Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

October 30, 2013 Technical Workshop

Engineering Presentation

Dam and Fish Passage Design

Introduction

- Objectives
  - Present preliminary dam and fish passage research findings
  - Receive input regarding dam and fish passage configurations
  - Receive suggestions for additional research needs
- Presentation
  - Task 1.1.1 Dam Design Study
  - Task 1.1.2 Fish Passage Design
  - Q&A/Discussion

Task 1.1.1 Dam Design Study Research

Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

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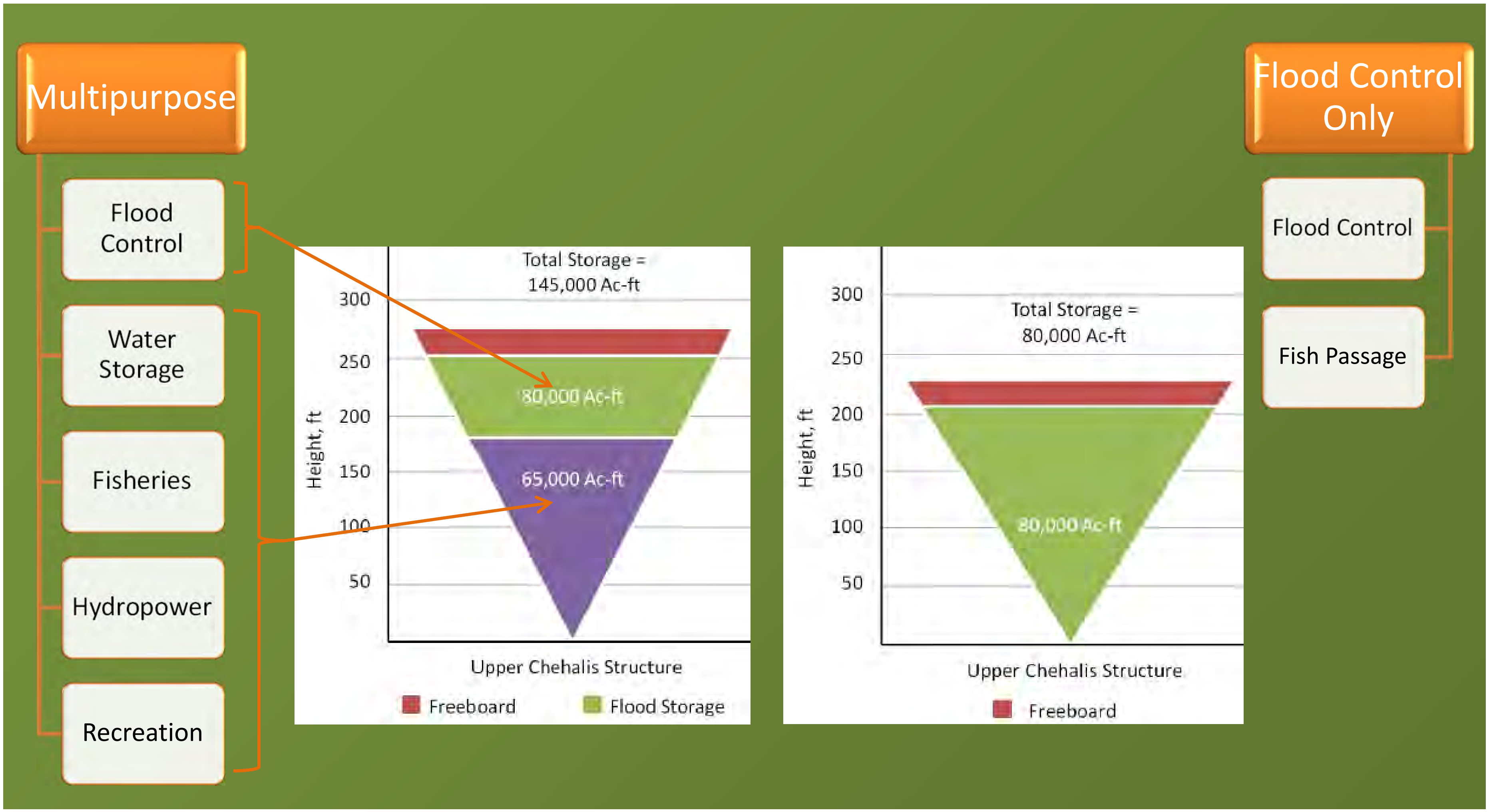
Outline

- Background Information
- Site Visit Findings
- Dam Structure Findings
- Hydraulic Structures
  - Open Slots
  - Fish Passage
  - Flood Control Outlets
  - Auxiliary Spillways
  - Debris Management
  - Other Considerations
- Design Criteria and Data Needs
- Schedule

Chehalis Dam Alternatives



Ranking and Similar Projects

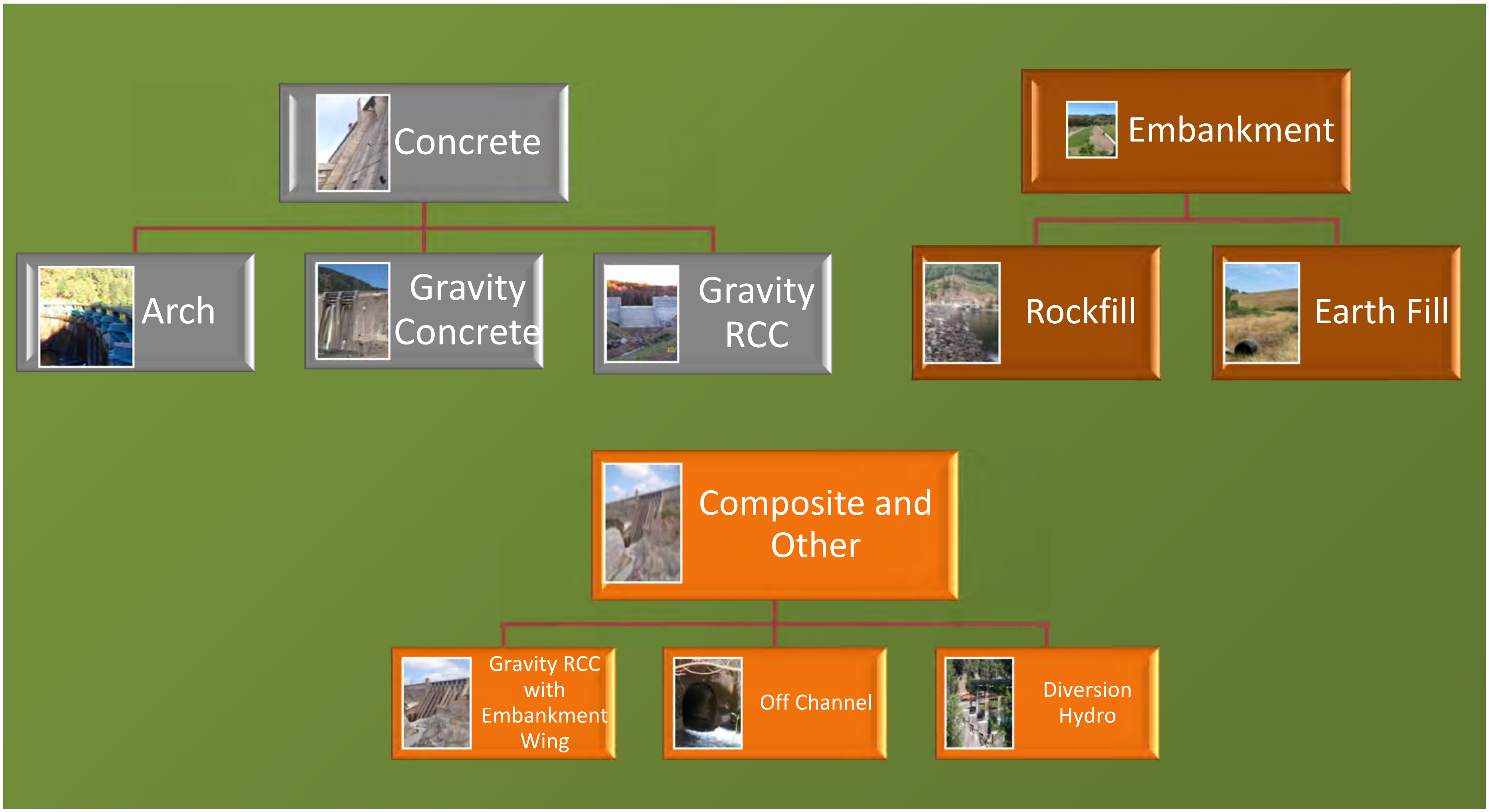
Dam Height (from previous evaluations)

Flood Control Only = 238 feet

Multipurpose = 288 feet

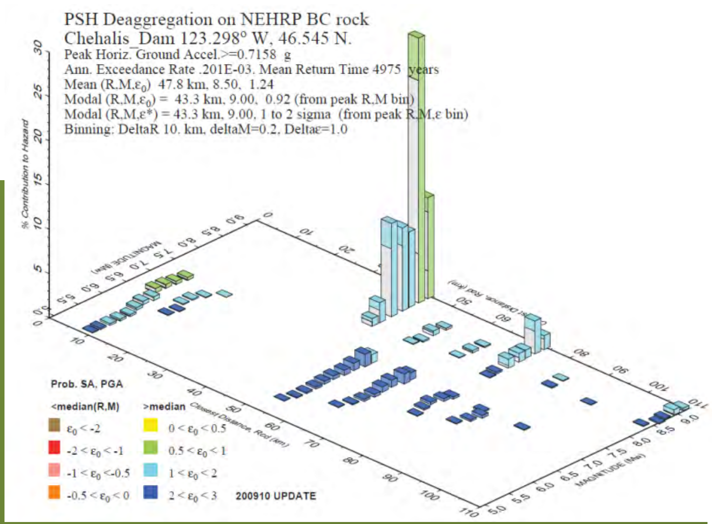
- National
  - A Dam over 290 feet would be in the top 100 dams (out of about 80,000) in the United States with regards to height. Above 290 feet would put it in the top 0.1%.
- International
  - Rockfill and Concrete (RCC) up to 1,000 feet high being constructed

Dam Types



Concrete
Arch
Gravity Concrete
Gravity RCC
Embankment
Rockfill
Earth Fill
Composite and Other
Gravity RCC with Embankment Wing
Off Channel
Diversion Hydro

Key Site Considerations



Seismic Hazards

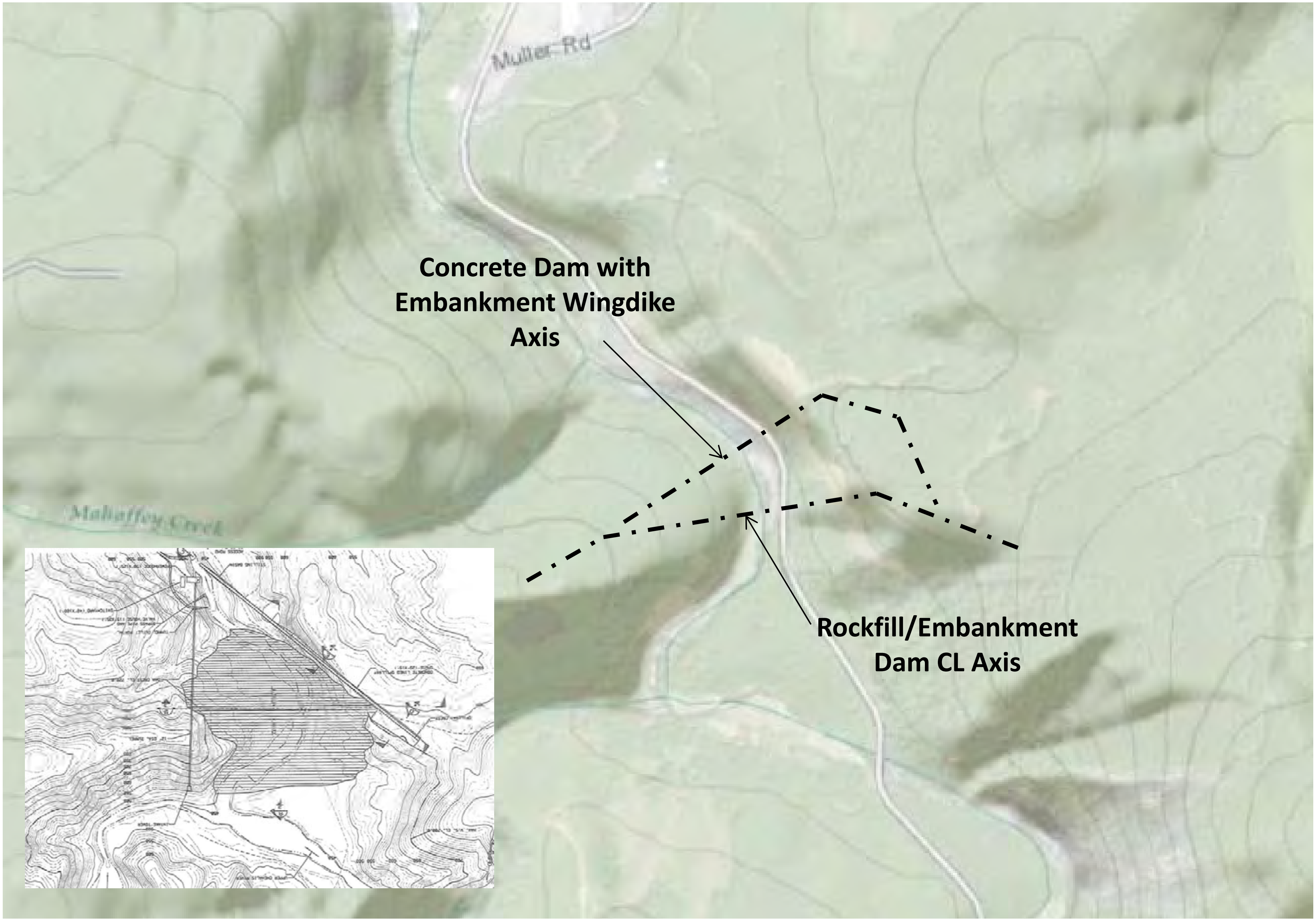
- 1/2,500 year - .56g pga
- 1/5,000 year - .72g pga

Landslide Hazards

- Landslide debris at the dam site on both banks of the Chehalis River and in the reservoir
- Construction and long-term risks

Foundation Conditions

Aerial View

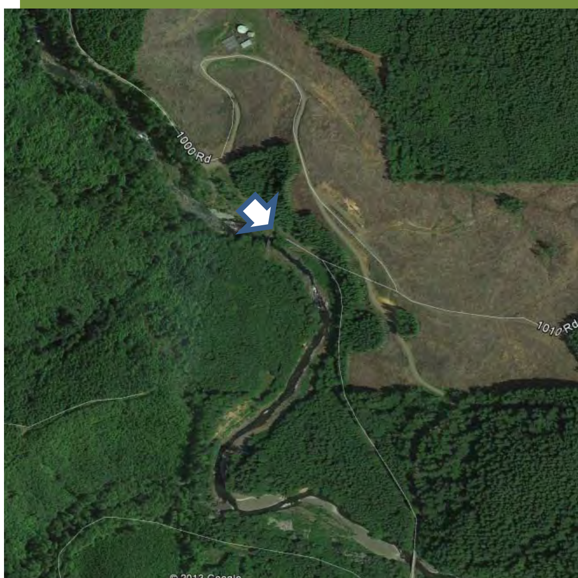


Muller Rd
Mahaffey Creek
Concrete Dam with
Embankment Wingdike
Axis
Rockfill/Embankment
Dam CL Axis

Site Visit

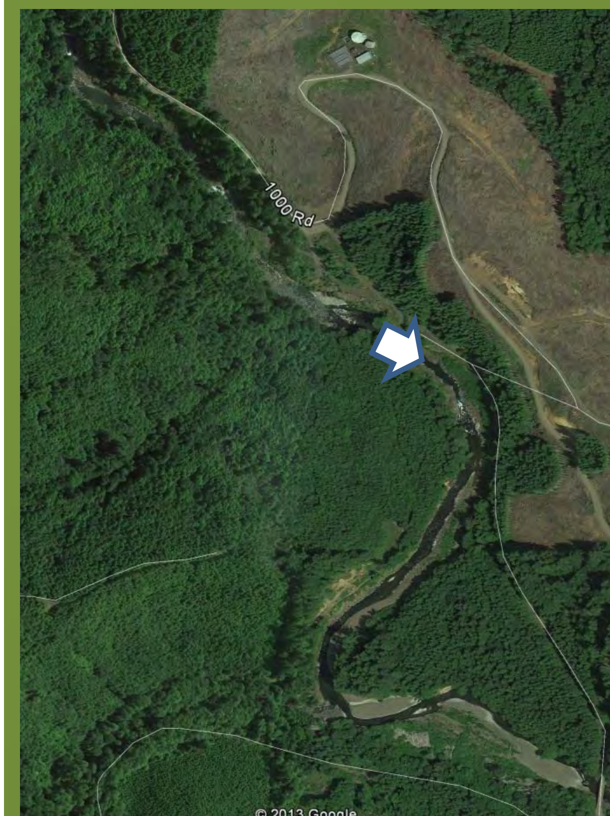
September 30 - October 1, 2013

AERIAL KEY



Site Visit

September 30 - October 1, 2013



Site Visit

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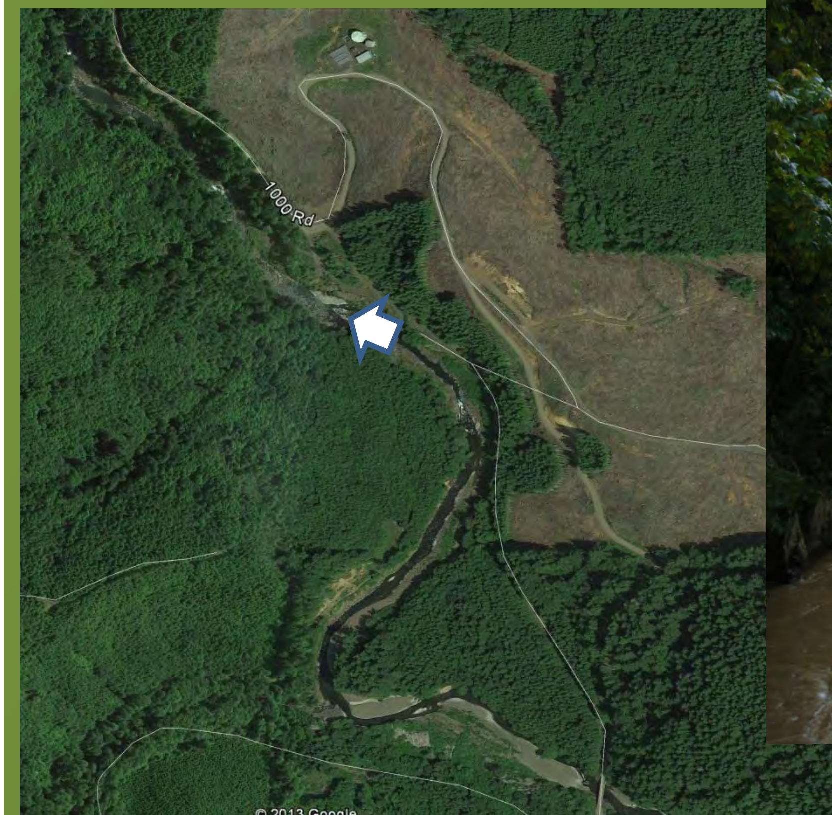

Site Visit

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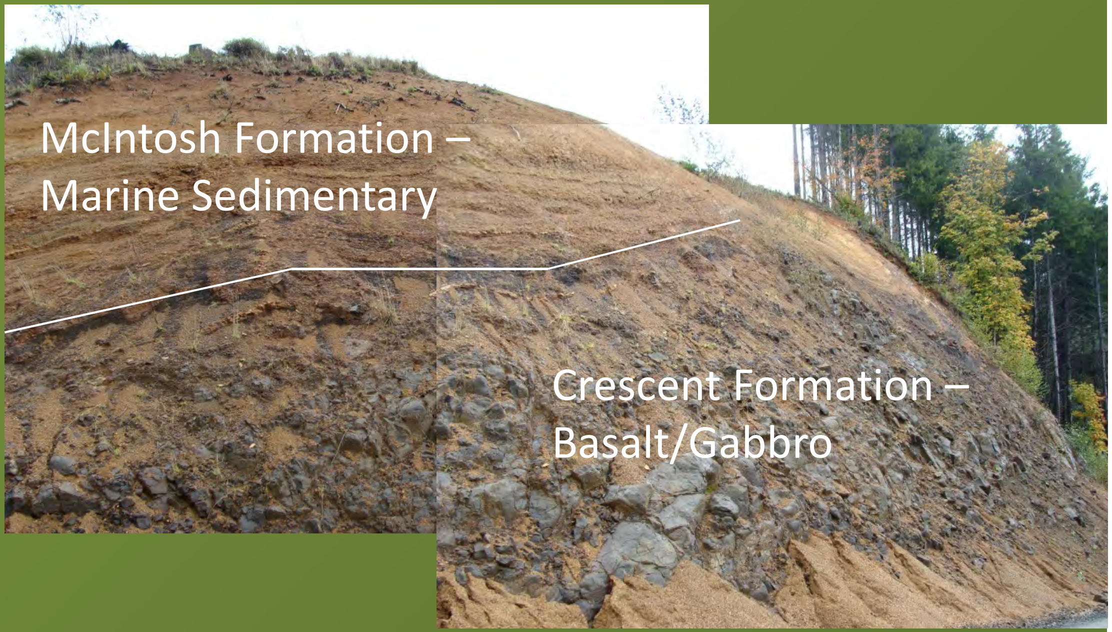
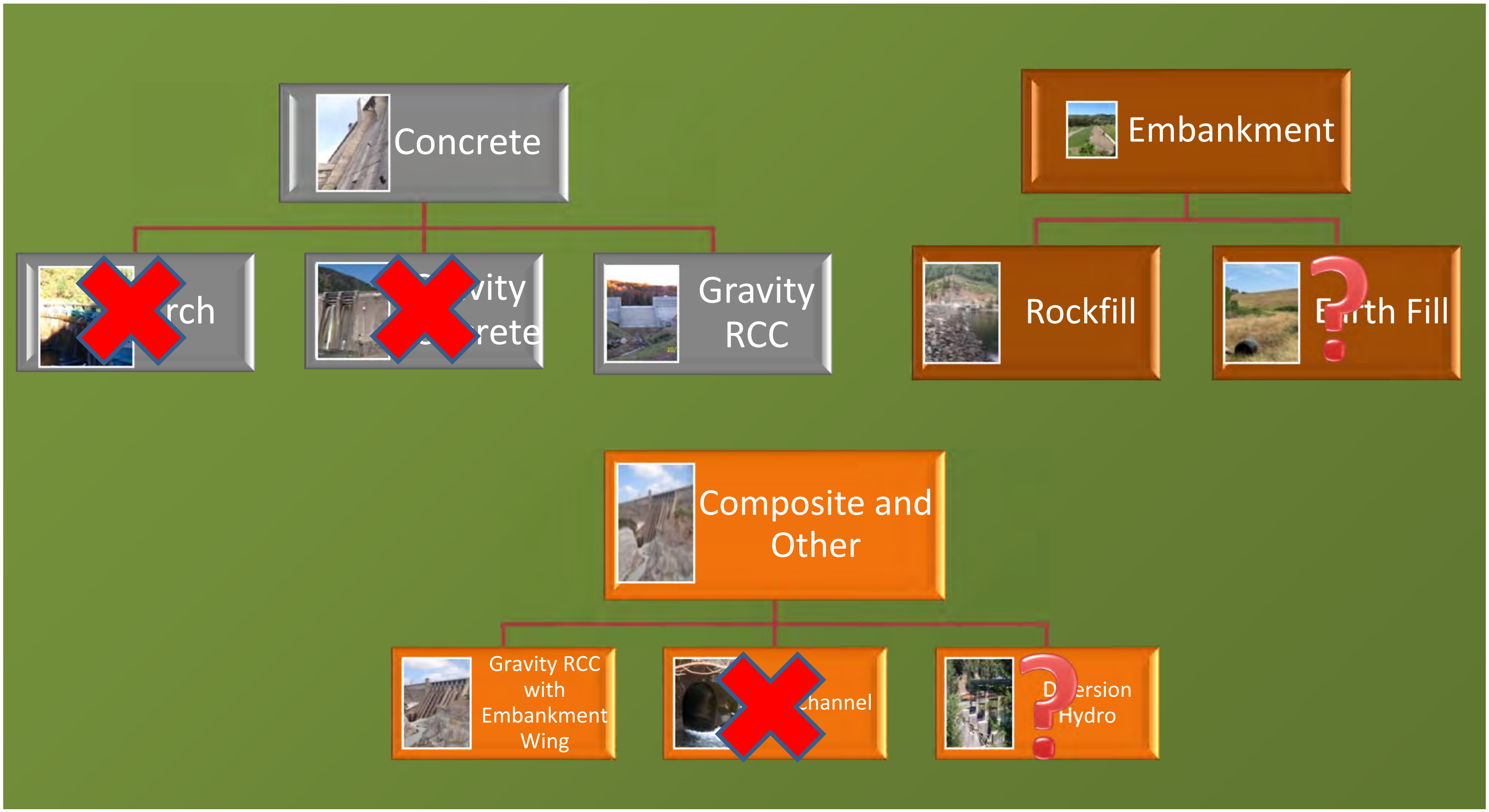


Site Visit

September 30 - October 1, 2013

Dam Type Findings



Roller Compacted Concrete Dams

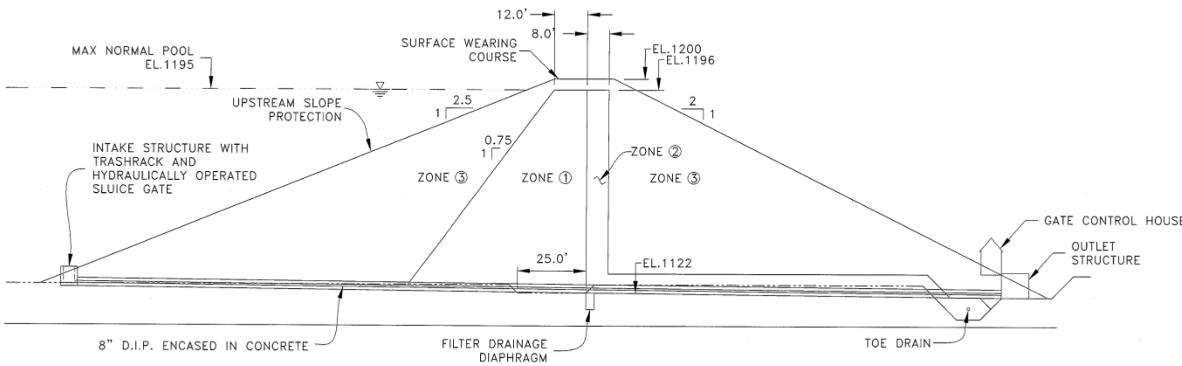
- Speed of construction
- Cost
- Integrated structural elements
- Effective seepage barriers
- Crack control strategies

Concrete Dam

- Advantages
  - Most flexible range of flood operations
  - Most flexible range of fish passage options
  - Lowest cost outlet works with maximum water quality operations and effectiveness
  - Fastest construction schedule

- Challenges
  - Requires “rock” foundation at reasonable depth
  - Construction materials

Central Clay Core Rockfill Dam

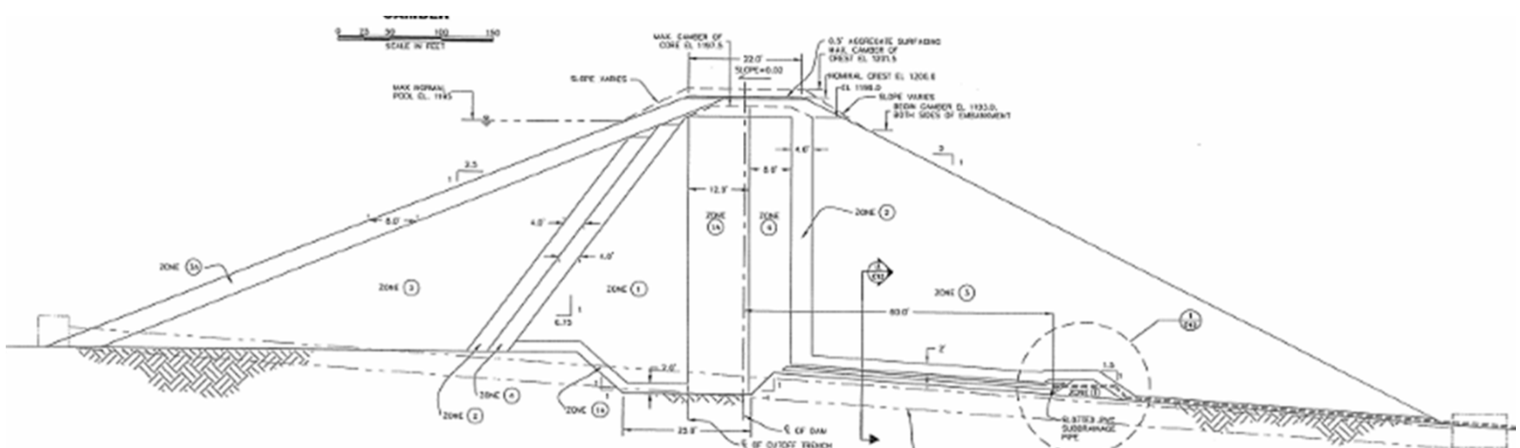


AUXILIARY EMBANKMENT TYPICAL SECTION

0 15 30 60 90
SCALE IN FEET

EXPLANATION

1. ZONE ① – CORE
2. ZONE ② – FILTER/DRAIN MATERIAL
3. ZONE ③ – ROCKFILL



MAIN EMBANKMENT TYPICAL SECTION

Rockfill Dams

- Advantages
  - Good seismic response
  - Very cost effective for dams over 150-feet-high
  - Good dam for “rock” sites with clay source
- Challenges
  - Flexible flood operations
  - Limited fish passage options
  - Intermediate construction duration
  - Construction materials
    - Core
    - Filters/drains
    - Rockfill

RCC/Embankment Composite Dam

Location: Folsom, CA

Operator: USACE/USBR Joint Federal Project

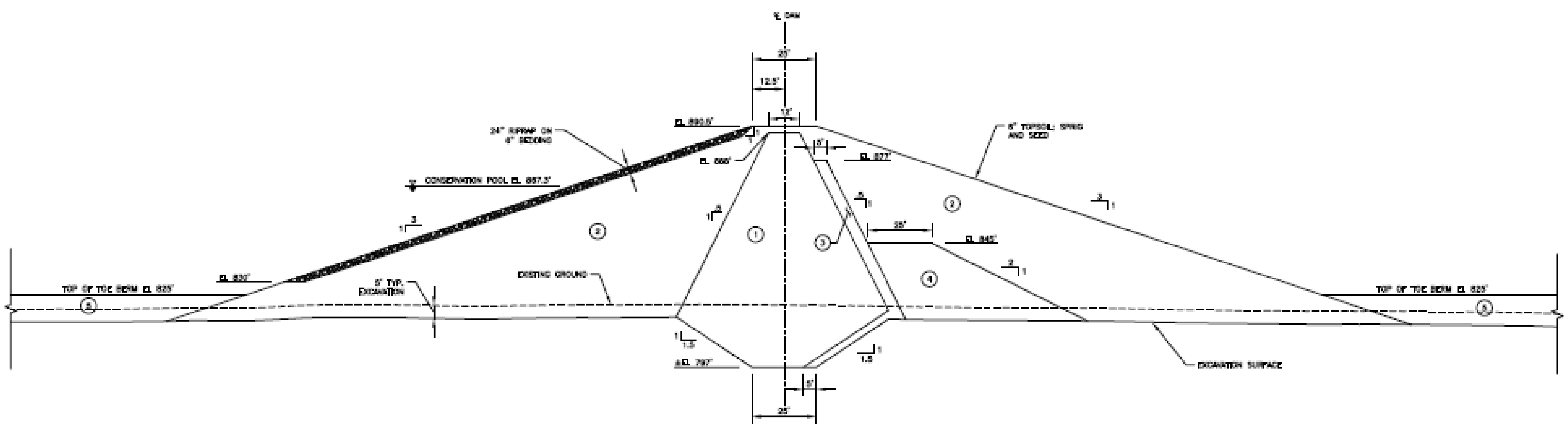
Dam Type: Concrete and Earthen

Length: Main 1,400 feet

Height: 340 feet

Gated Concrete Spillway

Earthfill dam

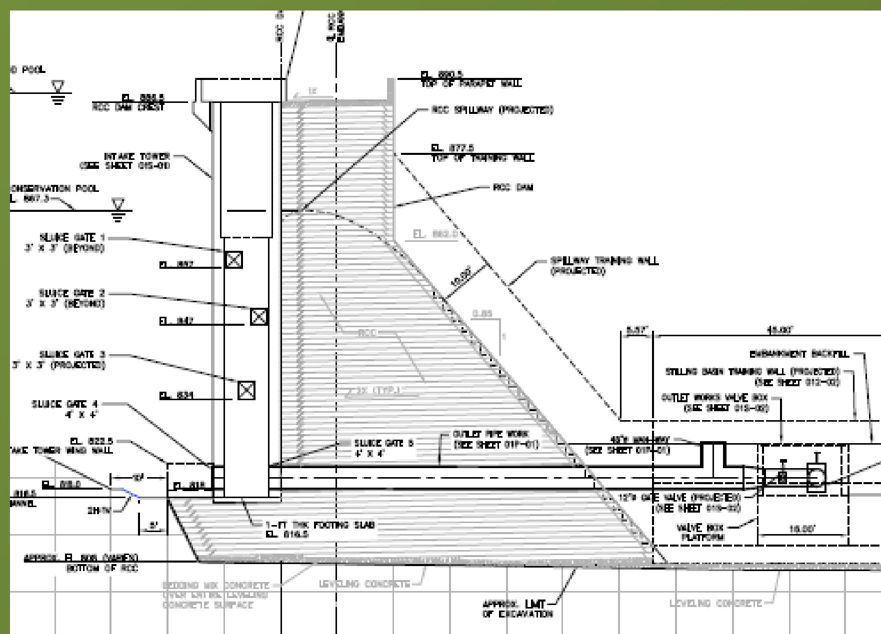


Findings – Dam Types

- Good Rock Site
- Gravity RCC Dam
- Central Clay Core Rockfill Dam
- Composite RCC and Embankment

Hydraulic Structures

- Open Slot Dam
- Fish Passage
- Auxiliary Spillway
- Flood Control Outlet



- Gates
- Valves
- Stoplogs
- Approach Canals and Channels

Open Slot Dam

Miter Gates – The Dalles

Location: The Dalles, Oregon

Operator: USACE – Portland District

Dam Type: Concrete Gravity

Length: 8,875 feet

Height: 80 feet

Lock Gates

Horizontal Slide Gates

ENR Construction Magazine

Location: Panama

Gate Type: Horizontal Roller Slide Gates

Height: 90 feet

Weight: 700+ Tons

Findings – Open Slot Dams

- Open Slot – limited to very low head applications
- Gated Slots – limited to 80 to 100 feet
- Gated Slots not designed for flood overtopping

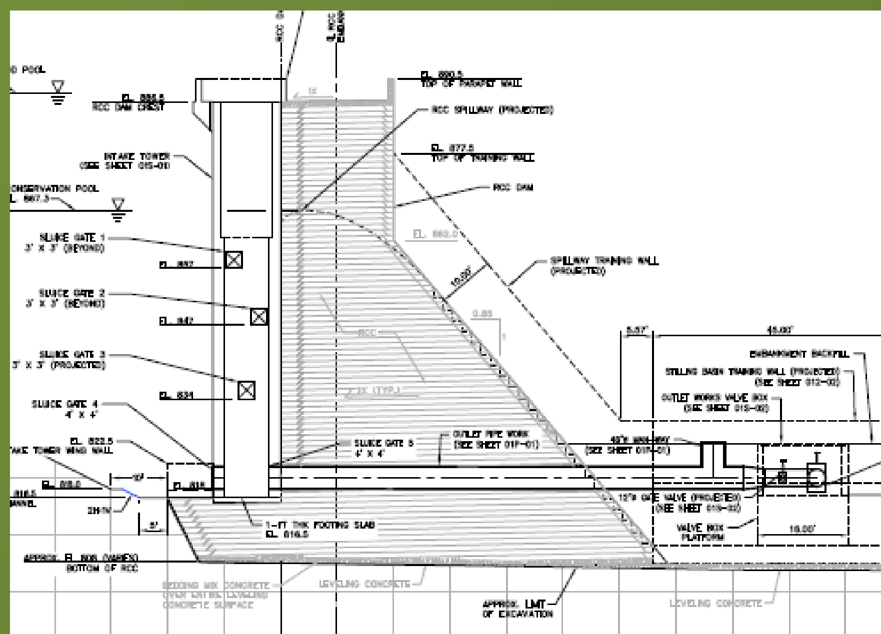
Hydraulic Structures

Open Slot Dam

Fish Passage

Auxiliary Spillway

Flood Control Outlet



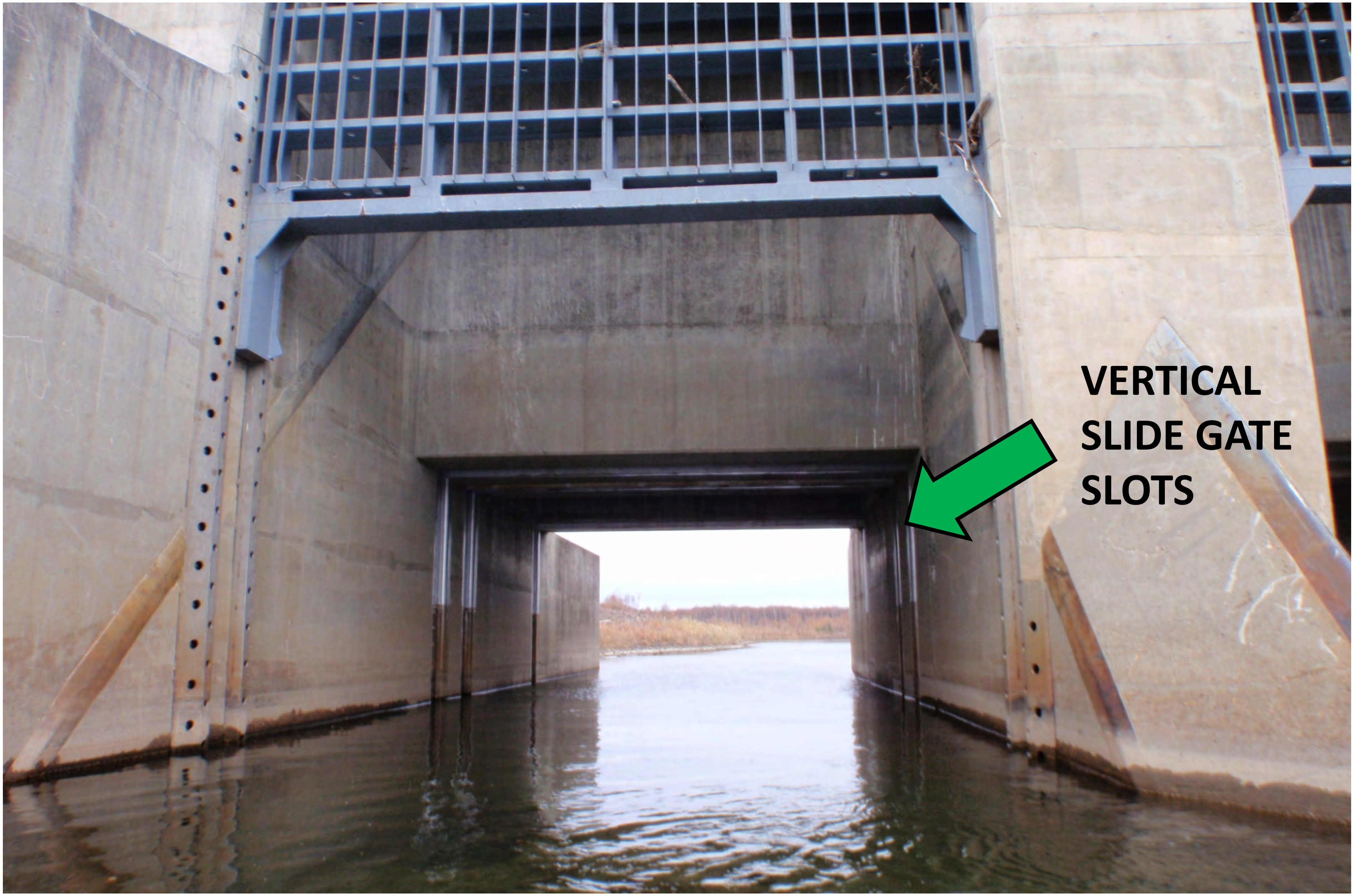
Gates

Valves

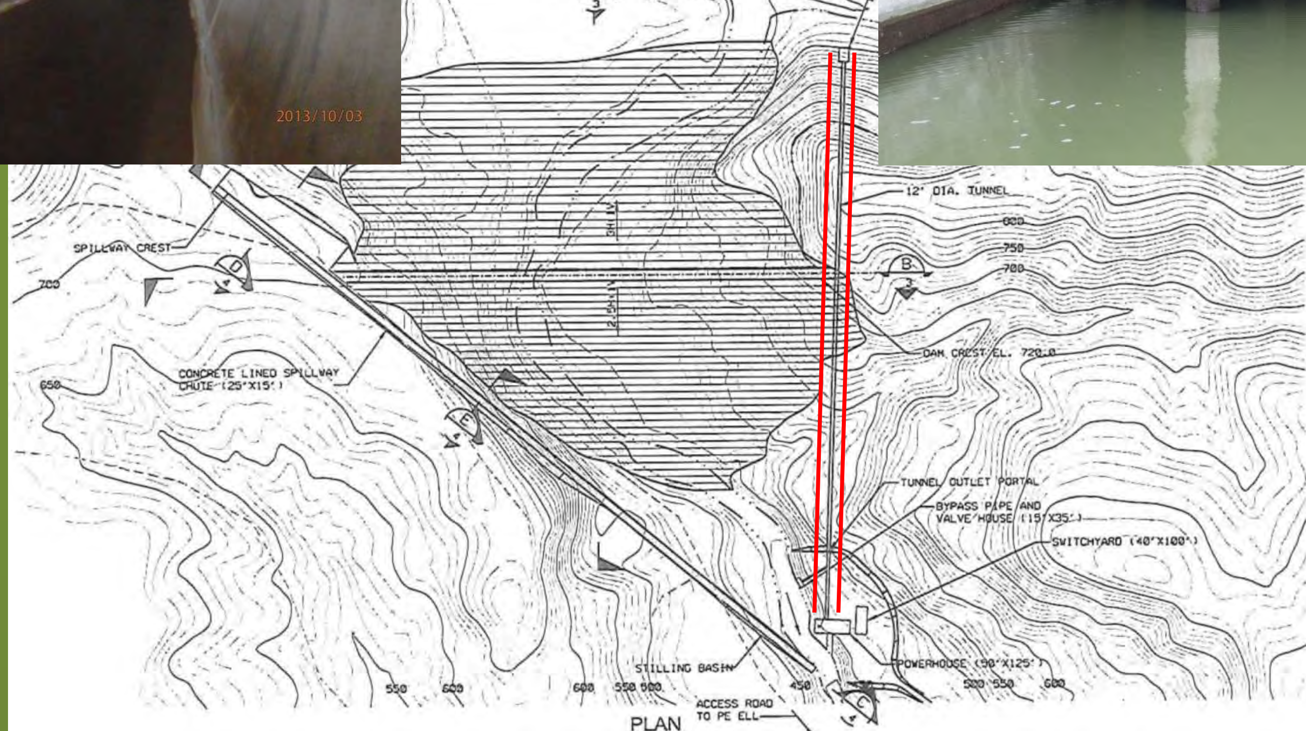
Stoplogs

Approach Canals and Channels

Fish Passage Outlet Tunnel Moose Creek Dam, USACE, Alaska



Fish Passage Outlet Tunnel



Regulated Outlet Gates – Radial and Sluice Gates

Project: Dworshak Dam, ID

Location: Orofino, ID

Operator: USACE Walla Walla District

Dam Type: Concrete Gravity

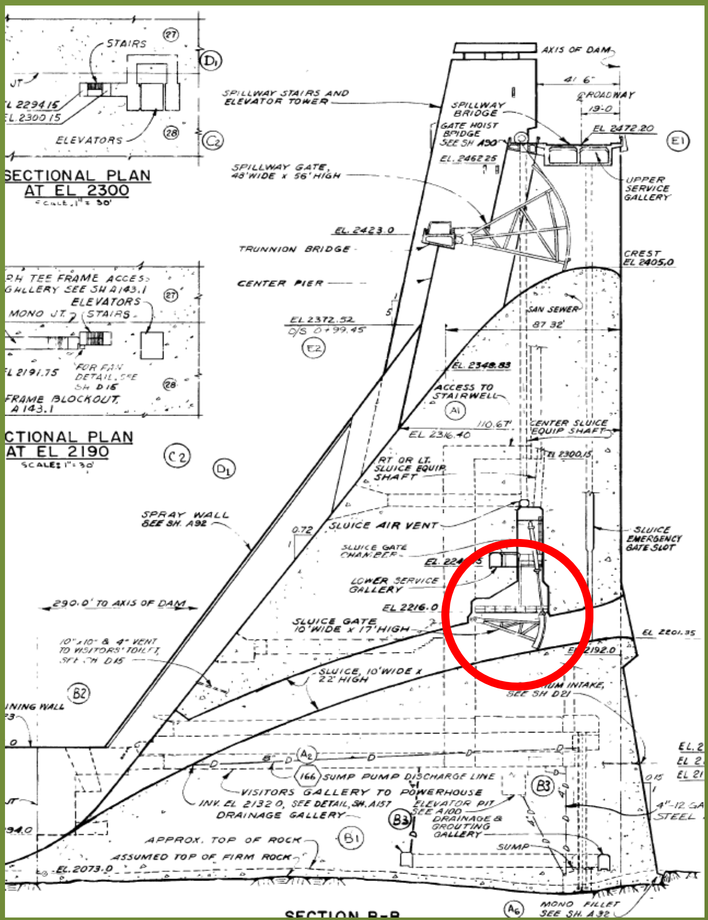
Length: 3,287 feet

Height: 717 feet

Gated Concrete Spillway

RO Depth: 250 feet

Regulating Outlet Gates or Sluice Gates



Project: Libby Dam
Location: Libby, MT
Operator: USACE - Seattle District
Dam Type: Concrete Gravity
Length: 3,055 feet
Height: 422
Gated Concrete Spillway
RO Depth: 258

Vertical Outlet Gates

Project: Libby Dam
Location: Libby, Montana
Operator: USACE – Seattle District
Dam Type: Concrete Gravity
Length: 3,055 feet
Height: 422 feet

Project: Lower Granite Dam
Location: Pullman, WA
Operator: USACE – Walla Walla District
Dam Type: Concrete Gravity
Length: 3,200 feet
Height: 100 feet

Bulkheads and Stoplogs

Project: Nimbus Dam

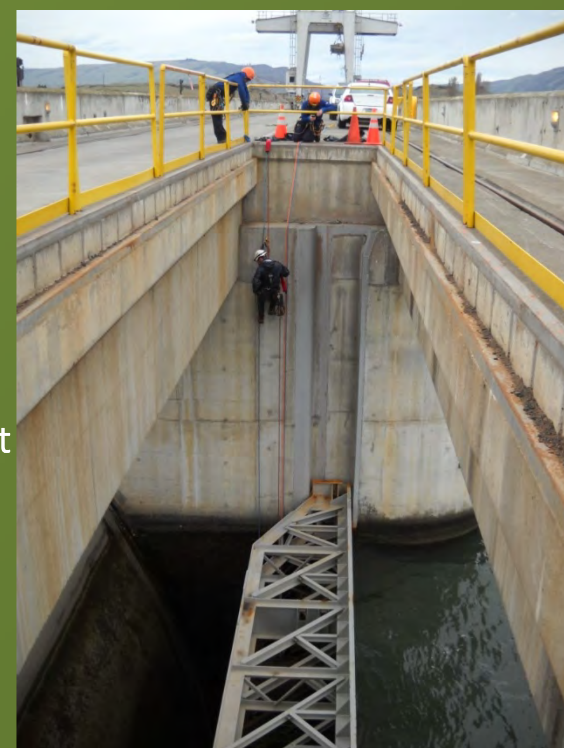
Location: Folsom, CA

Operator: USACE/USBR

Dam Type: Concrete Gravity

Length: 1,093feet

Height: 87 feet



Location: The Dalles, Oregon

Operator: USACE – Portland District

Dam Type: Concrete Gravity

Length: 8,875 feet

Height: 80 feet

Findings – Fish Passage

- Concrete Dam – Opening in base of dam is easiest but may be limited to FC only.
- Abutment Tunnels could be applicable to Concrete or Rockfill alternatives with limited permanent pool.

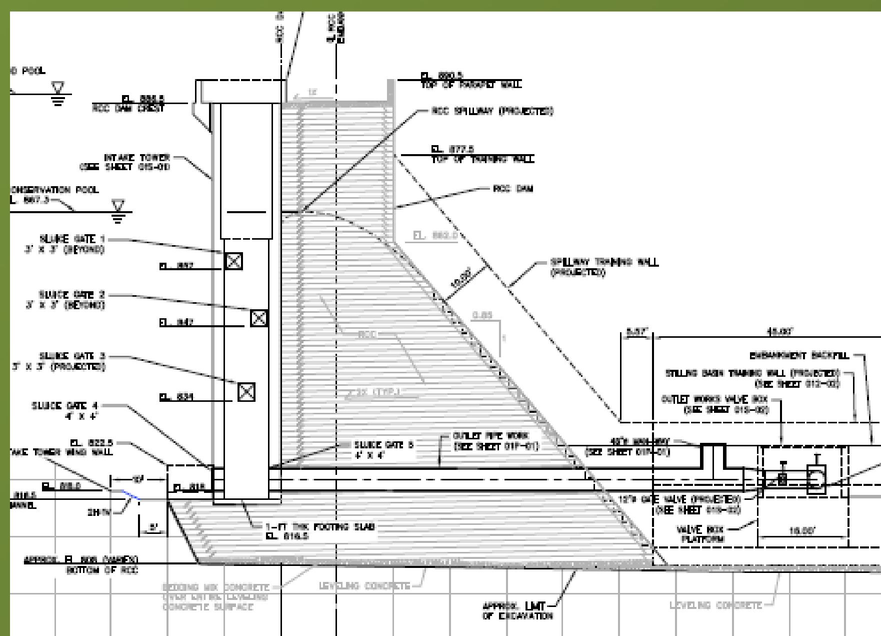
Hydraulic Structures

Open Slot Dam

Fish Passage

Auxiliary Spillway

Flood Control Outlet



Gates

Valves

Stoplogs

Approach Canals and Channels

Intake Towers - Freestanding

Project: Hills Creek Dam

Location: Eugene, CA

Operator: USACE Portland District

Dam Type: Concrete and Earthen

Length: 2,235feet

Height: 304 feet

Gated Concrete Spillway and Intake Tower

Project: Blue River Dam

Location: Eugene/Blue River, OR

Operator: USACE Portland District

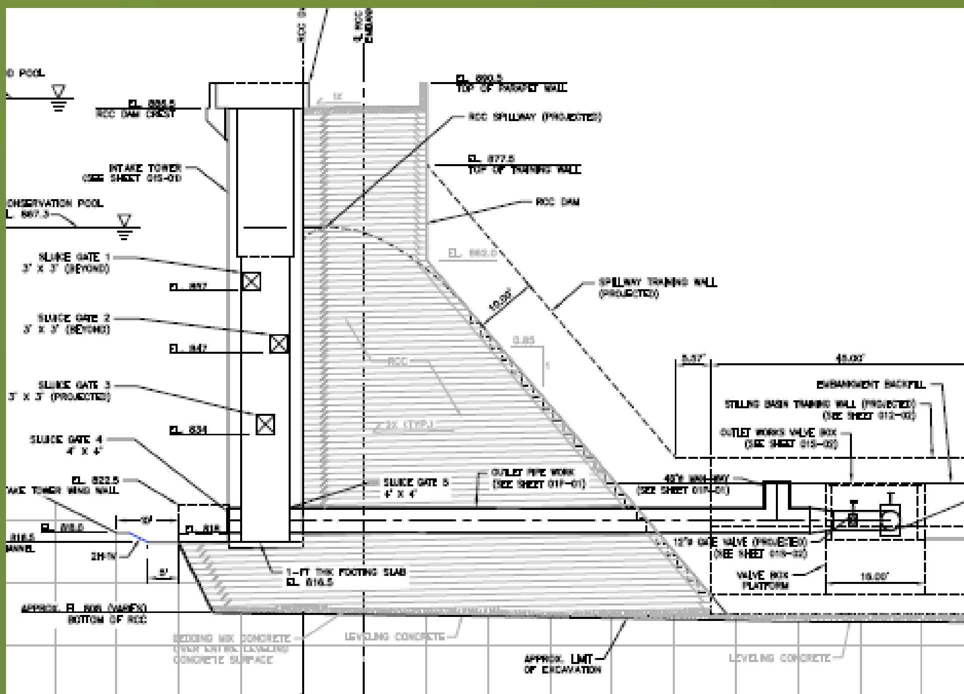
Dam Type: Rock Fill

Length: 1,265 feet

Height: 270 feet

Gated Concrete Spillway and Intake Tower

Intake Towers – Upstream Face of Dam



Project: New Big Cherry Dam

Location: Big Stone Gap, VA

Operator: Town of Big Stone Gap

Dam Type: Roller Compacted Concrete

Morning Glory Spillways

Project: Grayrocks Dam

Location: Wheatland, WY

Operator: Basin Electric Power Cooperative

Dam Type: Earthfill

Length: 2,400 feet

Height: 100 feet

Gated Concrete Spillway and Intake Tower

Project: San Pablo Dam

Location: El Sobrante, CA

Operator: East Bay Municipal Utilities District

Dam Type: Concrete and Earthen

Length: 2,235feet

Height: 304 feet

Gated Concrete Spillway and Intake Tower

Top Seal Radial Gates

Project: Oroville Dam
Location: Oroville, CA
Operator: California Department of Water Resources
Dam Type: Earthfill
Length: 6,920 feet
Height: 770 feet
Gated Concrete Spillway

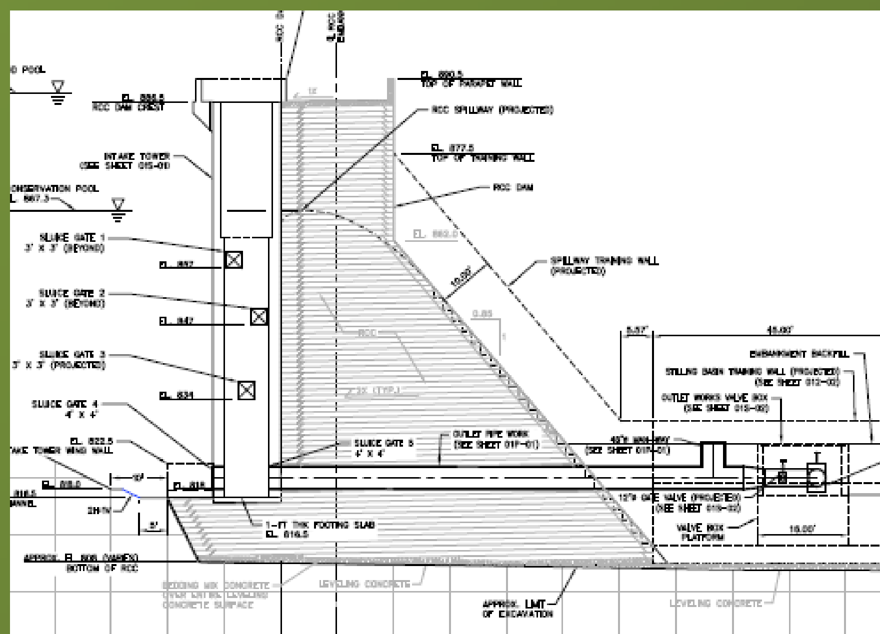
Project: Folsom Dam
Auxiliary Spillway
Under Construction

Findings – Flood Control Outlets

- Many configurations possible
- Seismic loads will be challenge for free-standing tower and large gates
- Both controlled and uncontrolled operations
- Debris management a significant consideration

Hydraulic Structures

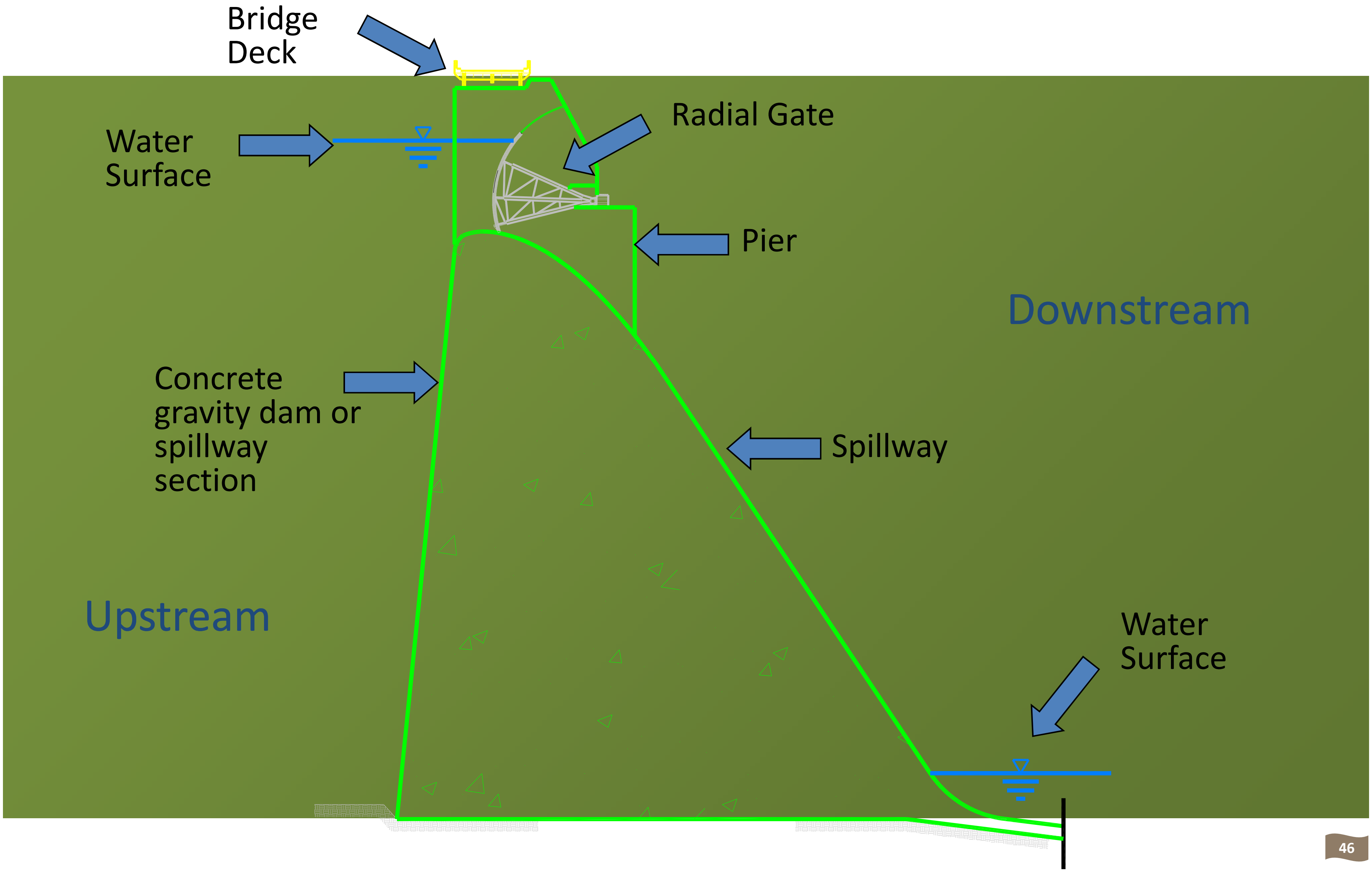
- Open Slot Dam
- Fish Passage
- Auxiliary Spillway
- Flood Control Outlet
  - Gates
  - Valves
  - Stoplogs
  - Approach Canals and Channels

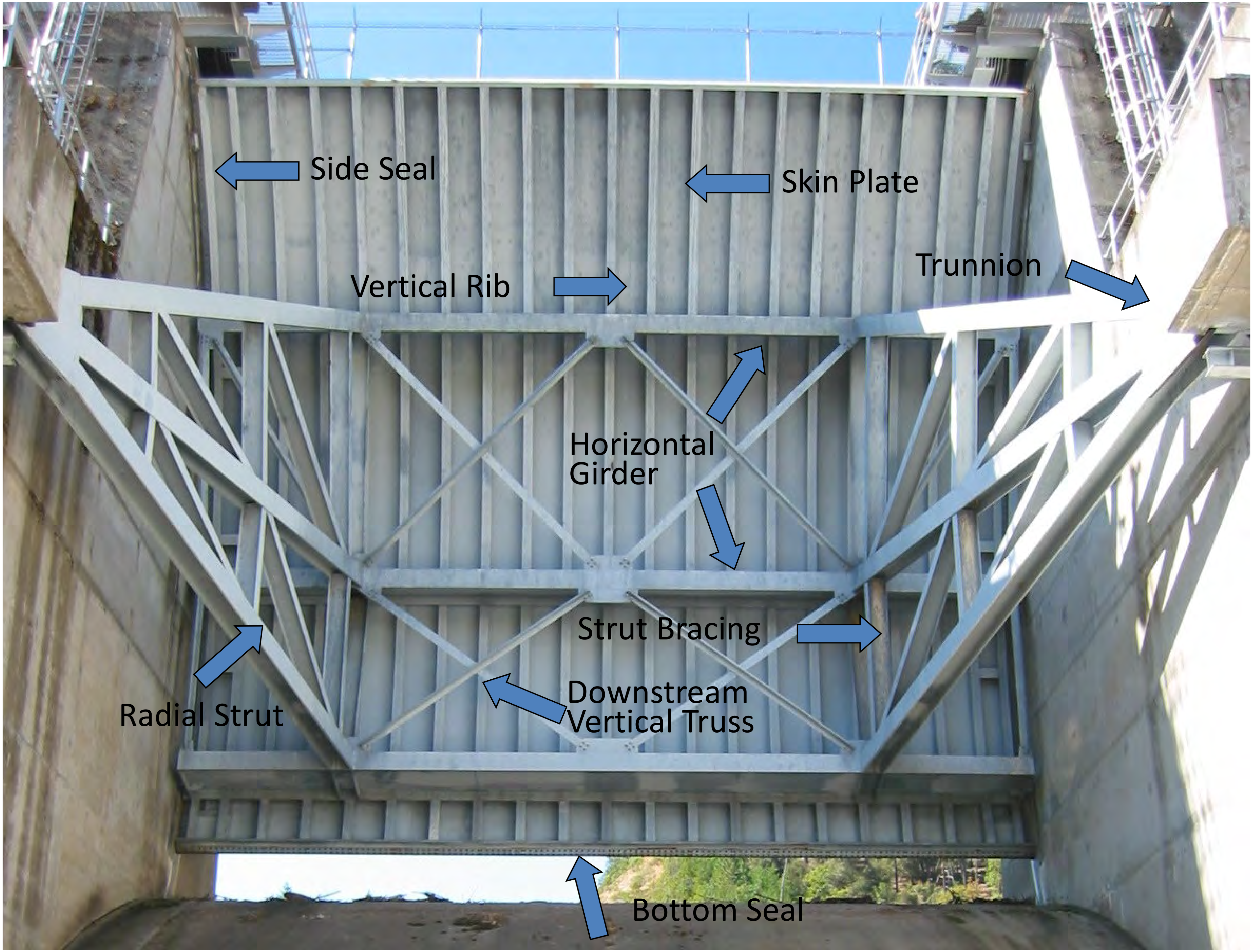


Overflow Spillway

- Over Center of Dam (Concrete Alternatives)
- Abutment (Rockfill Alternatives)

Radial / Tainter Gate




Side Seal
Skin Plate
Trunnion
Vertical Rib
Horizontal
Girder
Strut Bracing
Radial Strut
Downstream
Vertical Truss
Bottom Seal

Vertical Spillway Gates – Albeni Falls Dam

Location: Oldtown / Priest River, Idaho

Operator: USACE – Seattle District

Dam Type: Concrete Gravity

Length: 775 feet

Height: 90 feet

Gated Concrete Spillway

Findings – Auxiliary Spillway

- Will be a dam safety requirement
- Sized based on Inflow Design Flood (IDF) routing
- Controlled or uncontrolled configurations
- Seismic loads will be significant challenge
- Debris control will be significant consideration

Debris Control

Typical Debris Accumulation during Large Flood Event at Howard Hansen Dam, Washington

Debris Guard Gates at Moose Creek Dam, USACE, Alaska


Moose Creek Dam, USACE, Alaska


Moose Creek Dam, USACE, Alaska
6 AUG 2008

Screened Intakes

Project: Tiger Creek

Location: Pioneer, CA

Operator: Pacific Gas and Electric

Dam Type: Concrete Gravity Arch

Length: 448 feet

Height: 120 feet

Gated Concrete Spillway

More Project Examples

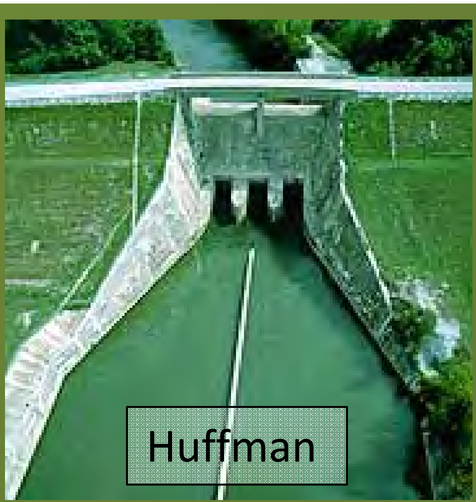
Flood Control Only – Morris Dam

Location: Leicester, NY
Operator: USACE – Buffalo District
Dam Type: Concrete Gravity
Length: 1,028 feet
Height: 230 feet
Low level conduits and Overflow Spillway

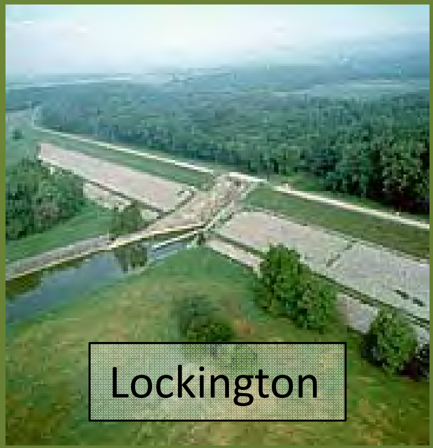
Flood Control Only
Masudagawa Dam- Japan

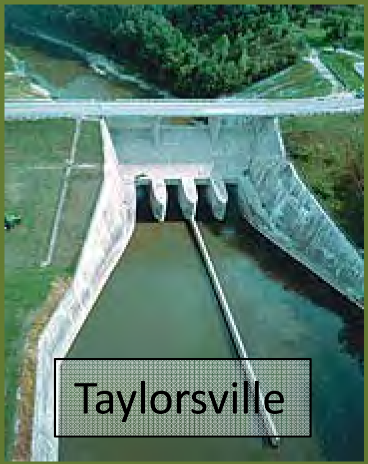
Location: Masuda, Japan
Dam Type: Concrete Gravity
Length: 554 feet
Height: 157 feet
Overflow Spillway

Flood Control Only
Miami Conservancy District – 5 Dams



Location: Southwest, OH
Operator: Miami Conservancy District
Dam Type: Earth Embankment
Length: 1,210 – 6,400 feet
Height: 65-110 feet
Low level conduits and Overflow Spillways





Multipurpose Detroit Dam

Location: Salem, OR
Operator: USACE – Portland District
Dam Type: Concrete Gravity
Length: 1,523 feet
Height: 463 feet
Low level conduits and Overflow Spillway

Research Input and Next Steps

- Additional Research Suggestions?
  - Need final input by November 4th
- Next Steps
  - Dam Configuration Brainstorming Workshop – week of December 4th or 11th
  - Draft Dam Design TM for review – February 28, 2014

Task 1.1.2 Fish Passage

Preliminary Fish Passage Design Criteria and Background Research

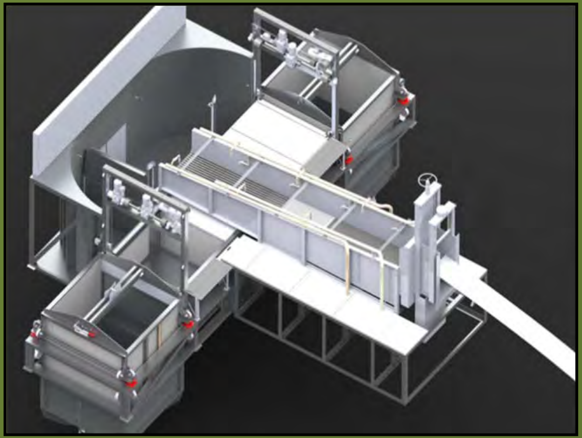
Mike Garello, P.E.

Outline

- Background and Facility Research
- Case Studies
- Fish Passage Options
- Design Criteria
  - Anticipated Species
  - Migration Timing (Periodicity)
  - Hydrology During Anticipated Migration Periods
  - Fishways, Screens, Bypasses, and Fish Holding

Background and Facility Research

- Most projects at high head dams in Pacific Northwest use CHTR for upstream passage
  - Baker River, Cowlitz River, Lewis River, Pelton-Round Butte, Cougar, and Cushman
- Hatcheries often used in tandem with passage

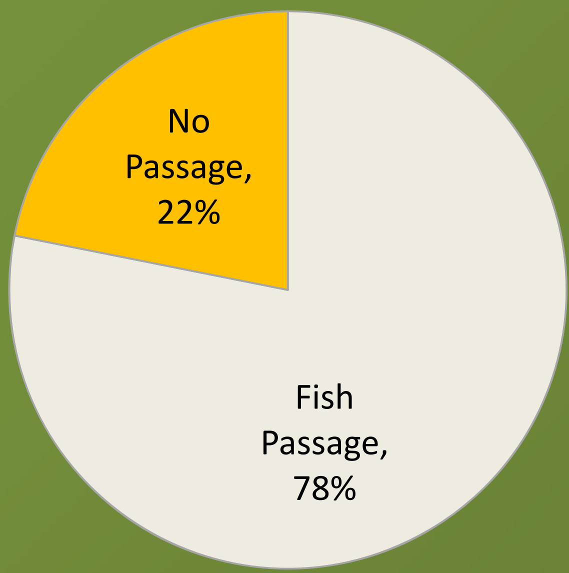


Cushman Surface Collector and Fish Handling Equipment. Figures by Tacoma Power

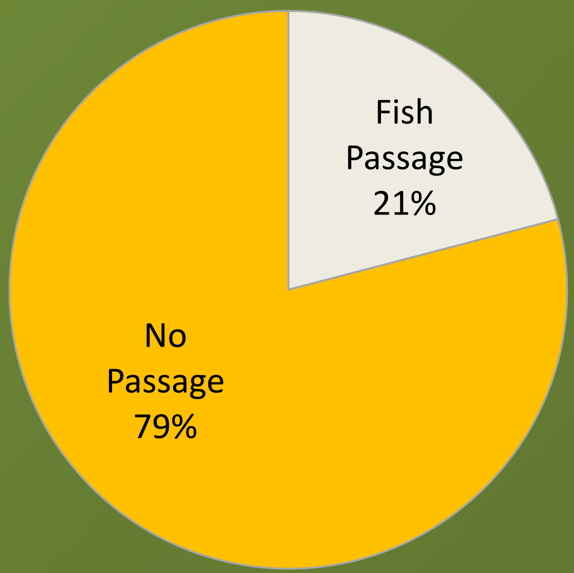
CHTR – Collect, Handle, Transfer, and Release ("Trap and Haul"

Background and Facility Research – Western US

- Results - case studies of 32 dams between 50 and 150 ft within WA, OR, ID, and CA

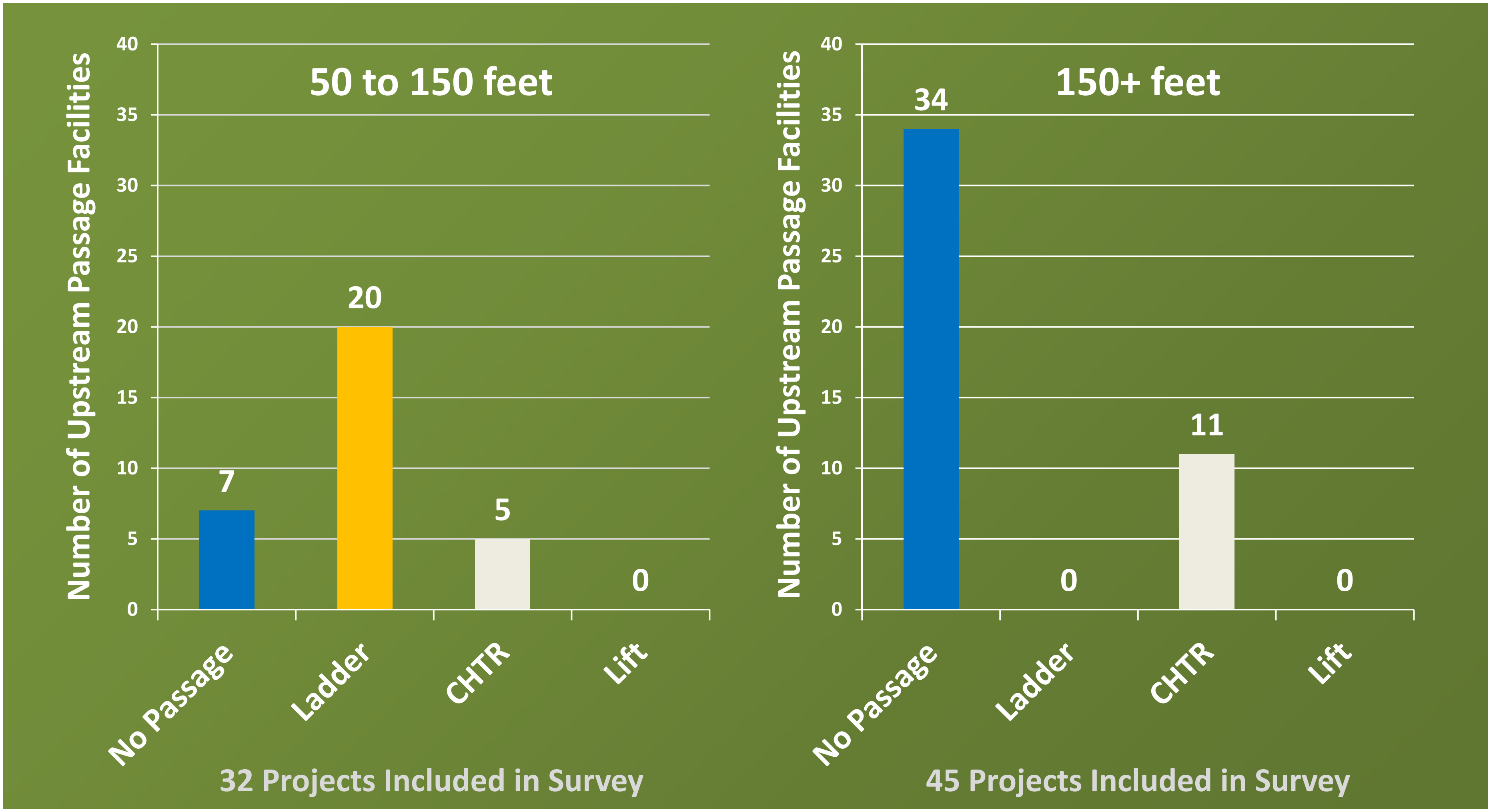


- Results - case studies of 45 dams over 150 ft within WA, OR, ID, and CA



94% (50 to 150 ft) and 75% (150+ ft) of WA Dams in the list of case studies are associated with a "Mitigation Hatchery" or pay into a hatchery supplementation program.

Background and Facility Research – Western US

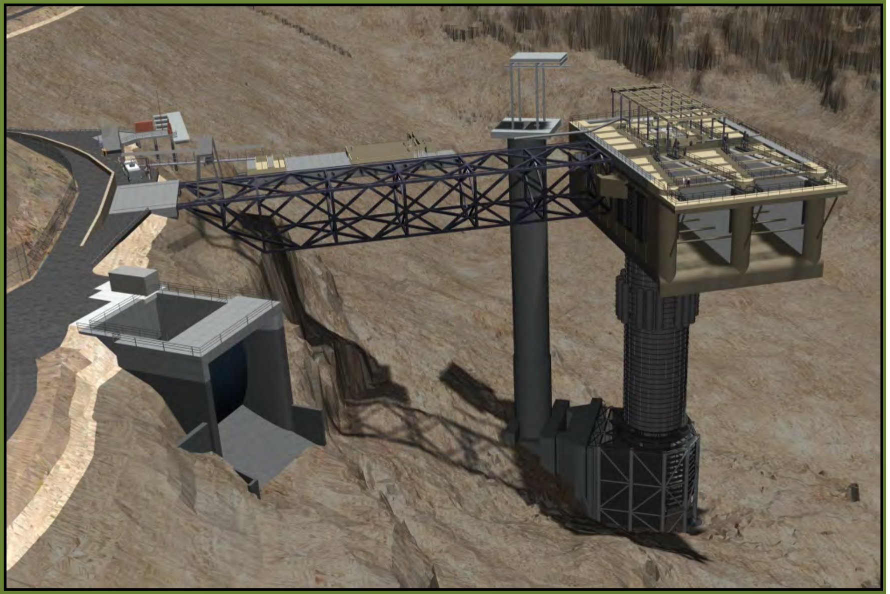


Background and Facility Research –
Key Northwest Example Fish Passage Projects

- Lower and Upper Baker Dams on Baker River, WA
- River Mill, Faraday, and North Fork Dams on Clackamas River, OR
  - 1.9 mile fish ladder around Faraday and North Fork Dams
- Pelton and Round Butte Dams on Deschutes River, OR
  - Abandoned 2.84 mile fish ladder
- Merwin and Swift Dams on Lewis River, WA
- Mayfield and Cowlitz Falls Dams on Cowlitz River, WA

Deschutes River, OR - Project Overview

- Dams: Downstream to Upstream
  - Reregulating Dam - hydraulic height 25 ft
  - Pelton Dam - hydraulic height 204 ft
  - Round Butte Dam - hydraulic height 425 ft
- Current Facilities
  - Upstream Passage: CHTR from below Reregulating Dam to reservoir above Round Butte Dam
  - Downstream Passage: Forebay collector with CHTR to below Reregulating Dam ($108 Million)
  - Mitigation hatchery



Selective Water Withdrawal Tower and collection facility. Figure by PGE

Pelton-Round Butte - History

Passage abandoned in the late 60's and early 70's primarily due to juvenile D/S migration problems in reservoir U/S of Round Butte and U/S ladder attraction problems

- 1956 – U/S passage CHTR facility constructed D/S of Rereg Dam
- 1957 – Completed 2.84 mile fish ladder from below Rereg to above Pelton
- 1958 – Rereg Dam and Pelton Dam construction completed
  - D/S passage: skimmer w/ horizontal, inclined plane perforated plate
- 1964 – Round Butte Dam constructed with passage facilities
  - U/S passage: fish lift
  - D/S passage: skimmer w/ vertical traveling screens, trucked downstream of Rereg or bypassed D/S of Round Butte
- 1966 – Begin hatchery mitigation for fish losses
- 1968 – Fish ladder abandoned, reverted to original CHTR facility
  - Began using fish ladder for hatchery rearing
- 1969 – Round Butte D/S passage facilities abandoned
- 1973 – Round Butte lift abandoned
- 1973 – Round Butte Hatchery constructed
- 2009 – Round Butte D/S CHTR facility completed, collected fish transported D/S of Rereg

Lewis River, WA - Project Overview

- Dams: Downstream to Upstream
  - Merwin Dam - hydraulic height 230 ft
  - Yale Dam - hydraulic height 309 ft
  - Swift Dam - hydraulic height 400 ft
- Current Facilities
  - Upstream Passage: Currently Constructing CHTR from below Merwin Dam to reservoir above Swift Dam (estimated $50 Million)
  - Downstream Passage: Floating forebay collector with CHTR to below Merwin Dam ($60 Million)
  - Mitigation hatchery

Swift Floating Surface Collector. Photo and Figure from PacifiCorp

Lewis River, WA - History

- 1931 – Merwin Dam completed
    - Included U/S CHTR passage facility
- 1953 – Yale Dam completed
- 1957 – Merwin CHTR abandoned
    - Returns were not sustainable enough to warrant continued CHTR operation, possibly due to lack of D/S passage
- 1958 – Swift Dam completed
- 2005 – Begin introducing 2,000 adult salmon annually to watershed above Swift Dam
- 2012 – Swift D/S passage: CHTR of juveniles via floating surface collector to location D/S of Merwin Dam
- 2014 – Merwin U/S passage: expected completion date of CHTR, collected fish transported U/S of Swift Reservoir

Cowlitz River, WA - Project History

- 1963 – Mayfield Dam constructed
    - U/S passage: lift
    - D/S passage: louvers guide fish to bypass pipe
- 1968 – Mossyrock Dam constructed
    - D/S passage: “Merwin” trap
- 1969 – Mayfield U/S passage lift abandoned, CHTR and hatchery constructed below Mayfield
- 1973 – D/S passage traps at Mossyrock Dam abandoned
- 1993 – Cowlitz Falls Dam constructed
- 1996 – Cowlitz Falls D/S passage via surface collection flume to sorting facility and then released below Mayfield Dam
- 2012 – New forebay collector currently under design

Cowlitz River, WA - Project Overview

- Dams: Downstream to Upstream
  - Mayfield Dam - hydraulic height 230 ft
  - Mossyrock Dam - hydraulic height 366 ft
  - Cowlitz Falls Dam - hydraulic height 120 ft
- Current Facilities
  - Upstream Passage: CHTR from below Mayfield Dam to Tilton River upstream of Mayfield Dam and upstream of Cowlitz Falls Dam
  - Downstream Passage: Surface collection flume at Cowlitz Dam with CHTR to downstream of Mayfield Dam. Two louvered intake facilities at Mayfield Dam with bypass pipe to river downstream
  - Mitigation hatchery

Mayfield CHTR and Hatchery. Photo from Google Maps

Fish Passage Options

- Upstream
  - Fishways
  - Lifts, Locks, and Elevators
  - CHTR – Collect, Handle, Transfer, Release ("Trap and Haul")
  - Bypass Facilities
- Downstream
  - Forebay Collectors
  - Surface Spills
  - Bypass Facilities
  - Turbine Passage
  - CHTR - Downstream

Fish Passage Systems for Flood Only and Multi-Purpose Dams

Passage Options	Flood Control Only	Multi-Purpose
Upstream Passage		
Fishways	**Limited by Forebay Fluctuation**	Yes
Lifts, Locks, Elevators	Yes	Yes
CHTR	Yes	Yes
Bypass Facilities	Yes	Yes
Downstream Passage		
Forebay Collectors	**Limited by Forebay Fluctuation**	Yes
Surface Spills	**Only when Coupled with Bypass Facility**	**Only when Coupled with Bypass Facility**
Bypass Facilities	Yes	Yes
Turbine Passage	N/A	No
CHTR	Yes	Yes

Design Criteria

- Fishways: leap heights, pool lengths, entrance design, flow requirements, juvenile criteria
- Screen criteria: approach and sweeping velocity
- Bypass systems: conduit and outfall criteria
- Fish Holding: pool volume and water quality
- Temporary/interim Passage Facilities

Design Criteria Process

- Identify target species and life stages
- Establish periodicity of target species and life stages
- Determine design flows for each target species and life stage

Anticipated Fish Species

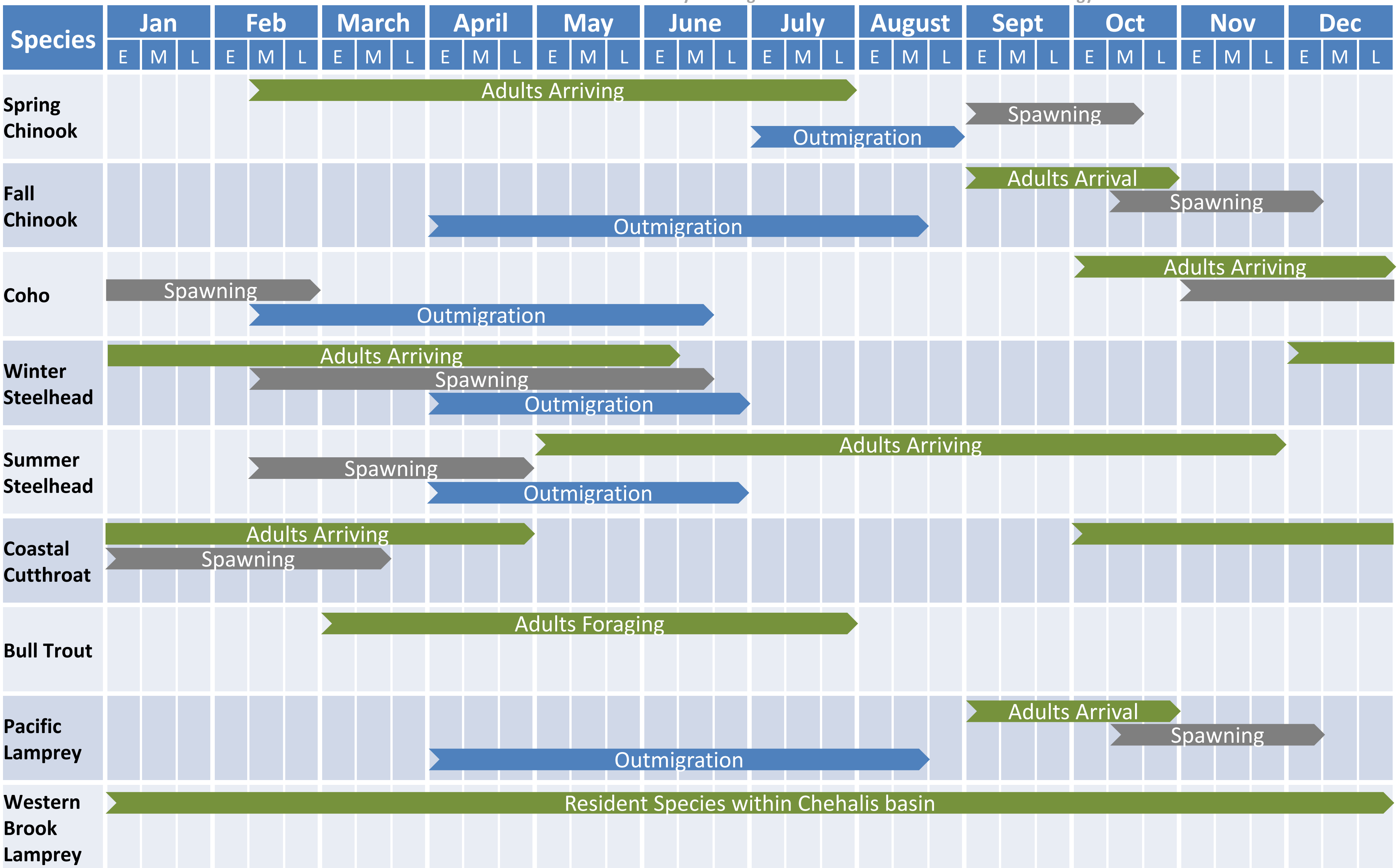
GRAY = Further Discussion Ongoing

SPECIES	UPSTREAM	DOWNSTREAM
Chinook salmon (spring and fall run)	Adult/Juvenile	Juvenile
Coho salmon	Adult/Juvenile	Juvenile
Steelhead	Adult/Juvenile	Adult/Juvenile
Pacific Lamprey	Adult	Ammocoetes / Macropthalmia
Western Brook Lamprey	Adult	Ammocoetes / Macropthalmia
Bull Trout	Adult/Juvenile	Adult/Juvenile
Coastal Cutthroat	Adult/Juvenile	Adult/Juvenile

Migration Timing (Periodicity)

E = Early
M = Mid
L = Late

Source: WA DOE and WDFW. 2004. Chehalis River Basin WRIAs 22 and 23 Fish Habitat Analysis Using the Instream Flow Incremental Methodology.



Hydrology – During Anticipated Time of Migration

Orange = Project Minimum and Maximum Fish Passage Design Flows

SPECIES	Min Design Flow (cfs) NMFS (95% Exceedance)	Max Design Flow (cfs) NMFS (5%)	Max Design Flow (cfs) WDFW (10%)
Spring Chinook	32	1072	724
Fall Chinook	**15**	482	278
Coho	21	**1941**	**1348**
Winter Steelhead	86	1835	1256
Summer Steelhead	17	710	374
Coastal Cutthroat	34	1921	1342
Bull Trout	30	895	592
Pacific Lamprey	**15**	482	278
Western Brook Lamprey	20	1467	967
Annual Statistics	20	1467	967

Design Criteria – Fishways:

RED = Upstream Juvenile Passage Criteria

ITEM	SPECIFIC CRITIERIA DESCRIPTION	AGENCY
Entrance Head Differential	Maintained between 1 and 1.5 ft (Maximum of 0.13 ft or 0.33 ft depending on fish size, could require separate adult and juvenile entrances)	NMFS & WDFW NMFS
Ladder Pool Head Differential	1 ft maximum (0.7 ft or 1 ft maximum depending on fish size)	NMFS & WDFW NMFS
Attraction Flow	Minimum 5% to 10% of high fish passage design flow	NMFS
Energy Dissipation Factor	Maximum of 4 ft-lb/ft^3-sec (Maximum of 2 ft-lb/ft^3-sec)	NMFS & WDFW NMFS
Pool Dimensions	Minimum 8 ft long, 6 ft wide, and 5 ft deep	NMFS
Depth Over Weir Crests	1 ft minimum	NMFS & WDFW
Ambient Lighting	Preferred throughout with no abrupt lighting changes	NMFS & WDFW

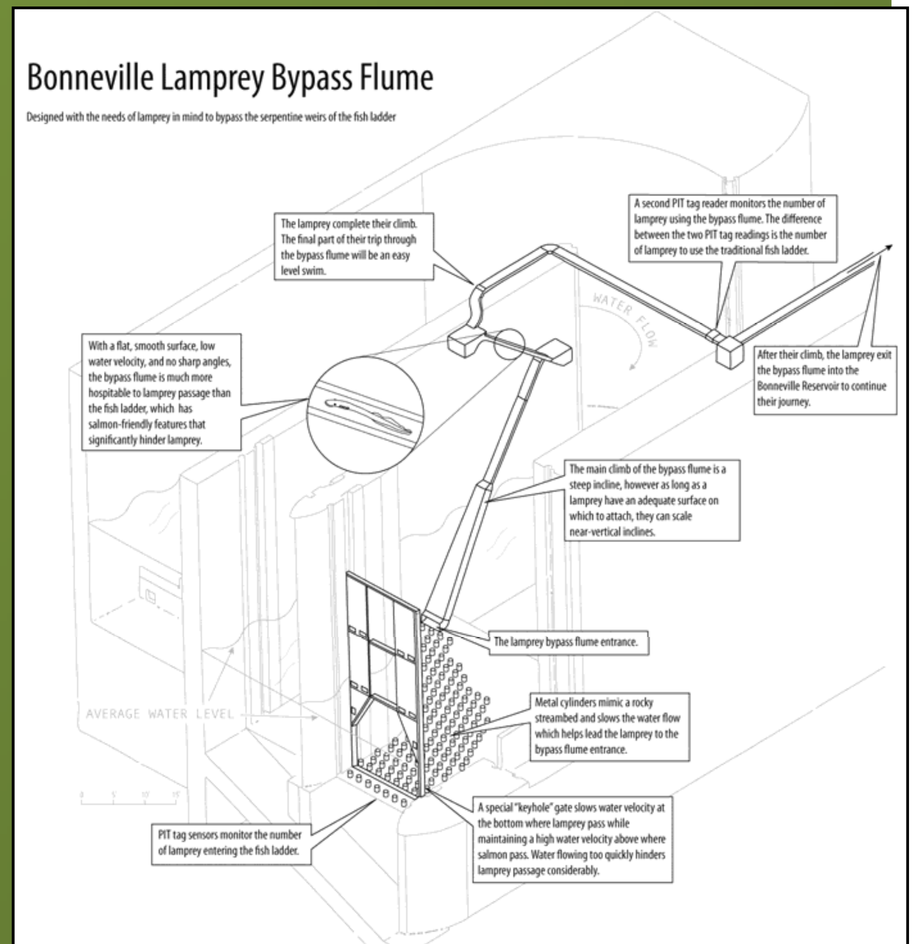
Note: Not a complete list of design criteria, only basic design criteria is presented.

Cutthroat and Bull Trout

- No official agency guidance
- Potential options for design:
  - Adopt similar design criteria as juvenile salmon and steelhead, or
  - Can be developed from species specific locomotion characteristics
- Further discussion is required to determine passage requirements and acceptable design criteria

Lamprey Passage

- Best Practices to Reduce Adverse Effects (USFWS)
- Modify design and construction activities to consider lamprey life history requirements
- Screening criteria developed for salmonids may or may not be appropriate
- Maintain flow velocities less than 5 to 6 ft/s
- Provide structures with rounded corners.
- Provide smooth ramps in and out of passage structures
- In some cases, separate passage facilities are required.



Design Criteria – Interim Passage During Construction

- Required if construction of an artificial impediment is scheduled during periods when migrating fish are present
- Interim passage facilities must meet all regular facility design criteria unless approved by NMFS

Research Input and Next Steps

- Additional Research Suggestions?
  - Need final input by November 4th
- Next Steps
  - Technical Committee review:
    - Fish Passage Design and Operation Criteria Interim Report – October 28th – November 8th
  - Fish Passage Alternatives Interim Briefing Report – November 29th
  - Fish Passage Alternatives Preliminary Feasibility Report – Jan 10, 2014