Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

November 13, 2013 Policy Workshop

Tasks 1.1.1 Dam Design and 1.1.2 Fish Passage

Research Findings

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Mike Garello. P.E.

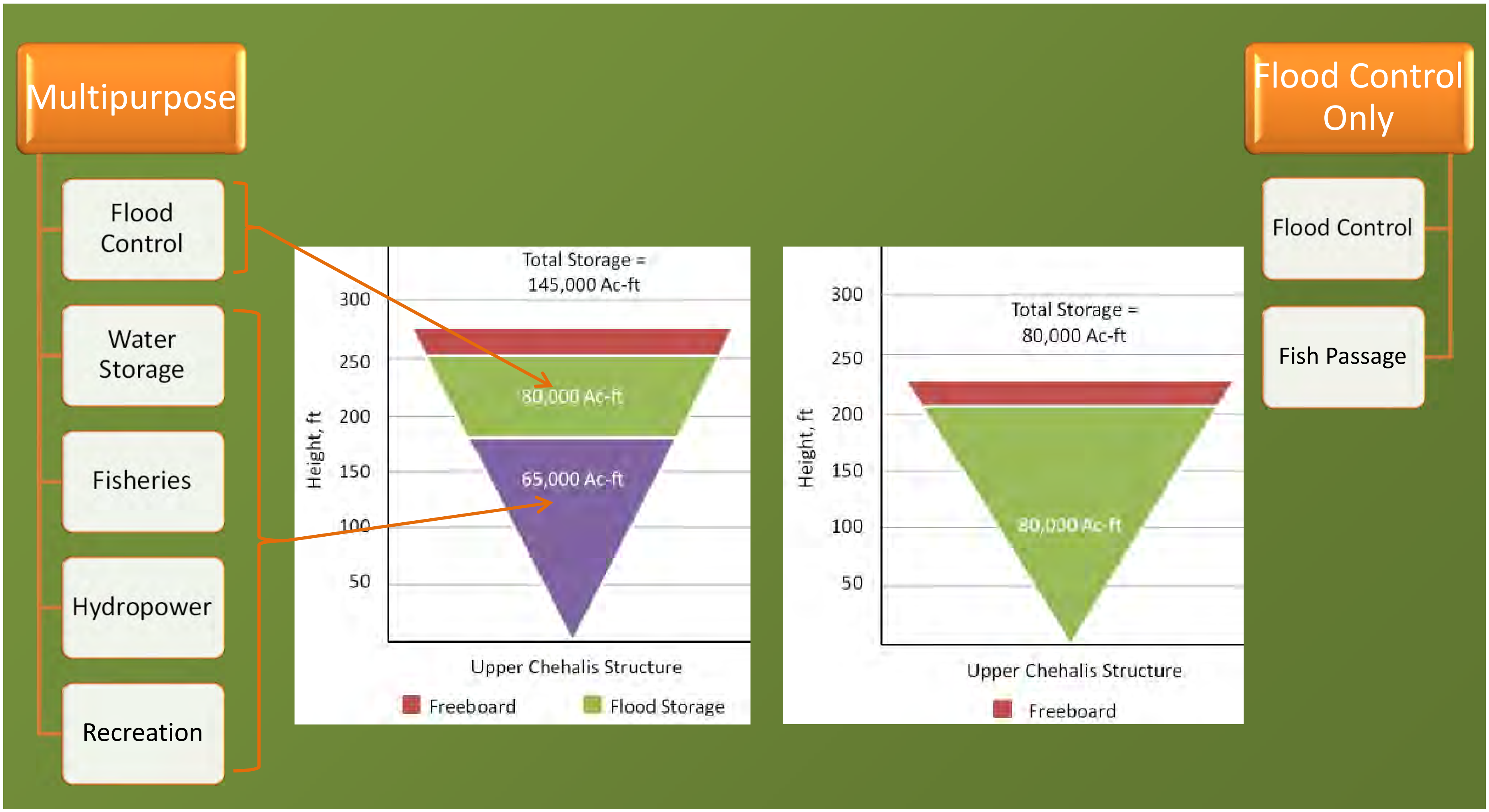
Introduction

- Objectives
  - Present preliminary dam and fish passage research findings
  - Identify any additional research needs with regard to dam alternatives and fish passage
- Presentation
  - Task 1.1.1 Dam Design Study
  - Task 1.1.2 Fish Passage Design
  - Q&A/Discussion

Outline

- Background Information
- Dam Examples – learning from the past
- Site Visit Findings
- Dam Types
- Hydraulic Structures
  - Slots and Tunnels for Fish Passage
  - Flood Control and Operation Outlets
  - Auxiliary Spillways
- Fish Passage
- Debris Management
- Research Findings and Next Steps

Chehalis Dam Alternatives



Ranking and Similar Projects

- Dam Height (from previous evaluations)
  - Flood Control Only = 238 feet
  - Multipurpose = 288 feet
- Research; leveraging roles and relationships with USSD and ICOLD
- Internationally
  - Rockfill and Concrete (RCC) up to 1,000 feet high being constructed
- Nationally
  - 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 (the top 0.1%).
  - Leading the way on multi-purpose, sustainability, and environmentally enhanced dams

Dams in the US

- Last 25 years
  - More than 8,900 NID new dams built
  - More than 1,500 NID dams modified

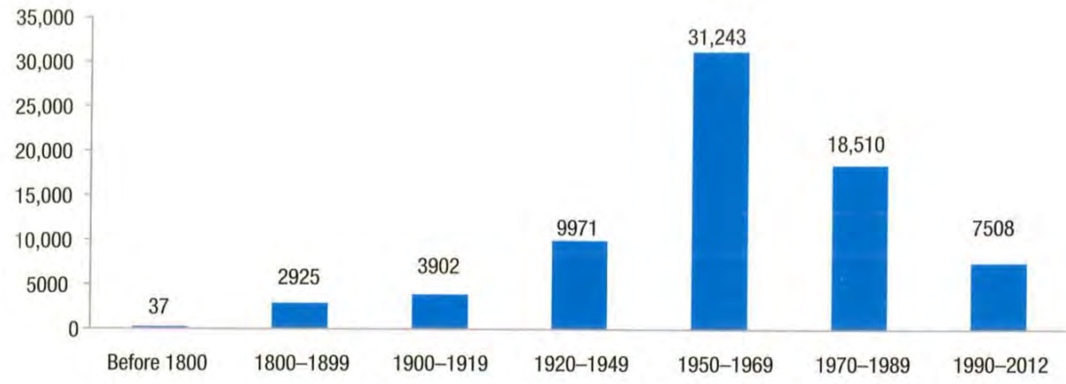


Figure 8. Dams constructed in the United States by completion date

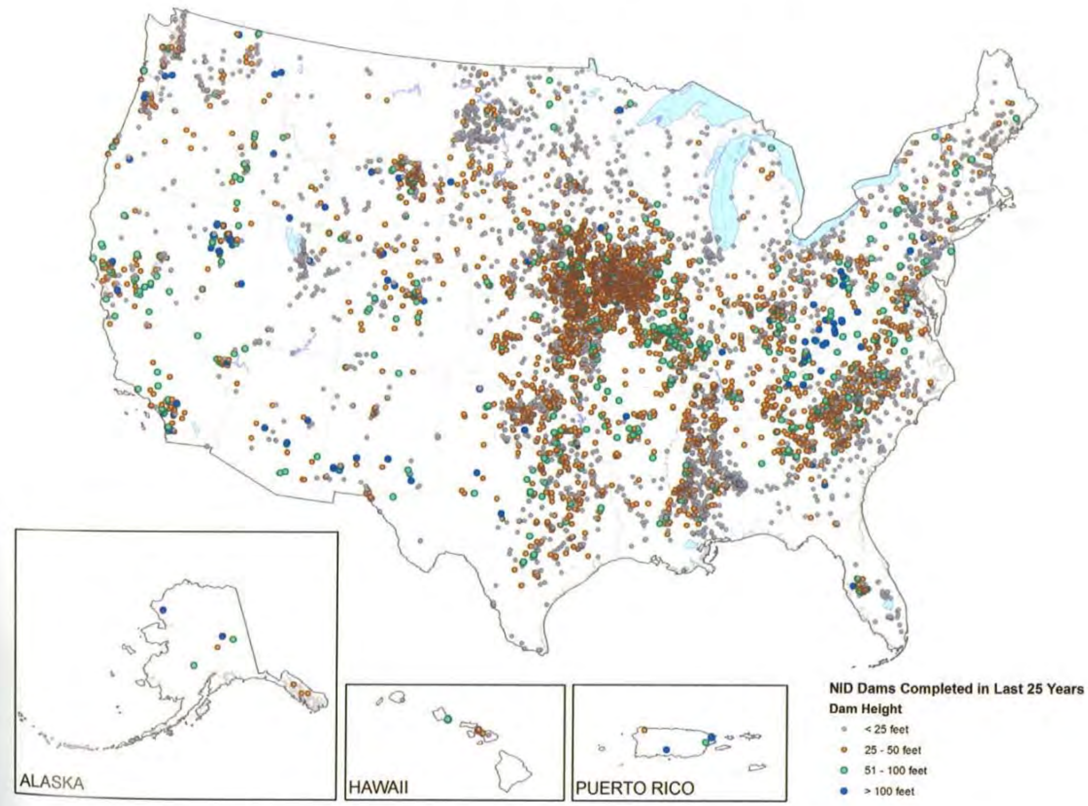


Figure 9. Dams constructed in the United States in the last 25 years by dam height

Dams in the US

- For new dams:
  - 10% greater than 50' high
  - 15% high hazard potential (HHP)
- HHP dams under construction in 2012:
  - 33 less than 50'
  - 16 between 50' and 100'
  - 7 over 100'

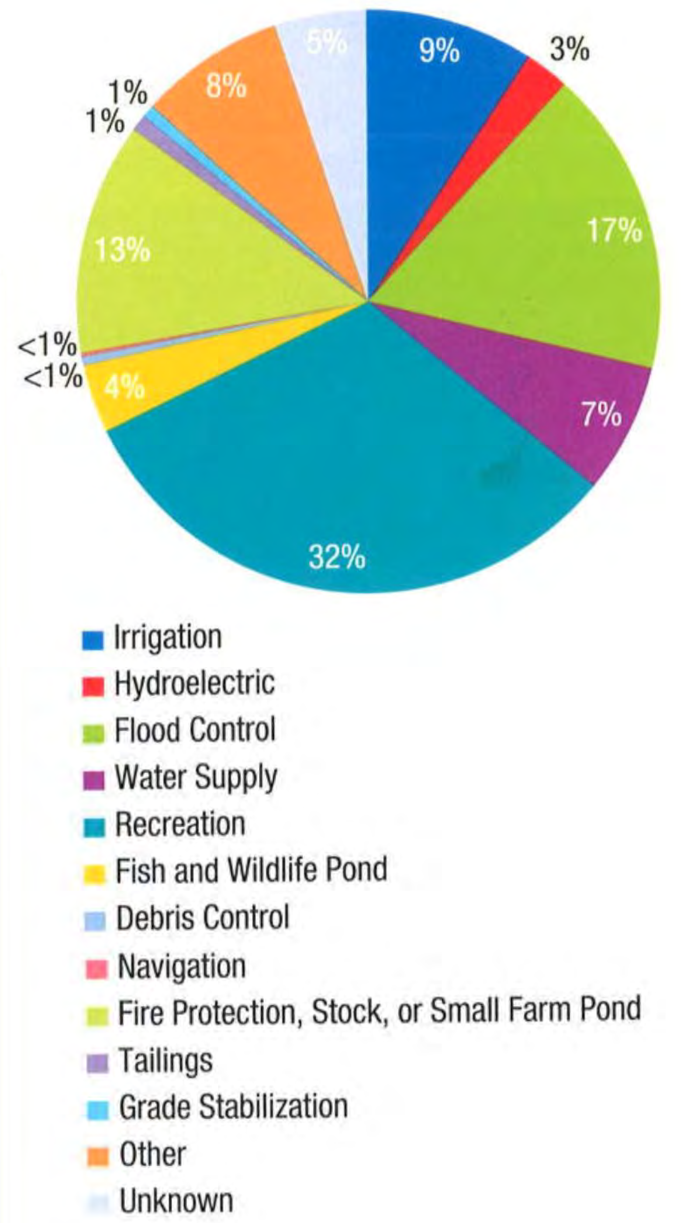
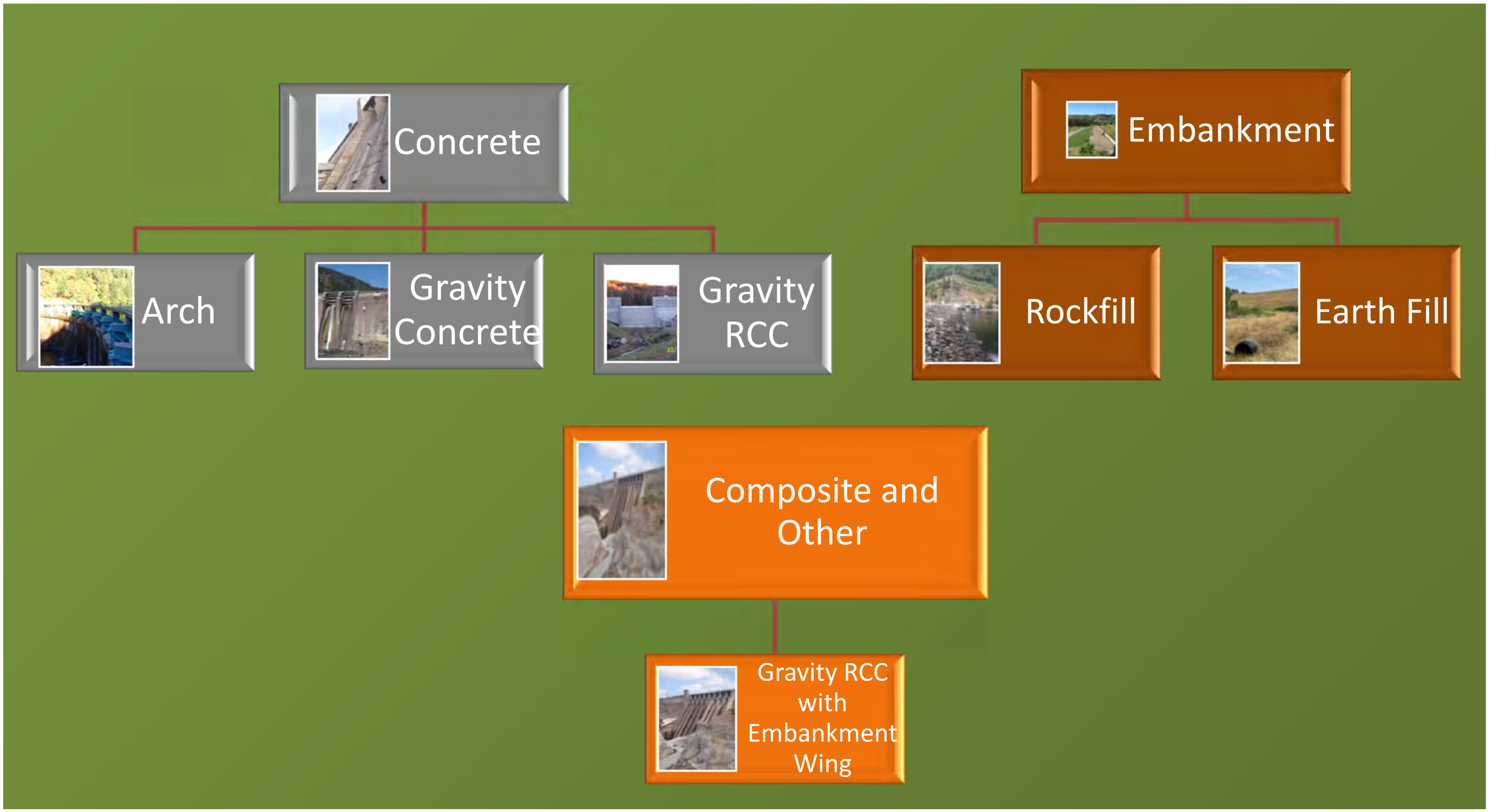


Figure 7. Distribution of U.S. dams by primary purpose

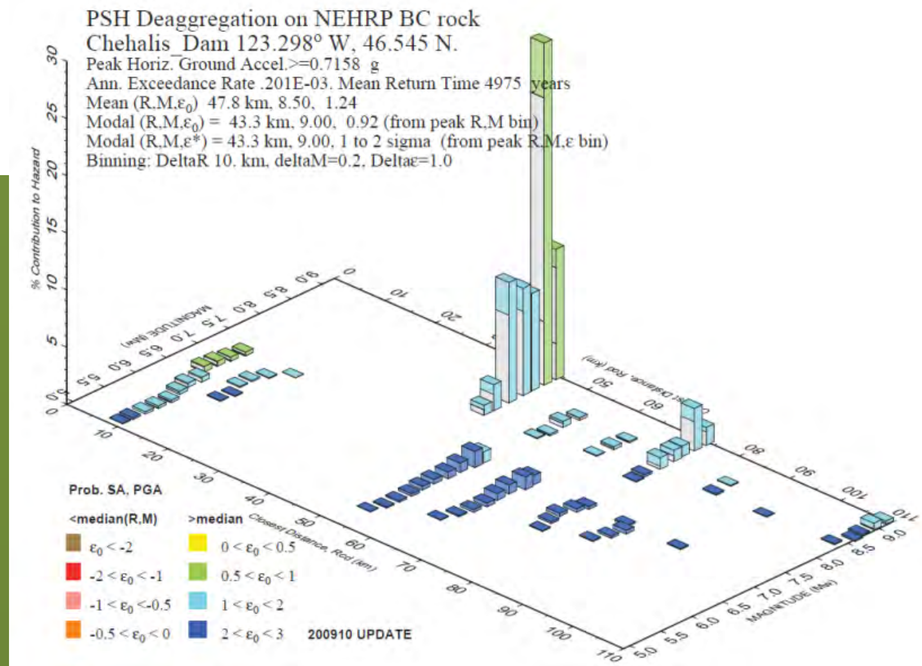
Dam Types


Concrete
Embankment
Arch
Gravity Concrete
Gravity RCC
Rockfill
Earth Fill
Composite and Other
Gravity RCC with Embankment Wing

Design Criteria

- Flood Control Only
  - High Hazard Potential
  - Dam Safety Flood – PMP
  - Watershed debris management, screening and handling
  - Seismic Loading - < MCE
  - Some cracking allowed for concrete dams
- Multi-purpose
  - High Hazard Potential
  - Dam Safety Flood – PMP
  - Debris screening and handling
  - Seismic Loading – MCE with partial pool
  - Cracking may not be allowed for concrete dam alternatives

Key Site Considerations



Seismic Hazards

- 1/2,500 year - 0.56g pga
- 1/5,000 year - 0.72g 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

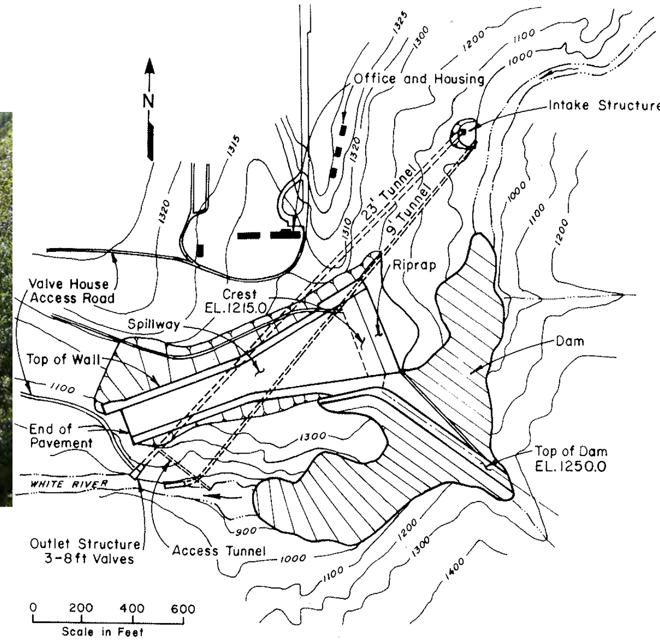
Foundation Conditions

Existing Dam Examples

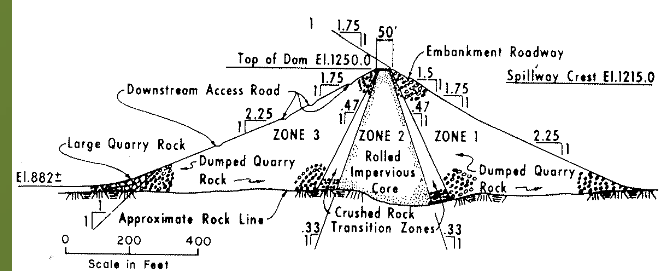
Learning from the Past

Flood Control Only
Mud Mountain Dam, WA

Location: Enumclaw, Washington
Operator: Seattle District, Corps of Engineers
Dam Type: Earth/rockfill Embankment (1948)
Length: 315 feet
Height: 380 feet
Low level flood control conduits and auxiliary spillway



GENERAL LAYOUT

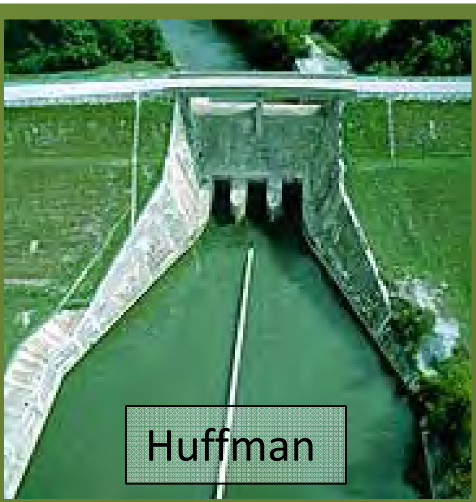


MAXIMUM SECTION

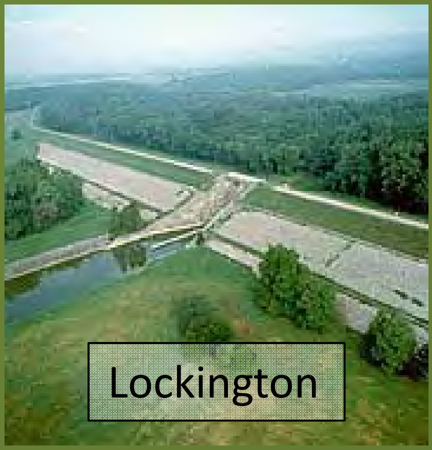
Flood Control Only – Morris Dam, NY

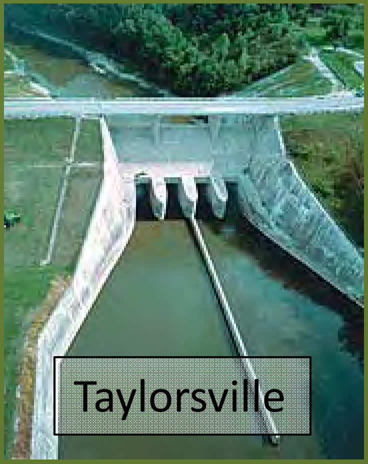
Location: Leicester, NY
Operator: USACE – Buffalo District
Dam Type: Concrete Gravity
Length: 1,028 feet
Height: 230 feet
Low level conduits and Overflow Spillway

Flood Control Only
Miami Conservancy District – 5 Dams, OH



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

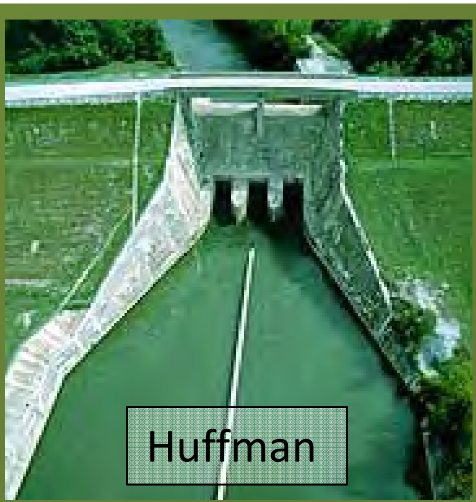




Multipurpose
Detroit Dam, OR

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

Flood Control Only
Miami Conservancy District – 5 Dams, OH



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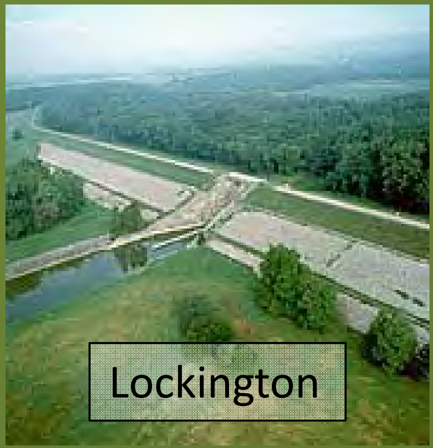
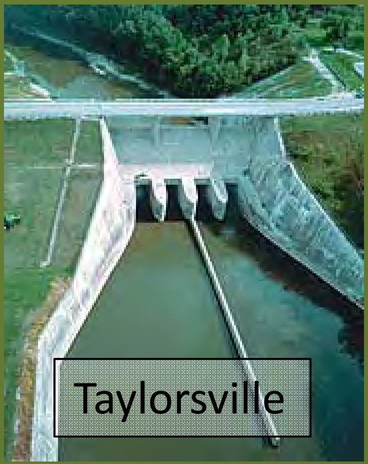




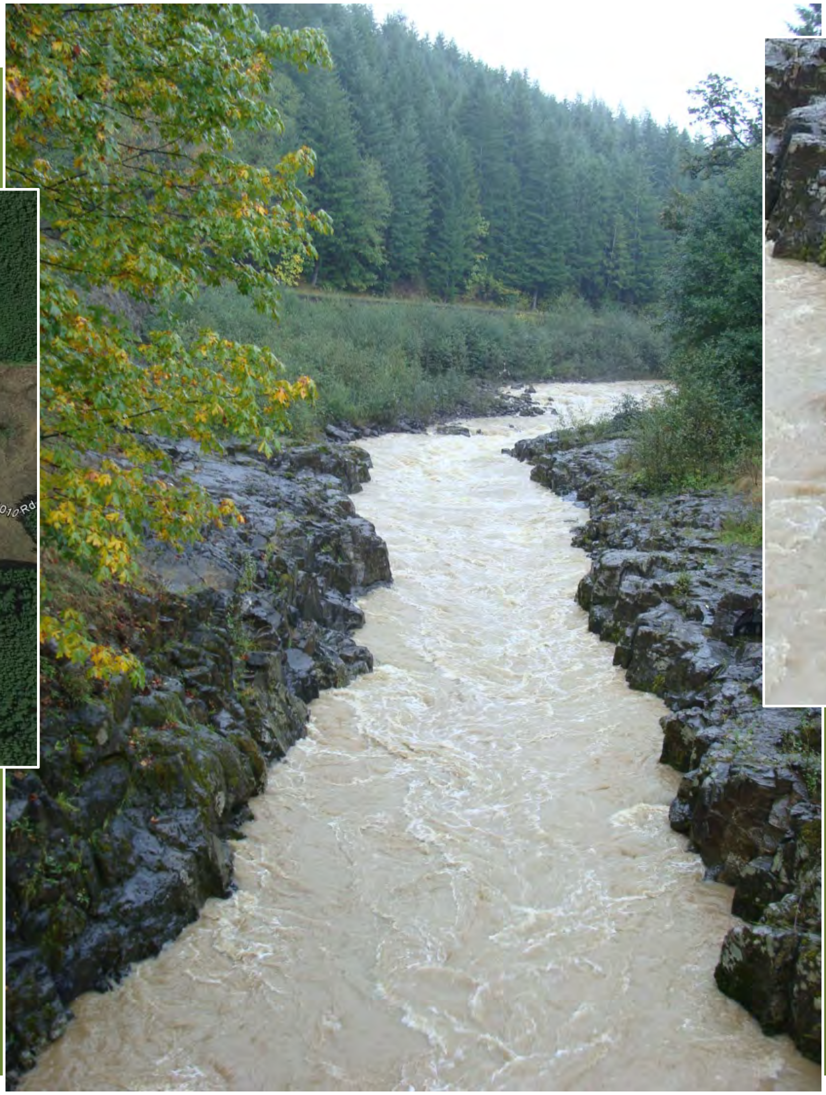
Site Visit

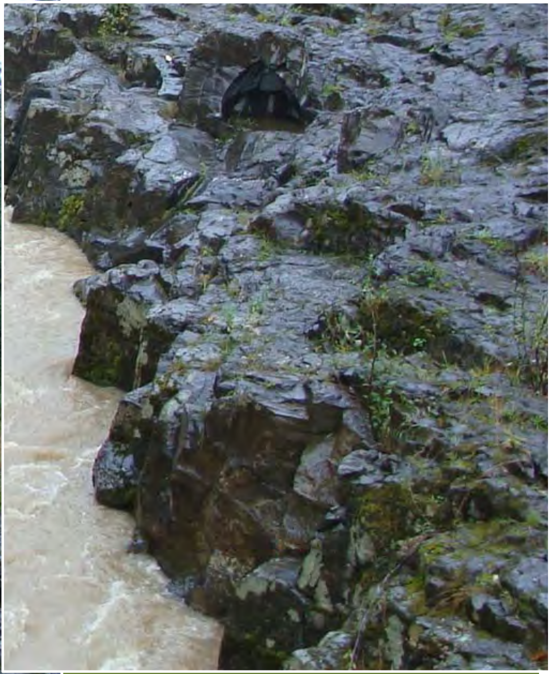
Dam Site
Aerial Views

Site Visit

October 1, 2013

AERIAL KEY





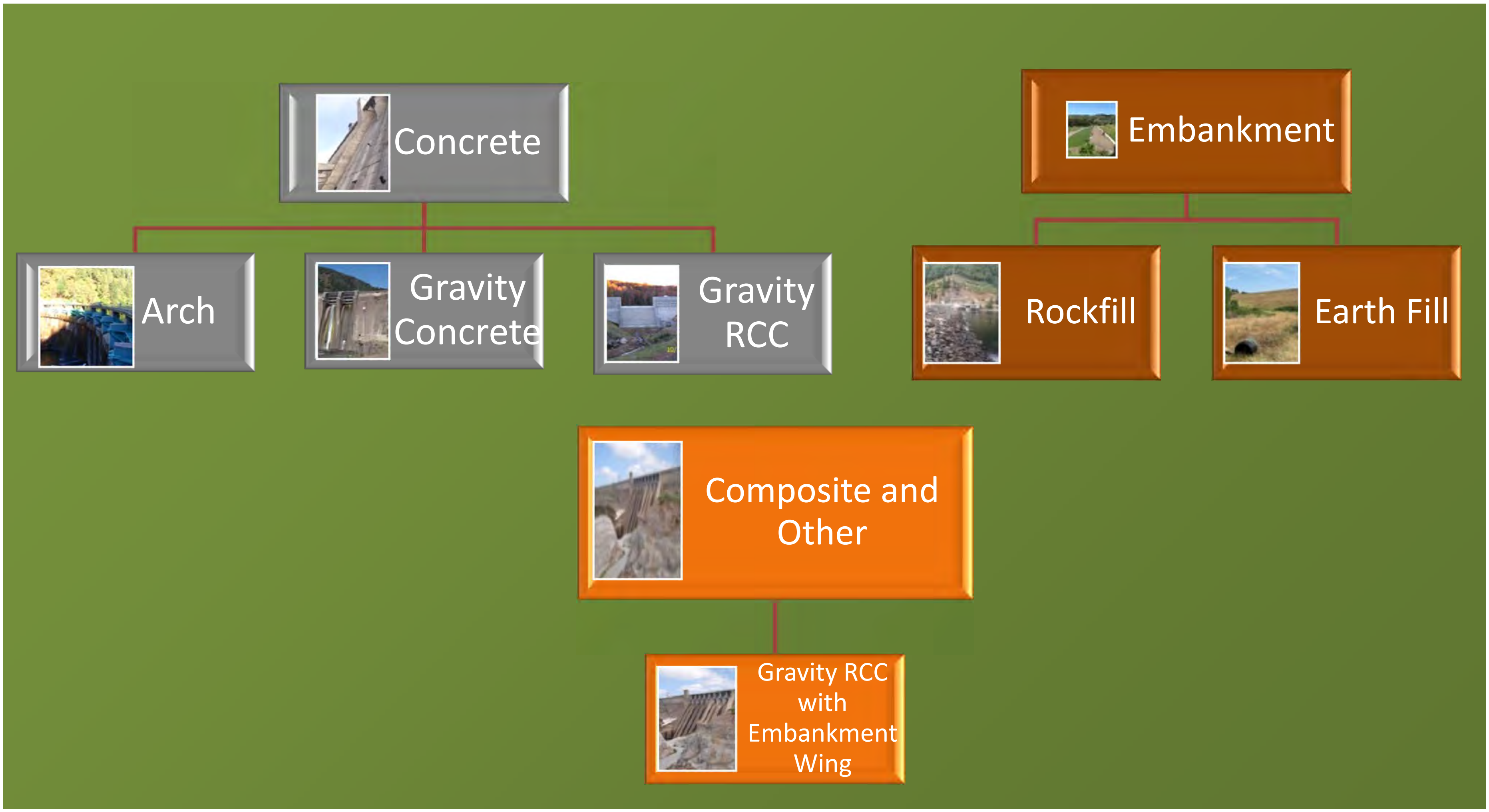
Site Visit

October 1, 2013

Site Visit

October 1, 2013

Dam Types


Concrete
Arch
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Composite and Other
Gravity RCC with Embankment Wing

Roller Compacted Concrete Dams

New Big Cherry Dam, VA 2006

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

Olivenhain Dam, CA 2004

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

Creekside Greywater Reservoir, OR, 2007

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

Diamond Valley Reservoir, CA 2000

RCC/Embankment Composite Dam

Location: Folsom, CA

Operator: USACE/USBR Joint Federal Project

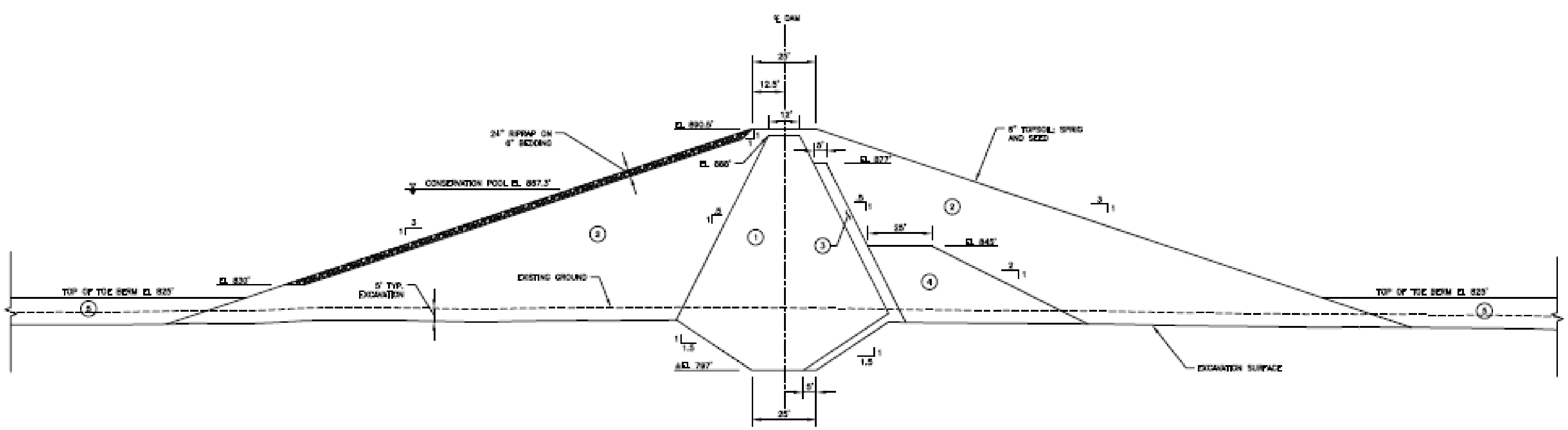
Dam Type: Concrete and Earthen

Length: Main 1,400 feet

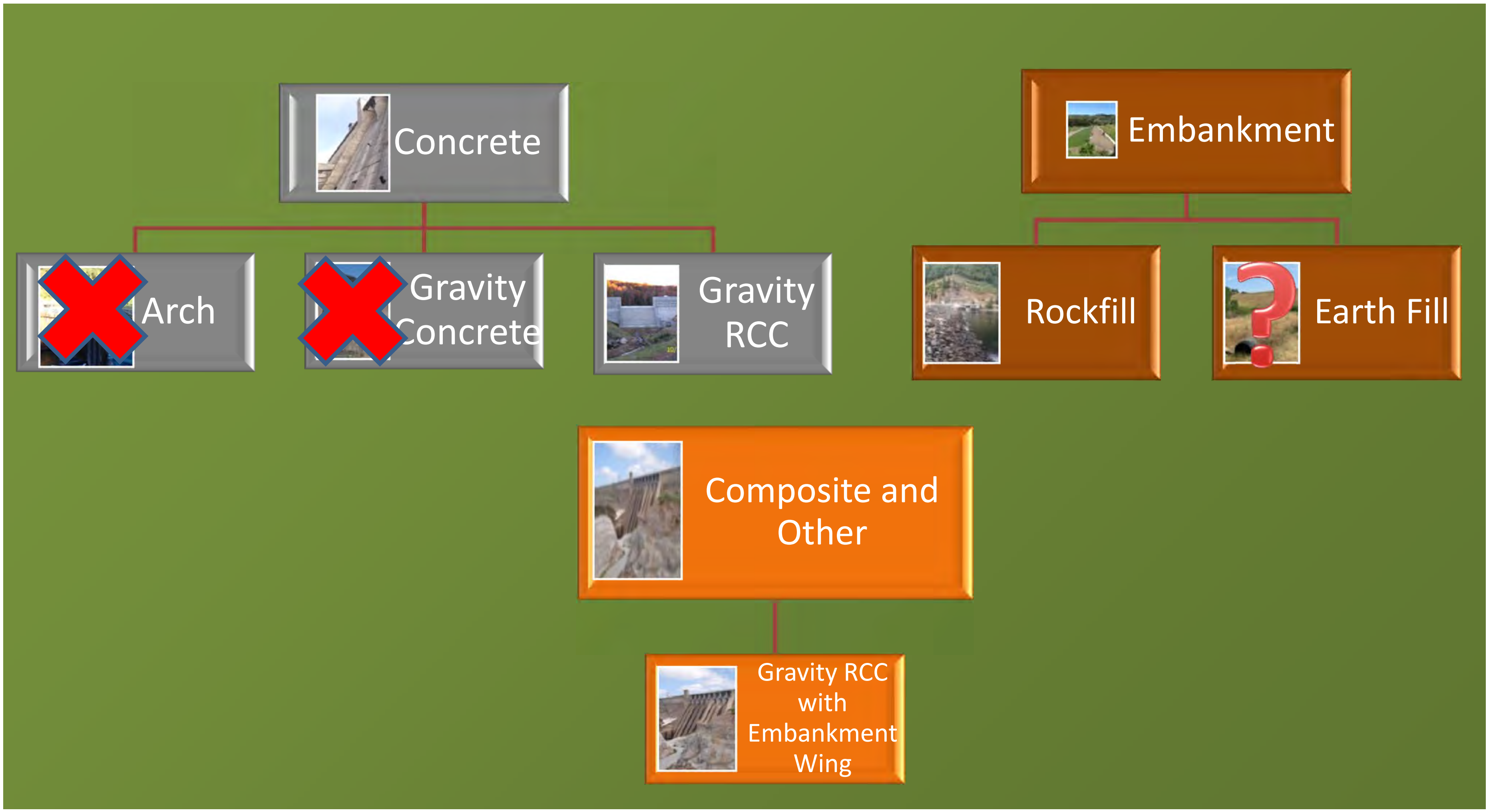
Height: 340 feet

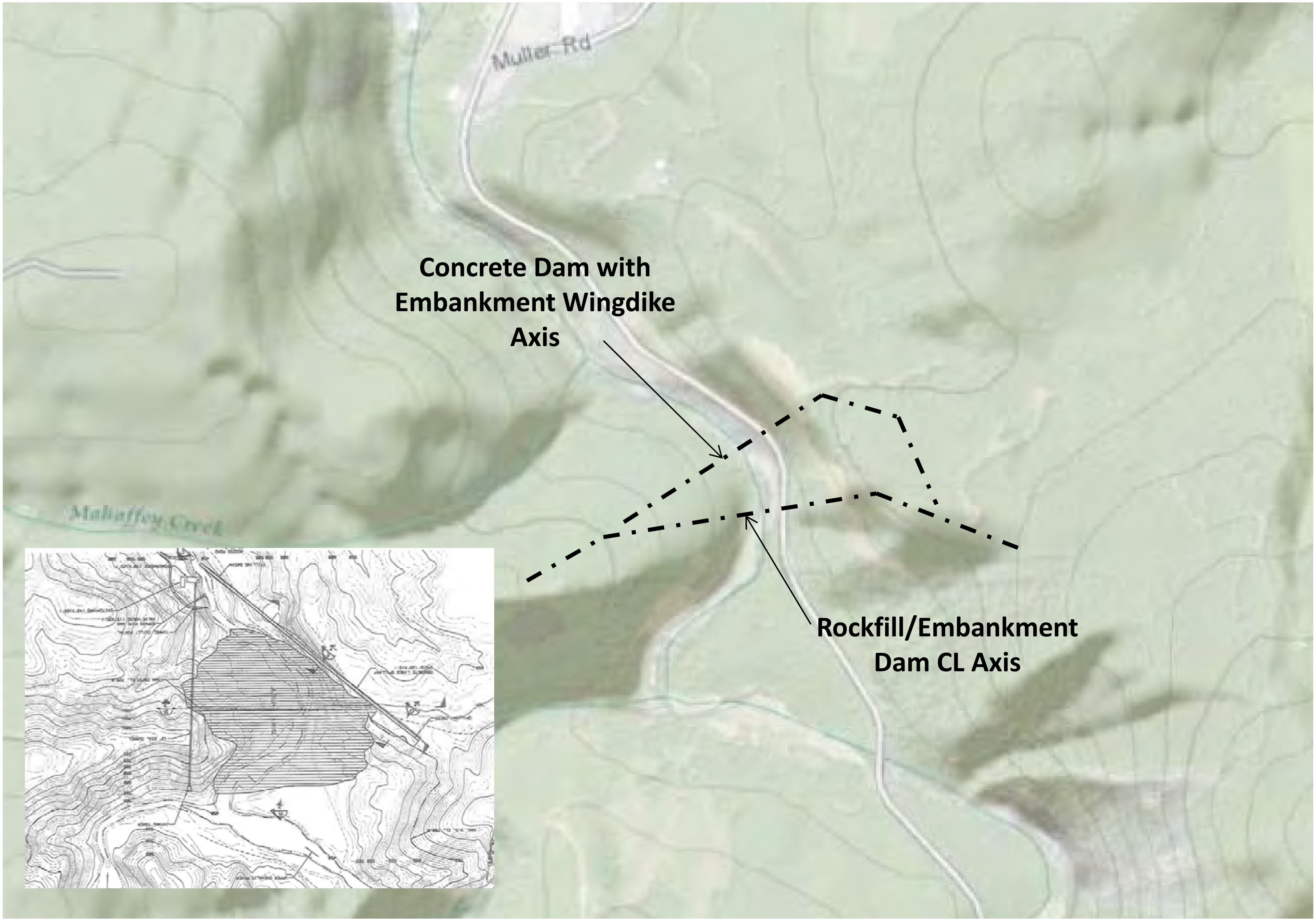
Gated Concrete Spillway

Earthfill dam



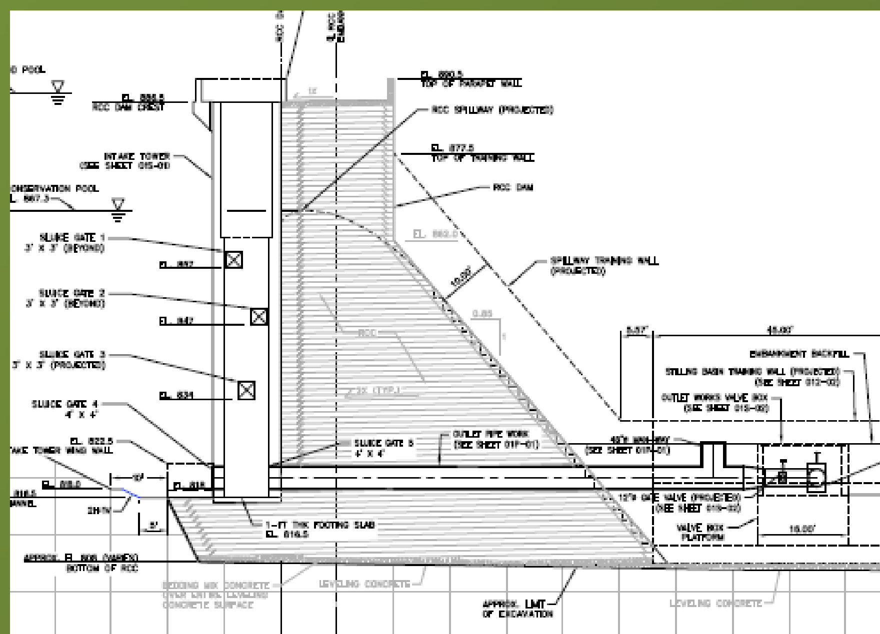
Dam Type Findings




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

Hydraulic Structures

- Slots in Dams
- Fish Passage
- Auxiliary Spillway
- Flood Control Outlet



- Gates
- Valves
- Stoplogs
- Approach Canals and Channels

Findings – Slots in Dams

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

Open Slot

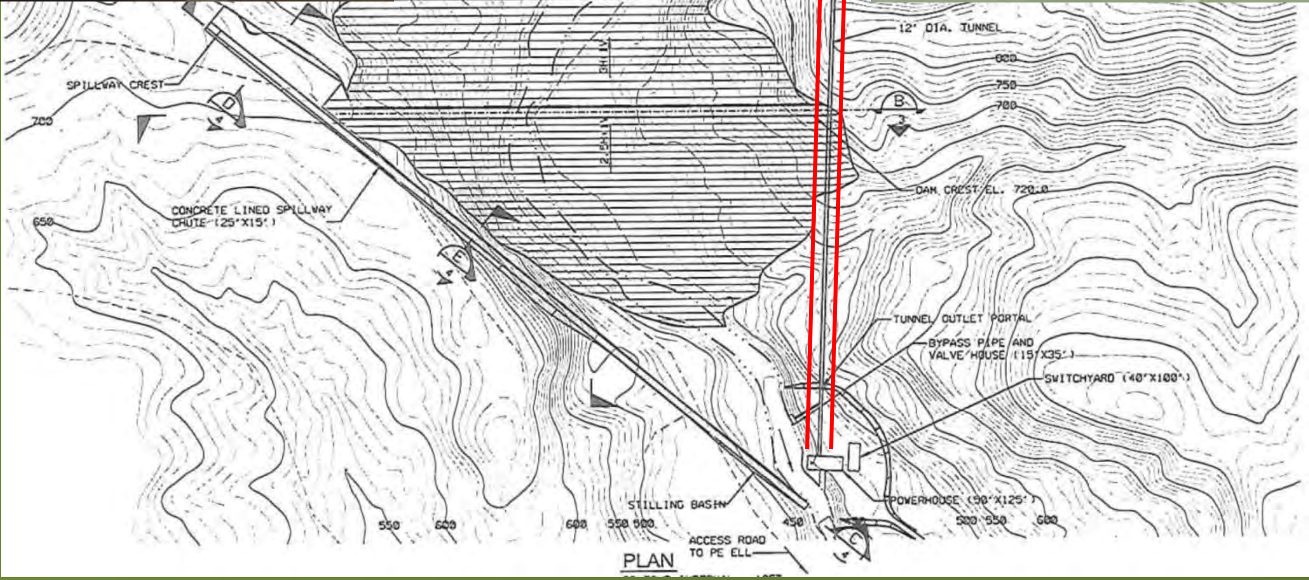
Baffled Slot

Gated Slot

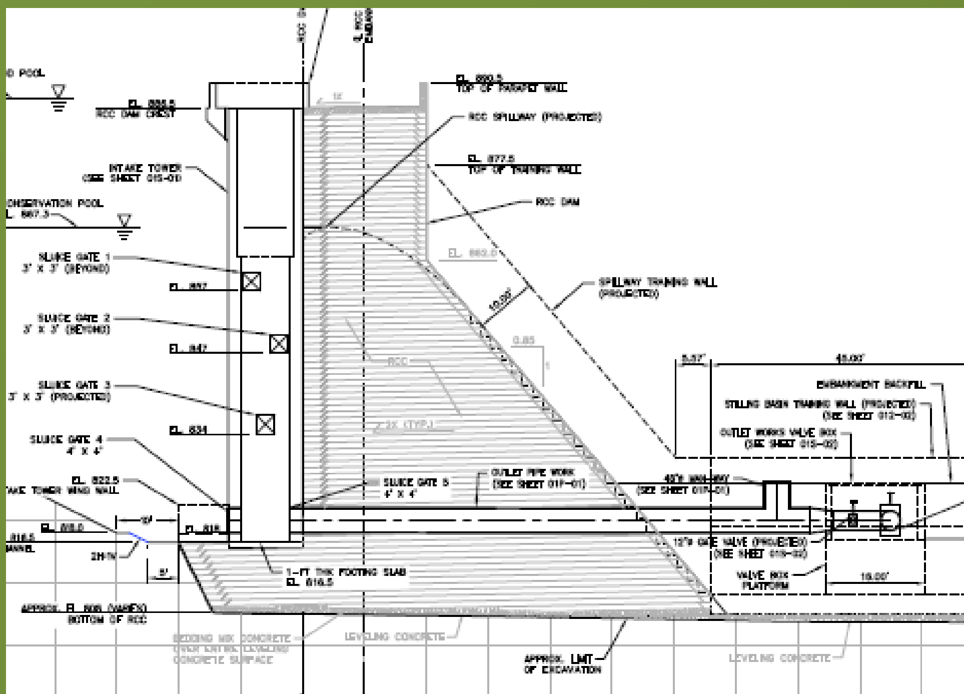
Outlet Tunnels – Base of Concrete Dam

Moose Creek Dam, USACE, Alaska

Outlet Tunnel - Abutments



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

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

Overflow Spillway

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

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

Fish Passage

Fish Passage Research

Several potential fish passage technologies were evaluated from around the world and the Pacific Northwest.

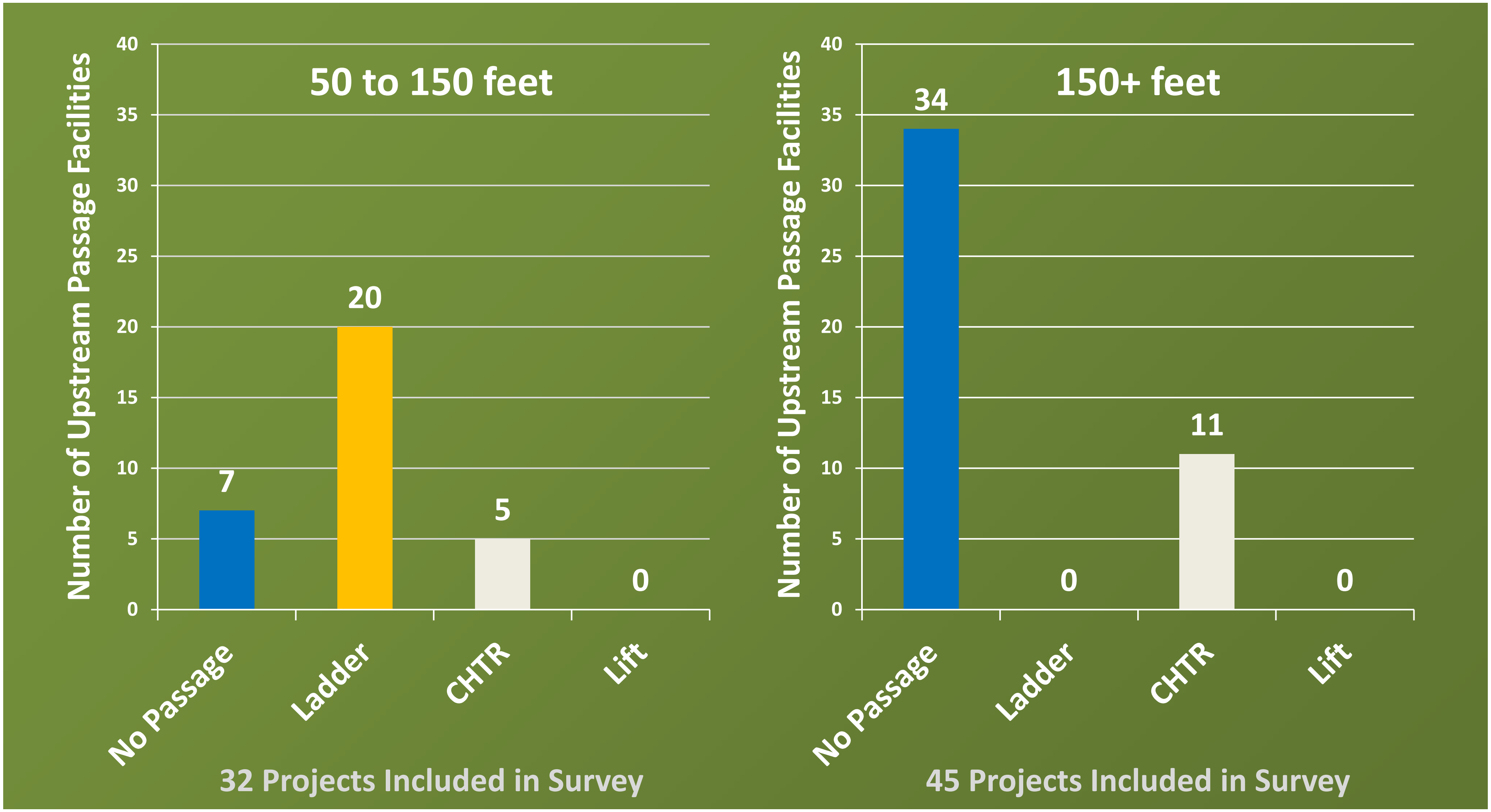
Summary of Fish Passage Technologies

- Upstream
  - Fishways (Nature-Like and Conventional)
  - Lifts, locks, and elevators
  - CHTR – Collect, Handle, Transfer, and Release "Trap and Haul"
  - Bypass Facilities
- Downstream
  - Surface Spill
  - Forebay Collector
  - CHTR
  - Turbine Passage
  - Bypass Facilities

Fish Passage Background

- The Fish Ladder
- Example - Ice Harbor Style Fishway
  Ice Harbor Dam, WA

Fish Passage at High Dams – Western US (WA, OR, CA, ID)



Fish Passage Trends for High Dams

Fish Ladders and Lifts Built During Dam Construction → **Fish Ladders and Lifts Modified and or Abandoned** → **New CHTR and Forebay Collectors Constructed**

1920s to 1930s | **1950s to 1970s** | **1990s to Current**

- Most projects at high head dams in Pacific Northwest use CHTR for upstream passage
- Forebay collectors are the most recent downstream passage technological advancement
- Mitigation hatcheries often used in tandem with passage

Potential Fish Passage Structures

Multi-Purpose Dam

- CHTR
- Forebay Collector

Potential Fish Passage Structures

Flood Control Only Dam

- Bypass Tunnel
- CHTR

Anticipated Fish Species

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

Fish Passage Findings

- CHTR and Forebay Collector type facilities are more frequently used for high dam passage
- Integration of a bypass tunnel through a flood control only dam would be an innovative approach to providing fish passage for all species

Debris and Sediment Management

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

Alternative Debris Management Strategies:

- Routine reservoir inundation and debris removal
- Routine clearing/grubbing
- Debris removal following flood events
- Alternative debris management and removal provisions in design elements
- Reservoir Operations to manage Sediment accumulation
- Sediment flushing systems

Moose Creek Dam, USACE, Alaska

Summary of Research Findings

- New dams over 100’ in height are being constructed in the US
- Design criteria would be more stringent for a multi-purpose dam than for flood control only
- The site appears to be best suited for either a RCC, rockfill, or RCC/embankment composite dam
- A slotted dam would not be suitable for this high dam application

Summary of Research Findings (cont)

- Several alternative configurations could be suitable hydraulic outlet, spillway, and bypass structures
- CHTR and forebay collection fish passage would be most suitable for high dam fish passage
- A flow through channel or tunnel would provide innovative fish passage for a flood-control only dam
- Debris and sediment management will be an important part of the dam/passage design

Next Steps

- Finalize configuration design criteria
- Fish Passage Workshop this week
- Dam configuration Workshop in early December
- Draft alternative dam and fish passage configurations for flood control only and multi-purpose dams
- Integrate operations criteria to refine recommended dam and passage systems
- Draft Dam Design TM – February 28, 2014