

3.4.2.1 CM1 Water Facilities and Operation

[Note to Reviewers: On January 29, 2010 the BDCP Steering Committee approved for the purposes of the detailed effects analysis a set of BDCP initial long-term operating criteria. A table of these criteria can be found in the February 11, 2010 agenda packet on the BDCP web site. A companion document titled “Aquatic Conservation Measures Proposed for Effects Analysis under BDCP” can also be found in the February 11 agenda packet and describes the steps that were used to develop this set of criteria. These criteria reflected the current thinking of the Steering Committee at that time for the purpose of a comprehensive effects analysis. The Steering Committee noted that these criteria might become the final criteria or they might be modified based on the results of the effects analysis, evaluation of alternatives under CEQA and NEPA or efforts to optimize them and permit achievement of the ecosystem and water supply goals of the BDCP. The Steering Committee envisioned an iterative process to refine the conservation strategy, including the development of the final set of initial long-term operating criteria and the adaptive range for these criteria.

An effects analysis has been underway by the SAIC team over the past 10 months and the Steering Committee has been given several presentations on the preliminary results of that analysis. The Effects Analysis continues to be reviewed by the technical staff of the Steering Committee representatives and will be revised as necessary. To date, several issues have been identified that may necessitate changes to the initial long-term operating criteria. These include:

- 1. North Delta intake configuration related to predation concerns (in-river vs on-bank)*
- 2. Spring-run salmon egg mortality on the Sacramento River in the fall*
- 3. Reduced Sacramento River flows downstream of the North Delta intakes*
- 4. Refinement of April-May south delta operations*
- 5. Winter-spring X2 and outflow effects on longfin smelt*
- 6. Summer and fall X2 and delta smelt abiotic habitat*

A process has begun to evaluate how modifications to some of the conservation measures, including initial long-term operating criteria might address some of these issues in a manner that provides a refined approach to fishery protection while being sensitive to the water supply goals. This will lead to an iteration process that will take place for the purpose of describing the final conservation strategy and the initial long-term operating criteria for complete evaluation in the effects analysis. Also, as part of this process, an adaptive range for the operational criteria will be developed.]

This conservation measure provides for significant proposed changes to water operations in the Delta under the BDCP. This conservation measure includes two major components: (1) construction of new water facilities, and (2) operations of new operational control facilities or changes to the operations of existing operational control facilities. The evaluation of proposed new conveyance facilities (or changes to existing facilities) addresses two core issues that are separate and distinct, but are also closely interrelated. The first is the design issue associated

1 with the new facility; that is, whether the new facility itself may enable improvements in flows
2 and hydrodynamics if operated properly, and how to design the facility to achieve those
3 improvements. The second issue is the operational issue; that is, what types of operational
4 parameters would be most appropriate for the new facility to contribute to BDCP goals and
5 objectives. It is important to recognize that these two aspects of proposed new water conveyance
6 facilities are separate and distinct yet also closely joined, and must be evaluated as such.

7 The proposed new north Delta diversion facility offers an instructive example of this distinction.
8 The appropriateness of the north Delta facility as a major new conservation measure for the
9 BDCP demonstrates how both issues must be addressed together. There is a relatively broad
10 agreement within the fisheries conservation community that a properly operated new north Delta
11 facility will provide substantial benefits for certain listed species over the existing system, for all
12 of the reasons enumerated below. The far more energetic debate focuses on what constitutes the
13 proper operating parameters for the new facility, and less on the design parameters of the north
14 Delta facility itself – although both are essential components of the proposal. Determining the
15 appropriateness of the north Delta facility, therefore, considers the operational parameters that
16 will govern it as much as the reliability of the governance structures that will apply those
17 parameters. Hence, clearly distinguishing the design features from the operational features is
18 important for an accurate appraisal of the merits of the measure overall.

19 The lower Sacramento River, Delta, and Suisun Bay and Marsh provide habitat for a diverse and
20 complex assemblage of resident and migratory fish and other aquatic organisms. Section 3.2.3
21 *Developing the Aquatic Resources Component of the Conservation Strategy*, describes the BDCP
22 approach to conservation and outlines the basic principles governing the approach. Several of
23 these principles apply directly to the design of the conservation measure proposed in this section
24 and are, therefore, expanded upon here. Development of water operations conservation measure as
25 part of the BDCP is based, in large part, on the balance of seasonal and interannual variation in
26 hydrologic conditions occurring within the watershed, and seasonal variation in the habitat
27 requirements and geographic distribution of each of the lifestages of the covered fish within the
28 estuary and tributary rivers, as well as many other factors. These include the beneficial interactions
29 between establishing new aquatic habitats and hydrodynamics, a variety of flow-based and other
30 mechanisms affecting the habitat quality and availability for these species and their food supplies,
31 growth, survival, reproduction, and overall population dynamics in response to implementation of
32 conservation measures. In addition, the water operations conservation measure is designed to
33 provide a reliable water supply in a manner that avoids and reduces adverse effects to covered
34 species and their habitat.

35 The proposed water operations also reflect the fact that the covered fish and other aquatic species
36 have evolved in the Central Valley rivers and Delta. Their life histories are keyed to seasonal
37 changes that naturally occur in flows, water temperatures, and other environmental cues that
38 affect processes such as the seasonal timing of juvenile emigration downstream through the
39 Delta, seasonal timing of reproduction, seasonal patterns in phytoplankton and zooplankton

1 production that are food for covered fish and other aquatic species, seasonal inundation of
2 floodplain habitat, and other important biological mechanisms.

3 One factor considered in the development of the water operations conservation measure is
4 unidirectional downstream sweeping flows across the new fish screens proposed for the lower
5 Sacramento River as part of long-term dual facility operations. Another consideration is the
6 downstream transport of planktonic fish eggs and larvae, organic material, phytoplankton, and
7 zooplankton from the lower Sacramento River into the Delta and Suisun Bay. A third factor is
8 the consideration of sufficient flows in the lower Sacramento River during the primary migration
9 period for juvenile Chinook salmon, steelhead, and other species (December-June) to reduce the
10 frequency of bidirectional tidal flows in areas like Sutter and Steamboat Sloughs that are thought
11 to reduce migration rates and increase the risk of juvenile fish to mortality from sources such as
12 predation. Another factor that is taken into account is the provision of operations to maintain
13 and improve habitat quality and availability for aquatic species in areas such as the Cache Slough
14 complex, the lower Sacramento River, Delta and the low salinity zone located in the western
15 Delta and Suisun Bay. The long-term water operations described below were developed to meet
16 these and other biological objectives, water supply objectives, and water quality objectives of the
17 BDCP. In addition to reducing direct entrainment loss as a result of BDCP covered activities, the
18 new water facilities and operations are designed to reduce other sources of harm to listed species,
19 both direct and indirect (e.g. stranding, loss of homing ability, and reduced predation). In
20 addition, implementation will be adaptively managed to optimize benefits to covered species
21 while maintaining water supply reliability (see Section 3.7, *Adaptive Management*).
22 Uncertainties concerning these actions will be managed through ongoing monitoring and
23 research under the BDCP monitoring and adaptive management programs.

24 Water operations in the Delta are an integrated collection of actions that affect flow and water
25 quality. This water facilities and operational conservation measure is closely intertwined with
26 other components of the conservation strategy, including measures that will restore habitat and
27 address other stressors to covered species. For example, the ability of habitat restoration in the
28 south Delta to increase the amount of biological productivity transported to the western Delta
29 and Suisun Bay will be realized only after preferential operation of the north Delta diversion
30 facility over south Delta facilities begins (i.e., long-term operations).

31 Where applicable, criteria (quantitative values) are identified here for each parameter for specific
32 times of year and specific water year types.

33 3.4.2.1.1 Water Facilities

34 This section presents an introduction to and summary of the proposed new and existing water
35 facilities operated by the SWP and CVP within and near the Plan Area (Figure 3-4). These
36 facilities include physical control structures such as gates, intakes, and pumps that can modify
37 flows and affect Delta hydrodynamics in the immediate vicinity of the structure and often across
38 large portions of the surrounding Delta. The physical construction and modification of these

1 facilities are described and evaluated separately from the operations of the facilities under the
2 BDCP.

3 The following is a list of new and existing water facilities and brief description of their functions:

- 4 1. North Delta Diversion Facilities and Tunnel/Pipeline – The north Delta diversion
5 facilities will include five new intakes along the Sacramento River between Freeport and
6 Courtland (Figure 3.4). Intakes will be equipped with state-of-the-art positive barrier fish
7 screens to reduce entrainment of fish and will connect to tunnel/pipeline to carry water to
8 a new regulating forebay adjacent and connected to existing south Delta SWP and CVP
9 export facilities. More detail on specific features of the tunnel/pipeline facility is
10 provided in Chapter 4, *Covered Activities*. [*Note to Reviewers: The design and location*
11 *of the new intakes and conveyance facilities to be included in the proposed BDCP have*
12 *not been determined.*]
- 13 2. Fremont Weir Operable Gates – New operable gates on the Fremont Weir will allow for
14 the control of the timing, duration, and frequency of inundation of the Yolo Bypass
15 during periods when the Sacramento River would not currently spill over the Fremont
16 Weir into the Yolo Bypass. Operations for Fremont Weir Operable Gates are described
17 in Section 3.4.2.2. *CM2 Yolo Bypass Fisheries Improvements*.
- 18 3. Delta Cross Channel Gates – Delta Cross Channel Gates are existing radial gates that
19 control the flow of Sacramento River water through the Delta Cross Channel into the
20 interior Delta.
- 21 4. Montezuma Slough Salinity Control Gate – Existing gate at the eastern opening of
22 Montezuma Slough that controls the flow of fresh and salt water into Montezuma Slough.
- 23 5. South Delta Diversions – Two existing diversion facilities, the CVP Jones Pumping Plant
24 and the SWP Banks Pumping Plant, divert water from the south Delta to meet water
25 supply demands outside the Delta.
- 26 6. North Bay Aqueduct Alternative Intake - The Barker Slough Pumping Plant diverts water
27 from Barker Slough into the North Bay Aqueduct (NBA) for delivery in Napa and Solano
28 counties. An additional intake on the Sacramento River will operate in conjunction with
29 the existing North Bay Aqueduct intake at Barker Slough.

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Figure 3.4. Water Operations Control Facilities in the Delta.

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1 3.4.2.1.2 Near-Term Water Operations

2 *[Note to Reviewers: At this time, BDCP does not have proposed near-term operations.]*

3 3.4.2.1.3 Long-Term Water Operations

4 This section provides descriptions of the long-term water operations for multiple parameters
5 across the Delta. Long-term operations are made possible by facilities constructed during the
6 near-term implementation period (e.g., new north Delta diversions, tunnel/pipeline, and new
7 gates at Fremont Weir). In the long-term implementation period, dual operations of the existing
8 south Delta diversion facilities and the new north Delta diversion facilities will provide greater
9 flexibility to benefit covered fish and water exports not possible during the near-term
10 implementation period. Long-term operations under the dual facility will allow water to be
11 diverted from the lower Sacramento River using state-of-the-art positive barrier fish screens that
12 are expected to substantially reduce the risk of entrainment of covered fish and other aquatic
13 organisms, but will also provide positive benefits resulting from a reduction in the rate of water
14 diversions occurring from the south Delta when covered fish species are present. Long-term
15 water operations described in this section will replace certain near-term water operations once
16 the new north Delta diversions and the new tunnel/pipeline are completed and functional.

17 Construction and preferential operation of a new water diversion facility in the north 18 Delta.

19 Five new water diversion facilities with 3,000 cfs capacity each (combined 15,000 cfs capacity)
20 will be constructed and operated on the Sacramento River in the north Delta to minimize impacts
21 on fish at the SWP and CVP south Delta diversion facilities. A tunnel/pipeline facility with a
22 15,000 cfs capacity will be constructed to convey water from the new diversion facilities to the
23 south Delta, where it will join existing SWP and CVP diversion facilities. The capacity of the
24 new facilities will be 15,000 cfs, which is approximately the capacity of existing export pumps at
25 SWP and CVP facilities in the southern Delta. The new tunnel/pipeline will follow a route
26 through the Delta (Figure 3.4). Each new intake will be screened with state-of-the-art positive
27 barrier fish screens and have a pump station, power lines, access roads, and other associated
28 infrastructure.

29 Five locations for intakes have been identified (Figure 3.4). Selection of locations is based on
30 multiple considerations including, but not limited to, maximizing function and effectiveness of
31 screens; minimizing impacts to in-channel, on-bank, and terrestrial resources; applicable
32 navigational and flood conveyance regulations; channel geometry and bathymetry; location
33 relative to tidal influence and ranges of covered fish; future climate change and sea level rise;
34 and proximity to other infrastructure (e.g., Sacramento Regional Wastewater outfall, existing
35 developed land, and other intakes). Each intake will be engineered to allow variable rate
36 pumping to handle variation in the location of covered fish and tidally-induced flows, as well as
37 sea level rise from climate change. The influence of tides, which could produce reverse or

1 stagnant flows in channels, attenuates upstream such that the most northern intakes are expected
2 to be less influenced by tides than downstream intakes, particularly during higher river flow.

3 After the comprehensive evaluation of three types of intake/screens structures (on-bank, near-
4 shore, and in-channel screens) for flood control, effects to covered fish species, and feasibility, it
5 was concluded that on-bank structures would best meet these criteria for this reach of the river
6 Fish screens will be designed to NMFS, DFG, and USFWS criteria to include specific screen
7 mesh sizes (1.75 mm open area), a maximum approach velocity of 0.2 feet per second (ft/sec),
8 sweeping velocity of at least two times the approach velocity (0.4 ft/sec), screen cleaning
9 mechanisms, and monitoring systems. Three types of screening materials are currently being
10 investigated: stainless steel, copper-nickel, and plastic. The advantages and disadvantages of
11 each will be considered in the ultimate decision by the Implementation Office of which material
12 to use. Further, with the high risk of invasion into the Delta by quagga and zebra mussels in the
13 future, the use of anti-fouling material or alternative cleaning systems is also being considered.

14 The tunnel/pipeline will route water through the Delta to a new 600-acre forebay on Byron Tract
15 (Figure 3.4). Water will be conveyed from the five intakes via pipelines to either an intake
16 tunnel or a 750-acre Intermediate Forebay. A 33.5-mile tunnel will convey water from the
17 Intermediate Forebay to the Byron Tract Forebay, where it will tie into existing SWP and CVP
18 facilities.

19 Although construction of the new north Delta facility and associated infrastructure will be
20 initiated as early as practicable following BDCP authorization, operation of the new facility will
21 not start until and defines the beginning of the long-term implementation period (estimated at
22 implementation year 10). The north Delta diversion facility will be operated in conjunction with,
23 but preferentially to (except during summer months and at other times where necessary to meet
24 the goals of fish conservation and water supply), existing south Delta SWP and CVP diversion
25 facilities to minimize adverse effects on fish in the Delta while maintaining water supply
26 reliability as described in Chapter 4, *Covered Activities*. The quantity and timing of diversions
27 will be affected by specific parameters described in this chapter.

28 The new intake facilities will be operated to maintain flows in the Sacramento River to meet five
29 primary objectives for flows at and downstream of the new north Delta facilities:

- 30 1. Maintain fish screen sweeping velocities,
- 31 2. Minimize undesirable upstream transport of water and aquatic resources from
32 downstream channels,
- 33 3. Support fish transport to regions of suitable habitat,
- 34 4. Minimize predation effects downstream, and
- 35 5. Maintain or improve rearing habitat in the north Delta.

36 These north Delta facilities “bypass flows” represent the rate of flow at which the Sacramento
37 River must pass downstream of the new diversion points. Bypass flows are intended to serve as

1 an operational parameters to limit or otherwise manage water diversions from the new north
2 Delta diversion facilities to minimize and reduce the effects of those diversions on downstream
3 hydrodynamics (e.g., reduce Sacramento River flow downstream of the point of diversion)
4 needed to support functions within and downstream of the river. Bypass flows for the
5 Sacramento River act as an operational criteria in which water diversions will only occur when
6 flows are maintained above the minimum criteria. The minimum bypass flow rates act as
7 restrictions on water diversions during those years and seasons when flow in the Sacramento
8 River is low. To meet water supply goals (see Chapter 4 *Covered Activities*), constraints on the
9 amount of water diverted from north Delta facilities may require commensurate increases in
10 diversions from the south Delta SWP and CVP facilities. To maintain water quality in the south
11 and central Delta during low flow periods on the San Joaquin River in summer months (July-
12 September), existing south Delta pumps will be preferentially operated up to 3000 cfs (see
13 Section 3.4.1.3.6 *Delta water quality maintenance*).

14 In addition to establishing the minimum bypass flow rates as one set of operating criteria, two
15 additional operating criteria will be implemented in response to low river flow conditions. The
16 first operational condition is preferential operation of the new diversion facilities located the
17 farthest upstream to reduce the effects of low Sacramento River flow on tidal reversal in the
18 vicinity of the diversion (maintain positive downstream flows across the intake structures and
19 reduce the likelihood that larval and juvenile fish will move upstream into the area of potential
20 entrainment/impingement at the diversion). Results of hydrodynamic modeling indicate that a
21 higher level of Sacramento River flow needs to be maintained to avoid tidal flow reversal
22 downstream (e.g., near Walnut Grove) when compared to the flow needed to maintain
23 downstream river flows at more upstream sites. A second operational response to low
24 Sacramento River flow conditions is to implement preferential diversion operations in response
25 to tidal conditions (e.g., divert water during ebb tide stage to maintain sweeping velocity and
26 avoid tidal flow reversal) and then reduce or curtail diversion during the flood tide stage.

27 Factors considered in developing north Delta diversion bypass flows included:

- 28 • Seasonal timing of various life stages of covered fish inhabiting the Sacramento River in
29 the vicinity of the proposed water diversion locations;
- 30 • Changes in the biological processes and relationship in response to river flow that occur
31 seasonally (e.g., differences in the biological processes of phytoplankton and zooplankton
32 production between winter-spring and summer-fall);
- 33 • The relationship between bypass flows and hydrologic synchrony of flows and
34 environmental cues within the Sacramento River watershed;
- 35 • The relationship between river bypass flow rate and constraints on water diversions and
36 water supplies;
- 37 • The relationship between downstream transport rate of planktonic particles (simulating
38 larval delta and longfin smelt transport between the upstream spawning areas, such as

- 1 Cache Slough, and the downstream estuarine habitat where first feeding and juvenile
2 rearing occur) and river flow rate;
- 3 • The relationship between river flow and downstream transport of phytoplankton,
4 zooplankton, and organic material;
 - 5 • The relationship between fall river flows and attraction and migration flows in the
6 mainstem river for adult upstream migration by fall-run and late fall-run Chinook salmon,
7 steelhead, delta and longfin smelt, splittail, and other upstream migrating adults;
 - 8 • Relationships between river flow rate and juvenile transit time through the lower river (a
9 factor thought to affect vulnerability to predation mortality), juvenile survival rates, and
10 river flow;
 - 11 • Relationships between river flow and habitat conditions for predatory fish (e.g., largemouth
12 bass, smallmouth bass, pikeminnow, and striped bass) in the river and sloughs;
 - 13 • The relationship between river flow rate and tidal dynamics (e.g., changes in water
14 velocity and direction in response to flood and ebb tide conditions) and the river flows at
15 various potential diversion locations that maintain a net unidirectional downstream flow
16 over all tidal conditions;
 - 17 • The relationship between mainstem river flows and seasonal flows into a floodplain
18 habitat such as the Yolo Bypass and the resultant effects on hydrodynamic conditions in
19 the river at the points of diversion;
 - 20 • The relationship between existing and expanded tidal marsh habitat within the Cache Slough
21 complex and tidal hydrodynamics within the river at various potential points of diversion;
 - 22 • The relationships between seasonal timing of juvenile winter-run Chinook salmon downstream
23 migration and pulse flows down the lower Sacramento River (del Rosario and Redler 2010); and
 - 24 • The relationship between river flow, channel geometry, and resulting sweeping velocities
25 across a positive barrier fish screen at each potential diversion location. Sweeping
26 velocity is intended to transport fish downstream in a timely manner to reduce their
27 exposure to entrainment and impingement at the diversion and to help remove
28 accumulated debris from the fish screen surface to maintain approach velocities.
- 29 Analysis of seasonal timing of juvenile winter-run Chinook salmon migration (del Rosario and
30 Redler 2010) suggests that pulse flows provide an environmental cue that stimulates the
31 downstream migration of juvenile winter-run Chinook salmon into the Delta and subsequently
32 their migration into coastal marine waters. Pulse flows provide a change in river flow over a
33 short time period and are also typically associated with increases in turbidity and suspended
34 sediments within the water column. Increased turbidity has been identified as an important
35 environmental condition affecting pre-spawning adult delta smelt geographic distribution within
36 the Delta and lower reaches of the Sacramento River. Therefore, bypass operations include
37 provisions for operations in response to seasonal pulse flow events.

1 **Operational Criteria and Adaptive Limits.** The north Delta facilities operations and bypass flow
2 requirements will apply in the BDCP long-term implementation period following completion of
3 facilities construction. Specifics on the operational criteria and adaptive range of north Delta
4 facilities bypass flows are provided in Table 3.5. The bypass operations will be based on three
5 parameters “Constant Low Flow Pumping,” “Initial Pulse Protection,” and “Post-Pulse
6 Operations.” Table 3.6 provides post-pulse flows criteria.

7 To allow for flexible and responsive implementation of the BDCP, several conservation
8 measures include a defined “adaptive range” that establishes the parameters within which a
9 conservation measure may be adjusted to improve its effectiveness or respond to changing
10 biological conditions. Adaptive Ranges are specifically established upper and lower boundaries
11 and limits that govern the scope of changes that can be made to water operations criteria for
12 specific operational parameters under this conservation measure pursuant to the adaptive
13 management program. These adaptive ranges are expected to be included within the bounds of
14 BDCP regulatory authorizations and provide for both flexibility to change operation criteria to
15 improve conservation or water supply performance and limitations to clearly define the confines
16 of the Plan. Adjustments to the water operations criteria set out in the BDCP and reflected in its
17 associated authorizations, and within the adaptive range for water operations described Tables 3-
18 5 and 3-6, may only be conducted through the process identified in section 3.7.3.2, *Decision*
19 *Process for Adjusting Water Operations within the Adaptive Range.*

20 *[Note to Reviewers: Adaptive range limits have not been determined at this time. Tables 3-5 and 3-
21 6 provide “analytical ranges” used in the BDCP Effects Analysis as a step in the process of
22 development of adaptive ranges.]*

23 **Problem Statement:** For decades, water has been diverted directly from the south Delta
24 through SWP and CVP facilities to meet agricultural and urban water demands south and
25 west of the Delta. These diversions both require and create an artificial north-to-south
26 flow of water through the Delta (as opposed to the natural general east-to-west flow
27 pattern) and have resulted in the development of reverse flows in major Delta channels
28 that result in entrainment of fish, invertebrates, nutrients, and other organic material.
29 Existing diversion facilities are equipped with louvers that guide juvenile and larger fish
30 into salvage facilities. Salvaged fish are subsequently transported to release locations on
31 the lower Sacramento and San Joaquin Rivers where they are subject to high predation
32 pressure (Miranda et al. 2010). Planktonic eggs, larvae, and small juveniles are not
33 effectively salvaged and do not survive when carried into conveyance facilities. Smelt
34 and juvenile salmonids that are drawn into Clifton Court Forebay are subject to predation
35 from the large populations of predatory fish that are present there as well as other sources
36 of mortality (Gingras 1997, Clark et al. 2009, Castillo et al. 2009).

Table 3-5. Proposed Long-Term Operational Criteria and Adaptive Range Limits[*Note to Reviewers: This table 3-5 and table 3.6 provide the proposed BDCP long term water operations for evaluation in the BDCP Effects Analysis. These two tables are the same as the tables provided to the Steering Committee in February 2010. The operational criteria identified in these table are the criteria agreed to by the BDCP Steering Committee on January 29, 2010 as documented in the handout titled: “SAIC Consultant Team Recommendations for Long Term Operations (January 29, 2010 draft D) – revised version based on SC input.*]

North Delta Diversion Bypass Flows		
<i>Objectives include flows of the functional equivalent thereof to (1) maintain fish screen sweeping velocities, (2) reduce upstream transport from downstream channels, (3) support salmonid and pelagic fish transport to regions of suitable habitat, (4) reduce predation effects downstream, and (5) maintain or improve rearing habitat in the north Delta.</i>		
Analytical Range A Operational Criteria ¹	Initial Operational Criteria	Analytical Range B Operational Criteria ¹
<p>Constant Low-Level Pumping (Dec-Jun): Diversions up to 10% of river flow for flows greater than 5,000 cfs. No more than 300 cfs at any one intake.</p>	<p>Constant Low-Level Pumping (Dec-Jun): Diversions up to 6% of river flow for flows greater than 5,000 cfs. No more than 300 cfs at any one intake.</p>	<p>Constant Low-Level Pumping (Dec-Jun): Diversions up to 2% of river flow for flows greater than 5,000 cfs. No more than 300 cfs at any one intake.</p>
<p>Initial Pulse Protection: No pulse flow protection criteria implemented.</p>	<p>Initial Pulse Protection: Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to pre-pulse flows (flow on first day of 5-day increase), (2) flows decrease for 5 consecutive days, or (3) flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A). These parameters are for modeling purposes. Actual operations will be based on real-time monitoring of fish movement.</p> <p>If the first flush begins before Dec 1, May bypass criteria must be initiated following first flush and the second pulse period will have the same protective operation.</p>	<p>Initial Pulse Protection: No range. (Same as initial operations)</p>

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¹ Analytical ranges represent the operational range limits for which the Effects Analysis will evaluate operational parameters. These analytical ranges are part of the process of identifying adaptive management ranges. It is expected that the eventual adaptive management range limits would fall within these analytical ranges.

Table 3-5. Proposed Long-Term Operational Criteria and Adaptive Range Limits (continued)

<p>Post-Pulse Operations: After initial flush(es), go to Level I post-pulse bypass rule (see SubTable A) until 10 total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule until 20 total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule.</p>	<p>Post-Pulse Operations: After initial flush(es), go to Level I post-pulse bypass rule (see SubTable A) until 15 total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule until 30 total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule.</p>	<p>Post-Pulse Operations: After initial flush(es), go to Level I post-pulse bypass rule (see SubTable A) until 20 total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule until 45 total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule.</p>
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Table 3-5. Proposed Long-Term Operational Criteria and Adaptive Range Limits (continued)

South Delta Channel Flows																																																																																																																																																																																
<i>Minimize take at south Delta pumps by reducing incidence and magnitude of reverse flows during critical periods for pelagic species.</i>																																																																																																																																																																																
Analytical Range A Operational Criteria			Initial Operational Criteria			Analytical Range B Operational Criteria																																																																																																																																																																										
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Table 3-5. Proposed Long-Term Operational Criteria and Adaptive Range Limits (continued)

<p>No Range.</p>	<p>South Delta Export – San Joaquin Inflow Ratio²</p> <ul style="list-style-type: none"> • Sliding scale for flows above the established OMR to share additional SJR flows between export and environment; export share would increase at higher flows • Time value of benefit; crediting outside of period in which flows are acquired <p>[Note that Conveyance WG/HOTT recommends continuing to evaluate the concept of isolating Old River to address south Delta channel flows.]³</p>	<p>South Delta Export – San Joaquin Inflow Ratio</p> <ul style="list-style-type: none"> • 50% Feb & Mar • 25% April & May
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²The effects of potential increased San Joaquin River inflows on BDCP goals and objectives will be evaluated separately from the BDCP Effects Analysis.

³The concept of isolating Old River to address south Delta channel flows will be evaluated separately from the BDCP Effects Analysis.

Table 3-5. Proposed Long-Term Operational Criteria and Adaptive Range Limits (continued)

Fremont Weir/Yolo Bypass		
<i>Considerations include (1) increasing spawning and rearing habitat for splittail and rearing habitat for salmonids for >30 days, (2) providing alternate migration corridor to the mainstem Sacramento River, and (3) increasing effectiveness of habitat and food transport in Cache Slough.</i>		
Analytical Range A Operational Criteria	Initial Operational Criteria	Analytical Range B Operational Criteria
No Range.	Sacramento Weir - No change in operations; improve upstream fish passage facilities Lisbon Weir - No change in operations; improve upstream fish passage facilities	No Range.
Fremont Weir – Improve fish passage at existing weir elevation; construct opening and operable gates at elevation 17.5 feet with fish passage facilities	Fremont Weir – Improve fish passage at existing weir elevation; construct opening and operable gates at elevation 17.5 feet with fish passage facilities; construct opening and operable gates at a smaller opening with fish passage enhancement at elevation 11.5 feet	No Range.
Fremont Weir Gate Operations		
December 1-March 30 open the 17.5 foot elevation gates when Sacramento River flow at Freeport is greater than 25,000 cfs (provides local and regional flood control benefit and coincides with pulse flows and juvenile salmonid migration cues) to provide Yolo Bypass inundation of 3,000 to 6,000 cfs depending on river stage. Operating the gates to allow Yolo Bypass inundation when Sacramento River flow is greater than 25,000 cfs will reduce impacts to water supply associated with Hood bypass flow constraints. Potential impacts to water supply would be avoided or minimized through an operations plan.	December 1-March 30 (extend to May 15, depending on hydrologic conditions and measures to minimize land use and ecological conflicts) open the 17.5 foot and 11.5 foot elevation gates when Sacramento River flow at Freeport is greater than 25,000 cfs (provides local and regional flood control benefit and coincides with pulse flows and juvenile salmonid migration cues, provides seasonal floodplain inundation for food production, juvenile rearing, and spawning) to provide Yolo Bypass inundation of 3,000 to 6,000 cfs depending on river stage. Operating the gates to allow Yolo Bypass inundation when Sacramento River flow is greater than 25,000 cfs will reduce impacts to water supply associated with Hood bypass flow constraints. Potential impacts to water supply would be avoided or minimized through an operations plan.	No Range.
Close the 17.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 25,000 cfs	Close the 17.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 20,000 cfs but keep 11.5 foot elevation gates open to provide greater opportunity for fish within the bypass to migrate upstream into the Sacramento River; close 11.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 15,000 cfs	No Range.

Table 3-5. Proposed Long-Term Operational Criteria and Adaptive Range Limits (continued)

Delta Inflow & Outflow		
<i>Considerations include (1) Provide sufficient outflow to maintain desirable salinity regime downstream of Collinsville during the spring, (2) explore range of approaches toward providing additional variability to Delta inflow and outflow.</i>		
Analytical Range A Operational Criteria	Proposed Operations	Analytical Range B Operational Criteria
<p><u>Delta Outflow:</u> Jul-Jan: Per D-1641 Feb-Jun: Per D-1641*, except no Roe Island triggering</p> <p>* Current relaxation of Collinsville standard to 4,000 cfs in May and June revised to state when the Eight River Index is 10.0 or less as established on May 1.</p> <p>** Proportional Reservoir Release concept will continue to be evaluated to the extent that it provides similar response to outflow, inflow, and upstream storage conditions</p>	<p><u>Delta Outflow:</u> Jul-Jan: Per D-1641 Feb-Jun: Per D-1641</p> <p>* Proportional Reservoir Release concept will continue to be evaluated to the extent that it provides similar response to outflow, inflow, and upstream storage conditions</p>	<p><u>Delta Outflow:</u> Summer, Winter, and Fall: Jul-Aug & Dec-Jan: Per D-1641 Sep-Nov: Fall X2 per FWS Smelt BO</p> <p>Spring: Feb-Jun: NGO X2-Eight River Index approach in all years (storage off-ramps in all year types will be refined to avoid upstream coldwater storage impacts on all reservoirs).</p> <p>* Proportional Reservoir Release concept will continue to be evaluated to the extent that it provides similar response to outflow, inflow, and upstream storage conditions</p> <p>** Continue analysis of NGO watershed unimpaired runoff approach as it relates to PREs and parties outside of BDCP. Carry into “related action” alternative.</p>

Table 3-5. Proposed Long-Term Operational Criteria and Adaptive Range Limits (continued)

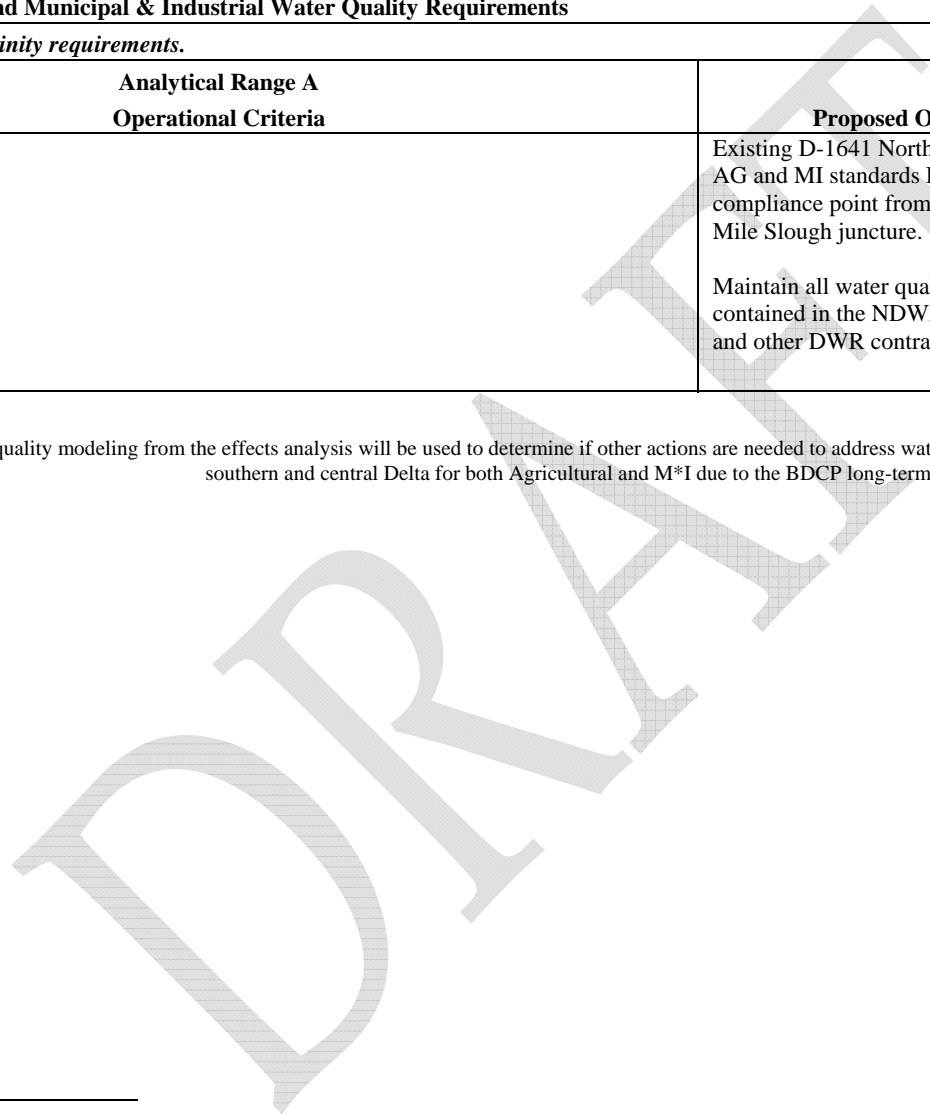
Delta Cross Channel Gate Operations		
<i>Considerations include (1) reduce transport of outmigrating Sacramento River fish into central Delta, (2) maintain flows downstream on Sacramento River, (3) and providing sufficient Sacramento River flow into interior Delta when water quality for M&I and AG may be of concern.</i>		
Analytical Range A Operational Criteria	Proposed Operations	Analytical Range B Operational Criteria
No Range.	Oct-Nov: DCC gate closed if fish are present (assume 15 days per month; may be open longer depending on presence of fish) Dec-Jun: DCC gate closed Jul-Sep: DCC gate open	No Range.
Rio Vista Minimum Instream Flows		
<i>Maintain minimum flows for outmigrating salmonids and smelt.</i>		
Analytical Range A Operational Criteria	Proposed Operations	Analytical Range B Operational Criteria
No Range.	Sep-Dec: Per D-1641 Jan-Aug: Minimum of 3,000 cfs	No Range.
Operations for Delta Water Quality and Residence Time		
<i>Considerations include (1) maintain a minimum level of pumping from the south Delta during summer to provide limited flushing for general water quality conditions (reduce residence times), (2) for M&I and AG salinity improvements, and (3) to allow operational flexibility during other periods to operate either north or south diversions based on real-time assessments of benefits to fish and water quality.</i>		
Analytical Range A Operational Criteria	Proposed Operations	Analytical Range B Operational Criteria
No Range.	<u>Assumptions for analysis:</u> Jul-Sep: Prefer south delta pumping up to 3,000 cfs before diverting from north Oct-Jun: Prefer north delta pumping (real-time operational flexibility)	No Range.

Table 3-5. Proposed Long-Term Operational Criteria and Adaptive Range Limits (continued)

In-Delta Agricultural and Municipal & Industrial Water Quality Requirements		
<i>Existing M&I and ag salinity requirements.</i>		
Analytical Range A Operational Criteria	Proposed Operations	Analytical Range B Operational Criteria
No Range.	Existing D-1641 North and Western Delta AG and MI standards EXCEPT move compliance point from Emmaton to Three Mile Slough juncture. Maintain all water quality requirements contained in the NDWA/ DWR Contract and other DWR contractual obligations. ⁴	No Range.

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⁶The results of the water quality modeling from the effects analysis will be used to determine if other actions are needed to address water quality issues that may arise, including water quality in the southern and central Delta for both Agricultural and M*I due to the BDCP long-term operations.



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Table 3-6. Post-Pulse Operations for North Delta Diversion Bypass Flows

[Note to Reviewers: This table 3-5 and table 3.6 provide the proposed BDCP long term water operations for evaluation in the BDCP Effects Analysis. These two tables are the same as the tables provided to the Steering Committee in February 2010. The operational criteria identified in these table are the criteria agreed to by the BDCP Steering Committee on January 29, 2010 as documented in the handout titled: "SAIC Consultant Team Recommendations for Long Term Operations (January 29, 2010 draft D) – revised version based on SC input.]

<i>Level I Post-Pulse Operations</i>			<i>Level II Post-Pulse Operations</i>			<i>Level III Post-Pulse Operations</i>		
Based on the objectives stated above, it is recommended to implement the following operating criteria:			Based on the objectives stated above, it is recommended to implement the following operating criteria:			Based on the objectives stated above, it is recommended to implement the following operating criteria:		
<ul style="list-style-type: none"> Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough. 			<ul style="list-style-type: none"> Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough. 			<ul style="list-style-type: none"> Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough. 		
Dec - Apr			Dec - Apr			Dec - Apr		
If Sacramento River flow is over--	But not over--	The bypass is:	If Sacramento River flow is over--	But not over--	The bypass is:	If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (see main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (see main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (see main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000	11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000	9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	18,400 plus 30% of the amount over 20,000 cfs	20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs

May			May			May		
If Sacramento River flow is over--	But not over--	The bypass is:	If Sacramento River flow is over--	But not over--	The bypass is:	If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (see separate table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (see separate table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (see separate table)
15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000	11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000	9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,900 plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs

Jun			Jun			Jun		
If Sacramento River flow is over--	But not over--	The bypass is:	If Sacramento River flow is over--	But not over--	The bypass is:	If Sacramento River flow is over--	But not over--	The bypass is:
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (see separate table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (see separate table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (see separate table)
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000	11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000	9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,400 plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs
Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs		

1 The Sacramento River, in addition to its upstream tributaries, is the primary migration
2 corridor and spawning/rearing habitat for Chinook salmon, Central Valley steelhead,
3 green and white sturgeon, and Pacific and river lamprey spawning in the Sacramento
4 River watershed. Further, both delta smelt and longfin smelt are thought to spawn in the
5 lower Sacramento River (Wang 1986, Bennett 2005). Important fishery issues with
6 respect to seasonal river flows include: (1) adult Chinook salmon, steelhead, green and
7 white sturgeon, and Pacific and river lamprey attraction flows and upstream migration;
8 (2) juvenile Chinook salmon, steelhead, and Pacific and river lamprey downstream
9 migration and survival; (3) downstream transport of planktonic fish eggs and larvae; (4)
10 downstream transport of food and other organic material; and (5) habitat for both resident
11 and migratory covered fish species within the lower Sacramento River. The importance
12 of river flows to each life stage of the covered fish species varies seasonally depending
13 life history and habitat requirements for each species. Because of the importance of the
14 Sacramento River as a migration route and habitat for covered fish species, maintaining
15 sufficient flows within the river to support this function is an important operational
16 objective for covered fish species. **Hypotheses:** Relocation and operation of the primary
17 point of SWP and CVP water diversions from the south Delta to multiple facilities on the
18 Sacramento River between Freeport and Courtland and conveying water through a
19 tunnel/pipeline facility are hypothesized to provide a broad range of benefits to covered
20 fish species, the Delta ecosystem, and water supply if operated according to an
21 appropriate set of operational parameters, which are described as part of this conservation
22 measure. The following hypotheses provide the justification for the relocation of the
23 primary point of diversion:

- 24 1. Relocation and operation of the primary point of diversion to the north Delta will
25 substantially reduce entrainment of the larvae of covered fish species by reducing the
26 spatial overlap of diversion intakes and covered fish species. The location of the
27 existing south Delta export facilities is within the influence of all covered fish species
28 for at least part of the year. However, the population centers of resident estuarine
29 species, particularly delta and longfin smelt, are downstream of the reach of the
30 Sacramento River where the north Delta intakes could be installed (Wang 1986,
31 Bennett 2005).
- 32 2. Equipping facility intakes with state-of-the-art positive barrier fish screens will
33 substantially reduce entrainment and impingement losses of juveniles and adults of
34 covered fish species. These screens will be engineered to provide a maximum
35 approach velocity coupled with a minimum unidirectional sweeping velocity to
36 protect covered fish species when fish are within the vicinity of intakes.
- 37 3. Constructing multiple intakes (rather than one or few) along the Sacramento River
38 between Freeport and Courtland will substantially reduce entrainment and
39 impingement losses of juveniles and adults of covered fish species. Multiple intakes
40 will reduce the distance fish must travel past each fish screen, allowing individuals to
41 rest between intake locations. Early estimates indicated that, if one 15,000 cfs intake

- 1 were constructed, a single fish screen nearly a mile long will need to be constructed to
2 meet approach and sweeping velocity criteria. This distance would expose fish to
3 screens for longer periods, potentially exhausting them, reducing their swimming
4 ability, and increasing their vulnerability to impingement.
- 5 4. Reducing water diversions in the tidal region of the Delta will substantially reduce
6 entrainment and impingement losses of juveniles and adults of covered fish species.
7 Reverse flows associated with tidal oscillations increase the zone of influence of
8 existing diversion facilities in many south Delta channels, potentially increasing the
9 risk of entrainment of covered fish species. Relocating the primary point of diversion
10 farther upstream will reduce the tidal influence on diversions, which will reduce
11 entrainment of covered fish species. Further, for positive barrier fish screens to
12 function properly to minimize fish entrainment and impingement risk, a minimum
13 unidirectional sweeping velocity must be maintained. Opportunities for such velocity
14 improve as tidal influence decreases farther upstream.
- 15 5. Relocation and operation of the primary point of diversion to the north Delta will
16 reduce the export of nutrients, phytoplankton, zooplankton, macroinvertebrates, and
17 other organic material from the estuary. The location of existing south Delta diversion
18 facilities is thought to be in an area that exports higher concentrations of nutrients,
19 phytoplankton, zooplankton, macroinvertebrates, and other organic material than will
20 occur with the new proposed reach of the Sacramento River. As a result, the loss of
21 Delta productivity may be lower if water is diverted at north Delta facilities compared
22 to existing south Delta facilities.
- 23 6. Improving hydrodynamics within Delta channels will improve fishery and aquatic
24 habitat within the Delta. Existing flow patterns in the Delta have been altered to
25 maintain high water quality in the south Delta for project exports, as well as for local
26 agricultural and other urban water uses. Such alterations include north to south flows
27 through the man-made Delta Cross Channel and reverse flows in Old and Middle
28 Rivers, generating adverse effects on fish and aquatic processes.
- 29 7. Relocation and operation of the primary point of diversion to the north Delta will
30 reduce or eliminate mortality of covered fish species associated with collection,
31 handling, transport, and release of salvaged fish from the existing export facilities and
32 predation within these facilities. A north Delta diversion facility will be designed to
33 avoid altogether the need to salvage fish by constructing in-river or on-river facilities.
- 34 8. Relocation and operation of the primary point of diversion to the north Delta will
35 improve water supply reliability and flexibility under conditions of future
36 environmental change. Because of their location, new diversion facilities could
37 withstand predicted future sea level rise in ways that existing diversion facilities will
38 not. Multiple intakes will add flexibility in operations to handle variation in the
39 location of covered fish and tidally-induced flows.

- 1 9. Reducing artificial north-to-south through-Delta flows when covered fish are present
2 will increase hydraulic residence time and improve aquatic productivity in the interior
3 Delta. Existing Delta operations promote north-to-south flow of water via the Delta
4 Cross Channel to offset high salinities and lower inflows from the San Joaquin River.
5 By reducing South Delta diversions, less water will move from north to south,
6 resulting in increased residence time of nutrients and organic matter, allowing these
7 materials to be assimilated into the Delta food web.
- 8 10. Reducing the reliance on through-Delta conveyance via the Delta Cross Channel and
9 intakes in the south Delta will provide greater opportunity for effective physical
10 habitat restoration and enhancement in the western, eastern, and southern Delta.
11 Decreased south Delta pumping will reduce the export of primary and secondary
12 ecological production that may result from restored habitat, which would otherwise reduce
13 or eliminate the expected benefits of the habitat restoration also proposed by the
14 BDCP. Restoration in these parts of the Delta, as well as Delta-wide hydrodynamic
15 changes expected from a north Delta diversion, will reestablish ecosystem complexity
16 by improving aquatic ecosystem processes, distribution, connectivity, migration,
17 transport, and residence time in ways that the current water conveyance system
18 cannot accommodate.
- 19 11. Reducing the reliance on through-Delta conveyance via the Delta Cross Channel and
20 intakes in the south Delta will substantially reduce the effects of existing water
21 projects on salmonids in the San Joaquin River system and tributaries, Mokelumne
22 River, and other east side tributaries. Such artificial flow patterns are thought to
23 entrain outmigrating juvenile salmonids in these channels towards the pumps and
24 confuse the upstream migration cues of adults. Although the potential for adverse
25 effects on Sacramento River salmonids may increase, these effects are predicted to be
26 avoided or minimized by the positive fish screen and sweeping and approach velocity
27 criteria (see #2-4 above) and other operational parameters.
- 28 12. Relocation and operation of the primary point of diversion to the north Delta will
29 facilitate the implementation of some other conservation measures focused on non-
30 flow and non-habitat related stressors.
- 31 13. Relocation and operation of the primary point of diversion to the north Delta will
32 allow for the emulation of more natural physical patterns (e.g., salinity regimes, flow
33 patterns) and processes in the Delta under which native resident species evolved. For
34 example, a change in the hydrograph could favor native species by providing proper
35 timing of biological processes from physical cues, such as those needed to initiate
36 upstream or downstream migration, and create conditions that disfavor non-native
37 species, such as reduced summer inflows, which are currently higher than would
38 occur naturally.

39 The following hypotheses provide the basis for maintaining bypass flows past the proposed new
40 north Delta diversions:

1 1. Maintaining bypass flows will maintain adequate flows in the mainstem Sacramento
2 River and distributaries downstream of the points of diversion for covered fish
3 species. Of particular interest are flow rates within Sutter and Steamboat Sloughs.
4 These sloughs are existing channels that convey water from the Sacramento River in
5 the general vicinity of Courtland downstream to approximately Rio Vista where they
6 re-enter the lower Sacramento River. Both channels currently have a hydraulic
7 capacity greater than 500 cfs. Benefits maintaining adequate flows in Sutter and
8 Steamboat Sloughs include:

- 9 • Providing an alternative migration route for salmonids (Perry and Skalski 2008)
10 and possibly splittail, sturgeon, and lamprey that circumvents the Delta Cross
11 Channel and Georgiana Slough, thereby reducing the likelihood of covered fish
12 species moving into the interior Delta where they may be exposed to higher
13 predation pressure and entrainment into the south Delta pumps.
- 14 • Providing high quality juvenile rearing habitat and adult holding habitat for
15 salmonids, sturgeon, and splittail. Both slough channels support substantially
16 more woody riparian vegetation and greater habitat diversity (e.g., water depths,
17 velocities, in-channel habitat, etc.) than is present along the mainstem Sacramento
18 River between Courtland and Rio Vista.
- 19 • Providing high quality spawning habitat for splittail during dry periods without
20 floodplain inundation.

21 Despite these anticipated benefits, Perry and Skalski (2009) and Perry et al. (2010)
22 indicate that survival rates of juvenile Chinook salmon in Sutter and Steamboat
23 sloughs are highly variable relative to the mainstem Sacramento River; in their
24 studies, they have found that survival has been higher than, lower than, and similar to
25 survival rates in the mainstem Sacramento River rates. Recent hydrodynamic
26 modeling indicates that substantial habitat restoration in the Cache Slough area (see
27 Section 3.4.3.2), in combination with bypass flow requirements for the north Delta
28 diversions, will enhance downstream flows in Sutter and Steamboat sloughs
29 substantially above those present under current conditions without facility north Delta
30 diversion facility (A. Munevar unpubl. data). Further, the BDCP proposes to enhance
31 channel margin habitat in Sutter and Steamboat sloughs in part to create habitat that is
32 unfavorable to non-native predators that may be reducing survival of Chinook
33 salmon, and likely other covered species in these sloughs. Therefore, in combination
34 with these other conservation measures, maintaining bypass flows is expected to
35 improve survival of salmonids, sturgeon, and splittail in Sutter and Steamboat
36 sloughs.

37 2. Maintaining bypass flows will provide transport flows necessary for downstream
38 movement of delta and longfin smelt. Newly hatched larval delta and longfin smelt,
39 called yolk-sac larvae, have a yolk sac attached to them with an oil globule (Wang

1 1986). The yolk sac provides nourishment for delta smelt larvae for approximately 4
2 to 6 days (Bennett 2005) and is thought to be similar for longfin smelt. These larvae
3 are very weak swimmers and drift downstream with flows from the Sacramento River
4 to the low salinity zone, where they can find suitable prey. To avoid starvation, this
5 downstream movement must take place before the entire yolk sac is absorbed.
6 Because downstream yolk-sac larval movement is driven nearly entirely by
7 downstream flows, a minimum bypass flow criteria that allows this movement to
8 occur is necessary.

- 9 3. Maintaining minimum bypass flows will provide downstream transport of food and
10 organic material. The Sacramento River is used as a major corridor through which
11 food and other organic material from upstream are transported downstream to the
12 Delta and bays. The Delta and bays acquire production from upstream habitats to
13 support their ecosystems.
- 14 4. Maintaining minimum bypass flows will provide necessary attraction flows for
15 upstream migration of adult Chinook salmon, steelhead, and green and white
16 sturgeon, including attraction flows through Sutter and Steamboat Sloughs.
- 17 5. Maintaining minimum bypass flows will minimize tidally driven bidirectional flows
18 near diversion intakes, reducing the exposure duration of covered fish species to
19 predators that will likely reside near intake structures. Unidirectional flows past intakes
20 may also affect local current patterns and hydrodynamics in the vicinity of the screen
21 surface that may affect fish entrainment or impingement, debris loading, effectiveness
22 of fish screen cleaning mechanisms in removing debris from the screen surface, and
23 maintaining a uniform approach velocity within the screen design criterion.

24 Developing bypass flow criteria for the north Delta diversion facilities involved consideration of
25 the seasonal timing of various life stages of covered fish species within the lower Sacramento
26 River, relationships between river flow, water velocity, transport time, and residence time, and
27 the growth, survival, and distribution of various life stages of the covered species.

28 **Adaptive Management Considerations:** Results of the biological monitoring would be used
29 adaptively in a variety of ways that include, but are not limited to: (1) changes in diversion
30 operations within a range of adopted diversion parameters that are based on “real-time”
31 monitoring of the occurrence of covered fish in the area; (2) selectively operating diversions
32 based on the geographic distribution of covered fish within the river; and (3) changing diversion
33 operations based on tidal velocity and river flows to increase sweeping velocity and the rate of
34 fish movement past fish screens.

35 Results of both biological and operational monitoring throughout the Delta could be used within
36 the BDCP adaptive management framework to refine and modify river bypass flow rates. For
37 example, additional information on the actual timing of fish migration downstream within the
38 Sacramento River within a given year could result in modification to the river bypass flows to

1 facilitate migration past the points of diversion and fish screens. The adaptive management
2 ranges provided for operational criteria under this conservation measure (Tables 3-5 and 3-6)
3 provide flexibility to incorporate new knowledge gained through monitoring and research and to
4 respond to changes in the system.

5 South Delta diversion operations and Old and Middle River flows.

6 To reduce the impacts of south Delta diversions on covered fish species and the Delta
7 environment, Old and Middle River reverse flows will meeting the operational criteria described
8 in Tables 3-5 and 3-6. These rivers are subject to reduced or reverse flows as a result of low San
9 Joaquin River inflow, flood tides, and water exports at SWP and CVP facilities. These flow
10 conditions can result in increased risk of entrainment of fish, invertebrates, phytoplankton, and
11 other organic material.

12 Diversions from the south Delta SWP and CVP facilities will be reduced considerably during
13 wetter periods with dual operation of new north Delta diversion facilities. During wetter periods
14 in the BDCP long-term implementation period, water will be diverted from the south Delta to
15 augment north Delta diversions and may be diverted in appropriate circumstances to improve
16 circulation and maintain water quality conditions in the interior and southern Delta.

17 **Operational Criteria and Adaptive Limits.** The operational criteria for south Delta operations
18 and Old and Middle River flows during the BDCP long-term implementation periods are
19 described in Table 3.5.

20 With operation of north Delta diversion facilities in the long-term implementation period, the
21 existing south Delta SWP and CVP export facilities will be operated as part of a dual conveyance
22 facility and exports from the south Delta will be substantially reduced (the north Delta diversion
23 facilities will be equipped with state-of-the-art positive barrier fish screens and will be the
24 primary point of long-term diversion during wetter periods). The dual export system will be
25 operated to meet water supplies.

26 **Problem Statement:** Export operations of the SWP and CVP diversion facilities in the
27 South Delta, in combination with San Joaquin and Sacramento River flows, tidal effects,
28 and substantially reduced inflows into the Delta, have been identified as primary factors
29 in altering hydrodynamic conditions within Delta channels and associated fishery habitat
30 (DWR 2006, Baxter et al. 2008). Export operations of the SWP and CVP pumping plants
31 contribute to local changes in water current patterns, water quality, and direct entrainment
32 and losses of fish, macroinvertebrates, nutrients, phytoplankton, and zooplankton from
33 the Delta environment (DWR 2006).

34 Although the response of various lifestages of covered species to flows within Old and
35 Middle rivers is dynamic and variable within and among species, there is a positive
36 relationship between the magnitude (average monthly) of reverse flows within Old and

1 Middle rivers and the occurrence of pre-spawning adult delta smelt in SWP and CVP fish
2 salvage during the winter months (Kimmerer 2008, USFWS 2009). Further, particle
3 tracking model simulations predict that there is a greater risk that planktonic early
4 lifestages of covered fish species (e.g., larval delta smelt) will be vulnerable to
5 entrainment at the SWP and CVP export facilities when reverse flows within Old and
6 Middle rivers increase. In addition, a number of the covered fish, including the juvenile
7 and adult lifestages of Chinook salmon, steelhead, delta smelt, longfin smelt, sturgeon,
8 lamprey, and splittail are expected to use hydrodynamic cues (e.g., channel flow direction
9 and magnitude) to help guide movement through the Delta. Reverse flows in Delta
10 channels are thought to contribute to false attraction to migration cues, longer migration
11 routes that may expose fish to sources of mortality such as predation, exposure to
12 seasonally elevated water temperatures and other stressors, and increased vulnerability to
13 entrainment at the SWP and CVP south Delta export facilities.

14 Reverse flows within the channels of Old and Middle rivers are also hypothesized to
15 affect local and regional habitat conditions for covered fish and other aquatic species.
16 Changes in channel velocity and flow patterns affect hydraulic residence time in the area
17 and the production of phytoplankton and zooplankton that are important to the diet of
18 covered fish. Channel velocities, scour, and deposition patterns affect habitat for benthic
19 organisms and other macroinvertebrates. Changes in tidal hydrodynamics, especially
20 channel velocity, affect habitat suitability for covered fish and other aquatic species in the
21 area.

22 Relationships between the magnitude of reverse flows in Old and Middle rivers and
23 corresponding changes in salvage of various covered fish, such as juvenile Chinook
24 salmon, steelhead, splittail, longfin smelt, lamprey, and sturgeon, are highly variable.
25 Analyses and evaluations are ongoing to further assess the potential biological benefits of
26 managing SWP and CVP south Delta exports based on direct diversion rates or changes
27 in the magnitude of reverse flows in Old and Middle rivers.

28 **Hypotheses:** Reducing diversions in the South Delta are hypothesized to:

- 29 • Reduce the risk of entrainment mortality of salmonids, smelt, splittail, sturgeon and
30 lamprey;
- 31 • Reduce the risk of predation mortality of salmonids, smelt, lamprey, and splittail in
32 Clifton Court Forebay; and
- 33 • Reduce the risk of entrainment of organic matter and food for salmonids, smelt,
34 splittail, and sturgeon.

35 **Adaptive Management Considerations:** Results of biological monitoring will be used within
36 the BDCP adaptive management framework to refine and modify seasonal operations of Old and
37 Middle River flows. The adaptive management ranges provided for operational criteria under

1 this conservation measure (Tables 3-5 and 3-6) provide flexibility to incorporate new knowledge
2 gained through monitoring and research and to respond to changes in the system.

3 Delta Cross Channel gate operations

4 The Delta Cross Channel gates will be operated during the long-term implementation period to
5 improve fish migration, hydrodynamics (including hydraulic residence time), and food and
6 organic material transport while minimizing changes to water quality for agriculture, municipal,
7 and industrial uses in the interior and southern Delta.

8 Delta Cross Channel gates are located on the Sacramento River near Walnut Grove (Figure 3.4).
9 The Delta Cross Channel serves as a conveyance facility for water to move from the Sacramento
10 River into the interior Delta. Water quality in the central and south Delta can degrade during low
11 San Joaquin River flows. The Delta Cross Channel was constructed to move higher quality
12 Sacramento River towards the central and south Delta to improve water quality there. Juvenile
13 Chinook salmon, and presumably a number of other fish species, move from the Sacramento
14 River into the interior Delta when the gate is open (Brandes and McLain 2001). Results of
15 survival studies using coded wire tagged and radio tagged fish suggest that survival juvenile
16 Chinook salmon passing into the Delta through the Delta Cross Channel is lower than survival of
17 those migrating down the mainstem Sacramento River (Brandes and McLain 2001, Perry and
18 Skalski 2009, Perry et al. 2010). Based on results of these studies, closure of Delta Cross
19 Channel gates between February 1 and May 20 was established under D-1641 for fish benefits.

20 **Operational Criteria and Adaptive Limits.** The operational criteria for the Delta Cross
21 Channel gates during the BDCP long-term implementation period are described in Table 3.5.

22 **Problem Statement:** When the Delta Cross Channel is open, fish move into the interior Delta
23 with Sacramento River water (Brandes and McLain 2001). Survival of juvenile Chinook
24 salmon, and likely other fish species, within the interior Delta is lower than survival in the
25 mainstem Sacramento River (Baker and Morhardt 2001, Brandes and McLain 2001, CALFED
26 2001, Perry and Skalski 2009, Perry et al. 2010), although it is unknown whether this reduced
27 survival has a population level effect on Chinook salmon (Manly 2002, 2008).

28 Current seasonal operations of the Delta Cross Channel gates designated by D-1641 are designed
29 to prohibit the migration of juvenile fish from the Sacramento River into the interior Delta
30 through the Delta Cross Channel during the spring. However, adverse effects of an open DCC
31 operation to anadromous fish, and other fish, also occur outside of this closure period.
32 Furthermore, open gates decrease velocities and increase bi-directional flows in the Sacramento
33 River and its distributaries, slowing the migration of covered species and increasing their
34 vulnerability to predation or mortality from poor habitat. Therefore, lengthening the closure
35 period or operating on a tidal or daily cycle may improve survival of salmonids and other
36 covered fish species.

37 **Hypotheses:** Revised operations of Delta Cross Channel gates are hypothesized to:

- 1 • Increase the survival of juvenile Chinook salmon and possibly other covered fish
2 species by: (1) improving downstream migration of fish in the Sacramento River and
3 tributaries, which will reduce their risk to predation and other sources of mortality;
4 and (2) reducing the proportion of fish entering the interior Delta, where survival of
5 juvenile Chinook salmon is lower (Baker and Morhardt 2001, Brandes and McLain
6 2001, CALFED 2001, Perry and Skalski 2009, Perry et al. 2010). Several hypotheses
7 have been suggested to explain reduced survival of juvenile Chinook salmon in the
8 interior Delta relative to the mainstem Sacramento River, including, but not limited
9 to: (1) increased exposure to unscreened water diversions within the Delta channels;
10 (2) exposure to seasonally elevated water temperatures and potentially toxic
11 contaminants; (3) increased residence time and longer migration routes leading to
12 longer exposure to environmental conditions within the Delta and increased
13 vulnerability to predation mortality; (4) delayed migration as a result of altered
14 hydrologic conditions in Delta channels as a result of SWP and CVP export
15 operations; and (5) direct losses as a result of entrainment, predation, or salvage
16 mortality at the south Delta SWP and CVP export facilities (Baxter et al. 2008).
- 17 • maintain sufficient water quality in the south Delta in combination with minimal
18 year-round pumping in the south Delta (see Section 3.4.1.3.6). Seasonally elevated
19 water temperatures and an accumulation of toxics can occur in the central and south
20 Delta, likely as a result of high residence times associated with low inflows from the
21 San Joaquin River. These impairments can have lethal and sublethal effects on
22 covered fish species inhabiting the south and central Delta. In addition, modeling
23 results indicate that drinking water quality standards for the south Delta under D-1641
24 would not be violated under this revised set of operational criteria (A. Munevar pers.
25 comm.).
- 26 • Improve the strength of migration cues and avoid false cues for adult migrating
27 steelhead, Chinook salmon, and sturgeon on the Sacramento and San Joaquin Rivers.
28 When the Delta Cross Channel is open, water from the Sacramento River mixes with
29 water from the Mokelumne, Cosumnes, and San Joaquin Rivers, reducing the strength
30 of migration cues to salmonids and sturgeon migrating upstream. Therefore,
31 increasing the duration of Delta Cross Channel closure will allow more anadromous
32 fish below the Delta Cross Channel to directly sense migration cues to upstream
33 habitat, thus increasing the ability to move upstream and reducing delays to
34 spawning; and
- 35 • Improve downstream flows and downstream transport of fish eggs, larvae, juveniles,
36 food, and organic material within the Sacramento River into the Delta.

1 **Adaptive Management Considerations: Results of biological monitoring will be used**
2 **within the BDCP adaptive management framework to refine and modify seasonal**
3 **operations of Delta Cross Channel gates.Rio Vista flows**

4 Sufficient Rio Vista flows will be maintained during the long-term implementation period for the
5 benefit of covered fish species. The lower Sacramento River serves as an important part of the
6 aquatic habitat within the Delta. Diversion of water at new north Delta Diversion Facilities, as
7 well as diversion of water from the mainstem river into side channels (e.g., Delta Cross Channel)
8 or seasonally inundated floodplain habitat (e.g., Yolo Bypass), has a direct effect on flow rates in
9 the Sacramento River at Rio Vista. Identification of a minimum flow requirement at Rio Vista is
10 intended to support fishery and aquatic habitat in the reach of the Sacramento River located
11 between Sacramento and Rio Vista. Flow in the mainstem Sacramento River at Rio Vista is
12 augmented by the flow contribution from Cache Slough, the Yolo Bypass, Sutter and Steamboat
13 Sloughs, and other local tributaries. Minimum river flows at Rio Vista in the fall are included in
14 current regulations (D-1641, biological opinions).

15 **Operational Criteria and Adaptive Limits.** The operational criteria for Rio Vista flows during
16 the BDCP long-term implementation periods are described in Table 3.5.

17 **Problem Statement:** The Sacramento River, in addition to its upstream tributaries, is the
18 primary migration corridor in the Delta for Chinook salmon, Central Valley steelhead, sturgeon,
19 and lamprey from the Sacramento River basin. In addition, both delta and longfin smelt likely
20 spawn in the lower river in the general vicinity of Rio Vista. Key fishery issues with respect to
21 seasonal river flows at Rio Vista have primarily focused on adult Chinook salmon and steelhead
22 attraction and upstream migration flows during the fall months. The importance of river flows to
23 each of the species and lifestages of covered fish species varies seasonally depending on the life
24 history and habitat requirements of the species.

25 **Hypotheses:** Maintaining sufficient flows past Rio Vista is hypothesized to:

- 26 • Maintain sufficient attraction and upstream migration flows for adult salmonids,
27 sturgeon, and lamprey in the Sacramento River;
- 28 • Maintain sufficient downstream migration of juvenile Chinook salmon, steelhead, and
29 lamprey from the Sacramento River basin;
- 30 • Maintain sufficient downstream transport of planktonic fish eggs and larvae;
- 31 • Maintain sufficient downstream transport of organic material, phytoplankton, and
32 zooplankton; and
- 33 • Provide high quality habitat for both resident and migratory species within the lower
34 river.

1 **Adaptive Management Considerations:** Results of biological monitoring will be used within
2 the BDCP adaptive management framework to refine and modify the seasonal river flow criteria
3 at Rio Vista.

4 Delta Outflows

5 Sufficient Delta outflows will be maintained during the long-term for the benefit of covered fish
6 species. Delta outflows provide for downstream transport of fish and other aquatic organisms as
7 well as organic material and prey for covered species into the lower reaches of the Delta and
8 Suisun Bay. In balance with upstream salinity intrusion from the bay, Delta outflows also
9 control the location of the low salinity region of the estuary (Baxter et al. 1999, Kimmerer 2004).
10 The abundance of life stages of a number of fish species, including some covered fish species
11 (longfin smelt), has been positively correlated with the location of the low salinity zone
12 (generally measured as X2) within the estuary (Baxter et al. 1999, Kimmerer 2004). Suisun Bay
13 and the western Delta represent important low salinity habitat areas within the estuary. Open
14 water habitat in this region serves as larval and juvenile rearing, adult holding, and foraging
15 habitat for resident and anadromous fish and a wide variety of other aquatic and wildlife species,
16 and as a migration corridor for anadromous species such as salmon, steelhead, sturgeon, and
17 lamprey. Based on the information regarding the relationship between fish abundance and X2
18 location, the State Water Quality Control Board's D-1641 and the USFWS Biological Opinion
19 include requirements for maintaining the X2 location during the late winter and spring within
20 Suisun Bay.

21 **Operational Criteria and Adaptive Limits.** The operational criteria for Delta outflow during
22 the BDCP long-term implementation period are described in Table 3.5.

23 **Problem Statement:** Fishery monitoring studies conducted by DFG (Baxter et al. 1999) suggest
24 that abundances of juvenile lifestages of many fish (e.g., starry flounder, splittail, longfin smelt,
25 and striped bass) and macroinvertebrates are correlated with the location of the low salinity zone
26 during the late winter and spring (e.g., February through June [Kimmerer 2004]). For example,
27 longfin smelt juvenile abundance indices increased as the location of X2 moved further
28 downstream (west) within Suisun Bay (Kimmerer 2004). Recent analyses have suggested that
29 previous correlations between X2 location and fish abundance indices have changed (Kimmerer
30 2004). The changes observed in these relationships have been hypothesized to be the result of
31 the introduction and rapid colonization of Suisun Bay by the filter feeding Asian overbite clam
32 (*Corbula*) and a subsequent reduction in phytoplankton and zooplankton as food supplies for
33 juveniles within Suisun Bay (Kimmerer 2004). Another change in this relationship has occurred
34 since 2001 in conjunction with the pelagic organism decline, although the cause of this change is
35 currently unknown (Baxter et al. 2008).

36 Factors that may contribute to the relationship between Delta outflow (as well as X2 location)
37 and juvenile fish abundance are heavily debated, but may include increased productivity and
38 availability of high quality habitat within Suisun Bay; downstream transport of fish, food, and

1 organic matter; reduced temperature and/or toxics exposure with lower X2; inundation of
2 backwater and floodplains with high flows; and the distribution of early lifestages of fish into
3 habitats that are located further downstream with decreased vulnerability to direct and indirect
4 effects of south Delta SWP and CVP export operations.

5 **Hypotheses:** Allowing Delta outflow in the adaptable range above is hypothesized to:

- 6 • Provide for downstream transport of fish and other aquatic organisms into the lower
7 reaches of the Delta and Suisun Bay;
- 8 • Provide sufficient flushing of the Delta to avoid and prolonged exposure to high
9 water temperatures and toxics by covered fish species;
- 10 • Provide a suitable location for the low salinity zone; and
- 11 • Provide for downstream transport of organic material and prey for covered species
12 into the lower reaches of the Delta and Suisun Bay.

13 **Adaptive Management Considerations:** Based on results and analysis of monitoring data,
14 adaptive modifications to management of Delta outflow under the BDCP adaptive management
15 framework could occur by modifying operational criteria by season or water-year type
16 (hydrology) or by addressing other stressors and factors that may affect the survival or
17 abundance of a covered fish species.

18 Delta Water Quality Maintenance.

19 Dual conveyance facilities in the Delta will be operated during the long-term implementation
20 period to balance flows and exports for fish protection and water quality for both fish and
21 humans while maintaining water supply reliability. Preferential south Delta operations during
22 summer months when flows in the San Joaquin River are lowest will provide flushing the south
23 and central Delta water with fresh Sacramento River water, thus reducing hydraulic residence
24 time and improving water quality for fish, agriculture, and M&I uses in the south and central
25 Delta.

26 Considerations regarding dual operations of conveyance facilities include: (1) providing limited
27 flushing for general water quality conditions (reduce residence times) during low San Joaquin
28 River flow periods, (2) maintaining adequate M&I and agricultural salinity in the central and
29 south Delta, and (3) allowing operational flexibility during other periods to operate either north
30 or south Delta diversions based on real-time assessments of benefits to fish, water quality, and
31 operational constraints.

32 **Operational Criteria and Adaptive Limits.** The operational criteria for dual conveyance
33 operations during the BDCP long-term implementation periods are described in Table 3.5.

34 **Problem Statement:** The balance of fish protection, water supply reliability, and water quality
35 for both fish and humans is dependant, in part, on hydrologic and water quality (e.g., salinity,

1 dissolved oxygen, etc.) conditions occurring within Delta channels, densities of covered fish in
2 the general region of the central and south Delta, and the magnitude of effect of south Delta
3 exports on reverse flows in Old and Middle rivers.

4 **Hypotheses:** Dual operation of conveyance facilities in the long-term implementation period
5 according to the operational criteria in Table 3.8 is hypothesized to:

- 6 • Reduce entrainment mortality of all covered fish species at south Delta facilities;
- 7 • Reduce toxic-related mortality and sublethal effects to all covered fish species in the
8 central and south Delta;
- 9 • Reduce the effects of the proliferation of noxious algae, such as *Microcystis*, in the
10 central and south Delta. *Microcystis* tends to grow in warm, slowly moving water
11 (Lehman et al. 2008). *Microcystis* is known to disrupt the food web by being toxic to
12 zooplankton and macroinvertebrates (Resources Agency 2007, Baxter et al. 2008); and
- 13 • Reduce the effects of the proliferation of SAV, such as *Egeria*, in shallow areas of the
14 central and south Delta. *Egeria* tends to establish and grow at faster rates in warm,
15 slowly moving water (Barko and Smart 1981, Gantes and Caro 2001) (see Section
16 3.4.3.10 *SAV/FAV Control* for detail on effects to these covered species),

17 **Adaptive Management Considerations:** Effectiveness monitoring of water quality parameters,
18 including EC, temperature, selenium, and other toxics as deemed necessary by the BDCP
19 Implementation Office, in central and south Delta before and after preferential south Delta
20 operations begin will inform adaptive management decisions to change pumping rates at the
21 south Delta.

22 *In-Delta agricultural, Municipal, and Industrial Water Quality Requirements.*

23 In the long-term implementation period, D-1641 North and Western Delta agricultural and
24 municipal and industrial (M&I) standards will be maintained, except that the D-1641 compliance
25 point will be moved from Emmaton to the Three Mile Slough juncture. All water quality
26 requirements contained in the North Delta Water Agency/DWR Contract and other DWR
27 contractual obligations will be maintained.

28 **Operational Criteria and Adaptive Limits.** The operational criteria for in-Delta agricultural,
29 municipal, and industrial water quality requirements during the BDCP long-term implementation
30 period are described in Table 3.5.

31 **Problem Statement.** Salinity in the Delta is primarily a function of freshwater flowing from
32 tributary rivers and saltwater intrusion from the Pacific Ocean. Areas located downstream such
33 as Suisun Bay and further west are characterized by increasing salinity gradients. The northern
34 and eastern Delta is characterized by primarily freshwater aquatic habitats. The lower San
35 Joaquin River and southern Delta are characterized by low salinity waters, primarily resulting

1 from saline agricultural drainage returns with elevated salt concentrations discharging into the
2 San Joaquin River (DWR et al. 2006). If salinity increases to levels above standards dictated in
3 D-1641, agricultural and M&I use of exported water can be severely limited.

4 **Hypotheses.** Maintaining existing D-1641 North and Western Delta agricultural and municipal
5 and industrial (M&I) standards and all water quality requirements contained in the North Delta
6 Water Agency/DWR Contract and other DWR contractual obligations_would permit existing
7 agricultural and M&I uses of water in these areas.

8 **Adaptive Management Considerations.** Within the BDCP framework of adaptive
9 management, the BDCP Implementing Entity will monitor and adaptively manage salinity in the
10 Delta in response to any adverse impacts resulting from the operational criteria described above

11 **Montezuma Slough Salinity Control Gate operations.**

12 Coordination will occur with the Suisun Marsh Charter Group over the term of the BDCP to seek
13 amendments to the Suisun Marsh Plan (in development) that will provide for reducing the long-
14 term operation of the Montezuma Slough Salinity Control Gate. This action will allow more
15 water to flow past Chipps Island and will improve access of covered fish species to existing and
16 future restored intertidal marsh habitats.

17 Suisun Marsh is currently managed largely to provide seasonal freshwater wetland habitat,
18 primarily to support waterfowl habitat and recreation. There are approximately 150 waterfowl
19 hunting clubs in the Suisun Marsh, and wetland managers flood their ponds in early October and
20 drain them after the end of the waterfowl season in January. The Montezuma Slough Salinity
21 Control Gate was originally installed and operated as a tidal pump to reduce salinity within the
22 marsh: the one-way gates were opened on the ebb tide to allow freshwater from upstream to
23 enter the slough and closed on the flood tide to prohibit saline water from entering the slough.
24 Operation of the gates also results in a net flow of water from east to west. The salinity control
25 structure (the gates and associated flashboards) not only alters local hydrodynamics and water
26 quality conditions but also impedes the migration and passage of various fish species. The gates
27 are operated on average 10 days every year, all during the period of early October through May
28 (B. Burkhard, pers. comm.). Operation of the gates is based on tidal stage and triggered by high
29 salinity readings in the marsh. DWR and USBR are required to meet water salinity standards for
30 the Suisun Marsh established by the SWRCB under D-1641.

31 **Operational Criteria and Adaptive Limits.** In the beginning of BDCP implementation,
32 Montezuma Slough Salinity Control Gates will continue to operate in the same way as existing
33 standards. However, as land use changes during the 50 year implementation period, the gates
34 may stay open for longer up to possibly remaining open year-round, as determined through
35 adaptive management (see Section 3.7 *Adaptive Management*).

1 **Problem Statement.** The Montezuma Slough Salinity Control Gate has been identified as an
2 impediment to migration and passage of species such as Chinook salmon, steelhead, and green
3 sturgeon through Montezuma Slough (Fujimura et al. 2000). In addition, existing operations of the
4 control structure alter local current patterns and tidal hydrodynamics within Montezuma Slough, in
5 large regions of Suisun Marsh, and in the main river channel between the control gate and Suisun
6 Bay (DWR 1999). For example, operation of the control structure during the late fall in dry years
7 can cause a significant upstream shift in X₂ location, potentially increasing the risk of entrainment
8 at the SWP/CVP export facilities of smelt and other species that are situated near X₂ location (D.
9 Fullerton pers. comm. 1). These changes in environmental conditions are thought to have resulted
10 in adverse effects on covered species and other aquatic resources within the area.

11 As levees are breached for tidal restoration, salinity levels may increase through much of Suisun
12 Marsh, complicating the feasibility of discontinuing the operation of the salinity control gates, or
13 eliminating the gates. First, rising salinity could negatively affect the managed wetlands of the
14 remaining waterfowl hunting clubs. Secondly, salinity standards at the Suisun Marsh may have
15 to be revised. Assuming that the Suisun Marsh's current salinity standards are maintained, tidal
16 restoration could even lead to an increase in the operation of the salinity control gates under the
17 Suisun Marsh Plan (S. Chappell pers. comm.).

18 **Hypotheses:** A reduction in operation of the Montezuma Slough Salinity Control Gate is
19 hypothesized to:

- 20 • Reduce delays in outmigration of juvenile salmonids and sturgeon by allowing more
21 water and fish to flow past Chipps Island; and
- 22 • Improve access of splittail, salmonids, and sturgeon to existing and future restored
23 intertidal marsh habitats in Suisun Marsh.

24 **Adaptive Management Considerations:** As land use changes over the period of the Plan,
25 monitoring and adaptive management could be used to alter operations of the salinity control
26 gates.