E. Lawson, CDFW
Engineering Comments and Questions
Provided in response to concepts presented in 11/15/2021 meeting and:

- **Hemphill Diversion Structure Fish Passage Project DRAFT Conception Design Report - November 2021**
- **Plan Sheet 2021_11**

The California Department of Fish and Wildlife (CDFW) submits these comments to the Nevada Irrigation District (NID) to aid in the development of concepts provided for the Hemphill dam and diversion. These comments aim to guide development of safe and timely passage of fish through the site for both upstream and downstream passage.

Overall Comments:

1. At 50% design, among the other design plans that will be included, we would also expect to see specific details regarding:
    a. Hydraulic analysis that shows how often the CDFW fish screen criteria is met;
    b. Bypass flow hydraulic analyses that detail entrance, exit and in-pipe conditions for fish;
    c. An operations plan that will outline how the fish screen and control gate will operate including details regarding sediment and debris passage.
2. The CDFW engineering checklist sections for fish screens and roughened channels should be completed and questions that arise can be discussed during future design meetings, or in writing along with 50% design drawings. The most recent version of the engineering checklist is attached.

Farmer's Fish Screen Concept:

The CDFW's fish screen criteria are included in Appendix S of Volume One of the California Salmonid Stream Habitat Restoration Manual (Habitat Restoration Manual), which can be found at:

https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=22672

Applicable Criteria for Discussion:

Habitat Restoration Manual:

> *1. B. In Canals (flowing water): The screen structure shall be located as close to the river source as practical, in an effort to minimize the approach channel length and the fish return bypass length. This "in canal" fish screen location shall only be used where an "onstream" screen design is not feasible. This situation is most common at existing diversion dams with headgate structures. The current National Oceanic and Atmospheric Administration (NOAA) Fisheries - Southwest Region criteria for these types of installations shall be used.*
>
> *2. B. 2. In Canals (flowing waters) - 0.40 feet per second, with a bypass entrance located every one-minute of travel time along the screen face.*

C. Screens Which Are Not Self-Cleaning: The screens shall be designed with an approach velocity one-fourth that outlined in Section B. above. The screen shall be cleaned before the approach velocity exceeds the criteria described in Section B

2. E. Screen Area Calculation: The required wetted screen area (square feet), excluding the area affected by structural components, is calculated by dividing the maximum diverted flow (cubic-feet per second) by the allowable approach velocity (feet per second).

Example: 1.0 cubic-feet per second / 0.33 feet per second = 3.0 square feet Unless otherwise specifically agreed to, this calculation shall be done at the minimum stream stage.

NOAA Southwest Regional Criteria:

11.6.1.7.7 Bypass Flow Depth: For horizontal screens, the bypass flow must pass over the downstream end of the screen at a minimum depth of one foot.

Comments:

1. In the presentation on 11/15/2021, NID's engineering contractor's presentation indicated that using NMFS criteria, and approach velocity of 0.25 ft/sec or less was appropriate for horizontal screens. However, CDFW's criteria specify that screens that are not self-cleaning should have one fourth the velocity outlined in Section B, which would indicate approach velocities of no greater than 0.1 ft/sec, which also affects screen sizing calculations.
2. NID should provide hydraulic modeling as well as operating instructions to justify how the proposed screen area will be consistently maintained and kept clear of debris and sediment.
3. Using NOAA's criteria for horizontal screens (11.6.1.7.7) NID should provide calculations and operations information that describe how the head gate at the diversion structure will be used throughout the range of flows during diversion season to either maintain one foot of depth or shut off diversions.

Roughened Ramp Fishway:

Fish passage criteria for nature-like fishways are defined in NOAA Fisheries Salmonid Passage Facility Design under Roughened Channels and can be found online at:

https://www.westcoast.fisheries.noaa.gov/publications/hydropower/fish_passage_design_criteria.pdf

These criteria specify that, in general, roughened channels should only be used when:

- Channel slope using stream simulation is less than 6%; and
- Total length of passage is less than 150 feet.

Additionally, the Habitat Restoration Manual Part XII: Fish Passage Design and Implementation (July 2009) can be found at:

https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=12512+&tabid=189&mid=601

The section on roughened channels (pages XII-57 through XII -80) contains the following table:

Bedform	Overall Roughened Channel Slope	Recommended Maximum Elevation Drop Across Roughened Channel
Rock Ramps	≤4.0%	5 feet[1]
Chutes and Pools	≤4.0%	2 feet per Sequence
Step-Pools	3.0-5%	5 feet per Sequence[2]
Cascade and Pool	4.0-6.5%	5 feet per Sequence

Table XII-1. Recommended range of overall design slopes and maximum elevation drops for various roughened channel bedforms.

Ramp Comments/questions:

1. In the design proposed by NID, both of the NOAA criteria for slope and length are met, but additionally the criteria specify that: "It should be demonstrated in the design analysis that any scouring of fines from the constructed channel will be refilled by subsequent bedload transport and aggradations." How will NID use modeling or other quantitative calculations to determine that scour/fill in the constructed channel will remain in equilibrium without need for continual refurbishment?
2. The guidance in the Habitat Restoration Manual calls for slope of rock ramps to be lower than 4%. Although NOAA guidelines allow slope using stream simulation for designs up to 6%, is there a possibility to extend the ramp in this location to be longer than 150' and provide a lower slope?
    a. For nearby reference, the slope of the Lincoln gaging station is a 4% slope with 187 feet length.
    b. Another consideration is a possible gradual transition to the 4.5% rock ramp to avoid a big water surface drop during the transition from elevation head to velocity head (for example, a pool and chute ladder where the second weir is often at the same elevation or higher than the first one).
3. The drawing designates the material in the rock ramp as "rip rap." The proposed size of rock mix for use in the ladder should be described in the 50% design and should reference equations and guidance in the "Sizing the Engineered Streambed Material" section of the Habitat Restoration Manual.
4. Although the 95% exceedance for flow at the NID - BR200 (1995 – 2021) was 13.3 cfs, flows lower than 13.3 cfs should considered during the design process. Examination of this gage data indicates that during fall-run Chinook and steelhead migration season, flows in Auburn Ravine at this location can be as low as 5 cfs.
5. Flow bypass through the fish screen will be routed back to the river *below* the roughened rock ramp. Please describe how flow will be split between the ladder and the fish screen/bypass during irrigation season.

Project Specific Information for Streamlining Fisheries Engineering Review

The lists provided below identify the information necessary for California Department of Fish and Wildlife (CDFW) fisheries engineering staff to complete reviews of project designs for fish passage and screening projects at water diversions. The lists were developed using CDFW (2000 and 2001) and National Marine Fisheries Service (NMFS) (1997 and 2001) screening criteria and new CDFW information on fish passage design (2009). CDFW and NMFS screening criteria, and California Salmonid Stream Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife are available online. [1]

Included are lists of information necessary for the adequate review of fish screens, fish ladders, boulder weirs, rock chutes, roughened channels, and at grade diversions. Use of these lists by CDFW staff will streamline the engineering review process and ensure that projects provide sustainable fish protection and passage. The project applicant should submit this information with the design plans. If a listed item is considered unnecessary, the rationale for excluding it should be provided by the project applicant. Conversely, while these lists attempt to cover the key parameters for most projects, there may be site-specific opportunities to provide better fish passage and that cannot be easily translated into a simple checklist (e.g., avoidance of predation habitat).

Fish Screens: *See current CDFW and NMFS screening criteria, and California Salmonid Stream Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife.*

1. Target species and life stages to be protected at proposed screening site (e.g. will steelhead rainbow trout fry be present?) (NMFS pg. 4-5).
2. Fish screen structure placement (e.g., on-stream, in-canal, in-reservoir, or pumped) (NMFS pg. 3).
3. Evidence of infeasibility of on-stream screen if an in canal screen is selected. Types of evidence would include, but not be limited to: coarse bed load, severely eroding banks, excessive channel velocities, etc.
4. Records of diversion flows **and** stream flows, including maximums and minimums, during irrigation season (NMFS pg. 2).
5. Stream flow vs. depth rating curve at diversion intake (NMFS pg. 2).
6. Description of fish screen openings, including porosity and dimensions of round, square, or slotted openings (NMFS pg. 5-6).
7. Applicable approach velocity and sweeping velocity criteria (NMFS pg. 4-5).
8. Fish screen area calculation performed in accordance with CDFW Fish Screening Criteria (6/19/00).

[1] Current CDFW and NMFS screening criteria, and California Salmonid Stream Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife are available at the following links:

- http://www.dfg.ca.gov/fish/Resources/Projects/Engin/Engin_ScreenCriteria.asp
- http://swr.nmfs.noaa.gov/hcd/fishscrn.pdf
- http://www.dfg.ca.gov/fish/REsources/HabitatManual.asp

9. Water depth and approach velocity calculations in front of the fish screen throughout range of diversion flows (NMFS pg 3-4).
10. Evidence that flow uniformity criterion will be met (NMFS pg. 5).
11. Sweeping velocity calculations at several locations along the length of the screen throughout range of diversion and bypass flows (NMFS pg. 5).
12. Screen exposure time calculation (NMFS pg. 7).
13. Velocity calculations between end of screen and bypass entrance (NMFS pg. 7).
14. Flow depth calculations within bypass conduit **and** in stream at bypass outlet at minimum bypass flow (NMFS pg. 8-9).
15. Estimated bypass flow needed to meet fish screen criteria (cfs) NMFS pgs. 5, 7, and 8).
16. Velocity calculations in stream at bypass outlet (NMFS pg. 8).
17. Drop height and impact velocity calculation at bypass outlet over the operating range of tailwater surfaces, if applicable (NMFS pg. 9).
18. For paddle wheel driven cleaning systems, fish screen area calculations showing passive screening criteria are met when paddle wheel driven wipers no longer operate.
19. Description of fish screen cleaning mechanism, including proposed frequency of cleaning.
20. Assessment of sediment transport/scour conditions at fish screen for on channel installations (NMFS pg. 2).
21. Specific information describing the type of corrosion-resistant screening material, bypass control/pipe and other materials that will directly affect fish. (NMFS pg. 6-8).
22. Design drawings showing site topography, control points, and dimensions of fish screen structure in plan, elevation, longitudinal profile, and cross-sectional views along with important component details.
23. Drawings should show smooth joints at bypass pipe bends and screen faces flush with adjacent walls and/or piers.
24. Any additional information which may be required to show that screen will meet current CDFW/NMFS screening criteria.
25. Operation and maintenance plan which includes preventive and corrective maintenance procedures, inspection and reporting requirements, maintenance logs, etc.
26. Post construction evaluation and monitoring plan with allocated money in the construction budget.

Fish Ladders: *See Parts IX, and XII, California Salmonid Stream Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife.*

1. Explanation as to why the specific fish passage design was selected, including a discussion of the elements considered when designing the fish ladder entrance.
2. Target species, life stages and migration timing at project site.
3. Calculation of lower and upper fish passage stream flows for each life stage and species.
4. Calculation showing attraction flow rates are appropriate.

5. Rating curves for headwater and tailwater conditions.
6. Hydraulic analysis of flow through the fish ladder demonstrating that the ladder functions properly over the anticipated range of stream and ladder flows. This should include an assessment of the flow rate and depth over each weir and through each orifice, and an assessment of the threshold between plunging flow and streaming flow.
7. Energy dissipation factor calculations at maximum design flow in fish ladder pools.
8. Water stage calculations showing fishway has 3 ft freeboard to keep leaping fish in ladder.
9. Flow patterns and in-stream velocities at entrance to fishway.
10. Geotechnical information may be necessary to ensure project design is structurally appropriate.
11. Design drawings showing site topography, control points, and structural dimensions in plan, elevation, longitudinal profile, and cross-sectional views along with important component details.
12. Maintenance plan which includes preventative and corrective measures, assignment of personnel for maintenance during/after storms, inspection and reporting requirements, maintenance logs, etc.
13. If the ladder contains operational components, such as adjustable weirs, multiple entrances, etc., the plans should include an Operations Manual and single page operations guide that will be kept on site.
14. Post construction evaluation and monitoring plan with allocated money in the construction budget.

Boulder Weirs: *See Parts IX and XII, California Salmonid Stream Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife.*

1. Target species, life stages and migration timing at project site.
2. Calculation of lower and upper fish passage stream flows for each life stage and species and 100-year flow.
3. Water surface profiles at existing conditions for upper and lower fish passage stream flows and 100-year flow.
4. Water surface profiles with proposed boulder weirs for upper and lower fish passage stream flows and 100-year flow.
5. Spacing of, drops over, cross-sections shape of, and pool depths above and below boulder weirs.
6. If specific low flow notches are planned, calculations of depths and velocities within notches at fish passage flows.
7. Rock sizing calculations
8. Ditch/pump hydraulic calculations showing boulder weirs provide sufficient head to divert maximum diversion flow and bypass flow at minimum stream flow considering head losses at flow measurement devices, fish screens, pipes, open ditches, headgates, etc.
9. Geotechnical information may be necessary to ensure project design is structurally appropriate.

10. Design drawings showing site topography, control points, structural dimensions in plan, elevation, longitudinal profile, and cross-sectional views, and important component details, including construction notes on placement of bed material and boulders.
11. Post construction evaluation and monitoring plan with allocated money in the construction budget.

Rock Chutes: *See Parts IX and XII, California Salmonid Stream Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife.*

1. Target species, life stages and migration timing at project site.
2. Calculation of lower and upper fish passage stream flows for each life stage and species and 100-year flow.
3. Water surface profiles at existing conditions for upper and lower fish passage stream flows and 100-year flow.
4. Water surface profiles with proposed rock chutes for upper and lower fish passage stream flows and 100-year flow.
5. Calculations of depths, velocities, and slope at fish passage flows along length of individual rock chutes.
6. Rock and engineered streambed material sizing calculations for both bed and banks.
7. If at a water diversion, ditch/pump hydraulic calculations showing rock chutes provide sufficient head to divert maximum diversion flow and bypass flow at minimum stream flow considering head losses at flow measurement devices, fish screens, pipes, open ditches, headgates, etc.
8. Geotechnical information may be necessary to ensure project design is structurally appropriate.
9. Design drawings showing site topography, control points, structural dimensions in plan, elevation, longitudinal profile, and cross-sectional views, and important component details, including construction notes on placement of bed material and boulders.
10. Post construction evaluation and monitoring plan with allocated money in the construction budget.

Roughened Channels: *See Parts IX and XII, California Salmonid Stream Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife.*

1. Target species, life stages and migration timing at project site.
2. Calculation of lower and upper fish passage stream flows for each life stage and species and 100-year flow.
3. Water surface profiles at existing conditions for upper and lower fish passage stream flows and 100-year flow.
4. Water surface profiles with proposed roughened channel for upper and lower fish passage stream flows and 100-year flow.
5. Rock and engineered streambed material sizing and thickness calculations for bed and banks.

6. Geotechnical information may be necessary to ensure project design is structurally appropriate.
7. Calculations of depths and velocities at fish passage flows along length of roughened channel.
8. Calculation of overall drop and slope along roughened channel.
9. If at a water diversion, ditch/pump hydraulic calculations showing roughened channel provides sufficient head to divert maximum diversion flow + bypass flow at minimum stream flow considering head losses at flow measurement devices, fish screens, pipes, open ditches, headgates, etc.
10. Design drawings showing site topography, control points, structural dimensions in plan, elevation, longitudinal profile, and cross-sectional views, and important component details, including construction notes on placement of bed material and boulders.
11. Post construction evaluation and monitoring plan with allocated money in the construction budget.

At-Grade Diversions:

1. Instream and ditch/pump hydraulic calculations showing there is sufficient head to divert maximum diversion flow and bypass flow at minimum stream flow considering head losses at flow measurement devices, fish screens, pipes, open ditches, headgates, etc.
2. Design drawings showing site topography, control points, structural dimensions in plan, elevation, longitudinal profile, and cross-sectional views, and important component details.

Stream Simulation: *See Parts IX and XII, California Salmonid Stream Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife.*

1. Justification/suitability of reference reach (include photographs).
    a. Stability of reach
    b. Similarity to project reach
    c. Location on plan view of crossing or description of location of reference reach in relation to crossing
2. Scaled plan view of reference reach showing meanders, woody debris/rootwads, steep cohesive banks, boulder/bedrock outcroppings, floodplains, etc.
3. Longitudinal Profile (with slopes identified).
    a. Reference reach
    b. Road crossing/project reach
    c. Downstream of project reach
    d. Range of possible bed profiles
4. Representative Cross-Section.
    a. Bankfull width
    b. Channel features (i.e. bedforms, banklines, floodplains, etc.)
5. Channel type – pool riffle, step pool, etc.
6. Gradation curves from bed samples in reference reach with photos of sampling location and location shown on plan view of reference reach.

7. Description of how roughness elements in reference reach are being simulated in project reach.
8. Model output from hydraulic analysis of:
    a. Channel-forming flows in reference and project reaches
    b. Q25 for stability of key pieces
    c. Q100 for channel and crossing capacity and floodplain and floodplain culvert hydraulics.
9. Stream simulation bed material mix and keystone sizing calculations.
10. Culvert dimensions and embedment.
11. Completed Design Form from Part XII.
12. Design drawings showing site topography, control points, structural dimensions in plan, elevation, longitudinal profile, and cross-sectional views, and important component details, including construction notes on placement of bed material and keystones.
13. Geotechnical information may be necessary to ensure project design is structurally appropriate, especially when replacing a culvert with a bridge.
14. Post construction evaluation and monitoring plan with allocated money in the construction budget.

No-slope Culvert Design: *See Parts IX, and XII, California Salmonid Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife.*

1. Target species, life stages and migration timing at project site.
2. Documentation that other fish passage methods are not feasible at site and that this installment meets the appropriate criteria for the no-slope method.
3. Documentation of natural channel slope in reach of crossing.
4. Demonstration of natural channel bankfull width.
5. Geotechnical information may be necessary to ensure project design is structurally appropriate.
6. Design drawings showing site topography, control points, structural dimensions in plan, elevation, and cross-sectional views, and important component details such as embedment. Channel and culvert slope as well as channel width outside the influence of the culvert must be shown. If profile control is being used, these elements (and appropriate items from other checklists) must be included.
7. Cattle exclusion, if planned, must be included in design drawings.
8. Maintenance plan which includes preventative and corrective measures (such as trash racks, if used), assignment of personnel for maintenance during storms, inspection and reporting requirements, maintenance logs, etc.
9. Post construction evaluation and monitoring plan with allocated money in the construction budget.

Hydraulic Design Culvert (new): *See Parts IX, and XII, California Salmonid Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife.*

1. Completed Design Form from Part XII.

2. Target species, life stages and migration timing at project site.
3. Documentation that other fish passage methods are not feasible at site.
4. Calculation of lower and upper fish passage stream flows.
5. Calculation of average water velocities and depths at lower and upper fish passage flows for each target species and life stage.
6. Demonstration that inlet and outlet conditions are not forming a velocity or height barrier over the range of fish flows.
7. Geotechnical information may be necessary to ensure project design is structurally appropriate.
8. Design drawings showing site topography, control points, structural dimensions in plan, elevation, and cross-sectional views, and important component details. Plan view must be of sufficient channel length to show culvert alignment with respect to the existing channel. Channel and culvert slope as well as channel width outside the influence of the culvert must be shown. If profile control is being used, these elements (and appropriate items from other checklists) must be included.
9. If crossing has multiple bores, all bores must be shown. If one is being designated or designed for fish passage, that bore must be so labeled.
10. Cattle exclusion, if planned, must be included in design drawings.
11. Maintenance plan which includes preventative and corrective measures (such as trash racks, if used), assignment of personnel for maintenance during storms, inspection and reporting requirements, maintenance logs, etc.
12. Post construction evaluation and monitoring plan with allocated money in the construction budget.

Hydraulic Design Culverts (retrofit): *See Parts IX, and XII, California Salmonid Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife.*

1. Completed Design Form from Part XII.
2. Target species, life stages and migration timing at project site.
3. Documentation that other fish passage methods are not feasible at site.
4. Calculation of lower and upper fish passage stream flows.
5. Calculation of current passage conditions.
6. Calculation of average water velocities and depths at lower and upper fish passage flows for each target species and life stage with modified conditions.
7. Demonstration that inlet and outlet conditions are not forming a velocity or height barrier over the range of fish flows.
8. Geotechnical information may be necessary to ensure project design is structurally appropriate.
9. Design drawings showing site topography, control points, structural dimensions in plan, elevation, and cross-sectional views, and important component details. Channel and culvert slope as well as channel width outside the influence of the culvert must be shown. If profile control is being used, these elements (and appropriate items from other checklists, must be included.

10. If crossing has multiple bores, all bores must be shown. If one is being designated or designed for fish passage, that bore must be so labeled. If a splitter wall is being used, it must also be shown.
11. Cattle exclusion, if planned, must be included in design drawings.
12. Maintenance plan which includes preventative and corrective measures (such as trash racks, if used), assignment of personnel for maintenance during storms, inspection and reporting requirements, maintenance logs, etc.
13. Post construction evaluation and monitoring plan with allocated money in the construction budget.

Baffles (only allowed on retrofits): *See Part XII, especially Appendix C, California Salmonid Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife.*

1. Completed Design Form from Part XII.
2. Target species, life stages and migration timing at project site.
3. Documentation that other fish passage methods are not feasible at site.
4. Calculation of lower and upper fish passage stream flows.
5. Design drawings showing site topography, control points, structural dimensions in plan, elevation, and cross-sectional views (including length and slope of existing culvert), and important component details. Channel and culvert slope as well as channel width outside the influence of the culvert must be shown. If profile control is being used, these elements (and appropriate items from other checklists must be included).
6. Calculation of current passage conditions (depth and average velocities).
7. Spacing and geometry (shape and height), material and attachment method for baffles.
8. Calculation of post-baffle passage conditions (depth and average velocities), EDF, plunging and streaming flow regimes, new hydraulic capacity at 100 yr storm.
9. Demonstration that inlet and outlet conditions are not forming a velocity or height barrier over the range of fish flows.
10. If crossing has multiple bores, all bores must be shown. If one is being designated or designed for fish passage, that bore must be so labeled. If a splitter wall is being used, it also must be shown.
11. Cattle exclusion, if planned, must be included in design drawings.
12. Maintenance plan which includes preventative and corrective measures including baffles and if used), assignment of personnel for maintenance during storms, inspection and reporting requirements, maintenance logs, etc.
13. Post construction evaluation and monitoring plan with allocated money in the construction budget.

Bridge and Bottomless Culverts *(Review pertains to impacts to stream and aquatic environment, but not structural integrity or bridge loading)*

1. Identify and apply applicable fish passage technique: stream simulation, hydraulic design, not applicable, etc.
2. Calculation of 100-year flow and any other design flow

3. Water surface profiles and average channel velocities for the design flows and the 100-year flow.
4. Description of geomorphic setting of bridge and why bridge design is appropriate for the setting
5. Potential for debris loads or jams at bridge site
6. Scour analysis
7. Justification for increases in water surface elevation or velocities near the bridge (if any) and the use of any scour protection.
8. Geotechnical assessment may be necessary to ensure project design is structurally appropriate.
9. Design drawings showing site topography, control points, dimensions of bridge/culvert structure in plan, elevation, longitudinal profile, and cross-sectional views, and important component details.
10. HEC-RAS model files including boundary conditions and other model parameters.

Bank Protection

1. Calculation of design flow and 100-year flow
2. Water surface profiles and average channel velocities for design and 100-year flows
3. Geotechnical assessment may be necessary to ensure project design is structurally appropriate.
4. Design calculations, i.e. shear stress, rock sizing; root strength and suitability of selected vegetation; and determination of spur, groin, bendway weir dimensions, spacing, angle, etc.
5. Alternatives analysis and justification for using rock slope protection, if applicable.
6. Design drawings showing site topography, control points, dimensions of the bank protection in plan, elevation, longitudinal profile, and cross-sectional views, and important component details, and planting plans.

APPENDIX S.

FISH SCREEN CRITERIA[1]

DEPARTMENT OF FISH AND GAME

1. STRUCTURE PLACEMENT

A. Streams And Rivers (flowing water): The screen face shall be parallel to the flow and adjacent bankline (water's edge), with the screen face at or streamward of a line defined by the annual low-flow water's edge.

The upstream and downstream transitions to the screen structure shall be designed and constructed to match the back-line, minimizing eddies upstream of, in front of and downstream of, the screen.

Where feasible, this "on-stream" fish screen structure placement is preferred by the California Department of Fish and Game.

B. In Canals (flowing water): The screen structure shall be located as close to the river source as practical, in an effort to minimize the approach channel length and the fish return bypass length. This "in canal" fish screen location shall only be used where an "on-stream" screen design is not feasible. This situation is most common at existing diversion dams with headgate structures.

The current National Oceanic and Atmospheric Administration Fisheries - Southwest Region criteria for these types of installations shall be used.

C. Small Pumped Diversions: Small pumped diversions (less than 40 cubic-feet per second) which are screened using "manufactured, self-contained" screens shall conform to the National Oceanic and Atmospheric Administration Fisheries - Southwest Region criteria.

D. Non-Flowing Waters (tidal areas, lakes and reservoirs): The preferred location for the diversion intake structure shall be offshore, in deep water, to minimize fish contact with the diversion. Other configurations will be considered as exceptions to the screening criteria as described in Section 5.F. below.

2. APPROACH VELOCITY (Local velocity component perpendicular to the screen face)

A. Flow Uniformity: The design of the screen shall distribute the approach velocity uniformly across the face of the screen. Provisions shall be made in the design of the

[1] June 19, 2000 Version

screen to allow for adjustment of flow patterns. The intent is to ensure uniform flow distribution through the entire face of the screen as it is constructed and operated.

B. Self-Cleaning Screens: The design approach velocity shall not exceed:

1. Streams And Rivers (flowing waters) - Either:

a. 0.33 feet per second, where exposure to the fish screen shall not exceed fifteen minutes, or

b. 0.40 feet per second, for small (less than 40 cubic-feet per second) pumped diversions using Amanufactured, self-contained@ screens.

2. In Canals (flowing waters) - 0.40 feet per second, with a bypass entrance located every one-minute of travel time along the screen face.

3. Non-Flowing Waters (tidal areas, lakes and reservoirs) - The specific screen approach velocity shall be determined for each installation, based on the species and life stage of fish being protected. Velocities which exceed those described above will require a variance to these criteria (see Section 5.F. below).

(Note: At this time, the U.S. Fish and Wildlife Service has selected a 0.2 feet per second approach velocity for use in waters where the Delta smelt is found. Thus, fish screens in the Sacramento-San Joaquin Estuary should use this criterion for design purposes.)

C. Screens Which Are Not Self-Cleaning: The screens shall be designed with an approach velocity one-fourth that outlined in Section B. above. The screen shall be cleaned before the approach velocity exceeds the criteria described in Section B.

D. Frequency Of Cleaning: Fish screens shall be cleaned as frequently as necessary to prevent flow impedance and violation of the approach velocity criteria. A cleaning cycle once every 5 minutes is deemed to meet this standard.

E. Screen Area Calculation: The required wetted screen area (square feet), excluding the area affected by structural components, is calculated by dividing the **maximum** diverted flow (cubic-feet per second) by the allowable approach velocity (feet per second). Example:

1.0 cubic-feet per second / 0.33 feet per second = 3.0 square feet

Unless otherwise specifically agreed to, this calculation shall be done at the **minimum** stream stage.

3. SWEEPING VELOCITY (Velocity component parallel to screen face)

A. In Streams And Rivers: The sweeping velocity should be at least two times the allowable approach velocity.

B. In Canals: The sweeping velocity shall exceed the allowable approach velocity. Experience has shown that sweeping velocities of 2.0 feet per second (or greater) are preferable.

C. Design Considerations: Screen faces shall be designed flush with any adjacent screen bay piers or walls, to allow an unimpeded flow of water parallel to the screen face.

4. SCREEN OPENINGS

A. Porosity: The screen surface shall have a minimum open area of 27 percent. We recommend the maximum possible open area consistent with the availability of appropriate material, and structural design considerations.

The use of open areas less than 40 percent shall include consideration of increasing the screen surface area, to reduce slot velocities, assisting in both fish protection and screen cleaning.

B. Round Openings: Round openings in the screening shall not exceed 3.96mm (5/32in). In waters where steelhead rainbow trout fry are present, this dimension shall not exceed 2.38mm (3/32in).

C. Square Openings: Square openings in screening shall not exceed 3.96mm (5/32in) measured diagonally. In waters where steelhead rainbow trout fry are present, this dimension shall not exceed 2.38mm (3/32in) measured diagonally.

D. Slotted Openings: Slotted openings shall not exceed 2.38mm (3/32in) in width. In waters where steelhead rainbow trout fry are present, this dimension shall not exceed 1.75mm (0.0689in).

5. SCREEN CONSTRUCTION

A. Material Selection: Screens may be constructed of any rigid material, perforated, woven, or slotted that provides water passage while physically excluding fish. The largest possible screen open area which is consistent with other project requirements should be used. Reducing the screen slot velocity is desirable both to protect fish and to ease cleaning requirements. Care should be taken to avoid the use of materials with sharp edges or projections which could harm fish.

B. Corrosion And Fouling Protection: Stainless steel or other corrosion-resistant material is the screen material recommended to reduce clogging due to corrosion. The use of both active and passive corrosion protection systems should be considered.

Consideration should be given to anti-fouling material choices, to reduce biological fouling problems. Care should be taken not to use materials deemed deleterious to fish and other wildlife.

C. Project Review And Approval: Plans and design calculations, which show that all the applicable screening criteria have been met, shall be provided to the Department before written approval can be granted by the appropriate Regional Manager.

The approval shall be documented in writing to the project sponsor, with copies to both the Deputy Director, Habitat Conservation Division and the Deputy Director, Wildlife and Inland Fisheries Division. Such approval may include a requirement for post-construction evaluation, monitoring and reporting.

D. Assurances: All fish screens constructed after the effective date of these criteria shall be designed and constructed to satisfy the current criteria. Owners of existing screens, approved by the Department prior to the effective date of these criteria, shall not be required to upgrade their facilities to satisfy the current criteria unless:

1. The controlling screen components deteriorate and require replacement (i.e., change the opening size or opening orientation when the screen panels or rotary drum screen coverings need replacing),

2. Relocation, modification or reconstruction (i.e., a change of screen alignment or an increase in the intake size to satisfy diversion requirements) of the intake facilities, or

3. The owner proposes to increase the rate of diversion which would result in violation of the criteria without additional modifications.

E. Supplemental Criteria: Supplemental criteria may be issued by the Department for a project, to accommodate new fish screening technology or to address species-specific or site-specific circumstances.

F. Variances: Written variances to these criteria may be granted with the approval of the appropriate Regional Manager and concurrence from both the Deputy Director, Habitat Conservation Division and the Deputy Director, Wildlife and Inland Fisheries Division. At a minimum, the rationale for the variance must be described and justified in the request.

Evaluation and monitoring may be required as a condition of any variance, to ensure that the requested variance does not result in a reduced level of protection for the aquatic resources.

It is the responsibility of the project sponsor to obtain the most current version of the appropriate fish screen criteria. Project sponsors should contact the Department of Fish and Game, the National Oceanic and Atmospheric Administration Fisheries (for projects in marine and anadromous waters) and the U.S. Fish and Wildlife Service (for projects in anadromous and fresh waters) for guidance.

Copies of the current criteria are available from the Department of Fish and Game through the appropriate Regional office, which should be the first point of contact for any fish screening project.

Northern California and North Coast Region; 601 Locust Street, Redding, CA 96001 - (530) 225-2300.

Sacramento Valley and Central Sierra Region; 1701 Nimbus Drive, Rancho Cordova, CA 95670 - (916) 358-2900.

Central Coast Region; 7329 Silverado Trail/P.O. Box 46, Yountville, CA 94599 - (707) 944-5500.

San Joaquin Valley-Southern Sierra Region; 1234 E. Shaw Avenue, Fresno, CA 93710 - (209) 243-4005.

South Coast Region; 4649 View Crest Avenue, San Diego, CA 92123 - (619) 467-4201.

Eastern Sierra and Inland Deserts Region; 4775 Bird Farms Road, Chino Hills, CA 91709 - (909) 597-9823.

Marine Region; 20 Lower Ragsdale Drive, #100, Monterey, CA 93940 - (831) 649-2870.

Technical assistance can be obtained directly from the Habitat Conservation Division; 1416 Ninth Street, Sacramento, CA 95814 - (916) 653-1070.

The current National Oceanic and Atmospheric Administration Fisheries criteria are available from their Southwest Region; 777 Sonoma Avenue, Room 325, Santa Rosa, CA 95402 - (707) 575-6050.

Fish Screening Criteria for Anadromous Salmonids [1]
National Oceanic and Atmospheric Administration Fisheries
Southwest Region

January 1997

I. General Considerations

This document provides guidelines and criteria for functional designs of downstream migrant fish passage facilities at hydroelectric, irrigation, and other water withdrawal projects. It is promulgated by the National Oceanic and Atmospheric Administration Fisheries (NOAA), Southwest Region as a result of its authority and responsibility for prescribing fishways under the Endangered Species Act (ESA), the Federal Power Act, administered by the Federal Energy Regulatory Commission (FERC), and the Fish and Wildlife Coordination Act (FWCA), administered by the U.S. Fish and Wildlife Service.

The guidelines and criteria are general in nature. There may be cases where site constraints or extenuating circumstances dictate a waiver or modification of one or more of these criteria. Conversely, where there is an opportunity to protect fish, site-specific criteria may be added. Variances from established criteria will be considered on a project-by-project basis.

The swimming ability of fish is a primary consideration in designing a fish screen facility. Research shows that swimming ability varies depending on multiple factors relating to fish physiology, biology, and the aquatic environment. These factors include: species, physiological development, duration of swimming time required, behavioral aspects, physical condition, water quality, temperature, lighting conditions, and many others. Since conditions affecting swimming ability are variable and complex, screen criteria must be expressed in general terms and the specifics of any screen design must address on-site conditions.

NOAA may require project sponsors to investigate site-specific variables critical to the fish screen system design. This investigation may include fish behavioral response to hydraulic conditions, weather conditions (ice, wind, flooding, etc.), river stage-discharge relationships, seasonal operations, sediment and debris problems, resident fish populations, potential for creating predation opportunity, and other pertinent information. The size of salmonids present at a potential screen site usually is not known, and can change from year-to-year based on flow and temperature conditions. Thus, adequate data to describe the size-time relationship requires substantial sampling over a number of years. NOAA will normally assume that fry-sized salmonids are present at all sites unless adequate biological investigation proves otherwise. The burden of proof is the responsibility of the owner of the screen facility.[2]

New facilities which propose to utilize unproven fish protection technology frequently require: 1) development of a biological basis for the concept; 2) demonstration of favorable behavioral responses in a laboratory setting; 3) an acceptable plan for evaluating the prototype installation;

[2] Adapted from NOAA, Southwest Region

and 4) an acceptable alternate plan should the prototype not adequately protect fish. Additional information can be found in *Experimental Fish Guidance Devices*, position statement of the National Oceanic and Atmospheric Administration Fisheries, Southwest Region, January 1994.

Striped Bass, Herring, Shad, Cyprinids, and other anadromous fish species may have eggs and/or very small fry which are moved with any water current (tides, streamflows, etc.). Installations where these species are present may require individual evaluation of the proposed project using more conservative screening requirements. In instances where state or local regulatory agencies require more stringent screen criteria to protect species other that salmonids, NOAA will generally defer to the more conservative criteria.

General screen criteria and procedural guidelines are provided below. Specific exceptions to these criteria occur in the design of small screen systems (less than 40 cubic feet per second) and certain small pump intakes. These exceptions are listed in Section K. Modified Criteria for Small Screens, and in the separate addendum entitled: Juvenile Fish Screen Criteria For Pump Intakes, National Oceanic and Atmospheric Administration Fisheries, Portland, Oregon, May 9, 1996.

II. General Procedural Guidelines

For projects where NOAA had jurisdiction, such as FERC license applications and ESA consultations, a functional design must be developed as part of the application or consultation. These designs must reflect NOAA design criteria and be acceptable to NOAA. Acceptable designs typically define type, location, method of operation, and other important characteristics of the fish screen facility. Design drawings should show structural dimensions in plan, elevation, and cross-sectional views, along with important component details. Hydraulic information should include: hydraulic capacity, expected water surface elevations, and flows through various areas of the structures. Documentation of relevant hydrologic information is required. Types of materials must be identified where they will directly affect fish. A plan for operations and maintenance procedures should be included-i.e., preventive and corrective maintenance procedures, inspections and reporting requirements, maintenance logs, etc. - particularly with respect to debris, screen cleaning, and sedimentation issues. The final detailed design shall be based on the functional design, unless changes are agreed to by NOAA.

All juvenile passage facilities shall be designed to function properly through the full range of hydraulic conditions expected at a particular site during fish migration periods, and shall account for debris and sedimentation conditions which may occur.

III. Screen Criteria for Juvenile Salmonids

A. Structure Placement

1. General:
The screened intake shall be designed to withdraw water from the most appropriate elevation, considering juvenile fish attraction, appropriate water temperature control downstream or a combination thereof. The design must accommodate the expected range of water surface elevations.

For on-river screens, it is preferable to keep the fish in the main channel rather that put them through intermediate screen bypasses. NOAA decides whether to require intermediate bypasses for on-river, straight profile screens by considering the biological and hydraulic conditions existing at each individual project site.

2. Streams and Rivers:

Where physically practical, the screen shall be constructed at the diversion entrance. The screen face should be generally parallel to river flow and aligned with the adjacent bankline. A smooth transition between the bankline and the screen structure is important to minimize eddies and undesirable flow patterns in the vicinity of the screen. If trash racks are used, sufficient hydraulic gradient is required to route juvenile fish from between the trash rack and screens to safety. Physical factors that may preclude screen construction at the diversion entrance include excess river gradient, potential for damage by large debris, and potential for heavy sedimentation. Large stream-side installations may require intermediate bypasses along the screen fact to prevent excessive exposure time. The need for intermediate bypasses shall be decided on a case-by-case basis.

3. Canals:
Where installation of fish screens at the diversion entrance is undesirable or impractical, the screens may be installed at a suitable location downstream of the canal entrance. All screens downstream of the diversion entrance shall provide an effective juvenile bypass system - designed to collect juvenile fish and safely transport then back to the river with minimum delay. The angle of the screen to flow should be adequate to effectively guide fish to the bypass. Juvenile bypass systems are part of the overall screen system and must be accepted by NOAA.

4. Lakes, Reservoirs, and Tidal Areas

a. Where possible, intakes should be located off shore to minimize fish contact with the facility. Water velocity from any direction toward the screen shall not exceed the allowable approach velocity. Where possible, locate intakes where sufficient sweeping velocity exists. This minimizes sediment accumulation in and around the screen, facilitates debris removal, and encourages fish movement away from the screen face.

b. If a screen intake is used to route fish past a dam, the intake shall be designed to withdraw water from the most appropriate elevation in order to provide the best juvenile fish attraction to the bypass channel as well as to achieve appropriate water temperature control downstream. The entire range of forebay fluctuations shall be accommodated by the design, unless otherwise approved by NOAA.

B. Approach Velocity

Definition: *Approach Velocity* is the water velocity vector component perpendicular to the screen face. Approach velocity shall be measured approximately three inches in front of the screen surface.

1. Fry Criteria - less than 2.36 inches {60 millimeters (mm)} in length.

If a biological justification cannot demonstrate the absence of fry-sized salmonids in the vicinity of the screen, fry will be assumed present and the following criteria apply:

Design approach velocity shall not exceed:
Streams and Rivers: 0.33 feet per second
Canals: 0.40 feet per second
Lakes, Reservoirs, Tidal: 0.33 feet per second (salmonids) [3]

2. Fingerling Criteria - 2.36 inches {60 mm} and longer

If biological justification can demonstrate the absence of fry-sized salmonids in the vicinity of the screen, the following criteria apply:

Design approach velocity shall not exceed:
All locations: 0.8 feet per second

3. The *total submerged screen area required* (excluding area of structural components) is calculated by dividing the maximum diverted flow by the allowable approach velocity. (Also see Section K, Modified Criteria for Small Screens, part 1).

4. The screen design must provide for uniform flow distribution over the surface of the screen, thereby minimizing approach velocity. This may be accomplished by providing adjustable porosity control on the downstream side of the screens, unless it can be shown unequivocally (such as with a physical hydraulic model study) that localized areas of high velocity can be avoided at all flows.

C. Sweeping Velocity

Definition: *Sweeping Velocity* is the water velocity vector component parallel and adjacent to the screen face.

1. Sweeping Velocity shall be greater than approach velocity. For canal installations, this is accomplished by angling screen face less than 45E relative to flow (see Section K. Modified Criteria for Small Screens). This angle may be dictated by specific canal geometry, or hydraulic and sediment conditions.

D. Screen Face Material

[3] Other species may require different approach velocity standards. e.g. in California the U.S. Fish & Wildlife Service requires 0.2 fps approach velocity where delta smelt are present in the tidal areas of the San Francisco Bay estuary.

1. Fry criteria. If a biological justification cannot demonstrate the absence of fry-sized salmonids in the vicinity of the screen, fry will be assumed present and the following criteria apply for screen material:

a. Perforated plate: screen openings shall not exceed 3/32 inches (2.38 mm), measured in diameter.

b. Profile bar: screen openings shall not exceed 0.0689 inches (1.75 mm) in width.

c. Woven wire: Screen openings shall not exceed 3/32 inches (2.38 mm), measured diagonally (e.g.: 6-14 mesh).

d. Screen material shall provide a minimum of 27% open area.

2. Fingerling criteria

If biological justification can demonstrate the absence of fry-sized salmonids in the vicinity of the screen, the following criteria apply for screen material:

a. Perforated plate: Screen openings shall not exceed 1/4 inch (6.35 mm) in diameter.

b. Profile bar: screen openings shall not exceed 1/4 inch (6.35 mm) in width.

c. Woven wire: Screen openings shall not exceed 1/4 inch (6.35 mm) in the narrow direction.

d. Screen material shall provide a minimum of 40% open area.

3. The screen material shall be corrosion resistant and sufficiently durable to maintain a smooth and uniform surface with long term use.

E. Civil Works and Structural Features

1. The face of all screen surfaces shall be placed flush with any adjacent screen bay, pier noses, and walls, allowing fish unimpeded movement parallel to the screen face and ready access to bypass routes.

2. Structural features shall be provided to protect the integrity of the fish screens from large debris. Trash racks, log booms, sediment sluices, or other measures may be needed. A reliable on-going preventive maintenance and repair program is necessary to ensure facilities are kept free of debris and the screen mesh, seals, drive units, and other components are functioning correctly.

3. Screens located in canals - surfaces shall be constructed at an angle to the approaching flow, with the downstream end terminating at the bypass system entrance.

4. The civil works design shall attempt to eliminate undesirable hydraulic effects (e.g. - eddies, stagnant flow zones) that may delay or injure fish, or provide predator opportunities. Upstream training wall(s), or some acceptable variation thereof, shall be utilized to control hydraulic

conditions and define the angle of flow to the screen face. Large facilities may require hydraulic monitoring to identify and correct areas of concern.

F. Juvenile Bypass System Layout

Juvenile bypass systems are water channels which transport juvenile fish from the face of a screen to a relatively safe location in the main migratory route of the river or stream. Juvenile bypass systems are necessary for screens located in canals because anadromous fish must be routed back to their main migratory route. For other screen locations and configurations, NOAA accepts the option which, in its judgement, provides the highest degree of fish protection given existing site and project constraints.

1. The screen and bypass shall work in tandem to move out-migrating salmonids (including adults) to the bypass outfall with minimum injury or delay. Bypass entrance(s) shall be designed such that out-migrants can easily locate and enter them. Screens installed in canal diversions shall be constructed with the downstream end of the screen terminating at a bypass entrance. Multiple bypass entrances (intermediate bypasses) shall be employed if the sweeping velocity will not move fish to the bypass within 60 seconds [4] assuming the fish are transported at this velocity. Exceptions will be made for sites without sufficient hydraulic conditions, or for screens built on river banks with satisfactory river conditions.

2. All components of the bypass system, from entrance to outfall, shall be of sufficient hydraulic capacity to minimize the potential for debris blockage.

3. To improve bypass collection efficiency for a single bank of vertically oriented screens, a bypass training wall may be located at an angle to the screens.

4. In cases where insufficient flow is available to satisfy hydraulic requirements at the main bypass entrance(s), a *secondary screen* may be required. Located in the main screen=s bypass channel, a secondary screen allows the prescribed bypass flow to be used to effectively attract fish into the bypass entrance(s) while allowing all but a reduced residual bypass flow to be routed back (by pump or gravity) for the primary diversion use. The residual bypass flow (not passing through the secondary screen) then conveys fish to the bypass outfall location or other destination.

5. Access is required at locations in the bypass system where debris accumulation may occur.

6. The screen civil works floor shall allow fish to be routed to the river safely in the event the canal is dewatered. This may entail a sumped drain with a small gate and drain pipe, or similar provisions.

[4] In California, 60 second exposure time applies to screens in canals, using a 0.4 fps approach velocity. Where more conservative approach velocities are used, longer exposure times may be approved on a case-by-case basis, and exceptions to established criteria shall be treated as variances.

G. Bypass Entrance

1. Each bypass entrance shall be provided with independent flow control, acceptable to NOAA.

2. Bypass entrance velocity must equal or exceed the maximum velocity vector resultant along the screen, upstream of the entrance. A gradual and efficient acceleration into the bypass is required to minimize delay of out-migrants.

3. Ambient lighting conditions are required from the bypass entrance to the bypass flow control.

4. The bypass entrance must extend from floor to water surface.

H. Bypass Conduit Design

1. Smooth interior pipe surfaces and conduit joints shall be required to minimize turbulence, debris accumulation, and the risk of injury to juvenile fish. Surface smoothness must be acceptable to the NOAA.

2. Fish shall not free-fall within a confined shaft in a bypass system.

3. Fish shall not be pumped within the bypass system.

4. Pressure in the bypass pipe shall be equal to or above atmospheric pressure.

5. Extreme bends shall be avoided in the pipe layout to avoid excessive physical contact between small fish and hard surfaces and to minimize debris clogging. Bypass pipe centerline radius of curvature (R/D) shall be 5 or greater. Greater R/D may be required for supercritical velocities.

6. Bypass pipes or open channels shall be designed to minimize debris clogging and sediment deposition and to facilitate cleaning. Pipe diameter shall be 24 inches (0.610 m) or greater and pipe velocity shall be 2.0 fps (0.610 mps) or greater, unless otherwise approved by NOAA. (See *Modified Criteria for Small Screens* for the entire operational range).

7. No closure valves are allowed within bypass pipes.

8. Depth of flow in a bypass conduit shall be 0.75 ft. (0.23 m) or greater, unless otherwise authorized by NOAA. (See *Modified Criteria for Small Screens).*

9. Bypass system sampling stations shall not impair normal operation of the screen facility.

10. No hydraulic jumps should exist within the bypass system.

I. Bypass Outfall

1. Ambient river velocities at bypass outfalls should be greater that 4.0 fps (1.2 mps), or as close as obtainable.

2. Bypass outfalls shall be located and designed to minimize avian and aquatic predation in areas free of eddies, reverse flow, or known predator habitat.

3. Bypass outfalls shall be located where there is sufficient depth (depending on the impact velocity and quantity of bypass flow) to avoid fish injuries at all river and bypass flows.

4. Impact velocity, including vertical and horizontal components, shall not exceed 25.0 fps (7.6 mps).

5. Bypass outfall discharges shall be designed to avoid adult attraction or jumping injuries.

J. Operations and Maintenance

1. Fish screens shall be automatically cleaned as frequently as necessary to prevent accumulation of debris. The cleaning system and protocol must be effective, reliable, and satisfactory to NOAA. Proven cleaning technologies are preferred.

2. Open channel intakes shall include a trash rack in the screen facility design which shall be kept free of debris. In certain cases, a satisfactory profile bar screen design can substitute for a trash rack.

3. The head differential to trigger screen cleaning for intermittent type systems shall be a maximum of 0.1 feet (.03 m), unless otherwise agreed to by NOAA.

4. The completed screen and bypass facility shall be made available for inspection by NOAA to verify compliance with design and operational criteria.

5. Screen and bypass facilities shall be evaluated for biological effectiveness and to verify that hydraulic design objectives are achieved.

K. Modified Criteria for Small Screens (Diversion Flow less than 40 cfs)

The following criteria vary from the standard screen criteria listed above. These criteria specifically apply to small screens. Forty cfs is the approximate cut off: however, some smaller diversions may be required to apply the general criteria listed above, while some larger diversions may be allowed to use the Asmall screen@ criteria below. NOAA will decide on a case-by-case basis depending on site constraints.

1. The required screen area is a function of the approach velocity listed in Section B, Approach Velocity, Parts 1, 2, and 3 above. Note that Amaximum@ refers to the greatest flow diverted, not necessarily the water right.

2. Screen Orientation:

a. For screen lengths six feet or less, screen orientation may be angles perpendicular to the flow.

b. For screen lengths greater than six feet, screen-to-flow angle must be less than 45 degrees. (See Section C Sweeping Velocity, part 1).

c. For drum screens, design submergence shall be 75% of drum diameter. Submergence shall not exceed 85%, nor be less than 65% of drum diameter.

d. Minimum bypass pipe diameter shall be 10 inches (25.4 cm), unless otherwise approved by NOAA.

e. Minimum pipe depth is 1.8 inches (4.6 cm) and is controlled by designing the pipe gradient for minimum bypass flow.

Questions concerning this document can be directed to NOAA Hydraulic Engineering Staff at:

National Oceanic and Atmospheric Administration Fisheries
Southwest Region
777 Sonoma Ave., Room 325
Santa Rosa, CA 95402
Phone: (707) 575-6050

Fish Screen Operation and Maintenance
Best Management Practices

- Fish screens shall be operated and maintained in compliance with current law, including Fish and Game Code, and Department of Fish and Game (DFG) fish screening criteria. DFG screening criteria may be referenced on the internet at: http://www.dfg.ca.gov/fish/Resources/Projects/Engin/Engin_ScreenCriteria.asp

- Notwithstanding Fish and Game Code section 6027, fish screens and bypass pipes or channels shall be in-place and maintained in working order at all times water is being diverted.

- If a screen site is dewatered for repairs or maintenance when targeted fish species are likely to be present, measures will be taken to minimize harm and mortality to targeted species resulting from fish relocation and dewatering activities. The responsible party shall notify DFG before the project site is de-watered and the stream flow diverted. The notification will provide a reasonable time for DFG personnel to supervise the implementation of a water diversion plan and oversee the safe removal and relocation of salmonids and other fish life from the project area. If the project requires dewatering of the site, and the relocation of salmonids, the responsible party will implement the following measures to minimize harm and mortality to listed salmonids:

- All electrofishing shall be performed by a qualified fisheries biologist and conducted according to the National Marine Fisheries Service (NMFS), Guidelines for Electrofishing Waters Containing Salmonids Listed under the Endangered Species Act, June 2000.

- The responsible party will provide fish relocation data to DFG on a form provided by the DFG, unless the relocation work is performed by DFG personnel.

- Additional measures to minimize injury and mortality of salmonids during fish relocation and dewatering activities shall be implemented as described in Part IX, pages 52 and 53 of the *California Salmonid Stream Habitat Restoration Manual*.

- If a fish screen is removed for cleaning or repair, a replacement screen shall be installed immediately or the diversion shut down until a screen is in place.

- Fish screens shall be inspected and maintained regularly (not less than two times per week) to ensure that they are functioning as designed and meeting DFG fish screening criteria.

- Existing roads shall be used to access screen sites with vehicles and/or equipment whenever possible. If it is necessary to create access to a screen site for repairs or maintenance, access points should be identified at stable stream bank locations which minimize riparian disturbance.

- Sediment and debris removal at a screen site shall take place as often as needed to ensure that screening criteria are met. Sediment and debris will be removed and disposed of where they will not re-enter the water course.

- Stationary equipment used in performing screen maintenance and repairs, such as motors, pumps, generators, and welders, located within or adjacent to a stream shall be positioned over drip pans.

- Equipment which is used to maintain and/or repair fish screens shall be in good condition and checked and maintained on a daily basis to prevent leaks of materials that could be deleterious to aquatic life, wildlife, or riparian habitat.

- All activities performed in or near a stream will have absorbent materials designed for spill containment and cleanup at the activity site for use in case of an accidental spill. Clean-up of spills shall begin immediately after any spill occurs. The State Office of Emergency Services (1-800-852-7550) and DFG shall be notified immediately after any spill occurs.

- To the extent possible repairs to a fish screen or screen site shall be made during a period of time when the target species of fish are not likely to be present (for example, in a seasonal creek, repair work should be performed when the stream is dry).

- Equipment used to maintain and/or repair fish screens shall not operate in a live stream except as may be necessary to construct coffer dams to divert stream flow and isolate the work site.

- For minor actions, where the disturbance to construct coffer dams to isolate the work site would be greater than to complete the action, measures will be put in place immediately downstream of the work site to capture suspended sediment.

- Turbid water which is generated by screen maintenance or repair activities shall be discharged to an area where it will not re-enter the stream. If the DFG determines that turbidity/siltation levels resulting from screen maintenance or repair activities constitute a threat to aquatic life, all activities associated with the turbidity/siltation shall cease until effective DFG-approved sediment control devices are installed and/or abatement procedures are implemented.

- No debris, soil, silt, sand, bark, slash, spoils, sawdust, rubbish, cement, or concrete or washings thereof; asphalt, paint, or other coating material; oil or petroleum products; or other organic or earthen material from any fish screen operation/maintenance/repair or associated activity of whatever nature shall be allowed to enter into, or placed where it may be washed by rainfall or runoff into a stream channel. When operations are completed, any excess materials or debris shall be removed from the work area and disposed of in a lawful manner.