

SJRRP Flow Bench Evaluation

February 28, 2019

Introduction

The following Flow Bench Evaluation (FBE) report analyzes a flow bench exercise that was scheduled for February 2019 to facilitate evaluation of groundwater conditions. Note that use of “FBE” throughout the report refers specifically to the FBE model-based analysis described in Appendix J of the Seepage Management Plan (SMP). Use of “flow bench” refers to the physical flows sustained in the San Joaquin River to evaluate Restoration Flow targets.

The flow bench exercise was prompted by execution of a seepage easement in Reach 4A at a property that previously limited Restoration Flows to less than 157 cfs below Sack Dam. Following completion of this easement and evaluation of then available groundwater data, the Reach 4A capacity was estimated at approximately 775 cfs. Reach 3 was estimated to be the more constraining reach, with a capacity near 520 cfs. These estimates were based on a comparison of empirical data collected by the San Joaquin River Restoration Program (SJRRP) on groundwater depth, well thresholds identified in the SMP, and flow rates from the nearest stream gauge. The SJRRP operates an extensive groundwater monitoring network of over 200 wells within the Restoration Area and has collected data since 2009 in some wells. As this previous estimate was based on empirical data, it was limited to locations where a monitoring well has been installed and could miss seepage-prone areas without a monitoring well, or locations where wells were installed only recently and therefore have short data records.

An updated Restoration Allocation was issued on February 11, 2019 (updated February 26, 2019) and a Restoration Administrator (RA) recommendation was received dated February 13, 2019. In lieu of a 2018 fall pulse recommendation from the RA, a flow bench was scheduled to evaluate the groundwater response in Reach 3 and Reach 4A to inform flow limitations; therefore, the subsequent FBE focuses on the groundwater response to the bench flow in these most constraining reaches. The RA called for releases from Friant Dam to achieve a target at Gravelly Ford of 531 cfs (increased to 556 cfs on February 14), to sustain releases downstream of Mendota Dam of 520 cfs. Benched flow of approximately 520 cfs was achieved from February 13 to March 3 in Reach 3. This FBE analyzes the groundwater response during the period of benched flows in Reaches 3 and 4A to verify and refine the approximated capacities in these reaches and inform any change to Restoration Flows.

As of February 28, 2019:

1. Channel conveyance: The 2019 Channel Capacity Report indicates a Middle Eastside Bypass capacity constraint of 1070 cfs to meet USACE levee freeboard criteria. Hidden and Buchanan Dams are currently being operated for flood management by USACE and are releasing flows in the Chowchilla Bypass and thereby into the Eastside Bypass. Flow gauging at the Middle Eastside Bypass has been particularly inaccurate recently, though a manual measurement made on February 19 indicated approximately 1,600 cfs at El Nido Road. The Department of Water Resources (DWR) is currently investigating to verify that Restoration Flows are not significantly increasing flood risk.

2. Operations Conference Call: An operations call was held on February 27, 2019. The operations at Mendota Pool, as well as this FBE, were discussed on the call.
3. Seepage Hotline Calls: The seepage hotline has received no calls regarding Restoration Flows in Water Year 2019; however, at a public meeting on February 22, 2019 a landowner raised concerns over potential impacts due to Restoration Flows near the confluence of the Merced River (Reach 5). This was discussed and documented for follow-up investigation.
4. Real-time wells: All telemetered groundwater monitoring well levels were below SMP thresholds on February 12, prior to the start of the benched flows in Reach 3. Data collected during the flow bench exercise will inform locations for the installation of new real-time equipment.
5. Priority wells: As indicated in the Weekly Groundwater Reports, priority wells were increased to weekly monitoring prior to and during the flow bench. Additional critical wells were identified for targeted monitoring throughout the flow bench period based on empirical well data evaluated to-date. Therefore, this FBE includes more wells than the Weekly Groundwater Report contains.
6. Flow Stabilization: Flows in the system have been relatively stable during the flow bench; releases from Friant Dam have varied between 556 and 636 to maintain the Gravelly Ford target of 531 cfs through February 13 and the Gravelly Ford target of 556 cfs beginning February 14. Reclamation, Wonderful Orchards, and Henry Miller Reclamation District have been coordinating to maintain approximately 520 cfs below Mendota Dam into Reach 3 for the purpose of this flow bench. Daily average flows released below Mendota Dam, which contain both Restoration Flows and Arroyo Canal deliveries, have varied between 514 and 522 cfs during the flow bench. The SDP gauge, below Sack Dam, had a shift correction on February 20, in the middle of this flow bench. Adjusting for this correction, daily average flows released below Sack Dam have varied between daily values of 313 and 445 cfs. Similar shifts occurred at the SWA gauge at Washington Ave during the evaluation, and the SWA gauge was not reporting from February 22 through February 27. Using a mass balance between the Mendota Pool releases and the Arroyo Canal deliveries, the SJRRP approximates that on average, 380 cfs was released below Sack Dam into Reach 4A for the duration of this flow bench.
7. Projected Groundwater Level Changes: Groundwater levels were projected to increase with this flow bench exercise; however, the flow rates for this flow bench were determined with a conservative approach to ensure all wells would remain below threshold based on the empirical data evaluated. This analysis required comparing depth to water measurements for the monitoring well network to well thresholds identified in the SMP for the historic record of 2009-2018. For all instances where the groundwater level was below threshold, the flow rate was identified at the nearest stream gauge. Identifying the maximum flow rate that occurred while depths to groundwater were below SMP thresholds provides an estimate based on empirical data as to when wells in the groundwater monitoring network may be impacted. A 0.3 ft stage buffer or 100 cfs

flow buffer was applied to the estimated flow constraint for a conservative flow bench target. This FBE documents those increased groundwater levels.

8. Restoration Flows: Based on initial analysis described in the above bullet, Restoration Flows were determined to be below seepage thresholds up to flows of 520 cfs in Reach 3. Following the analysis in this FBE, Restoration Flows were rescheduled to decrease to 235 cfs in Reach 4A to decrease groundwater level elevations. Restoration Flows in Reach 3 will be managed to account for the identified constraining well in Reach 4A in conjunction with Arroyo Canal demands.
9. Levees: The Middle Eastside Bypass Reach O levee is being investigated by DWR.
10. Water Districts: Henry Miller Reclamation District communicated projected 4-day demands to the Program during this flow bench. This communication is much appreciated for prompt coordination and precise flow scheduling.
11. Gauges: There has been significant discrepancy between flow gauges with the high flows of February. In some cases, adjacent gauges disagreed by up to 50%. DWR’s efforts to take additional measures and calibrations is most appreciated.

Data

The following Data section considers monitoring measurements collected during the flow bench exercise to describe the conditions reached upon flow bench stabilization. These values are referred to as “pre-condition” to inform any changes to Restoration Flows that need to occur based on the levels observed during the flow bench. The “projected” values indicate the modeled results from this FBE model-based analysis with the recommended flow change.

Table 1 shows groundwater depths in three real-time wells and twelve manual measurements from field staff in response to the flow bench. Measurements are reported from the field for the week of February 25, 2019 or as in the Weekly Groundwater Report with a publish date for the week ending February 23, 2019. Reclamation publishes the Weekly Groundwater Report with manual measurements via electronic well sounder on the SJRRP website [HERE](#). To calculate field depths, Reclamation adds ground surface buffers and lateral gradient buffers to measured groundwater depths in the well (Equation 1, Figure 1). For the February 2019 flow bench, some soil borings have also been measured to verify groundwater levels directly in fields.

$$Field\ Depth_{Current} = D_{well} - GS_{Buffer} + LG_{Buffer} \quad (1)$$

Where:

$Field\ Depth_{Current}$	Current groundwater level depth in the field
D_{Well}	Current groundwater level depth as measured in the monitoring well
GS_{Buffer}	Ground surface buffer, or the difference in elevation between the well and the field
LG_{Buffer}	Lateral gradient buffer, to account for losing reaches where the groundwater table slopes away from the river (if any)

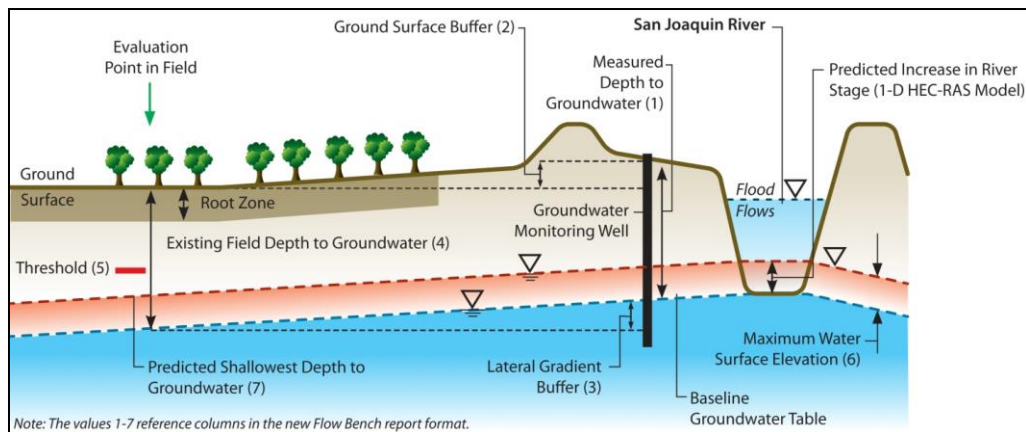


Figure 1. Conceptual Model for Observed Groundwater Level Method

The pre-condition well data for Reaches 3 and 4A in Table 1 show acceptable conditions throughout the critical monitoring locations, with the exception of well MW-17-225. Again, the pre-condition data represents the levels observed during the flow bench rather than levels observed prior to the flow bench since the purpose of this FBE is to verify and refine the approximated capacities in Reaches 3 and 4A and inform any change to Restoration Flows. The measurements for MW-17-225 are based on soil borings in field and are described further below. Groundwater depths in all other wells indicate conditions below thresholds where well thresholds are assigned and have stabilized under the flow bench. From Table 1, note that a ground surface buffer value was updated in field for MW-13-199 and a ground surface buffer value needs to be re-surveyed for MW-13-195; however, the land adjacent to MW-13-195 is currently fallow and therefore does not have a threshold assigned. Fields are also fallow at PZ-09-R3-5, MW-10-78, MW-12-190, MW-18-80B, and MW-10-188, so have no threshold assigned. The groundwater monitoring network is currently being re-surveyed and is expected to be processed in April 2019.

MW-17-225 is a Reach 4A well where groundwater levels were observed during the flow bench exercise to approach threshold at flows much less than the 775 cfs estimated based on the empirical data analysis described in the Introduction. This well did not have an estimated flow impact level as part of that initial analysis as there is no survey data yet associated with the well. MW-17-225 was installed in 2017 and completion of survey data for this well is expected in April 2019. The threshold for MW-17-225 has yet to be calculated, as it does not have a historical method threshold established because it is outside of the historical water level surface layers created to estimate historic data; nor was it installed between December 2011 - January 2016 when Restoration Flows were not released past Mendota Pool, so there is no data from this period to serve as a proxy as evaluated in the historical C4 method described in Appendix H of the SMP. However, CCID well 132 (within 1800 ft) and other nearby wells on the same bank are all driven by the agricultural threshold method. In lieu of surveyed metadata for this newer well, assuming the agricultural threshold method is defensible because Reach 4A has been historically dry. Therefore, it is likely that historical levels at this site under dry conditions would have been deeper than the agricultural threshold method. The field type is alfalfa (6 ft root zone) with sandy soils (0.5 ft capillary fringe), so therefore would be expected to have a 6.5 ft_bgs threshold in field. Soil borings in field read 6.05 ft on 2/20/2019, 5.85 ft on 2/22/2019, and 5.8 ft on 2/25/2019, resulting in “Not Acceptable” groundwater conditions.

Table 1. Pre-Condition Well Data for Reach 3 and Reach 4A (Benched Condition)

Well	Reach	1 - Measured Groundwater Depth in Well (feet bgs)	Date Measured	2 - Ground Surface Buffer (feet)	3 - Lateral Gradient Buffer (feet)	4 - Field GW Depth (feet bgs)	5 - Field Threshold (feet bgs)	Comment
PZ-09-R3-5	3	10.4	2/20/2019	1.2	0.0	9.2	-	Acceptable ⁴
MW-12-191	3	11.8	2/20/2019	1.0		10.8	6.5	Acceptable
PZ-09-R3-7	3	8.0	2/22/2019	0.7	0.0	7.2	6.5	Acceptable
MW-10-75	3	17.6	2/22/2019	0.5	0.2	17.3	8.0	Acceptable
MW-13-200	3	13.4	2/19/2019	8.1		5.3	5.5	Acceptable
MW-10-78	3	7.8	2/20/2019	3.0		4.8	-	Acceptable ⁴
MW-13-195	3	11.4	2/19/2019	6.5 ³		4.9	-	Acceptable ^{3,4}
MW-13-199	3	13.4	2/19/2019	0.0 ¹		13.4	7.8	Acceptable
MW-13-201	3	12.3	2/19/2019	2.9		9.4	8.0	Acceptable
MW-12-190	3	8.7	2/20/2019	2.4		6.3	-	Acceptable ⁴
PZ-09-R3-3	3	12.9	2/19/2019	4.3		8.6	7.4	Acceptable
MW-10-89	4A	9.7	2/22/2019	1.0	0.0	8.7	6.5	Acceptable
MW-18-80B	4A	9.0	2/26/2019	-		6.1 ²	-	Acceptable ⁴
MW-17-225	4A	7.6	2/26/2019	-		5.8 ²	6.5	Not Acceptable
MW-10-188	4A	8.7	2/26/2019	2.1	0.0	6.6	-	Acceptable ⁴

bgs = below ground surface; GW = groundwater

¹ Ground surface buffer was verified in field.

² Soil boring measurements were taken in field.

³ Ground surface buffer needs survey verification.

⁴ Field is currently fallow and therefore no threshold is assigned.

Analysis

After consideration of soil borings at MW-17-225, it is recommended that flows below Sack Dam be reduced to allow a 0.7 ft stage decrease. From the HEC-RAS models used in this FBE, and assuming initial flow conditions of 380 cfs in Reach 4A, this equates to a 145 cfs flow reduction and a target of 235 cfs below Sack Dam. 380 cfs is the estimated mean SDP flow based on MEN (near Mendota) gauge readings, Arroyo Canal deliveries, and losses. Given the conservative approach of the conceptual model depicted in Figure 2, this stage decrease should reduce groundwater elevations at this site to below threshold. Weekly monitoring will continue at this location to record changes in groundwater elevation. Once below projected thresholds, subsequent FBEs may be completed to inform any potential flow increases.

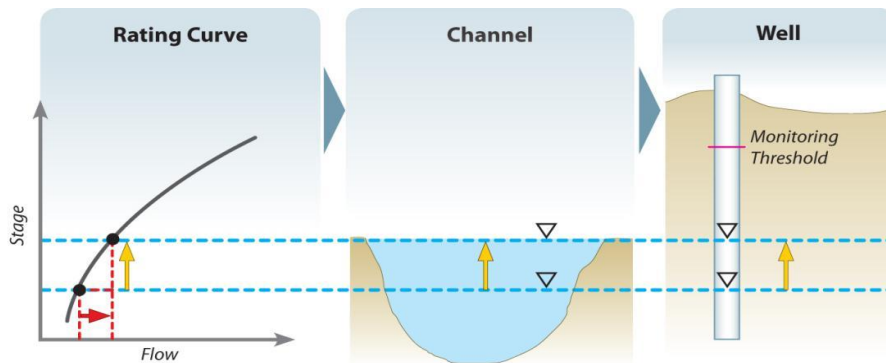


Figure 2. Conceptual Relationship between River Stage and Groundwater Levels

Table 2 shows the projected flow rates used to evaluate projected groundwater depths. Reclamation calculated losses based on the values assumed in Exhibit B. Henry Miller Reclamation District demands were also accounted for in Reach 3 using the operations report sent February 28. Pre-condition flows are based on the flow bench target in Reach 3 and the estimated sustained peak in Reach 4A with Henry Miller Reclamation District demands removed. The comparison of pre-condition and projected flows informs the estimated result of decreasing flows in Reach 4A, and therefore informs the approximate maximum flow allowed in Reach 4A as estimated by this evaluation. This limitation will be refined further through future FBEs following sustained constant flow rates.

Table 2. Anticipated Change in Flows.

	Pre-condition Flows (cfs)	Projected Flows from Evaluation (cfs)
Reach 3	520	395 ¹
Reach 4A	380	235

¹ Assumes 160 cfs demand for Arroyo Canal

Table 3 shows the change in groundwater based on estimated changes in river stage and the conceptual models shown in Figures 1 – 2. Field depths are calculated by taking the most recent measurements from Table 1, adding the ground surface and the lateral gradient buffers, and subtracting the maximum predicted stage increase (Equation 2).

$$Field\ Depth_{Predicted} = Field\ Depth_{Current} - WSEL_{Max\ Increase} \quad (2)$$

Looking ahead, the Program also used the FBE to model the maximum flow rates allowable in Reach 3. This analysis may be necessary as Arroyo Canal demands increase during irrigation season. The combination of Restoration Flows and Arroyo Canal demands could encroach on the SJRRP seepage limitations in Reach 3 at Restoration Flow rates at or below the Reach 4A limitation. Assuming the same pre-condition data representing the levels observed during the flow bench, the projected acceptable flow rate in Reach 3 is a maximum of 721 cfs. The 721 cfs would include any Restoration Flows in combination with Arroyo Canal demands. Therefore, Arroyo Canal demands will need to be monitored as demands increase, since any increasing irrigation demands may reduce the capacity in Reach 3 for Restoration Flows. Further verification and potential refinement of this value will be necessary in Reach 3 if the combined flow rates approach this projected limitation.

It is also important to note that MW-17-225 is not the sole limitation within Reach 4A, and lifting this constraint alone may not be sufficient for increased capacity of Restoration Flows in Reach 4A. At present, MW-18-80B does not have a threshold assigned since the adjacent field is fallow. Based on historical land use at this location, if planted, the field would likely have a row crop. If and when a row crop is planted, this well is expected to be constraining at similar levels of MW-17-225. Similar to MW-17-225, survey data for MW-18-80B has yet to be collected but is expected to be complete in April 2019 to allow for calculation of the threshold. MW-18-80B is a replacement well for MW-10-80, for which the historical method threshold indicates a depth of 6.7 ft_bgs in field (by the agricultural threshold method for a conservative row crop, the threshold in field would be 7.0 ft_bgs). Soil borings in field read 6.0 ft on 2/20/2019, 6.0 ft on 2/22/2019, and 6.08 ft on 2/25/2019, and would have resulted in “Not Acceptable” if not fallow.

Table 3. Predicted Groundwater Levels for Priority Wells with Projected Flows

Well	Reach	1 - Measured Groundwater Depth in Well (feet bgs)	Date Measured	2-Ground Surface Buffer (feet)	3 - Lateral Gradient Buffer (feet)	4 - Field GW Depth (feet bgs)	6 - Predicted WSEL Change (feet)	7 - Predicted Shallowest GW Depth (ft bgs_field)	5 - Field Threshold (feet bgs)	Comment
PZ-09-R3-5	3	10.4	2/20/2019	1.2	0.0	9.2	-0.6	9.8	-	Acceptable ⁴
MW-12-191	3	11.8	2/20/2019	1.0		10.8	-0.6	11.4	6.5	Acceptable
PZ-09-R3-7	3	8.0	2/22/2019	0.7	0.0	7.2	-0.6	7.8	6.5	Acceptable
MW-10-75	3	17.6	2/22/2019	0.5	0.2	17.3	-0.5	17.7	8.0	Acceptable
MW-13-200	3	13.4	2/19/2019	8.1		5.3	-0.5	5.8	5.5	Acceptable
MW-10-78	3	7.8	2/20/2019	3.0		4.8	-0.3	5.1	-	Acceptable ⁴
MW-13-195	3	11.4	2/19/2019	6.5 ³		4.9	-0.5	5.4	-	Acceptable ^{3,4}
MW-13-199	3	13.4	2/19/2019	0.0 ¹		13.4	-0.5	13.9	7.8	Acceptable
MW-13-201	3	12.3	2/19/2019	2.9		9.4	-0.5	9.9	8.0	Acceptable
MW-12-190	3	8.7	2/20/2019	2.4		6.3	-0.6	6.9	-	Acceptable ⁴
PZ-09-R3-3	3	12.9	2/19/2019	4.3		8.6	-0.5	9.1	7.4	Acceptable
MW-10-89	4A	9.7	2/22/2019	1.0	0.0	8.7	-0.9	9.6	6.5	Acceptable
MW-18-80B	4A	9.0	2/26/2019	-		6.1 ²	-0.7	6.8	-	Acceptable ⁴
MW-17-225	4A	7.6	2/26/2019	-		5.8 ²	-0.7	6.5	6.5*	Acceptable
MW-10-188	4A	8.7	2/26/2019	2.1	0.0	6.6	-0.7	7.3	-	Acceptable ⁴

bgs = below ground surface; GW = groundwater; WSEL = water surface elevation

¹ Ground surface buffer was verified in field.

² Soil boring measurements were taken in field.

³ Ground surface buffer needs survey verification; however, field is currently fallow and therefore no threshold is assigned.

⁴ Field is currently fallow and therefore no threshold is assigned.

*See Data for discussion of MW-17-225

Summary

This analysis, in combination with recent field measurements, indicates acceptable conditions for 235 cfs past Sack Dam. Groundwater levels will continue to be monitored at soil borings for MW-17-225 so as not to surpass the field threshold. The maximum allowable flow below Sack Dam is currently limited by conditions at this well. Monitoring will also continue at other critical wells (Figure 3) and the remainder of the network. Arroyo Canal demands will also be monitored to determine if the capacity for Restoration Flows in Reach 3 becomes limited. Reclamation retains the right to recapture Restoration Flows in Mendota Pool to adjust for Arroyo Canal demands. Subsequent FBEs will be performed to inform any potential flow changes.

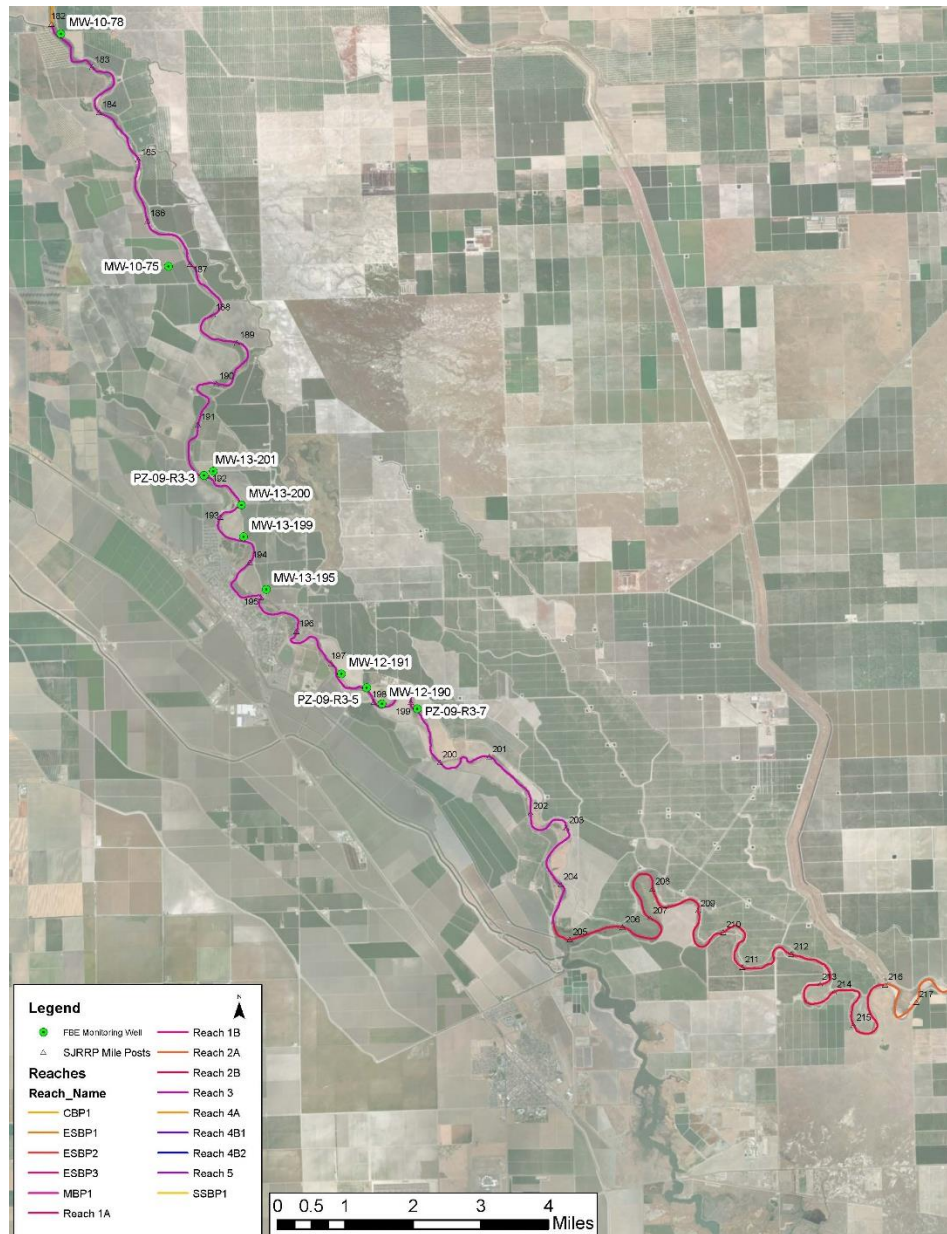


Figure 3a. Critical Monitoring Well Locations in Reach 3

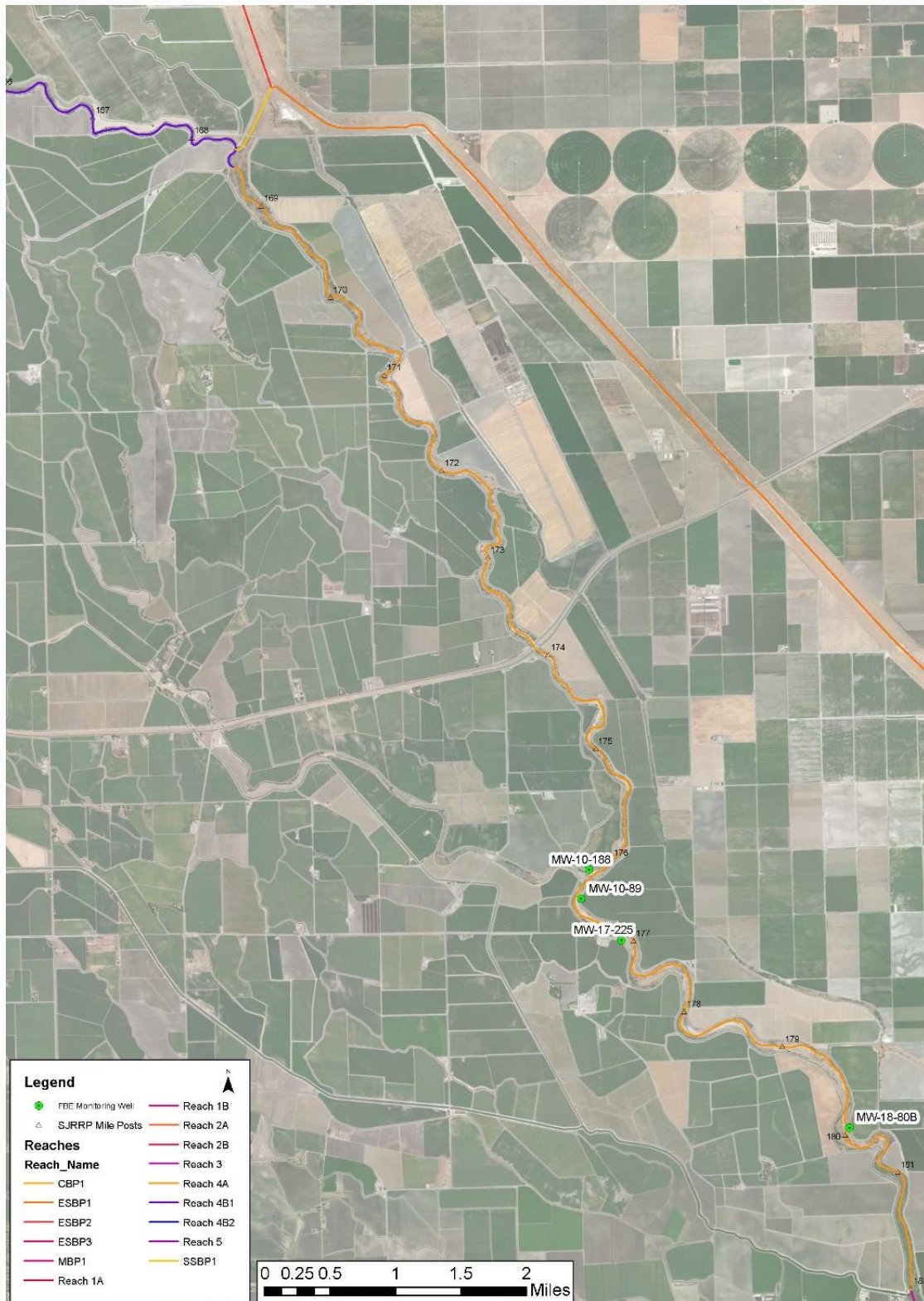


Figure 3b. Critical Monitoring Well Locations in Reach 4A