

Science, Service, Stewardship




Upstream Passage  
Fishway Component Design

September 3, 2010

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## Fishway Entrance

What is it?

- It is a gate or slot through which fishway attraction flow is discharged and through which fish enter the upstream passage facility.
- It may be the most critical component in the design of an upstream passage system.

*Please refer to course handout, section 1.9*

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## Fishway Entrance



Slotted entrance,  
Photos courtesy of GPUD

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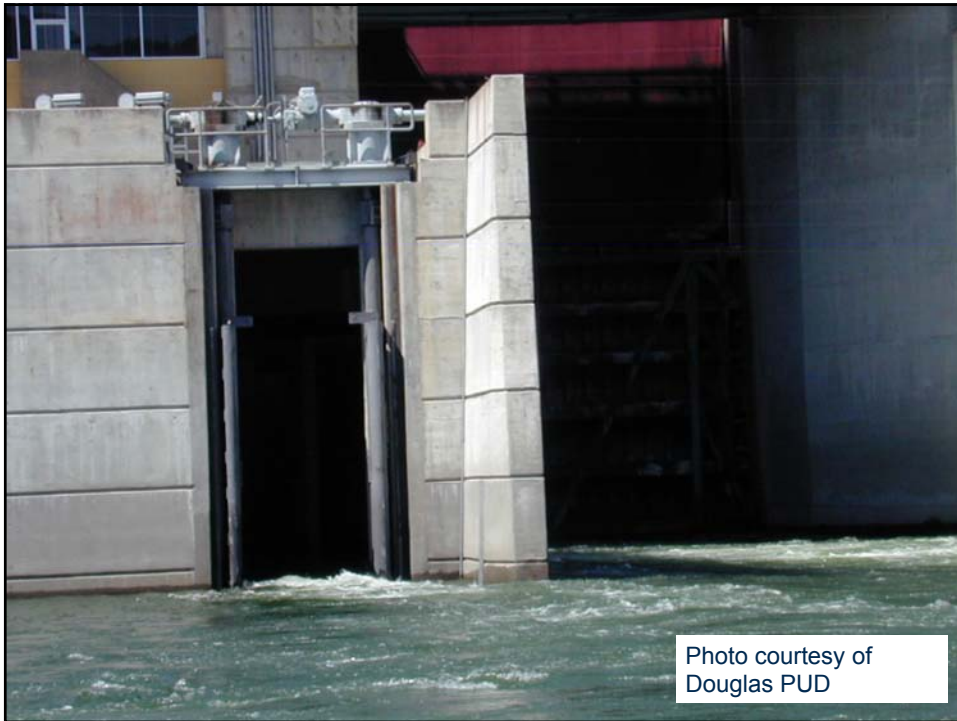
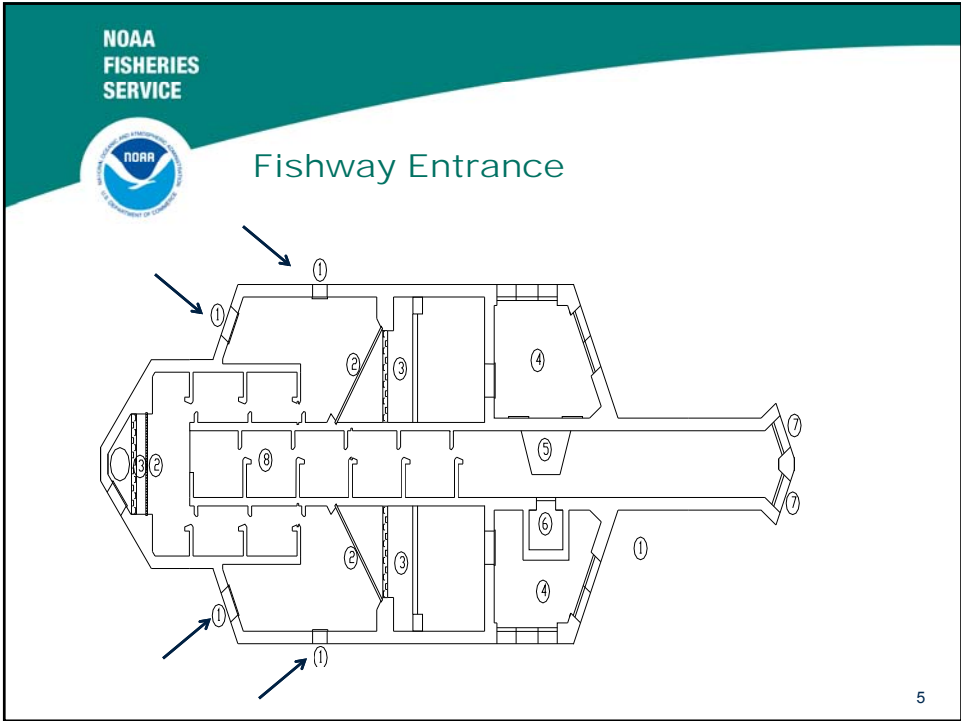



Photo courtesy of  
Douglas PUD



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### Fishway Entrance

Important design aspects:

- Location
- Shape of discharge
- Amount of flow
- Approach channel
- Accommodating changing project conditions




Photo courtesy of EWEB

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## Fishway Entrance

### Criteria:

- Provide 5% to 10% of design high flow.
- Operate with a differential between 1 and 1.5 feet (designed to operate from 0.5 to 2.0 feet).
- Minimum width 4 feet.
- Minimum depth 6 feet.

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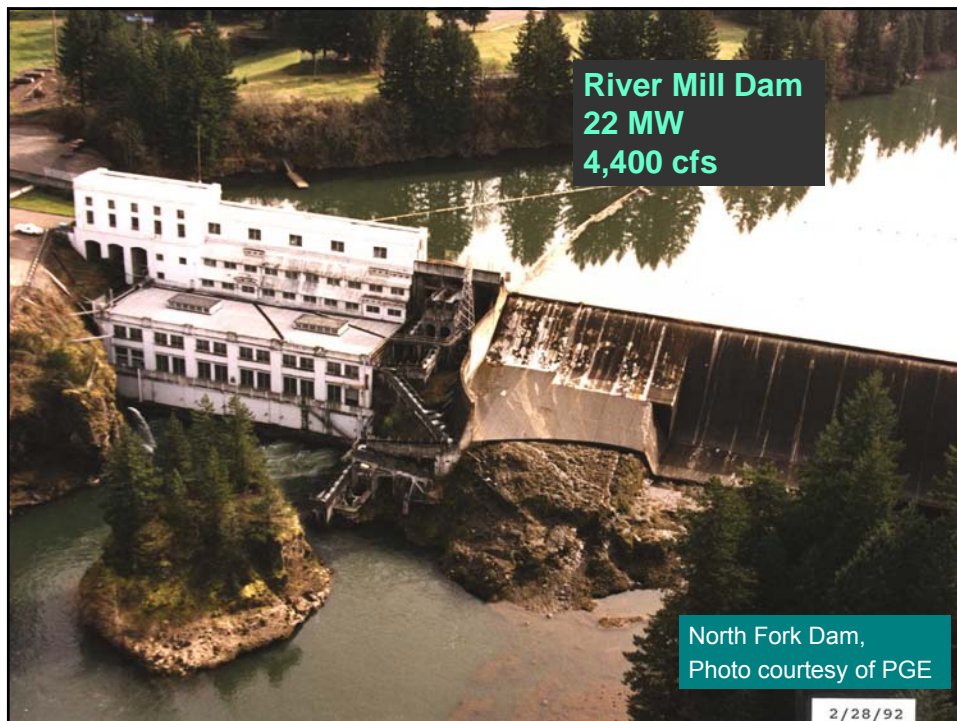


## Fishway Entrance

Criteria...continued:

- Fishway entrances must be located at points where fish can easily locate it.
- Adequate number of fishways and/or entrances.
- Outflow jet hydraulic must produce a streaming flow condition.

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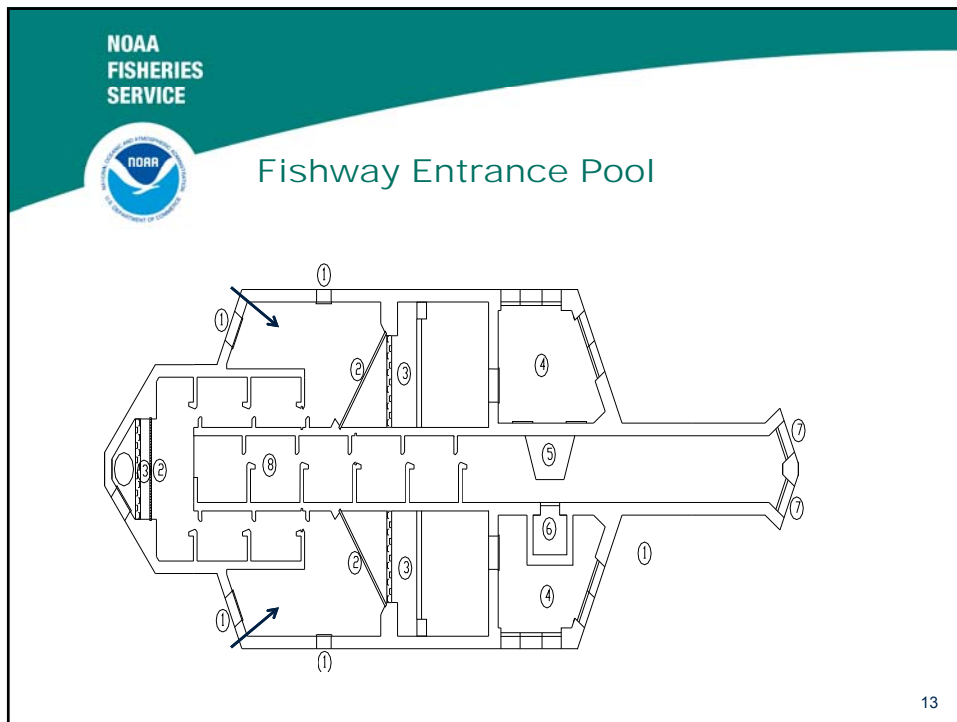


## Fishway Entrance Pool


What is it?

- The pool just upstream of the entrance.
- It is the pool where ladder flow and auxiliary water system flow combine.
- It is a pool configured to readily guide fish toward ladder weirs or slots.

*Please refer to course handout, section 1.9*



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### Fishway Entrance Pool

Criteria:

- Transport velocities between the fishway entrance and first fishway weir, 1.5 and 4.0 ft/s.
- The fishway entrance pool geometry must be designed to optimize attraction to the lower fishway weirs.

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## Auxiliary Water System

What is it?

- A system to make up additional flow and provide adequate competing flow. Where?
  - Entrances
  - Transition pools
- Often referred to as the AWS.

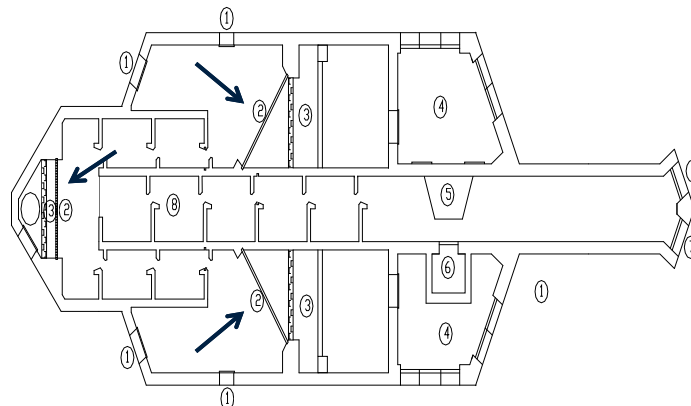
*Please refer to course handout, section 1.10*

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## Auxiliary Water System



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## Auxiliary Water System

### Criteria:

- Can be oriented vertically or horizontally.
- Must be made of non-corrosive material.
- Vertically-oriented diffuser panels must be made of vertically-oriented flat bar stock.

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## Auxiliary Water System

### Criteria...continued:

- Horizontally-oriented diffuser panels must be made of horizontally-oriented flat bar stock.
- Regardless of orientation the maximum 1-inch clear spacing.

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## Auxiliary Water System

Criteria...continued:

- Velocity (based on total diffuser panel area)
  - <1.0 ft/s for vertical diffusers and
  - <0.5 ft/s for horizontal diffusers.
- Diffuser velocities should be uniform.
- Design velocity should be lower for species other than salmon.

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## Auxiliary Water System

Criteria...continued:

- The AWS design must include access for debris removal.
- All flat-bar diffuser edges and surfaces must be ground smooth to the touch.
- Vertical diffusers top at or below the low design entrance pool water surface elevation.

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## Auxiliary Water System

Interesting note - Vertical diffuser velocities can be higher than horizontal diffuser velocities....Our rationale:

- 1) *Proper layout of the fishway will guide fish toward the first fishway weir, and*
- 2) *Salmon (and some other species) have a lateral line on their sides that allows detection and orientation to water velocities in line with their bodies. Therefore, they can be guided by flow velocities along their body length, but not by flow velocity oriented upward.*

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## Vertical Diffuser



Photo courtesy of  
R2 Resource  
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### Horizontal Diffuser



Photo courtesy of  
Grant County PUD

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### Horizontal Diffuser



Photo courtesy of  
Grant County PUD

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## AWS Fine Trash Rack

### What is it?

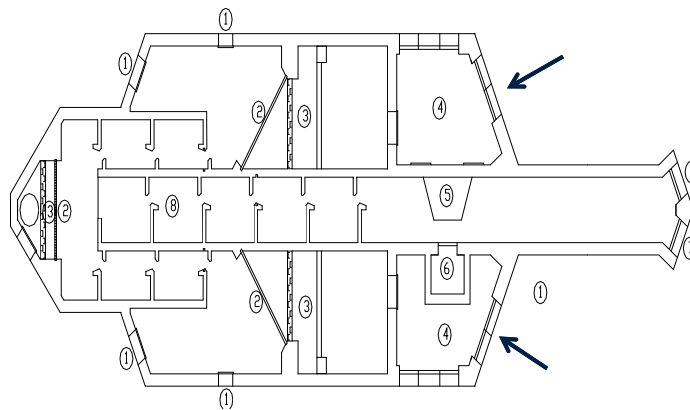
- It is a rack with smaller spacing than the downstream diffuser rack.
  - It is a physical way of preventing debris build up within the AWS.
  - It is a barrier to preclude fish that would be too small to get out through the downstream diffuser rack.

*Please refer to course handout, section 1.10*

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## AWS Fine Trash Rack



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### AWS Fine Trash Rack

Criteria:

- Clear space between the vertical flat bars of 7/8 inch or less, but **ALWAYS** less than the diffuser grating size opening specified above.
- Max through rack velocity must be less than 1 ft/s.
- Design must allow for cleaning of the system.

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## AWS Fine Trash Rack

Criteria...continued:

- The fine trash rack should be installed at a 1:5 (H:V) slope (or flatter) for ease of cleaning.
- Staff gages must be installed to indicate head differential.

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## AWS Fine Trash Rack

An interesting question...should my AWS fine trash rack comply with juvenile fish screen criteria?

*Maybe...*

*In instances where the AWS poses a risk to passage of juvenile fish (high head systems and convoluted flow paths), juvenile fish screen criteria applies to the design of the AWS fine trash rack.*

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## AWS Flow Control

What is it?

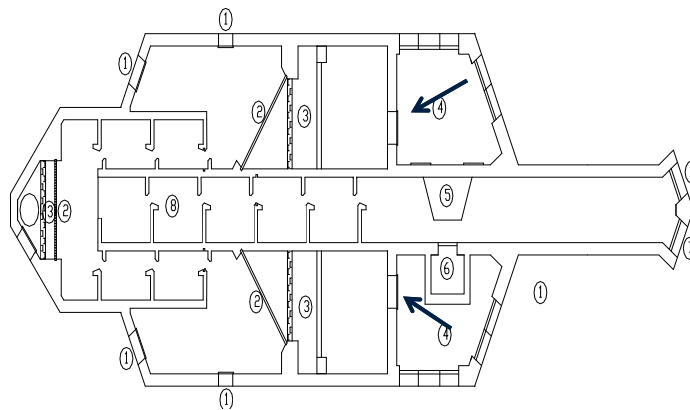
- It is a control gate, turbine intake, or other system, to ensure the AWS correct quantity of flow is discharged at all project operations.
  - Be careful...space it far enough downstream in the AWS, to ensure uniform flow distribution at the fine trash rack.

*Please refer to course handout, Section 1.10*

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## AWS Flow Control



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## AWS Excess Energy Dissipation

### What is it?

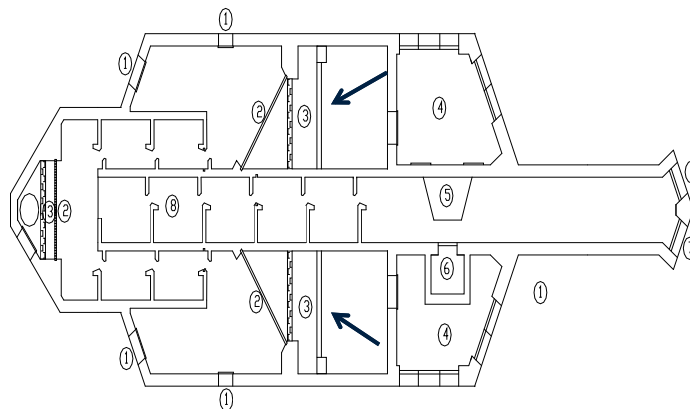
- It is a system to eliminate excess energy in the AWS. Excess energy may cause surging and non-uniform velocity distribution at the diffusers. It can be dissipated by passing flow through:
  - a pool and diffuser system,
  - a turbine,
  - a series of valves/weirs/orifices, or
  - a pipeline with concentric rings.

*Please refer to course handout, section 1.10*

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## AWS Excess Energy Dissipation



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## AWS Excess Energy Dissipation

Energy Dissipation Pool Volume:

$$V = \frac{(\gamma)(Q)(H)}{(16 \text{ ft-lbs/s}) / \text{ft}^3}$$

where:  $V$  = pool volume, in  $\text{ft}^3$   
 $\gamma$  = unit weight of water, 62.4 pounds (lb) per  $\text{ft}^3$   
 $Q$  = fish ladder flow, in  $\text{ft}^3/\text{s}$   
 $H$  = energy head of pool-to-pool flow, in feet




## Orifice Plate AWS Energy Dissipation

Photo Courtesy of Grant PUD






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### AWS Gravity Feed Butterfly Valve


Photo Courtesy of Grant PUD



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### AWS Energy Dissipation



(Photo courtesy of R2 Resource Consultants)

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## AWS - General Considerations

- The AWS must be valved or gated to provide for easy shutoff during maintenance activities.
- Consider bedload issues.

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## Transport Channel



What is it?

- A transport channel conveys flows and allows fish to pass between different sections of the upstream passage facility.

*Please refer to course handout, Section 1.11*

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Transport Channel

(Photo courtesy of R2 Resource Consultants)

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## Transport Channels

Criteria:

- Minimum of 5-feet deep.
- Minimum of 4-feet wide.
- Ambient natural lighting should be provided.

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## Transport Channels

Criteria...continued:

- Open channel design.
- No hydraulic or lighting transitions.

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## Transport Channels

Criteria...continued:

- Must not expose fish to any moving parts.
- Free of exposed edges that protrude from channel walls.

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## Counting Stations

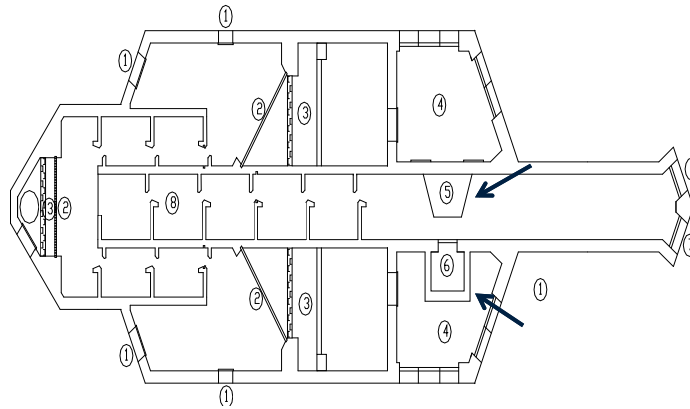
What is it?

- A place to observe and enumerate fish in the fishway. It can include:
  - a camera/fish count technician or both,
  - crowder,
  - leads, and
  - count window

*Please refer to the course handout, section 1.13*



## Counting Stations





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Photo Courtesy of Grant PUD

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Photo: A-JB  
2/4/02 7:18:26 PM  
Wanapum Green Window  
Direction: Going Upstream (Going Right)  
Comment: "Hatchery"  
Clip: gwsp00714x191425\_00000\_10\_ .mov File: gwsp00714x191426A\_ah4a\_0a1 .bat

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## Counting Stations - Location

Criteria:

- Located in:
  - a hydraulically stable,
  - low velocity (i.e., around 1.5 ft/sec), and
  - accessible area of the upstream passage facility.
- The pool downstream of the counting station at least two pool lengths from the downstream end of the picket leads.

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## Counting Stations - Location

Criteria....continued:

- The pool upstream extend at least one pool length from the upstream end of the picket leads.
- Both pools must be straight and in line with the counting station.

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## Counting Stations - Windows

### Criteria:

- Convenient to clean.
- Abrasion resistant.
- Vertically oriented.
- Window sill allow full viewing of the passage slot.

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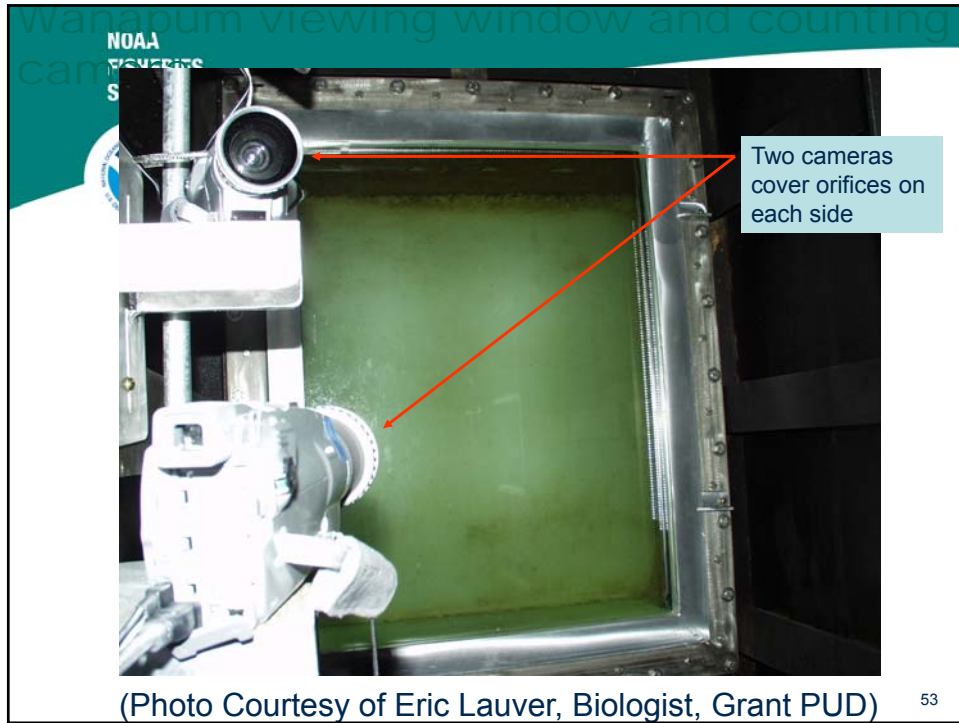


## Counting Stations - Windows


### Criteria...continued:

- Sufficient indirect artificial lighting to provide satisfactory fish identification at all hours of operation.
- Minimum width 5 feet.
- Minimum height full water depth.

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### Counting Stations – The Slot


What is it?

- The structure that concentrates fish into the crowded viewable area.

*Please refer to the course handout, section 1.13*

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## Counting Stations – The Slot

Criteria:

- Minimum width 18 in.
- Include an adjustable crowder.

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## Counting Stations – The Slot

Criteria...continued:

- Picket leads must be included in the design.
  - oriented at 45° relative to the direction of fishway flow.
  - clearance, and max velocity must conform to specs for diffusers.
  - flat stock bars, oriented parallel to flow,
  - max head differential through both sets less than 0.3 feet.
  - “witness marks” to verify correct position when installed.
  - opening to allow escape of smaller fish.

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## Counting Stations – Transition Ramp

What is it?

- A transition structure (a physical ramp guide) to minimize flow separations created by head loss.
  - Without the ramp, passage is impeded and fallback behavior occurs at the counting window.
  - These ramps provide gradual transitions between walls, floors and the count window slot.

*Please refer to the course handout, section 1.13*

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## Counting Stations – Transition Ramp

Criteria:

- Transitions should be more gradual than 1:8 (V:H).
- A free water surface must exist over a counting window.

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## Fishway Exit Section

What is it?

- It is a flow channel for fish to exit the fishway and attenuated forebay water surface elevation fluctuations.
- It may include the following features:
  - add-in auxiliary water valves and/or diffusers,
  - exit pools with varied flow,
  - exit channels,
  - coarse trash rack, and
  - AWS water fine trash racks and control gates.

*Please refer to course handout, section 1.14* <sup>59</sup>

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Fishway Exit



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## Fishway Exit Section

### Criteria:

- Length of a minimum of two standard ladder pools.
- Located along a shoreline
  - velocity zone of less than the cruising speed of the fish passed
  - sufficiently far enough upstream of a spillway, sluiceway or powerhouse to minimize the risk of fish falling back through these routes.

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## Fishway Exit Section

### Criteria...continued:

- Public access near the ladder exit should not be allowed.

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## Coarse Trash Rack

What is it?

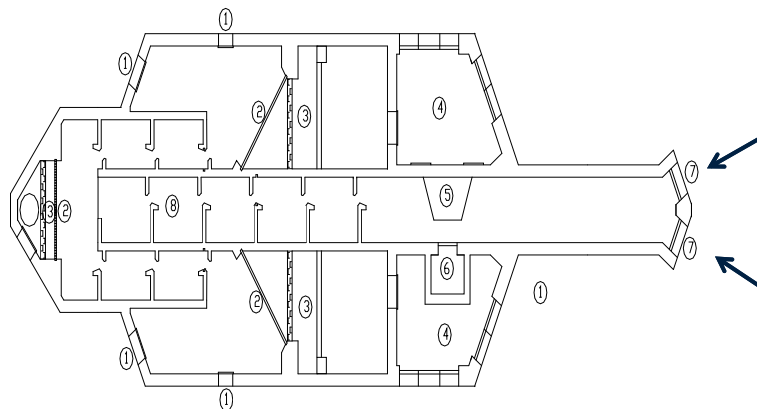
- A rack, at the exit of the fishway (where fish exit and flow enters), which is intended to keep out large debris and allow easy removal of debris.

*Please refer to course handout, section 1.15*

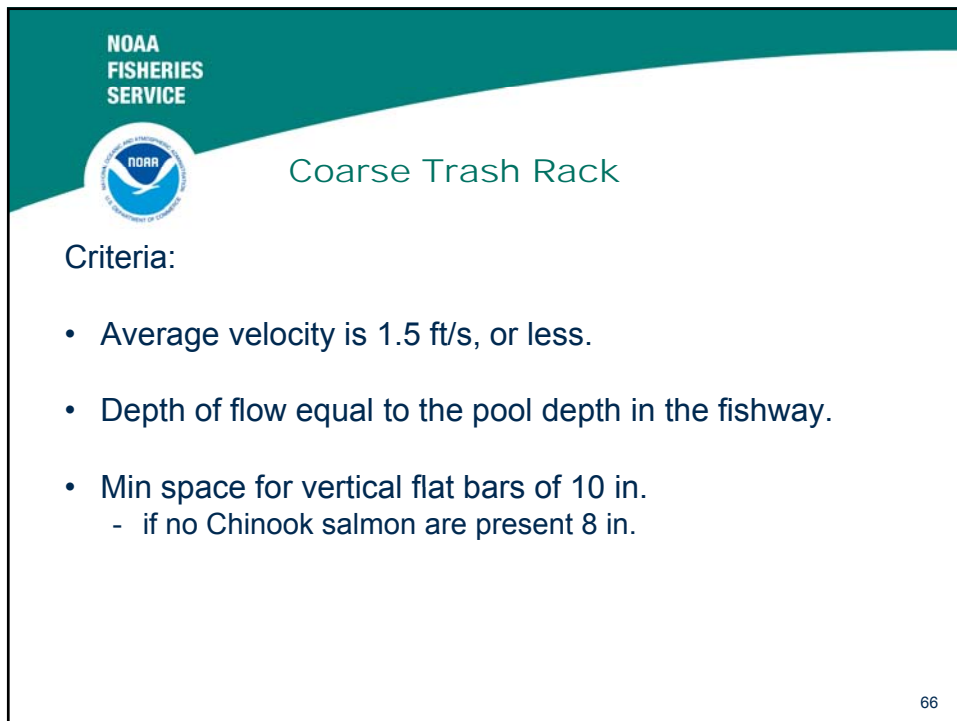
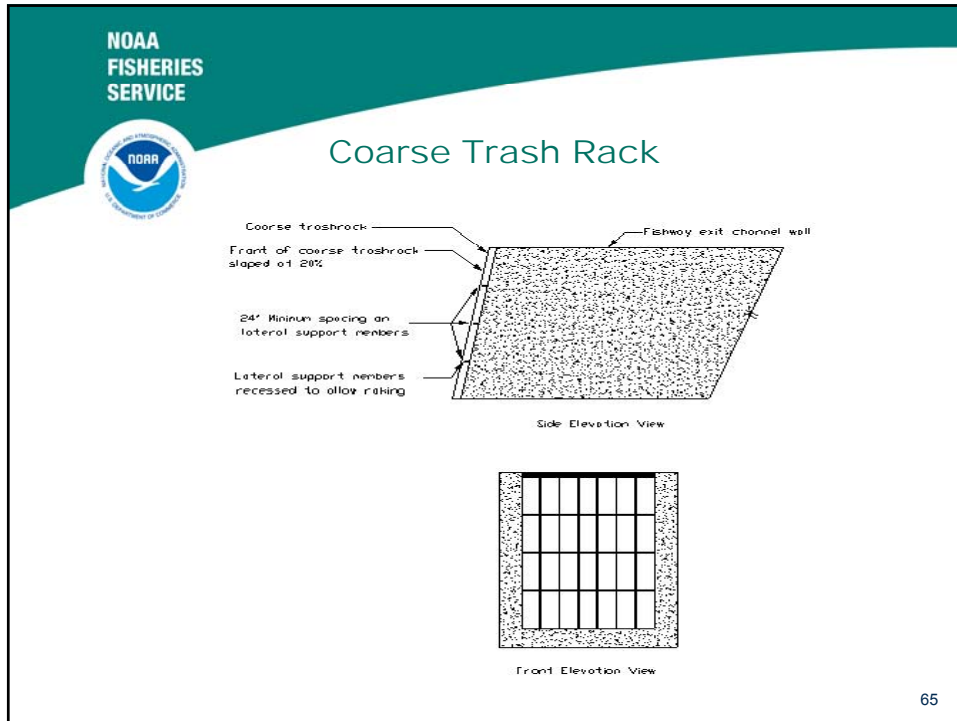
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## Counting Station



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## Coarse Trash Rack

Criteria...continued:

- The coarse trash rack should be installed at 1:5 (H:V) slope (or flatter) for ease of cleaning.
- The coarse trash rack design must allow for easy maintenance.





## Coarse Trash Rack

Criteria...continued:

- Lateral bar spacing min of 24 in.
  - sufficiently back set of the coarse trash rack face to allow full trash rake tine penetration.
- Extend to the appropriate elevation above water to allow easy removal of raked debris.
- Oriented at a deflection angle greater than 45° relative to the direction of river flow.

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## Miscellaneous Considerations

- Think about security issues.
- Natural lighting should be consistently provided throughout the fishway.
- Personnel access must be provided to all areas of the fishway.
- Walkway grating should allow as much ambient lighting into the fishway as possible.

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## Miscellaneous Considerations

- Provide smooth surfaces throughout the fishway.
- Protrusions must not extend into the flow path of the fishway.
- All control gates exposed to fish must have a shroud or be recessed to minimize or eliminate fish contact.