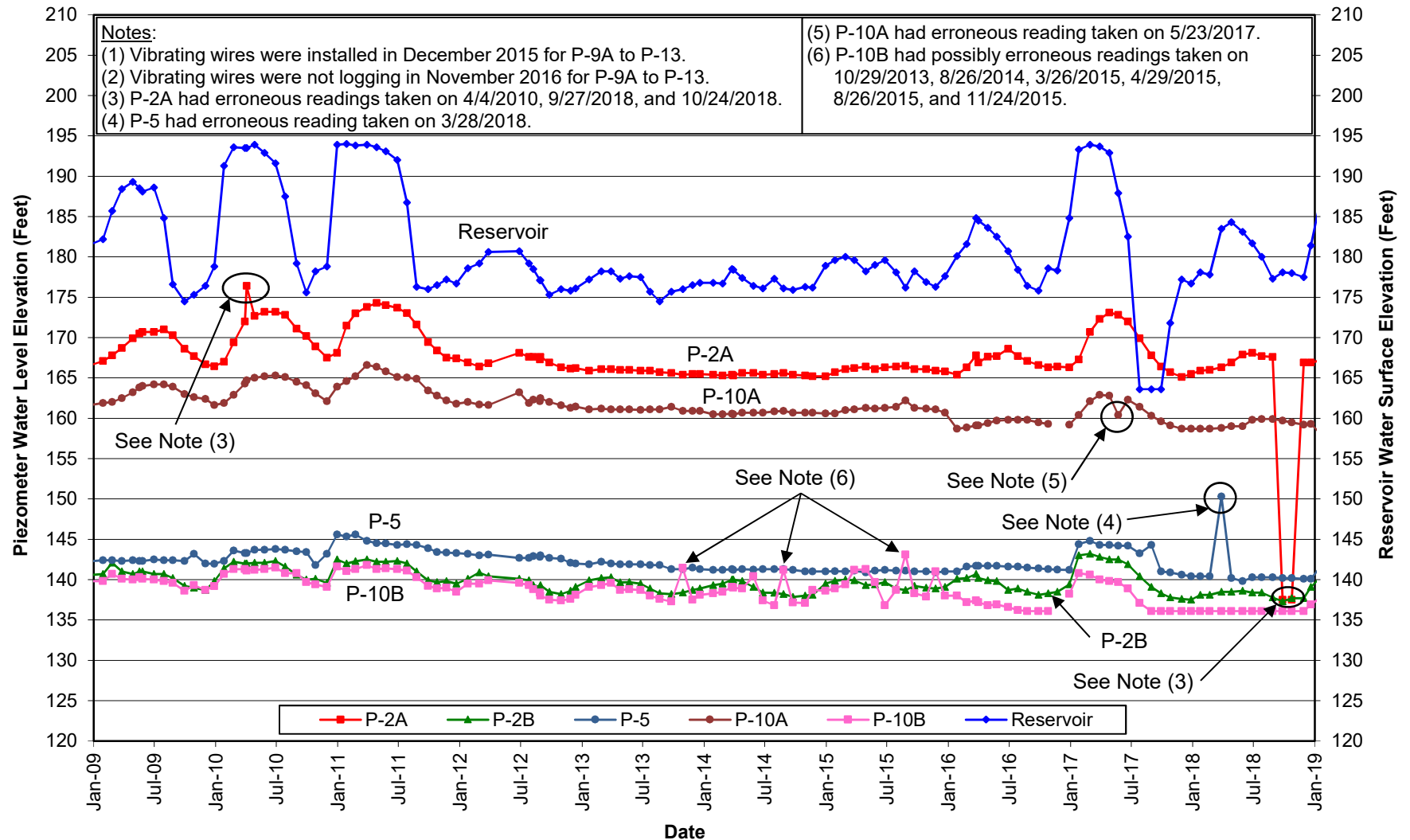
**SAND CANYON DAM  
2-YR PIEZOMETER AND RESERVOIR WATER SURFACE ELEVATIONS  
PIEZOMETERS P-12 AND P-13  
JANUARY 2017 THROUGH DECEMBER 2018**



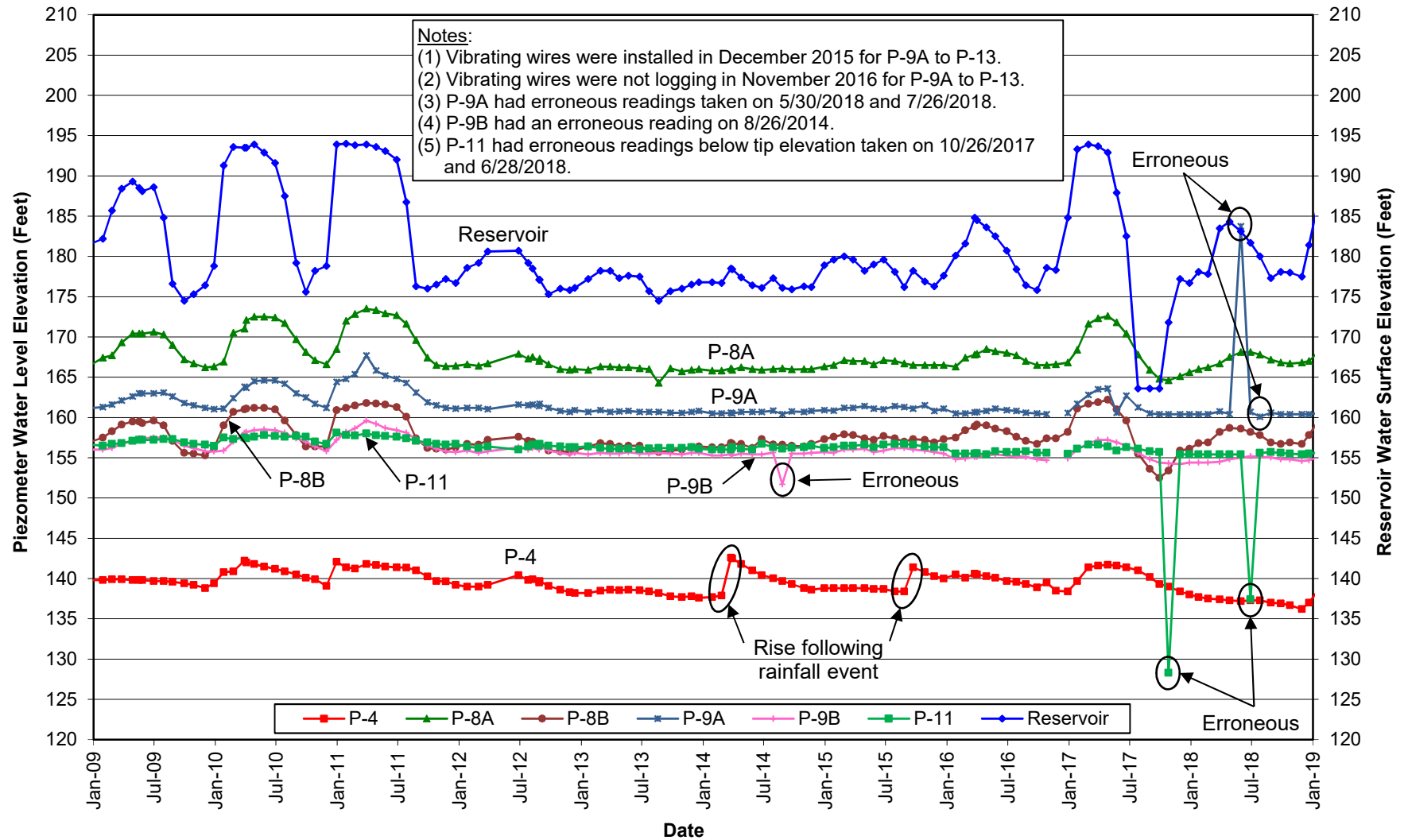
**SAND CANYON DAM**  
**10-YR HISTORICAL PIEZOMETER AND RESERVOIR WATER SURFACE ELEVATIONS**  
**PIEZOMETERS P-1A, P-1B, AND P-6**  
**JANUARY 2009 THROUGH DECEMBER 2018**



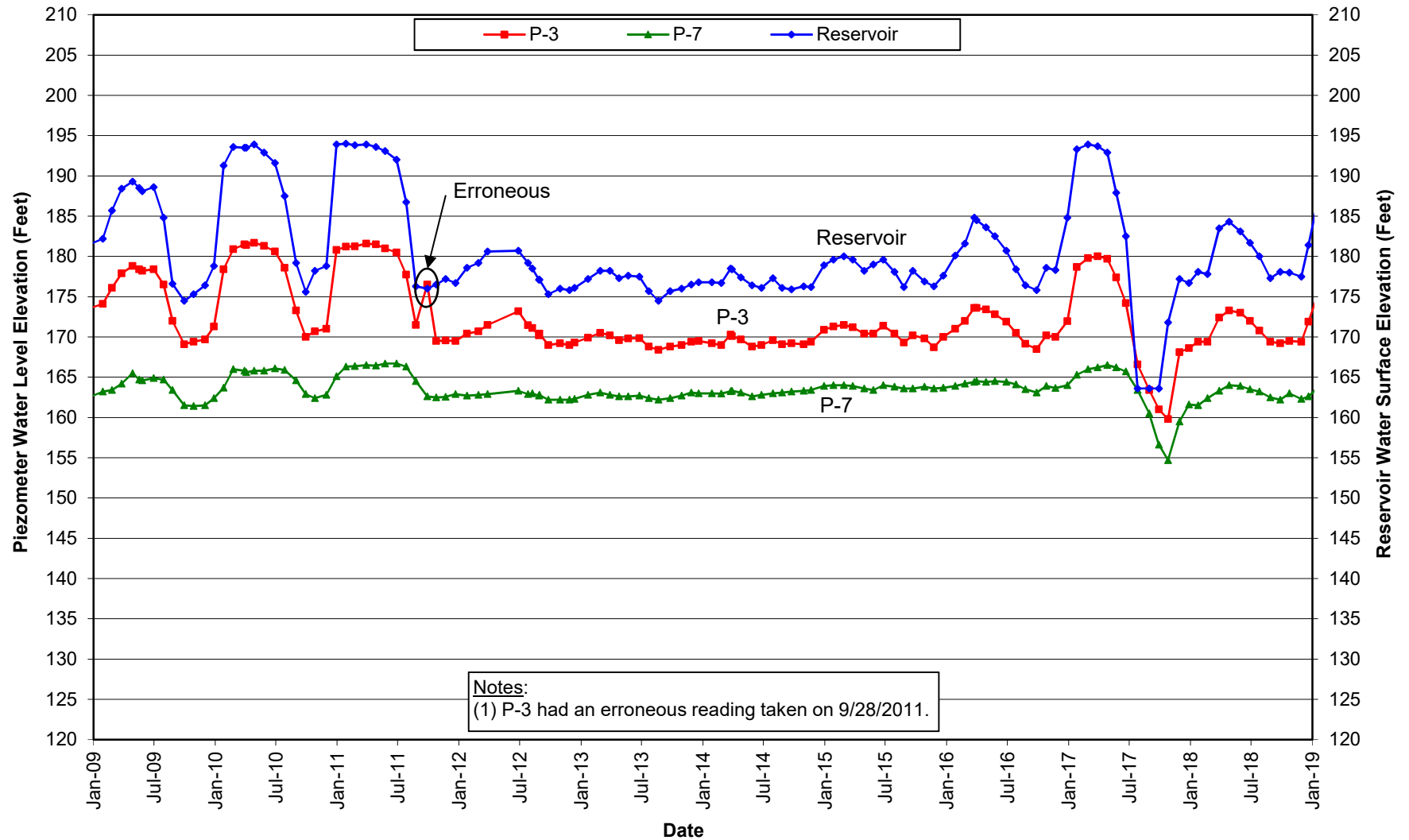
**SAND CANYON DAM**  
**10-YR HISTORICAL PIEZOMETER AND RESERVOIR WATER SURFACE ELEVATIONS**  
**PIEZOMETERS P-2A, P-2B, P-5, P-10A, AND P-10B**  
**JANUARY 2009 THROUGH DECEMBER 2018**



**SAND CANYON DAM**  
**10-YR HISTORICAL PIEZOMETER AND RESERVOIR WATER SURFACE ELEVATIONS**  
**PIEZOMETERS P-4, P-8A, P-8B, P-9A, P-9B, AND P-11**  
**JANUARY 2009 THROUGH DECEMBER 2018**

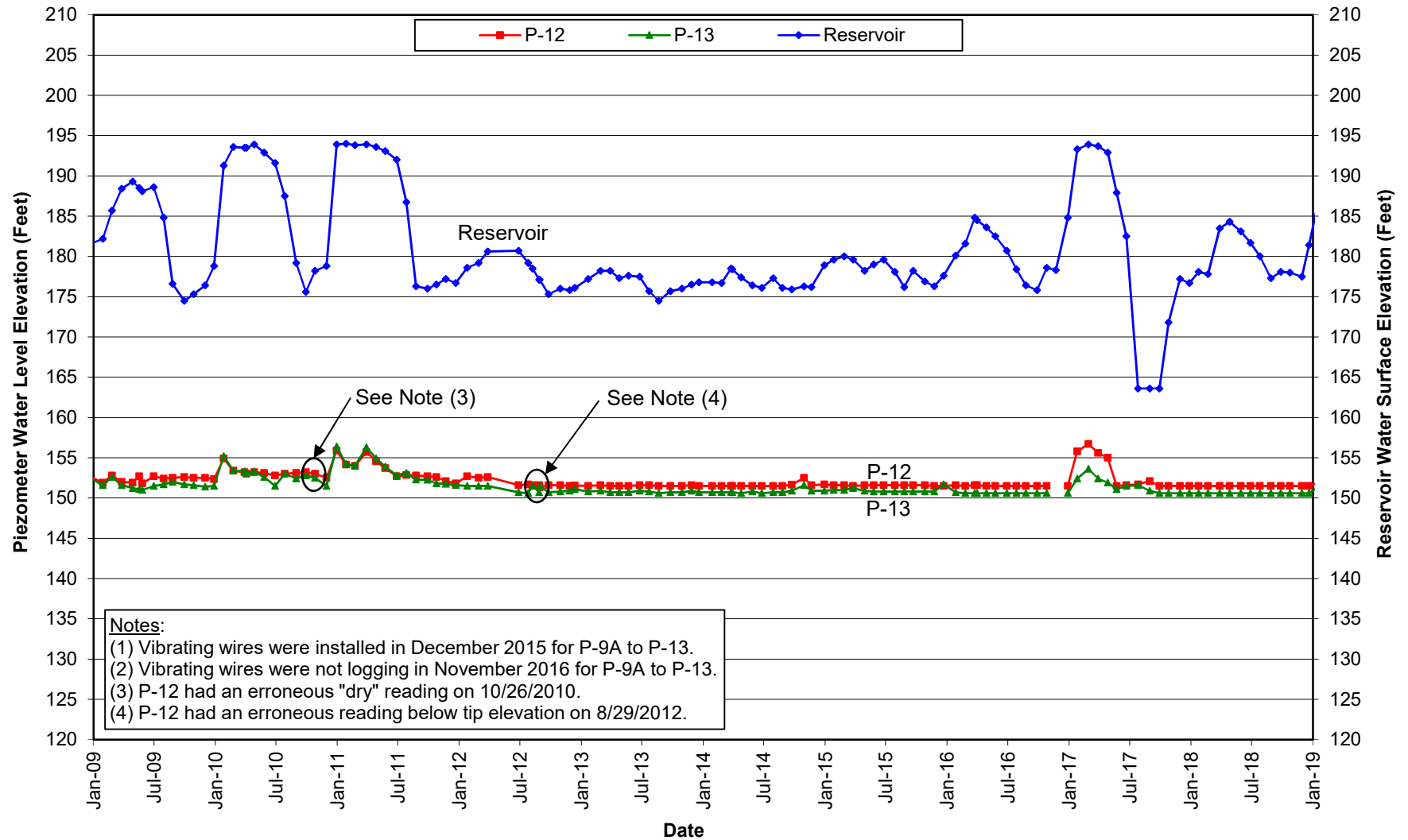


**SAND CANYON DAM**  
**10-YR HISTORICAL PIEZOMETER AND RESERVOIR WATER SURFACE ELEVATIONS**  
**PIEZOMETERS P-3 AND P-7**  
**JANUARY 2009 THROUGH DECEMBER 2018**

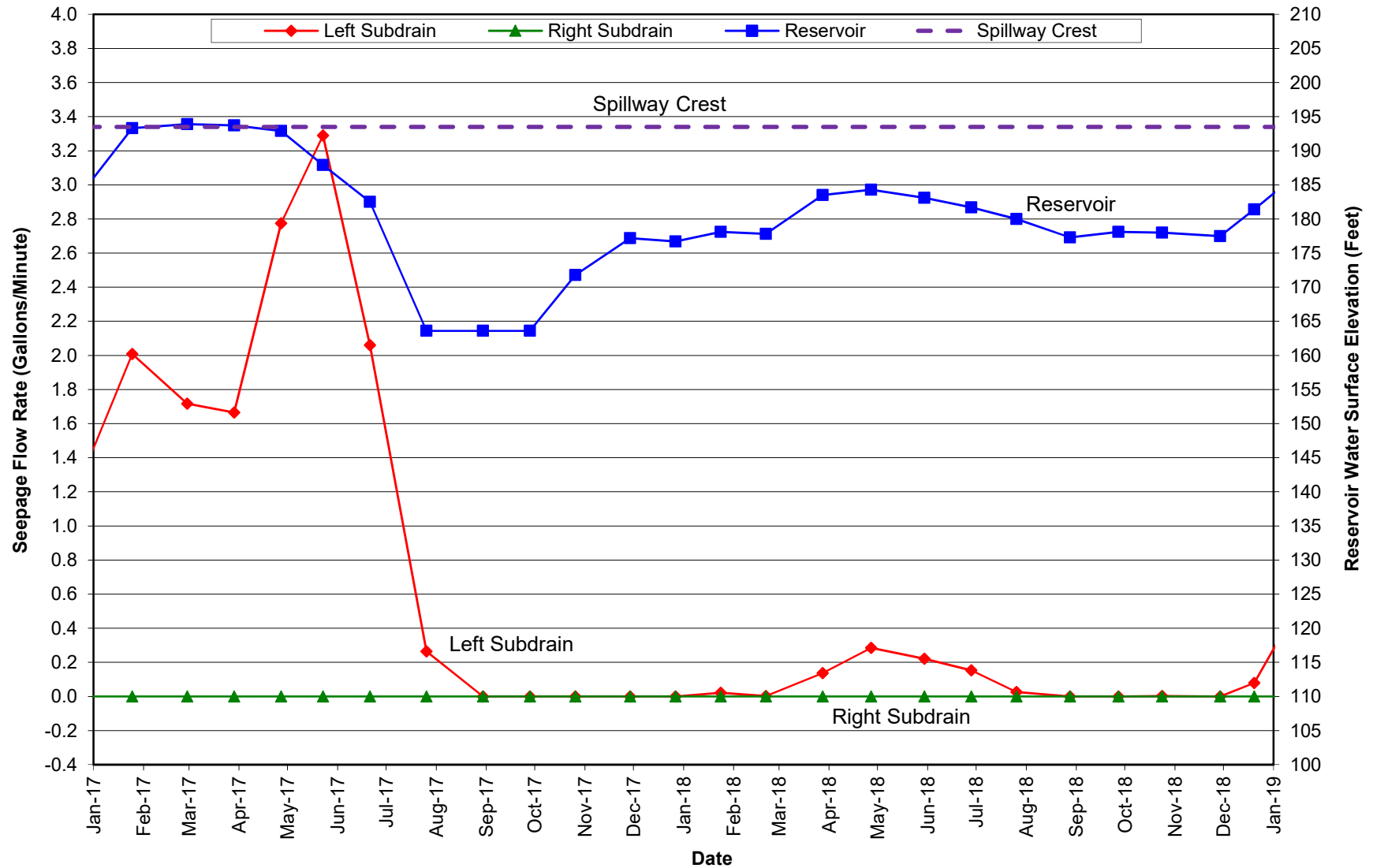




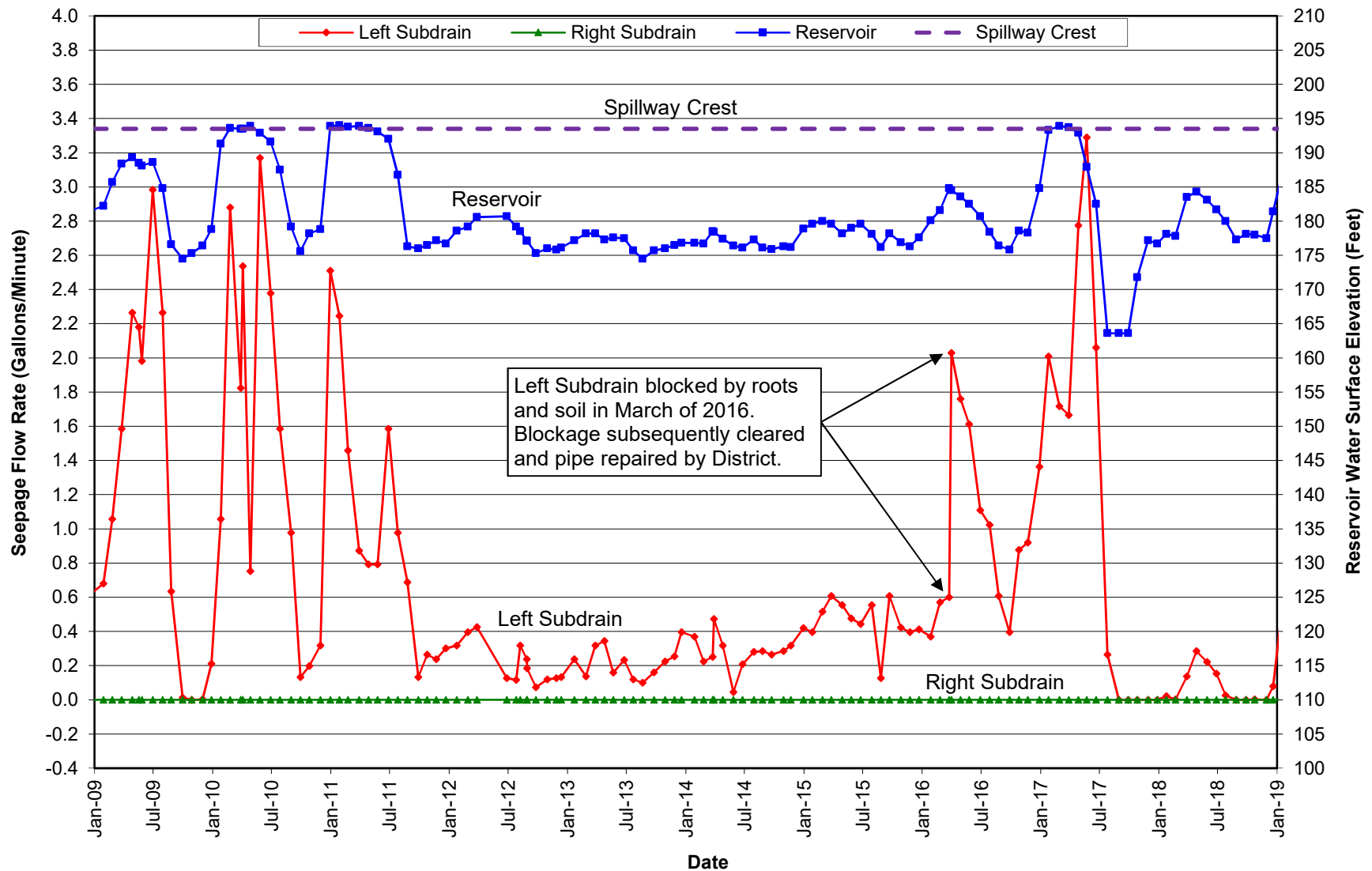
**SAND CANYON DAM  
10-YR HISTORICAL PIEZOMETER AND RESERVOIR WATER SURFACE ELEVATIONS  
PIEZOMETERS P-12 AND P-13  
JANUARY 2009 THROUGH DECEMBER 2018**



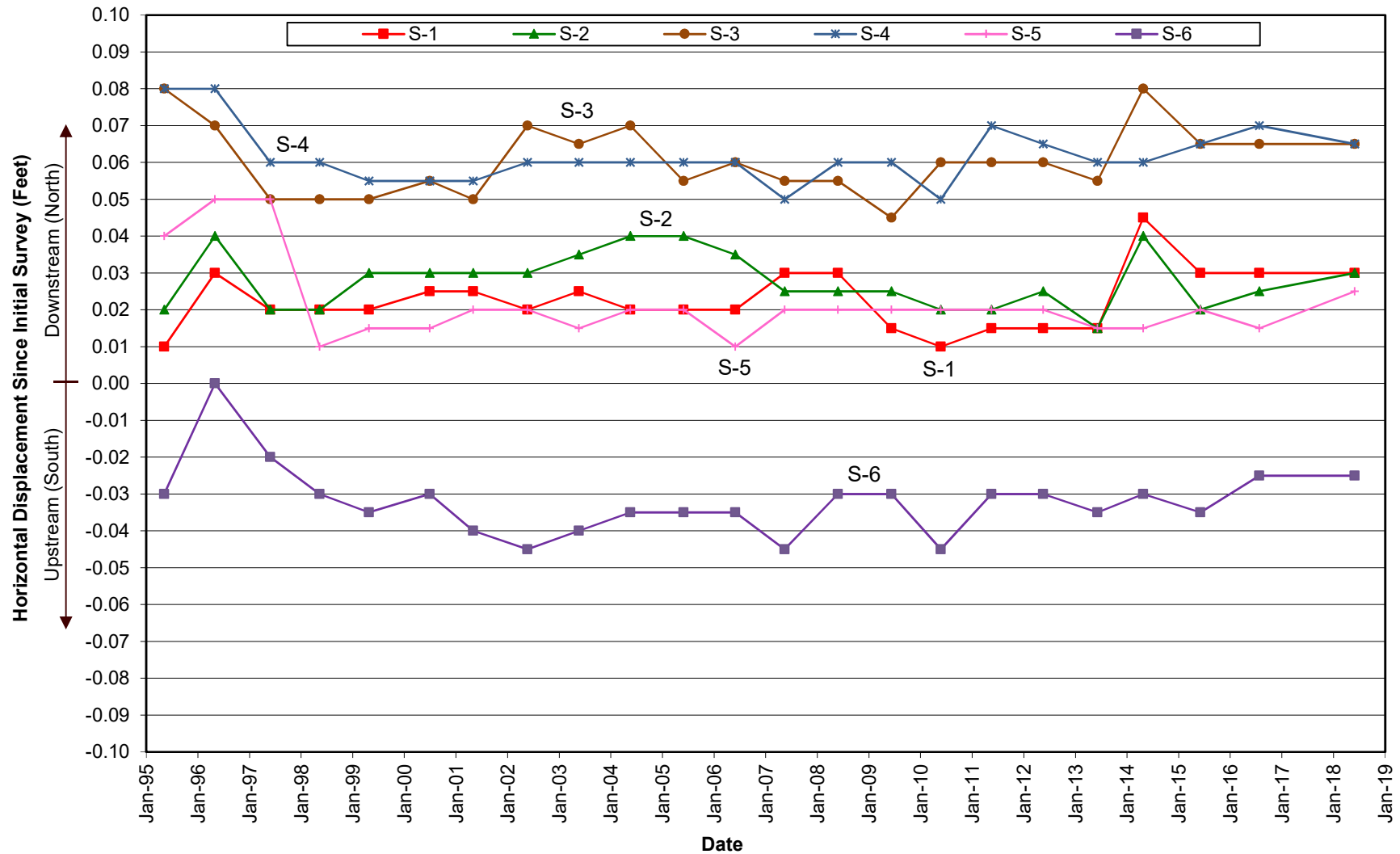
**SAND CANYON DAM  
2-YR SEEPAGE FLOW RATES AND RESERVOIR WATER SURFACE ELEVATIONS  
JANUARY 2017 THROUGH DECEMBER 2018**



**SAND CANYON DAM**  
**10-YR HISTORICAL SEEPAGE FLOW RATES AND RESERVOIR WATER SURFACE ELEVATIONS**  
**JANUARY 2009 THROUGH DECEMBER 2018**



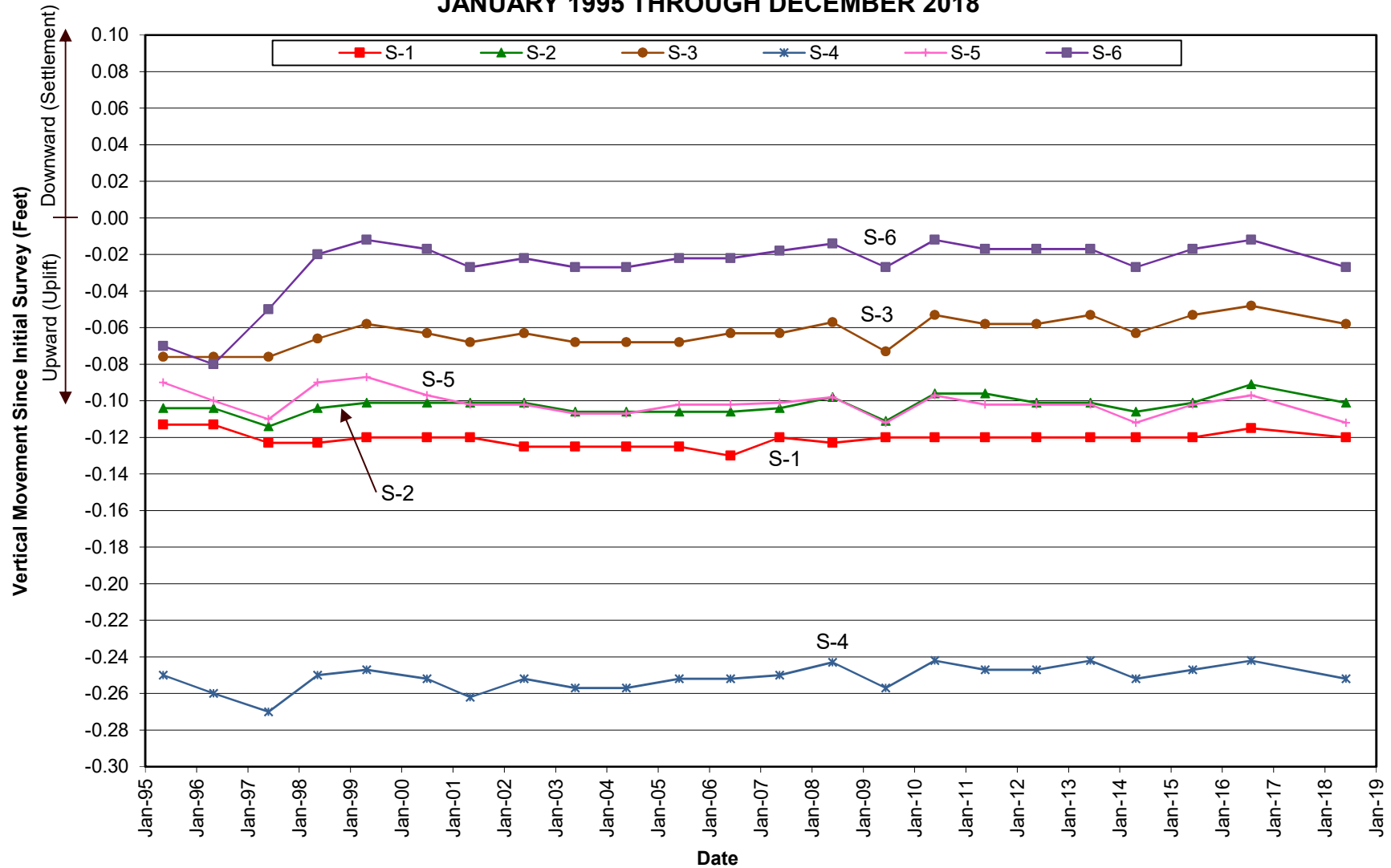
**SAND CANYON DAM  
24-YR HISTORICAL NET HORIZONTAL DISPLACEMENT  
SURVEY MONUMENTS S-1 THROUGH S-6  
JANUARY 1995 THROUGH DECEMBER 2018**



IRVINE RANCH WATER DISTRICT

FIGURE 8

**SAND CANYON DAM  
24-YR HISTORICAL NET VERTICAL MOVEMENT  
SURVEY MONUMENTS S-1 THROUGH S-6  
JANUARY 1995 THROUGH DECEMBER 2018**



IRVINE RANCH WATER DISTRICT

FIGURE 9