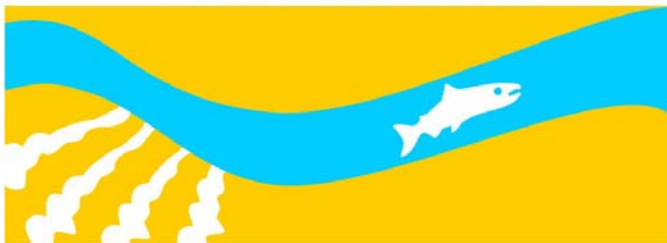


DRAFT

Seepage Management Plan

SAN JOAQUIN RIVER
RESTORATION PROGRAM



1. Introduction

This Seepage Management Plan (Plan) for the San Joaquin River Restoration Program (SJRRP) describes the monitoring and operating guidelines for reducing Interim or Restoration Flows to the extent necessary to address any material adverse impacts caused by Interim and Restoration Flows in the San Joaquin River identified by the SJRRP groundwater monitoring program. The geographic scope of this Plan, referred to as the Restoration Area, is the area within five miles of the San Joaquin River and associated bypass system along the 150-mile reach from Friant Dam to the confluence with the Merced River. This 150-mile reach and associated defined sub-reaches are shown in Figure 1.



Figure 1. Restoration Area

This Plan is meant to be a dynamic, adaptive plan. Implementation of SJRRP activities over time will result in new information and subsequent revisions of the Plan. The Plan provides the framework to facilitate this adaptive process. Stakeholder input and feedback has helped to shape this plan and will continue to improve the process.

The seepage-related effects considered in this Plan are related to lateral flow through levees and associated seeps, and rising of the water table in areas where it is shallow. The former is straightforward in concept, but the latter requires some explanation. Two mechanisms may cause the water table to rise in association with Restoration Flows. Along losing reaches, where river water surface elevation is above groundwater level, increased seepage from the river/bypass system may result in increased groundwater recharge. Along gaining reaches, where river water surface elevation is below groundwater level, groundwater discharge to surface water may be impeded by an increase in surface-water stage. In response, the water table will rise until equilibrium with surface water, or the discharge to surface water is established, or

1 evapotranspiration and/or other forms of discharge increase to regain the previous rate of
 2 discharge. In this document, all impacts caused by groundwater rise associated with changes in
 3 river/bypass stage, regardless of mechanism, are referred to as *seepage impacts*.

4 The Plan provides a means to reduce or avoid risk of seepage impacts through a combination
 5 of monitoring and analyses to better understand and predict system response to Restoration
 6 activities, and development of thresholds and response actions designed to reduce or avoid
 7 undesirable outcomes. Components of the Plan include:

- 8 • Purpose and Objectives: the purpose and intended outcomes of the Plan;
- 9 • Seepage Effects: description of undesirable outcomes and the processes that contribute to
 10 seepage.
- 11 • Locations of Known Risks: areas identified as at risk for seepage effects through
 12 landowner identified parcels, historical groundwater levels, the Central Valley
 13 Hydrologic Model (CVHM), and the current monitoring program.
- 14 • Operations Plan: procedures for assessing flow rates and responding to real-time
 15 concerns identified by monitoring and landowner feedback through making changes in
 16 flow releases.
- 17 • Monitoring Program: the data collection program including a series of telemetry, logged,
 18 and manually measured monitoring well transects and staff gages spaced roughly 8-10
 19 miles apart with additional wells at locations identified by the SJRRP and landowners
 20 to document the hydrologic response to Interim and Restoration Flows, inform
 21 analyses, constrain modeling, and identify potential or actual seepage impacts.
- 22 • Thresholds, Triggers, and Operational Criteria: groundwater levels that identify the
 23 potential for seepage effects, and events that result in increased scrutiny and provide
 24 operational criteria to restrict the magnitude, timing, or duration of flows.
- 25 • Site Visits and Response Actions: specific actions or alternative actions that will be
 26 implemented as necessary to meet operational criteria and avoid or reduce seepage
 27 impacts;
- 28 • Projects: potential modifications to reduce seepage effects and allow for higher flows that
 29 require independent, supplemental environmental documentation and regulatory
 30 review; and
- 31 • Revision Process: process for modifying and/or updating the Plan on the basis of
 32 information obtained during implementation of the Plan.

33
 34 Data and tools to support the Plan include historical measurements, anecdotal evidence,
 35 hydrologic models, and analytical computations. The release of Interim Flows allows the SJRRP
 36 to study groundwater and seepage effects and remove conveyance constraints prior to the release
 37 of full Restoration Flows. Implementation requires a number of site-specific tasks to determine
 38 monitoring locations, install monitoring systems, establish thresholds, and prescribe response
 39 actions for various levels of SJRRP-induced changes. Local landowners can provide information
 40 to improve the effectiveness of the program including continued input through the Seepage and
 41 Conveyance Technical Feedback Group meetings. The main body of the Plan describes the

1 components and interactions of operations to reduce or avoid seepage impacts. The following
2 appendixes contain supporting technical information:

- 3 A. Seepage Effects
- 4 B. Areas Potentially Vulnerable to Seepage Effects
- 5 C. Historic Groundwater Levels and Surface-Water Flow
- 6 D. Sediment Texture and Other Data
- 7 E. Operations
- 8 F. Monitoring Well Network Plan and Other Seepage-Related Monitoring
- 9 G. Development of Soil Salinity Thresholds
- 10 H. Development of Groundwater-Level Thresholds
- 11 I. Landowner Claims Process
- 12 J. Modeling
- 13 K. References Cited

14 This Plan is part of the project description for the SJRRP and the expected environmental
15 impacts of implementing the Plan must comply with NEPA and CEQA criteria.

16 **2. Purpose and Objectives**

17 The Plan will convey Interim and Restoration Flows while reducing or avoiding SJRRP-
18 induced seepage impacts along the San Joaquin River and the Eastside and Mariposa Bypasses
19 from Friant Dam to the Merced Confluence. This Plan addresses several components of the San
20 Joaquin River Restoration Settlement Act, H.R. 146, which requires the Secretary of the Interior
21 to:

- 22 (1) prepare an analysis that includes channel conveyance capacities and the potential for
23 levee or groundwater seepage;
- 24 (2) describe a seepage monitoring program; and
- 25 (3) evaluate possible impacts associated with the release of Interim Flows.

26 **3. Seepage Effects**

27 This plan identifies and evaluates a physical impact by describing the measurable impact
28 mechanisms, processes, and thresholds where actual or pending seepage could cause damage.
29 Impact mechanisms under the Plan include:

- 30 1. **Waterlogging of crops** – inundation of the root zone resulting in mortality or reduced
31 crop yields.
- 32 2. **Root-zone salinization** – salinity increases resulting in mortality or reduced crop yields.
- 33 3. **Levee instability** – boils or piping (seeps) that may compromise the short- or long-term
34 integrity of the levee.

35 **4. Locations of Known Risks**

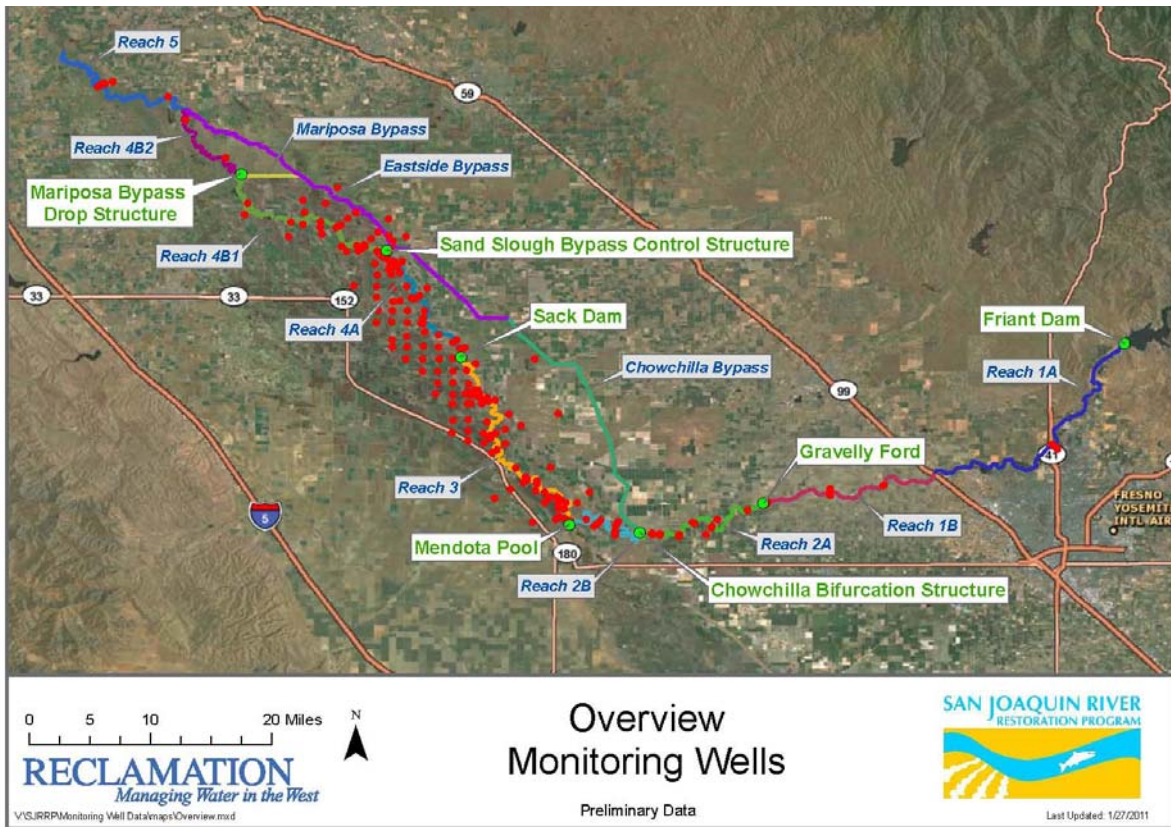
36 This plan represents potential risks by sites and areas of likely or known vulnerability to
37 seepage effects on the basis of (1) mapped depth to the water table using measured water levels;
38 (2) problematic areas identified by landowners; (3) analysis of flow, precipitation, and water-
39 level data; and (4) simulation results using a regional hydrologic model, particularly in areas

1 where water-level data are sparse. Appendix B: Areas Potentially Vulnerable to Seepage Effects
 2 includes documentation of these data and analyses.

3 The analysis of potential risks documents local knowledge, assists in siting monitoring
 4 stations, and scopes additional studies. Data and analyses that support baseline seepage
 5 conditions are included in Appendixes B: Areas Potentially Vulnerable to Seepage Effects and
 6 Appendix C: Historic Groundwater Levels and Surface-Water Flow.

7 5. Monitoring Program

8 Reclamation monitors the effects of SJRRP activities which informs identification of when,
 9 where, what, and how potential response actions may be implemented. Thresholds, discussed in
 10 Section 6, indicate potential for seepage effects and inform response actions and/or additional
 11 data collection needs. The monitoring program informs modeling and analysis to evaluate
 12 strategies for implementing response actions. See Appendix F: Monitoring Well Network Plan
 13 and Other Seepage-Related Monitoring for details on the existing Monitoring Plan and future
 14 directions.



15 **Figure 2. Cover of SJRRP Monitoring Well Atlas showing SJRRP monitoring well
 16 network including stakeholder wells**

17 Areas underlain by a shallow water table, herein referred to as shallow groundwater areas, are
 18 of particular interest in the monitoring program. The SJRRP currently takes measurements in
 19 111 monitoring wells as of February 21, 2011. The monitoring program includes:

- 1 1. Well transects spaced at roughly every 8–10 miles with 4–6 shallow monitoring wells
2 (indicative of the water table aquifer), a staff gage measuring river stage, and 1–2 deeper
3 monitoring wells (potentially indicative of the underlying semiconfined or confined
4 aquifer) at each transect;
- 5 2. Additional shallow wells located in known shallow groundwater areas that may be
6 affected by seepage, in collaboration with local landowners and the Central California
7 Irrigation District (CCID);
- 8 3. Soil sampling and soil salinity surveys using electromagnetic (EM) methodology, in
9 collaboration with local landowners;
- 10 4. Reporting from local landowners on visual crop health, levee seeps, and other
11 observations through phone and email with established SJRRP-designated points of
12 contact.

13 Information from monitoring, analysis, and local landowners will be used to determine well
14 locations, subject to potential access limitations. New information may indicate that wells
15 should be added, decommissioned, excluded from particular cross-sections or otherwise
16 modified in the future. The Monitoring Well Atlas, available on the SJRRP website, contains
17 details of the monitoring well network and will be updated periodically as additional information
18 is gained and wells are installed or modified.

19 **6. Thresholds**

20 Thresholds identify transition points where seepage effects cross into a range that may cause
21 damages. Thresholds also collect information before an impact occurs and provide time to
22 initiate a response. Thresholds may take the following forms:

- 23 1. **Water surface elevation** – measured elevation of the water surface in a well relative to a
24 vertical datum.
- 25 2. **Depth to water** – measured vertical distance to the water surface in a well relative to the
26 land surface.
- 27 3. **Root-zone salinity** – measured (using direct or indirect methods) salinity in the plow or
28 root zone and/or distribution of salinity in soil profiles.

29 A groundwater levels shallower than a threshold indicates the potential for impacts in the
30 absence of actions to avoid, minimize, rectify, reduce, or compensate for seepage impacts. Site-
31 specific customization of specific thresholds will continue to be enhanced by coordination with
32 local landowners and may depend upon characteristics such as:

- 33 1. Local geology;
- 34 2. Presence, design considerations, and state/condition of the levee system;
- 35 3. Historical experience and areas of known historical seepage problems;
- 36 4. Structures and operations;
- 37 5. Soil salinity profile;
- 38 6. Crop type; or
- 39 7. Intent of threshold.

Draft thresholds associated with the water table and monitoring thresholds for soil salinity in farmed shallow groundwater areas are shown in Table 1. The salinity thresholds apply only where current conditions are more favorable than the threshold values. If current conditions exceed threshold values, thresholds will be a specified change from current conditions.

Table 1. Draft thresholds for groundwater and soil salinity underlying agricultural lands

Impact indicator	Threshold	Basis
Plow layer soil salinity (0-12 inches below land surface)	ECe ¹ = 2.0 deciSiemens/m (ds/m) (See Appendix G)	Salinity affects germination or emergence of vegetable and other crops
Active root zone soil salinity (0-30 inches below land surface)	River-reach-specific; e.g., ECe ¹ = 1.5 ds/m for reach 2B (See Appendix G)	Known salt tolerance for crops
Minimum depth to water table	Variable, depending on crop type, historical water levels, and local conditions (see Appendix H)	Waterlogging affects crop yields and increases soil salinity

¹ ECe is electrical conductivity of soil-water extract (saturation extract)

The SJRRP has identified specific groundwater thresholds for each well and priority wells for measuring groundwater thresholds in areas of known risk. There are three methods for determining the groundwater threshold. These include:

- Agricultural Practices
- Historical Groundwater
- Drainage

The thresholds are generalized, and adjustments may be required to account for on-site and/or seasonal conditions. Crop health can be affected by conditions unrelated to SJRRP activities, including various climatic conditions and other factors such as plant diseases. The procedures used for establishing thresholds are described in Appendix G: Development of Soil-Salinity Thresholds and Appendix H: Development of Groundwater-Level Thresholds.

7. Operations Plan

The approach to operations is a conservative, iterative one. The SJRRP will estimate a release from Friant Dam and Mendota Dam that avoids seepage impacts. The release will estimate non-damaging flows by establishing groundwater thresholds, as described in Section 6 and Appendix H, and linking thresholds to river stage through a conceptual model. The conceptual model initially assumes one foot of increase in river stage causes one foot of increase in groundwater. If the monitoring program identifies areas where the conceptual model predicts overly conservative flow limits, the SJRRP may update flow releases based on site specific information. When the SJRRP cannot estimate a higher release that will not exceed a threshold, the stage or flow rate in the river becomes an operational criterion. An operational criterion is a specific measurable or observable criterion (such as a river stage) that indicates impending impacts, is established based on site-specific analysis, and will limit flow releases.

1
2 Prior to an increase in the targeted Friant Dam release, the SJRRP conducts a Flow Bench
3 Evaluation. The purpose of the Flow Bench Evaluation is to avoid seepage impacts through
4 checking factors and reducing or eliminating the proposed increase accordingly. Flow Bench
5 Evaluations verify:

6 1) Conveyance Capacity:

7 Avoid levee instability by limiting flows to the rated conveyance capacity of the
8 channel.

9 2) Flow Stability:

10 Account for travel time and potential changes that may not have materialized
11 since the prior change in releases by allowing flows to stabilize before the next
12 change in releases.

13 3) Groundwater Projections:

14 Avoid seepage impacts by predicting groundwater level rise from the proposed
15 increase assuming a one foot increase in river stage equates to a one foot increase
16 in groundwater level. If groundwater levels are predicted to rise above thresholds,
17 this triggers a site visit as described in Section 8, prior to the change in flow.

18 4) Groundwater Telemetry:

19 Avoid seepage impacts by monitoring real-time groundwater wells and
20 conducting a site visit if levels are near thresholds.

21 5) Groundwater Manual Measurements:

22 Avoid seepage impacts by measuring groundwater wells weekly and conducting a
23 site visit if levels are near thresholds.

24 6) Mendota Pool Operations:

25 Avoid infeasible operations through the Mendota Pool operations calls including
26 exchangeable demand, water quality, and Central Valley Project South of the Delta
27 operations.

28 7) Landowner Feedback (Seepage Hotline):

29 Avoid potential seepage impacts by gathering data from Seepage Hotline calls and
30 subsequent site visits.

31 8) Operations Feedback:

32 Avoid infeasible operations and levee instability through coordination with the
33 Central California Irrigation District, San Luis Canal Company, and Lower San
34 Joaquin Levee District on potential concerns with the proposed flow increase.
35

1 In addition to Flow Bench Evaluations, the SJRRP conducts Daily Flow Evaluations when flows
2 are above 475 cfs. Daily Flow Evaluations include documentation of the checks on conveyance
3 capacity, Mendota Pool operations, and landowner feedback as described above. Daily Flow
4 Evaluations also trigger site visits if real-time or measured groundwater levels are near
5 thresholds.

6
7 Flow Bench Evaluations and Daily Flow Evaluations help the SJRRP avoid seepage impacts and
8 document decisions to increase flows. These evaluations also trigger site visits and response
9 actions based on SJRRP's monitoring network.

10
11 See Appendix E: Operations for example forms.

12 **8. Triggers**

13 Triggers describe when the SJRRP will take action through site visits and flow management.
14 There are three different types of triggers. Two of these are SJRRP actions, and the last one
15 allows landowners observations to trigger SJRRP action. These triggers include:

- 16 1. Flow Bench Evaluations: A site visit and response action is triggered when groundwater
17 levels are predicted to rise above thresholds
- 18 2. Daily Flow Evaluations: A site visit and response action is triggered when measured
19 groundwater levels are near thresholds
- 20 3. Seepage Hotline Call: A site visit and response action is triggered when landowners
21 observe seepage-related issues

22 Following a trigger, the SJRRP will initiate a site visit. The SJRRP may re-evaluate the
23 estimated flow rate and/or the threshold as a result of information collected at a site visit.

24 **9. Site Visits and Response Actions**

25 Site visits, triggered by flow bench evaluations, daily flow evaluations, or seepage hotline
26 calls, collect a variety of information to inform management response decisions. Site visits
27 provide an initial assessment to determine the type of impact, description of the seepage, the
28 relationship to interim flows, the immediacy of the response, a recommended real-time response
29 action, and any needed follow-up regarding projects. Site visits may include monitoring and
30 conversation with the landowner to gather the following types of data:

- 31 1. Landowner Input on Seepage Effects
- 32 2. River Stage
- 33 3. Soil Texture
- 34 4. Hand Auger Groundwater Levels (allows rapid response rather than waiting for backhoe
35 or well installation)
- 36 5. Drive Point Installation
- 37 6. Soil Salinity
- 38 7. Infrastructure

1 8. Crop Health

2 9. Photos

3 The operations for releasing Interim and Restoration Flows are designed to safely convey flows
4 without triggering the need for response actions. If site visits are triggered, response actions will
5 be evaluated and implemented as soon as practicable to avoid or reduce seepage impacts. Flood
6 operations supersede SJRRP releases and may occur irrespective of groundwater monitoring.
7 Potential response actions include:

8 1. **Planned releases can occur** – no seepage impacts are anticipated at the site based on the
9 planned release schedule. Anticipated releases can occur.

10 2. **Increased monitoring** – no seepage impacts are anticipated at the site for the near-term
11 anticipated releases, however, an increased monitoring frequency will gather additional
12 information to assist in evaluating the potential seepage impacts of future releases.

13 3. **Adjustment to local flow rate** – the conceptual model linking thresholds to river stage
14 may be adjusted at this site based on information gathered at the site visit. This may or
15 may not create a new restriction on maximum release.

16 4. **Adjustment to threshold** – information gathered at the site visits regarding crops,
17 historical groundwater, or drainage will adjust the threshold at the site. This adjustment
18 will be done in collaboration with the landowner.

19 5. **Flow Response Actions** – an immediate or future change in flows is needed to prevent
20 material adverse seepage impacts. Potential flow response actions include:

21 a. **Restrictions on maximum release** – flow rates in each reach will be established
22 below documented historical rates known to cause seepage impacts, to be
23 accomplished through a combination of releases from Friant Dam, infiltration,
24 and agreements with diverters.

25 b. **Restrictions on ramping rates and duration** – limits on the incremental
26 increases in flow rates provide the ability to evaluate the system response through
27 the monitoring program while limiting the volume of upstream water if an
28 impending impact is observed, measured, or predicted through simulation.

29 c. **Reduction of Restoration Flow releases at Friant Dam** – reductions in
30 Restoration Flows released from Friant Dam will limit the amount of water
31 available to cause seepage impacts. Reductions at Friant Dam will need to
32 consider travel time and the associated delay in response.

33 d. **Redirection of flows at Chowchilla Bifurcation Structure** – directing flow into
34 the bypass system at the Chowchilla Bifurcation Structure will provide a faster
35 response for downstream reaches compared to Friant Dam operational changes.
36 This response requires coordination with the Lower San Joaquin River Levee
37 District for such operations.

38 e. **Delivery of flows to Exchange Contractors and Refuges at Mendota Pool** –
39 delivery of water to Mendota Pool will reduce flows in Reach 3 and downstream.
40 Use of diversion into Mendota Pool to reduce downstream flows will require

1 coordination with the Central California Irrigation District and the San Luis
2 Delta-Mendota Water Authority.

- 3 f. **Delivery of flows to Exchange Contractors and refuges at Sack Dam** – at
4 times when the San Luis Canal Company has canal conveyance capacity,
5 additional water diversions at Sack Dam can assist with reducing potential
6 seepage impacts in Reach 4A and downstream. Use of the Sack Dam response
7 will require coordination with the San Luis Canal Company.
- 8 g. **Redirection of flows at Sand Slough Control Structure** – during Interim Flows
9 water will not be directed into Reach 4B. In subsequent years, water causing
10 concerns in Reach 4B may be diverted into the Eastside Bypass. Use of the
11 Eastside Bypass will require coordination with the Lower San Joaquin River
12 Levee District.

13 **10. Projects**

14 Potential future actions may be needed if meeting Settlement goals through specified
15 Restoration Flows is sufficiently compromised by seepage-related constraints. Such actions may
16 include real estate actions or structural additions. These actions likely would require landowner
17 agreements and initiation of project-specific environmental documentation to comply with
18 NEPA, CEQA, and other regulatory requirements. Potential future actions may include:

- 19 1. Easements and/or compensation for seepage effects;
- 20 2. Acquisition of lands;
- 21 3. Slurry walls between the river/bypass and seepage-impacted lands to reduce water-table
22 response to increased surface-water stage;
- 23 4. Seepage berms to protect against levee failure;
- 24 5. Drainage interceptor ditches to lower the water table;
- 25 6. Tile drains to lower the water table;
- 26 7. Operate new drainage and/or existing irrigation wells to lower the water table; and/or
- 27 8. Conveyance improvements such as sand removal.

28 The Plan will not result in planning, design, environmental compliance or construction of
29 potential projects, but will assist in identifying such actions.

30 **11. Revisions**

31 Updates to the Plan may include changes derived from data obtained through the monitoring
32 program, results from improved modeling and analysis tools, modified objectives or thresholds,
33 and/or identification of additional concerns that arise through Plan implementation. The policy
34 for revising the Plan includes:

- 35 1. Stakeholders may submit recommendations to the Program Manager at any time;
- 36 2. The Program Manager will acknowledge and respond to recommendations; and

- 1 3. A periodic review of the Plan through the Seepage and Conveyance Technical Feedback
- 2 Group meetings may incorporate changes, including any new information such as the
- 3 findings of a peer review panel.
- 4 The revision process sets the expectations for stakeholder and management participation. The
- 5 SJRRP may not be able to commit to specific recommended actions, but all comments and
- 6 recommendations will be considered.