WILDERMUTH ENVIRONMENTAL, INC.

# Technical Memorandum

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| **To:** | **San Juan Basin Authority**<br>**Attn: Norris Brandt, Administrator** |
| **From:** | **Mike Blazevic, PG, CHG - Supervising Hydrogeologist**<br>**Samantha Adams, Principal Scientist** |
| **Date:** | **May 6, 2020** |
| **Subject:** | **Recommended 2020 Adaptive Pumping Management Plan** |

## Summary

The recommended 2020 Adaptive Pumping Management plan for the Stonehill and Inland management zones is based on the most up-to-date understanding of the hydrogeologic conceptual model and current climatic, groundwater level, and groundwater quality conditions in the San Juan Basin. **Based on these conditions, the initial 2020 pumping allocation may be set at the maximum limits allowed under existing agreements for wells in the Stonehill and Inland management zones.** The 2020 pumping allocation is as follows:

- 1,300 acre-feet per year for the South Coast Water District within the Stonehill management zone.
- 6,150 acre-feet per year for the City of San Juan Capistrano within the Inland management zone (up to 5,800 acre-feet per year at the Alipaz well field plus the Tirador well and up to 350 acre-feet per year at CVWD-5A and South Cooks on behalf of the San Juan Hills Golf Club).

In addition, the 2020 Adaptive Pumping Management plan includes criteria for adjusting pumping based on changing conditions in the San Juan Basin observed through monthly monitoring protocol. The Stonehill management zone's monitoring plan is documented on **pages 17 and 18**, and the Inland management zone's monitoring plan is documented on **pages 18 and 19**.

This document also recommends a supplemental monitoring and testing program for the 2020 Adaptive Pumping Management plan: passive aquifer testing (**page 19**). Another testing program: tracer testing (**pages 19 and 20**), is also discussed in this document. The information derived from tracer testing could support the development of future Adaptive Pumping Management plans.

The recommended 2020 Adaptive Pumping Management plan has been reviewed by the San Juan Basin Authority's Technical Advisory Group, and their comments have been incorporated into this technical memorandum.

## Introduction

Pursuant to the recommendations of the 2014 San Juan Basin Groundwater and Facilities Management Plan[1] (SJBGFMP), the San Juan Basin Authority (Authority) directed Wildermuth Environmental, Inc. (WEI) to develop an Adaptive Pumping Management (APM) plan to assist it in the annual allocation and management of groundwater pumping to ensure compliance with its water rights permit for the diversion and use of water in the San Juan Basin (Basin). The first APM plan, the 2016 APM plan,[2] was adopted by the Authority in August 2016. The APM plan is updated each April, after most of the rainy season has passed, to define an initial pumping allocation for the subsequent 12-month period (May to April), based on current Basin conditions. The APM plan also includes a monitoring and reporting program to support adjustments to the initial allocation, if appropriate, based on changes in Basin conditions. This technical memorandum defines the recommended 2020 APM plan for the period of May 2020 to April 2021.

## Background on Permit 21074 and the Determination of Water Available for Pumping

Groundwater in the Basin is regulated by the State Water Resources Control Board (State Board) as flow of an underground stream. As such, the Authority holds a *Permit for Diversion and Use of Water* (Permit 21074) that regulates its extractions (pumping) from the Basin. Permit 21074 was issued by the State Board in October 2000 and amended in October 2011. Under Permit 21074, the Authority may extract up to 8,026 acre-feet per year (afy), subject to various terms and conditions. The conditions that limit pumping rights allocated by Permit 21074 include, but are not limited to:

> **Groundwater storage**. Pumping must be managed to ensure that the cumulative pumping by all producers does not decrease the volume of water in storage in the Basin to less than 50 percent of full capacity.
>
> **Water quality**. Pumping must be managed to ensure that water quality degradation that would cause injury to the reasonable and beneficial uses of water recognized for the San Juan Creek Watershed in the Water Quality Control Plan for the San Diego Basin (Basin Plan) does not occur—the Authority interprets this condition to specifically ensure that

[1] WEI. (2013). *San Juan Basin Groundwater and Facilities Management Plan*. Prepared for the San Juan Basin Authority. November 2013. Available at: http://www.sjbauthority.com/programs.html#1

[2] WEI. (2016). *San Juan Basin 2016 Adaptive Pumping Management (APM) Plan*. Prepared for the San Juan Basin Authority. August 30, 2016. http://sjbauthority.com/assets/downloads/20160830_APM_Memo.pdf

pumping does not result in increased chloride and total dissolved solids (TDS) concentrations, resulting from seawater intrusion.

**Riparian vegetation**. Pumping must be managed to ensure that riparian vegetation along San Juan Creek in the reach between Interstate 5 and Ortega Highway is not impacted.

Currently, the City of San Juan Capistrano (City) is the only member of the Authority pumping water under Permit 21074, and it is doing so pursuant to the October 2002 *Project Implementation Agreement for the San Juan Basin Desalter Project.*[3] Groundwater pumped pursuant to Permit 21074 is treated at the City's Groundwater Recovery Plant (GWRP). The agreement allows the City to produce up to 5,800 afy of the Authority's water right.

The South Coast Water District (SCWD) also holds a permit to divert and use water in the Basin. Permit 21138 was issued by the State Board in December 2002 and amended in July 2012. Under amended Permit 21138, the SCWD may extract up to 1,300 afy, subject to various terms and conditions that are similar to those of Permit 21074 (excluding requirements to protect riparian vegetation between Interstate 5 and Ortega Highway). Groundwater pumped pursuant to Permit 21138 is treated at the SCWD's Groundwater Recovery Facility (GRF).

In 1998, prior to the issuance of Permits 21074 and 21138, the Authority and the SCWD (successor to the Capistrano Beach Water District) entered into an agreement that settled their protests on each other's applications to appropriate water.[4] Pursuant to the 1998 agreement, the Authority serves as the "Basin Manager" responsible for annually determining the amounts of "available safe yield" that it and the SCWD can pump pursuant to their water rights. Once determined, the water available for pumping is allocated as follows:

- 80 percent to the Authority, up to a maximum of 12,500 afy
- 20 percent to the SCWD, up to a maximum of 1,300 afy[5]

The Authority established the "Basin Management Committee," to perform the monitoring activities required to support compliance with the water rights permits, which subsequently developed a comprehensive monitoring program and began implementing it in 2004. Today, the Authority Board of Directors serves as the Committee. In 2010, the Authority began developing the SJBGFMP to improve Basin operations and management. The SJBGFMP recommended, as a first step, the development and implementation of an APM program that would enable the Authority to annually determine the water available for pumping based on the latest hydrogeologic characterization and current Basin conditions. To collect the data needed to support the APM program development, the Authority began implementing an expanded

[3] The implementation agreement is available at http://www.sjbauthority.com/programs/project-committee.html; once at the site, click on the link for Project Committee #4.

[4] *Protest Settlement Agreement Between San Juan Basin Authority and Capistrano Beach Water District*. Dated March 1, 1998. Available at http://www.sjbauthority.com/programs/project-committee.html; once at the site, click on the link for Project Committee #10.

[5] Note that the SCWD's permit limit of 1,300 afy is about 18 percent of the total rights of 7,100 afy (5,800 + 1,300) that can currently be allocated.

groundwater monitoring program in 2013. The objectives of the expanded groundwater monitoring program were to (1) collect baseline groundwater quality and groundwater level data that could be used to define metrics for monitoring the occurrence of seawater intrusion, and (2) expand groundwater level monitoring to improve annual characterizations of groundwater storage. Data collected by cooperating agencies (including members of the Authority) and provided to the Authority continue to be used to support these management efforts. Figure 1 shows the location of all sites in the San Juan Basin where data is collected to support the Authority's Basin management efforts, including those referenced in this report.

The 2016 APM plan documented a technical methodology for determining the pumping allocation, a monitoring and reporting program to continually evaluate Basin conditions, and criteria for adjusting an initial allocation based on Basin conditions. Since the development of the 2016 APM plan, the understanding of the Basin's hydrogeology has continually improved, and the technical methodology for setting the annual APM allocation has evolved accordingly. Though the technical methodology to establish the initial allocation may change from year to year, the basic framework of the plan remains the same: an initial pumping allocation is established in April, but it can be adapted based on changes in Basin conditions, observed through monthly monitoring protocols.

## Updated Hydrogeologic Conceptual Model of the Lower San Juan Basin

This section summarizes the most up-to-date understanding of the hydrogeologic conceptual model of the Basin, based on the recently completed Bedrock Barrier Investigation (Investigation)[6,7] and subsequent passive aquifer testing. This discussion focuses on the area shown in Figure 2.

### Test Hole Drilling and Monitoring Well Completions

In early 2017, during investigations performed in support of the San Juan Watershed Project,[8] WEI identified an unmapped bedrock-high located approximately between the City and SCWD well fields and hypothesized that the bedrock-high acts, at least partially, as an impediment to groundwater flow. It was previously assumed that the aquifers from which the City and SCWD pumped groundwater were hydraulically connected and that pumping operations by the City and SCWD impacted each other and therefore had to be managed together. For example, in past APM plans (2016 and 2017), both the City and SCWD pumping allocations were managed (reduced) to protect against seawater intrusion when groundwater levels declined along the coast. The

[6] WEI. (2018). *Summary of Work Completed and Results of the Bedrock Barrier Investigation*. Prepared for the San Juan Basin Authority. April 2018.

[7] WEI. (2019). *Drilling, Construction, and Development of the SJBA Wells: SJC18 MW-9 and SJC18 MW-10*. Prepared for the San Juan Basin Authority. April 2019.

[8] The San Juan Watershed Project is the follow-on work to design and implement the groundwater management facilities defined in the San Juan Basin Optimization Program, an engineering study to refine the management alternatives defined in the SJBGFMP. The San Juan Watershed Project is being implemented by the Santa Margarita Water District and the SCWD.

existence of the bedrock-high has potential implications for how pumping in the Basin is managed to comply with the Authority and SCWD water rights permits. In other words, if the bedrock-high, or other hydrogeologic features, prove to limit interaction between the two areas from which the City and SCWD produce groundwater, pumping could be managed separately to comply with the water rights permits.

In September 2017, the Authority authorized WEI to perform an Investigation to determine the extent of the bedrock-high and its impact on the groundwater flow system. Figure 2 shows the Investigation study area. The Investigation was completed in two phases. The first phase of the Investigation consisted of the exploratory drilling and logging of nine test holes within the study area to characterize the lateral extent, depth, and lithologic characteristics of the hypothesized bedrock-high, and to determine if the bedrock-high acts as an impediment to groundwater flow between the City and SCWD well fields. The second phase of the Investigation consisted of drilling and constructing two monitoring wells east of San Juan Creek—SJC18 MW-9 and SJC18 MW-10 (see Figure 2)—to further characterize the hydrogeology east of San Juan Creek. The two monitoring wells have been equipped with pressure transducer, temperature, and electrical conductivity data loggers that continuously record data. The data collected from the two monitoring wells are currently being used to help understand the groundwater flow system east of San Juan Creek.

Lithologic data collected as part of the Investigation were analyzed and used to develop several hydrostratigraphic[9] cross-sections that illustrate the subsurface lithology and to update the Basin's bottom of aquifer geometry. Appendix A contains the hydrostratigraphic cross-sections, and Figure 2 shows the cross-section profile locations. The hydrostratigraphic cross-sections show:

1. the bottom of the aquifer geometry as understood before the Investigation, as characterized by Geoscience Support Services, Inc.[10];
2. updated bottom of the aquifer geometry based on new drilling results;
3. subsurface lithology at boreholes, color-coded based on the lithology and general hydraulic conductivities of the materials;
4. well-screen intervals, if applicable; and,
5. the locations and depths of the Orange County Public Works (OCPW) sheet-piles

The bedrock-high extends from about Via Del Rey south to Calle Jardin (about 1,500 feet) and from the western boundary of the Basin to the eastern levee of San Juan Creek (about 2,300 feet). The general extent of the bedrock-high is shown in Figure 2 as a dashed polygon. For a

[9] A hydrostratigraphic unit is a geologic formation, or part of a formation, or a group of formations with similar hydrologic characteristics or properties (e.g. hydraulic conductivity or permeability) relating to groundwater flow.

[10] Geoscience Support Services (2013). *South Orange County Ocean Desalination Project, Phase 3 Extended Pumping and Pilot Plant Testing, Volume 3 – San Juan Basin Regional Watershed and Groundwater Models.* Prepared for the Municipal Water District of Orange County.

more detailed discussion on the hydrogeology of the Basin to the west and east of the San Juan Creek eastern levee, see footnotes 8 and 9 referenced in this document.

Figure 3 shows the depth to the bottom of the aquifer[11] and illustrates the thickness of the aquifer in the Investigation area in plan-view. Figure 3 also shows the approximate extent of the bedrock-high as characterized based on available data. The Investigation determined that the bedrock-high west of the San Juan Creek eastern levee is likely considered to be an impediment to groundwater flow between the City and SCWD well fields. For example, if groundwater levels north of the bedrock-high are deeper than about 13 ft-bgs (an elevation of about 42 feet-msl), groundwater will not be able to flow over the bedrock-high. Instead, groundwater will follow a tortuous flow path around the bedrock-high.

## Aquifer Testing

To better understand the groundwater flow system east of the San Juan Creek eastern levee, aquifer tests were conducted at the SCWD's Stonehill well and the City's Kinoshita well in fall 2018. The objectives of the aquifer tests were to collect data and information to support the characterization of the Basin's aquifer and groundwater flow system, update the aquifer's hydraulic properties, and assess if any groundwater no-flow boundaries (i.e. Basin boundaries, bedrock-high, and/or the OCPW sheet-piles) are impacting groundwater flow to the City and SCWD well fields. The aquifer tests, methods, and results are discussed in the well completion report for SJC18 MW-9 and SJC18 MW-10 (see footnote 9). Based on the aquifer tests results, the following key observations were derived regarding the Basin's groundwater flow system and the hydraulic connection between the City and SCWD well fields:

- During the Kinoshita well aquifer test, the cone of depression centered at the well did not extend much further beyond SJC18 MW-10 or reach the northern extent of the bedrock-high mapped west of the San Juan Creek western levee. In other words, SJC18 MW-10 is located within the Kinoshita well's cone of influence.
- During the Stonehill well aquifer test, the cone of depression centered at the well did not extend much further beyond SCWD MW-2S or reach the southern extent of the bedrock-high. Likewise, the cone of depression did not extend to SJC18 MW-9 on the east side of San Juan Creek. In other words, SCWD MW-2S is located within the Stonehill well's cone of influence, but SJC18 MW-9 is not.

There may be several reasons why groundwater levels in SJC18 MW-9 did not respond to the Stonehill well aquifer test. For example, the 24-hour aquifer test period may not have been long enough to stress the system, and a longer pumping period, higher production rate, and/or different aquifer conditions (i.e. lower groundwater elevations) may have been needed to stress the aquifer-system and produce a groundwater level response in SJC18 MW-9. The lack of a

[11] The depth to the bottom of the aquifer for the Investigation area shown in Figure 3 was developed by adjusting the prior bottom of the aquifer contours developed by GSSI, based on information developed during the Investigation. Both the WEI- and GSSI-estimated bottom of aquifer elevations are shown in the hydrostratigraphic cross-sections in Appendix A.

groundwater level response in SJC18 MW-9 could also indicate that some type of hydraulic barrier[12] exists in the aquifer-system between the Stonehill well and SJC18 MW-9. Such a hydraulic barrier could be represented as a zone of low hydraulic conductivity materials or some type of ridge or escarpment in the Capistrano Formation that is acting as a groundwater flow impediment between the Stonehill well and SJC18 MW-9. The general area where the hydraulic barrier is hypothesized to occur is shown in Figure 3 as a red dashed line.

### Groundwater-flow Gradients

The groundwater-flow gradients, calculated from groundwater level data currently available through the Authority's monitoring programs, are among the primary lines of evidence indicating a hydraulic barrier may exist between the Stonehill well[13] and SJC18 MW-9. Figure 4 is a hydrostratigraphic cross-section that extends from MWDOC MW-2M to SJC18 MW-10. Figure 2 shows the location of this hydrostratigraphic cross-section (E-E'). Figure 4 illustrates graphically the groundwater-flow gradients between monitoring wells at the coast (MWDOC MW-2M) and monitoring wells east of San Juan Creek for three points in time: October 2018, March 2019, and March 2020.

The groundwater-flow gradients are expressed as a line representing the groundwater level elevation change between each pair of wells. Expressed as a value (percentage), the groundwater-flow gradient is equal to the difference in groundwater level elevation at two locations divided by the distance between these two locations and is directly proportional to the amount of water flowing across the two locations. The table below summarizes the groundwater-flow gradients for the monitoring wells shown in Figure 4 at the same three points in time. The value is positive when the groundwater-flow gradient between two points is seaward and the value is negative when the groundwater-flow gradient is landward. When the groundwater-flow gradient is zero, the slope of the water table is flat and the groundwater-flow between two points is considered to be stagnant.

| Monitoring Wells | Groundwater-flow Gradients | | |
|---|---|---|---|
| | October 2018 | March 2019 | March 2020 |
| SJC18 MW-10 to SJC18 MW-9 | -0.03% | 0.22% | 0.23% |
| SJC18 MW-9 to SCWD MW-1S | **1.3%** | **0.82%** | **1.14%** |
| SJC18 MW-9 to SCWD MW-4S | **0.53%** | **0.50%** | **0.61%** |
| SCWD MW-4S to MWDOC MW-2M | 0% | 0.19% | 0.01% |

As shown in Figure 4 and the above table, the groundwater-flow gradients between SJC18 MW-9 and SCWD MW-1S and SJC18 MW-9 and SCWD MW-4S are greater than the other well pairs and

[12] A general term referring to modifications of a groundwater flow system to restrict or impede movement of groundwater.

[13] The groundwater level elevations measured at SCWD MW-1S (adjacent to the Stonehill well) are used as a proxy for the groundwater level elevations at the Stonehill well to assess the groundwater-flow gradients between the Stonehill well and SJC18 MW-9.

are higher when the Stonehill well is continuously pumped (i.e. March 2020) versus when not pumped (i.e. March 2019). This indicates: (1) there is likely some type of hydraulic barrier in the aquifer-system located between the Stonehill well and SJC18 MW-9, (2) the hydraulic barrier is likely controlling the shape and upgradient extent of the Stonehill well's cone of depression, and (3) the lack of groundwater-flow from upgradient causes the well's cone of influence to preferentially expand towards the coast and not inland towards SJC18 MW-9. This supports the hypotheses that pumping from the Stonehill well may not impact groundwater levels east of the San Juan Creek eastern levee between the Stonehill well and SJC18 MW-9 and that pumping from the Stonehill well hydraulically prevents high-chloride waters from flowing upgradient towards the City's well field.

### Passive Aquifer Testing

In the SJC18 MW-9 and -10 well completion report and in the 2019 APM plan, WEI recommended performing passive aquifer testing[14] to further refine the characterization of the groundwater flow system to the east of San Juan Creek and to support the development of future adaptive pumping plans. The Authority's passive aquifer testing program began in June 2018 and consisted of collecting and analyzing high-frequency measurements of the groundwater level response to fluctuations in recharge and discharge from natural (i.e. precipitation-induced changes in streamflow or rising groundwater) and anthropogenic activities (i.e. changes in groundwater pumping) over a long period of time.

Figure 5 is a time-history chart that shows groundwater level responses at four monitoring wells (SCWD MW-4S, SCWD MW-2S, SJC18 MW-9, and SJC18 MW-10) to pumping from the Stonehill and Alipaz well fields between June 2018 and March 2020. Also shown are daily precipitation and streamflow measured at the La Novia station over the same time-period. The main observations and interpretations from this chart are:

- During summer months (June to August) and fall months (September to November), groundwater levels at each monitoring well show a general declining trend in response to drier climatic conditions and increased pumping. During winter months (December to February) and spring months (March to May), groundwater levels at each monitoring well show an increasing trend in response to wetter climatic conditions and decreased pumping.
- The groundwater level response at monitoring well SJC18 MW-9 shows a more muted response to the above noted seasonal groundwater level fluctuations compared to the groundwater level response at the other monitoring wells.
- Groundwater levels at monitoring wells SCWD MW-4S and -2S respond to immediate (instantaneous) and short-term (about one week) changes in pumping at the Stonehill well. Groundwater levels at these two wells show distinct drawdown and recovery curves in response to the Stonehill well turning on and off.

[14] Passive aquifer testing involves collecting production and water level data to observe the basin response to the intermittent cessation of pumping (for a minimum of four hours) after production wells have pumped continuously for at least 30 days.

- Groundwater levels at monitoring well SJC18 MW-10 respond to immediate (instantaneous) and short-term (about one week) changes in pumping at the Alipaz well field. Groundwater levels at this well show distinct drawdown and recovery curves in response to the Alipaz well field turning on and off. Groundwater levels at monitoring well SJC18 MW-9 do not appear to respond to immediate (instantaneous) and short-term (about one week) changes in pumping at either the Stonehill well or Alipaz well field.

The "hydraulic barrier" observations are most notable when the Stonehill well was shutdown between December 15, 2018 and May 9, 2019. When it shutdown, there was an immediate groundwater level recovery response at SCWD MW-4S and -2S but not at SJC18 MW-9. Conversely, on May 9, 2019, when the Stonehill well resumed pumping an immediate and persistent groundwater level drawdown response was observed at SCWD MW-4S and -2S, but not at SJC18 MW-9. This suggests that the Stonehill well produces some groundwater from a small portion of the aquifer immediately upgradient of the pumping well, but it mainly produces groundwater from the downgradient aquifer(s). It also indicates that other areas contributing recharge to the Stonehill well (surface water recharge and groundwater-flow upgradient of the Stonehill well) are limited. Taken collectively, these observations indicate the potential existence of a hydraulic barrier between the Stonehill well and SJC18 MW-9.

### Implications for Adaptive Pumping Management

The bedrock-high west of the San Juan Creek eastern levee and the potential hydraulic barrier between the Stonehill well and SJC18 MW-9 suggest that there may be two distinct sub-basins in the lower Basin that are connected primarily by surface water flow in San Juan Creek. Based on the updated hydrogeologic conceptual model discussed above and for the purpose of complying with water rights permits, pumping in the two sub-basin areas should be managed separately. The downstream sub-basin is referred to as the Stonehill management zone and the upstream sub-basin is referred to as the Inland management zone.

The recommended 2020 APM is based on this updated and current understanding of the Basin's hydrogeologic conditions, and the pumping allocation and methodology for adjusting the allocation for each management zone are based on current Basin conditions (Spring 2020). The hydrogeologic criteria for managing pumping to comply with the water rights permits are described below.

## Criteria for Managing Pumping in the Stonehill Management Zone

Figure 6 is a time-history chart that shows the groundwater level response at SCWD MW-4S and MWDOC MW-2M to pumping at the Stonehill well. Figure 6 also shows the theoretical optimal operating range of groundwater elevations that would need to be maintained to prevent seawater intrusion (lower limit) and the rejection of groundwater recharge (upper limit). The lower limit elevation of 5.1 feet above mean sea level was computed based on the Ghyben-Herzberg principal and is intended to represent the elevation at which the freshwater/seawater interface would terminate downgradient of SCWD MW-4S, thus protecting the Basin from seawater intrusion. If, as described in the discussion of the hydrogeologic conceptual model, the

Stonehill well predominantly pumps groundwater from the downgradient aquifers, groundwater levels at downgradient SCWD MW-4S would need to be maintained at elevations that prevent the occurrence of seawater intrusion. Data collected since 2017 suggest that this is not a practical management criterion. For example, under this criterion, the SCWD would have been required to cease pumping just six months after resuming operations in February 2017 under "full" Basin conditions.

In order to make practical beneficial use of the groundwater, the SCWD needs to be able to pump more consistently than six months at a time. Therefore, developing a pumping plan for the Stonehill management zone based on criteria that completely prevents seawater intrusion is not practical. However, if the management criterion is defined to manage pumping to "not cause injury to the reasonable and beneficial uses of water designated in the Basin Plan," as is the intention of the water rights permits, a practical APM methodology can be developed that allows some increase in TDS and chloride concentrations and less frequent periods of non-operation.

The designated beneficial uses of the Lower San Juan Hydrologic Sub-Area are municipal water supply, agricultural water supply, and industrial water supply.[15] From a beneficial use standpoint, the water quality of the Basin (in both the Stonehill and Inland management zones) is naturally high in TDS, and in fact, absent the GRF and GWRP, groundwater cannot be put to beneficial use—the existence of these treatment plants enables the beneficial use of the water and creates space for low-TDS stormwater to recharge. Thus, allowing for some increases in TDS and chloride concentrations in the Stonehill management zone does not constitute "degradation that would cause injury to the reasonable and beneficial uses of water designated in the Basin Plan."

Currently, the SCWD is the only entity using groundwater in the Stonehill management zone, and for this reason, pumping should be managed to protect the SCWD's beneficial use. This translates to managing pumping such that TDS and chloride concentrations do not exceed the concentrations the GRF can successfully treat to meet potable municipal supply standards. This requires a method that considers:

1. the duration of time between the onset of conditions conducive to seawater intrusion and when TDS and chloride concentrations increase at a sentinel monitoring well;
2. the duration of time from which the occurrence of seawater intrusion is observed at a sentinel monitoring well and its subsequent occurrence at the SCWD well field;
3. whether groundwater quality can generally return to pre-intrusion conditions; and,
4. TDS and/or chloride concentration limits that protect the SCWD's beneficial use.

Collectively, the time durations defined in (1) and (2) above are referred to herein as "lag times." An analysis of the data available to characterize these lag times, based on the one observed occurrence of seawater intrusion for the period of record for the coastal monitoring wells, is

[15] See chapter 2 of the San Diego Basin Plan:
https://www.waterboards.ca.gov/sandiego/water_issues/programs/basin_plan/docs/update082812/Chpt_2_2012.pdf

documented in the 2018 APM plan.[16] The 2014 occurrence of seawater intrusion was the result of both pumping and streambed recharge conditions: pumping was occurring near design rates, and there was limited streambed recharge over multiple years due to extreme dry climate conditions. These extreme conditions suggest that the lag times estimated based on this event are representative of worst case (fastest) lag times. The main conclusions from the analysis presented in the 2018 APM Plan are as follows:

- It took about 22 months between the onset of conditions conducive to seawater intrusion —when the groundwater-flow gradient reversed from seaward to landward between SCWD MW-4S and MWDOC MW-2M[17] in July 2012—and when TDS and chloride concentrations increased at SCWD MW-4S in April 2014. Figure 6 illustrates this time lag by comparing the groundwater level time history at SCWD MW-4S and MWDOC MW-2M with the time history of chloride concentrations measured at SCWD MW-4S.
- It took about five months for the TDS and chloride concentration increases observed at SCWD MW-4S to be observed at upgradient SJBA MW-01S (Costco well) and about seven months to be observed at further upgradient SCWD MW-1S.
- Following a seawater intrusion event, TDS and chloride concentrations can generally return to pre-intrusion concentrations with the recovery time dependent on climate conditions—recovery will occur faster in wet periods than dry periods.

The chloride concentration time history shown in Figure 6 demonstrates that the increase in chloride concentrations can generally be reversed: it is not permanent. Chloride concentrations at both SCWD MW-4S and SCWD MW-1S returned to pre-intrusion concentrations following a wet period. However, at the Costco well – which is located between SCWD MW-4S and -1S and further east of San Juan Creek, – chloride concentrations did not fully return to pre-intrusion concentrations. This is likely because there is less influence from streambed recharge and less circulation of groundwater in this area. A more detailed discussion of the chloride concentration trends observed at the Costco well is described in the section, "Chloride Concentrations in the Stonehill Management Zone."

Based on the lag time and water quality analysis, it is reasonable to allow TDS and chloride concentrations to increase in the Stonehill management zone until they approach the beneficial use limits defined by the SCWD. The limits have to be determined by the SCWD to accurately account for the specifics of plant operations and the goals for GRF product water to protect the SCWD's beneficial use. These limits are subject to refinement by the SCWD.

A preliminary TDS concentration limit of 3,500 mgl was defined by the SCWD to protect its beneficial use. This translates to an approximate chloride concentration limit of 1,000 mgl, as

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[16] WEI. (2018). *San Juan Basin 2018 Adaptive Pumping Management (APM) Plan*. Prepared for the San Juan Basin Authority. May 30, 2018.

[17] When groundwater elevations at SCWD MW-4S are greater than those at MWDOC MW-2M, the groundwater-flow gradient is seaward, and when groundwater elevations at SCWD MW-4S are less than those at MWDOC MW-2M, the groundwater-flow gradient is landward.

estimated in the 2018 APM plan analysis. Thus, pumping would have to be reduced or curtailed once chloride concentrations approaching 1,000 mgl are estimated to imminently arrive at the Stonehill well. This occurrence can be estimated based on (1) the lag time (at least 22 months) once conditions of seawater intrusion are observed at SCWD MW-4S and continue to persist, and (2) the lag time (about five months) once the chloride concentration at SCWD MW-4S is 1,000 mgl.

In order to confirm and refine these estimated lag times, it will be necessary to continue pumping until the chloride and TDS concentrations measured at the Stonehill well reach 1,000 and 3,500 mgl, respectively. Although it is believed there likely is a hydraulic barrier between the City and SCWD well fields, additional safeguards should be included in the APM plan to ensure that any increase in TDS and chloride concentrations that occur in the Stonehill management zone do not have the ability to impact the Inland management zone. Based on analysis to date, one way for groundwater to potentially migrate upgradient into the Inland management zone is through the aquifer channel to the east of San Juan Creek, and this that can only occur if the groundwater-flow gradient (direction of flow) is landward. Thus, the APM monitoring program should regularly assess the groundwater-flow gradient to the east of San Juan Creek to ensure that groundwater cannot move landward beyond SJC18 MW-9.

## Criteria for Managing Pumping in the Inland Management Zone

Based on the updated hydrogeologic conceptual model, pumping in the Inland management zone needs to be managed to: (1) protect riparian vegetation in the reach of San Juan Creek between I-5 and Ortega Highway (green shaded area on Figure 1), and (2) ensure that pumping does not decrease the volume of water in storage in the Basin to less than 50 percent of full capacity.

During the development of the 2016 APM plan, WEI collaborated with Glenn Lukos Associates (GLA), the Authority's Biologist of Record, to define groundwater level elevation thresholds that are protective of riparian habitat based on historical observed groundwater level elevations at three monitoring wells and riparian habitat conditions. The thresholds represent the minimum groundwater level elevation that can support riparian vegetation in the absence of precipitation and surface water flows and are generally about twenty feet below ground surface.[18]

Figure 7 is a time-history chart of pumping and groundwater level elevations in the riparian habitat area for January 2004 to April 2020 and shows the protective thresholds defined for the Authority's three monitoring wells in this area (SJBA MW-4, SJBA MW-5, and SJBA MW-6). To ensure these thresholds would be maintained, the 2016 APM plan also recommended that all Authority pumping pursuant to the plan be limited to the City's Alipaz well field, meaning that the City could not pump the allocation from its three production wells in the riparian habitat

[18] For a full discussion of the protective thresholds, refer to WEI. (2016). *San Juan Basin 2016 Adaptive Pumping Management (APM) Plan*. Prepared for the San Juan Basin Authority. August 30, 2016. http://sjbauthority.com/assets/downloads/20160830_APM_Memo.pdf

area—the Tirador, South Cooks, and CVWD-5A wells. The basis of this recommendation was twofold:

1. prior to the initiation of pumping at the South Cooks and CVWD-5A wells in 2011, the City's pumping was limited to the Tirador well, and groundwater level elevations were generally always above the protective thresholds; and,
2. groundwater modeling performed in support of the 2016 APM plan suggested that not pumping all three wells was required to guarantee that groundwater level elevations would remain at or above the protective thresholds.

As part of the 2018 APM plan, based on the results of the monitoring through March 2018, shown in Figure 7, which shows that the City's prior pumping at the Tirador well did not result in groundwater level elevations declining below the protective thresholds, WEI and GLA concluded that it is reasonable to allow some pumping in the riparian area, but that pumping should be limited to the Tirador well and the APM should include monitoring protocols to adjust pumping if groundwater levels decline below the protective thresholds. The pumping allocation would need to be incrementally adjusted from month-to-month to observe groundwater level responses to reduced production.

In 2019, the City informed the Authority that it needed to resume pumping at its South Cooks and CVWD-5A wells in the riparian habitat area in order to meet its obligations to provide water to the San Juan Hills Golf Club (SJHGC). The agreement between the City and the SJHGC calls for the City to deliver up to 350 afy, and the City generally expects deliveries to range between 220 and 350 afy. These deliveries are meant to supplement or replace pumping from the SJHGC's two production wells. The pumping rights are being exercised under the SJHGC's water rights permit 21142. The location of the SJHGC's production wells are shown in Figure 1. Although the criteria for pumping discussed above recommend limiting pumping in the riparian habitat area to the Tirador well, because the pumping volumes proposed by the City at the South Cooks and CVWD-5A wells are small and are substituting or replacing pumping that would otherwise occur at the adjacent SJHGC wells, the impacts to groundwater levels in the riparian habitat area are expected to be minimal.

The City has recently expressed interest in increasing pumping at the South Cooks and CVWD-5A wells beyond its obligations to provide water to the SJHGC. In a letter dated July 27, 2015, the Biologist of Record (GLA) recommended that resuming groundwater pumping in the riparian habitat area should be considered only if pumping does not result in the expansion of impacts to riparian vegetation and does not impede the long-term recovery of riparian habitat. In the same letter, GLA also recommended developing a sustainable groundwater pumping plan and establishing a series of monitoring protocols prior to and during pumping if the City pursues pumping from the South Cooks and CVWD-5A wells. Such a pumping and monitoring plan would need to be developed in consultation with GLA.

With regard to managing storage in the Basin, storage should continue to be assessed quarterly based on groundwater level monitoring to ensure that levels are not approaching 50 percent of full capacity.

## Current Basin Conditions

This section summarizes the current Basin conditions that, in combination with the criteria for managing pumping in the Stonehill and Inland management zones, serve as the basis for the 2020 APM Plan.

### Climate

The Authority reviews precipitation data measured at the Orange County's San Juan Capistrano Station at La Novia (Station 215) to characterize and understand historic as well as real-time and local precipitation trends. Table 1 summarizes the measured monthly and annual precipitation at Station 215. The period of record for this station is 1991 to present. Table 1 also shows summary statistics for the station's period of record and for water years (WY) 2005 through 2020[19] – the time period since pumping began pursuant to Permit 21074. Total precipitation in WY 2019 was 16.3 inches, about 13 inches greater than precipitation in the prior water year (WY 2018), about four inches higher than the average for the period of record (1991 to present), and about five inches higher than the average for the 2005 through 2019 period. Thus far, total precipitation in WY 2020, as of April 19, 2020, was 15.5 inches.

Figure 8 shows the cumulative precipitation by water year for the wettest, driest, average, previous, and current year at Station 215.[20] The average precipitation is about 12 inches per year and primarily occurs between the months of October and April. The driest year occurred in 2018, with a total precipitation of about 4 inches. The wettest year occurred in 2005, with a total precipitation of about 28 inches. WY 2019 was above average at about 16 inches. Precipitation Thus far in WY 2020, is just above the average precipitation recorded at Station 215, totaling 15.5 inches through April 19, 2020.

Figure 9 is a time-history chart of daily (cfs) and annual (af) streamflow in San Juan Creek at the La Novia and in Arroyo Trabuco stations by water year. The above average precipitation observed in WY 2019, in November and December 2019 and March 2020 contributed significant streamflow to San Juan Creek and Arroyo Trabuco. As of April 19, 2020, there was still measurable streamflow at both surface water stations.

**Based on these conditions, the initial 2020 pumping allocation should be set at the maximum limit for both the Stonehill and Inland management zones.**

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[19] The water year is October 1 through September 30. Water year 2020 corresponds to the period from October 1, 2019 through September 30, 2020. For the purposes of the 2020 APM, total precipitation is reported through the end of March 2020.

[20] Note that the period of record for the La Novia station only extends back to 1984. However, due to the strong correlation between measured precipitation at this station and the annual watershed precipitation based on the PRISM dataset, an estimated historical record for the La Novia station can be extrapolated back to 1895.

## Groundwater Levels

**Coastal area.** Figure 6 shows that as of the end of March 2020, the groundwater level at SCWD MW-4S is just above the lower limit of the theoretical optimal operating range, which is preventative of seawater intrusion. The groundwater level elevation at SCWD MW-4S is also just slightly above the groundwater level elevation at MWDOC MW-2M, which indicates that the groundwater flow-gradient is flat[21]; a flattened groundwater-flow gradient is not, by itself conducive to seawater instruction. Figure 4 illustrates this: the groundwater-flow gradient between SCWD MW-4S and MWDOC MW-2M was approximately 0.01% as of March 2020.

**East of San Juan Creek**. Figure 4 shows the groundwater-flow gradients from SJC18 MW-10 to MWDOC MW-2M. At the end of March 2020, all gradients were positive, indicating that the gradient of flow was seaward from the Inland management zone to the Stonehill management zone.

**Riparian vegetation monitoring area**. Figure 7 shows the time series of groundwater level elevations in the riparian vegetation monitoring area as observed at monitoring wells SJBA MW-4, -5, and -6. For each well, the 2016 APM groundwater elevation thresholds that are protective of riparian vegetation are shown as horizontal lines. As of the end of March 2020, the groundwater level elevations at SJBA MW-4, -5, and -6 were eleven, seven, and five feet above the protective threshold, respectively. There has been little to no change in groundwater level elevations in the riparian habitat monitoring area since March 2017. This is in large part due to the cessation of pumping in this area.

**Basin-wide Levels and Storage**. Figure 10 shows the time series of groundwater level elevations at selected wells from January 2005 through March 2020 in four areas of the Basin: the Stonehill management zone, the Alipaz well field, the San Juan Creek arm (riparian vegetation monitoring area), and the Arroyo Trabuco arm. For each area, the chart shows monthly groundwater pumping within the area and measured groundwater level elevations for the representative well. Also shown, as a horizontal line, is the elevation of the stream bottom near the representative wells; this is the elevation at which the Basin is considered to be 100 percent full at that location. This figure shows that groundwater level elevations across the Basin are close to or above the stream bottom elevation as of March 2020, indicating that the Basin is full.

**Based on these four area assessments of groundwater level conditions across the Inland and Stonehill management zones, the Basin is near full, suggesting that the initial 2020 pumping allocations should be set at the maximum limits.**

## Chloride Concentrations in the Stonehill Management Zone

Figure 6 includes a time-history chart of the chloride concentration measured at SCWD MW-4S, SCWD MW-1S, Stonehill, and the Costco well since in 2010. As of March 26, 2020, the chloride concentration at SCWD MW-4S was 220 mgl, which is at the bottom range of observed

[21] A hydraulic gradient greater than -0.05% (a negative gradient indicates a landward gradient) and less than 0.05% (a positive gradient indicates a seaward gradient) is considered to be flat. Typical hydraulic gradients in California's basins and valleys range from 0.05% to 1% (Harter, 2003).

concentrations since water quality returned to pre-seawater intrusion conditions in March 2017 (220 to 430 mgl).

As of March 26, 2020, the chloride concentration at the Costco well was 1,600 mgl, which is higher than any other monitoring wells located adjacent to San Juan Creek (SCWD MW-1S and -4S) and higher than the maximum observed chloride concentration of 1,200 mgl at the Costco well during the seawater intrusion event in 2014. As previously discussed, chloride concentrations at the Costco well did not fully return to pre-seawater intrusion concentrations in 2017. One explanation may be that there is less influence from low-TDS streambed recharge and less circulation of groundwater near the Costco well. As such, it is possible that when groundwater-flow gradients are landward (i.e., summer 2014, summer 2018, and fall 2019, as shown on Figure 6) due to groundwater level declines from seasonal dry climatic conditions and consistent pumping from the Stonehill well, high-chloride seawater likely migrates landwards and preferentially towards the Costco well and the high-chloride seawater is then subsequently "cut-off" from the larger groundwater flow system. Based on available information, it is not possible to know if the high chloride concentrations currently observed are from a prior seawater intrusion event or representative of an active occurrence of seawater intrusion following a different preferential path than was observed in 2014. For reference, Figure 11 shows chloride concentrations from wells in the Stonehill management zone (including SJC18 MW-9) between January 2010 and March 2020. It is important to note that the chloride concentrations, variability, and overall increasing trend observed at the Costco well is not observed in any other wells in the Stonehill management zone. It is also important to note that the Costco well is a monitoring well, not a production well representing a beneficial use.

Based on the chloride concentration trends observed exclusively at the Costco well, the 2020 APM monitoring plan should include monthly sampling of the Stonehill well (when it is in operation) and monthly review of the continuously recorded electrical conductivity (EC) data from the data logger installed in the Costco well to asses and verify the chloride concentration trends described above and to ensure the Stonehill well doesn't exceed the beneficial use threshold defined by the SCWD.

**Based on current groundwater quality conditions, the initial 2020 pumping allocation should be set at the maximum limit for the Stonehill management zone.**

## Recommended 2020 APM Plan: May 2020 to April 2021

This section summarizes the recommended 2020 APM plan for the Stonehill and Inland management zones based on the most up-to-date understanding of the hydrogeologic conceptual model of the Basin, criteria for managing pumping in the Stonehill and Inland management zones, and current Basin conditions (climate, groundwater levels, and groundwater quality). Both management plans will be complemented with the passive aquifer testing program recommended as part of this APM plan.

## APM Plan for the Stonehill Management Zone

Based on the preceding discussions, the recommended 2020 APM plan for the Stonehill management zone is as follows:

- Pumping by the SCWD is limited to the amount allowed under Permit 21138: 1,300 afy. Note that the SCWD's current maximum pumping capacity at the Stonehill well is about 1,100 afy.
- To track changes in groundwater-flow gradients, groundwater level data from the continuously recording data loggers installed at the following wells will be downloaded on a monthly basis: MWDOC MW-2M, SCWD MW-4S, SCWD MW-1S, SJC18 MW-9, and SJC18 MW-10.[22]
- To track the changes in coastal groundwater quality:
  - Grab samples for laboratory analysis will be collected monthly at SCWD MW-4S and the Stonehill well (when it is in operation).[23] The list of analytes to be tested is provided in Table 2.
  - EC data from the continuously recording data loggers installed at the following wells will be downloaded monthly: SCWD MW-4S, SCWD MW-4D, SCWD MW-1S, SCWD MW-1D, and the Costco well.[24]
- When the chloride concentration at SCWD MW-4S equals or exceeds 1,000 mgl, water quality samples will also be collected monthly at SCWD MW-4D, the Costco well, SCWD MW-1S, and SCWD MW-1D.
- The Authority will recommend that the SCWD cease pumping when the TDS concentration at the Stonehill well exceeds 3,500 mgl.
- The TDS and chloride concentration metrics defined in this plan can be updated upon notification from the SCWD that influent to the GRF can be managed to an alternative concentration limit.

The recommended monitoring frequencies in this plan are necessary to refine the understanding of chloride concentration travel times and to provide sufficient lead time for the SCWD to plan for shutdown of the GRF. It may also be appropriate to adjust the monitoring protocols during the year based on monitoring results or changes to the pumping plan.

WEI will analyze the data monthly and prepare quarterly reports to the Authority that summarize monitoring results and include any recommended modifications to the 2020 APM plan for the

[22] The data loggers in SCWD monitoring wells are downloaded by SCWD staff, and the data are provided to the Authority monthly. The remaining data loggers are downloaded by the Authority.

[23] Water quality samples from Stonehill well are collected by the SCWD staff, and the data are provided to the Authority monthly. The remaining wells are sampled by the Authority.

[24] The data loggers in SCWD monitoring wells are downloaded by the SCWD staff, and the data are provided to the Authority monthly. The remaining data loggers are downloaded by the Authority.

Stonehill management zone. The recommended reporting schedule for the 2020 APM plan is: August 2020, November 2020, February 2021, and May 2021.

## APM Plan for the Inland Management Zone

Based on the preceding discussions, the recommended 2020 APM pumping plan for the Inland management zone is as follows:

- Pumping by the City under the Authority's allocation is limited to the amount allowed under the October 2002 *Project Implementation Agreement for the San Juan Basin Desalter Project*: 5,800 afy.
- Pumping by the City under the Authority's allocation is limited to the wells in the Alipaz well field plus the Tirador well.
- Pumping by the City under the SJHGC's permit pursuant to its agreement with the SJHGC is limited to 350 afy.[25] To the extent that the pumping continues at the SJHGC wells, the total combined pumping by the SJHGC and by the City for SJHGC is limited to 350 afy. If the City uses the South Cooks and CVWD-5A wells to meet its obligation to the SJHGC, total pumping from these two wells is limited to 350 afy.
- If the City would like to resume production at the South Cooks and CVWD-5A for uses beyond meeting the agreement with the SJHGC, a consultation with the Biologist of Record must be initiated and a plan developed and implemented to ensure the protection of riparian vegetation.
- To track that groundwater levels are being maintained at levels that are protective of riparian vegetation:
  - Groundwater level elevation data from the continuously recording data logger installed at SJBA MW-4 will be downloaded monthly.
  - Groundwater level elevation data from the continuously recording data loggers installed at SJBA MW-5 and -6 will be downloaded quarterly.
- When groundwater level elevations at SJBA MW-4, -5, and/or -6 drop below the protective threshold, the City will either change its pumping allocation among the riparian habitat area wells or reduce pumping in the riparian habitat area; this will trigger monthly monitoring at these three monitoring wells.
- If the groundwater level elevations remain below the protective threshold under the adjusted pumping in the riparian habitat area, the Authority will request that the City reduce or cease pumping in the riparian habitat area.

If the groundwater level elevations remain below the protective threshold under ceased pumping, the City will reduce pumping in the Alipaz well field and consult with the Biologist of Record to develop additional criteria for pumping. WEI will analyze the data monthly and prepare

[25] In other words, the City's total pumping limit is 6,150 afy (5,800 + 350).

quarterly reports to the Authority that summarize current Basin conditions and include any recommended modifications to the 2020 APM plan for the Inland management zone. The recommended reporting schedule for the 2020 APM plan is: August 2020, November 2020, February 2021, and May 2021.

## Passive Aquifer Testing Program

Based on the results of the Investigation and the 2019 APM plan recommendation, the passive aquifer testing program began in June 2018 and has continued through present day. An important aspect of the passive aquifer testing program is that it provides an assessment of groundwater level changes and aquifer-system responses to both natural and man-made stresses over a large area and over a long-period of time. The overall intent of the passive aquifer testing program is to support the development of future adaptive pumping plans that ensure the protection of beneficial uses of the Basin, as required by water rights permits.

The 2019 APM plan recommended the passive aquifer testing program to occur for a minimum of 12 months and up two to three years to observe a full range of seasonal aquifer conditions (different groundwater levels), hydrologic conditions (changes in streamflow), and pumping conditions (i.e., pumping rates, pumping duration, and shutdown periods). An assessment of hydrologic, pumping, and aquifer-system conditions indicates that the above average annual precipitation for WY 2019 (see Table 1) and prolonged shutdown period of the Stonehill well between mid-December 2018 and mid-May 2019 (see Figure 5) had kept groundwater levels in the lower Basin elevated for much of 2019. Because of these conditions, the Basin was not "stressed" sufficiently to test or observe, specifically, the groundwater level response in the program's monitoring wells. It is recommended the passive aquifer testing program continue as part of the 2020 APM plan to capture more variability in the lower Basin's groundwater level response to hydrologic, pumping, and aquifer-system conditions.

## Tracer Testing

In 2018, WEI and the TAG members began discussing possible technical approaches to further test for the presence of a potential hydraulic discontinuity between the Stonehill well and SJC18 MW-9 and to better characterize the groundwater flow-system east of San Juan Creek between the City and SCWD wells fields. Based on these discussions, the TAG directed WEI to perform research and scope out a work plan to implement a tracer study as a next step. Tracer testing is a well-established technique that can be used in a wide variety of subsurface environments to further hydrogeologic site characterization. Specifically, for the lower Basin, results from tracer testing would yield information on groundwater-flow paths, groundwater velocities and travel times, and aquifer parameters. The information derived from tracer testing could also support the development of adaptive pumping plans that ensure the protection of beneficial uses of the Basin as required by water rights permits and would be used to refine the analytical and numerical tools to support current and future water resources management plans.

The work plan is currently being prepared and will include a description of the tracer testing options including tracer type, tracer application(s) (location and dosing method), other implementation logistics, tracer monitoring (sample collection), field and laboratory analysis, and reporting. The work plan will also characterize the risks and challenges associated with implementing a tracer study (e.g. the risk that the tracer is never detected downgradient of the application point). As originally proposed, the work plan is intended to be completed, including review by the TAG by the end of fiscal year 2019/20~~.~~

If the work plan identifies a feasible and economic approach to a tracer study, it is recommended that the tracer study be implemented in fiscal year 2020/21 to support the development of future APM plans.

## Attachments

| | |
|---|---|
| Table 1 | Monthly and Annual Precipitation: San Juan Capistrano Station at La Novia (Station 215) Water Years: 1991 - 2020 |
| Table 2 | Analytes Sampled for the 2020 APM Monthly Water Quality Field Program |
| Figure 1 | Monitoring Sites in the San Juan Basin |
| Figure 2 | Lower San Juan Basin Key Well Locations and Other Features |
| Figure 3 | Lower San Juan Basin Depth to the Bottom of the Aquifer |
| Figure 4 | Groundwater-flow Gradients East of the San Juan Creek |
| Figure 5 | Groundwater Levels, Pumping, Precipitation and Streamflow in the Alipaz and Stonehill Management Zones |
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| Figure 9 | Streamflow at San Juan Creek and Arroyo Trabuco |
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| Appendix A | Lower San Juan Basin Hydrostratigraphic Cross-sections |

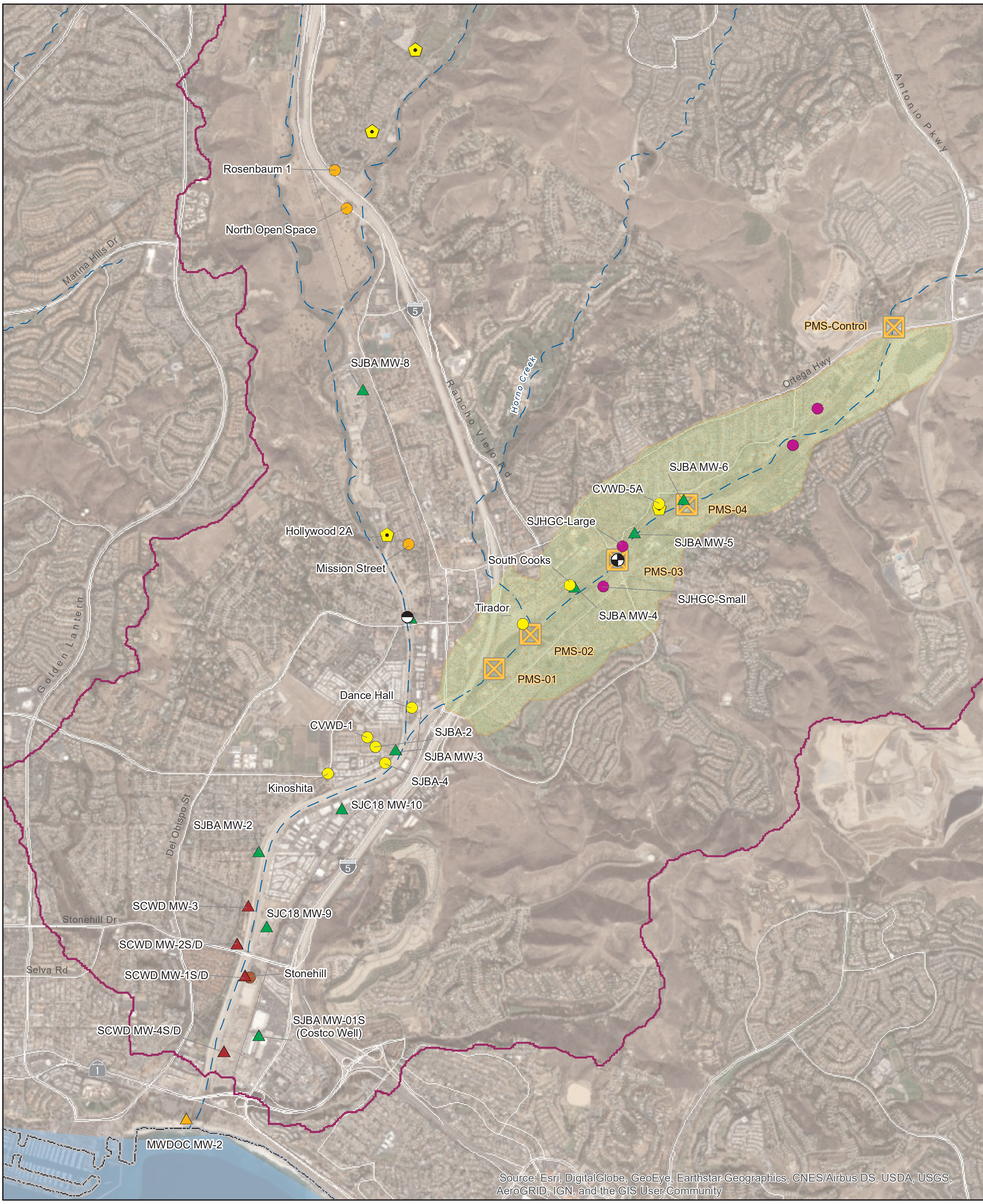
**Table 1**
**Monthly and Annual Precipitation: San Juan Capistrano Station at La Novia (Station 215)**
**Water Years: 1991 - 2020**
(inches)

| Water Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991 | 0.08 | 1.42 | 0.31 | 1.18 | 4.29 | 5.67 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.08 | **13.1** |
| 1992 | 0.35 | 0.00 | 1.85 | 2.13 | 7.32 | 4.48 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **16.4** |
| 1993 | 0.59 | 0.00 | 3.82 | 4.25 | 2.28 | IR | IR | IR | IR | IR | IR | IR | IR |
| 1994 | 0.35 | 0.67 | 0.56 | 0.67 | 4.61 | 1.45 | 0.83 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | **9.3** |
| 1995 | 0.04 | 0.00 | 0.86 | 10.55 | 1.30 | 6.58 | 1.65 | 0.40 | 0.23 | 0.16 | 0.00 | 0.00 | **21.8** |
| 1996 | 0.04 | 0.04 | 1.26 | 3.74 | 4.52 | 1.18 | 0.32 | 0.43 | 0.00 | 0.00 | 0.00 | 0.00 | **11.5** |
| 1997 | 1.34 | 2.99 | 3.19 | 5.15 | 0.16 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | **13.0** |
| 1998 | 0.00 | 2.05 | 2.71 | 3.00 | 12.44 | 4.53 | 1.10 | 1.18 | 0.12 | 0.00 | 0.00 | 0.35 | **27.5** |
| 1999 | 0.00 | 1.54 | 1.69 | 1.14 | 0.51 | 1.07 | 1.33 | 0.00 | 0.36 | 0.00 | 0.00 | 0.00 | **7.6** |
| 2000 | 0.00 | 0.00 | 0.00 | 0.00 | 5.08 | 2.44 | 1.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | **8.6** |
| 2001 | 1.69 | 0.32 | 0.00 | 4.25 | 7.48 | 0.91 | 0.90 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | **15.6** |
| 2002 | 0.00 | 1.85 | 0.46 | 0.28 | 0.00 | 0.83 | 0.39 | 0.04 | 0.04 | 0.00 | 0.00 | 0.00 | **3.9** |
| 2003 | 0.00 | 1.57 | 2.68 | 0.00 | 5.20 | 3.46 | 1.69 | 0.59 | 0.04 | 0.32 | 0.00 | 0.00 | **15.6** |
| 2004 | 0.59 | 0.47 | 0.75 | 0.35 | 3.67 | 1.10 | 0.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | **7.4** |
| 2005 | 5.67 | 1.26 | 3.03 | 8.47 | 7.72 | 0.90 | 1.38 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | **28.6** |
| 2006 | 1.22 | 0.19 | 0.59 | 0.79 | 1.14 | 2.76 | 2.16 | 0.56 | 0.07 | 0.00 | 0.00 | 0.00 | **9.5** |
| 2007 | 0.00 | 0.12 | 0.82 | 0.48 | 1.14 | 0.12 | 0.78 | 0.00 | 0.00 | 0.00 | 0.00 | 0.43 | **3.9** |
| 2008 | 0.00 | 1.26 | 1.03 | 3.30 | 2.21 | 0.00 | 0.04 | 0.31 | 0.00 | 0.00 | 0.00 | 0.04 | **8.2** |
| 2009 | 0.12 | 2.28 | 3.23 | 0.35 | 3.55 | 0.04 | 0.00 | 0.04 | 0.03 | 0.00 | 0.00 | 0.00 | **9.6** |
| 2010 | 0.67 | 0.00 | 2.36 | 3.98 | 3.50 | 0.16 | 0.63 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | **11.3** |
| 2011 | 2.44 | 1.14 | 10.87 | 1.10 | 2.05 | 2.64 | 0.15 | 0.55 | 0.04 | 0.08 | 0.00 | 0.08 | **21.1** |
| 2012 | 0.75 | 1.93 | 0.19 | 0.94 | 1.03 | 1.65 | 1.27 | 0.20 | 0.00 | 0.27 | 0.00 | 0.00 | **8.2** |
| 2013 | 0.94 | 0.63 | 2.26 | 1.14 | 0.40 | 0.67 | 0.00 | 0.27 | 0.00 | 0.00 | 0.00 | 0.00 | **6.3** |
| 2014 | 0.55 | 0.08 | 0.43 | 0.00 | 2.05 | 0.23 | 0.55 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | **3.9** |
| 2015 | 0.08 | 0.23 | 3.39 | 0.79 | 0.74 | 0.12 | 0.04 | 0.36 | 0.00 | 0.82 | 0.00 | 0.75 | **7.3** |
| 2016 | 0.16 | 1.38 | 1.14 | 2.32 | 0.24 | 1.45 | 0.20 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | **7.0** |
| 2017 | 0.00 | 1.38 | 4.13 | 7.77 | 3.27 | 0.04 | 0.00 | 0.55 | 0.00 | 0.00 | 0.00 | 0.08 | **17.2** |
| 2018* | 0.04 | 0.00 | 0.00 | 1.63 | 0.24 | 1.42 | 0.04 | 0.32 | 0.00 | 0.00 | 0.00 | 0.08 | **3.8** |
| 2019 | 0.83 | 0.48 | 2.04 | 4.91 | 6.15 | 1.10 | 0.16 | 0.67 | 0.00 | 0.00 | 0.00 | 0.00 | **16.3** |
| 2020** | 0.00 | 2.88 | 4.26 | 0.48 | 0.59 | 3.47 | 3.81 | | | | | | **15.5** |
| **Statistics for the Period of Record (1991 to 2020)** | | | | | | | | | | | | | |
| Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **3.8** |
| Max | 5.67 | 2.99 | 10.87 | 10.55 | 12.44 | 6.58 | 3.81 | 1.18 | 0.36 | 0.82 | 0.08 | 0.75 | **28.6** |
| Average | 0.62 | 0.94 | 2.00 | 2.50 | 3.16 | 1.74 | 0.73 | 0.25 | 0.03 | 0.06 | 0.00 | 0.07 | **11.9** |
| Median | 0.14 | 0.65 | 1.48 | 1.16 | 2.25 | 1.10 | 0.43 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | **9.6** |
| Standard Dev. | 1.12 | 0.91 | 2.14 | 2.71 | 2.93 | 1.79 | 0.85 | 0.29 | 0.08 | 0.17 | 0.02 | 0.17 | **6.7** |
| Coeff. of Variation | 1.82 | 0.97 | 1.07 | 1.08 | 0.93 | 1.03 | 1.16 | 1.16 | 2.44 | 2.74 | 3.89 | 2.34 | **0.6** |
| **Summary Statistics for the Period of Operation under Permit 21074 (2005 to 2020)** | | | | | | | | | | | | | |
| Min | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **3.8** |
| Max | 5.67 | 2.88 | 10.87 | 8.47 | 7.72 | 3.47 | 3.81 | 0.67 | 0.07 | 0.82 | 0.04 | 0.75 | **28.6** |
| Average | 0.84 | 0.95 | 2.49 | 2.40 | 2.25 | 1.05 | 0.70 | 0.27 | 0.01 | 0.08 | 0.00 | 0.10 | **10.8** |

Notes:

**Table 2**
**Analytes Sampled for the 2020 APM Monthly**
**Water Quality Field Program**

| Analyte |
|---|
| Potassium |
| Specific Conductance (at 25° Celsius) |
| Total Dissolved Solids |
| Hydroxide as OH (calculated) |
| Nitrate as Nitrogen |
| Nitrite as Nitrogen |
| Sulfate |
| Chloride |
| Bromide |
| Carbonate as $CO_3$ (calculated) |
| Alkalinity as $CaCO_3$ (calculated) |
| Iron |
| Magnesium |
| Manganese |
| Sodium |
| Boron |
| Calcium |
| Fluoride |
| Bicarbonate Alkalinity as $HCO_3$ (calculated |
| Total Hardness as CaCO3 (calculated) |
| pH |
| Total Nitrate, Nitrite-N |




Author: AP Date: 4/14/2020 N:\MapDocs\Clients\SJBA\2020 APM\MonitoringPrgrm_LocationMapv1.mxd

***Monitoring Sites***

- SJBA Monitoring Well
- SCWD Monitoring Well
- MWDOC Monitoring Well
- Plant and Surface Water Monitoring Station
- San Juan Capistrano Surface Water and Precipitation Station at La Novia
- San Juan Capistrano Surface Water Station at Arroyo Trabuco

***Other Wells in the San Juan Basin***

- SCWD GRF Desalter Well
- CSJC GWRP Desalter Well
- Other CSJC Production Well
- CSJC Inactive Production Well
- Private Production Well

***Boundaries***

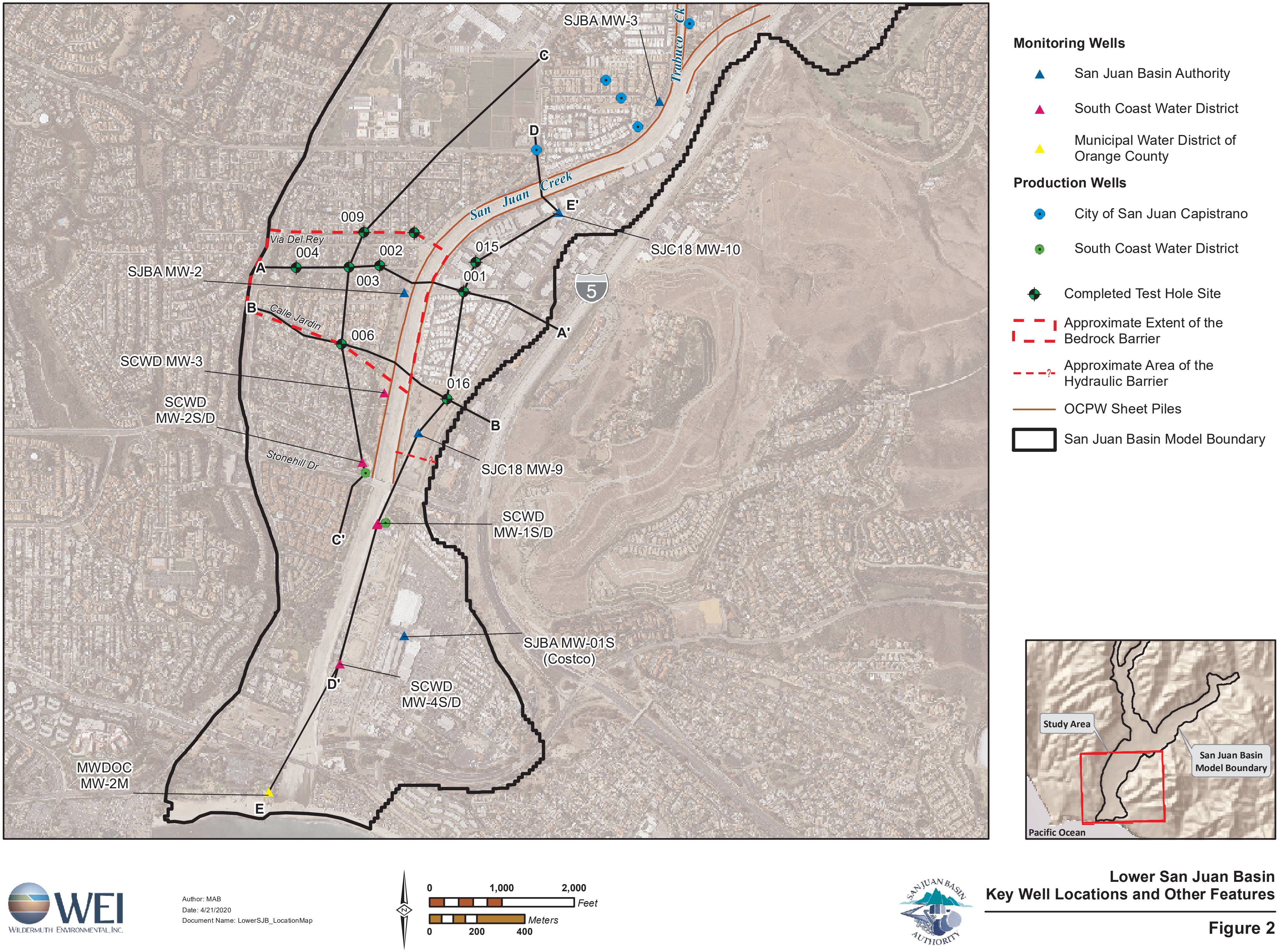
- Riparian Vegetation Monitoring Area
- San Juan Basin Watershed


0 1,000 2,000 Feet

0 400 800 Meters

**Monitoring Sites in the San Juan Basin**

**Figure 1**

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Date: 4/21/2020
Document Name: LowerSJB_LocationMap

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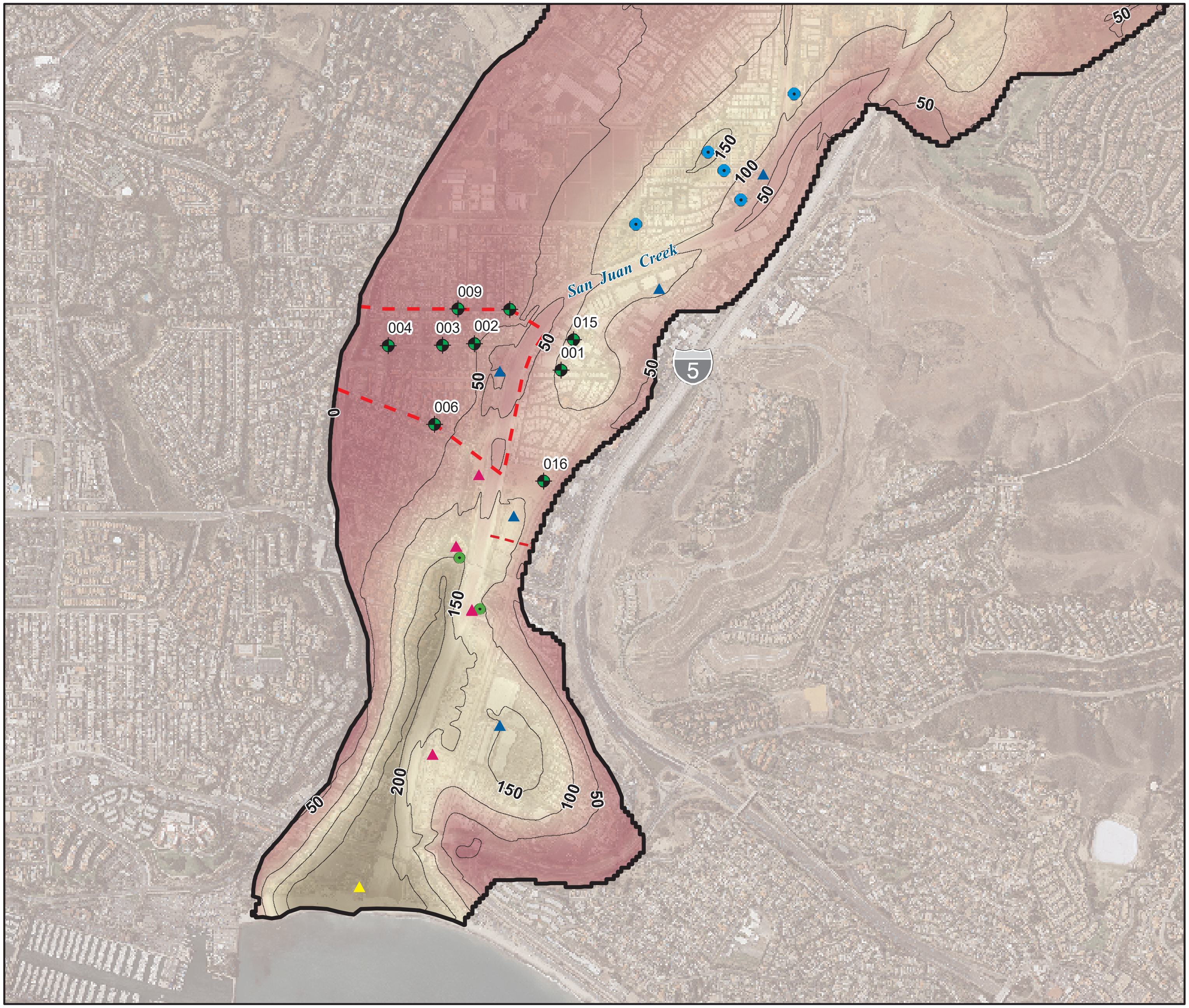
**Lower San Juan Basin**
**Key Well Locations and Other Features**

**Figure 2**




**Monitoring Wells**

- San Juan Basin Authority
- South Coast Water District
- Municipal Water District of Orange County

**Production Wells**

- City of San Juan Capistrano
- South Coast Water District

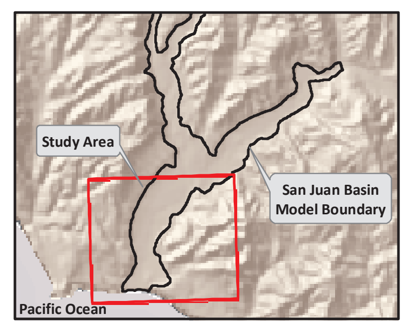
- Completed Test Hole Site
- Approximate Extent of the Bedrock Barrier
- Approximate Area of the Hydraulic Barrier

Depth to the Bottom of the Aquifer (ft)

High : 250

Low : 0

- Contour of equal depth
- San Juan Basin Model Boundary

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Date: 4/21/2020
Document Name: LowerSJB_BOA

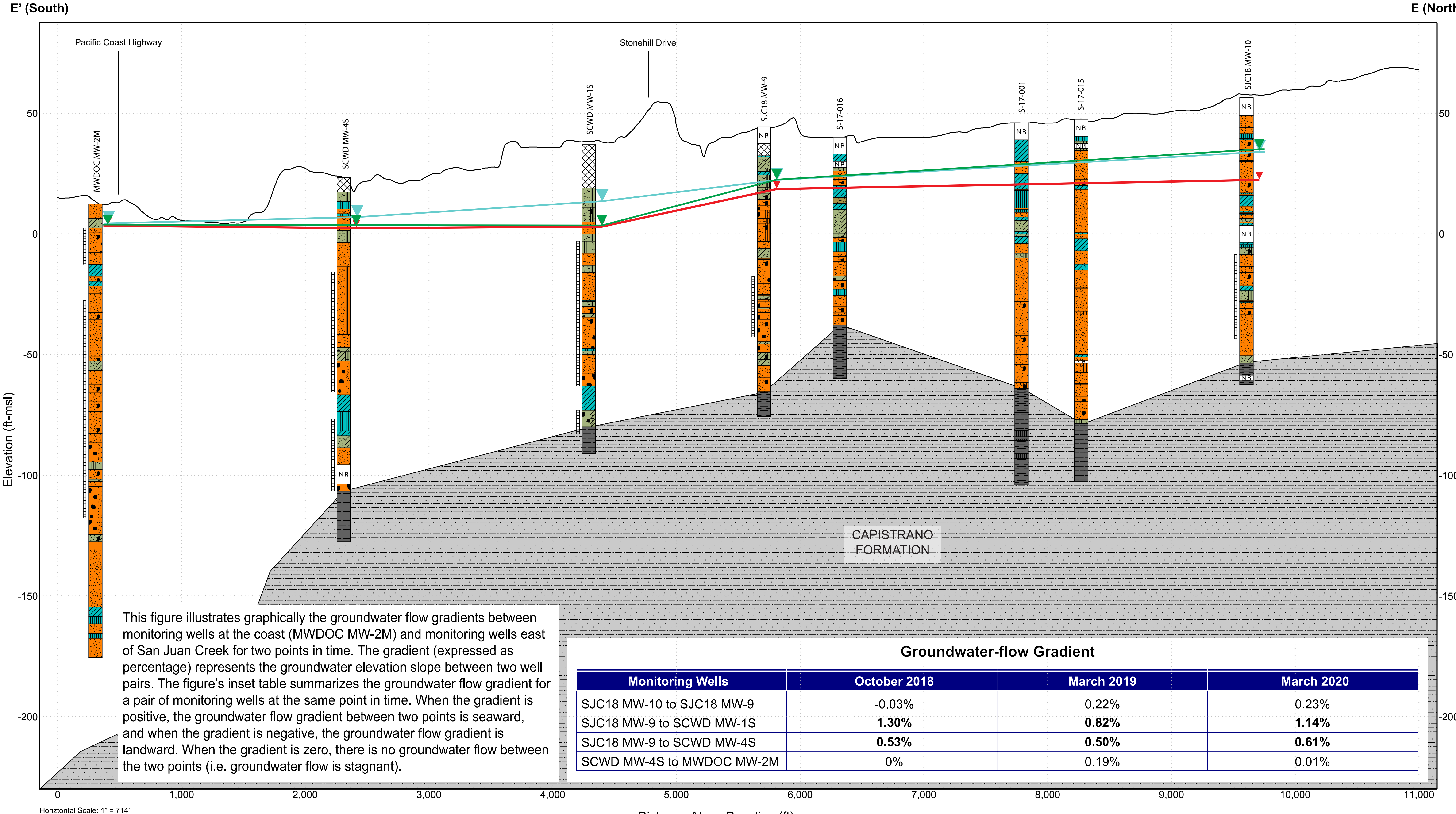
0 1,000 2,000 Feet

0 200 400 Meters

SAN JUAN BASIN AUTHORITY

**Lower San Juan Basin**
**Depth to the Bottom of the Aquifer**

**Figure 3**




Horiztontal Scale: 1" = 714'
Vertical Scale: 1" = 37'
Vertical Exaggeration = 19.3

This figure illustrates graphically the groundwater flow gradients between monitoring wells at the coast (MWDOC MW-2M) and monitoring wells east of San Juan Creek for two points in time. The gradient (expressed as percentage) represents the groundwater elevation slope between two well pairs. The figure's inset table summarizes the groundwater flow gradient for a pair of monitoring wells at the same point in time. When the gradient is positive, the groundwater flow gradient between two points is seaward, and when the gradient is negative, the groundwater flow gradient is landward. When the gradient is zero, there is no groundwater flow between the two points (i.e. groundwater flow is stagnant).

**Groundwater-flow Gradient**

| Monitoring Wells | October 2018 | March 2019 | March 2020 |
|---|---|---|---|
| SJC18 MW-10 to SJC18 MW-9 | -0.03% | 0.22% | 0.23% |
| SJC18 MW-9 to SCWD MW-1S | **1.30%** | **0.82%** | **1.14%** |
| SJC18 MW-9 to SCWD MW-4S | **0.53%** | **0.50%** | **0.61%** |
| SCWD MW-4S to MWDOC MW-2M | 0% | 0.19% | 0.01% |

Fine-grained deposits (low hydraulic conductivity)
Coarse-grained deposits (high hydraulic conductivity)
Fine- and coarse-grained deposit mixtures (low to medium hydraulic conductivity)
Capistrano FM/ (non-water bearing)
Fill (made ground)
NR No Sample
October 2018 Groundwater Elevation
March 2019 Groundwater Elevation
March 2020 Groundwater Elevation

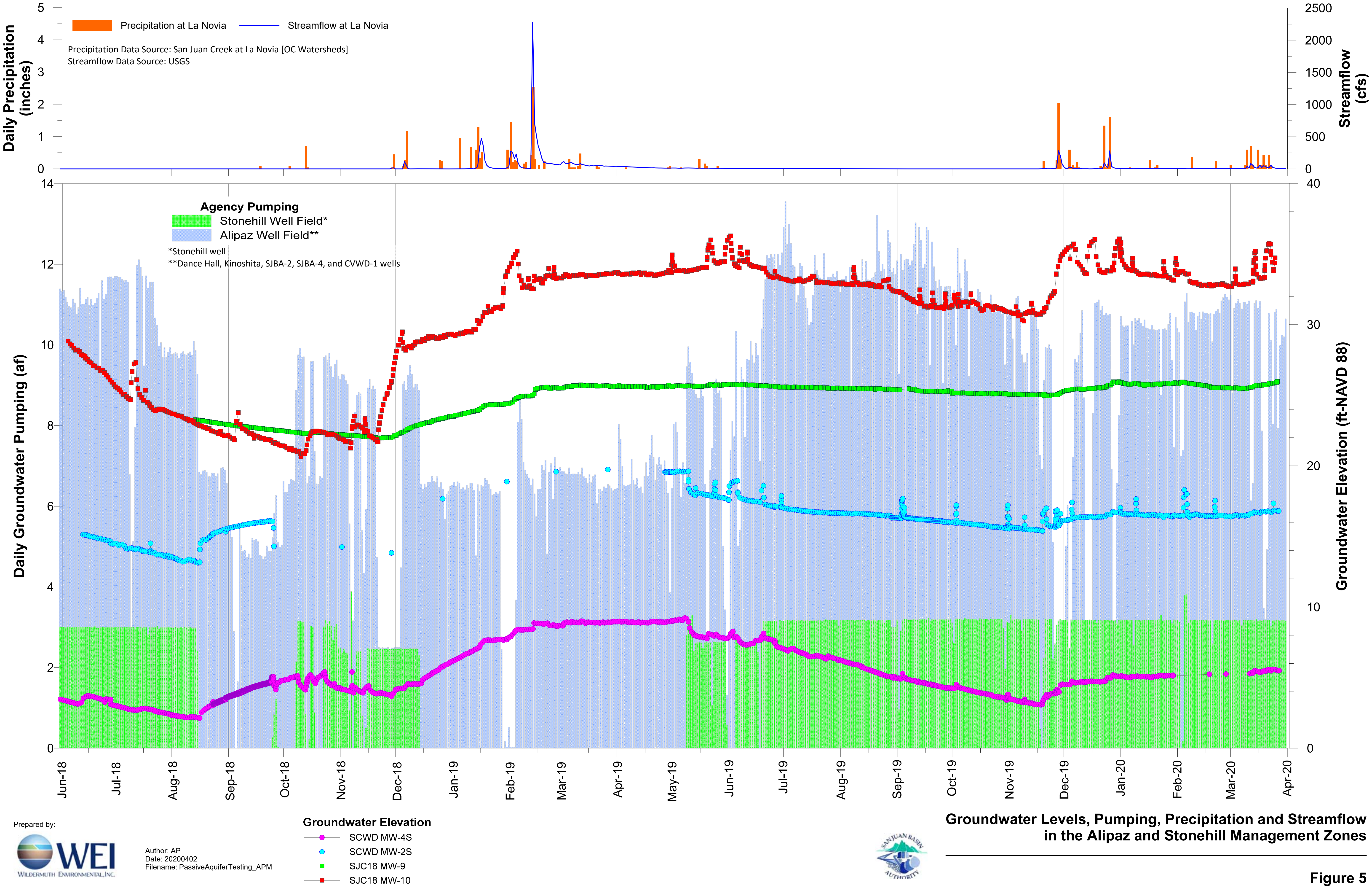
Prepared by:
WEI
Wildermuth Environmental, Inc.

Author: AP
Date: 20200331
Filename: GWgradients_eastSJC.ai

## Groundwater-flow Gradients East of the San Juan Creek

*MWDOC MW-2M to SJC18 MW-10*

Figure 4



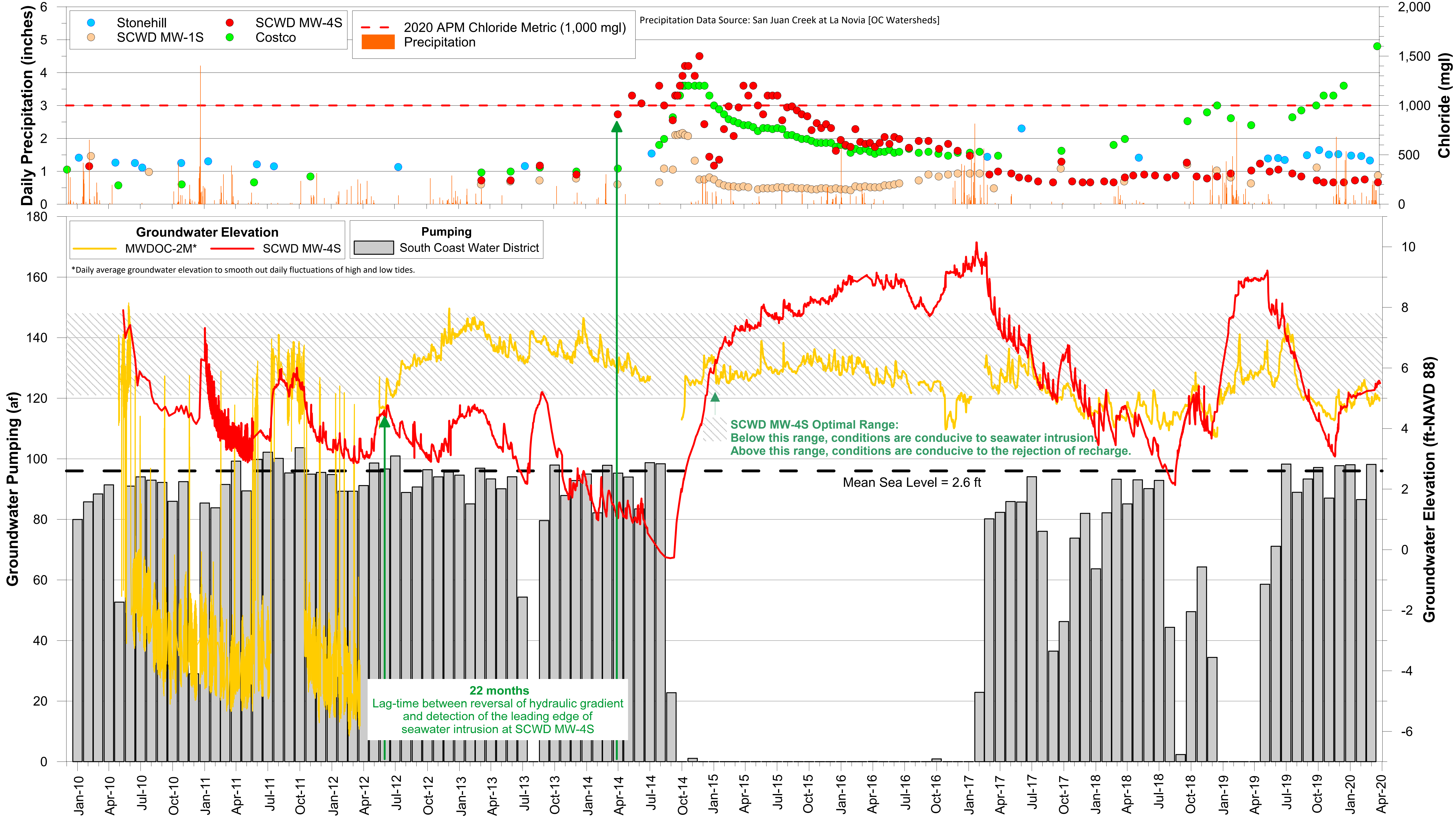

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: AP
Date: 20200402
Filename: PassiveAquiferTesting_APM

## Groundwater Levels, Pumping, Precipitation and Streamflow in the Alipaz and Stonehill Management Zones

**Figure 5**



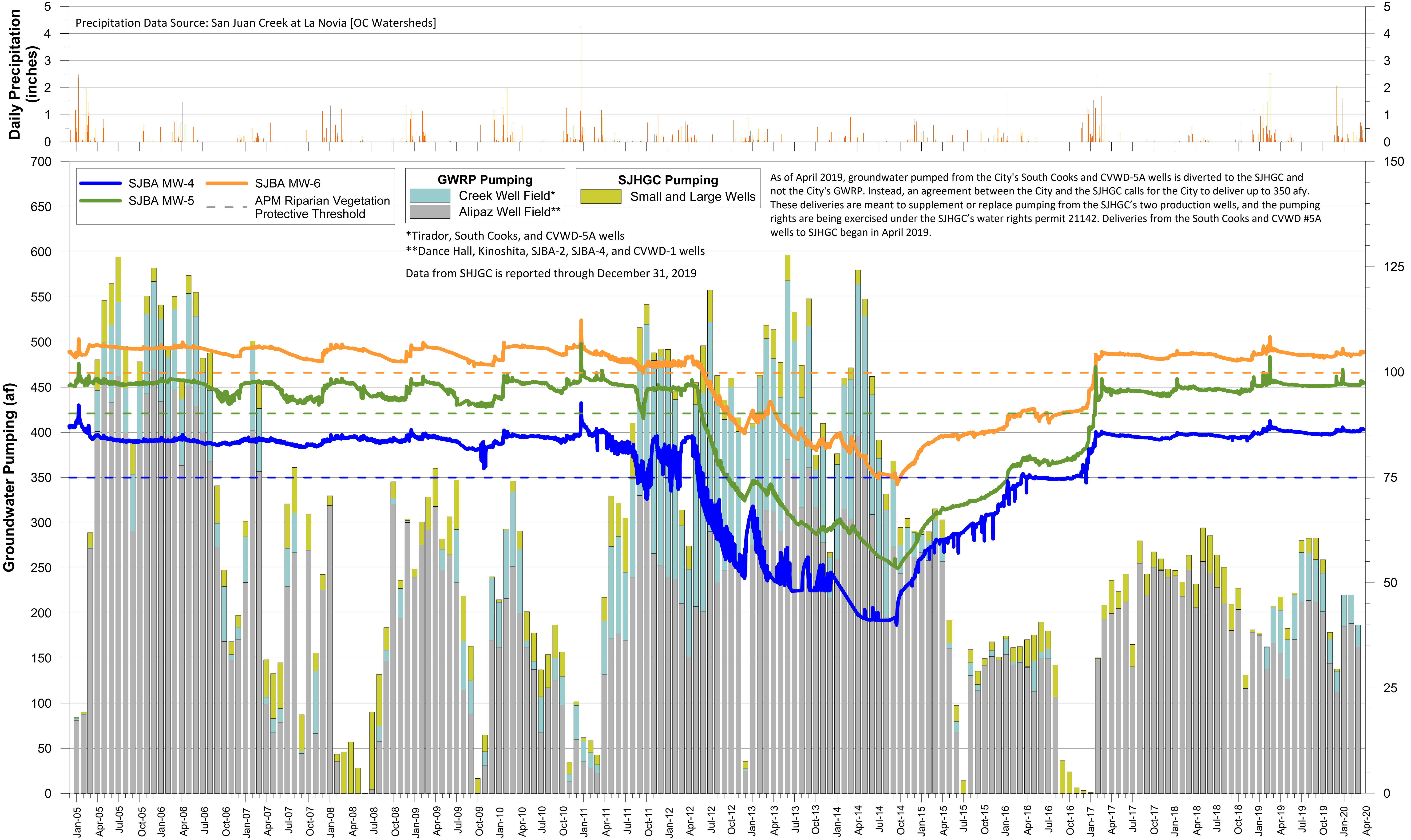

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: AP
Date: 20200402
Filename: Stonehill_MZ_APM.grf

**Groundwater Levels, Pumping, and Chloride Concentrations in the Stonehill Management Zone**

**Figure 6**



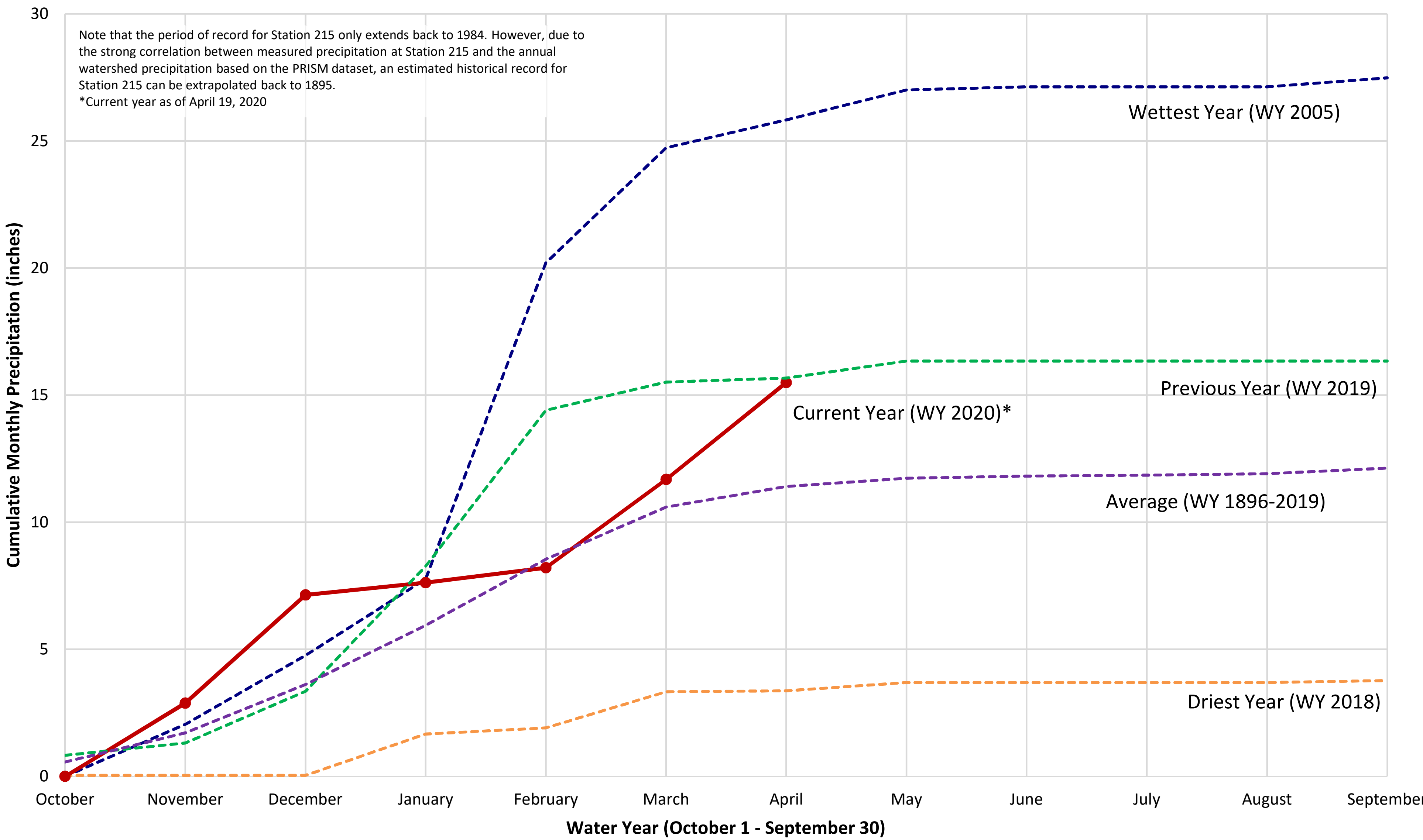

Prepared by:

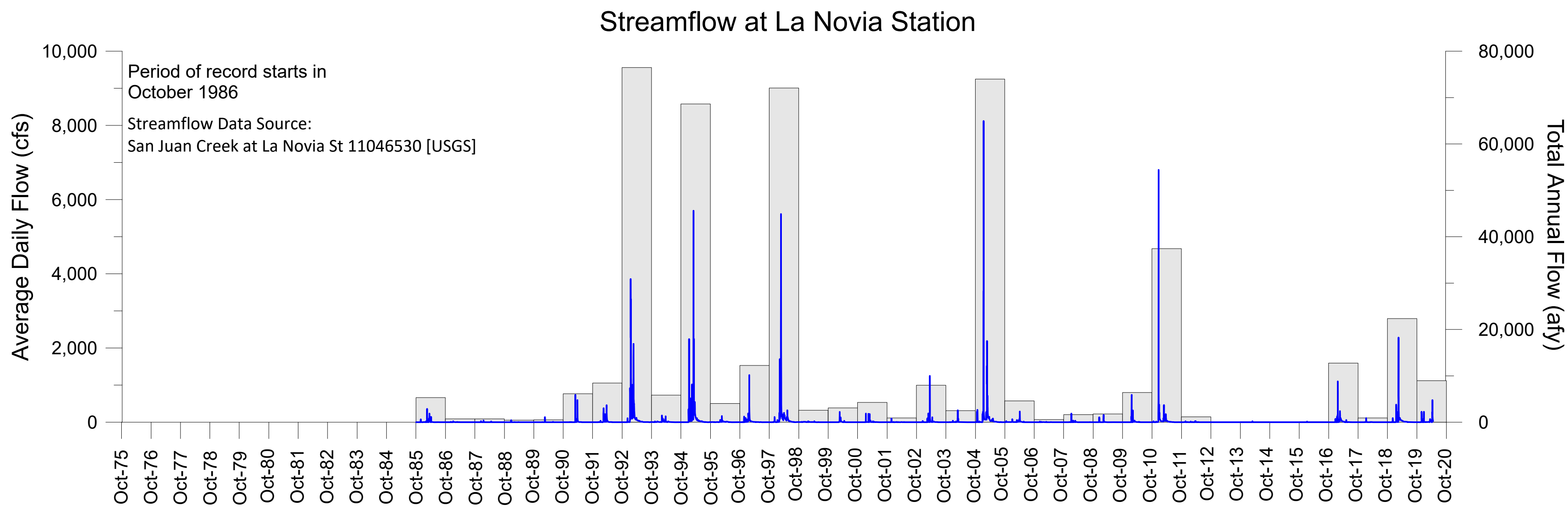
Author: AP
Date: 20200402
Filename: Inland_MZ_APM.grf

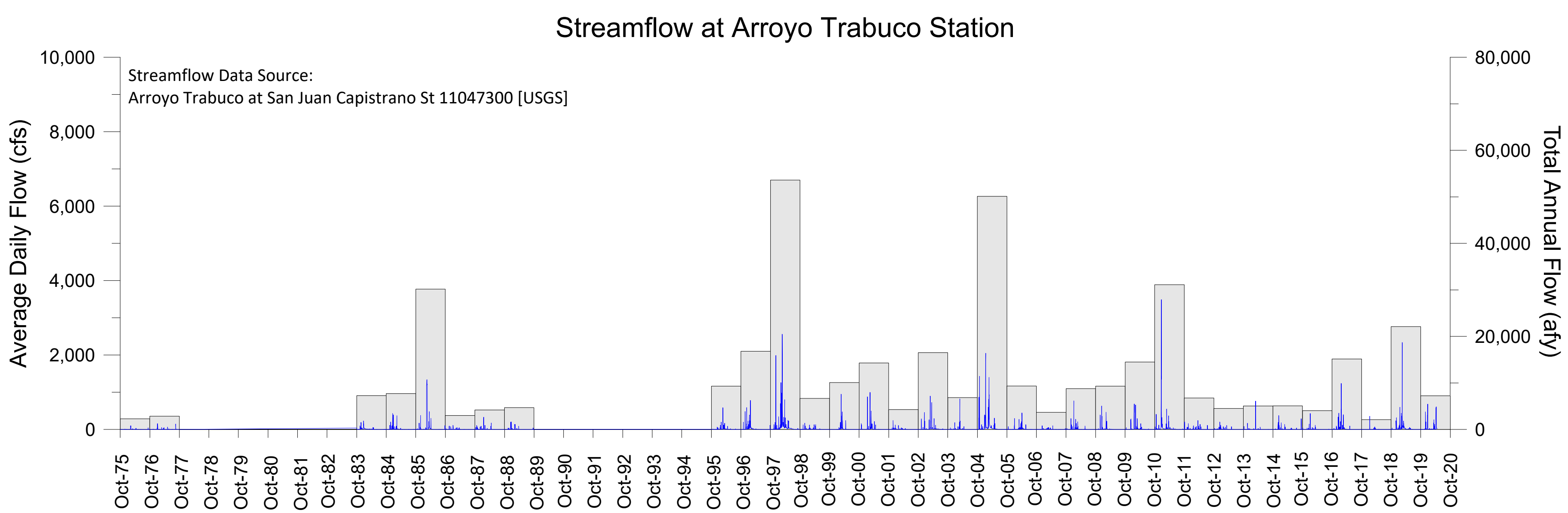
**Groundwater Levels and Pumping in the Riparian Habitat Area**

**Figure 7**

**Figure 8**
**San Juan Basin Cumulative Precipitation: San Juan Capistrano Station at La Novia (No. 215)**
**Water Years: 1896 - 2020**






Average daily streamflow
Total annual streamflow

Data for WY 2020 ends on March 31, 2020

Prepared by:

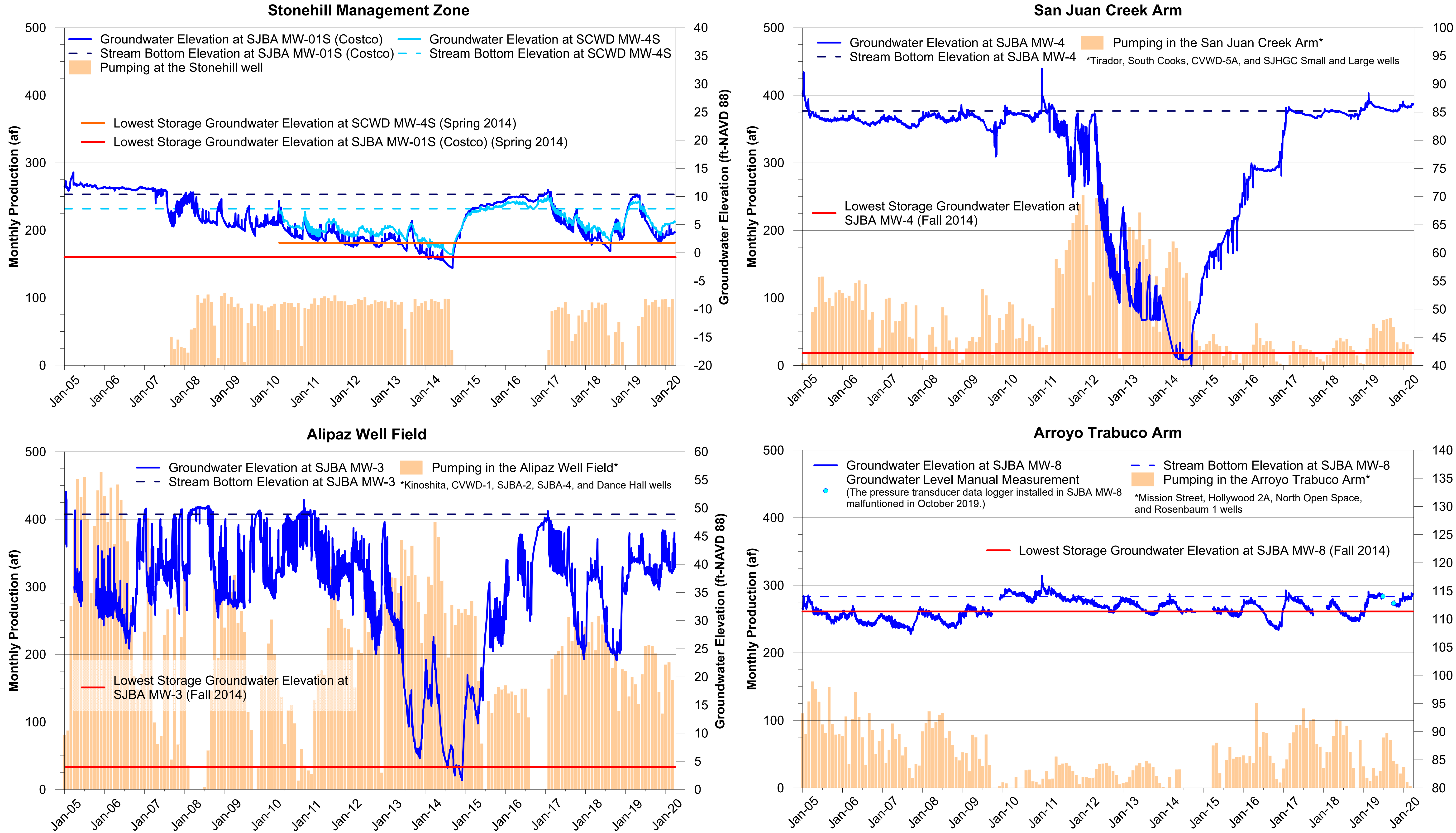
WEI
Wildermuth Environmental, Inc.

Author: AP
Date: 20200402

San Juan Basin Authority

**Streamflow at San Juan Creek and Arroyo Trabuco**

**Figure 9**



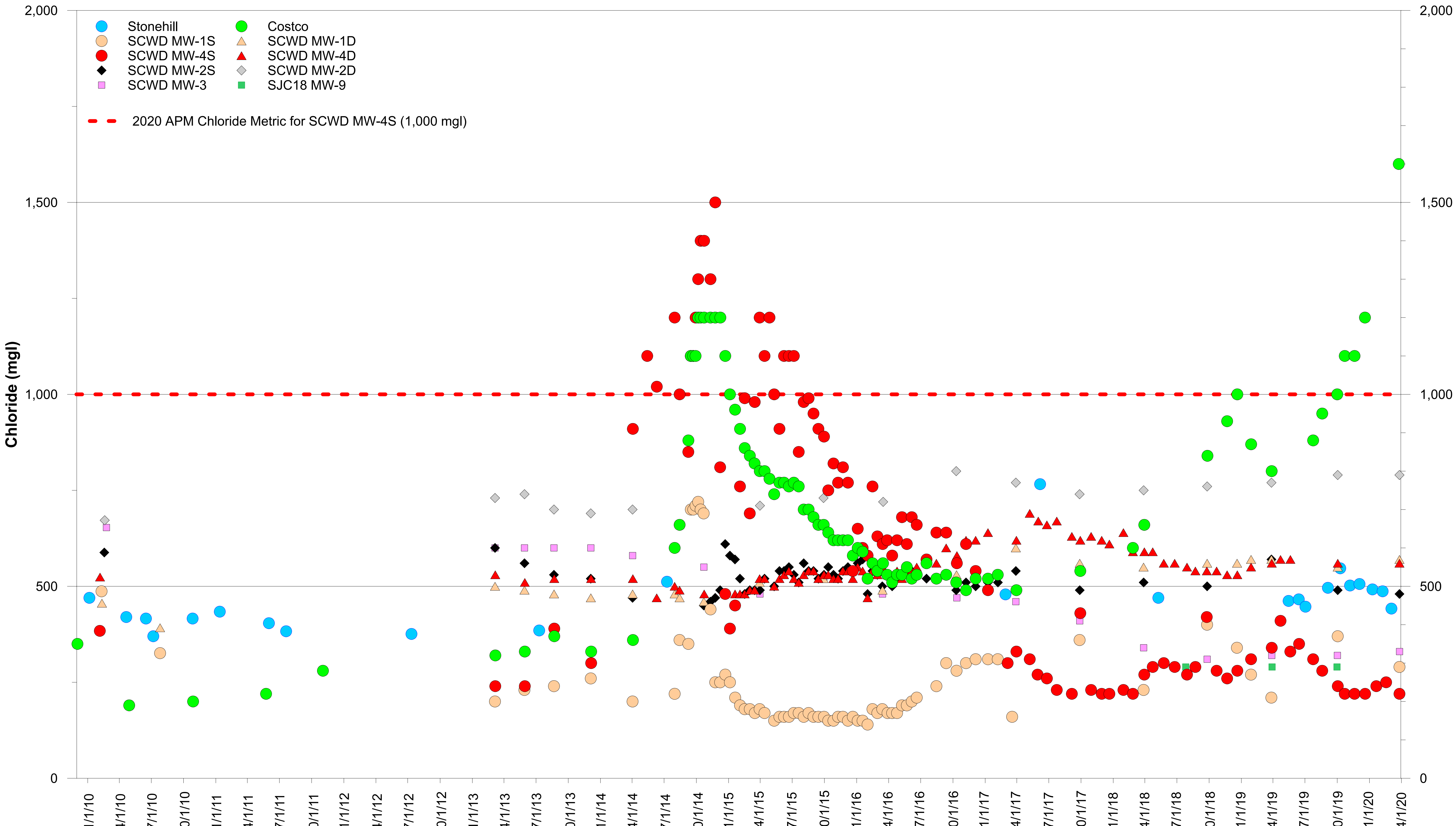

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: AP
Date: 20200402
Filename: PumpingStorage_APM

**Groundwaterwater Level Elevations and Pumping at Four Areas in the Basin**

**Figure 10**




Prepared by:

WEI
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Author: CS
Date: 20200414
Filename: Stonehill_MZ_APM.grf

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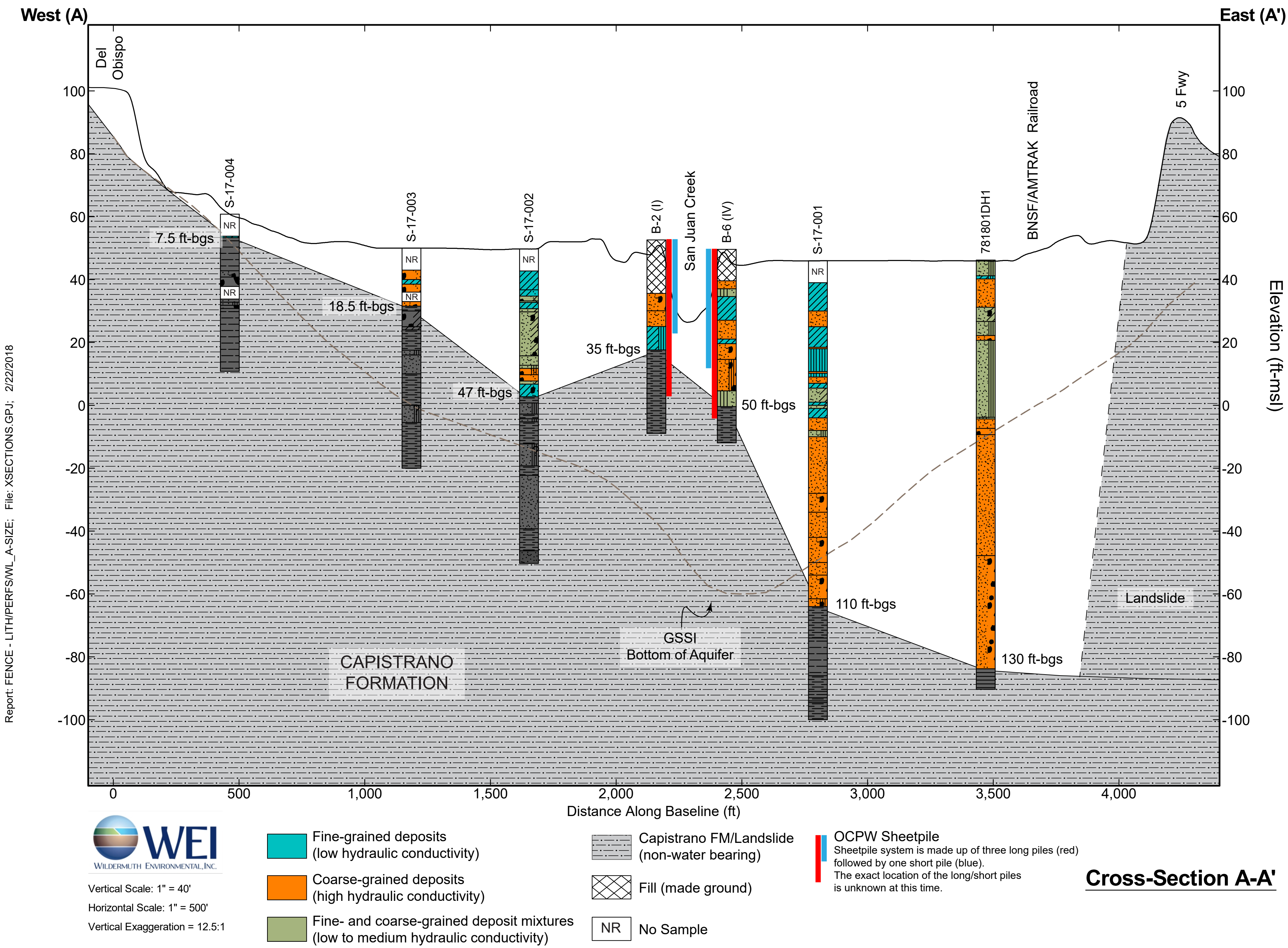
**Chloride Concentrations in the Stonehill Management Zone**

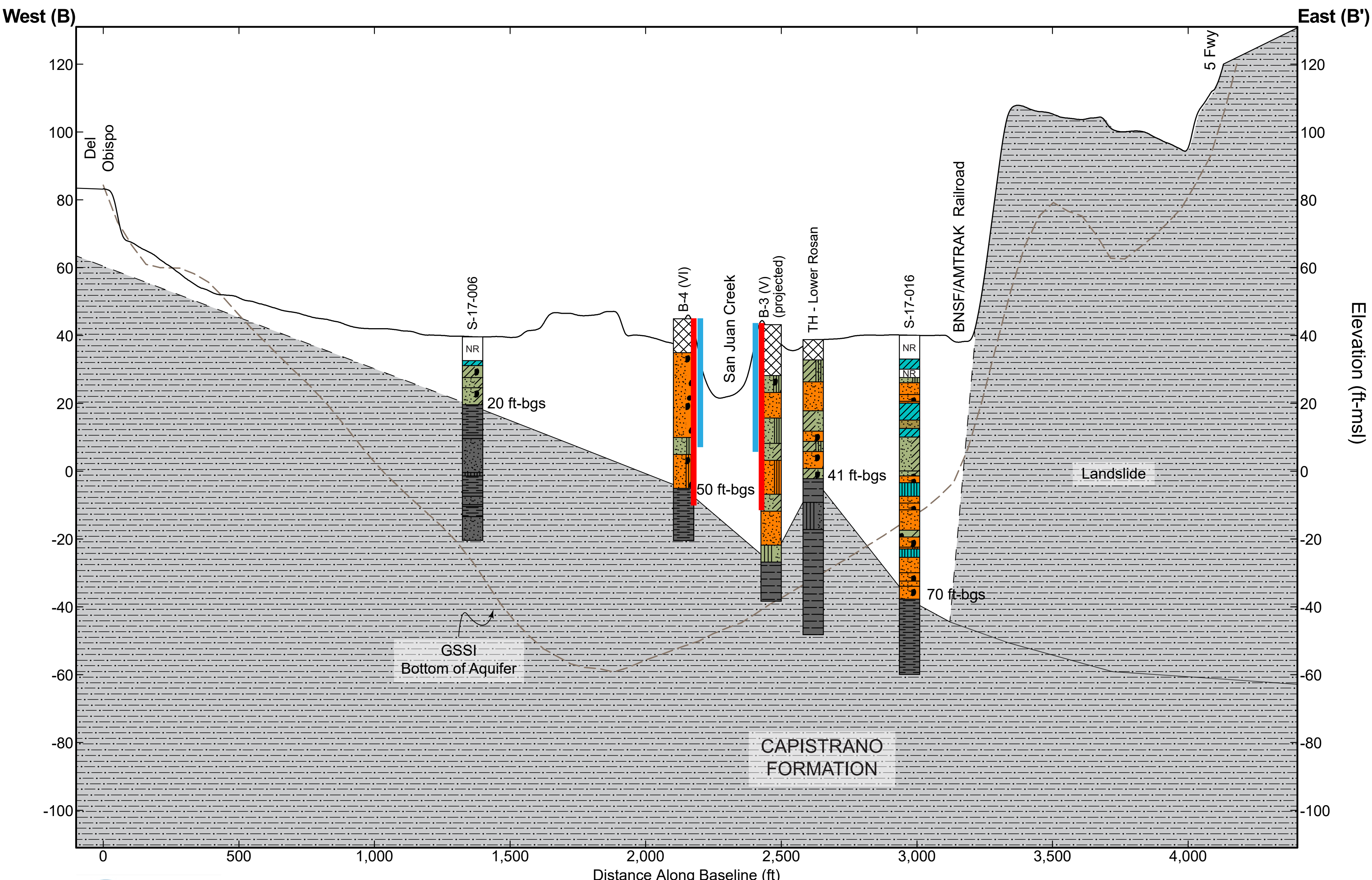
**Figure 11**

# Appendix A

## Lower San Juan Basin Hydrostratigraphic Cross-sections




**Cross-Section A-A'**




Report: FENCE - LITH/PERFS/WL_A-SIZE; File: XSECTIONS.GPJ; 2/28/2018

WEI
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Vertical Scale: 1" = 40'
Horizontal Scale: 1" = 500'
Vertical Exaggeration = 12.5:1

Fine-grained deposits (low hydraulic conductivity)

Coarse-grained deposits (high hydraulic conductivity)

Fine- and coarse-grained deposit mixtures (low to medium hydraulic conductivity)

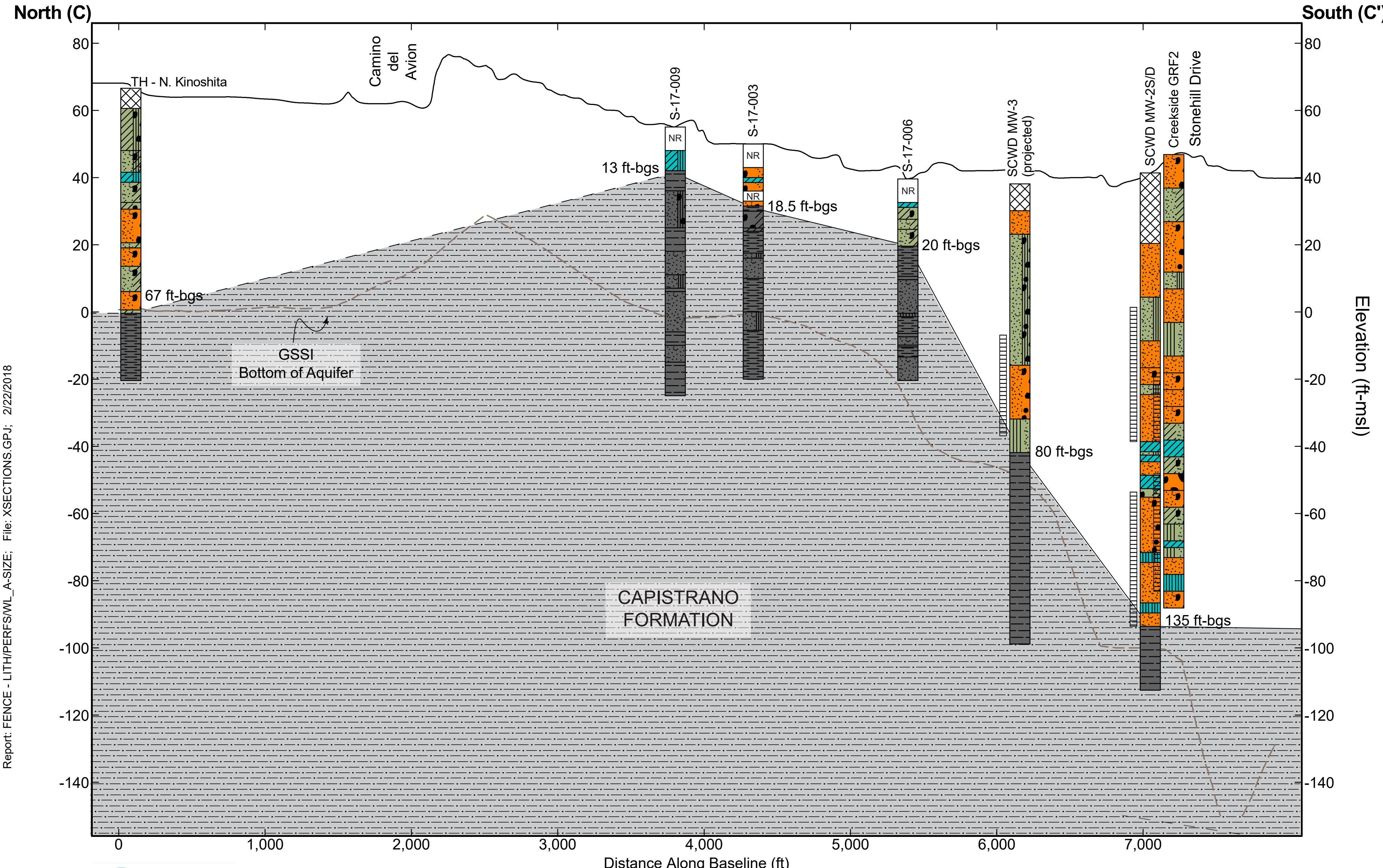
Capistrano FM/Landslide (non-water bearing)

Fill (made ground)

NR No Sample

OCPW Planned Sheetpile
Sheetpile system is made up of three long piles (red) followed by one short pile (blue).
The exact location of the long/short piles is unknown at this time.

## Cross-Section B-B'




Report: FENCE - LITH/PERFS/WL_A-SIZE; File: XSECTIONS.GPJ; 2/22/2018

WEI
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Vertical Scale: 1" = 40'
Horizontal Scale: 1" = 915'
Vertical Exaggeration = 5.7:1

Fine-grained deposits (low hydraulic conductivity)

Coarse-grained deposits (high hydraulic conductivity)

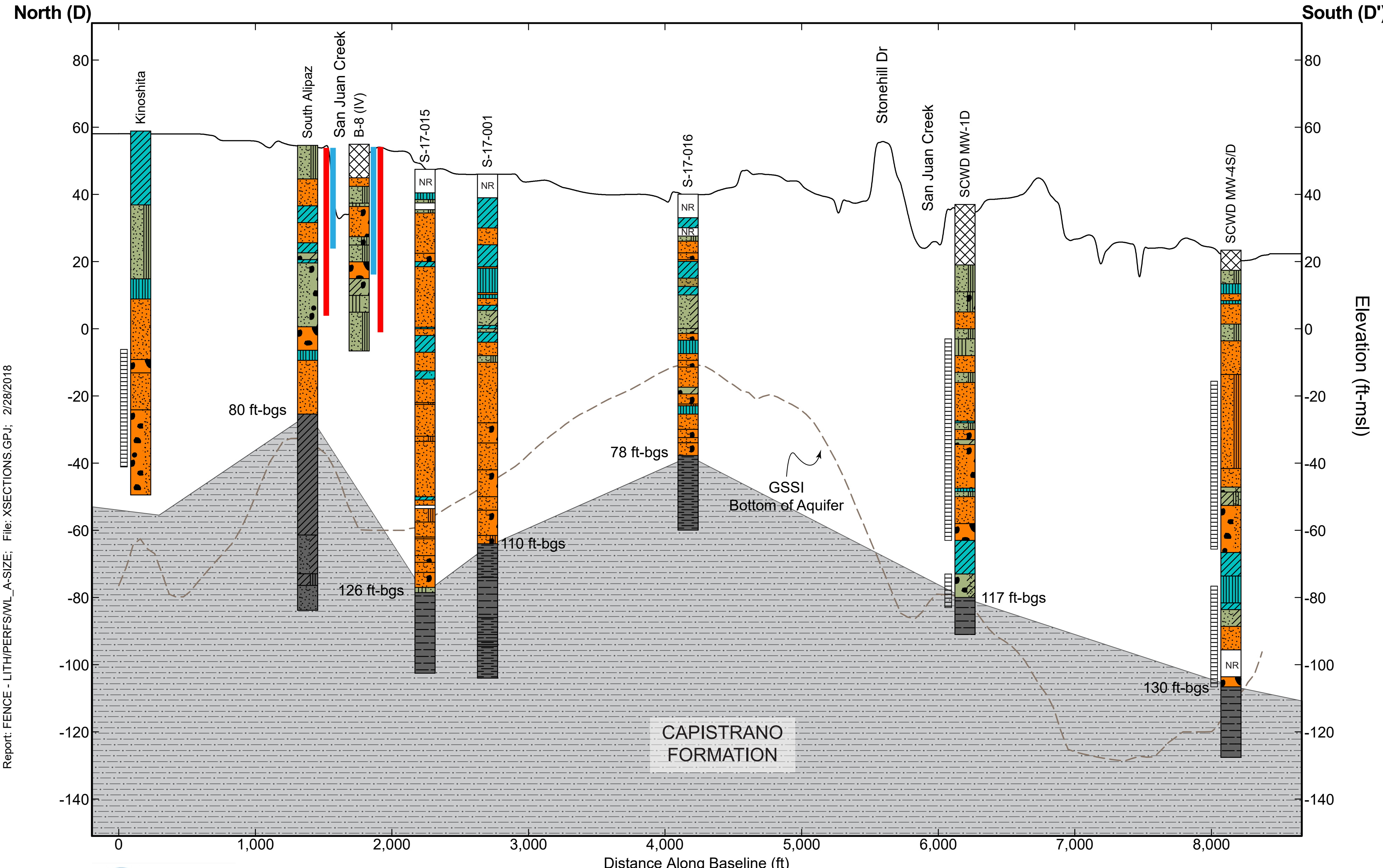
Fine- and coarse-grained deposit mixtures (low to medium hydraulic conductivity)

Capistrano FM/Landslide (non-water bearing)

Fill (made ground)

NR No Sample

**Cross-Section C-C'**




Report: FENCE - LITH/PERFS/WL_A-SIZE; File: XSECTIONS.GPJ; 2/28/2018

WEI
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Vertical Scale: 1" = 40'
Horizontal Scale: 1" = 1000'
Vertical Exaggeration = 25:1

Fine-grained deposits (low hydraulic conductivity)

Coarse-grained deposits (high hydraulic conductivity)

Fine- and coarse-grained deposit mixtures (low to medium hydraulic conductivity)

Capistrano FM/Landslide (non-water bearing)

Fill (made ground)

NR No Sample

OCPW Sheetpile
Sheetpile system is made up of three long piles (red) followed by one short pile (blue).
The exact location of the long/short piles is unknown at this time.

**Cross-Section D-D'**