

FISH PASSAGE BARRIER AND SURFACE WATER DIVERSION SCREENING ASSESSMENT AND PRIORITIZATION MANUAL

CHAPTER 8

Revised 12/21/09

SURFACE WATER DIVERSIONS

Surface water diversions are common instream features in agricultural areas where the water is used for irrigation. Throughout the state, water is also diverted for hydropower, industrial, recreational, residential, municipal, and hatchery purposes. Washington State law (RCW 77.57.070 and RCW 77.57.010) requires that all surface water diversions be screened to prevent fish from being drawn into the diversions where they are at risk for injury or mortality. Appendix I outlines the screening requirements for surface water diversions.

There are three primary inventory goals for surface water diversions:

- Locate and describe the type of diversion.
- Determine the presence and condition of screening.
- Collect information necessary to prioritize unscreened or inadequately screened diversions for correction.

Surface water diversions are often screened to keep debris out, but not necessarily to protect fish. Additionally, many diversions are unscreened.

For technical assistance with evaluating diversions and screening, contact the WDFW Habitat Program at (360) 902-2534, or TAPPS@dfw.wa.gov.

8.1 Locate & Describe

Standard site data (Chapter 2) are collected for all surface water diversions to define the location. Data elements collected in the field to describe the diversion are summarized in Table 8.1, with detailed descriptions of key elements provided below.

Diversion Type

Surface water diversions are categorized into two general types, gravity and pump. Gravity diversions are typically characterized by open channels or canals leading off the stream channel where flow is controlled by differences in elevation (gravity). They are often accompanied by dams that divert flow into the channel. Pump diversions employ mechanical pumps to remove water from the stream. The pumps are either located directly in the stream (submersible) or on land with an intake pipe in the stream.

Access

Identifies the means by which the diversion site can be accessed (e.g. by foot, vehicle, boat, or off-road vehicle).

Point of Diversion

Identifies which stream bank the diversion is located on, right or left, looking downstream.

Intake Location

More detailed description of where the diversion intake is located. The three options are riverbank, offshore, and lagoon. Riverbank means the intake is at or immediately adjacent to the shoreline of the main channel. Offshore indicates the intake is in the channel away from the shoreline. A lagoon is out of the main flow and often isolated from the river by a channel or pipe. Gravity diversion intakes are usually located along the riverbank or offshore (infiltration galleries). Pump intakes are found at all locations.

Diversion Dam

Many diversions use a dam to deflect water into the intake location. This data element is a flag to indicate the presence or absence of a diversion dam. If present, the dam needs to be assessed for fish passage per the protocol in Chapter 4.

Headgate

A headgate is a structure used to control the amount of water being diverted. They are typically associated with gravity diversions and are located upstream of a screen (if present). Headgates can range in form from a simple weir to a screw valve. This data element is a flag indicating the presence or absence of a headgate. Figure 8.1 shows examples of some common headgate styles.

Diversion Comments

The comments section is used to briefly describe important aspects of the diversion not captured by the standard data elements. It is also a space for explanations when “Other” or “Unknown” are selected for items on the field forms.

Screen Presence

This data element indicates the presence or absence of a screen at the diversion. It provides documentation that a screen is present even when access to the screen is restricted and the information in Section 8.2 cannot be collected. If it is not possible to determine if a screen is present or absent (see Section 8.4), “Unknown” should be selected.

Table 8.1. Field descriptions for the Surface Water Diversion data collection form for diversions (Appendix C). Items in bold text represent predefined choices on the form.

Field Form Name	Description
Site ID	Unique identifier for each diversion. Must be identical to the Site ID for the site.
Field Crew	Last names of individuals responsible for collecting field data on culverts. Separate names with a semicolon. (e.g. Johnson;Collins)
Diversion Type	Indicate type of surface water diversion: Gravity or Pump diversion.
Access	Type of transportation capable of accessing site: Boat, Vehicle, Foot, or ORV (off-road vehicle).
Point of Diversion	Point of diversion (POD): LB = left bank, RB = right bank, referenced looking downstream.
Intake Location	RB = riverbank (or stream bank), OS = offshore, LN = lagoon, CV = cove. A lagoon is separated from the river by a pipe or channel. A cove is open to the river.
Diversion Dam	Presence of an instream diversion dam structure: Yes = present or No = not present. If yes, also complete a dam form.
Headgate	Presence of headgate: Yes = present or No = not present.
Diversion Comments	Diversion specific comments.
Screen Presence	Reports the presence of some type of screening device: Yes = present, No = not present, or Unknown = unable to determine presence or absence.



Figure 8.1. Examples of common headgate styles.

8.2 Screens

When screens are present, the data elements summarized in Table 8.2 are collected to describe the screen and its general condition. Detailed descriptions of key elements are provided below.

Screen Type

Surface water diversion screens have been classified into a small number of general types; however, each type may have a number of variations due to size and cleaning strategies. Gravity diversion screens are commonly categorized as traveling belt, rotary drum, vertical fixed plate, non-vertical fixed plate, or infiltration gallery. Screens configurations that do not fit these categories are identified as “Other”.

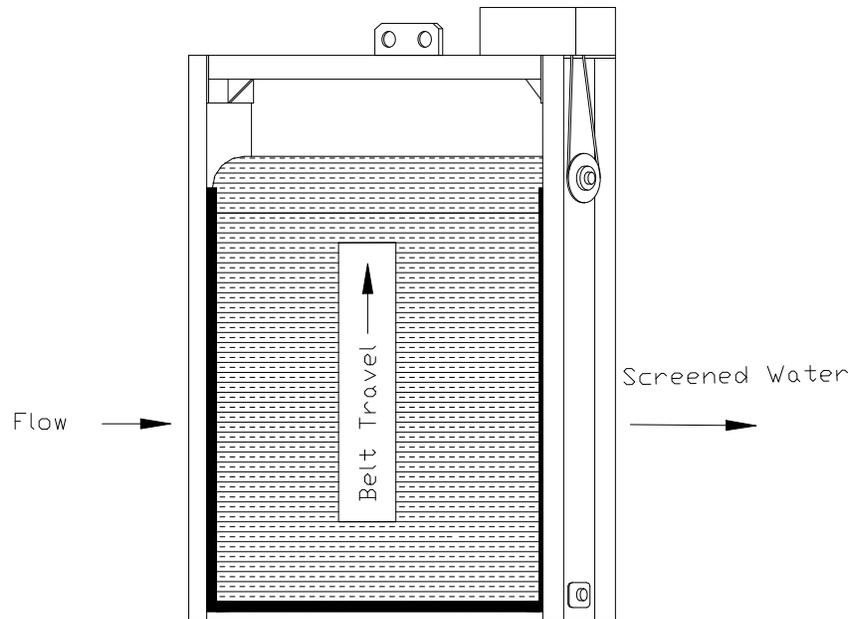
Traveling belt screens (figures 8.2 and 8.3) consist of an endless mesh (wire or plastic) conveyor belt that excludes debris while allowing surface water to be diverted to an irrigation system.

A rotary drum screen (figures 8.4 and 8.5) is a cylindrical drum constructed with mesh (wire or plastic) which allows water to flow through while excluding debris.

Fixed plate screens are simply a flat plate mesh aligned in a stream channel at a gravity diversion. Vertical fixed plate screens (figures 8.6 and 8.7) are aligned vertically in the stream. “Active” cleaning plate screens require an additional debris removal system (e.g. brush or wiper). “Passive” plate screens have no cleaning system. Non-vertical fixed plate screens (figures 8.8 and 8.9) may be aligned horizontally or sloping upward or downward in the direction of the stream flow and typically do not require debris removal systems.

Infiltration galleries (figures 8.10 and 8.11) include one or more horizontal screens, perforated pipe manifolds, or single pipes, buried in a streambed or bank. Another type of infiltration gallery is a “Raney well”, which is simply a depression dug off-channel (in a stream or river) with a pump and/or pipe present. Infiltration galleries are generally used for pump diversions but can be used for gravity diversions in steep channels. The screen area is the area of the streambed or bank through which the water flows rather than the area of the intake pipe.

Pump diversion screens attached to the end of a pump include box, barrel, cylinder, or cone (figures 8.12 and 8.13). Pump diversions may also be screened by an infiltration gallery.



TRAVELING BELT

Figure 8.2. Traveling belt screen.

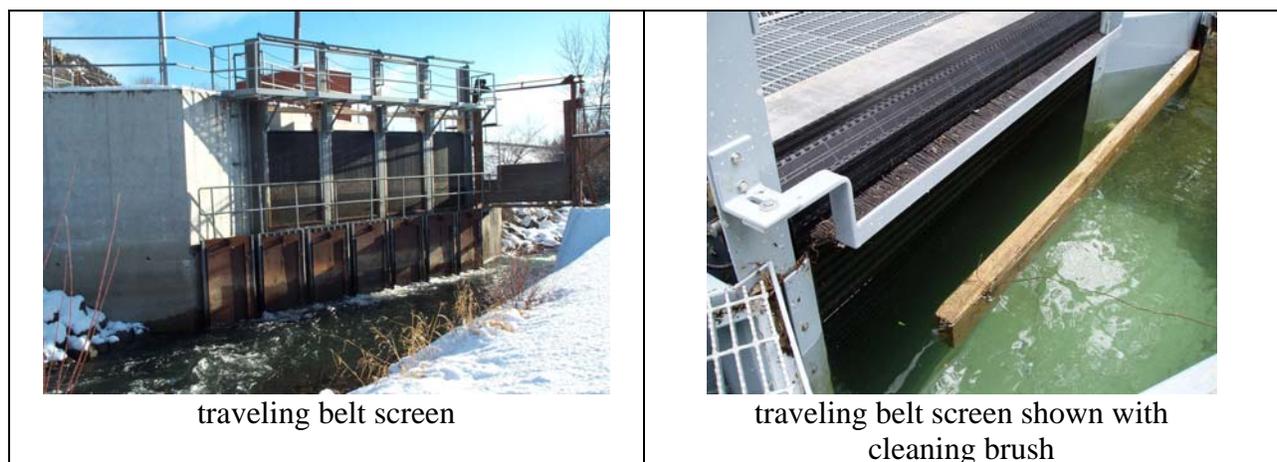


Figure 8.3. Photo examples of traveling belt screens.

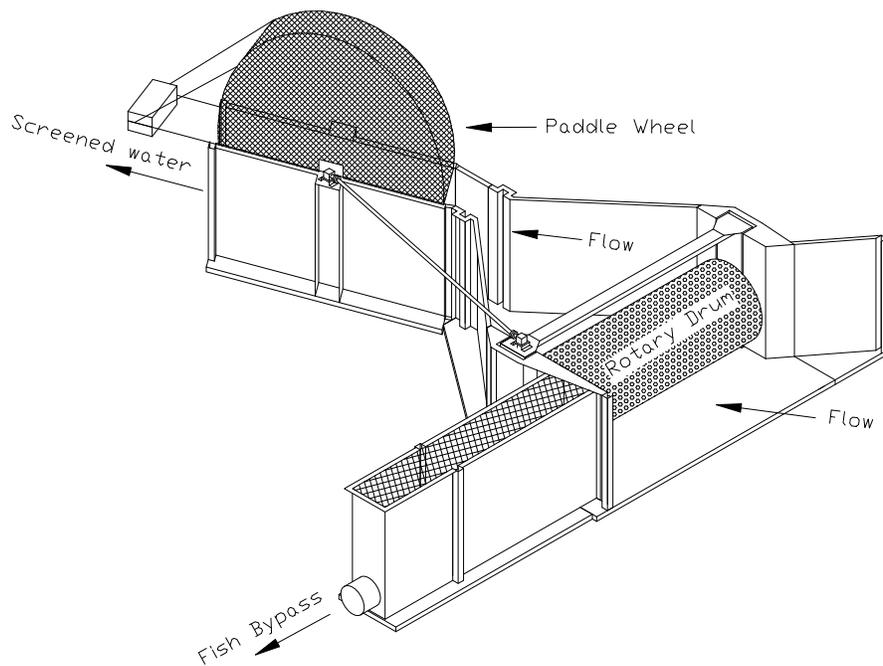
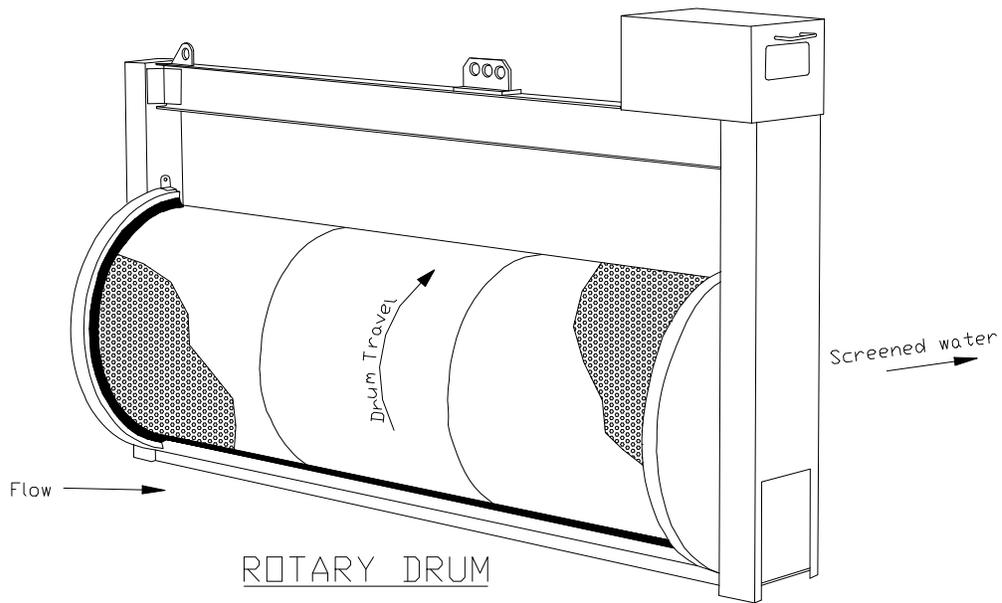


Figure 8.4 Rotary drum screen.

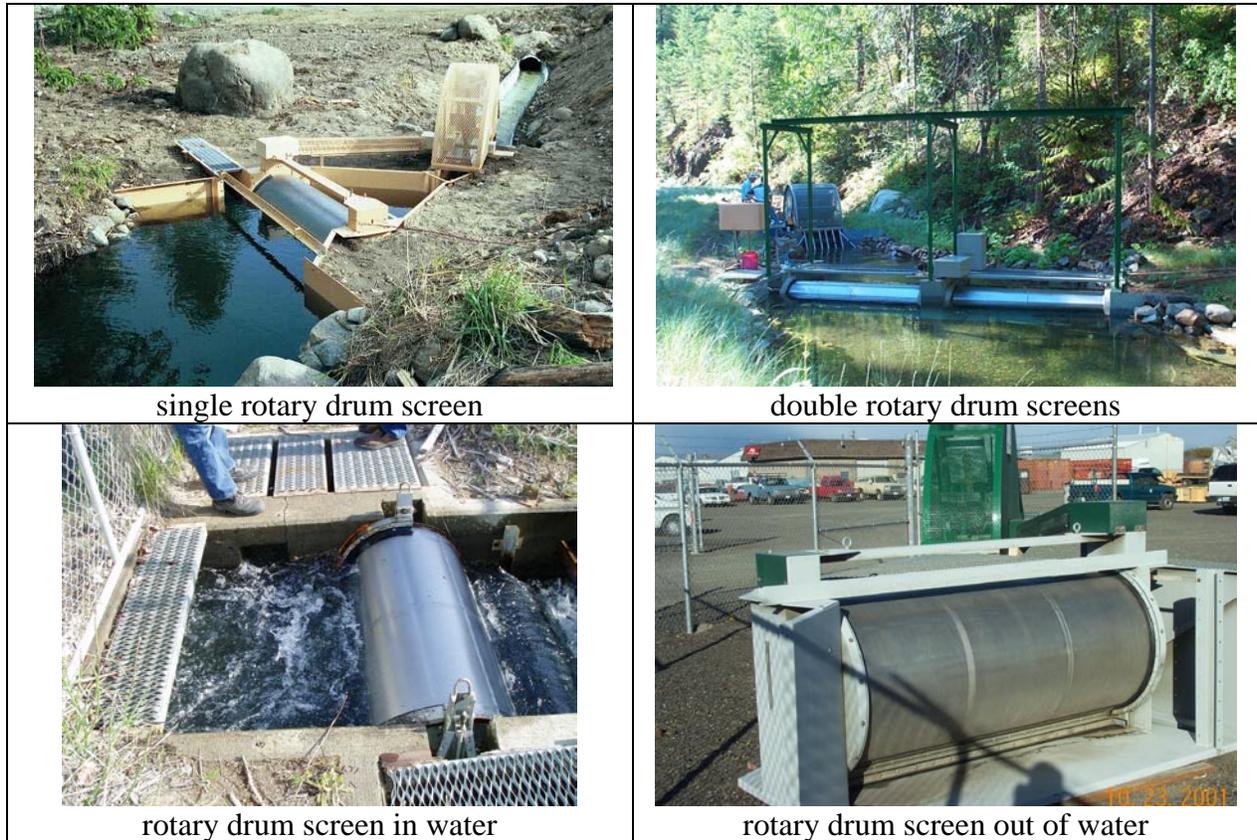


Figure 8.5. Photo examples of rotary drum screens.

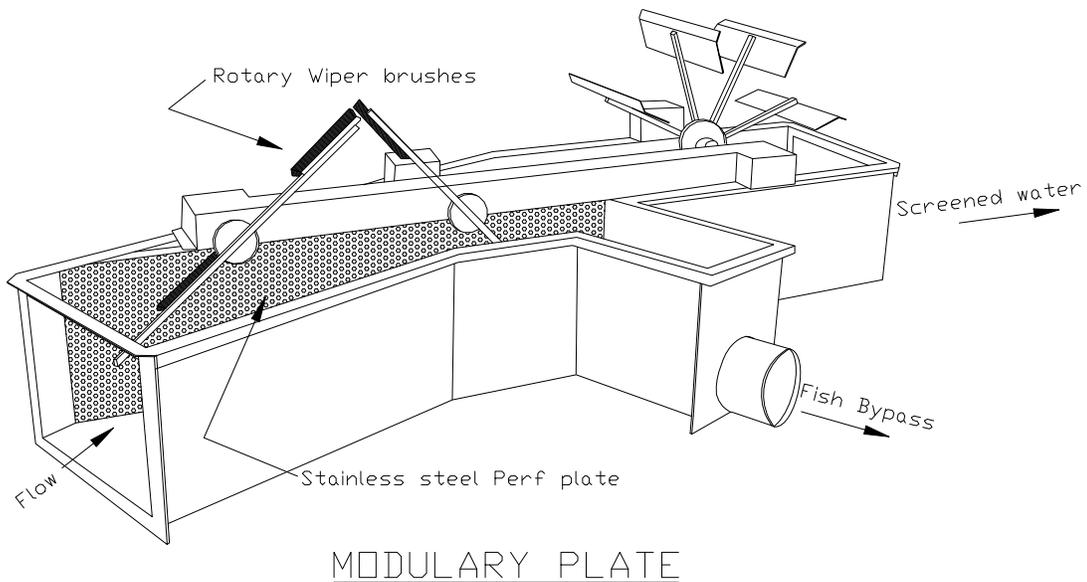
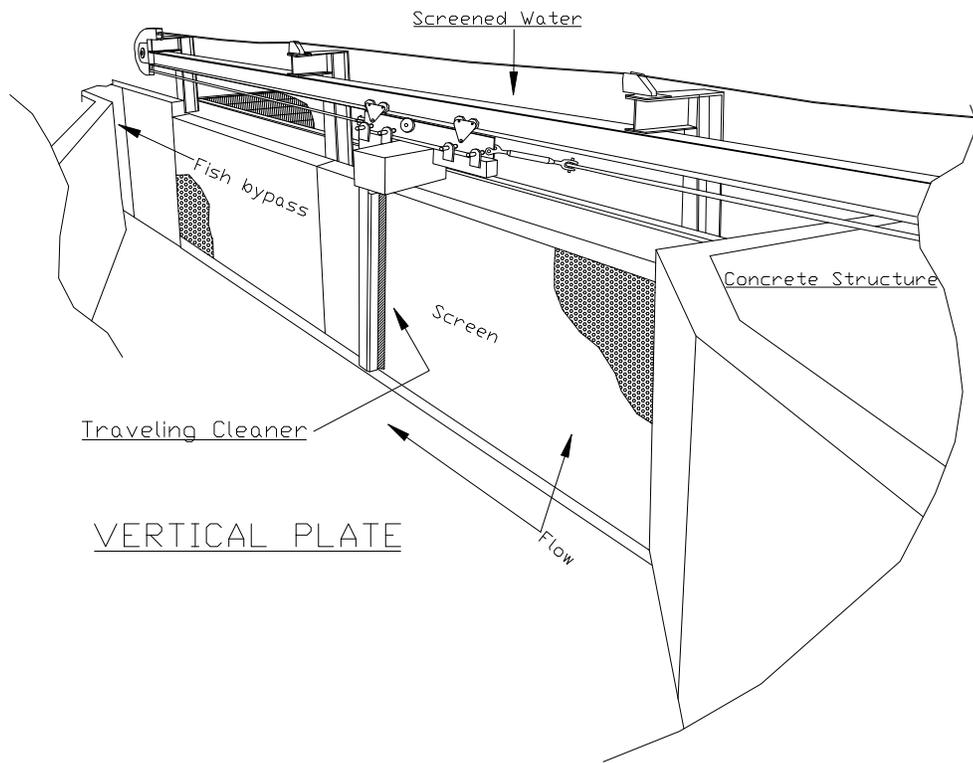


Figure 8.6 Vertical fixed plate screen.

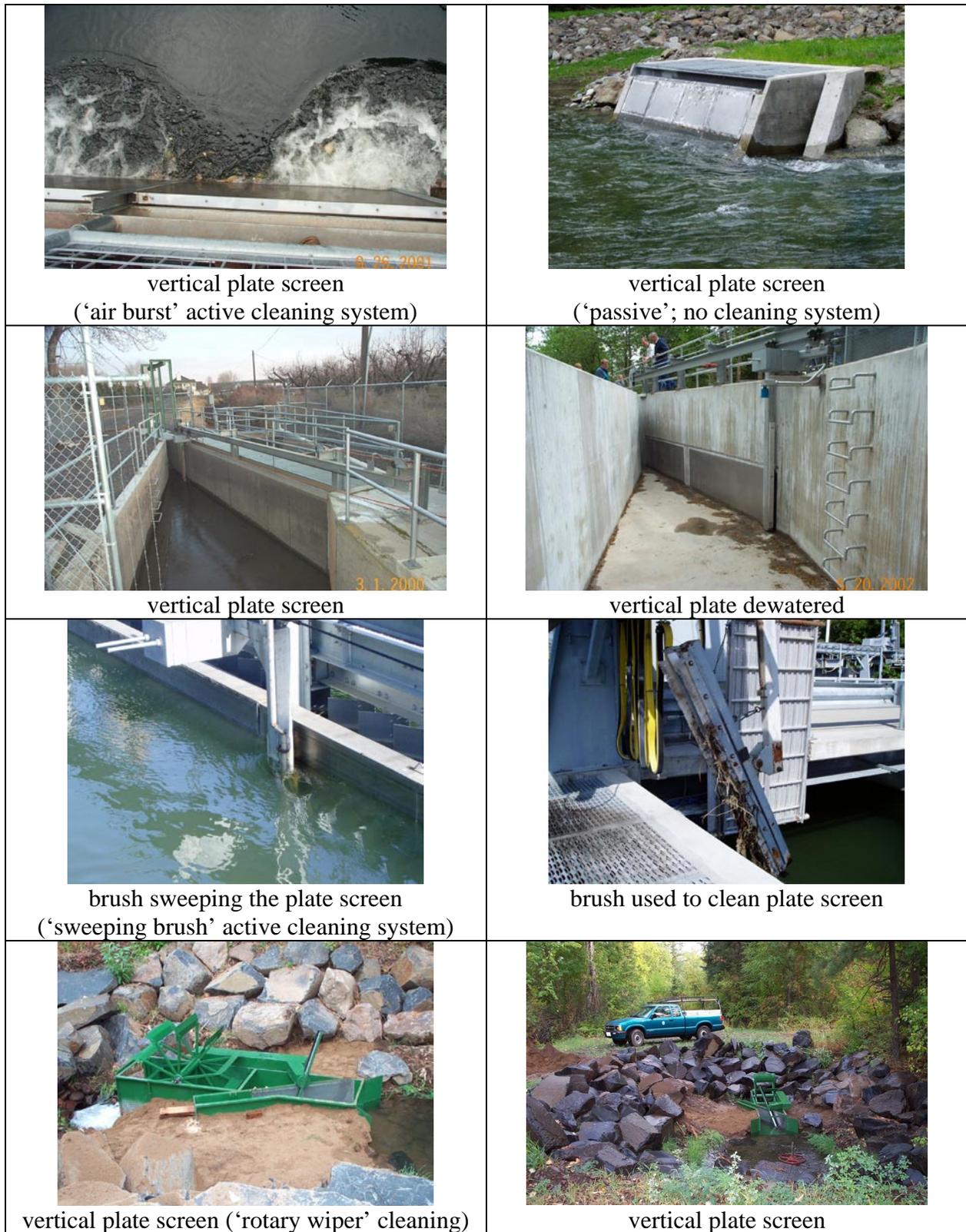


Figure 8.7. Photo examples of vertical plate screens.

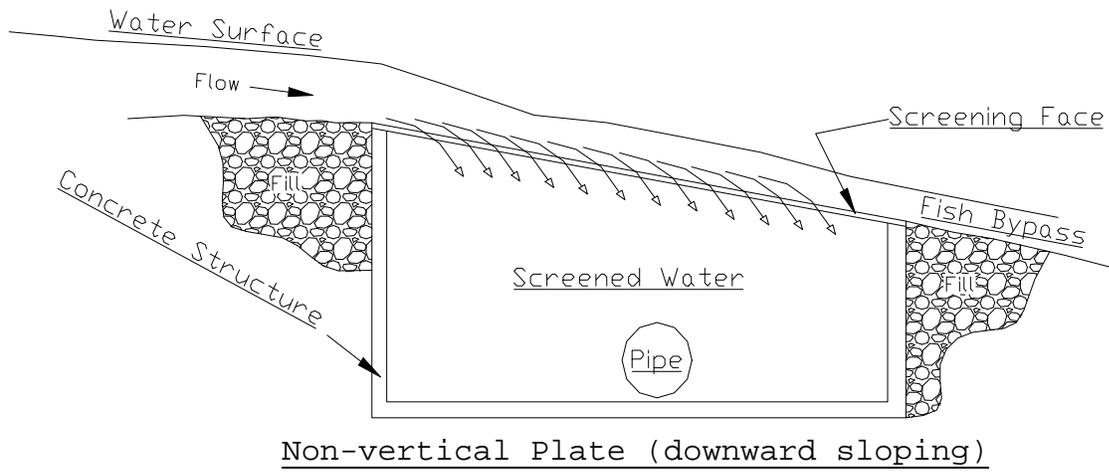


Figure 8.8 Non-vertical plate screen.



non-vertical fixed plate screen

Figure 8.9. Photo example of non-vertical plate screen.

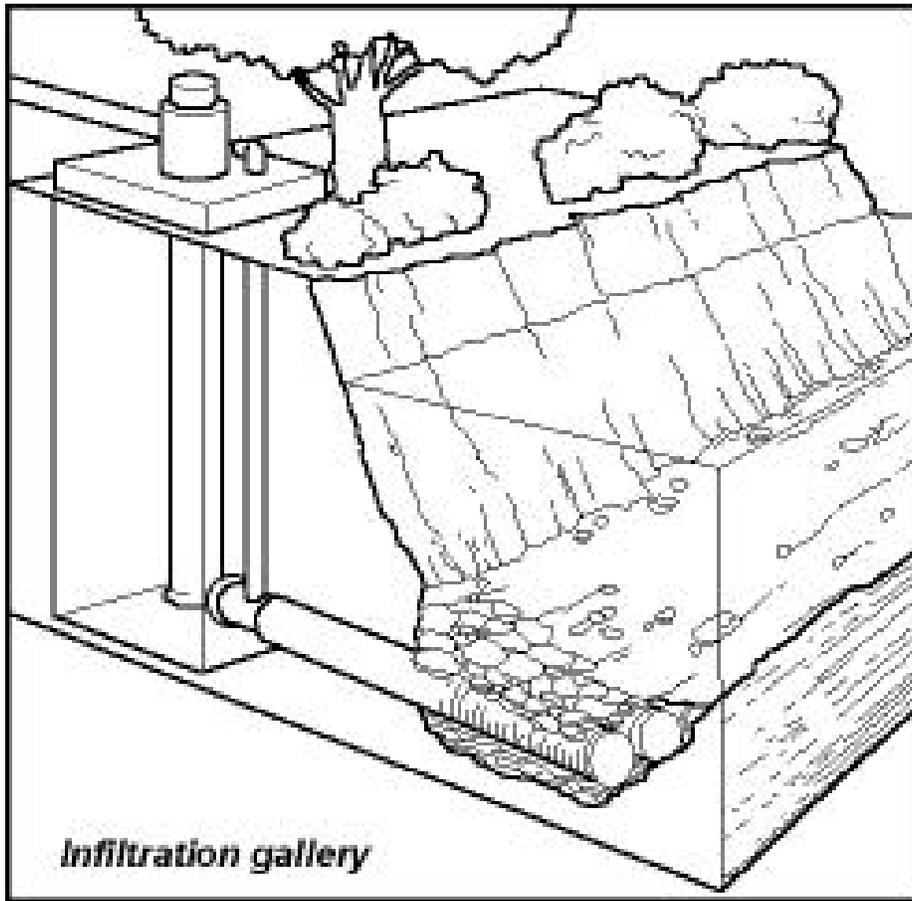


Figure 8.10 Infiltration gallery screen.



Figure 8.11. Photo example of passive infiltration gallery

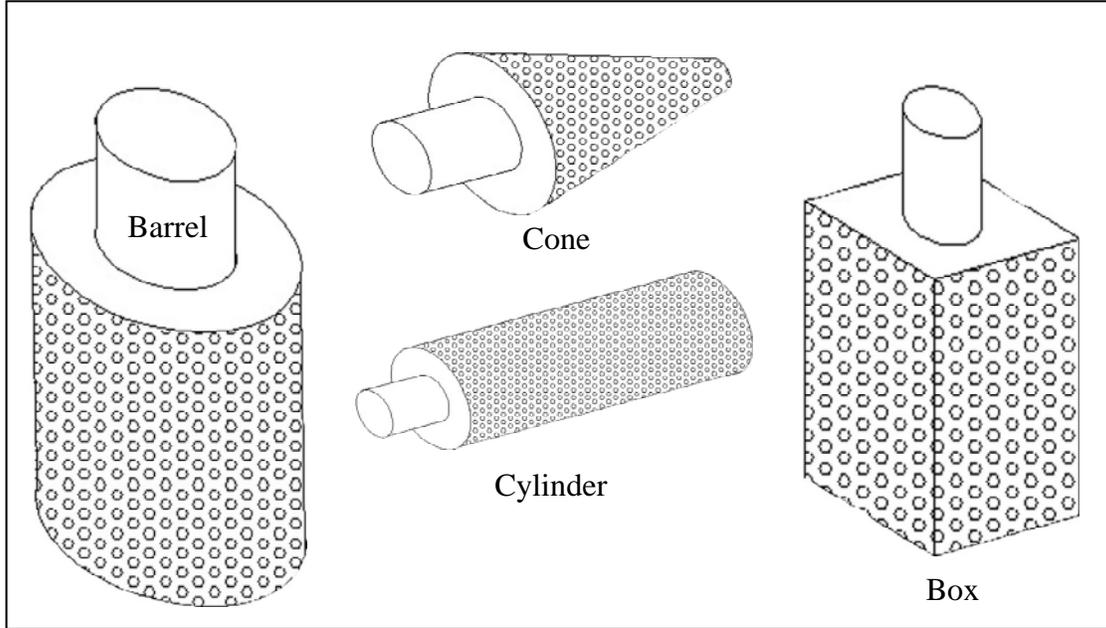


Figure 8.12. Common types of end of pump screens.

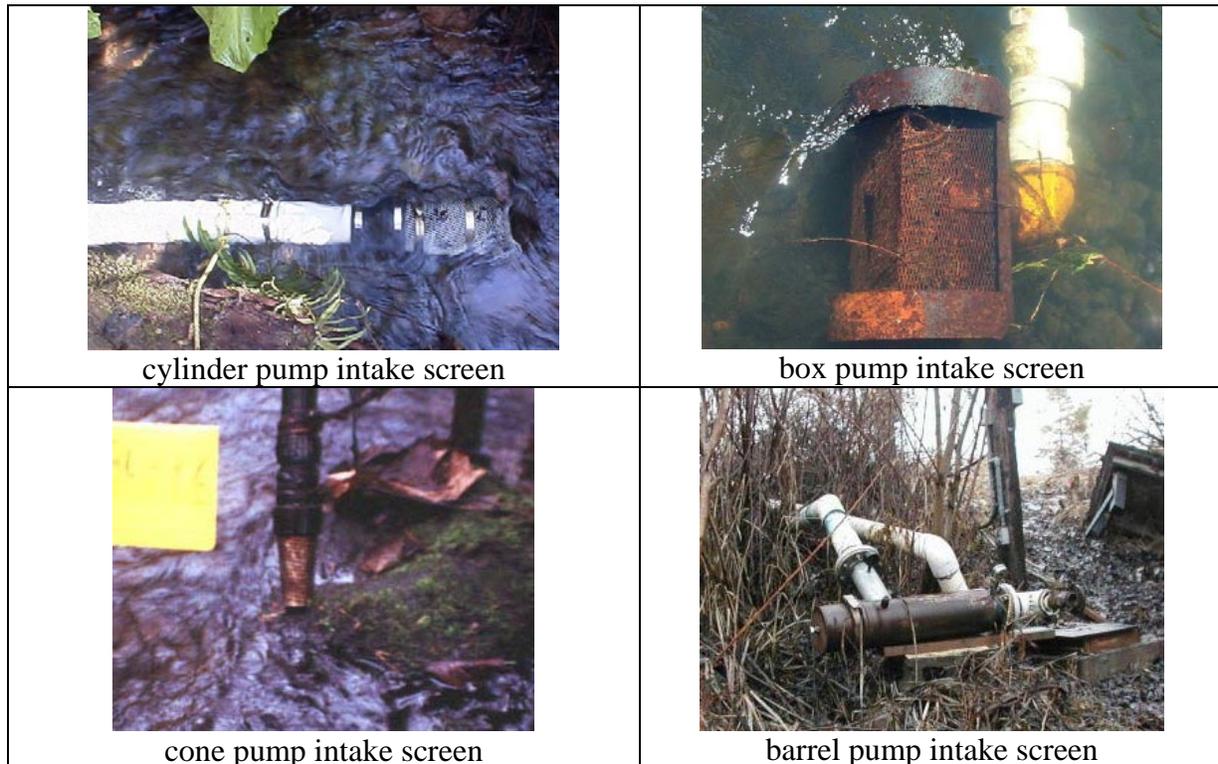


Figure 8.13. Photo examples of common pump intake screens.

Screen Material

Screen material refers to the porous part of the diversion screen. Common materials are woven wire mesh, plastic mesh, perforated plate (stainless steel, aluminum or brass with round or slotted holes), stainless steel profile bar (also called wedge wire or well screen), and slotted polyvinyl chloride pipe (PVC). Figure 8.14 illustrates these common screen material types. Materials not meeting these descriptions are designated as “Other”.

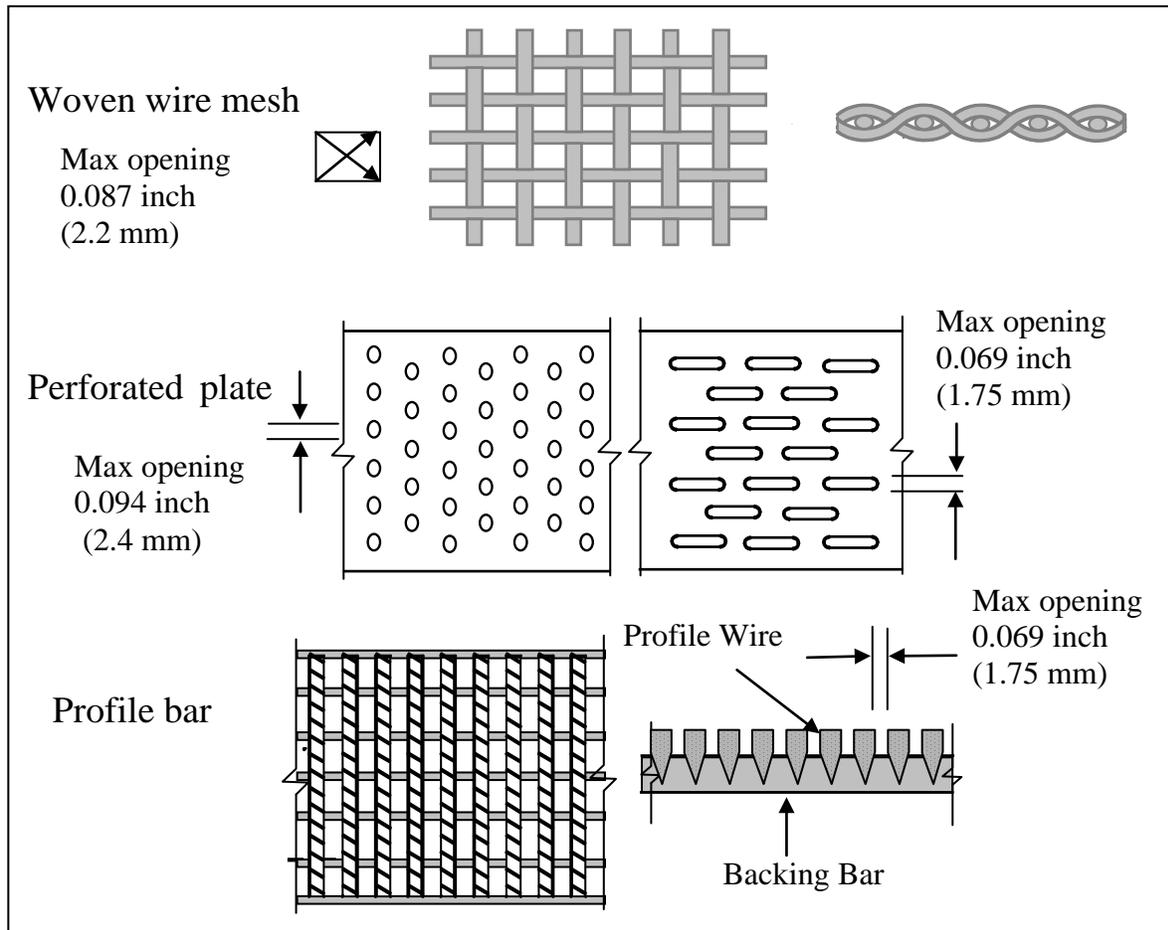


Figure 8.14. Common fish screening materials.

Mesh Size

Mesh size refers to the opening in the screen material. Screen mesh diameter can easily be measured using a set of calipers. How mesh size is measured is dependent on the type of screen material (Figure 8.14). For wire or plastic mesh, measure the largest diagonal dimension. For perforated plate measure the diameter of the hole or the narrowest dimension of the slot. For profile bar and slotted PVC measure the narrowest dimension of the slot. On damaged screens, measure the undamaged mesh opening and note the screen damages in the comments section. Mesh size is reported in inches to the nearest ten thousandths (10000's).

Fish Bypass

Gravity diversions with fish screens installed downstream of a headgate and pump diversions withdrawing water from a lagoon, usually require a "fish bypass system" to collect fish from in front of the screen and safely transport them back to the stream. Gravity diversion bypass systems consist of an entrance/flow control section and a fish conveyance channel or pipeline. Lagoons must be configured with an outlet channel (or pipe) having sufficient flow away from the pump intake to carry fish back to the parent water body. The intake channel or pipe to a lagoon does not constitute a bypass channel, since it requires fish to swim upstream to get back to the parent water body. This data element is a flag indicating the presence or absence of a bypass system at the diversion.

Comments on Bypass Condition

Describe the condition of the bypass at the time of the site visit. Evaluate and comment on the following items:

- Is the bypass entrance or return pipe blocked with debris?
- Is there sufficient flow to allow fish to find and enter the bypass and return to the river?
- Do the flows in front of screens allow fish bypass without delay or impingement?
- Does the bypass return have an outfall drop? What is the height and condition of the outfall?

Note: there are cases during low river flow when the bypasses are shut off to enable the diverter to obtain the water right.

Screen Dimensions

The following general measurements are taken to help characterize the screen. Not all dimensions apply to all screen types. Measurements are reported in English units.

- Screen mesh/slot opening diameter (to the nearest 0.0001 inch)
- Screen width (to the nearest 0.01 feet)
- Screen height (to the nearest 0.01 feet)
- Screen area (to the nearest 0.01 square feet)
- Diameter (to the nearest 0.01 feet)

Screen Condition

Screen condition reflects whether a screen is clean and intact or if it is in need of maintenance. *It is not an evaluation of compliance with federal and/or state screening requirements.*

Inadequately maintained screens can result in entrainment (passage through, around or under the screen) or impingement (involuntary contact and immobilization on the screen surface) of fish.

The following items should be considered when evaluating screen condition:

- Holes or dents in the screen surface or frame that would allow small fish to pass through the screen or be injured by contact with the surface. Screens should be adequately sealed to prevent fish injury or entrainment.
- Screen mesh openings that exceed the maximum allowable opening diameter for type of screen (see Table 8.14)
- Gaps and spaces greater than 0.094 inches (2.4 mm) between the screens, structural frames, and/or civil works (wood, metal or concrete section in the channel that the screen fits into).
- Side and bottom rubber seals **not** intact and in continuous contact with the screen.
- Screens or trash racks plugged with debris.

If any of these situations exist the screen condition should be indicated as “maintenance needed”.

Screen Comments

The comments section is used to briefly describe important aspects of the screen not captured by the standard data elements. It is also a space for explanations when “Other” or “Unknown” are selected for items on the field forms.

Screen Compliance

Survey crews may not always be able to determine whether a screen is compliant and meets WDFW screening criteria. Advanced expertise is needed for determining whether the approach velocity, sweeping velocity, and minimum screen area criteria are met. However, if the screen mesh size exceeds the WDFW criteria (see maximum openings in Figure 8.14 and Appendix I), then screening is not compliant. Likewise, if the diversion is unscreened, then the screening is non-compliant. When the screening criteria cannot be adequately evaluated, then compliance is ‘unknown’.

Table 8.2. Table 8.2 Field descriptions for the Surface Water Diversion data collection form for screens (Appendix C). Items in bold text represent predefined choices on the form.

Field Form Name	Description
Site ID	Unique identifier for each diversion. Must be identical to the Site ID for the site.
Screen Type	Specify the type of screen. For Gravity Diversions: RD = rotary drum, VFP = vertical fixed plate, NVFP = non-vertical fixed plate, TB = traveling belt, IG = infiltration gallery, OT = other. For Pump Diversions: BX = box, BR = barrel, CY = cylinder, CN = cone, IG = infiltration gallery, OT = other.
Screen Material	Material screen is constructed of: WM = woven wire mesh, PM = plastic mesh, PP = perforated plate, PB = profile bar, EM = expanded metal, SP = slotted PVC, OT = other.
Mesh Size	Largest dimension of the screen material opening, measured in inches (0.0001).
Screen Height	Height of screen, measured in feet (0.01).
Screen Width	Width of screen, measured in feet (0.01).
Screen Condition	Indicate screen condition: OK = screen clean and intact, MN = maintenance needed.
Fish Bypass	Presence of fish bypass. Yes = present, No = not present, or Unknown = unable to determine presence or absence.
Bypass Condition	Indicate whether fish bypass is in operation and comment on the condition of the bypass.
Screen Comments	Screen specific comments.
Screen Compliant	Is the screen compliant with WDFW criteria? Indicate Yes , No , or Unknown .

8.3 Diversion Flow

Determining maximum diverted flow is a critical piece of information used by WDFW to prioritize the diversion for screening, establish the size and type of screen needed, and to estimate construction costs. Table 8.3 summarizes the data elements collected or recorded for diversion flow calculations. Key elements are described in detail below.

Flow is the volume of water moving through the diversion for a specified unit of time (e.g. cubic feet per second, gallon per minute). Some of the methods described in this section yield flow in cubic feet per second (cfs), however, the Screen Priority Index (Chapter 10) requires flow in gallons per minute (gpm). To convert cfs to gpm, multiply by 449 (1.0 cfs = 449 gpm).

The preferred value for flow is that allowed by the diverters water right permit or certificate. Most surface water diversions require authorization from the Washington State Department of Ecology (WDOE). The water right permit or certificate defines the legal, maximum instantaneous flow allowed for the diversion. Water right information can be requested from WDOE's public disclosure office at (360) 407-6040, or obtained from the agency's Water Right Tracking System (WRTS), available online at:

<http://www.ecy.wa.gov/PROGRAMS/wr/rights/tracking-apps.html>. If flow cannot be obtained from water rights then it can be measured or calculated by the techniques described below.

Pump Diversions

For diversions equipped with an in-line flow meter, the instantaneous flow in gpm can be read directly from the meter if the diversion is in operation. Unfortunately, most diversions are not equipped with flow meters. Pump flow may also be estimated based on the outside diameter or circumference of the intake pipe. Table 8.4 provides estimated flow in gpm based on these dimensions.

Gravity Diversions

Some gravity diversions are equipped with calibrated staff gages from which flow can be read directly when the diversions are in use. Figure 8.15 shows photo examples of staff gages. Otherwise, flow is calculated by multiplying water velocity (ft/sec) times the cross-sectional area (ft²) of the diversion channel. The result is flow in cubic feet per second (cfs). Velocity can be measured with a portable flow meter or by the three-chip method (described below) when the diversion is in use. If the diversion is not in operation, an average velocity (described below) can be used as a surrogate. The cross-sectional area of the channel is calculated based on simple measurements.

Cross-Sectional Area

The bank full, cross-sectional area of the channel should be calculated from measurements taken approximately 100-300 feet downstream of the point of diversion where the normal waterline is readily apparent on the bank. Measure the width of the channel at the waterline elevation. Then measure the vertical distance (depth) from the horizontal waterline elevation to the channel bottom. Multiply the width times the depth to generate the bank full cross-sectional area. The area must be expressed in square feet to the nearest tenth of a foot (0.1 ft²). If the ditch cross-section is not rectangular, calculate area as accurately as possible by using the formula for a trapezoid (Area = $\frac{1}{2}$ (width_{waterline} + width_{bottom}) x depth).

Three Chip Method

With the three chip method, velocity is estimated by measuring the time it takes a floating object to travel a set distance, then dividing the distance traveled by the time. For example, if the object travels ten feet in twenty seconds, the velocity is 0.5 feet per second (10 ft / 20 sec = 0.5 ft/sec). This is repeated three times with the results used to compute an average velocity. Multiply the average velocity by the diversion channel cross-sectional area to generate flow in cfs. Multiply the result by 449 to obtain gpm.

Average Velocity

An average velocity of 0.75 ft/sec, based on velocities measured by WDFW crews in a number of diversion channels, may be used. To calculate flow, multiply the diversion channel cross-sectional area by 0.75 ft/sec. The result will be flow in cfs. Multiply the result by 449 to obtain gpm. The flow generated by this method is not as accurate as the other methods described above.

Table 8.3. Flow calculation data elements, collected on the Surface Water Diversion Data Form (Appendix C). Items in bold text represent predefined choices on the form.

Field Form Name	Description
Cross-Sectional Area	Bank full, cross-sectional area of the diversion ditch, canal, flume, or pipe, in square feet (0.1). <i>For Gravity Diversions only.</i>
Intake Pipe Outside Diameter	Measured outside diameter of the intake pipe in inches (0.001). <i>For Pump Diversions only.</i>
Diversion Flow	Volume of water diverted in gallons per minute (gpm).
Flow Derivation	How flow was determined: Staff Gauge, Flow Meter, Three-Chip Method, Water Right, WDFW Average Velocity, Pipe Capacity, Other. Non-standard (“Other”) flow derivation methods require explanation in diversion comments section (e.g. landowner provided information; from a report; from an HPA; etc).
Water Right Number	Water Right number issued by the Washington Department of Ecology, if known.
Power Meter Number	Number issued to Power Meter servicing the diversion, if known.

Table 8.4. Pump diversion pipe flow estimation table.

Standard PVC & Steel Pipe Sizes (inches)		Outside Diameter (inches)		Outside Circumference (inches)		Estimated Flow
Fraction	Decimal	Fraction	Decimal	Fraction	Decimal	GPM
1	1	1 ^{5/16}	1.313	4 ^{1/8}	4.125	14
1 ^{1/4}	1.25	1 ^{11/16}	1.688	5 ^{3/16}	5.188	25
1 ^{1/2}	1.50	1 ^{7/8}	1.875	6	6	35
2	2	2 ^{3/8}	2.375	7 ^{7/16}	7.438	40
2 ^{1/2}	2.50	2 ^{7/8}	2.875	9 ^{1/16}	9.063	65
3	3	3 ^{1/2}	3.500	11	11	90
4	4	4 ^{1/2}	4.500	12 ^{3/4}	12.750	160
5	5	5 ^{9/16}	5.563	20	20	180
6	6	6 ^{5/8}	6.625	28 ^{7/8}	28.875	280
8	8	8 ^{5/8}	8.625	27 ^{1/8}	27.125	460
10	10	10 ^{3/4}	10.750	33 ^{3/4}	33.750	750
12	12	12 ^{3/4}	12.750	40 ^{1/16}	40.063	1100



Figure 8.15. Examples of staff gages.

8.4 Field Considerations

If screening facilities are fenced, locked, or otherwise inaccessible, there may be an existing record of the facility at WDFW; please check with WDFW/TAPPS screening experts in Yakima or contact the WDFW Habitat Program.

Fish screening facilities at gravity diversions are usually present near the point of diversion, but in some cases they are a significant distance downstream. At a minimum, the inventory crew should walk a 200-meter reach of the diversion channel to search for a screening facility. If the entire diversion channel cannot be walked, and a screening facility is not found within 200-meters, then select 'Unknown' on the data collection form for "Screen Presence" and report in the comments section the distance (meters) walked.

Pump diversions are usually screened at the intake. When evaluating pump diversions, do not pull pumps or pump intake lines out of the water or remove the pump housing; this may result in damage or personal injury. If you are unable to collect the data without disturbing the pump equipment, then leave the data entry fields blank and explain the situation in the comments field.

8.5 Additional Reading

NMFS (National Marine Fisheries Service). 2008. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon. http://www.nwr.noaa.gov/Salmon-Hydropower/FERC/upload/Fish_Passage_Design.pdf

Nordlund, B. and K. Bates. 2000. Fish Protection Screen Guidelines (WDFW) – DRAFT 4/25/00. Co-published by the NOAA Fisheries and Washington Department of Fish and Wildlife. Olympia, Washington. <http://wdfw.wa.gov/hab/ahg/screen51.pdf>