

11.6.1.7 Horizontal Screens: Horizontal screens have been evaluated as experimental technology, because they operate fundamentally different than conventional vertically oriented screens. This fundamental difference relates directly to fish safety, because when inadequate flow depth exists with vertically oriented screens, there is no potential for fish to get trapped over the screened surface. In contrast, when water level on horizontal screens drops and most or all diverted flow goes through the screens, there is high likelihood that fish will become impinged and killed on the screened surface. In addition, if depths become shallow and flow rate is high over a horizontal screen, the resulting cross-section velocity may be too high to allow fish to swim away from the horizontal screen surface.

Horizontal screens are considered to biologically equivalent to conventional screens only if the following criteria and guidelines are achieved in design and operation:

11.6.1.7.1 Design Development: Since site-specific design considerations are required, NMFS engineers must be consulted throughout the development of the horizontal screen design.

11.6.1.7.2 Hydrologic and Hydraulic Analysis: The horizontal screen design process must include an analysis to verify that sufficient hydrologic and hydraulic conditions exist in the stream so as not to create a passage impediment in the stream channel (see Section 4.1), or in the off-stream conveyance, including the screen and bypass. This analysis must conclude that all criteria listed below can be achieved for the entire juvenile outmigration. If the following criteria cannot be maintained per this design analysis, a horizontal screen design must not be used at the site.

11.6.1.7.3 Screen Geometry: Horizontal screens must be set at slopes and other geometry consistent with prototypes developed through conducted research and/or associated physical models. The screen designer must provide evidence of research or an example site that confirms the adequacy of the design.

11.6.1.7.4 Site Limitation: Horizontal screens must not be used in stream or river channels.

11.6.1.7.5 Flow Regulation: For a horizontal screen to be installed, the site must have a good headgate, capable of maintaining sufficiently consistent diversion rates to allow a horizontal screen and bypass to operate within these criteria and guidelines.

11.6.1.7.6 Channel Alignment: Horizontal screens must be installed such that the approaching conveyance channel is completely parallel and in line to the screen channel (no skew) for at least twenty feet or two screen channel lengths upstream of the screen civil works (whichever is greater). Horizontal screens must be installed such that a smooth hydraulic transition occurs from the approach channel to the screen channel (no abrupt expansion or contraction).

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.

11.6.1.7.8 Bypass Flow Amount: Bypass flow is used for transporting fish and debris across the plane of the screen and into the bypass. For diversion rates less than 100 cfs, about 15% of the total diverted flow should be used as bypass flow for horizontal screens. For diversion rates more than 100 cfs, about 10% of the total diverted flow should be used for bypass flow for horizontal screens. The amount of bypass flow must be approved by NMFS engineers.

11.6.1.7.9 Diversion Shut-off: If inadequate bypass flow exists at any time (per Sections 11.6.1.7.8 and 11.6.1.7.9), the horizontal screen design must include an automated means to shut off the diversion flow, or a means to route all diverted flow back to the originating stream.

11.6.1.7.10 Sediment Removal: The horizontal screen design must include means to simply and directly remove sediment accumulations under the screen, without compromising the integrity of the screen while water is being diverted.

11.6.1.7.11 Screen Approach Velocity: If a horizontal screen is not equipped with an automated mechanical screen cleaning system, screen *approach velocity* must be less than 0.2 ft/s and uniform over the entire screen surface area. If equipped with an automated mechanical screen cleaning system, screen *approach velocity* must be less than 0.4 ft/s and uniform over the entire screen surface area.

11.6.1.7.12 Screen Sweeping Velocity: For horizontal screens, *sweeping velocity* must exceed twice the approach velocity and gradually increase for the entire length of screen. Higher *sweeping velocities* may be required to achieve reliable debris removal and to keep sediment mobilized. The design *sweeping velocity* must be consistent with successful prototypes developed through conducted research. *Sweeping velocity* should never be less than 2.5 ft/s, or an alternate minimum velocity based on an assessment of sediment load in the water diversion system.

11.6.1.7.13 Screen Approach Velocity: For horizontal screens, *approach velocity* and *sweeping velocity* must work in tandem to allow self cleaning of the entire screen face and to provide good bypass conditions. If this has not been demonstrated by a prototype to be hydraulically similar to the proposed design, the screen design must include retrofit capability for an automated screen cleaning system.

11.6.1.7.14 Inspection and Maintenance: Daily inspection and maintenance must occur of the screen and bypass to maintain operations consistent with these criteria.

11.6.1.7.15 Monitoring: Post construction monitoring of the facility must occur for at least the first year of operation. This monitoring must occur whenever water is diverted, and include a inspection log (in table form) of date and time, water depth at the bypass, debris present on screen (including any sediment retained in the screen openings), fish observed over the screen surface, operational adjustments made, maintenance performed and the observer's name. A copy of the inspection log must be provided annually to the NMFS design reviewer, who will review operations and make recommendations for the next year of operation.