PRELIMINARY DRAFT

Conceptual Proposal for Screening Water Diversion Facilities along the Sacramento River

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Fish Facilities Technical Team
Bay-Delta Conservation Plan
August 2008

Conceptual Proposal
for
Screening Water Diversion Facilities along the Sacramento River

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1.0 Introduction

The purpose of this proposal is to document the efforts and current status of the Bay Delta Conservation Plan (BDCP) Fish Facilities Technical Team (FFTT) review and evaluation of approaches to screening a maximum diversion of 15,000 cubic feet per second (cfs) along the Sacramento River between the City of Sacramento and Walnut Grove as part of an isolated conveyance system to route water around the Delta to existing state and federal export facilities in the south Delta. This document is intended to provide the BDCP Conveyance Workgroup initial direction regarding location, composition, and arrangement of fish protective diversion facilities.

The FFTT consists of agency, stakeholder, and consultant representatives charged with developing, analyzing, and proposing concepts on fish screen facilities to the BDCP Conveyance Working Group. The members of the FFTT and the experts providing technical support are listed below:

Team Members:

George Heise, Department of Fish and Game
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Dan Meier, US Fish and Wildlife Service
Steve Hiebert, US Bureau of Reclamation
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This proposal presents the four initial concepts for diversion screening up to 15,000 cfs using one or more screens at multiple locations along the Sacramento River to meet fish protection needs. **The concepts and locations contained in this proposal are for illustration purposes only and require additional discussion and analysis.** These concepts have been developed focusing primarily at the requirements of diverting water from the river and not beyond the limits of the bordering river levees. Additional information will be needed to further develop and refine potential fish screen type; size and number (multiple versus a single intake); configuration and geometry; and locations(s) to support both through and around the Delta conveyance facilities.

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2.0 Criteria / Principles

The FFTT recognizes that operating criteria for a maximum diversion of up to 15,000 cfs using multiple diversion facilities will be fundamental to ensure fish protection as they affect the number, types and design of screens. The concepts illustrated in this proposal will need to be coordinated with the Habitat Operations Technical Team (HOTT) and others, as needed, in an iterative process to evaluate compatibility of proposed operating criteria with fish screening requirements important to the protection and reduction of stressors for species of concern. This is one of several pending efforts and issues that will need to be addressed in further developing the proposed concepts as described in Section 5 of this proposal.

The concepts for screening water diversions would be designed in accordance with NMFS, and CDFG design criteria and USFWS guidance for an intake within the Delta where Chinook salmon, delta smelt and other sensitive fish species are present. Adopted fish screen design criteria by CDFG and NMFS have been established primarily to protect salmonids and steelhead. The FFTT recognizes that these criteria may not provide full protection for weakly swimming fish or fish eggs and larvae of non-salmonid fish species and suggests additional information needs in Section 4 of this proposal.

Fish protection criteria and guidelines include, but are not limited to:

Structure Placement
Approach Velocity
Sweeping Velocity/Fish Exposure duration
Screen Material
Screen Opening size
Civil Works and Structural Features
Bypass System
Operations and Maintenance

Fish screen criteria are primarily based on fish swimming ability and behavior to avoid and escape entrainment and impingement. Research has documented the varying swimming ability of several fish species. Fish swimming ability may depend on several factors, including but not limited to:

Fish length
Life stage (adult/juvenile)
Fish swimming behavior
Physical condition of fish
Channel flow condition
Dissolved oxygen concentration
Water temperature
Time of day/light conditions

Site-specific criteria such as screen orientation can also be proposed where opportunities exist to further protect fish species. Variances from an established criterion may be evaluated on a project-by-project basis based on site constraints and operational requirements. For example, the FFTT believes that the 0.33 ft/s approach velocity criteria established to protect salmonids and steelhead should be used to design the proposed facilities and use reduced diversions at these sites in real-time to provide a the 0.2 ft/s approach velocity, as deemed necessary to be more protective of weakly swimming fish and fish eggs or larval life stages, when they are present at the site. Each facility would be engineered to allow variable rate pumping in order to accomplish this operational scheme. This approach reduces the required length of the fish screen and thereby reduces fish exposure to the screen during facility operations, and it also minimizes environmental impacts associated with construction by reducing the size of the required facility.

A list of available fish screen references for the design and operation of fish screen facilities can be found in Section 6 of this proposal.

The FFTT agreed to the following general principles to guide development of conceptual fish screening proposals:

(1) Use the most biologically protective fish screen concepts as the foundation of the proposed designs;

(2) Provide a positive, physical fish screen barrier between fish and water intakes;

(3) Avoid the need to collect, concentrate, and handle fish passing the water intake;

(4) Avoid the need for fish bypasses that concentrate fish and increase the risk of predation;

(5) Eliminate consideration of an 'off-channel screen with a bypass back to the river' alternative because it is ineffective at achieving primary objectives of avoiding fish mortalities as compared to in-channel and on-bank screen alternatives; The off-channel screen approach results in stress and predation related fish mortalities associated with required concentration/handling of fish;

(6) Avoid creating areas where predators may congregate or where potential prey would have increased vulnerability to predation;

(7) Select screening locations that have desirable hydraulic characteristics (uniform sweeping velocities, reduced turbulence);

(8) Select screening locations as far north on the Sacramento River as possible in order to minimize fish exposure to screens by avoiding tidally induced reverse flows or stagnant flow conditions;

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(9) Use the best available existing fish screening technology in use such as on-bank vertical flat plate screening systems in place at Sutter Mutual and Reclamation District 108, in-river vertical flat plate screening systems used by the City of Sacramento, or multiple small retrievable screens, such as in place at Reclamation District 999;

(10) Use multiple intakes with modules capable of diverting from 500 cfs to 1,500 cfs per screen face with a combined maximum diversion up to 5,000 cfs at a single location. A single 15,000 cfs diversion was not considered since there is no diversion/screen facility of this size in the Sacramento Valley and it is unknown what hydrodynamic effects would be on the river channel;

(11) Minimize the length of screen intake(s) to reduce the duration of fish exposure to the screen surface;

(12) Select locations on the Sacramento River as far north as practicable to reduce the exposure of delta smelt, longfin smelt, and other estuarine species;

(13) Avoid areas of existing riparian habitat

(14) Cost information was not used in developing concepts, but recognized that it will be a consideration in subsequent development phases and in selection of preferred screening concepts.

The FFTT identified several design issues that require further analysis and discussion. The information needed to further define the fish screening concepts can be found in Section 4 of this proposal.

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3.0 Conceptual Proposals

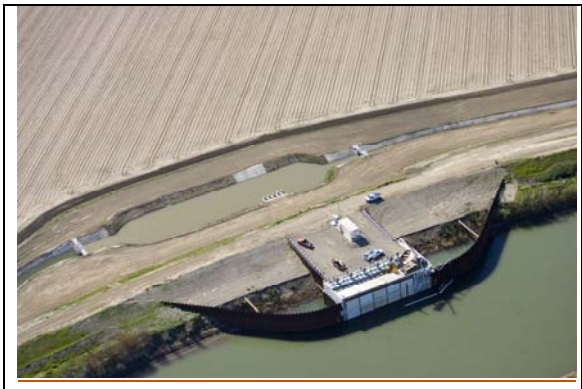
The FFTT has developed four preliminary concepts **for illustration purposes only** in screening up to 15,000 cfs from the Sacramento River which focus on protecting fish based on the criteria and principles described above in Section 2. The FFTT did not analyze additional factors such as; water quality, and aesthetics, on whether 15,000 cfs can be diverted without resulting in significant unavoidable environmental impacts. Screen configurations, locations, and capacities will be determined and refined based on additional analysis of relevant constraints including land use, infrastructure, biological resources and other factors. The additional information needed to further define these concepts is identified in Section 4.

A 15,000 cfs diversion facility at a single location would be five times larger than the biggest existing diversion on the Sacramento River. Hence, a single facility is considered too large to assure fish protection goals of this project would be met. In addition, the uncertainty for local and downstream hydraulic and ecosystem effects led the FFTT to propose the use of smaller diversion facilities at multiple locations. The overall concept is that facilities at several locations on the Sacramento River would be proposed to cumulatively achieve a maximum total diversion of 15,000 cfs. Each diversion facility could consist of one or more screen types to provide optimum protection for fish. All of the proposed concepts adhere to the principles of multiple diversion facilities (intakes) without fish bypasses and/or direct handling of fish.

Each reach of the river between Sacramento and Walnut Grove has unique hydraulic and habitat conditions depending on the time of year and flow and the species to be protected at that location. The location and operation of any diversion facility has an effect on species protection and the level of protection varies for different fish species and life stages. The main differences among the concepts are the proposed number of intakes and type of screens selected to provide optimum fish protection using a single screen type or in combination with other screen types. The three main types of screens include: On-bank screens similar to those used at Reclamation District 108 and currently under construction at Freeport on the Sacramento River, In-river screens similar to those used by the City of Sacramento, and cylindrical screens similar to those used by Reclamation District 999.

Descriptions of conventional screen technologies deemed by the FFTT best suited for this project are as follows:

On-bank screens consist of a single plane of flat plate screen panels, either aligned vertically or with an angle of repose. This type of intake configuration is located near and parallel to the bankline, is accessible from the adjacent embankment, and produces little relative projection or silhouette within the water column. Screens would be similar to the many flat plate wedge wire screens operating on the Sacramento River including Sutter Mutual, Princeton-Codura-Glenn/Provident and Reclamation District 108 (Wilkins Slough and Poundstone Pumping Plants). The proposed concepts illustrate the use of one or more on-bank screens at several locations, or in combination with other screen-type facilities. Photographs of on-bank screened intakes are provided below.

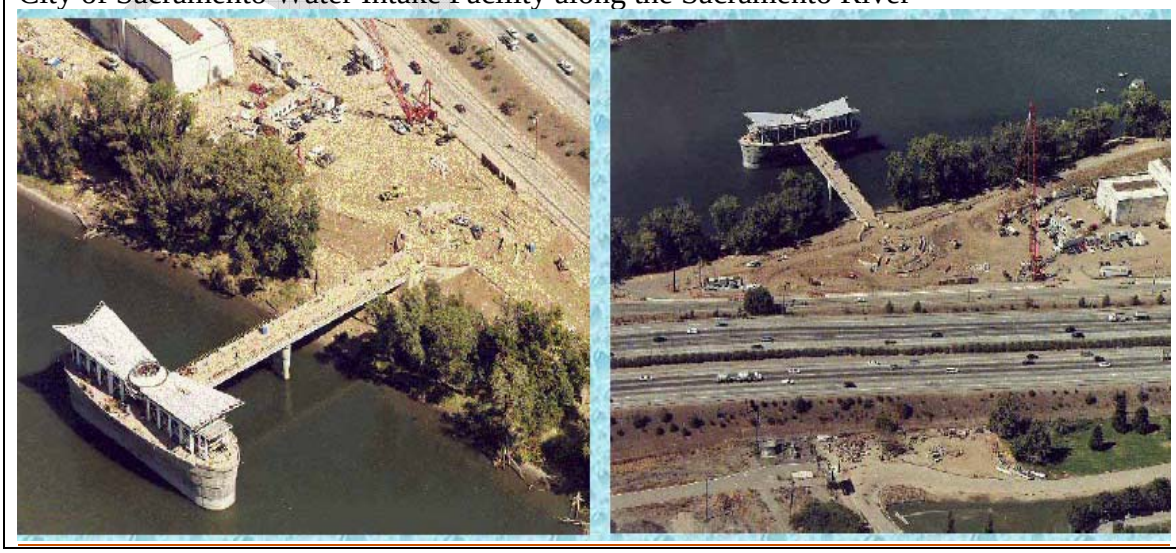


Reclamation District 108 Poundstone Pumping Plant

Reclamation District 108 Wilkins Slough

In-river screens consist of a screened diversion constructed in the river, detached from the bankline, and include an aerial bridge span for access. This configuration is a long, narrow, streamlined structure capable of housing dual screen banks at opposing faces. The intake tower with single or dual screen surfaces would be similar to the City of Sacramento's water intakes on the Sacramento River and the American River. The in-river screens have the advantage of being in the deeper part of the river cross-section than the on-bank screens. Therefore, the in-river screens can have a greater depth and can divert a larger flow for the same length of an on-bank screen. In addition, the length would be shorter than a similarly sized on-bank facility due to the use of dual screen surfaces for an in-river facility. The proposed concepts illustrate the use of one or more in-river screens at several locations or in combination with other screen-type facilities. Photographs of the City of Sacramento in-river intake are provided below

City of Sacramento Water Intake Facility along the Sacramento River



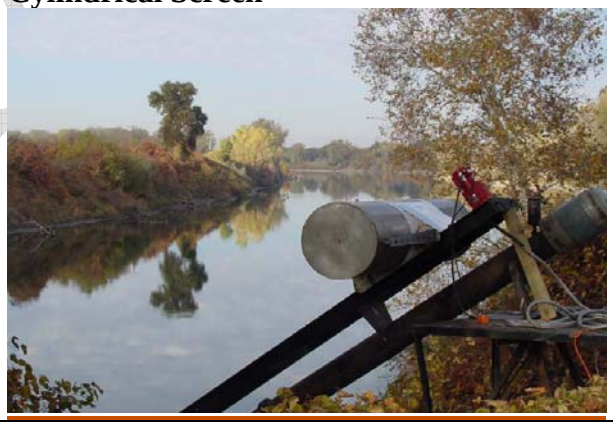
Cylindrical screens would be similar to the many cylindrical screens operating on the Sacramento River. This type of screen is more aptly suited to smaller diversions (100 cfs and less) due to its relatively small screen area. However, multiple units can be combined to provide comparable capacities. Cylindrical screens are pre-manufactured elements assembled in a tee-type configuration with screen elements at each side of a manifold connection. Each module requires above ground superstructure to support an intake conduit/pump casing and guide rails or tracks for guiding the screen into the water body over the conduit inlet.

The advantages of this screen configuration are its relatively low cost, its shallow profile, its retrievable and interchangeable design, and its ability to be constructed in the "wet" without cofferdams and dewatering systems. Obvious drawbacks are the volume of moving parts and hydraulic components, exposure to impact damage from debris/bed load, single-source manufacturing, and potential for producing structure which supports predation. Application of this screened intake concept requires further evaluation but has proven to be viable for other small diversion installations on the Sacramento River.

Examples of this screen type on the Sacramento River are a variety of installations for Reclamation District 999 near Clarksburg and other locations. The proposed concepts require series of cylindrical screens to provide the desired capacity at each location, as well as, in combination with other screen-type facilities. Photographs of cylindrical screened intakes are provided below

Cylindrical Screen

Cylindrical Screen



Sacramento River Cross Sections Evaluated to Date

The FFTT was directed by the Conveyance Workgroup to focus on a reach of the Sacramento River between the City of Sacramento and Walnut Grove for siting fish screen intake facilities. To supplement their working knowledge of this section of the river, the FFTT collected and reviewed a variety of information ranging from aerial images to fishery survey data in order to identify potentially suitable locations. The following is a list of the maps and images used by the FFTT which can be found in Appendix A:

- Delta Map
- Delta Waterways map
- Infrastructure and sensitive natural communities
- Land Elevation layer
- Transportation corridor layers (Highways, local roads, railroads);
- Electrical Transmission and Gas lines and related infrastructure layers;
- Bathymetry layer (latest data available);
- Existing regions of critical habitat that should be avoided within area of interest;

In addition, the FFTT reviewed general fisheries temporal and spatial patterns, critical habitat, and fall mid-water trawl delta smelt data which can be found in Appendix B. However, the FFTT identified the need for more detailed fish species presence, timing, and distribution information for applicable life stages (i.e., eggs, larval, juveniles and adults) within the reach of the Sacramento River between the City of Sacramento and Walnut Grove.

Based on the review of the available information, the team identified twelve potentially suitable locations for placing a diversion facility. These sections were primarily selected to characterize river cross-section geometry based on alignment and to develop a general understanding of water depth and average velocity versus flow. These twelve potentially suitable locations identified by the team for further analysis are shown in Figure 1. Although bathymetry data for each location could be obtained, the most recent data for portions of the reach of interest was obtained in 1997 and some data obtained as far back as 1977 which may not reflect current conditions. In addition, detailed river flow and stage information was unavailable and it was necessary to estimate values for each location based on two existing stations (one at Freeport and one near the Delta Cross Channel). Additional information needs require updated river bathymetry and hydrodynamic information for the reach of interest. The cross sectional information and aerial images can be found in Appendix C.

The FFTT participated in a multi-agency tour of the Sacramento River lead by the US Geological Survey (USGS) on July 29, 2008. The tour provided an opportunity to verify information regarding potentially suitable intake locations, to discuss USGS hydrodynamic and fish tracking studies, to view potentially suitable intake locations firsthand, and to identify potential constraints such as ongoing or proposed levee repair sites and/or riparian habitat restoration areas.

Sacramento River Cross Sections Evaluated to Date

For illustration purposes only,
actual locations would be determined and refined based on additional analysis of relevant constraints including land use, infrastructure, biological resources and other factors.

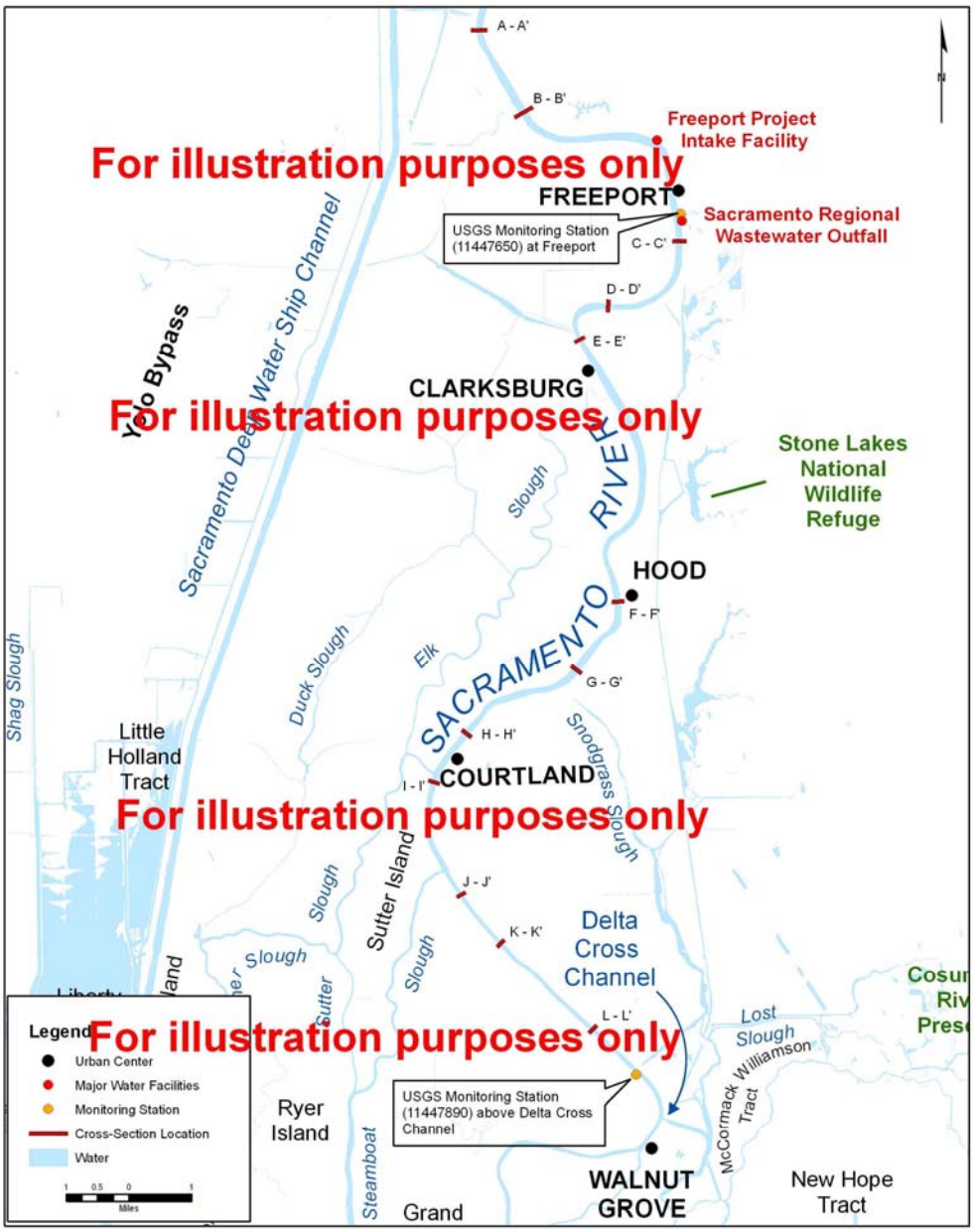


FIGURE 1

Conceptual Proposal A

Concept A consists of a combination of in-river and on-bank screens situated at three locations on the Sacramento River between Freeport and Courtland. Each location would provide a diversion capacity of 5,000 cfs for a combined maximum diversion capacity of 15,000 cfs. The use of multiple locations provides redundancy and increases operational flexibility. Redundancy provided by multiple units and/or facilities provides an opportunity to shift diversions from one location to another, as needed, to protect sensitive species that may be near a given location and/or address maintenance or outages for units or facilities. The use of in-river and on-bank screens eliminates the handling of fish or need for bypass facilities. The screens would be located in a relatively straight stretch of the river to avoid complex flow patterns, scour, and sediment issues associated with river bends.

The length of the screen surface would be kept as short as possible to minimize fish exposure to the screen surface. The in-river screens have the advantage of being in the deeper part of the river cross-section than the on-bank screens. Therefore, the in-river screens have a greater depth and can divert a larger flow for the same length of screen as the on-bank screens. The in-river screens have a screen surface on both sides of the supporting structure allowing for a total screened flow up to 2,500 cfs each. The in-river screened flow would be limited to 2,250 cfs each when they are used in combination with the on-bank screen which would be limited to 500 cfs. In-river screens would be used at each location and on-bank screens would only be used at a location in combination with in-river screens. Configurations for the conceptual layout of these screens are shown in Figures 2, 3, and 4 at representative locations selected by the team for illustration purposes only.

The in-river screens would consist of towers with dual screen surfaces similar to the City of Sacramento's water intakes on the Sacramento River and the American River. The major difference is that the pumps would not be situated on the tower but on the landside of the levee. Water would flow through the screens on the tower, then into pipes buried in the river bottom and under the levee, then into a wet well system where the water would be pumped into a collection channel. A conceptual drawing for illustration purposes only of in-river fish screens is shown in Figure 5.

The on-bank screen would consist of a single screen surface along the bank of the river with transitions at the upstream and downstream ends to achieve uniform sweeping flows and velocities across the screens. The on-bank screen would be used in combination with in-river screens and share common infrastructure (pumps, pipelines, etc…) as described for the in-river screens. A conceptual drawing for illustration purposes only of a combination in-river and on-bank fish screens is shown in Figure 6.

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CONCEPT A – Section C-C'

(For illustration purposes only, actual locations would be determined and refined based on additional analysis of relevant constraints including land use, infrastructure, biological resources and other factors.)

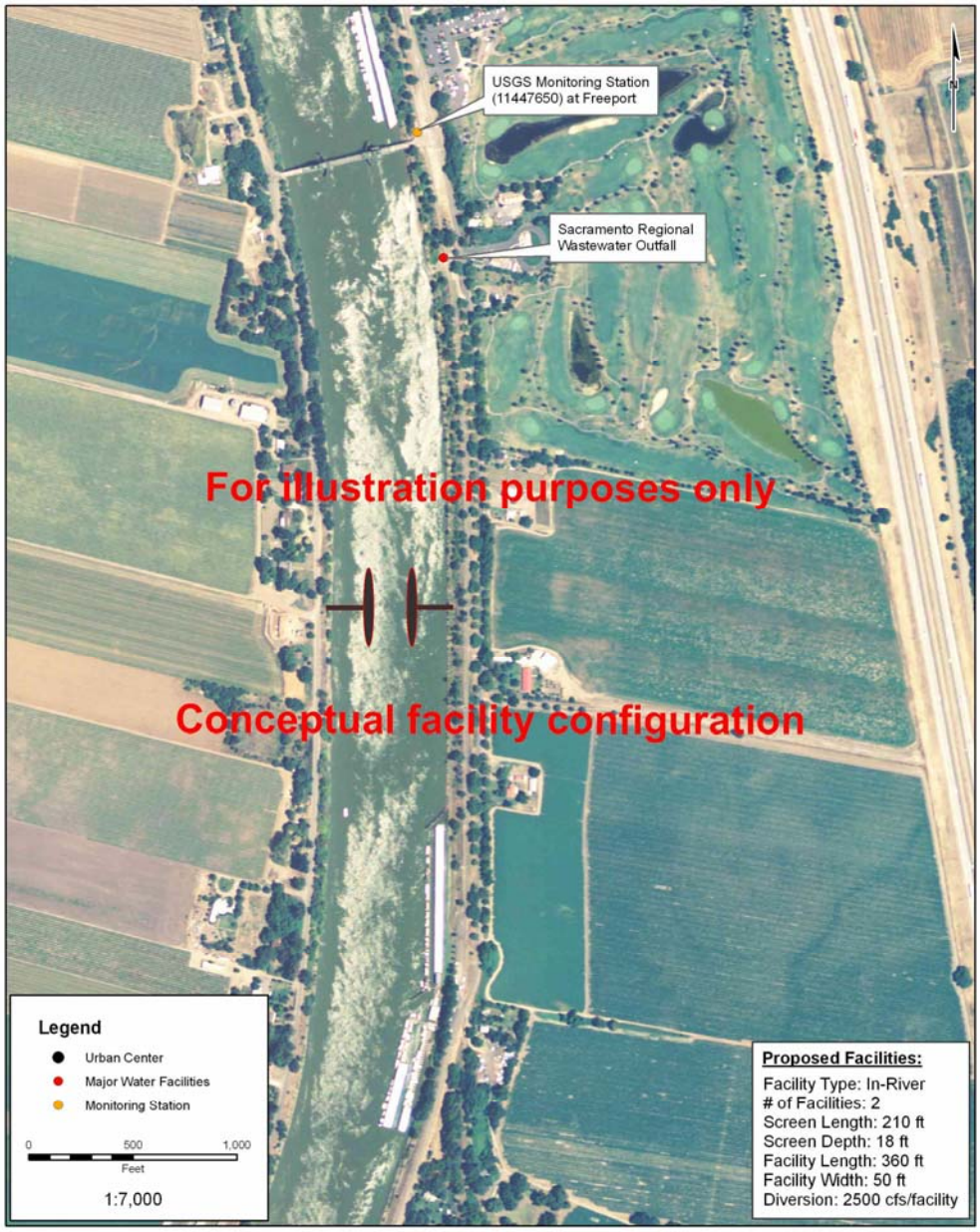

FIGURE 2 - Aerial view showing potential footprint

CONCEPT A – Section F-F'

(For illustration purposes only, actual locations would be determined and refined based on additional analysis of relevant constraints including land use, infrastructure, biological resources and other factors.)

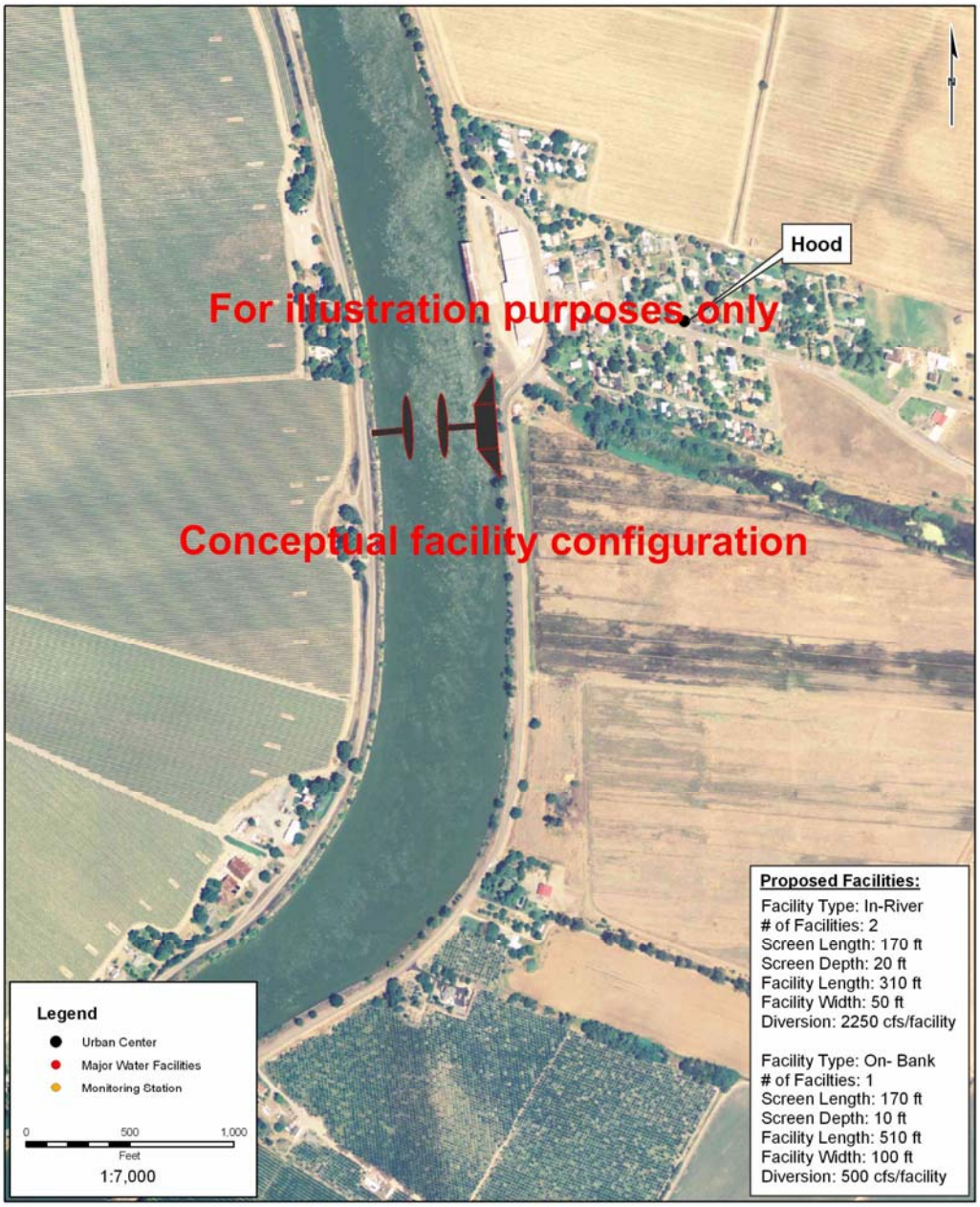

FIGURE 3 – Aerial view showing potential footprint

CONCEPT A – Section H-H'

(For illustration purposes only, actual locations would be determined and refined based on additional analysis of relevant constraints including land use, infrastructure, biological resources and other factors.)

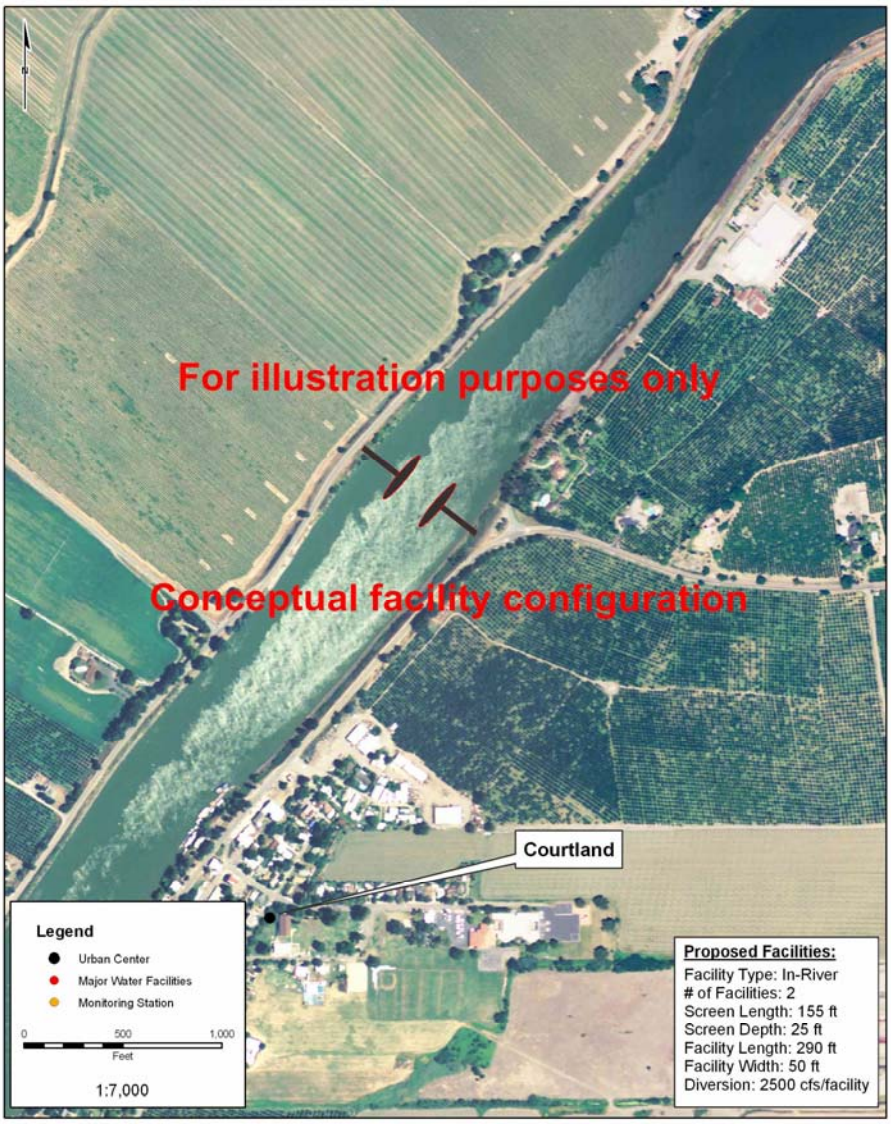

FIGURE 4 - Aerial view showing potential footprint

Figure 5 – Conceptual In-River drawing
(For illustration purposes only)

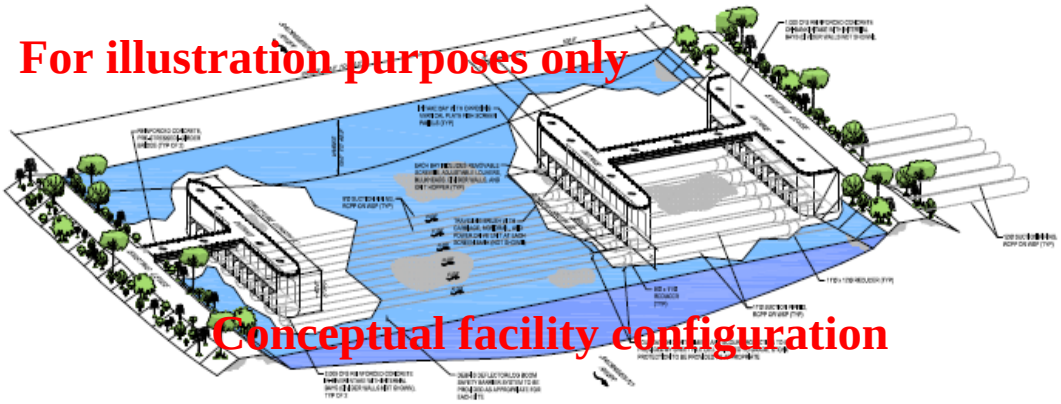

Figure 6 – Conceptual In-River and On-Bank drawing
(For Illustration purposes only)

Conceptual Proposal B

Concept B consists of a series of cylindrical screens at ten locations along the Sacramento River between the City of Sacramento and Walnut Grove. Each location would consist of fifteen 100 cfs cylindrical screens providing a cumulative diversion capacity of 1,500 cfs. The combined maximum diversion capacity of all ten locations would be 15,000 cfs. The use of ten smaller diversions reduces the potential hydraulic effects and exposure time in comparison to the three larger diversions described in Concept A, and the increased number of smaller diversions provides increased redundancy and operational flexibility. The use of cylindrical screens eliminates the handling of fish or need for bypass facilities. The screens would be located in a relatively straight stretch of the river to avoid complex flow patterns, scour, and sediment issues associated with river bends.

Each cylindrical screen is approximately 7 feet in diameter and 23 feet in length with an estimated screened flow of 100 cfs each. A total of fifteen cylindrical screens at each location will be needed to provide the desired diversion capacity of 1,500 cfs. A total of ten locations will be necessary to achieve a combined maximum diversion capacity of 15,000 cfs. Although removable and retractable features of cylindrical screens provide easy access for maintenance purposes, the increased number of diversions in comparison to Concept A would require greater conveyance infrastructure. Configurations for the conceptual layout of the cylindrical screens are shown in Figure 7 at a representative location for illustration purposes only.

Water would flow through the screens, then into pipes buried in the river bottom and under the levee, then pumped into a collection channel. Alternatively, the flow from each screen could be pumped over the levee and then piped to a collection channel. The cumulative effect of multiple cylindrical screens may cause hydraulic complexities that affect the uniformity of flow through screens and sweeping flows past the screens. Clusters may also create habitat for predatory fish. Cylindrical screens may be more susceptible to impact damage from flood borne debris since they extend into the waterway. A conceptual drawing for illustration purposes only of a multiple cylindrical fish screen layout is shown in Figure 8.

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CONCEPT B – Section C-C'

(For illustration purposes only, actual locations would be determined and refined based on additional analysis of relevant constraints including land use, infrastructure, biological resources and other factors.)

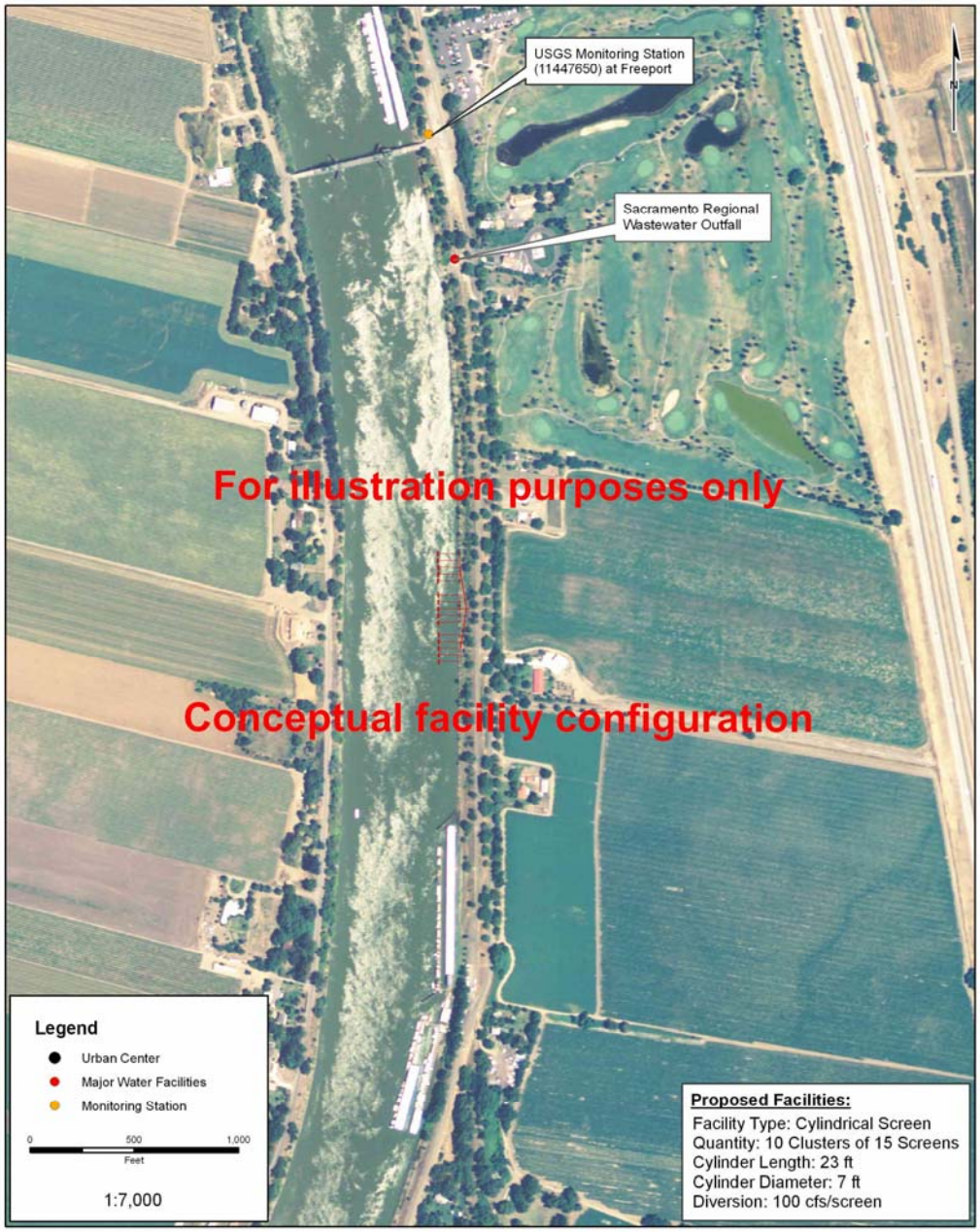

Figure 7 – Aerial view showing potential footprint

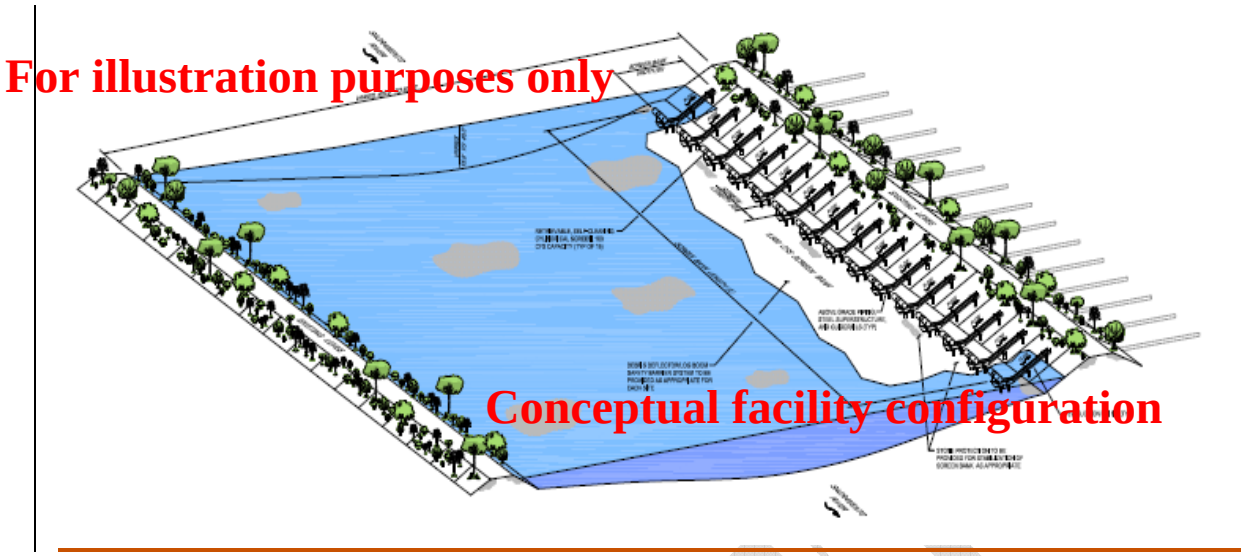

Figure 8 – Cylindrical Screen conceptual drawing
(For illustration purposes only)

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Conceptual Proposal C

Concept C consists of a combination of on-bank and in-river screens situated at ten locations on the Sacramento River between the City of Sacramento and Walnut Grove. Each location provides a diversion capacity of 1,500 cfs for a combined maximum diversion capacity of 15,000 cfs. The use of ten smaller diversions reduces potential hydraulic effects and exposure time than for the larger diversions described in Concept A, and provides increased redundancy and operational flexibility similar to Concept B. Similar to Concept B, the increased number of diversions in comparison to Concept A would require greater conveyance infrastructure. The use of in-river and on-bank screens eliminates the handling of fish or need for bypass facilities. The use of multiple screen types may require a variety of maintenance and back up screens and material at each site rather than a single type of modular replacement or serviceable screen. The screens would be located in a relatively straight stretch of the river to avoid complex flow patterns, scour, and sediment issues associated with river bends.

The length of the screen surface would be kept as short as possible to minimize fish exposure to the screen surface. The in-river screens have the advantage of being in the deeper part of the river cross-section than the on-bank screens. Therefore, the in-river screens have a greater depth and can divert a larger flow for the same length of screen as the on-bank screens. The in-river screens have a screen surface on both sides of the supporting structure allowing for a total screened flow up to 1,000 cfs each. The in-river screened flow would be limited to 650 cfs each when they are used in combination with the on-bank screen which would be limited to 200 cfs. In-river screens would be used at each location and on-bank screens would only be used at specific locations in combination with in-river screens. Configurations for the conceptual layout of these screens are shown in Figures 9 and 10 at representative locations for illustration purposes only.

The in-river screens would consist of towers with dual screen surfaces similar to the City of Sacramento's water intakes on the Sacramento River and the American River. The major difference is that the pumps would not be situated on the tower but on the landside of the levee. Water would flow through the screens on the tower, then into pipes buried in the river bottom and under the levee, then into a wet well system where the water would be pumped into a collection channel. A conceptual drawing for illustration purposes only of in-river fish screens are shown in Figure 11.

The on-bank screen would consist of a single screen surface along the bank of the river with transitions on the upstream and downstream ends to achieve uniform sweeping flows and velocities across the screens. The on-bank screen would be used in combination with in-river screens and use the infrastructure (pumps, pipelines, etc…) as described for the in-river screens above. A conceptual drawing for illustration purposes only of a combination in-river and on-bank fish screen is shown in Figure 12.

CONCEPT C – Section C-C'

(For illustration purposes only, actual locations would be determined and refined based on additional analysis of relevant constraints including land use, infrastructure, biological resources and other factors.)

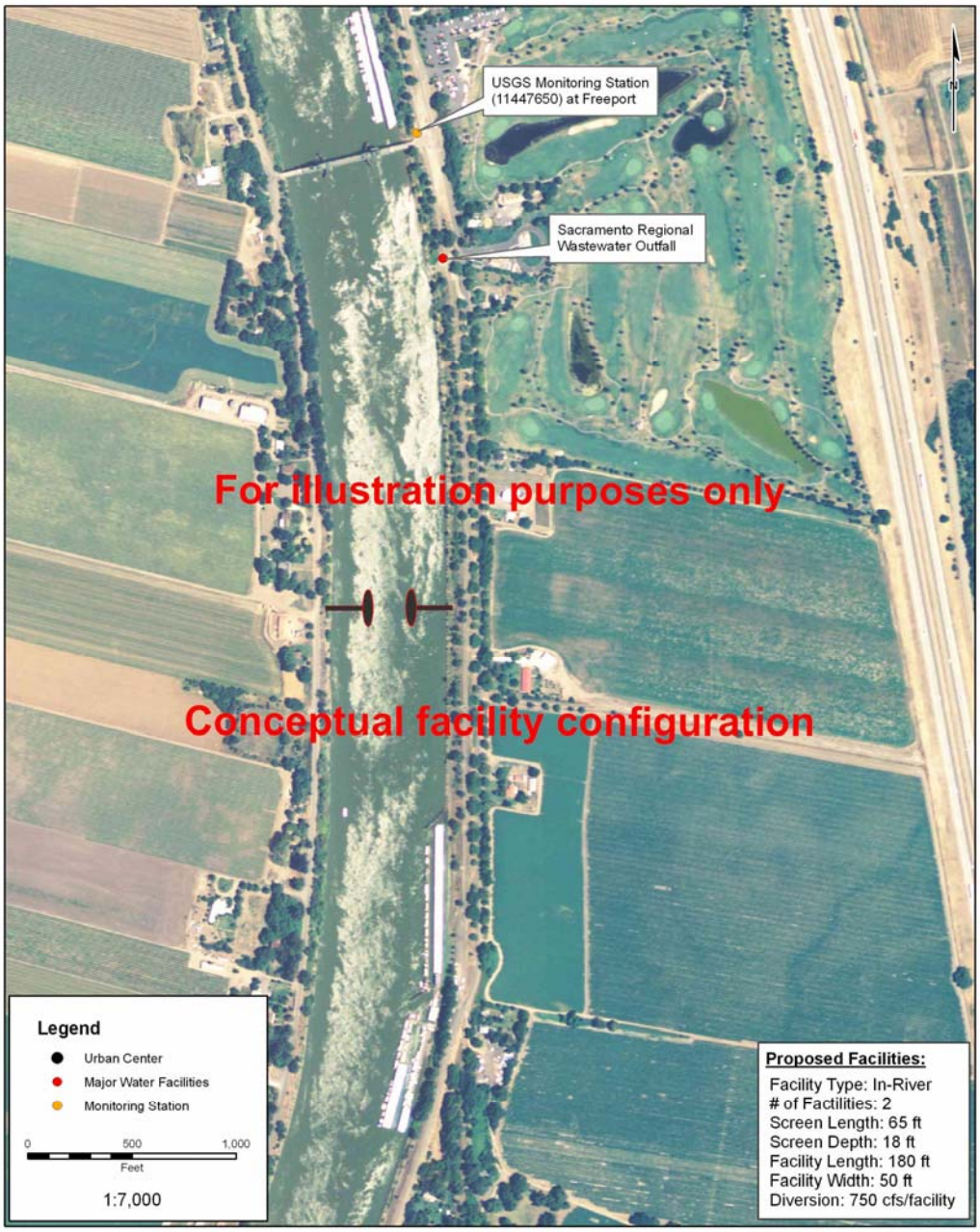

Figure 9 – Aerial view showing potential footprint

CONCEPT C – Section F-F'

(For illustration purposes only, actual locations would be determined and refined based on additional analysis of relevant constraints including land use, infrastructure, biological resources and other factors.)

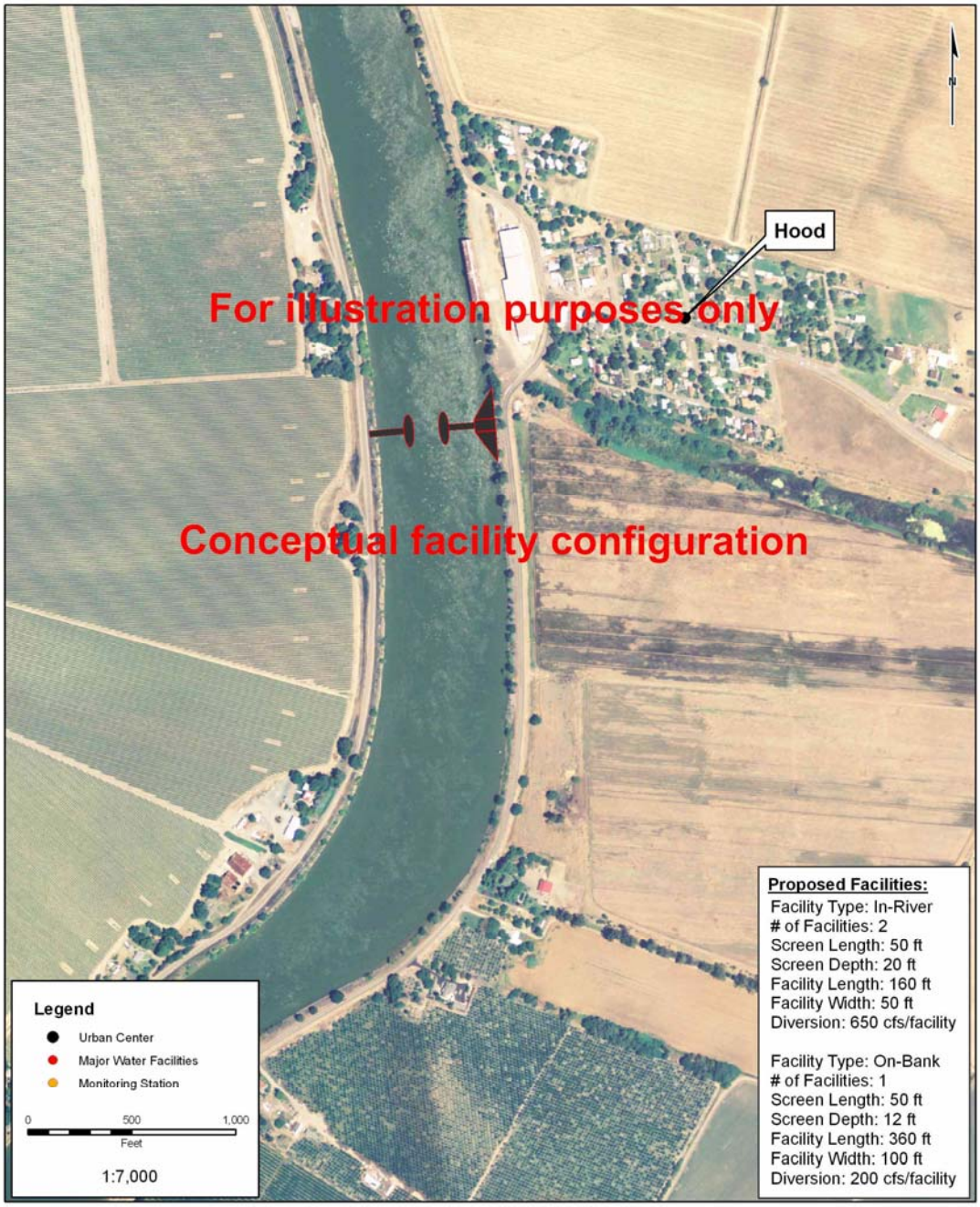

Figure 10 – Aerial view showing potential footprint

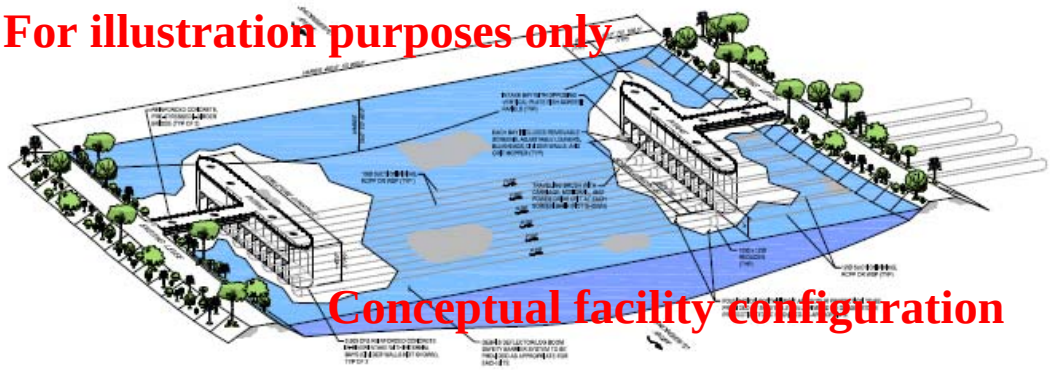

Figure 11 – In-River Conceptual drawing
(For illustration purposes only)

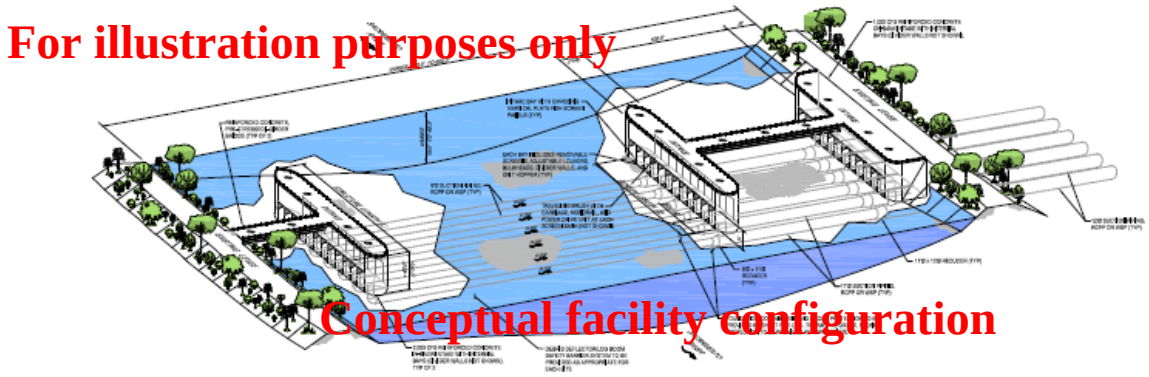

Figure 12 – In-River and On-Bank Conceptual drawing
(For illustration purposes only)

Conceptual Proposal D

Concept D consists of a combination of cylindrical and in-river screens situated at ten locations on the Sacramento River between the City of Sacramento and Walnut Grove. Each location provides a diversion capacity of 1,500 cfs for a combined maximum diversion capacity of 15,000 cfs. The use of ten smaller diversions reduces potential hydraulic effects and exposure time than for the larger diversions described in Concept A, and provides increased redundancy and operational flexibility similar to concepts B and C. However, the increased number of diversions in comparison to Concept A would require greater conveyance infrastructure similar to Concepts B and C. The use of cylindrical and in-river screens eliminates the handling of fish or need for bypass facilities. The use of multiple screen types will require a variety of maintenance and back up screens and material at each site rather than a single type of modular replacement or serviceable screen. The screens would be located in a relatively straight stretch of the river to avoid complex flow patterns, scour, and sediment issues associated with river bends.

The length of the screen surface would be kept as short as possible to minimize fish exposure to the screen surface. The in-river screens have the advantage of being in the deeper part of the river cross-section than the on-bank screens. Therefore, the in-river screens have a greater depth and can divert a larger flow for the same length of screen as the on-bank screens. The in-river screens have a screen surface on both sides of the supporting structure allowing for a total screened flow up to 750 cfs each. The in-river screened flow would be limited to 500 cfs each when they are used in combination with the cylindrical screens which would be limited to 100 cfs each. In-river screens would be used at each location and cylindrical screens would only be used at specific locations in combination with in-river screens. Configurations for the conceptual layout of these screens are shown in Figures 13 and 14 at representative locations for illustration purposes only.

The in-river screens would consist of towers with dual screen surfaces similar to the City of Sacramento's water intakes on the Sacramento River and the American River. The major difference is that the pumps would not be situated on the tower but on the landside of the levee. Water would flow through the screens on the tower, then into pipes buried in the river bottom and under the levee, then into a wet well system where the water would be pumped into a collection channel. A conceptual drawing for illustration purposes only of in-river fish screens is shown in Figure 15.

The cylindrical screens would be used in combination with in-river screens and use the infrastructure (pumps, pipelines, etc) as described for the in-river screens above. Each cylindrical screen is approximately 7 feet in diameter and 23 feet in length with an estimated screened flow of 100 cfs each. A total of five cylindrical screens will be needed to provide the desired diversion capacity of 500 cfs at selected locations. The removable and retractable features of cylindrical screens provide easy access for maintenance purposes. A conceptual drawing for illustration purposes only of a combination cylindrical and in-river fish screens is shown in Figure 16.

CONCEPT D – Section C-C'

(For illustration purposes only, actual locations would be determined and refined based on additional analysis of relevant constraints including land use, infrastructure, biological resources and other factors.)

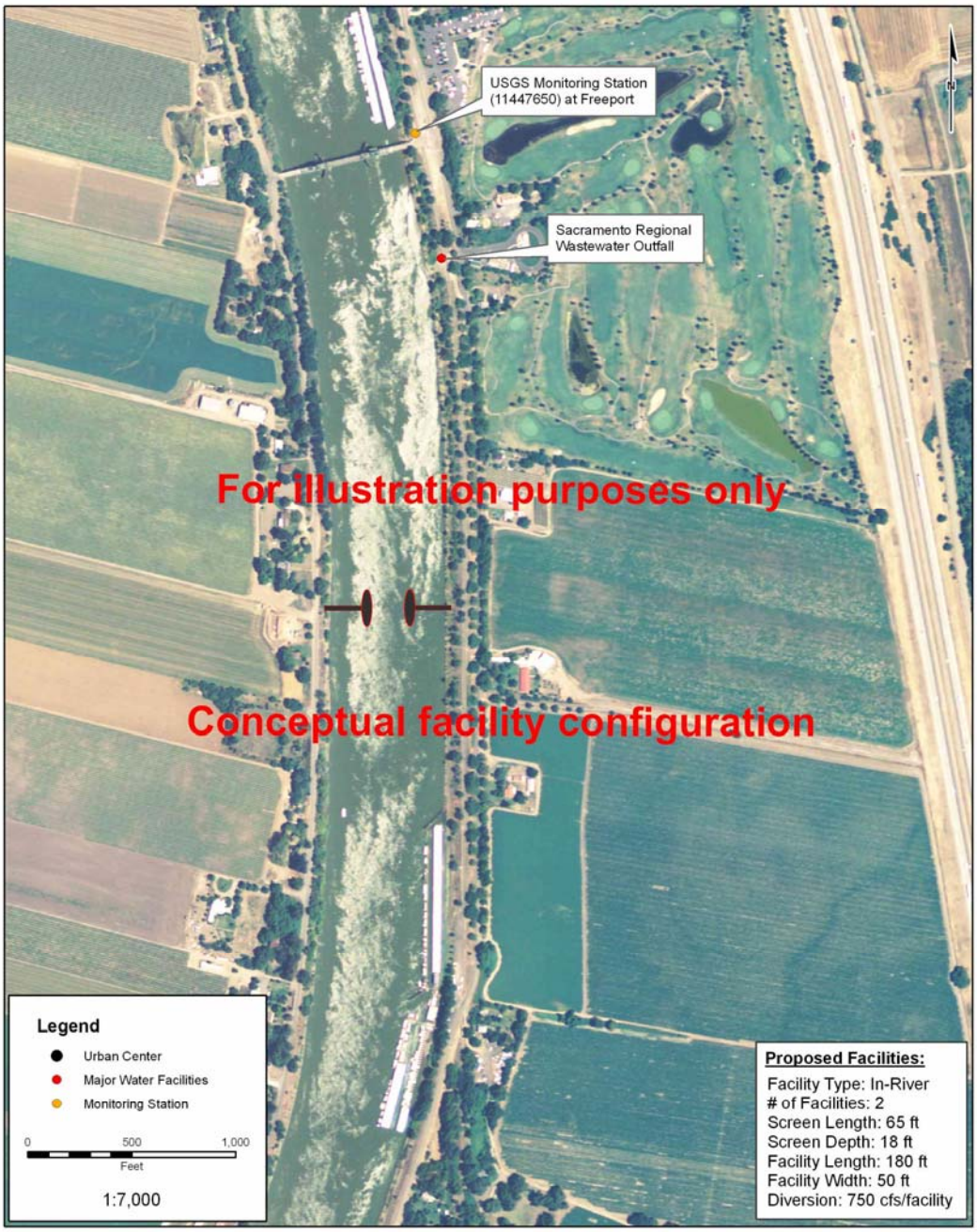

Figure 13 – Aerial view showing potential footprint

CONCEPT D – Section F-F'

(For illustration purposes only, actual locations would be determined and refined based on additional analysis of relevant constraints including land use, infrastructure, biological resources and other factors.)

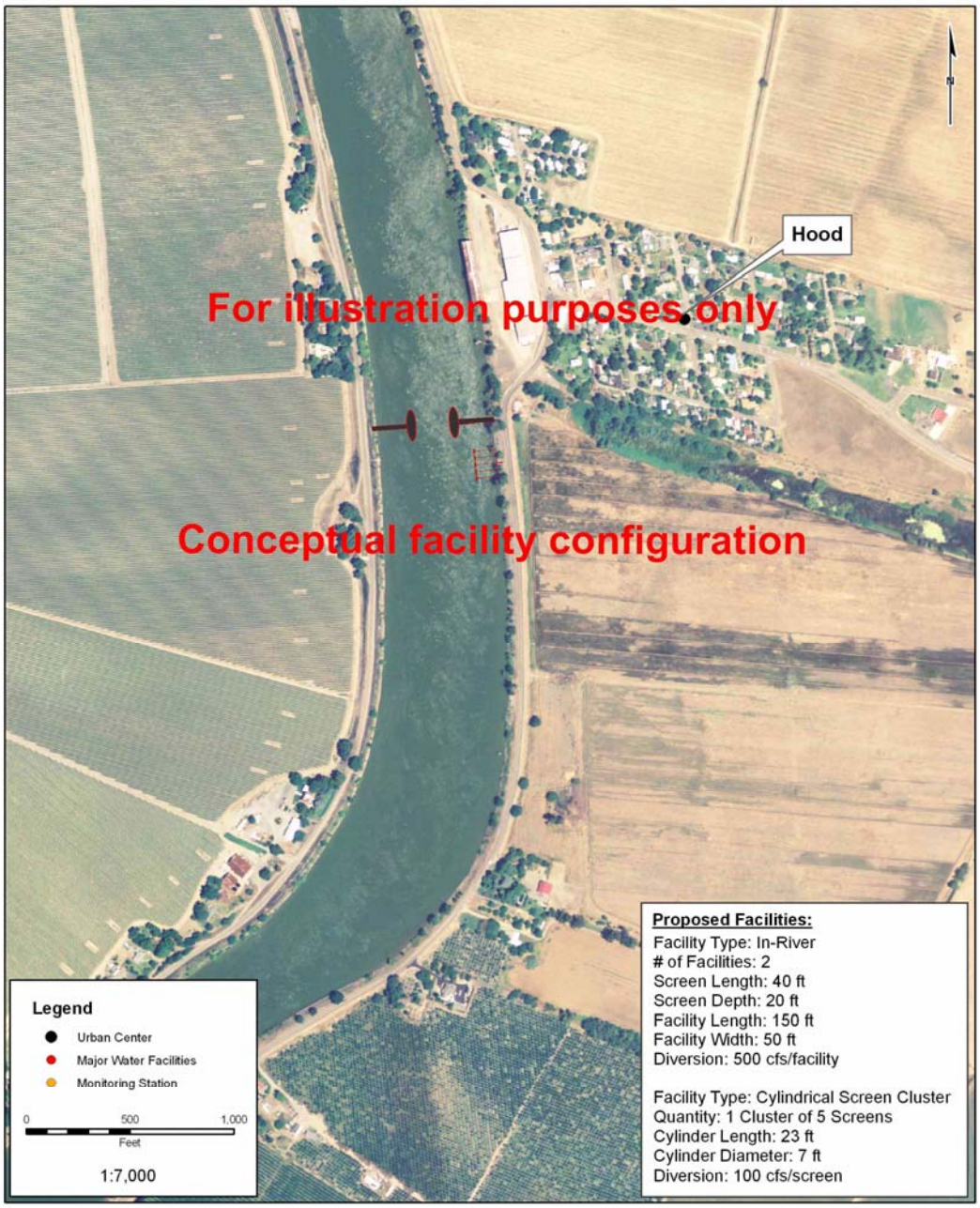

Figure 14 – Aerial view showing potential footprint

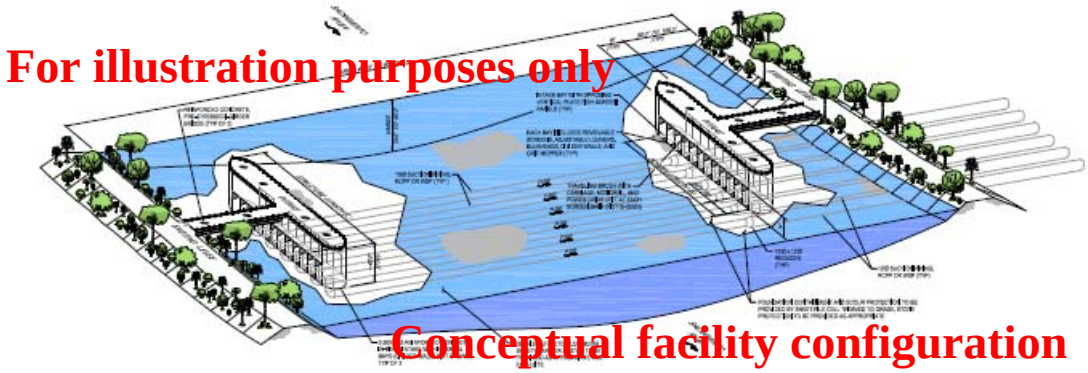

Figure 15 – Conceptual drawing
(For illustration purposes only)

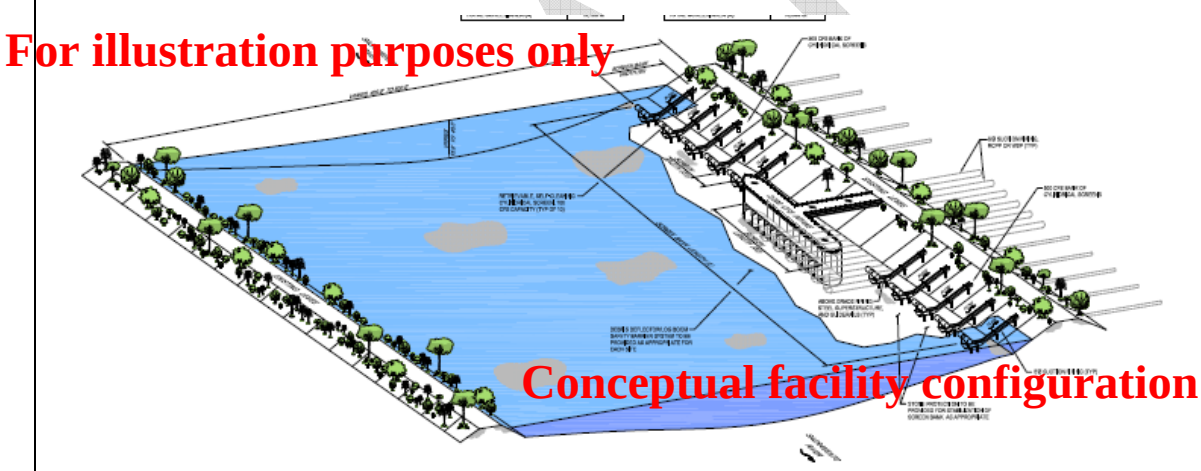

Figure 16 – Conceptual drawing
(For illustration purposes only)

4.0 Information/Study Needs and Additional Considerations

During the process of developing the concepts in this proposal, the FFTT identified the need for additional information for the reach of the Sacramento River being considered for diversion facility locations. The information pertaining to river hydrology and hydraulics and fisheries information includes:

- Need for detailed bathymetry data;
- Need for river depth and velocity profile data for various locations;
- Need to further understand current hydro-dynamics ;
- The need to model the estimated changes to hydro-dynamics with the addition of the proposed diversion;
    - Effects of facility on the river channel flood flow carrying capacity
    - Additional analysis may include hydraulic and hydro-dynamic modeling, physical modeling, sediment modeling, 2-dimensional testing of baffle systems ('dynamic baffling'), and further analysis of delta smelt and green sturgeon interaction with fish screen designs.
    - Effects on the near and far field velocity patterns as they affect the amount of water going into Steamboat, Sutter, and Georgiana Slough as well as the Delta Cross Channel. This information will be needed to address many of fish migration issues in the north Delta.
- Need to consider future hydrologic conditions associated with climate-change;
- Fish species presence, timing, and distribution for applicable life stages;
- Need for any applicable navigational and flood conveyance regulations established by the U.S. Coast Guard and U. S. Army Corps of Engineers that could affect placement of in-river structures.
- Restrictions or variances for construction of piping through flood control levees.
- Anticipated facility/system operations.

The above information will contribute to defining operations (timing, volume/rate, percentage of river flow) of the facility, subsequent location and design of proposed facilities, and to determine the effect on flows downstream of proposed diversion locations.

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Additional factors for consideration in selecting diversion facility locations, screen types, and associated conveyance includes:

- Land use – existing and proposed land use.
- Infrastructure – existing and proposed infrastructure (highways, railroads, transmission lines).
- Other biological resources in addition to fish resources.

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5.0 Next Steps

There are several pending efforts and issues that will need to be addressed in further developing the proposed concepts above for screening a maximum diversion of 15,000 cubic feet per second (cfs) along the Sacramento River between the City of Sacramento and Walnut Grove. These efforts and issues include:

- Operating Criteria for Diversions
  The overall concept in this proposal is a maximum diversion of up to 15,000 cfs using multiple diversion facilities. While placing the diversions at several locations on the Sacramento River could offer the most flexibility to provide protection for fish, each diversion, as well as the combination of all the diversions will need criteria beyond the screening criteria discussed in this proposal to define their individual and combined operations. These operating criteria will need to be determined as they affect the number, types and design of screens. While the focus of the FFTT has been on the criteria for design and operation of the individual fish screens, a physical approach in meeting proposed operating criteria was discussed by the FFTT. This facility design approach would provide technical safeguards and physical assurances that water diversion rates operate within agreed upon limits is referred to as "Selective Withdrawal". This approach is based on the concept that ecosystem protection and water export limitations must be guaranteed during periods of low river flows, while at the same time offering opportunities to significantly increase water diversion flow rates during high flow. Physical design features (and control and instrumentation) can be incorporated into the structure(s) to always allow diversion of a limited "base flow" from the lower portion of the water column. In order to divert "surplus flows" (stage 2, 3, etc.) additional intake points would be situated at incrementally higher elevation(s) in the water column- corresponding to higher flows in the river. Alternatively, the use of retrievable cylindrical screens as a single facility or in combination with other facilities as described in this proposal could be implemented to achieve similar objectives. Either approach could be used to physically curtail export capacities at times when additional pumping would cause ecosystem degradation and fish losses, but would allow the facilities to divert and export high flows at high pumping rates so that conveyance and storage facilities capture the water for later delivery.

- Investigate Material types
  A variety of materials are available for use in constructing fish screens. The team has identified the advantages and disadvantage of stainless steel, copper-nickel, and plastic and will need to further discuss the type of materials most appropriate for the specific site conditions of proposed locations. The FFTT may consider the need for additional field studies of coated materials to complement previous studies of commonly used materials.

- Investigate Cleaning Mechanisms
  A variety of cleaning mechanisms are available for use in cleaning fish screens. The team has identified the advantages and disadvantage of air burst systems, and mechanical arm/brushes and will need to further discuss the type of cleaning system most appropriate for the specific site conditions of proposed locations.

- Investigate Biofouling and Introduced Mussel Infestation/Cleaning
  Quagga and Zebra mussels are spreading through the west and it appears it is simply a matter of time before many screening facilities become infested. Both Quagga and Zebra mussels have been recently found in California and the potential exists for these to move into the Delta and Sacramento River system via unauthorized or accidental introductions. At the large diversion concept facilities, use of traveling screens, anti- fouling alloys and coatings, and alternative cleaning systems or other methods should be investigated as alternatives to the commonly used stainless steel flat plate screens. On smaller concepts, alloys and alternative cleaning systems should be investigated for use.

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6.0 References Related to Fish Screen Facilities

1) DFG Fish Screen Criteria, 2000
http://www.dfg.ca.gov/fish/Resources/Projects/Engin/Engin_ScreenCriteria.asp

2) NMFS Fish Screen Criteria, 1997
http://swr.nmfs.noaa.gov/hcd/fishscrn.pdf

3) NMFS Fish Screen Criteria, 1995
http://www.ser.org/sernw/pdf/NOAA_fish_screen_guidance.pdf

4) Bureau of Reclamation Water Resources Technical Publication
Fish Protection at Water Diversions
A Guide for Planning and Designing Fish Exclusion Facilities, April 2006
Note: Fish Screen Chapter: Chapter IV. Positive Barrier Screens
http://www.usbr.gov/pmts/hydraulics_lab/pubs/manuals/fishprotection/index.html

5) Fish Screening and Fish Passage Analysis of the CALFED Bay-Delta Program,
Phase II Delta Conveyance Alternatives
July, 1997

6) Debris Rack: Debris Capture and Fish Passage; March, 2008
(DWR Technical Memorandum)
http://baydeltaoffice.water.ca.gov/ndelta/fishery/documents/DWR_memo_031008_UCD_TDF_Debris%20rack%20study.pdf

7) A Pilot Study on the Bio-fouling Resistance of 304 and 316 Stainless Steels and
Copper Nickel Metal; July 2005
(A DWR Study Report)
http://baydeltaoffice.water.ca.gov/ndelta/fishery/documents/BiofoulingStudyFinal.pdf

7.0 List of Appendices

Appendix A: Maps (Bathymetry, Habitat, Infrastructure, etc…)

- Urban land use layer;
- Land Elevation layer;
- Transportation corridor layers (Highways, local roads, railroads);
- Electrical Transmission and Gas lines and related infrastructure layers;
- Bathymetry layer (latest data available);
- Existing regions of critical habitat that should be avoided within area of interest;
- Parcel Data.

Appendix B: Spatial / Temporal Patterns of Fish in the Sacramento River

Appendix C: Cross Sections and Aerial Imagery Data

Appendix D: Fish Screen Component Matrix

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