

Hells Gate Fishways Fraser River

Right Bank High
Gauge 54 - 70 ft

Right Bank Main
Gauge 20 - 54 ft

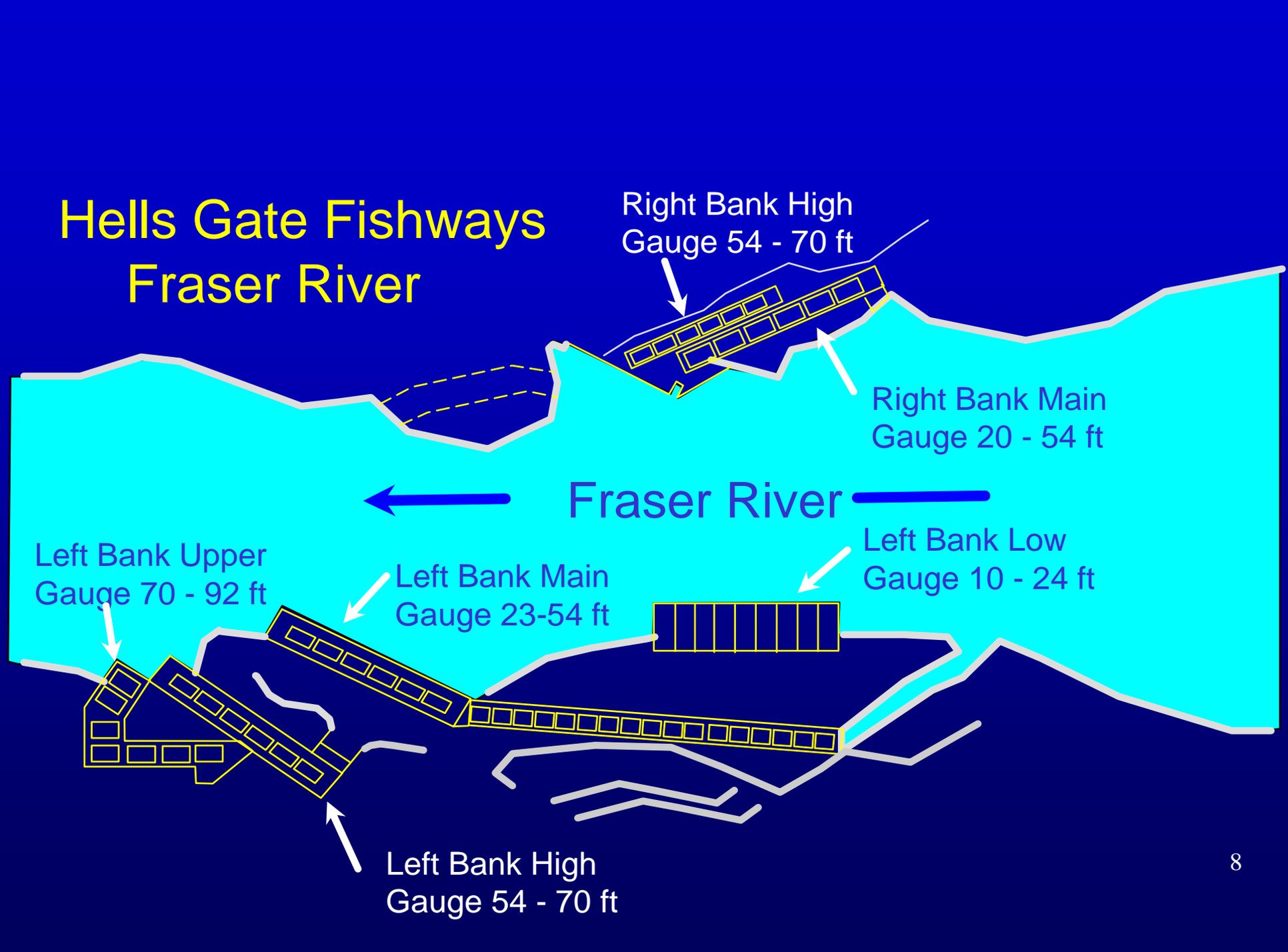
Fraser River

Left Bank Upper
Gauge 70 - 92 ft

Left Bank Main
Gauge 23-54 ft

Left Bank Low
Gauge 10 - 24 ft

Left Bank High
Gauge 54 - 70 ft





Right Bank High
Gauge 54 - 70 ft

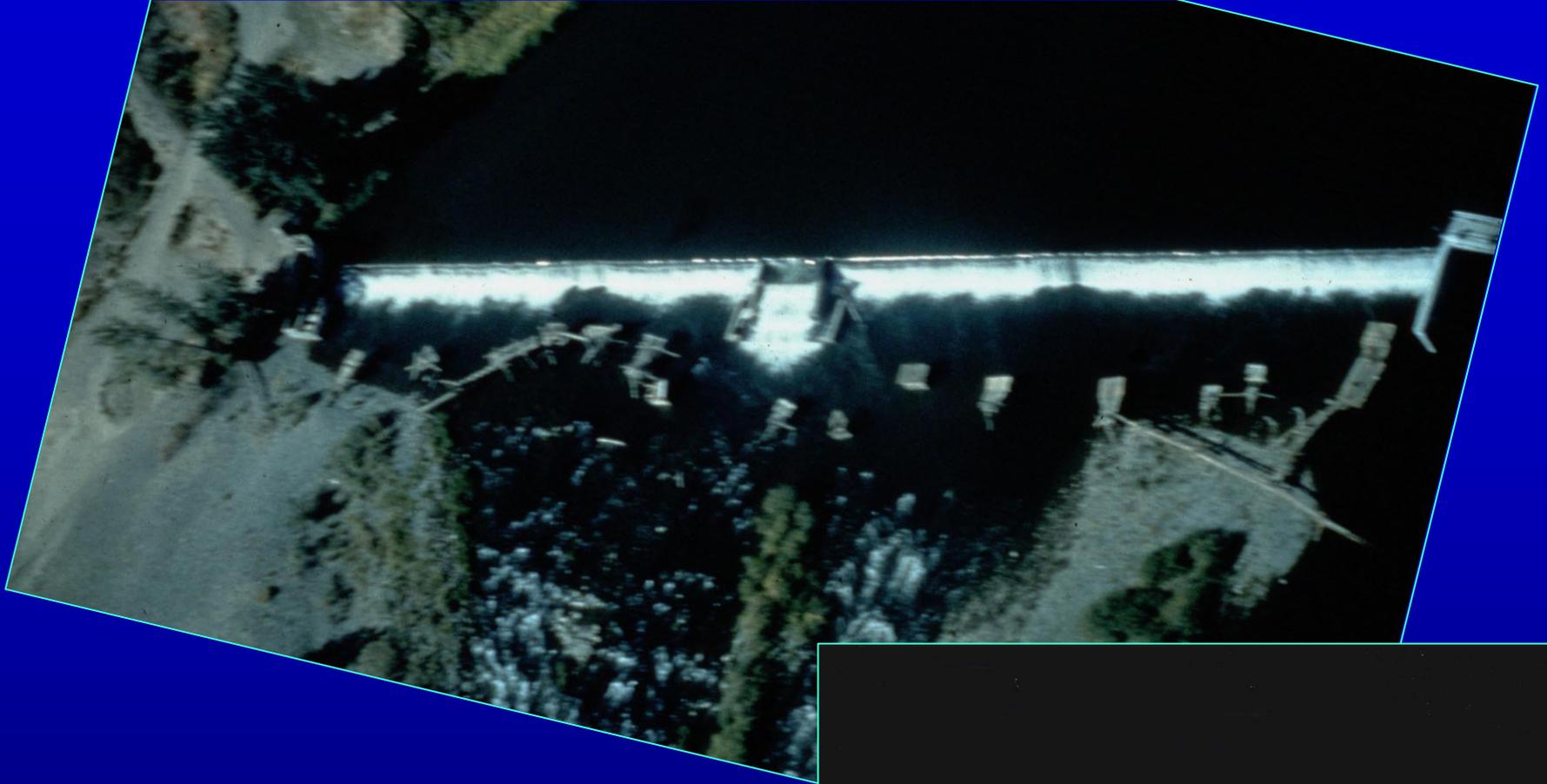
Right Bank Main
Gauge 20 - 54 ft

Left Bank Main
Gauge 23-54 ft



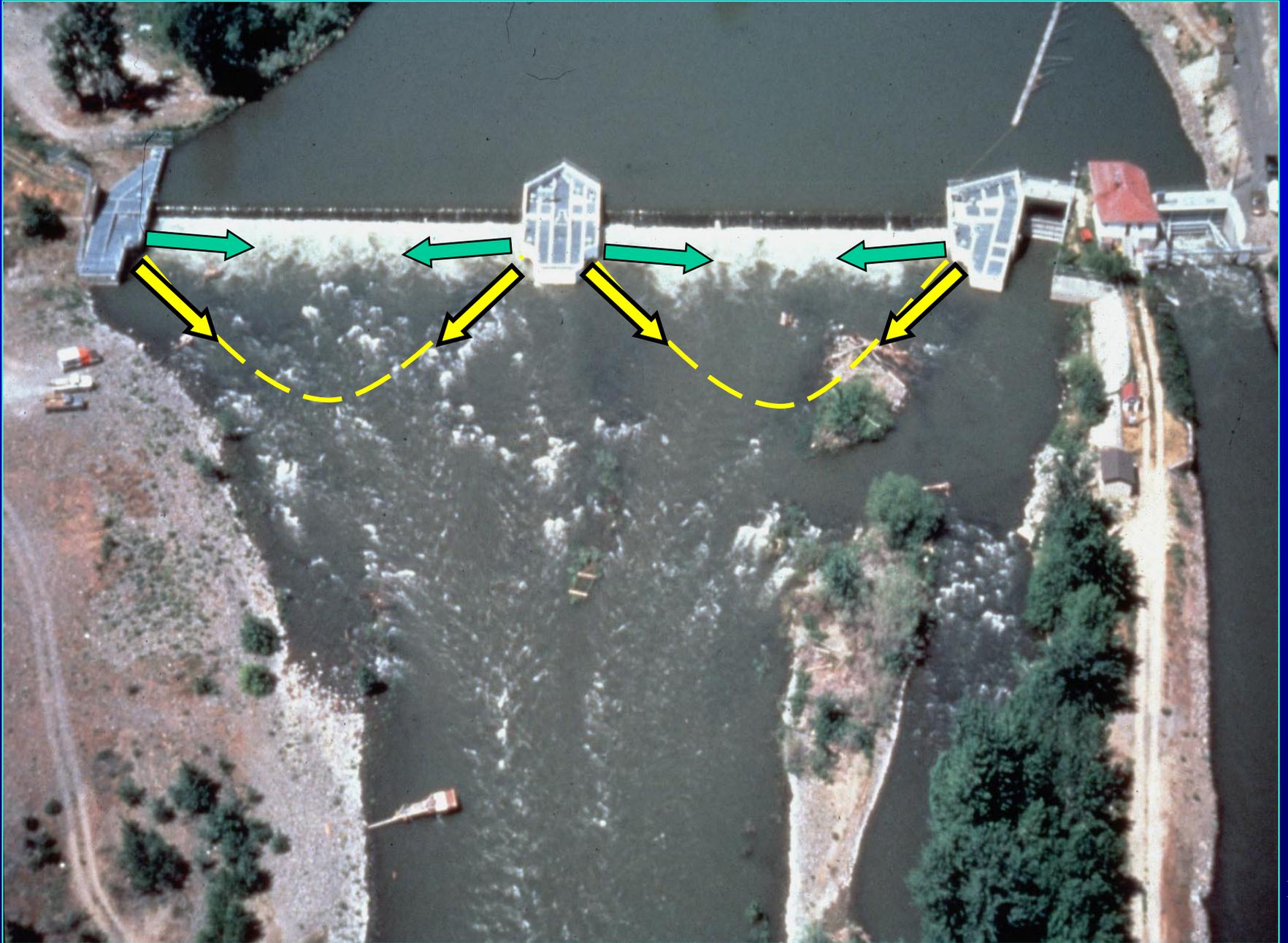
Left Bank Low
Gauge 10 - 24 ft





How many
fishways?
Entrances?



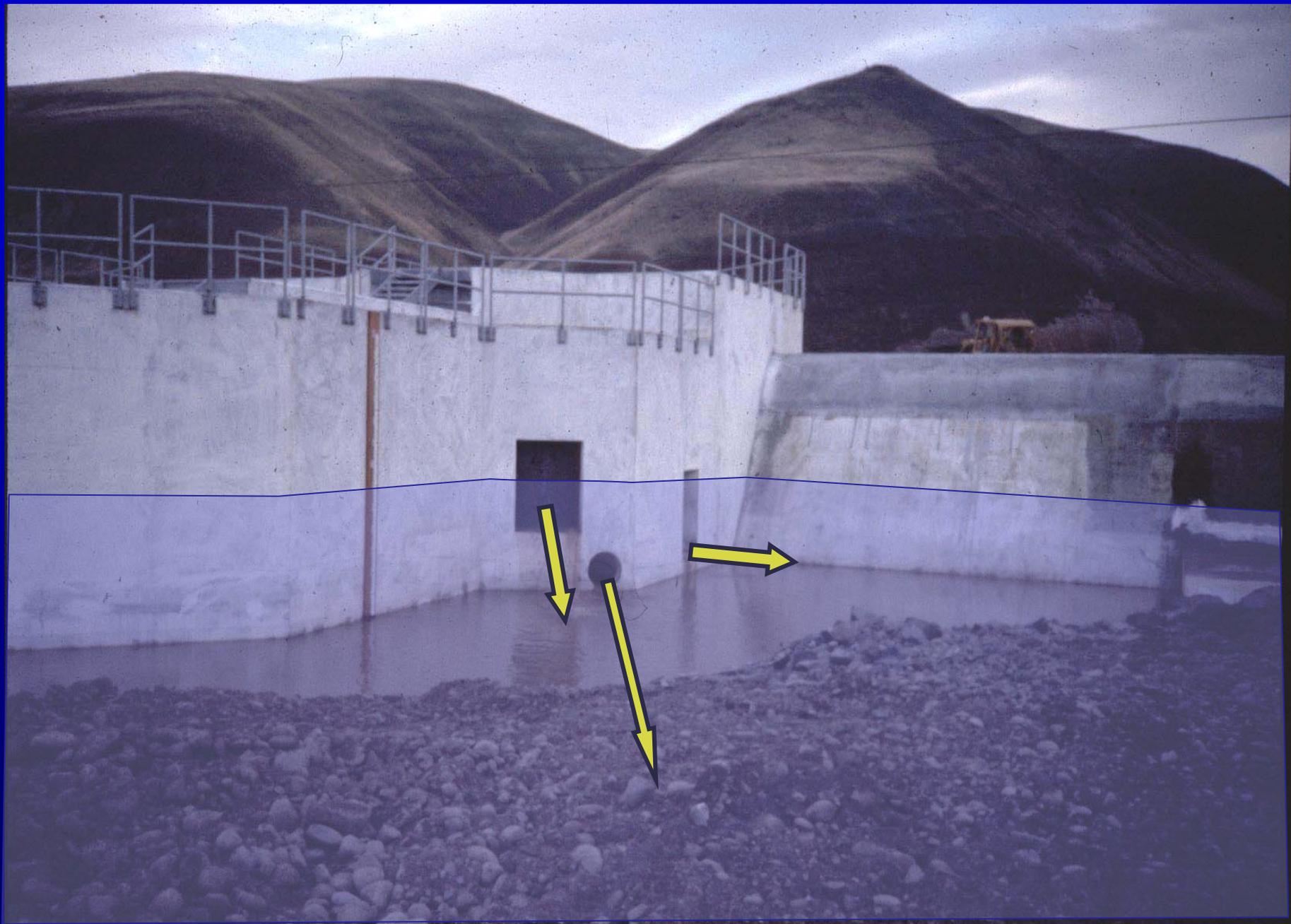




Fishway entrance attraction flow examples

Fishway; Location	Entrance flow; cfs	Design flow; cfs	Q_e / Q_{hp} %
Sunnyside - Yakima R	416	12,000	3.5
Sunset - Skykomish R	234	6,000	3.9
Naches Cowiche - Naches R	92	2,500	3.7
Centralia – Nisqually	80	1,750	4.6
Easton Dam – Yakima	120	1,300	9.2
Anderson Cr - Nooksack tr	9.7	112	8.7

NMFS Guidance (2008): Entrance attraction flow 5 to 10% of fish passage design flow





"That guy thinks like a fish."

A photograph showing a fishway entrance. On the left, there is a concrete structure with a metal grate and some electrical equipment. The water is turbulent and white with foam as it flows through the tailrace. The text is overlaid in the upper center of the image.

A good fishway entrance
extends the entrance into the tailrace

Fishway Entrance Preferences

Size (flow?)

Light

Percentage fish entering each orifice or [C] failing to enter any orifice.

Species	Percentage fish entering each orifice or [C] failing to enter any orifice.									
	3.9' x 3.9'	1.5' x 4.0'	C	Dark	1.5' x 2.0'	C	Dark	1.5' x 4.0'	C	
V = 8 fps Q = 78, 31 cfs	Chinook	41	48	11	49	9	42	2	93	5
	Coho	27	58	15	13	50	37	-	-	-
	Steelhead	45	46	9	63	17	20	11	87	2
V = 8 fps Q = 78, 16 cfs	Chinook	90	10	0	69	4	27	7	80	13
	Coho	100	0	0	67	20	13	10	90	0
	Steelhead	80	19	1	87	4	9	26	69	5

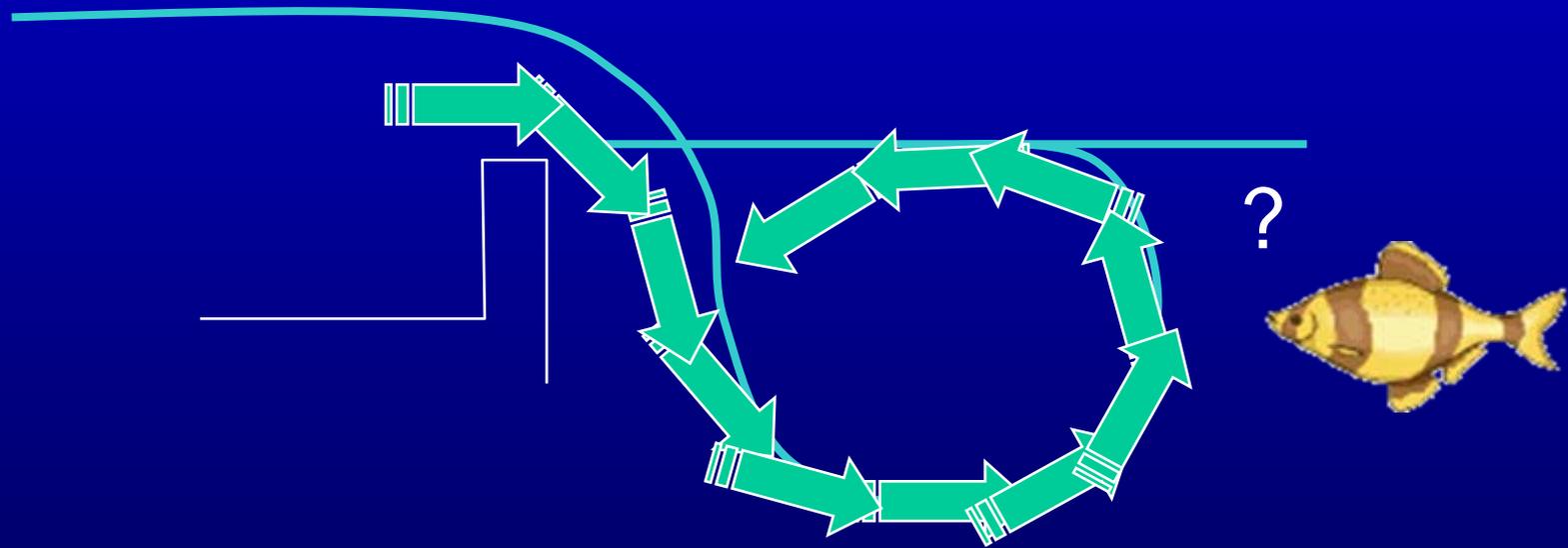
3.9' x 3.9'
 1.5' x 4.0'
 1.5' x 2.0'
 Dark

Fishway Entrance Preferences

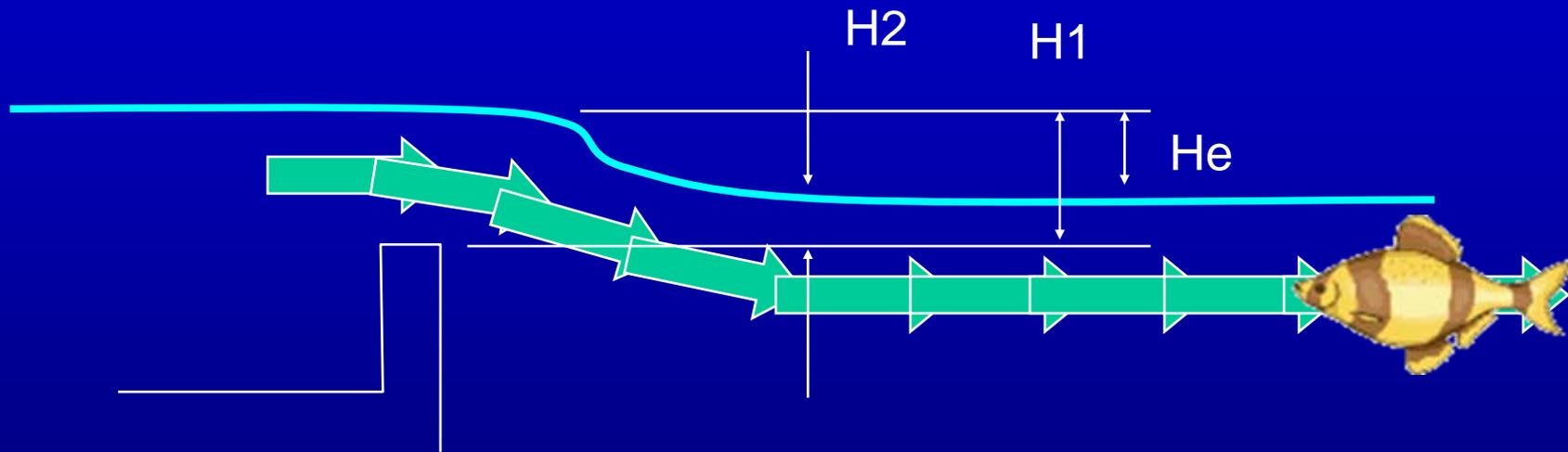
Velocity	Species	Percentage fish entering each orifice or [C] failing to enter any orifice.								
				C			C			C
V = 3.2, 8 fps Q = 31 cfs	Chinook	43	51	6	7	65	28	0	100	0
	Coho	21	79	0	0	75	25	0	100	0
	Steelhead	21	76	1	11	65	24	1	85	14
V = 1.6, 8 fps Q = 16 cfs	Chinook	51	46	3	9	23	68	3	95	2
	Coho	40	53	7	0	15	85	15	85	0
	Steelhead	37	54	9	22	56	22	0	71	9

 3.9' x 3.9'
  1.5' x 4.0'
  1.5' x 2.0'
  Dark

Plunging entrance flow



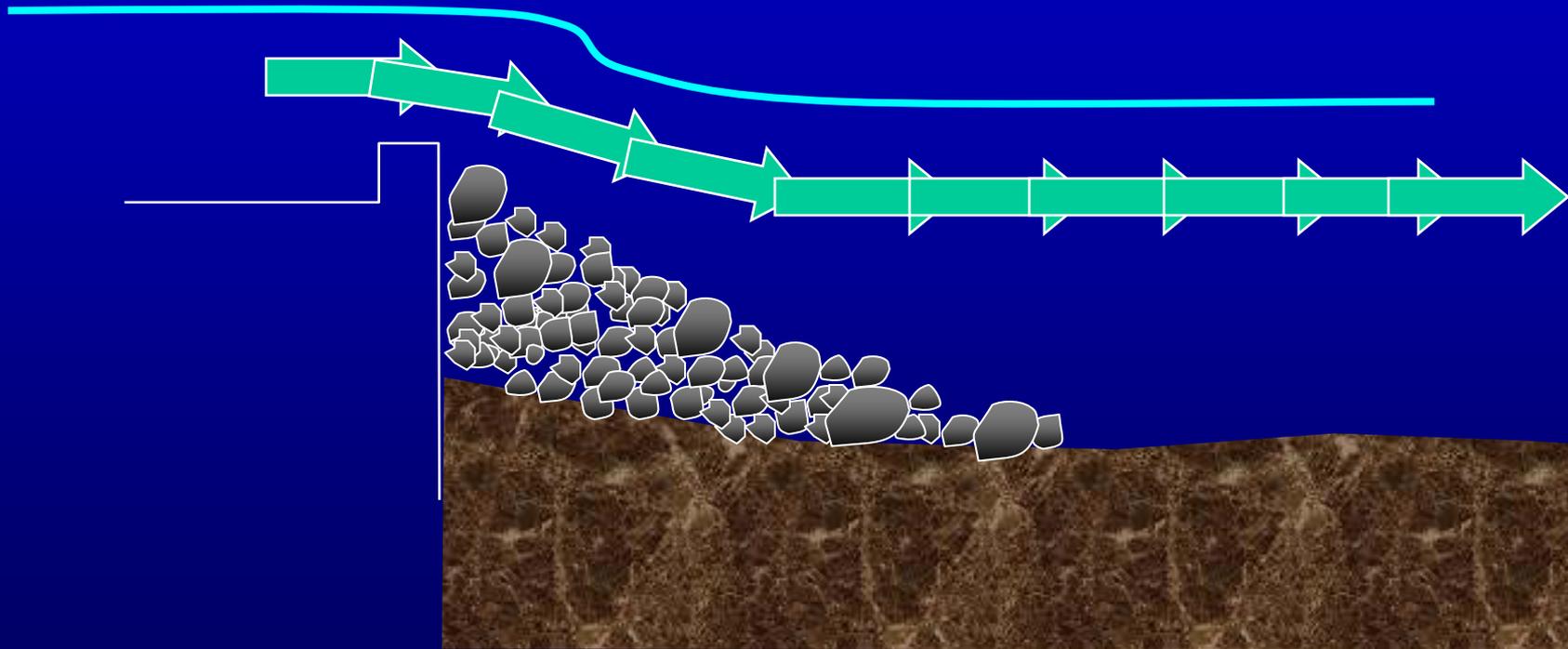
Streaming entrance flow



$H1 > 1.5 He$ (a Kozmo rule of thumb)

(Submerged weir equation)

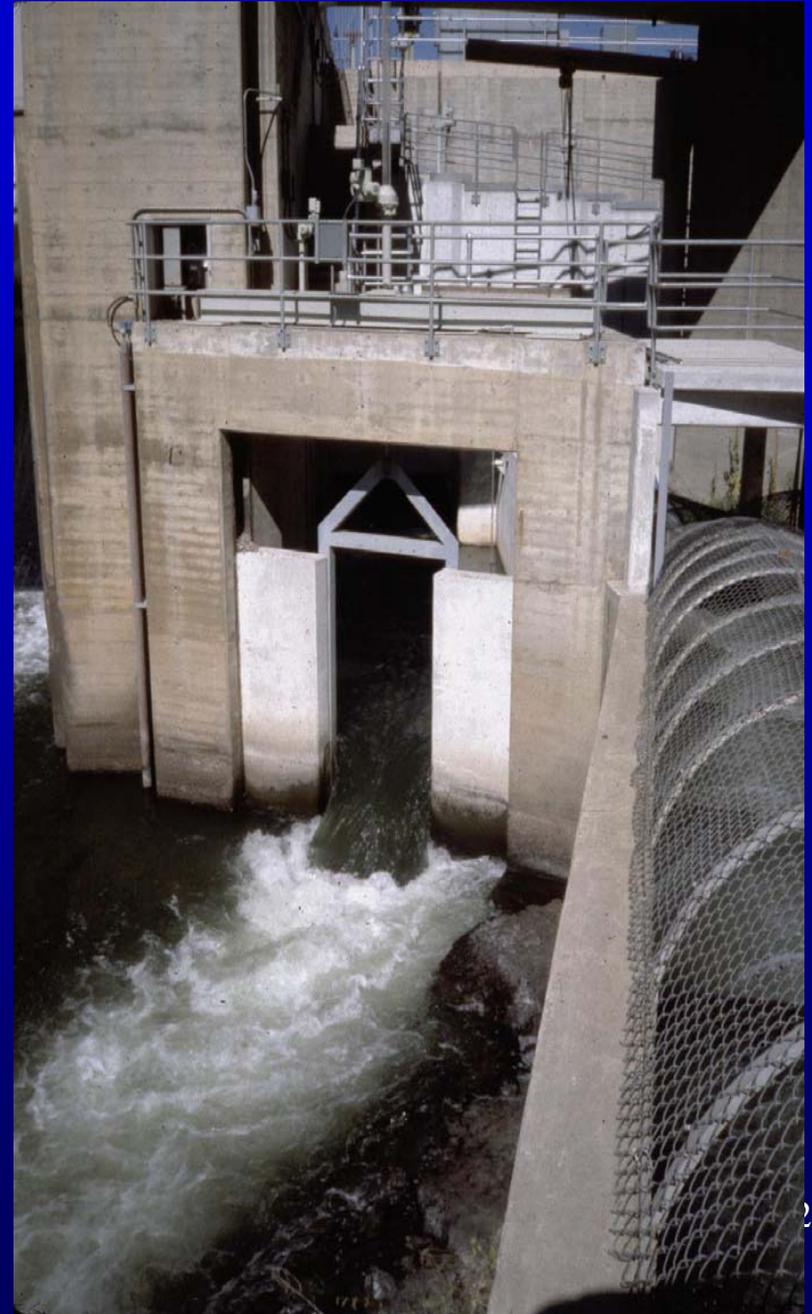
Streaming entrance flow



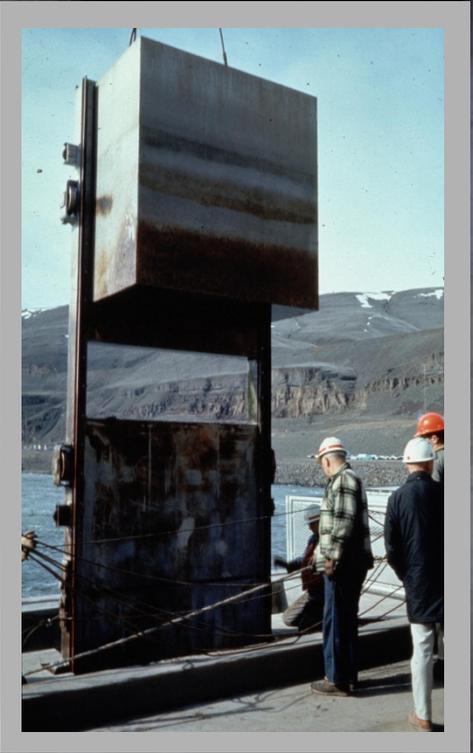
Static weir entrance



Telescoping entrance

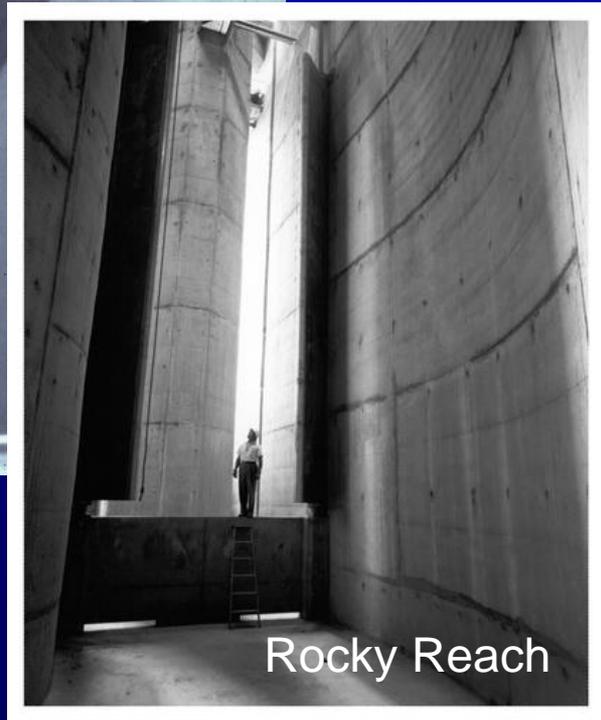


Orifice entrance





Wing gate entrance





Nappe entrance





Attraction jet
Extends entrance



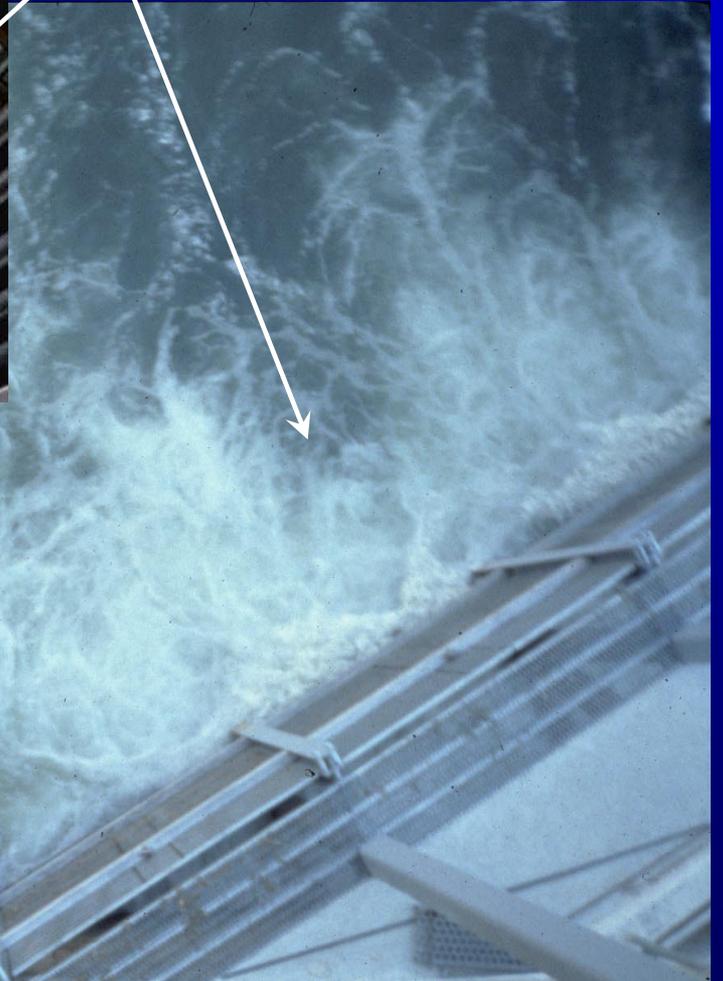
Sloping weir with notch
Doesn't always help



Photo: Stream Corridor Restoration 10/98



Wasteway flow aerated and spilling



Fishway entrance



Fishway water supply

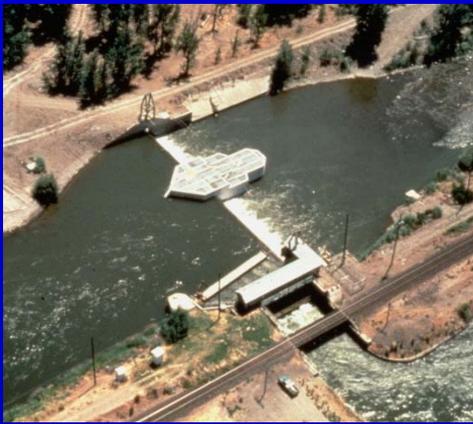


Angled Spillway



Fishway Entrance Pools

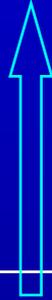
- Access to fishway
- Attraction
- Introduce auxiliary water
- Hydraulic control for multiple entrances
- Transition from river to concrete
- Combine multiple entrances



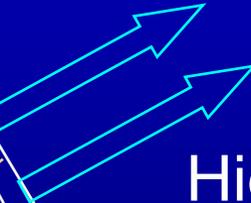
Spillway
(Powerhouse)



Low Flow Entrance
3'x5'

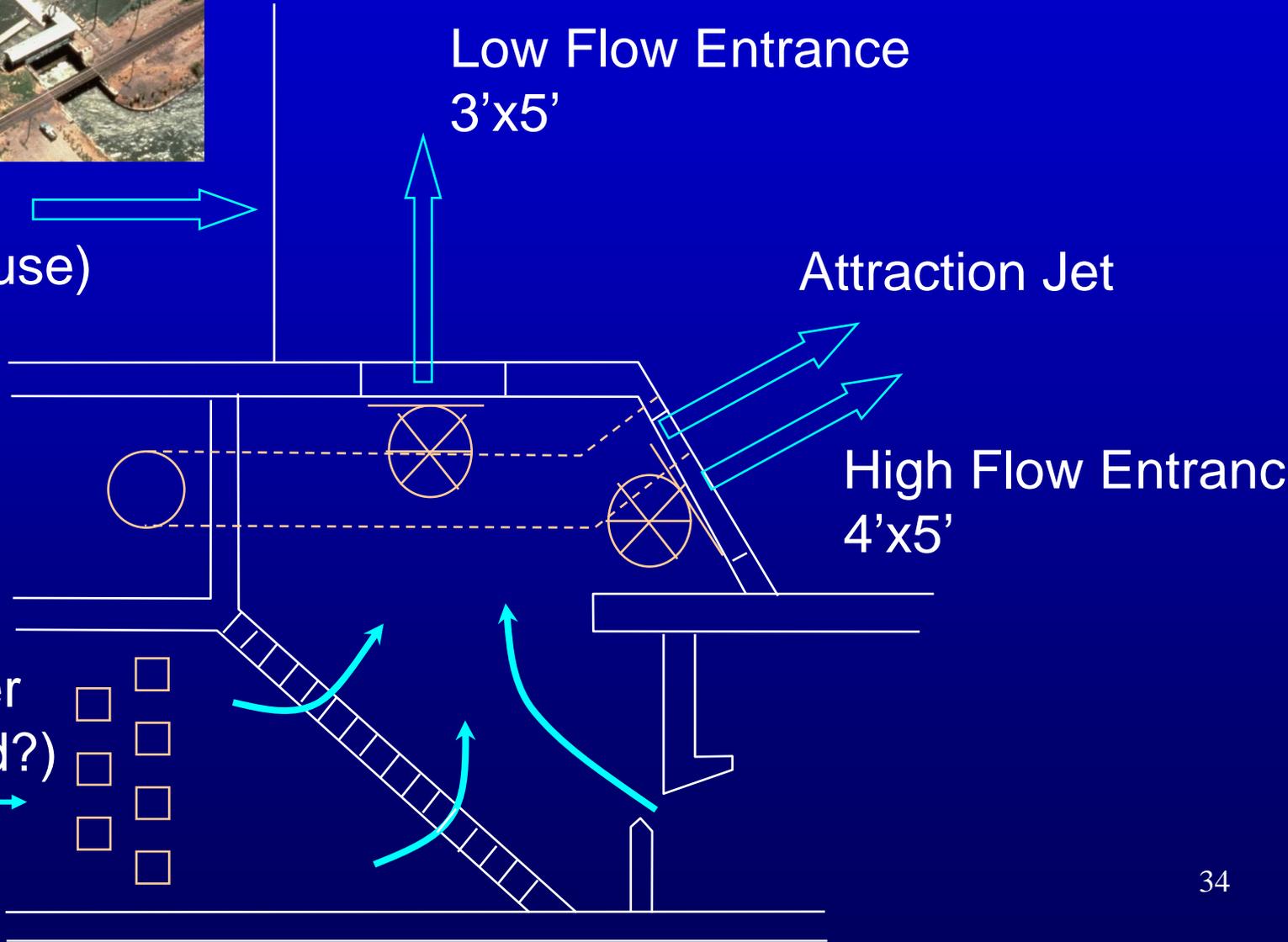
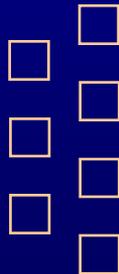


Attraction Jet

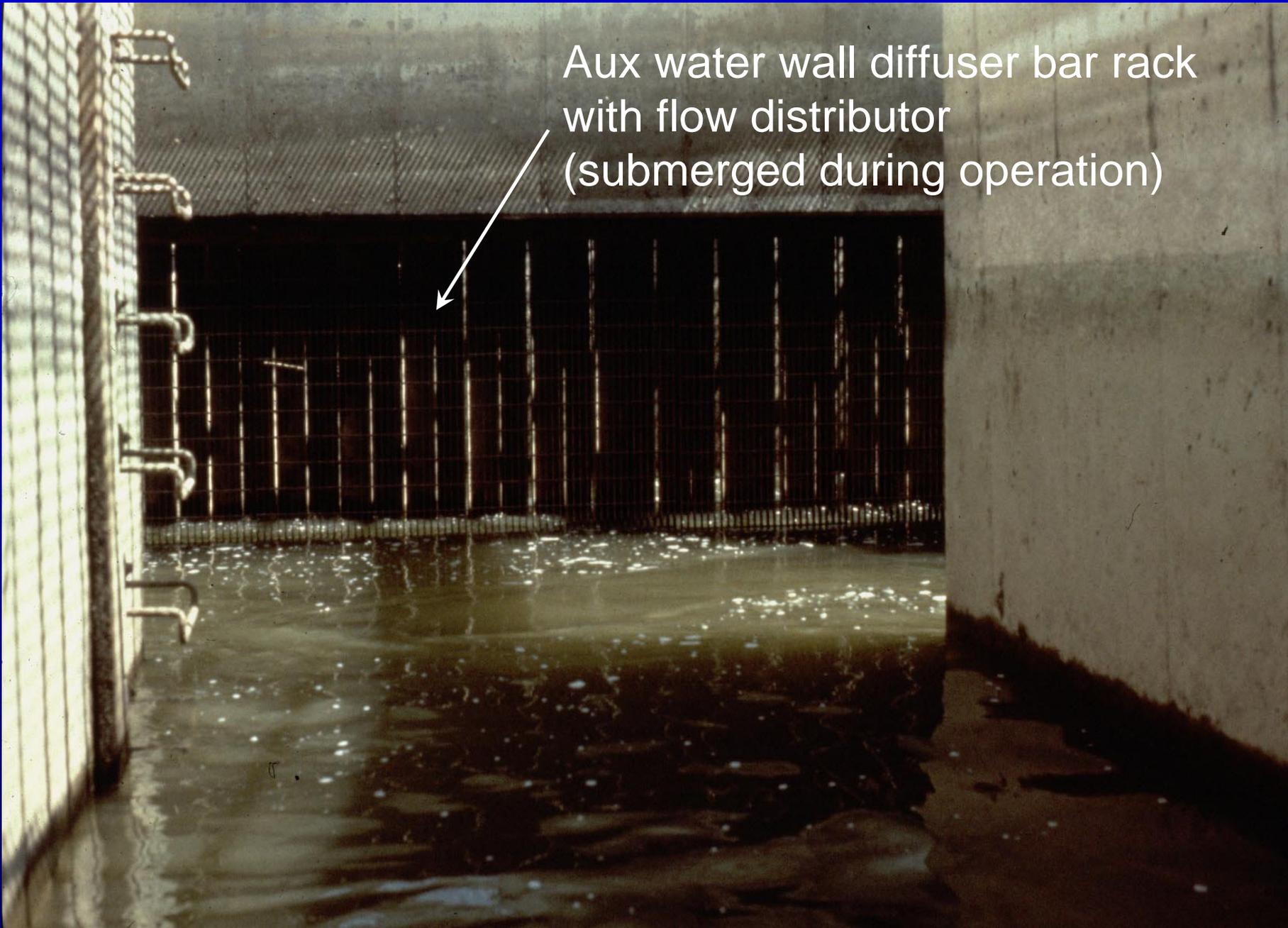


High Flow Entrance
4'x5'

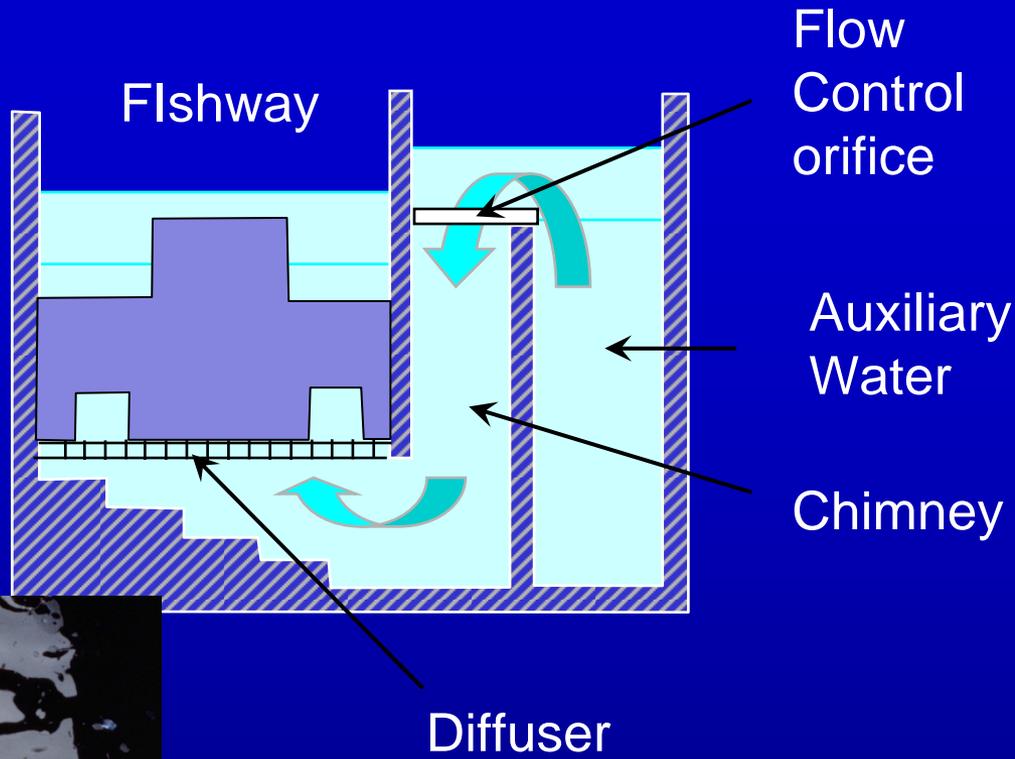
Aux Water
(screened?)



Aux water wall diffuser bar rack
with flow distributor
(submerged during operation)

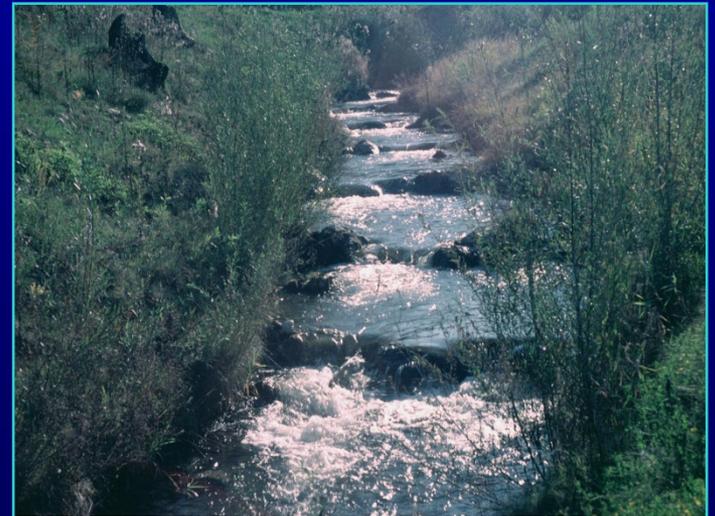


Auxiliary Water Chimney



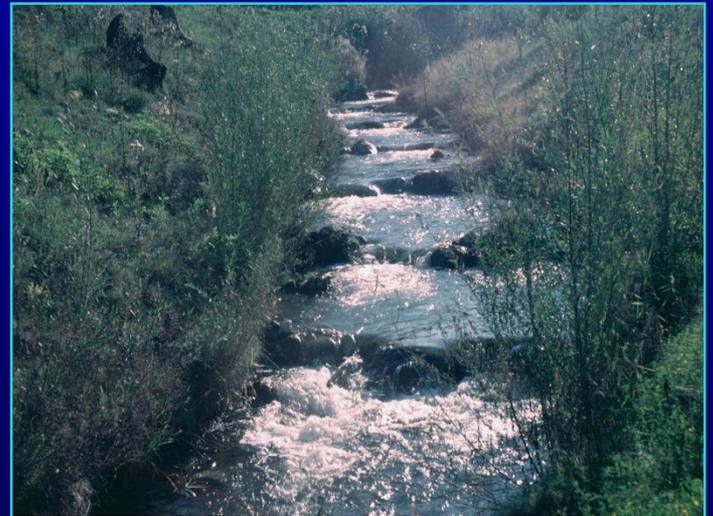
Fishway Styles at Hydro Plants

- Pool fishways
 - Pool and weir
 - Vertical slot
 - Pool and chute
- Roughened channels
 - “Natural” channel
 - Denil, Steeppass
- Mechanical
 - Lifts, locks, trams
 - Trap and Haul



Selection of fishway style

- Project objectives, mitigation goal
- Species and age class – ability, behavior
- Scale and context of river; channel, hydrology
- Single or series
- Flow control available
- Water availability
- Dependability of O&M
- Debris, bedload, ice



Pool-Style Fishway Design Parameters

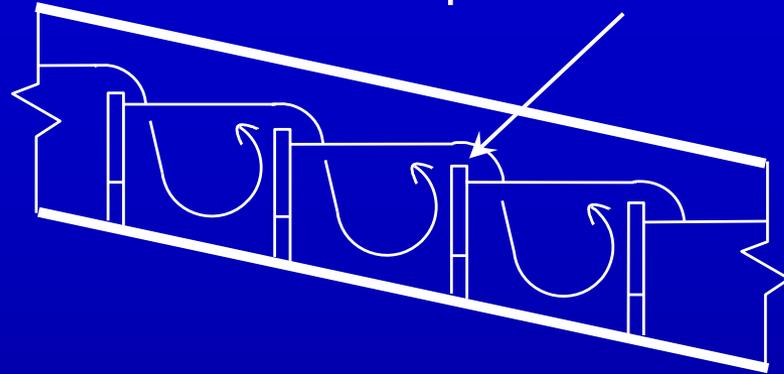
- Step type; orifice, weir, chute
- Pool volume
 - Fish capacity
 - Turbulence
- Step head differential
- Depth over weirs
- Flow regime; plunging, streaming
- Pool depth
- Freeboard
- Flow control



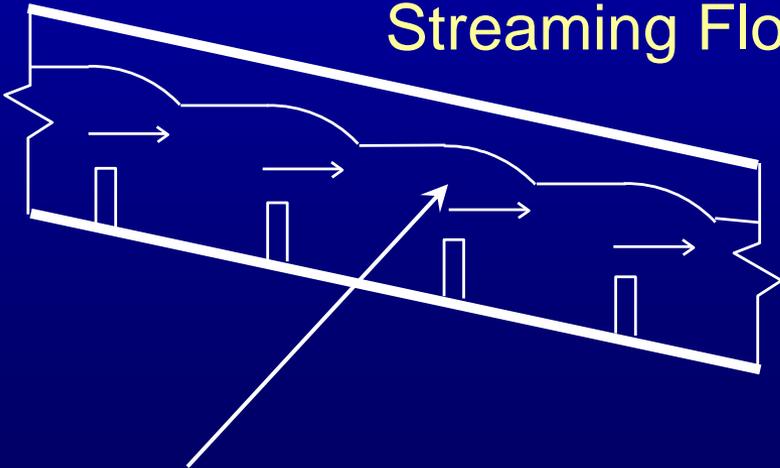
Plunging Flow (weir)



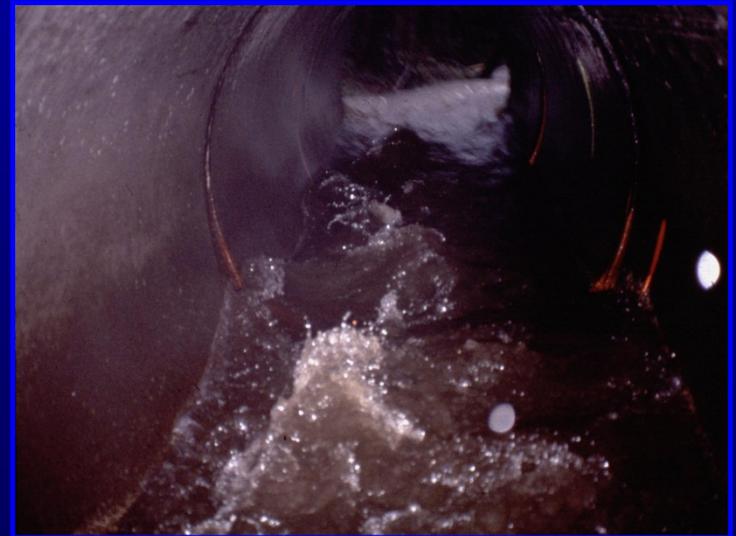
Shallow flow depth over weir
with respect to weir height



Streaming Flow (baffle)



Increased flow depth over baffle
with respect to baffle height



Fish behavior



Species	Behavior	Fishway type	Flow
Chinook	Move at bottom	All, prefer orifices	P, S
Coho	Leap, swim through	All	P, S
Sockeye	Leap, swim through	All	P, S
Chum	Swim through	All	S
Pink	Swim through	All	S
Steelhead	Move at bottom, leap	All, prefer orifices	P, S
Juvenile salmon		Pool and weir, surface	P
Atlantic salmon	Leap, swim through	All	P, S
American shad	Swim through	All, streaming flow	S
Sturgeon	Move at bottom	Orifices	S
Lamprey	Attaches	Orifices	S

P = Plunging
S = Streaming

Pool style fishway design criteria

Design Criteria for Pacific Salmon

Pool volume; Energy dissipation factor 4 ft-lb/sec/ft³

Head differential 1.0 foot (higher at entrance)
0.7 foot; salmon fry (less at entrance)

Flow regime streaming flow; chum, pink, lamprey, shad
plunging flow; juveniles

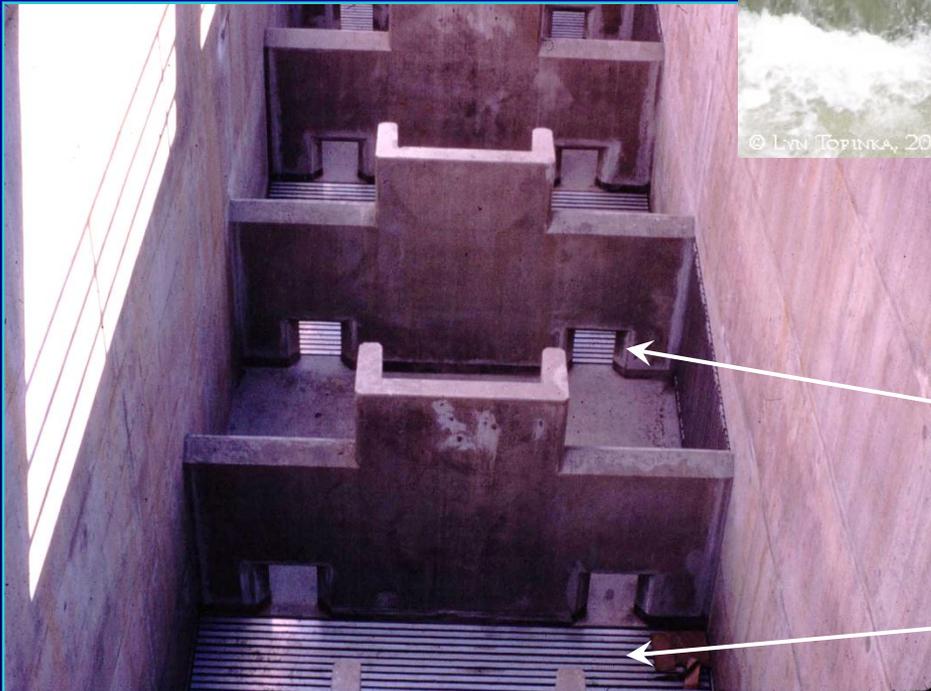
Depth over weir crest 0.33 foot minimum

Water depth 3 – 5 ft

Freeboard 3.0 foot minimum

Fishway Styles

Ice Harbor
Pool and weir fishway



Rocky Reach

Ice Harbor fishway orifice

(Aux water floor diffuser)



Seiche: *fr*
“to sway back and forth”

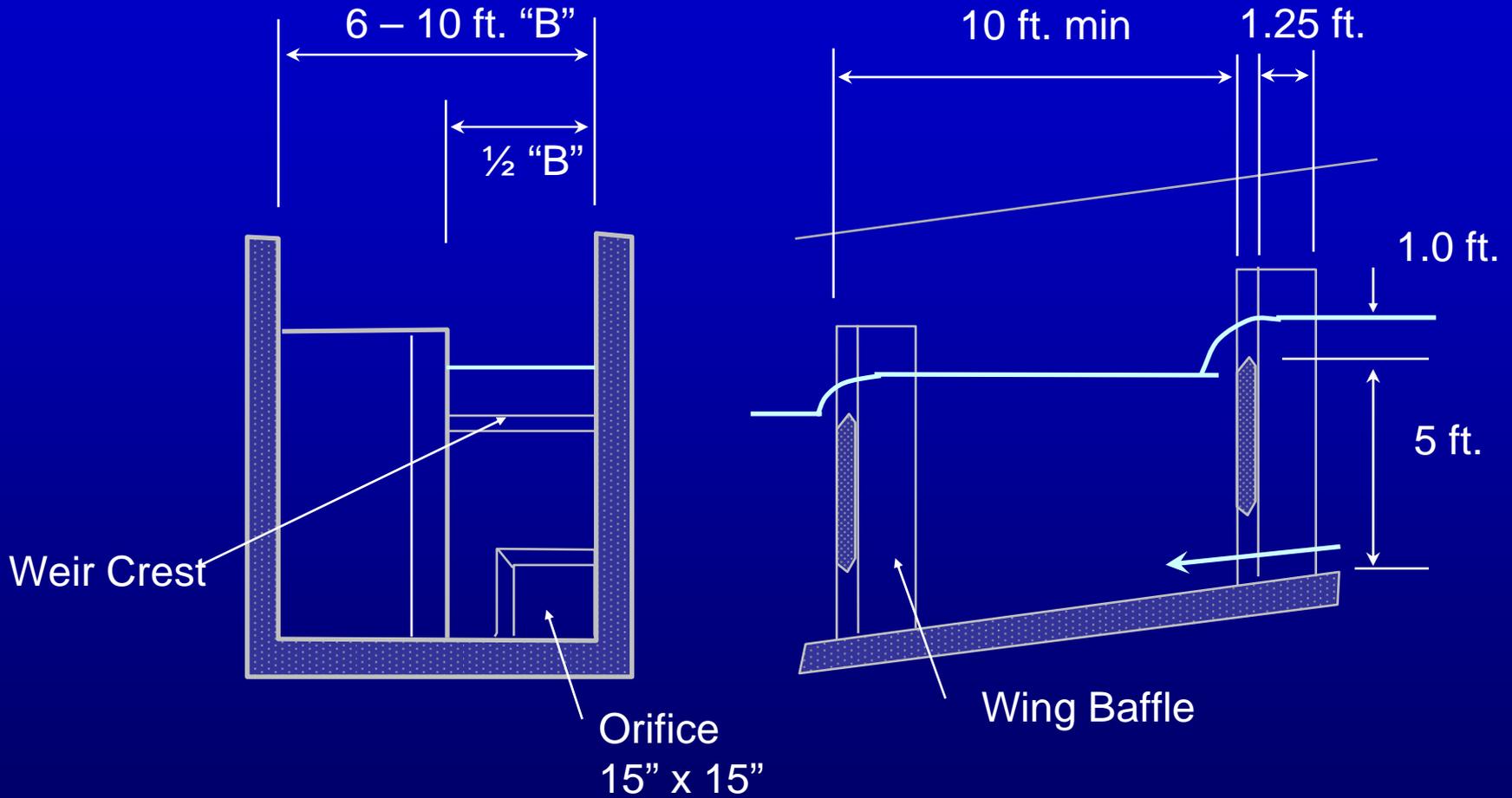
16 - 56

Half Ice Harbor



Kristen Abraham pic

Half Ice Harbor Fishway



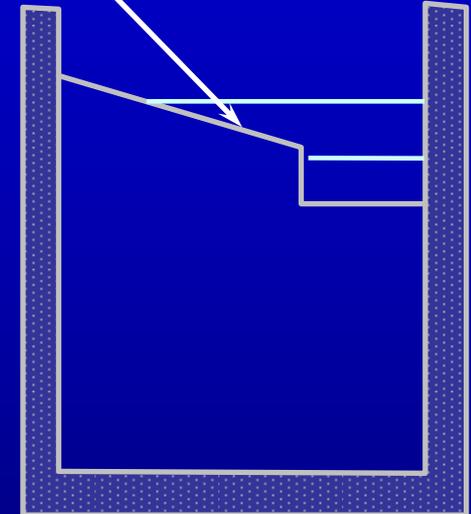
Weir Elevation View

Weir Section View

Simple Pool and Weir designed for juv passage

Weir Crest for
juvenile passage

4 – 6 + ft.



Little Park Cr

Orifice Fishway with Bed Material



Buffalo Fishway
Henry's Fork Snake River



L. Mabey pic

E. Gaedeke pic

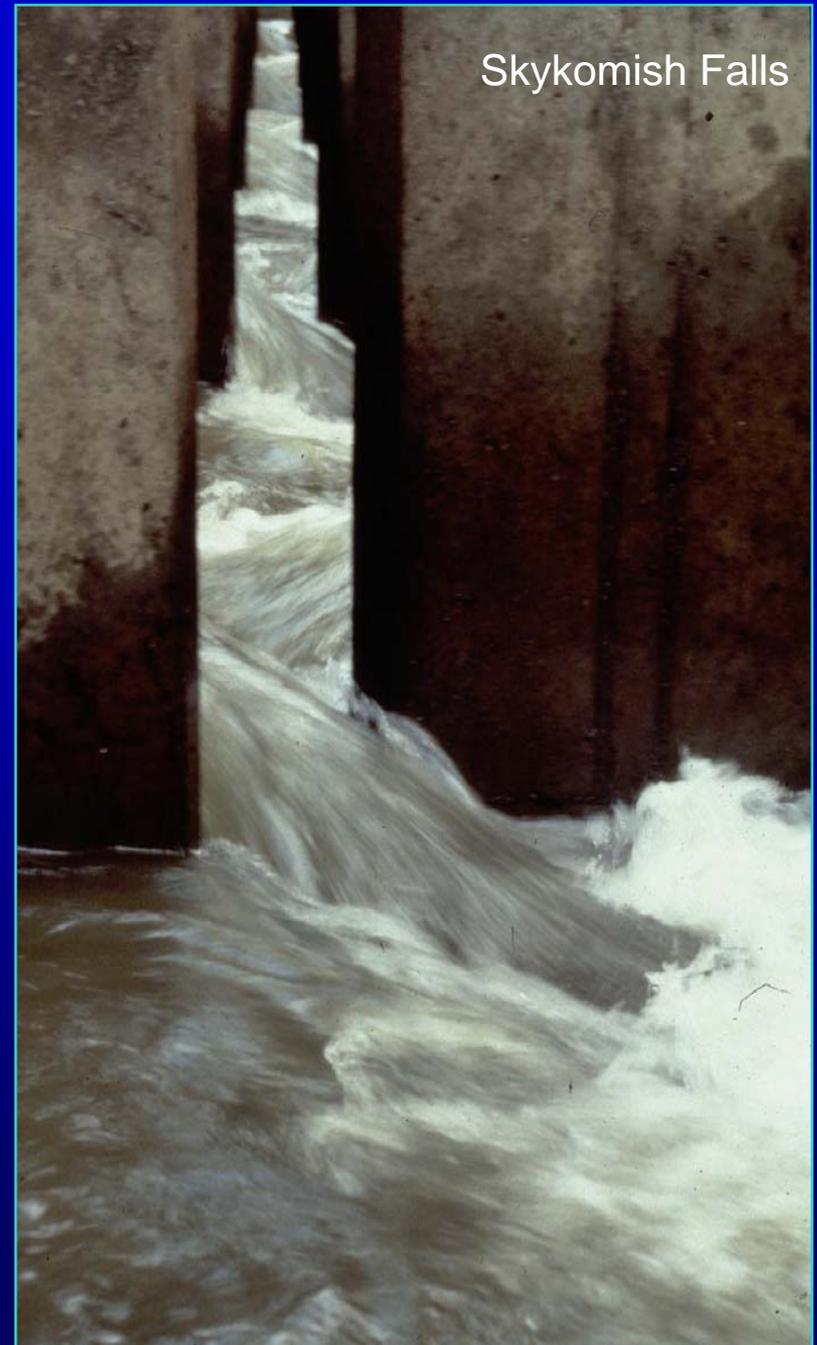
Pool and Weir Fishway Summary

- Most applicable fishway at hydro
- Individual pools, Energy dissipated within pools
- - Surface flow (if no orifices)
- + Orifice passage possible
- + Wall passage corridor possible
- + Low flow operation (if no orifices)
- - Narrow flow operating range. Flow control required.
- - Affected by sediment and debris
- + Simple design, construction, maintenance

Vertical Slot Fishways



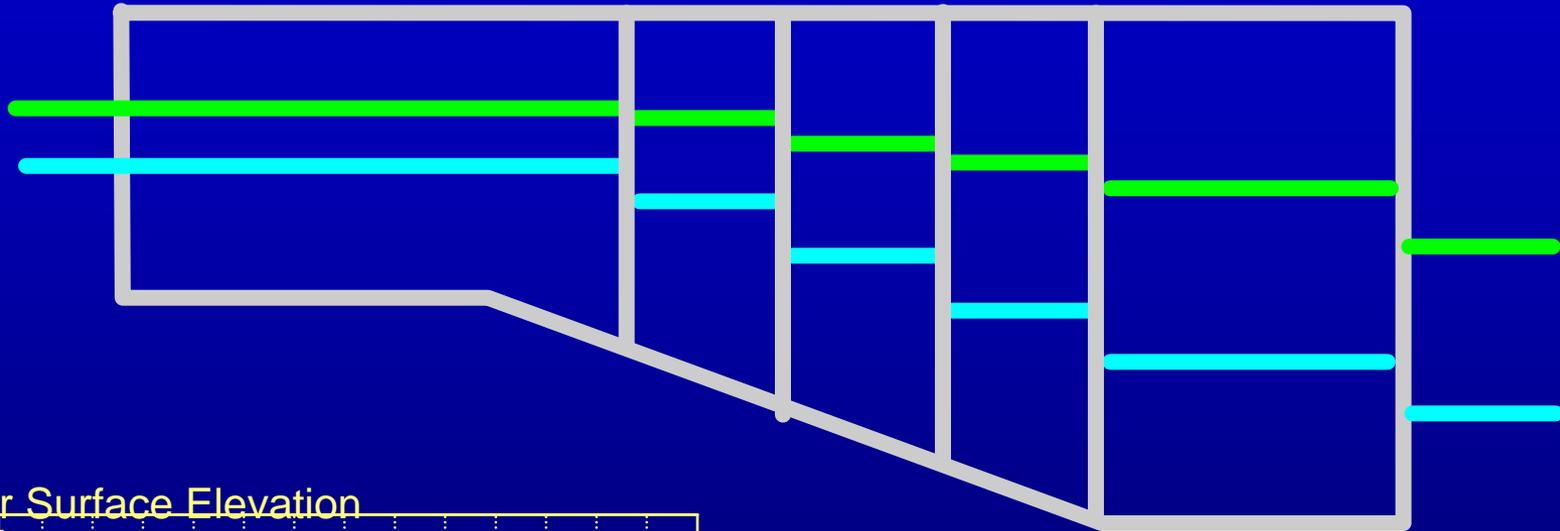
Leaburg-Waltermville
E. Gaedeke pic



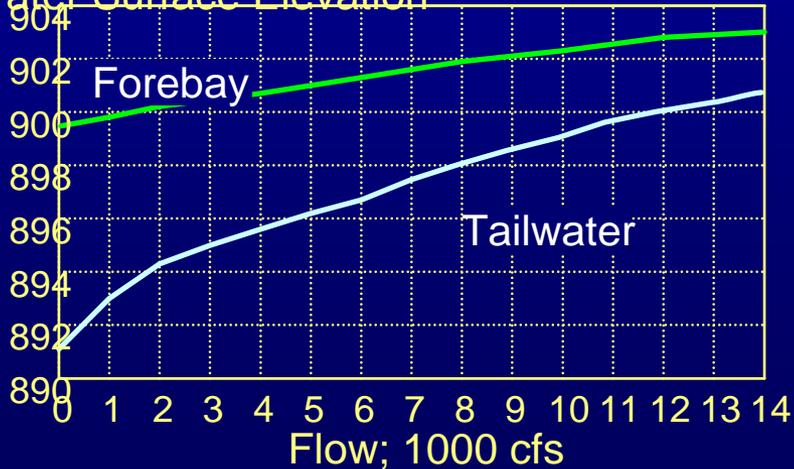
Vertical Slot Fishway

Forebay

Tailwater

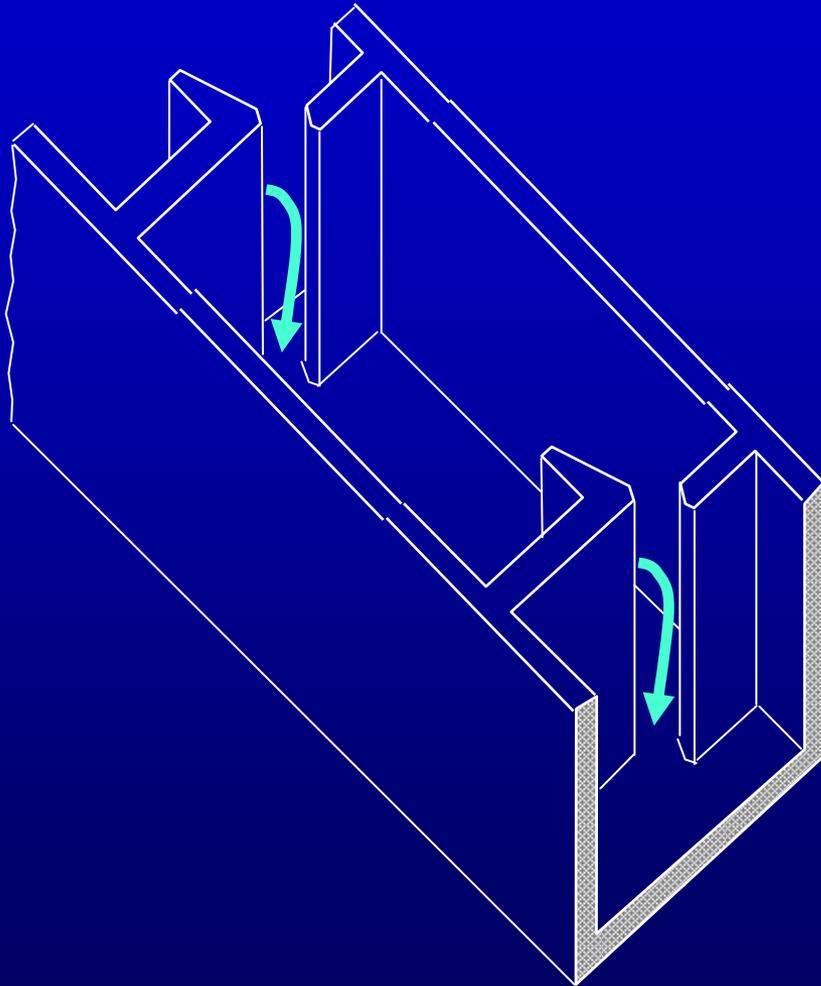


Water Surface Elevation

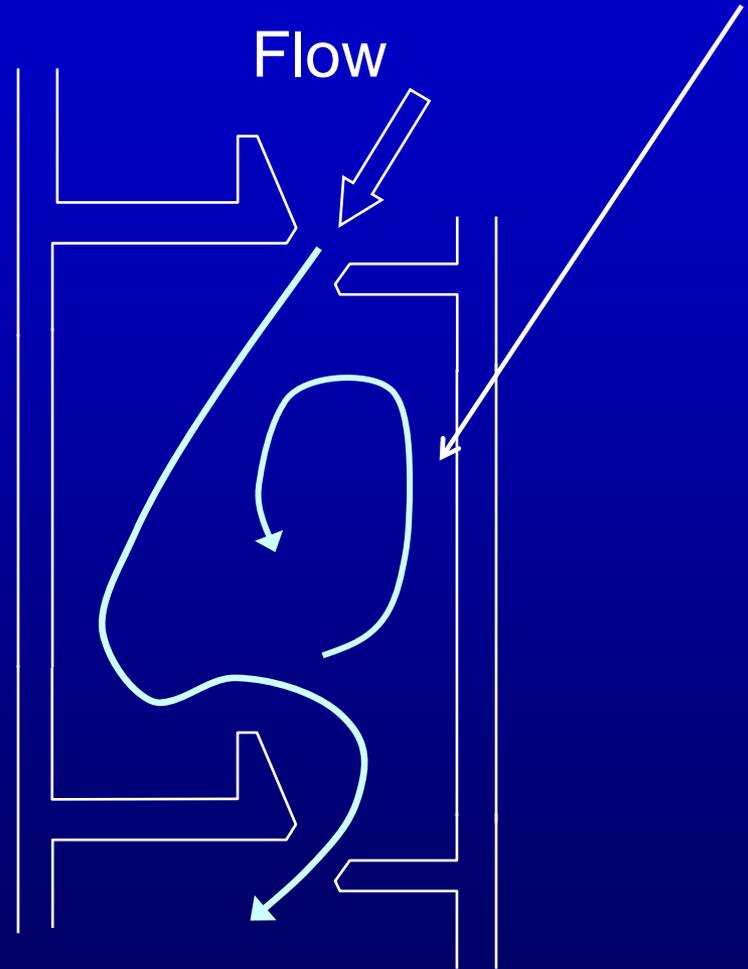


++ Vertical Slot is Self regulating with consistent EDF

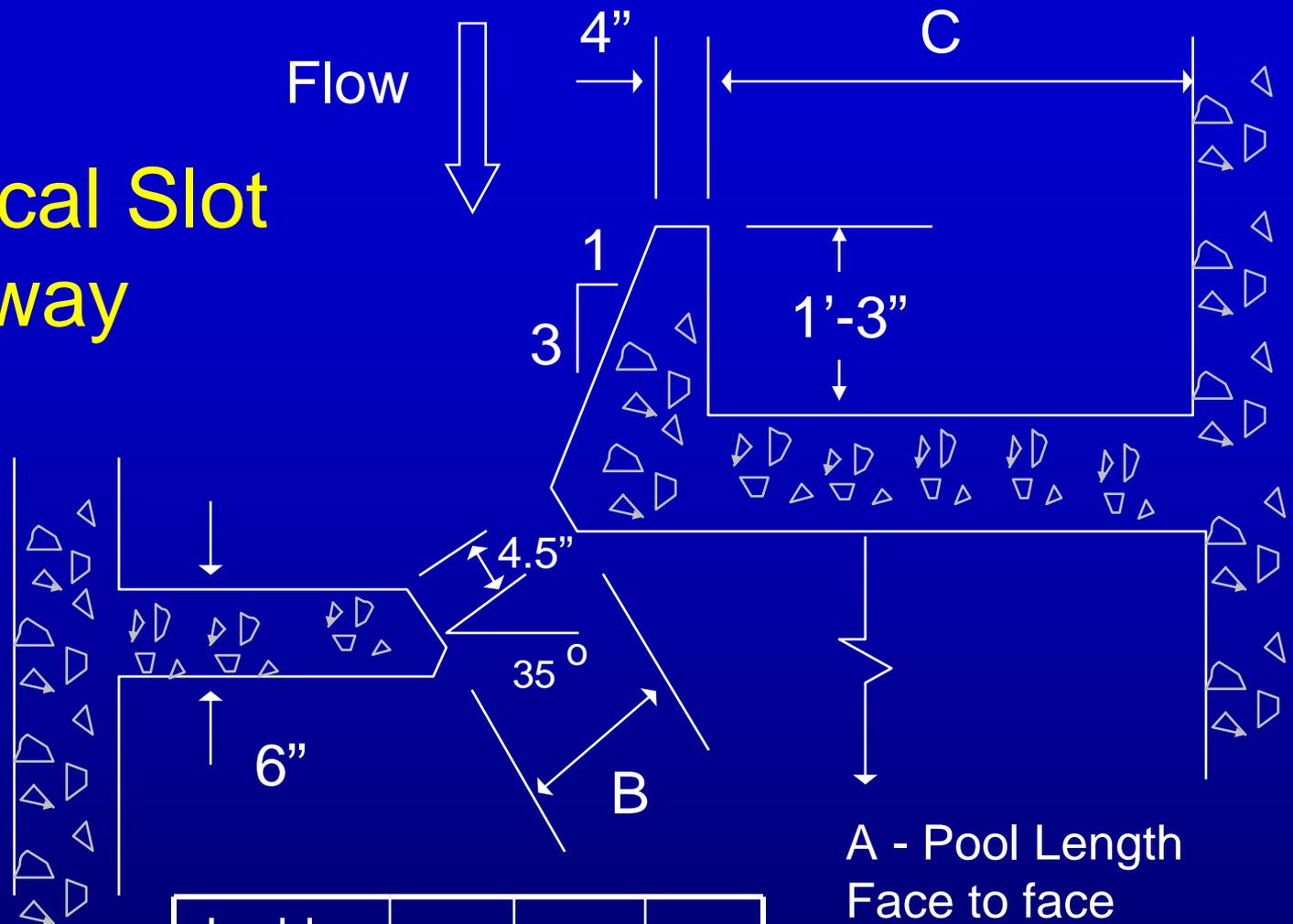
Vertical Slot Fishway



Flow pattern dissipates energy and provides holding area



Vertical Slot Fishway



Ladder Width	A	B	C
6'	8'	9"	3'1"
8'	10'	12"	3'7"

A - Pool Length Face to face

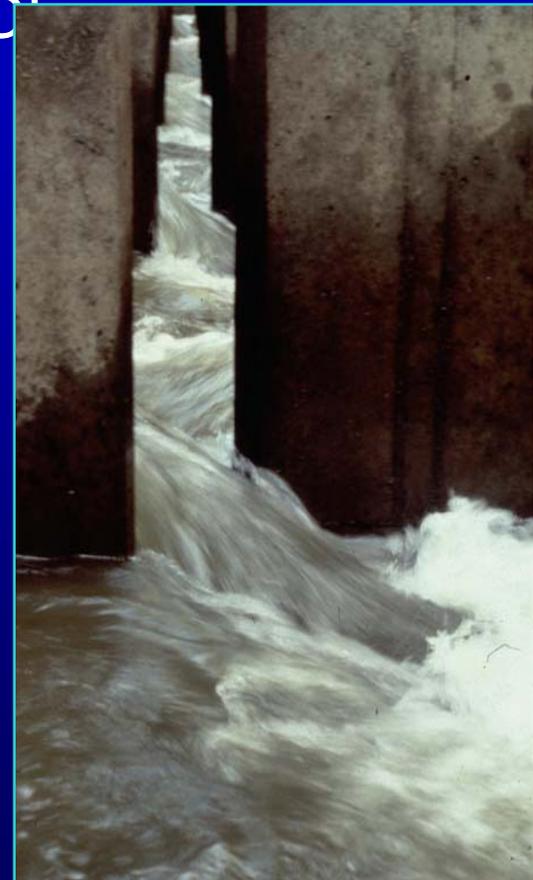
12" vertical slot clogged with debris
downstream of 9" open trash rack



Granite Falls fishway

Vertical Slot Fishway Summary

- ++ Self regulating with constant EDF
- + Full depth passage corridor
- - High minimum flow
- - Complex migration route
- - No wall or leaping passage
- - Vulnerable to debris
- + Sediment does not accumulate
- Complex concrete construction



Hybrids - Pool and Chute Fishway



City of Albany
N. Santiam R.





Pool and chute fishway

Low Flow

High fish passage design flow

