SJRRP Flow Bench Evaluation

April 5, 2019

Introduction

This Flow Bench Evaluation (FBE) report evaluates the transition from flood flows to Restoration Flows. Flood control releases from Friant Dam are not subject to the Seepage Management Plan (SMP). Restoration Flows and seepage thresholds became effective instantaneously throughout the Restoration Area on April 5 at noon.

The Restoration Administrator (RA), as of February 28, 2019, recommends Restoration Flow releases of 330 cfs past Gravelly Ford. Mendota Dam releases are to be adjusted to result in 235 cfs passing below Sack Dam. Any difference between Mendota Pool inflow credit and releases below Sack Dam would be creditable as Mendota Pool recapture for the San Joaquin River Restoration Program (SJRRP). This is expected to occur until flood flows may resume (currently forecasted to resume in May – 50% forecast, or June – 90% forecast) or until an update to channel capacity is determined.

As of April 5, 2019:

1. Channel conveyance: Flow rates are below known conveyance thresholds in all reaches. A low berm breach on the former MLT property recently acquired by Reclamation may constrain Reach 2B flow rates below those listed in the Channel Capacity Advisory Group report, however this berm is scheduled to be repaired on April 9 and appears to not be worsening at flood flows of approximately 800 cfs.

2. Operations Conference Call: An operations call was held on April 3, 2019. The transition from flood flows to Restoration Flows was discussed on this call.

3. Seepage Hotline Calls: The seepage hotline received one call regarding elevated groundwater levels in Water Year 2019 on March 30, 2019; however, the elevated groundwater conditions were due to flood flows. Although the conditions were due to flood flows and not Restoration Flows, the SJRRP recorded this report for further investigation to inform the response at this site for higher flow rates.

4. Real-time wells: Telemetered groundwater monitoring equipment was removed from MW-09-49B due to flood flows, but other real-time equipment remains intact. Real-time equipment was removed from MW-11-130 due to years of dry conditions and reinstalled at MW-17-225. This well is currently being set up with a real-time link on CDEC. All telemetered groundwater monitoring well levels were below SMP thresholds as of April 5; however, manual measurements at MW-09-49B indicate groundwater levels above threshold due to flood flows.

5. Priority wells: As indicated in the Weekly Groundwater Reports, Reach 2A and Reach 2B priority wells exceeded thresholds with flood flows. Additional critical wells were identified for targeted monitoring during flood operations. Therefore, this FBE includes more wells than the Weekly Groundwater Report contains.

6. Flow Stabilization: Flood flow operations into the San Joaquin River (SJR) began on March 15 and peaked at 3000 cfs release from Friant Dam. The ramp down from flood flows began on March 29 and occurred as outlined in Table 1.

Table 1. Flood Flow Ramp Down Schedule for Friant Dam River Releases

Date	Time (hrs)	From (cfs)	To (cfs)
March 29	1400	3000	2500
April 1	0900	2500	2250
April 1	1300	2250	2000
April 2	1000	2000	1750
April 2	1400	1750	1500
April 3	0900	1500	1400
April 3	1300	1400	1300
April 4	0900	1300	1200
April 4	1300	1200	1000
April 5	0800	1000	900
April 5	1000	900	750
April 5	1200	750	375

7. Projected Groundwater Level Changes: Groundwater levels are projected to decrease with the ramp down to Restoration Flows. Groundwater levels are anticipated to be above seepage thresholds in upper reach locations as a result of flood flows. These residual flood flow impacts are expected to drain with decreased stage in the San Joaquin River. As described in Appendix J of the SMP, Reclamation will evaluate transitions between flood flows and Restoration Flows first using the Groundwater Level Method to determine if the predicted stage change between the flood release and the proposed Restoration Flow release would result in groundwater levels below the groundwater level threshold defined in Appendix H of the SMP. The Drainage Method will then be evaluated for any wells predicted to be above threshold to ensure that groundwater levels are able to drain into the SJR.

8. Levees: LSJLD has not expressed concerns about this transition to Restoration Flows.

9. Water Districts: The SJRECWA has not identified any operational concerns.

Data

The following Data section considers monitoring measurements collected during flood flows to inform conditions prior to the transition to Restoration Flows. These values are referred to as "pre-condition" to inform any changes to Restoration Flows that may need to occur based on the levels observed during flood flows. The "projected" values indicate the modeled results from this FBE model-based analysis with the current RA recommendation for Restoration Flows and are discussed in the Analysis section.

Table 2 shows groundwater depths in three active real-time wells and 18 manual measurements from field staff in response to flood flows. Measurements are reported from the field for the weeks of March 25, 2019 and April 1, 2019. Values for priority wells are published by Reclamation in the Weekly Groundwater Report on the SJRRP website HERE, and are taken with manual measurements via electronic well sounder. To calculate field depths, Reclamation adds ground surface buffers and lateral gradient buffers to measured groundwater depths in the well (Equation 1, Figure 1). 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)

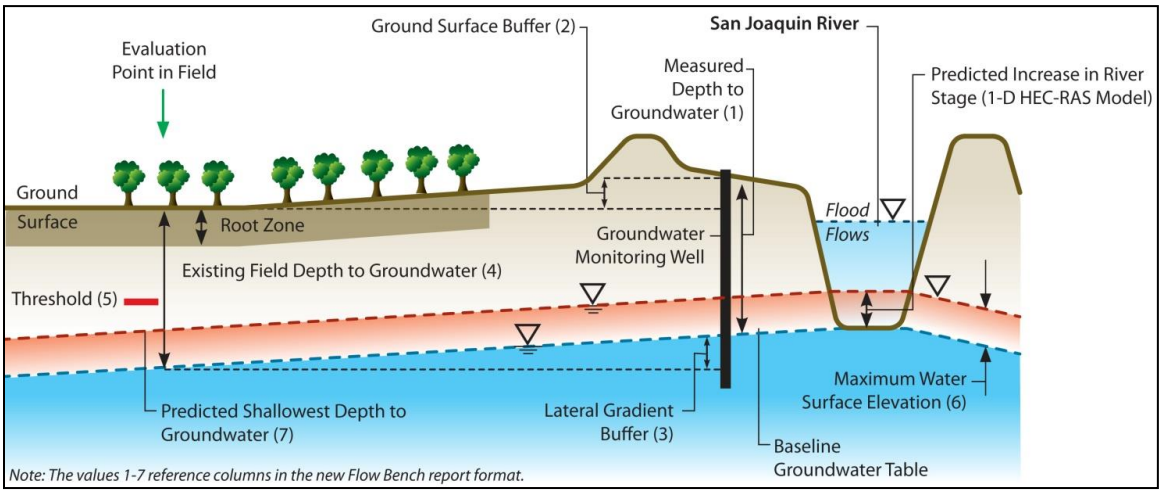

Figure 1. Conceptual Model for Observed Groundwater Level Method

Pre-Condition

The pre-condition well data in Table 2 shows some groundwater levels above threshold during flood flow operations. Flood flows primarily impacted Reach 2A and Reach 2B; however, groundwater levels were also elevated at some Reach 3 and Reach 4A wells from various influences. From Table 2, 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-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.

During flood flow operations, MW-09-47, MW-09-49B, MW-13-200, and MW-10-78 exceeded thresholds. Reach 2A wells MW-09-47 and MW-09-49B were directly influenced by flood flows. Reach 3 wells MW-13-200 and MW-10-78 appear to trend with irrigation demands. Reach 4A wells were responding to fluctuations below Sack Dam of flows up to 300 cfs according to the SDP gauge.

Table 2. Pre-Condition Well Data (Flood Flows)

Well	Reach	1 - Measured Groundwater Depth in Well (feet bgs)	Date Measured	2 - Ground Surface Buffer (feet)	3 - Lateral Gradient Buffer (feet)	4 – Calculated Field GW Depth (feet bgs)	5 - Field Threshold (feet bgs)	Comparison of Calculated Field GW and Field Threshold
FA-9	2A	6.0	4/3/2019	2.0	2.5	**6.5**	**6.0**	**Acceptable**
MW-09-47	2A	4.9	4/3/2019	2.5	3.3	**5.7**	**6.5**	**Above Threshold**
MA-4	2A	9.4	4/3/2019	6.1	4.6	**7.9**	**7.0**	**Acceptable**
MW-09-49B	2A	2.3	4/3/2019	1.7	2.4	**3.2**	**5.5**	**Above Threshold**
MW-09-54B	2B	11.2	4/3/2019	7.9	5.5	**8.8**	**7.0**	**Acceptable**
MW-09-55B	2B	6.2	4/3/2019	3.7	3.0	**5.5**	**5.5**	**Acceptable**
PZ-09-R3-5	3	10.5	3/28/2019	1.2	0.0	**9.4**	-	**Acceptable**[4]
MW-12-191	3	11.9	3/28/2019	1.0	0.0	**10.9**	**6.5**	**Acceptable**
PZ-09-R3-7	3	9.2	4/3/2019	0.7	0.0	**8.5**	**6.5**	**Acceptable**
MW-10-75	3	16.5	4/5/2019	0.5	0.2	**16.2**	**8.0**	**Acceptable**
MW-13-200	3	13.5	3/25/2019	8.1[3]		**5.4**	**5.5**	**Above Threshold**[3]
MW-10-78	3	6.9	4/4/2019	3.0		**3.8**	**3.9**	**Above Threshold**
MW-13-195	3	11.3	3/25/2019	6.5[3]		**4.8**	-	**Acceptable**[3,4]
MW-13-199	3	13.3	3/25/2019	0.0[1]		**13.3**	**7.8**	**Acceptable**
MW-13-201	3	11.9	3/25/2019	2.9		**8.9**	**8.0**	**Acceptable**
MW-12-190	3	9.0	4/3/2019	2.4		**6.7**	-	**Acceptable**[4]
PZ-09-R3-3	3	-	-	4.3		-	**7.4**	-
MW-10-89	4A	10.2	4/5/2019	1.0	0.0	**9.2**	**6.5**	**Acceptable**
MW-18-80B	4A	10.0	4/4/2019	-		**6.5**[2]	-	**Acceptable**[4]
MW-17-225	4A	8.6	4/4/2019	-		**6.9**[2]	**6.5**	**Acceptable**
MW-10-188	4A	9.1	4/4/2019	2.1	0.0	**7.0**	-	**Acceptable**[4]

bgs = below ground surface; GW = groundwater; Header numbers refer to Figure 1

[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

Under the current RA recommendation, all wells except MW-09-49B will be below threshold given the conceptual model for the Observed Groundwater Level Method (Figure 1 and depicted further in Figure 2). All sites should have reduced groundwater elevations with the predicted stage decreases. For MW-09-49B, the Drainage Method (Figure 3) is applied for the transition from flood flows to provide at least 0.3 ft stage difference for drainage from the field threshold elevation to the SJR. Monitoring will continue with the operation of Restoration Flows to record changes in groundwater elevation. Once below projected thresholds, subsequent FBEs may be completed to inform any potential flow changes.

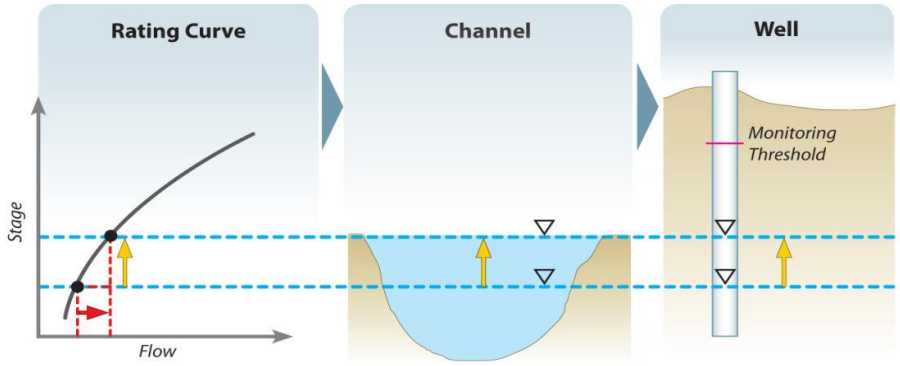

Figure 2. Conceptual Relationship between River Stage and Groundwater Levels

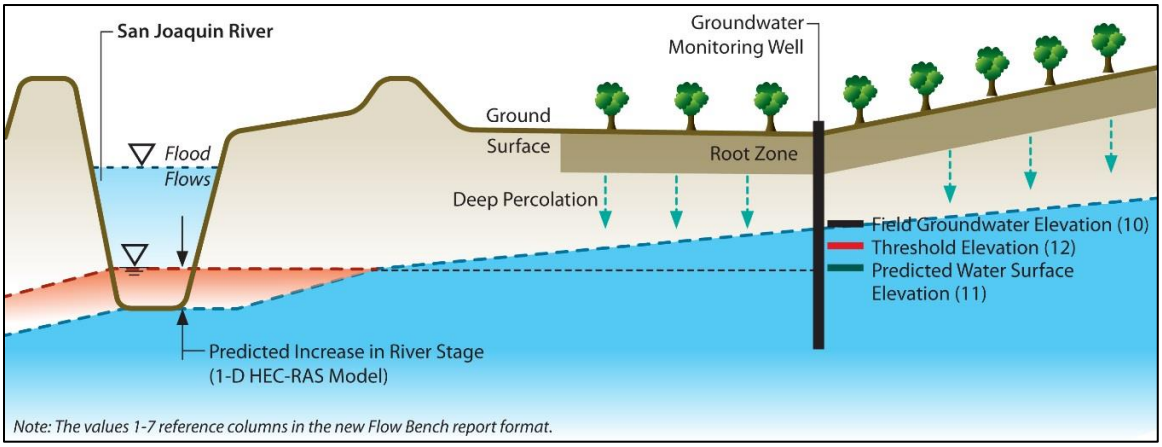

Figure 3. Conceptual Model for Drainage Method

Projected Conditions

Table 3 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 SJRRP Operations Report sent April 5. Pre-condition flows are based on the flood flows sustained through March 29 prior to ramp down. The comparison of pre-condition and projected flows informs the estimated result of decreasing flows from flood operations. Acceptable Restoration Flows may be refined further through future FBEs following groundwater monitoring.

Table 3. Anticipated Change in Flows.

	Pre-condition Flows (cfs)	Projected Flows from Evaluation (cfs)
Reach 2A	2718	330
Reach 2B	797	260
Reach 3	390	370[1]
Reach 4A	250	235

[1] Assumes 135 cfs demand for Arroyo Canal

Table 4 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 2, adding the ground surface and the lateral gradient buffers, and subtracting the maximum predicted stage increase (Equation 2).

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

Table 4. Predicted Groundwater Levels for Priority Wells with Projected Flows

Well	Reach	1 - Measured GW 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)	Comparison of Predicted Field GW and Field Threshold
FA-9	2A	6.0	4/3/2019	2.0	2.5	6.5	-4.4	**10.9**	**6.0**	**Acceptable**
MW-09-47	2A	4.9	4/3/2019	2.5	3.3	5.7	-4.4	**10.1**	**6.5**	**Acceptable**
MA-4	2A	9.4	4/3/2019	6.1	4.6	7.9	-2.1	**10.0**	**7.0**	**Acceptable**
MW-09-49B	2A	2.3	4/3/2019	1.7	2.4	3.2	-2.1	**5.3**	**5.5**	**Acceptable**[5]
MW-09-54B	2B	11.2	4/3/2019	7.9	5.5	8.8	-0.1	**8.9**	**7.0**	**Acceptable**
MW-09-55B	2B	6.2	4/3/2019	3.7	3.0	5.5	-0.1	**5.6**	**5.5**	**Acceptable**
PZ-09-R3-5	3	10.5	3/28/2019	1.2	0.0	9.4	-0.1	**9.5**	-	**Acceptable**[4]
MW-12-191	3	11.9	3/28/2019	1.0	0.0	10.9	-0.1	**11.0**	**6.5**	**Acceptable**
PZ-09-R3-7	3	9.2	4/3/2019	0.7	0.0	8.5	-0.1	**8.6**	**6.5**	**Acceptable**
MW-10-75	3	16.5	4/5/2019	0.5	0.2	16.2	-0.1	**16.3**	**8.0**	**Acceptable**
MW-13-200	3	13.5	3/25/2019	8.1		5.4	-0.1	**5.5**	**5.5**	**Acceptable**
MW-10-78	3	6.9	4/4/2019	3.0		3.8	-0.1	**3.9**	**3.9**	**Acceptable**
MW-13-195	3	11.3	3/25/2019	6.5		4.8	-0.1	**4.9**	-	**Acceptable**[4]
MW-13-199	3	13.3	3/25/2019	0.0		13.3	-0.1	**13.4**	**7.8**	**Acceptable**
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PZ-09-R3-3	3	-	-	4.3		-	-0.1	-	**7.4**	-
MW-10-89	4A	10.2	4/5/2019	1.0	0.0	9.2	-0.5	**9.6**	**6.5**	**Acceptable**
MW-18-80B	4A	10.0	4/4/2019	-		6.5	-0.2	**6.7**	-	**Acceptable**[4]
MW-17-225	4A	8.6	4/4/2019	-		6.9	-0.2	**7.0**	**6.5**	**Acceptable**
MW-10-188	4A	9.1	4/4/2019	2.1	0.0	7.0	-0.3	**7.3**	-	**Acceptable**[4]

bgs = below ground surface; GW = groundwater; WSEL = water surface elevation; Header numbers refer to Figure 1

[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.

[5] Acceptable by the Drainage Method which allows at least 0.3' stage difference from the threshold elevation to the SJR water surface.

Summary

This analysis indicates acceptable conditions for the current RA Recommendation. Groundwater levels will continue to be closely monitored at MW-09-49B, which is currently elevated due to flood flows, so as not to impede drainage. Monitoring will also continue at other critical wells (Figure 4) and the remainder of the network. The maximum allowable flow below Sack Dam is currently limited to 235 cfs. 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 when constrained by seepage in Reach 3. Subsequent FBEs will be performed to inform any flow changes with the potential to impact seepage.

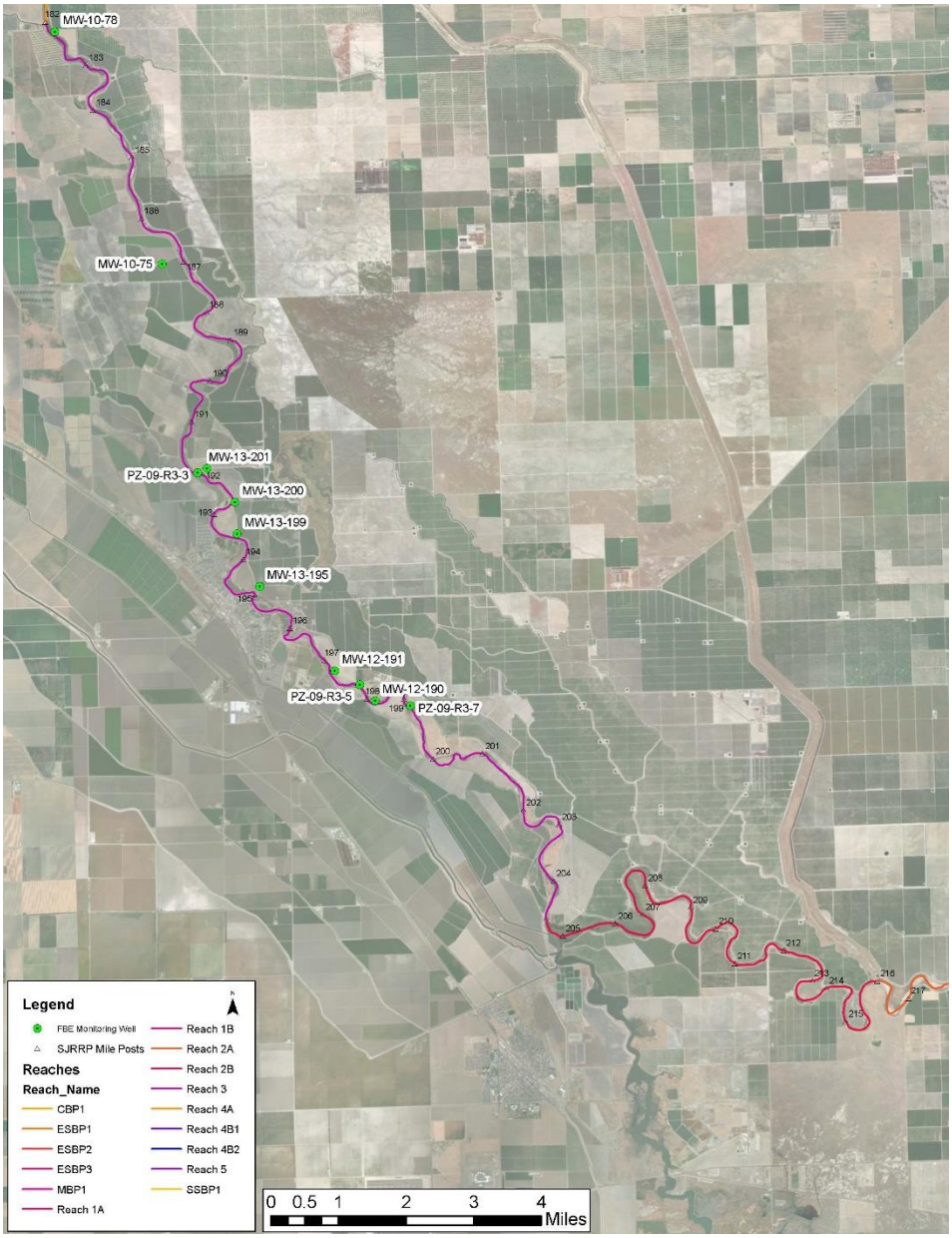

Figure 4a. Critical Monitoring Well Locations in Reach 3

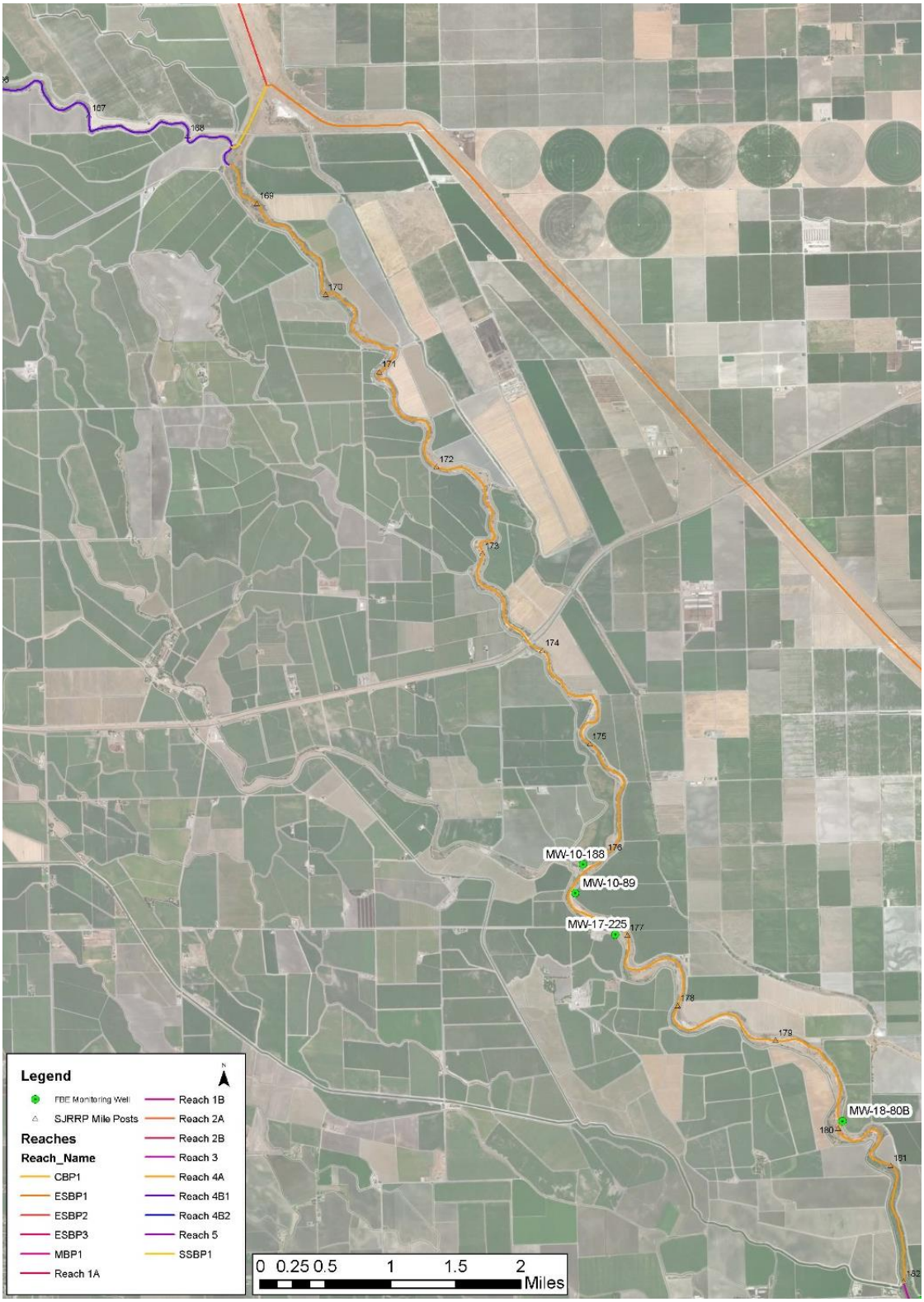

Figure 4b. Critical Monitoring Well Locations in Reach 4A