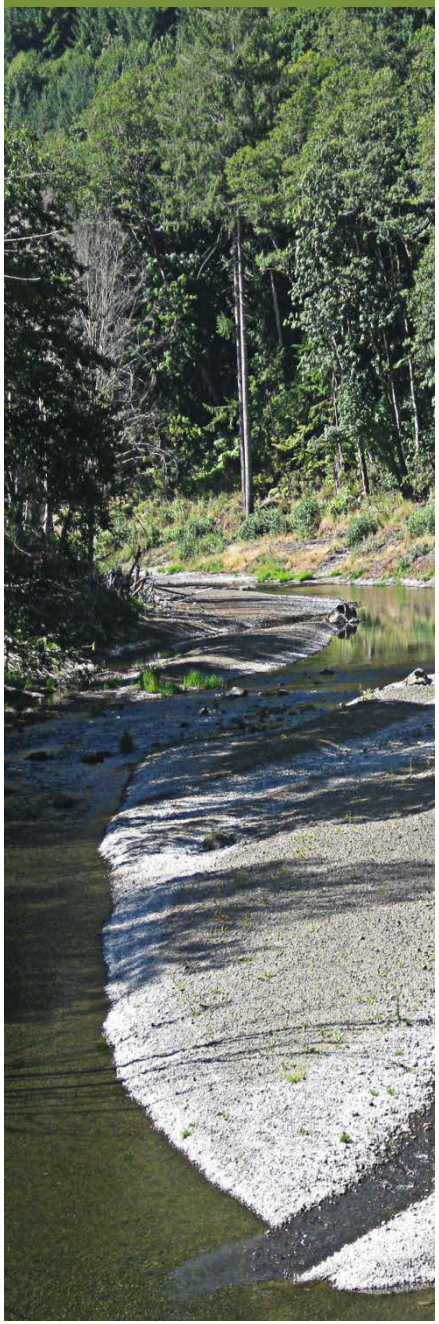
# Chehalis Basin Strategy

***Policy Workshop***

***Water Retention***

***May 22, 2014***

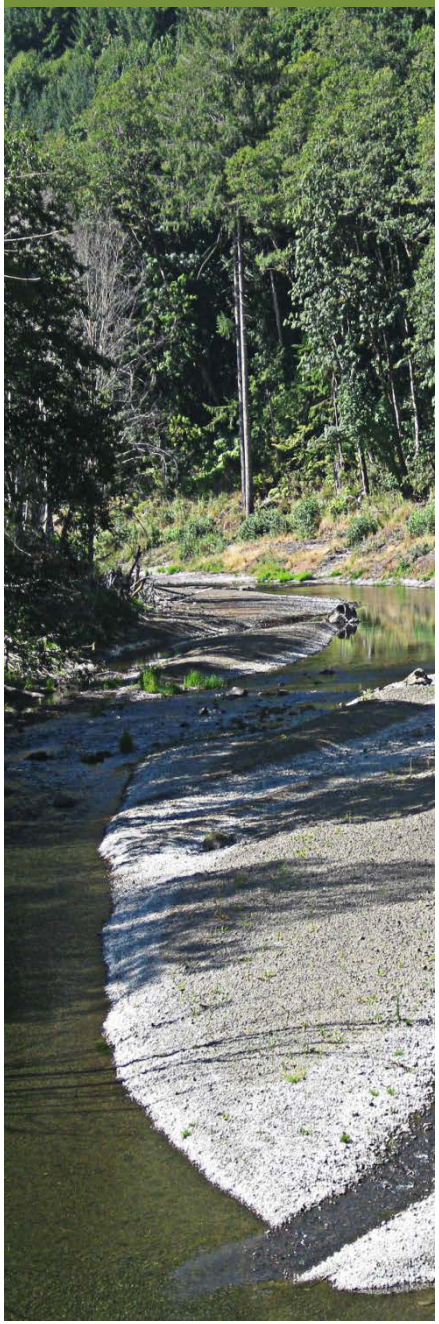


# Dam Structure Options Selected for further Evaluation

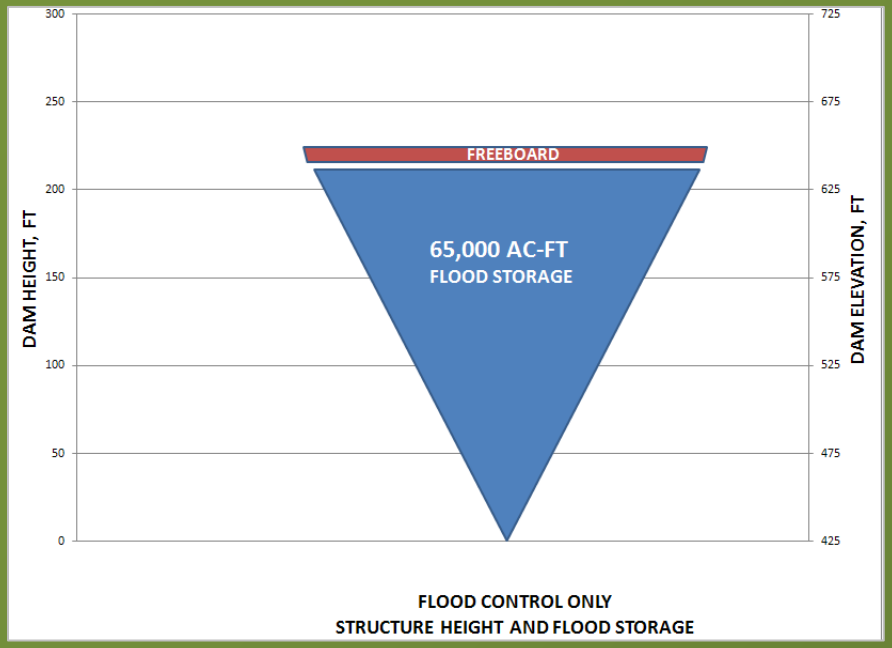
- Flood Retention RCC* Dam (FR-RCC)
- Multipurpose RCC Dam (MP-RCC)
- Multi-purpose Rockfill Dam (MP-Rockfill)

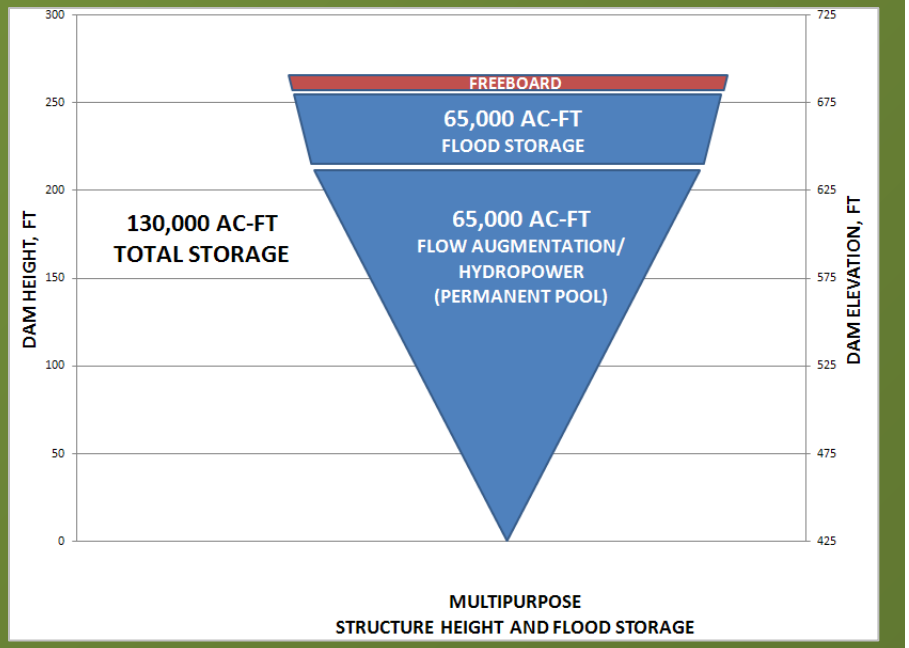
*Roller Compacted Concrete (RCC)

# Dam Alternatives Overview



# Basis of Design – Key Assumptions

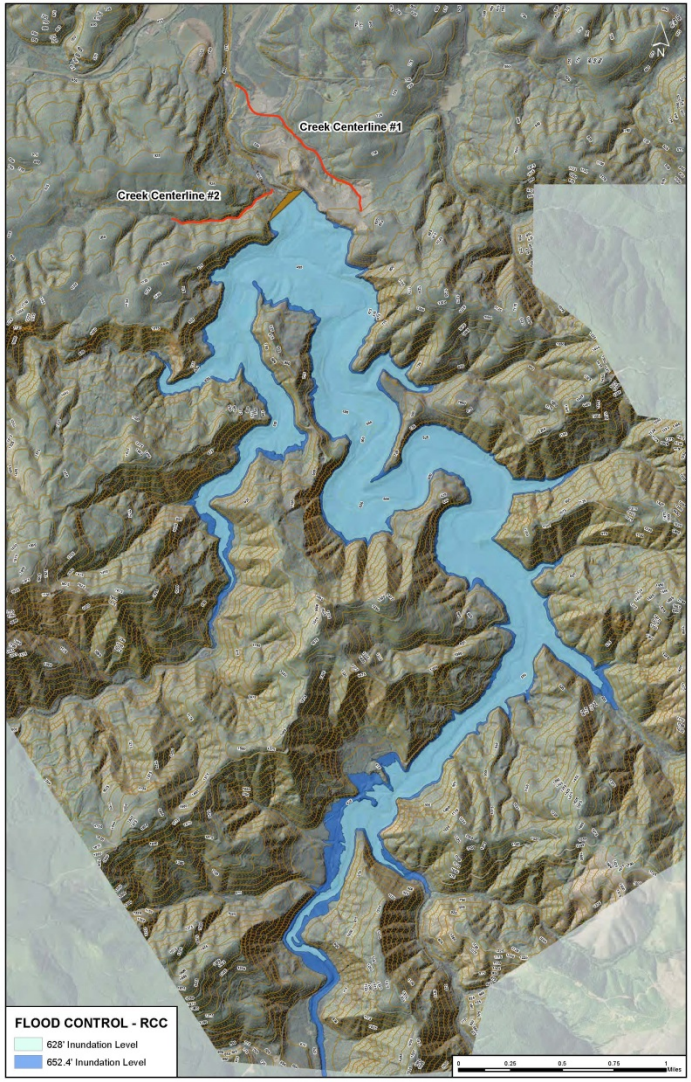



Flood Retention Only Crest Elevation: 654

Multipurpose Crest Elevation: 714

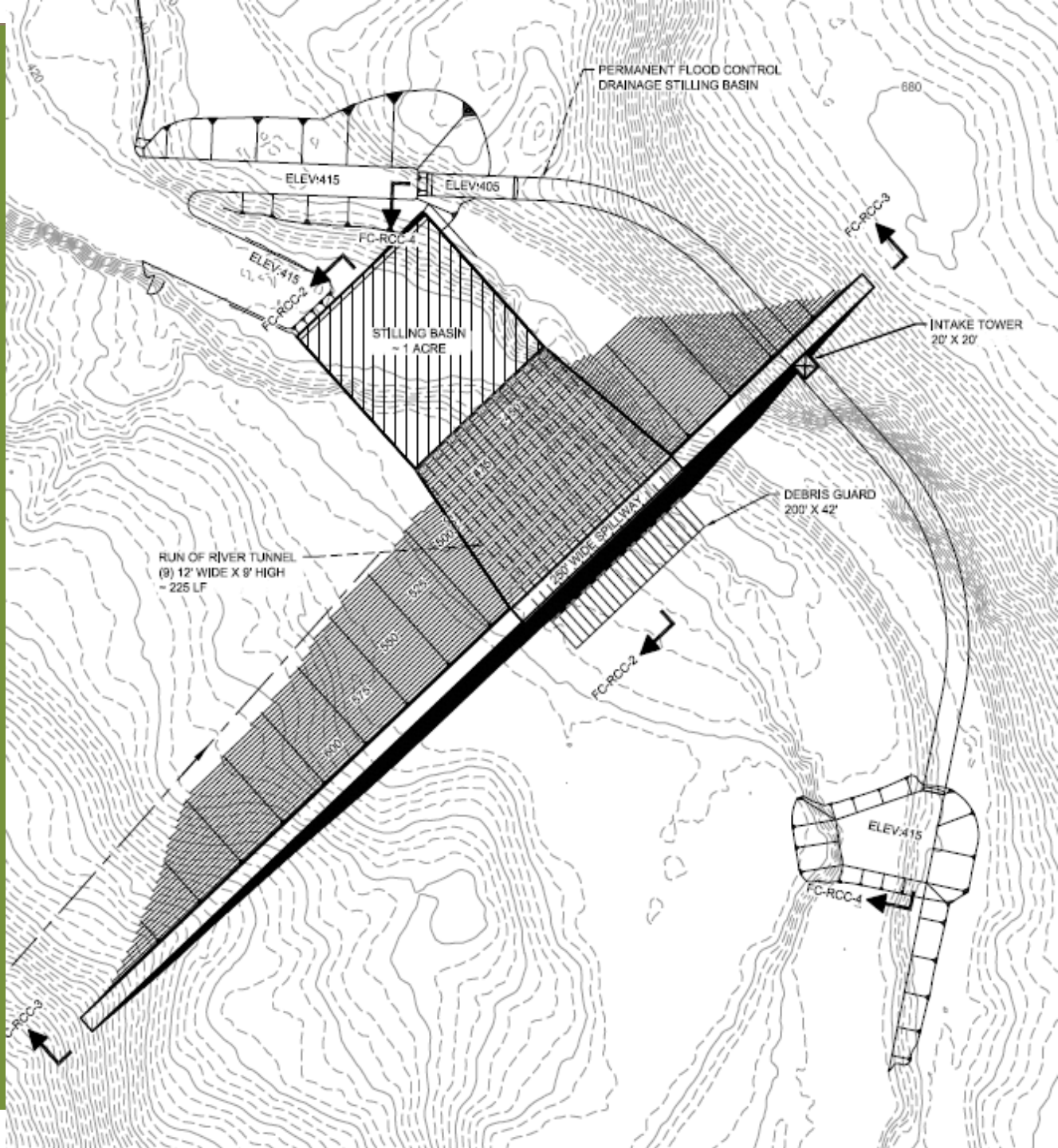
# Flood Retention Only Reservoir



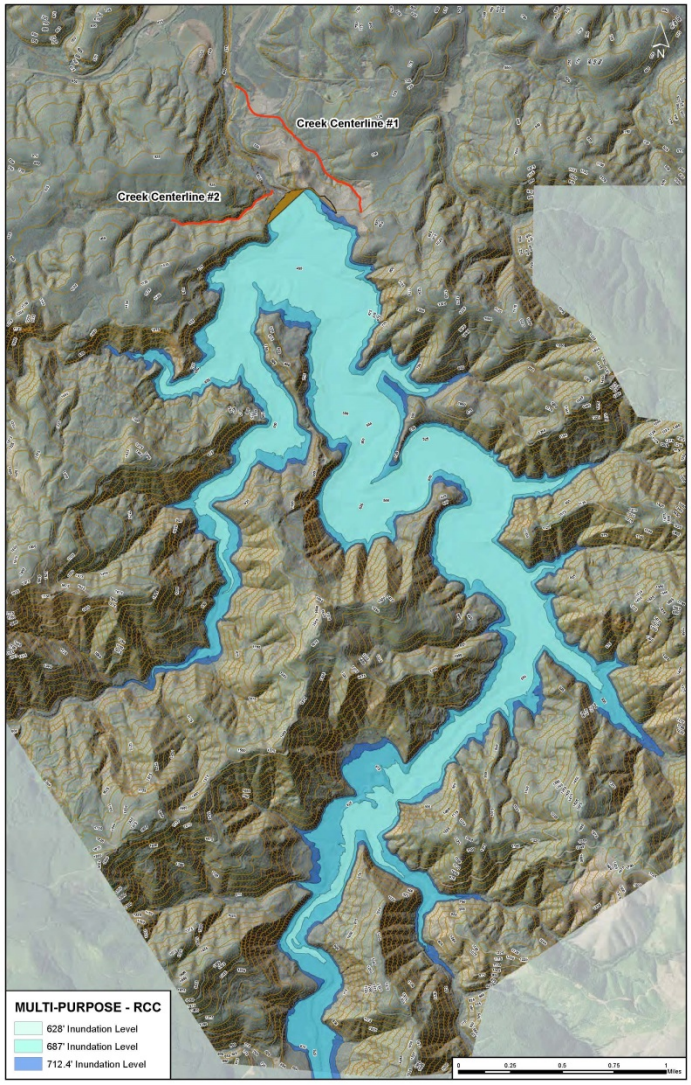

- Dam Height = 227’
- Spillway Crest Elev. = 628
- Dam Crest Elev. = 654
- Area = 860 Acres
- River Inundation Length = 6.8 mi

# Flood Retention Only RCC Dam

Footprint = 6 acres

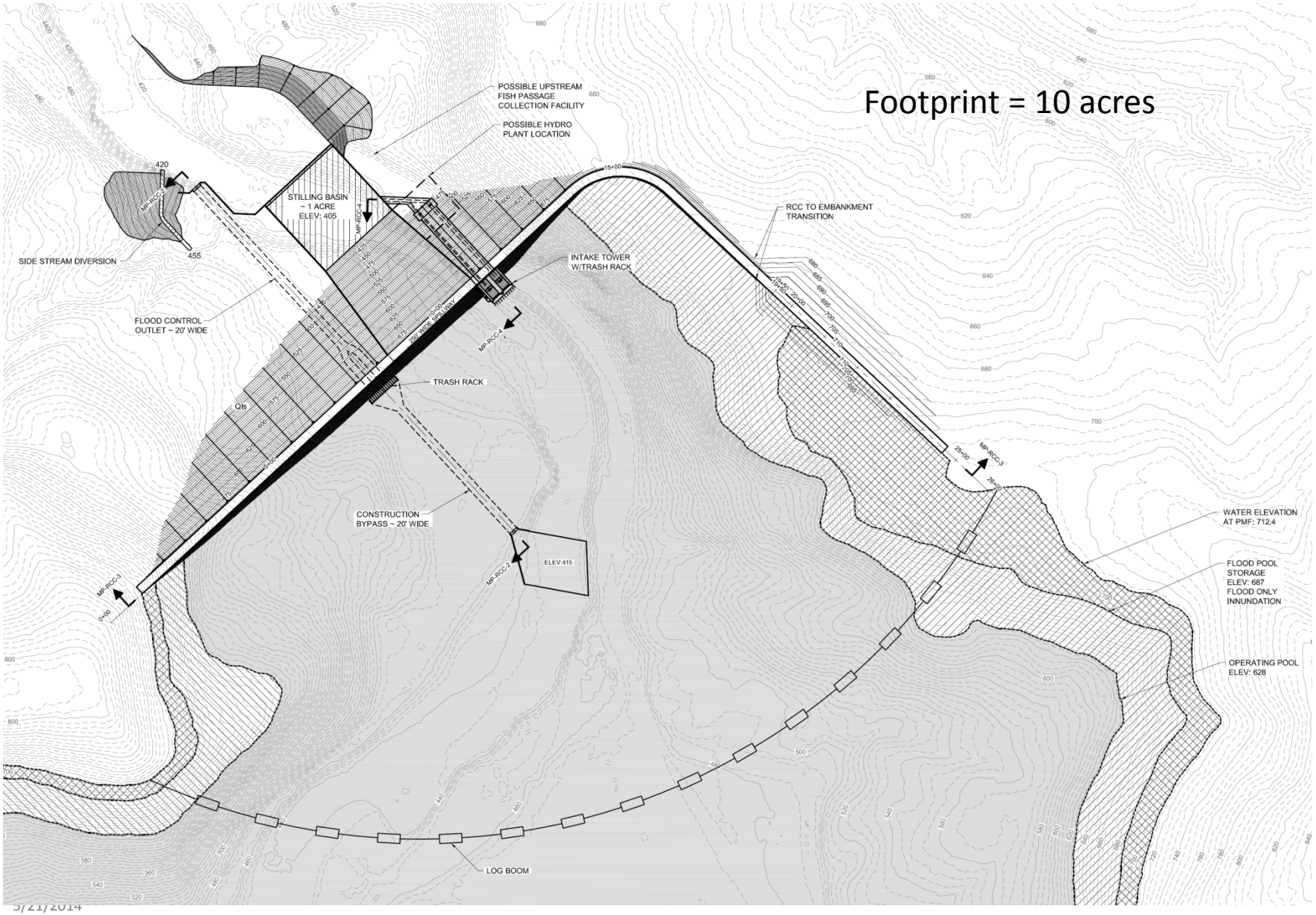


# Multi-purpose Reservoir Overview

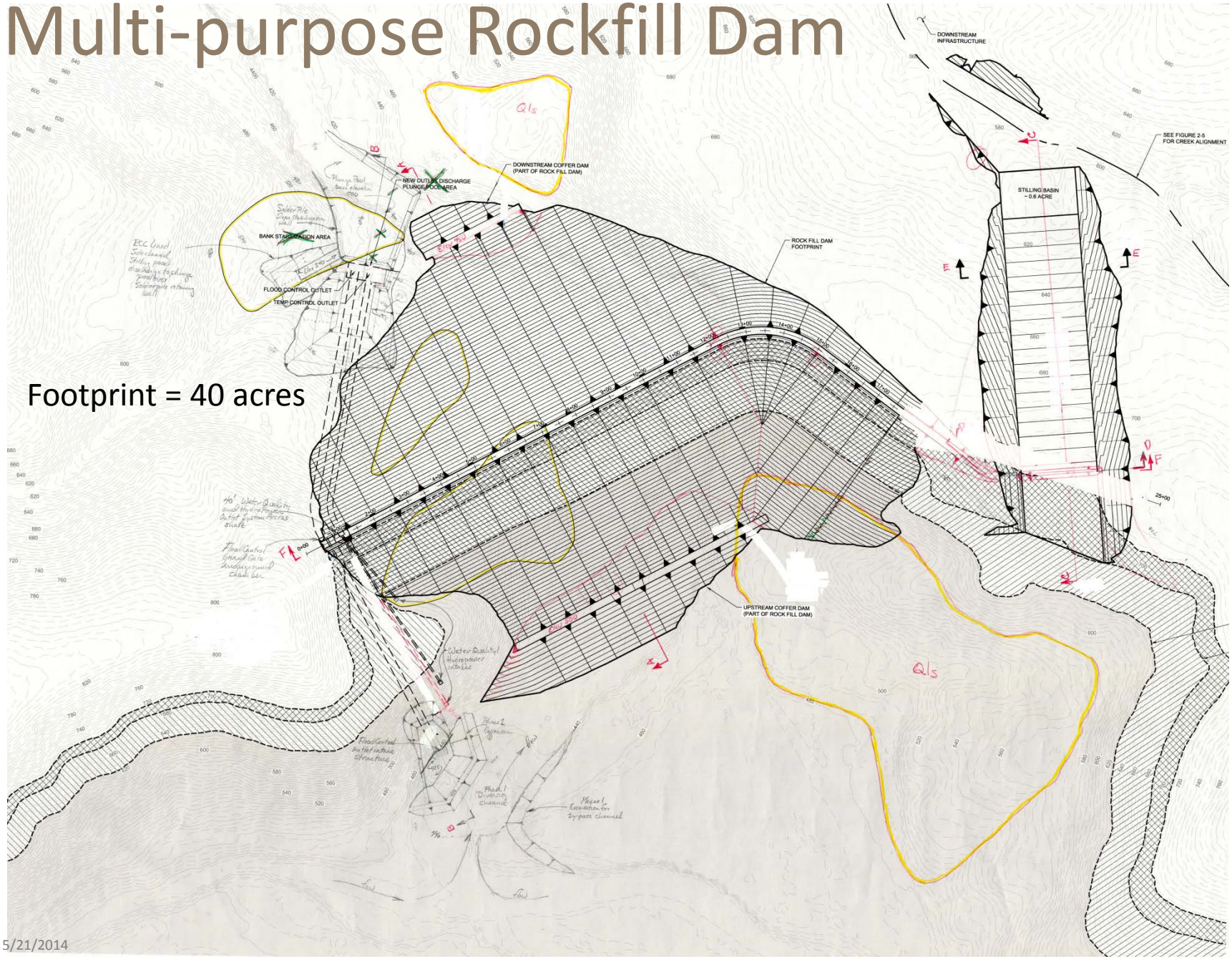



- Dam Height = 287’
- Spillway Crest Elev. = 687
- Dam Crest Elev. = 714
- Area = 1,307 Ac
- River Inundation Length = 7.5 mi

# Multi-purpose RCC Dam



# Multi-purpose Rockfill Dam

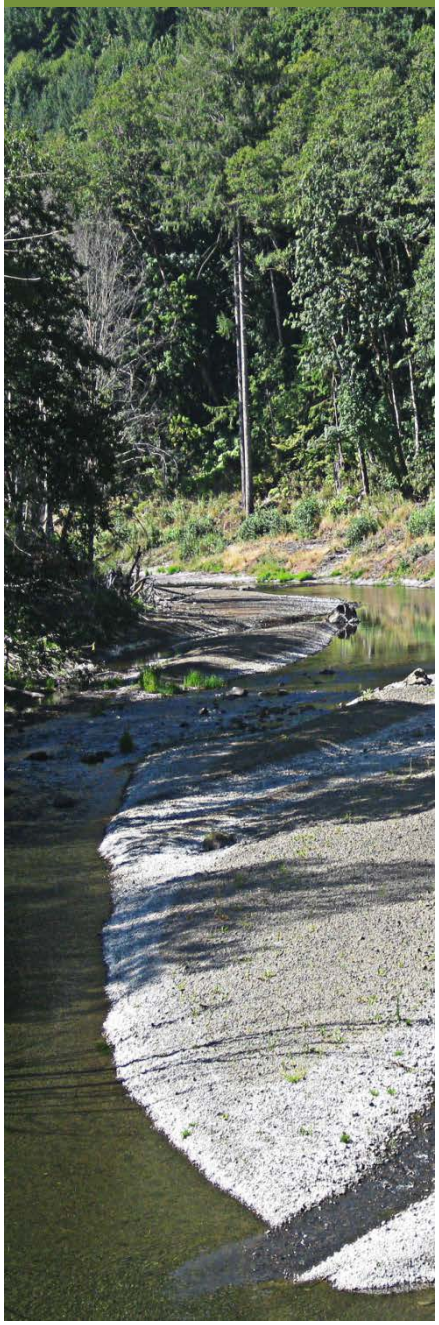



Footprint = 40 acres

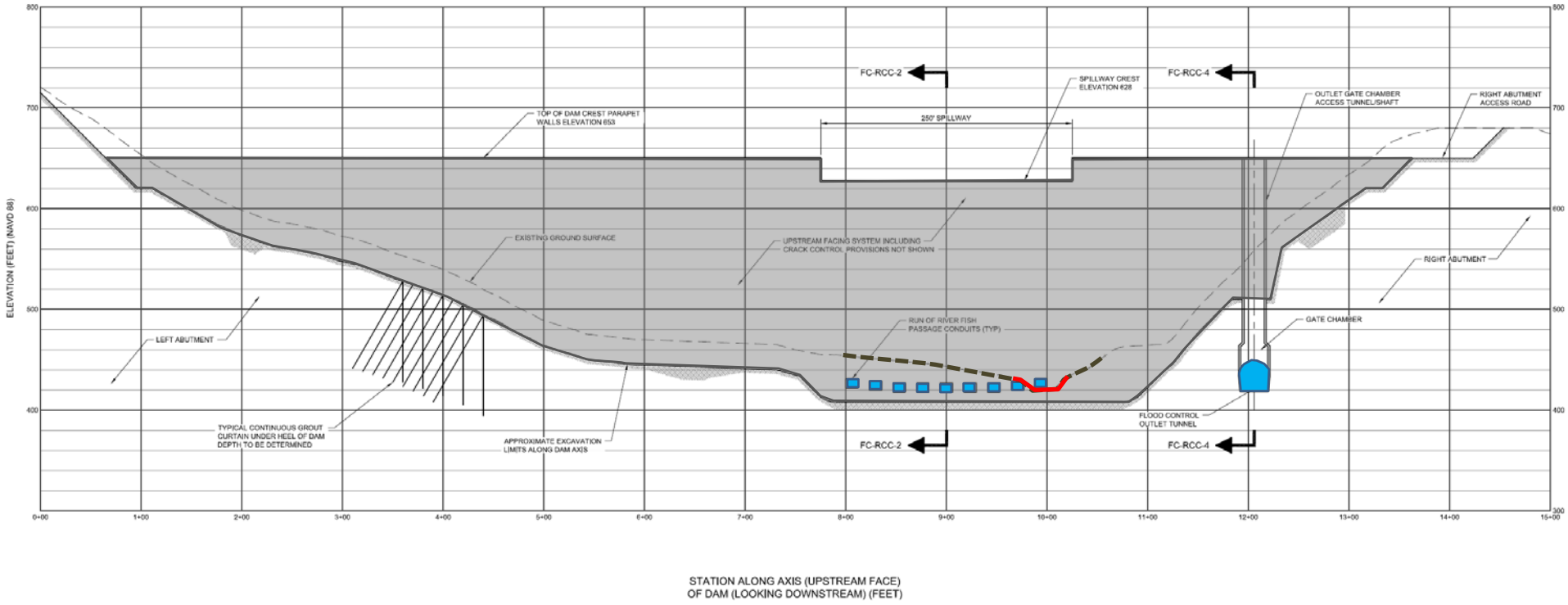
# Material Sources Study

- Determine location(s) of suitable dam materials
  - RCC concrete aggregate
  - Rockfill dam fill  and filter sand and gravel
- Determine available materials qualities
- Potential Sites Investigation
  - DNR permitted and active quarries
  - WSDOT-owned pit information
  - Other local quarries
  - WSDOT's Aggregate Source Approval (ASA) reports

# Fish Passage Options



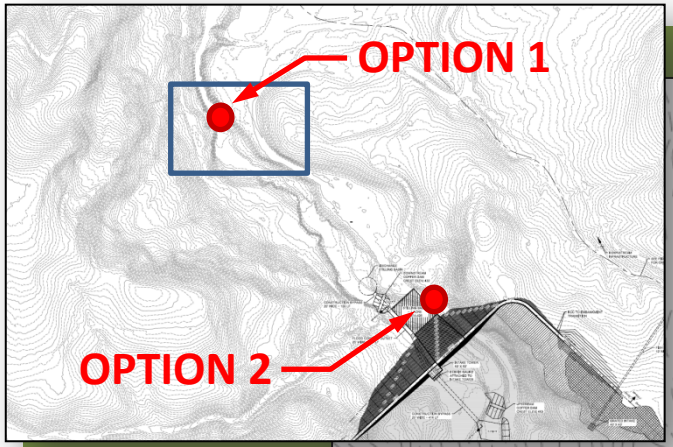
# Flood Retention Only Dam Fish Passage – Fish Passage Tunnels



# Flood Retention Only Dam Fish Passage Option – Fish Passage Tunnel

- Upstream and Downstream: Fish Passage Tunnel
- 9 - 9 x 12 x 200 ft long fish passage tunnels
- Multiple inverts to accommodate a range of inflows and water surface elevations
- Accommodates 2 ft/s velocity up to 2,000 cfs (more when the alternative flood control bypass is used)
- Gates shut off flow to tunnels when the facility is used to retain flood flows

# Multi-Purpose Dam Fish Passage Options - CHTR




COLLECTION, HOLDING, AND TRANSFER FACILITIES

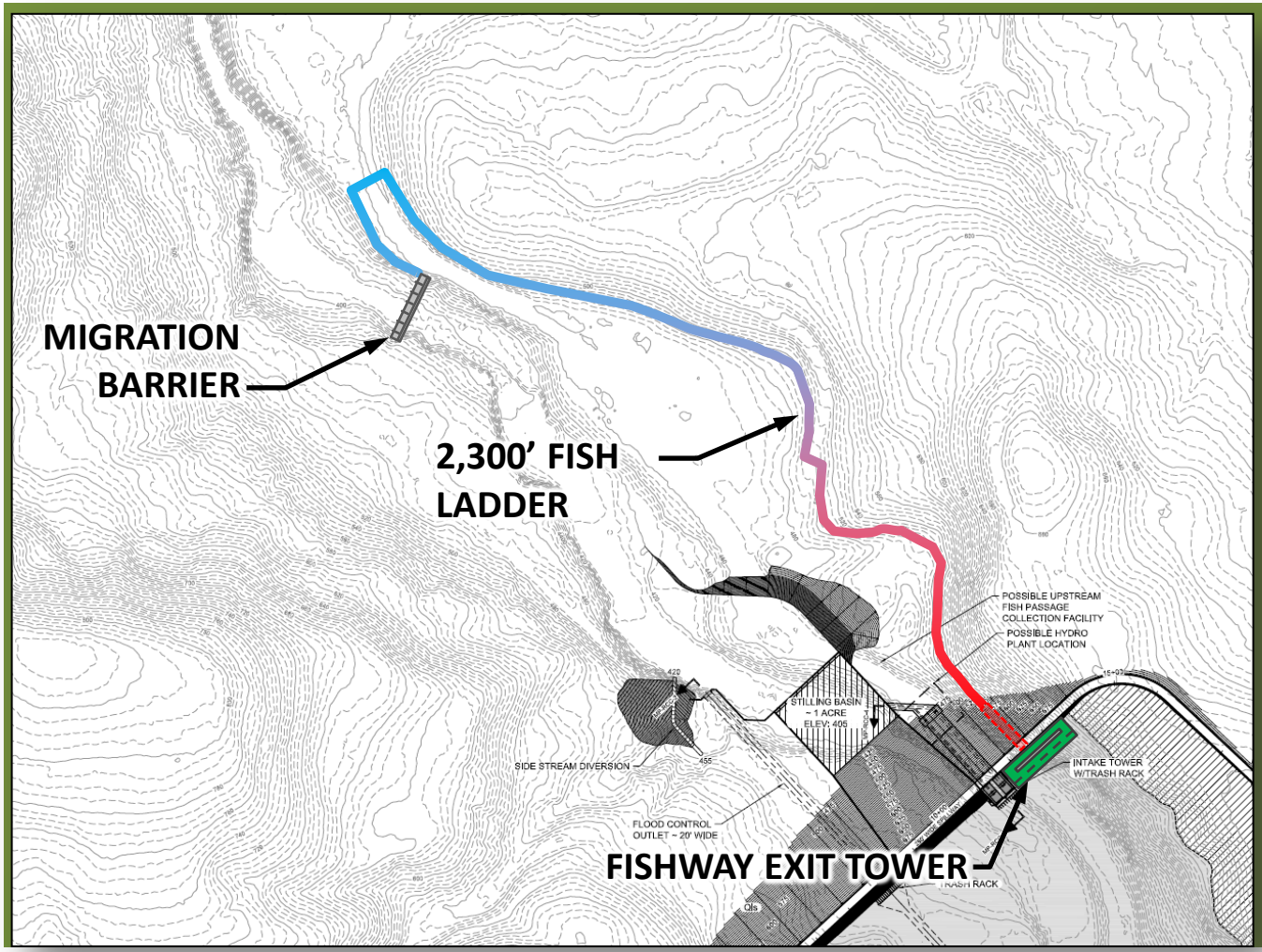
FISH LADDER

PHYSICAL MIGRATION BARRIER

WATER SUPPLY PIPING

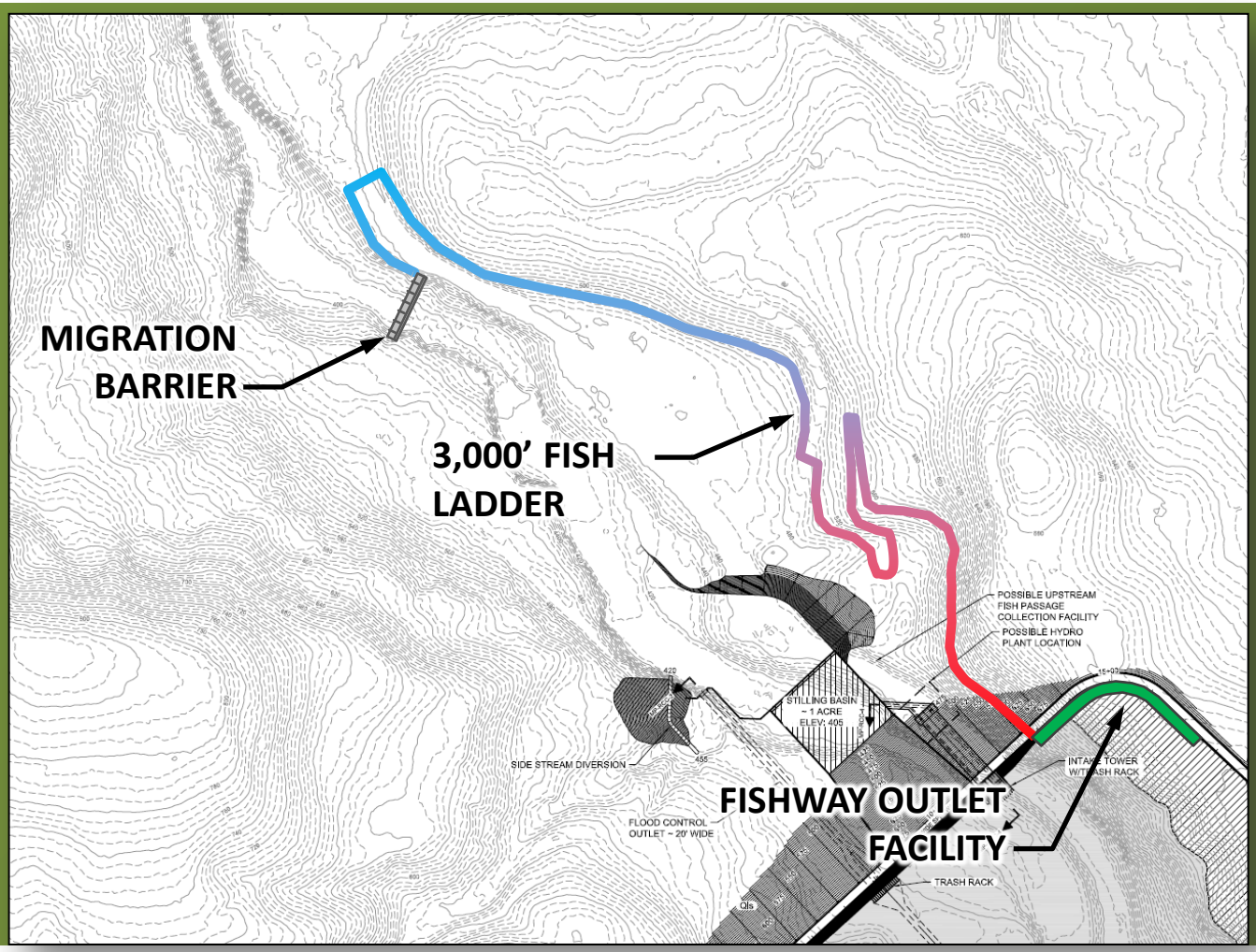
ACCESS AND ROAD IMPROVEMENTS

# Multi-Purpose Dam Fish Passage Options – Conventional Fishway with Experimental Exit Tower




- Guidance to fishway entrance
- 2,300 ft long fishway
- 148 ft total height
- 0.9 ft head drop per pool
- 80 ft tall spiral exit tower
- 80 automated hydraulic control gates

# Multi-Purpose Dam Fish Passage Options – Conventional Fishway

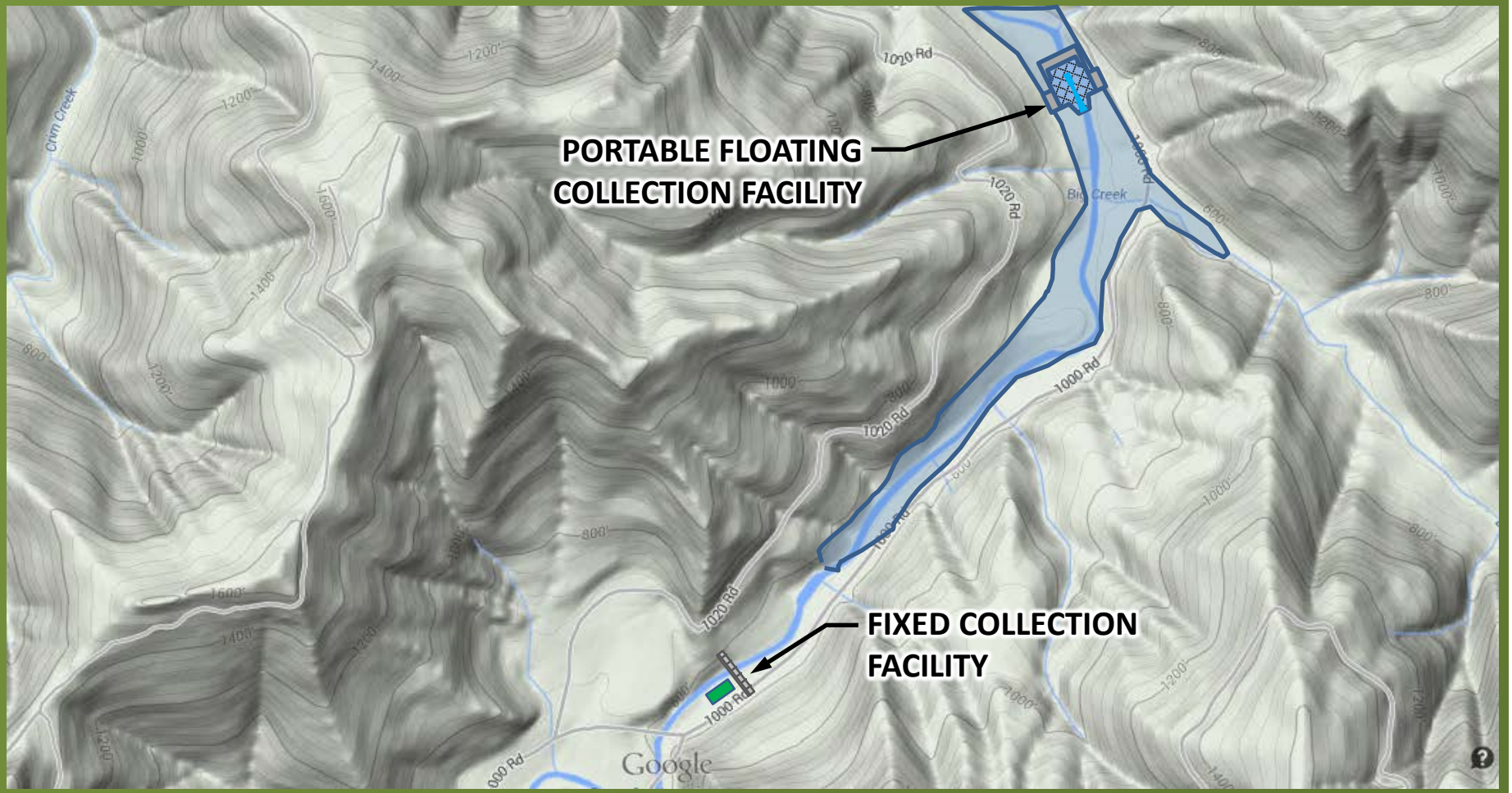



- Guidance to fishway entrance
- 3,000 ft long fishway
- 198 ft total height
- 0.9 ft head drop per pool
- 30 ft tall exit structure
- 30 automated hydraulic control gates

# Multi-Purpose Dam Fish Passage Options – Head of Reservoir Combination Collection Facilities

- Downstream 1: Head of Reservoir Floating Collector and Fixed In-Stream Collection Facility
- Small portable floating collector at head of reservoir
- Fixed collection facility on main stem
- The combination of collection facilities accommodates a wider range of species over a wider flow regime
- Access and road improvements

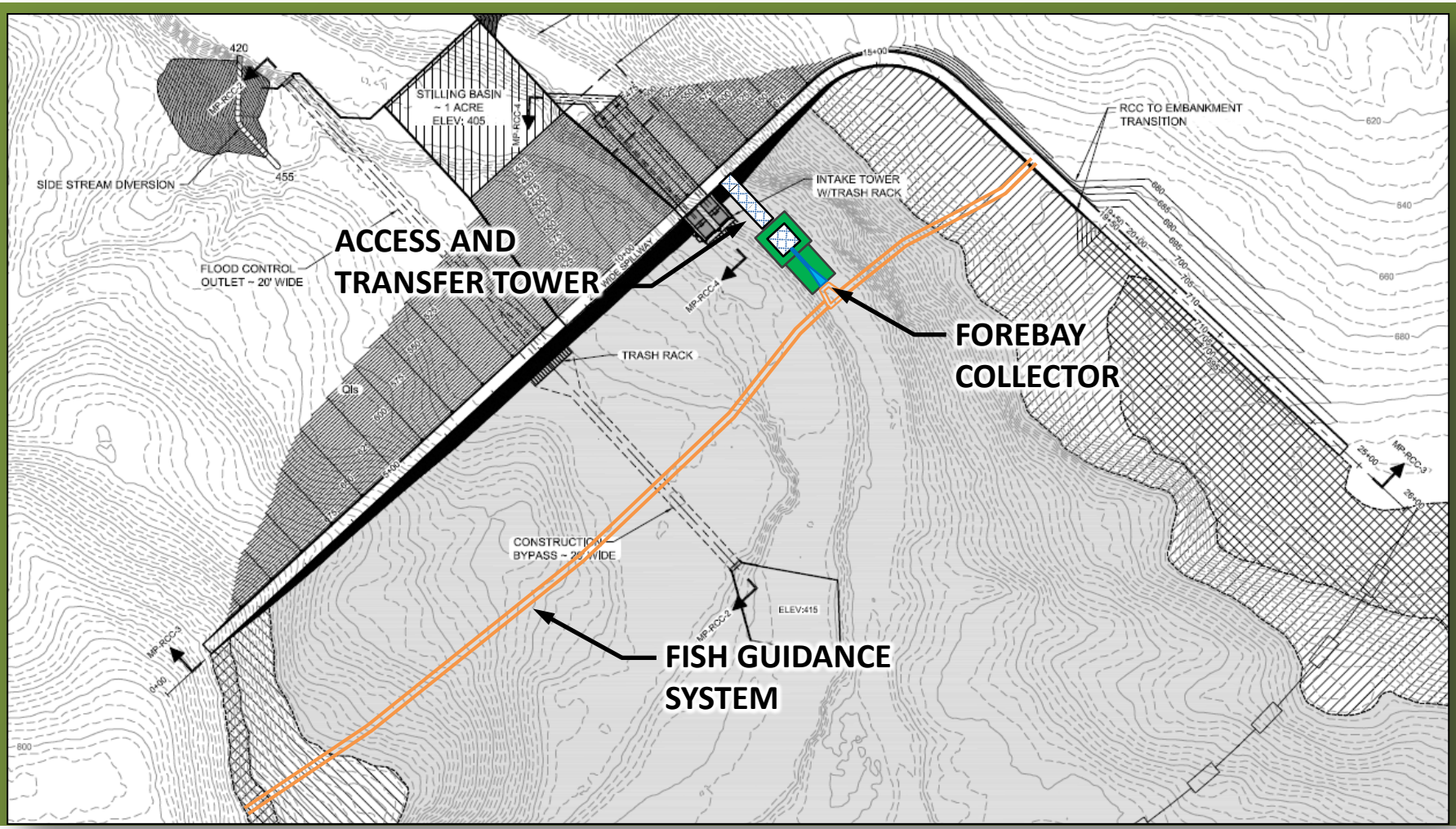
# Multi-Purpose Dam Fish Passage Options – Head of Reservoir Combination



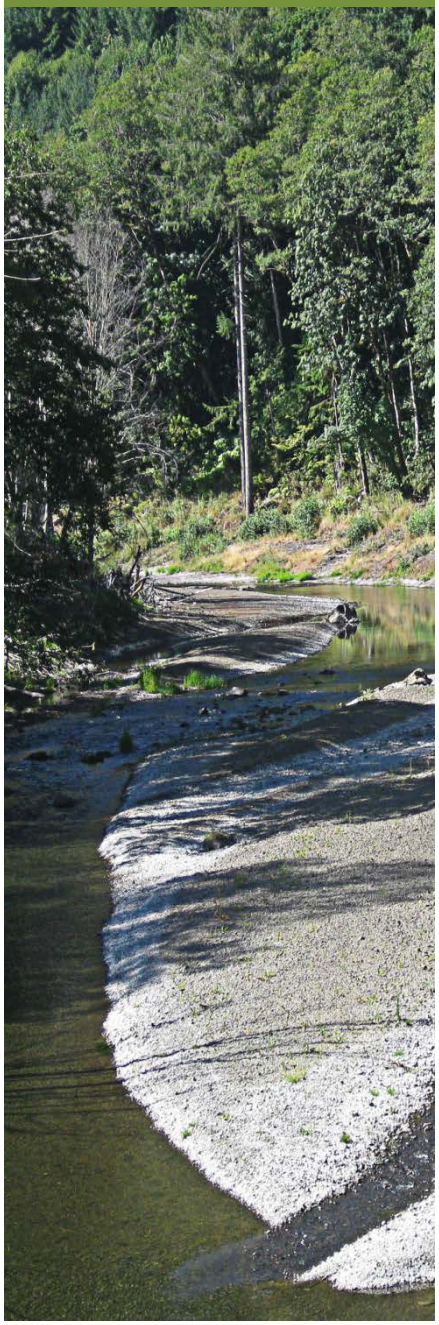
# Multi-Purpose Dam Fish Passage Options – Forebay Collector

- Downstream 2: Floating Forebay Collector
- Floating platform connected to guide rails on intake tower
- Capable of accommodating 80 to 100 feet of forebay fluctuation
- Fish guidance system
- Primary gravity flow system with pumped auxiliary flow
- CHTR method for fish transfer
- Access and road improvements

# Multi-Purpose Dam Alternative Fish Passage Options – Forebay Collector



# Operations of Dam



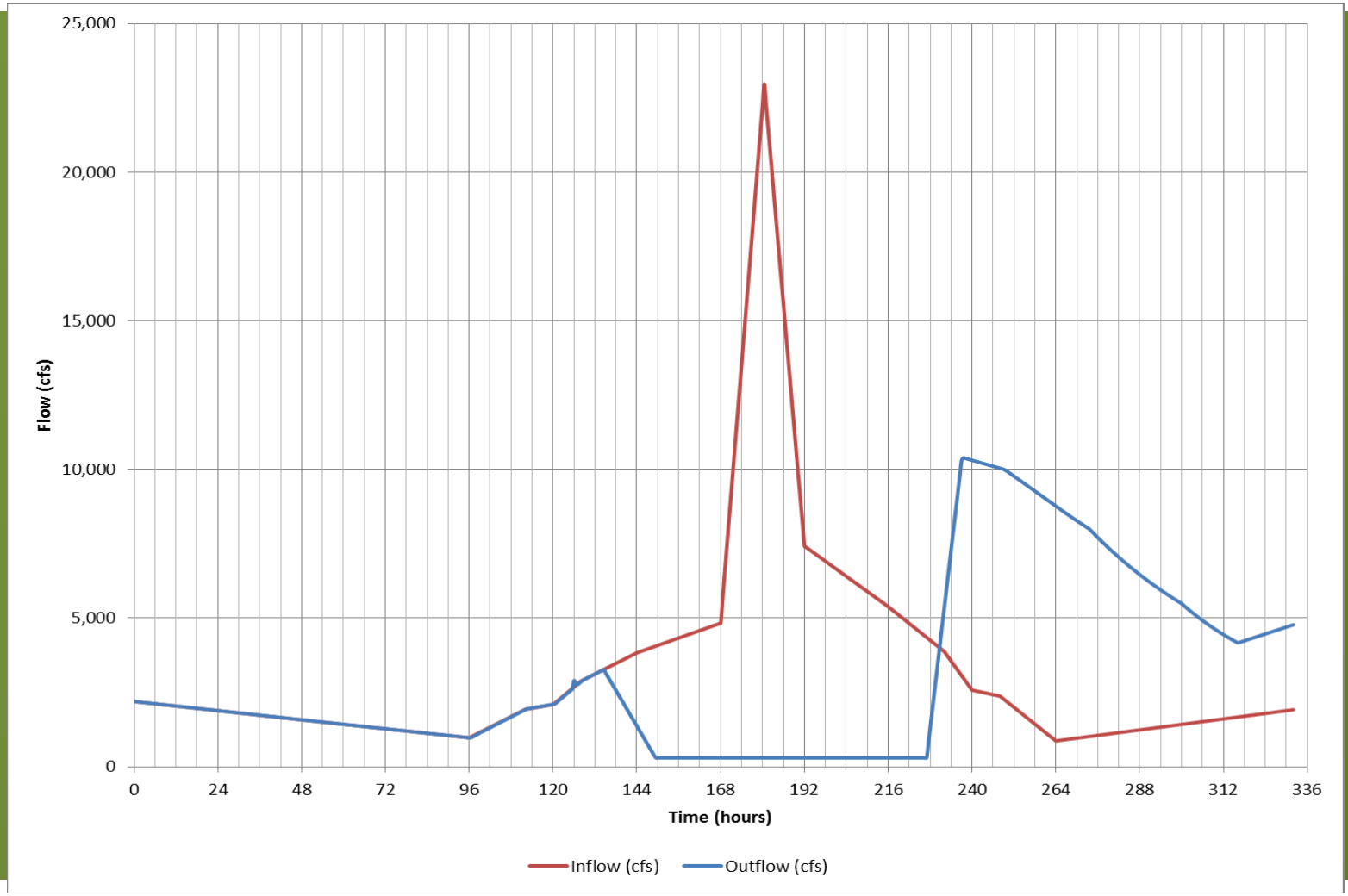
# Operational Considerations

- Provide flood reduction in downstream areas
- Preserve geomorphic processes downstream
- Maintain slope stability in reservoir
- Keep rate of change in flows downstream within accepted limits to minimize fish stranding
- Store water during winter and release during summer for fisheries and water quality enhancement (Multi-purpose Alternative)

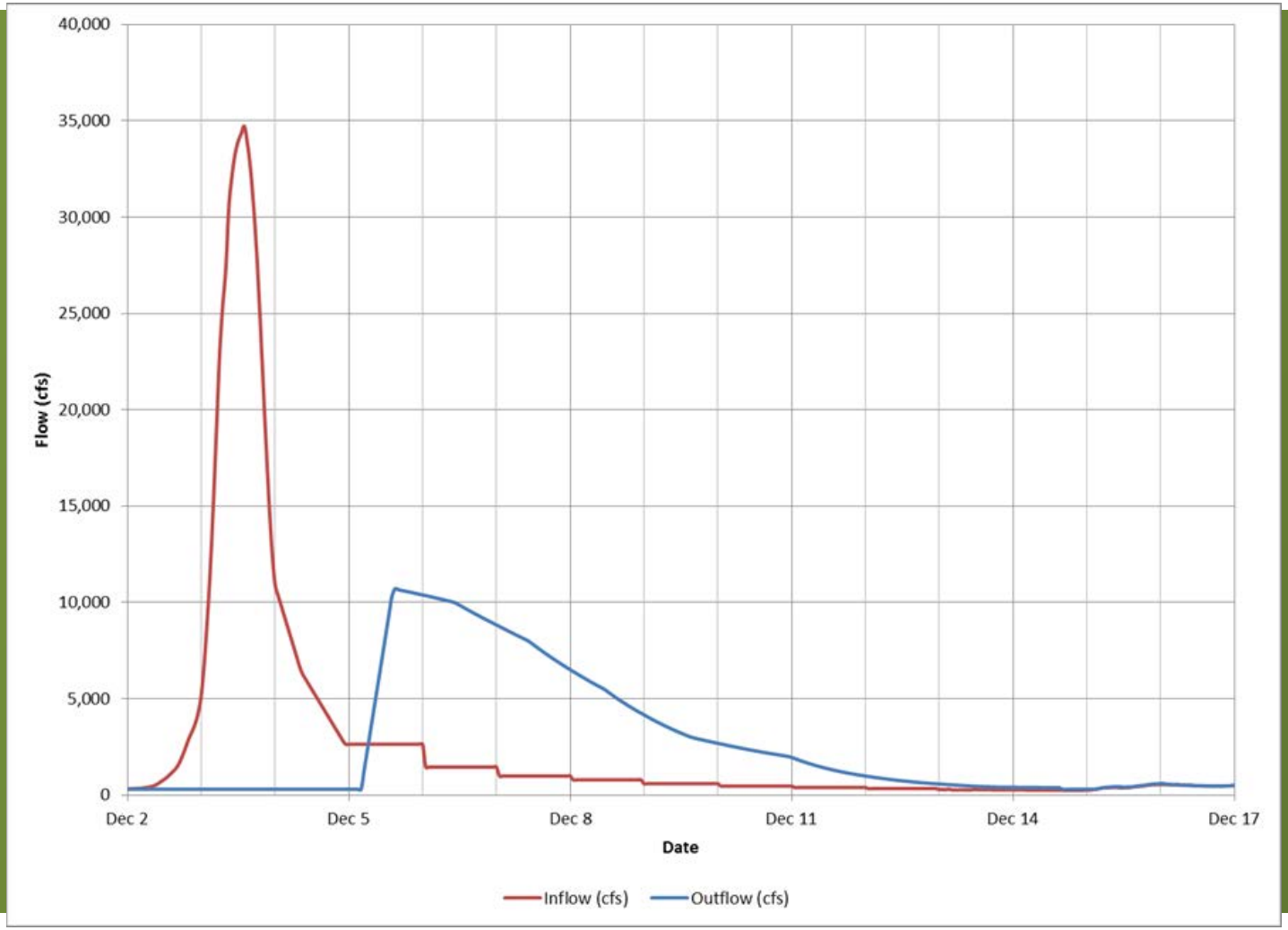
# Proposed Operating Rules – Flood Retention Only

- Available flood storage capacity = 65,000 acre-feet
- Operate the facility without impounding water except during a potentially damaging flood
- Begin storing when Grand Mound flows are predicted to be above the “Major Flood” (38,800 cfs) within 48 hours
- Reduce reservoir outflow at a rate of 200 cfs/hr until reaching 300 cfs
- Two days after dropping below flood stage, increase outflow at a rate of 1,000 cfs per hour, but less than 30 feet per day
- Drawdown rate may be reduced to allow for debris removal

# Reservoir Inflow/Outflow during Large Flood – 100-Year Flood



# Reservoir Inflow/Outflow during 2007 Event



# Operating Rules – Multi-purpose

- The Multi-Purpose facility would have a conservation pool of 65,000 acre-feet and a flood storage pool also with 65,000 acre-foot capacity. The conservation pool would be utilized to provide instream flows during period of low flow (typically summer). The flood storage pool would capture high flows to reduce downstream flooding.

# Operating Rules – Multi-purpose

- Instream Flows
  - Minimum releases for instream flows are proposed

| TIME PERIOD | FLOW |
|---|---|
| **Jan-Feb** | 290 cfs |
| **Mar-Jun 15** | 250 cfs |
| **Jun 16-Aug 15** | 190 cfs |
| **Aug 16-Dec 15** | 160 cfs |
| **Dec 16-31** | 290 cfs |

  - During drought years, reservoir releases are reduced by 20% to prevent the reservoir from completely running out

# Downstream Flood Reduction

*Drop in Water Surface Elevation (in feet) - With Dam versus Baseline*

| FLOOD EVENT | NEWAUKUM CONFLUENCE | CHEHALIS-CENTRALIA AIRPORT | MELLEN STREET | SKOOKUM-CHUCK CONFLUENCE | BLACK RIVER CONFLUENCE | WYNOOCHEE CONFLUENCE |
|---|---|---|---|---|---|---|
| **100-year** | 1.2 | 1.5 | 1.5 | 1.4 | 0.9 | 0.7 |
| **10-year** | 1.4 | 1.6 | 2.2 | 1.7 | 0.5 | 0.3 |
| **1996** | 0.9 | 1.4 | 1.3 | 1.3 | 0.8 | 0.1 |
| **2007** | 1.3 | 2.1 | 2.0 | 2.2 | 1.8 | 1.1 |
| **2009** | 1.3 | 1.7 | 1.5 | 1.2 | 1.1 | 0.1 |

# Downstream Flood Reduction

| FLOOD EVENT | EXISTING PEAK FLOW (CFS)[1] | ESTIMATED RECURRENCE INTERVAL (YEARS) | PEAK FLOW WITH FLOOD RETENTION DAM (CFS) | ESTIMATED RECURRENCE INTERVAL (YEARS) | DIFFERENCE IN FLOW (%) |
|---|---|---|---|---|---|
| **100-year** | 74,800 | 100 | 61,100 | 40 | -18.3% |
| **10-year** | 41,500 | 10 | 35,600 | 5 | -14.2% |
| **1996** | 72,100 | 90 | 61,200 | 40 | -15.1% |
| **2007** | 79,800 | 140 | 59,300 | 40 | -25.7% |
| **2009** | 57,300 | 35 | 48,600 | 15 | -15.2% |

[1] This table shows simulated flows from the HEC-RAS model – these may differ from USGS observed flows

# Frequency of Reservoir Usage – Flood Retention Only Structure

| WATER YEAR (OCT 1 – SEPT 30) | NUMBER OF TIMES UTILIZED | NUMBER OF DAYS UTILIZED | PEAK RESERVOIR STAGE (FT) |
|---|---|---|---|
| **1990** | 2 | 23 | 578.9 |
| **1991** | 2 | 23 | 569.1 |
| **1996** | 2 | 14 | 600.7 |
| **1997** | 1 | 1 | 467.9 |
| **2008** | 1 | 13 | 620.7 |
| **2009** | 1 | 13 | 584.3 |
| **Total (1989 – 2012)** | 9 | 87 (10 days on average or 1% of the time) | |

# Structures Affected

*Baseline conditions versus with dam conditions*

| Summary of Structures At Risk of Flooding in Chehalis River Floodplain | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| Number of Structures | Baseline | | | With Dam and Airport Levee | | |
| | Dec 07 | 500-Year | 100-Year | Dec 07 | 500-Year | 100-Year |
| Flooded | 2040 | 3645 | 1384 | 753 | 2031 | 821 |
| >1.0 feet | 1368 | 2743 | 829 | 432 | 1306 | 459 |
| >2.0 feet | 820 | 1926 | 489 | 241 | 762 | 241 |
| >3.0 feet | 470 | 1159 | 293 | 139 | 471 | 117 |
| >4.0 feet | 263 | 657 | 155 | 65 | 300 | 54 |
| >5.0 feet | 159 | 385 | 76 | 28 | 158 | 25 |
| | | | | | | |
| Assessed Value of Improvements Inundated ($Million) | $238 | $411 | $137 | $64 | $206 | $73 |

# Structures Affected

*Baseline versus various flood reduction alternatives*

| Summary of Structures At Risk of Flooding in Chehalis River Floodplain | | | | |
|---|---|---|---|---|
| | | | | |
| Number of Structures | Baseline | With Dam and Airport Levee | With WSDOT Alt 1 | With Dam and WSDOT Alt 1 |
| | 100-Year | 100-Year | 100-Year | 100-Year |
| Flooded | 1384 | 821 | 1295 | 778 |
| >1.0 feet | 829 | 459 | 781 | 428 |
| >2.0 feet | 489 | 241 | 446 | 233 |
| >3.0 feet | 293 | 117 | 257 | 113 |
| >4.0 feet | 155 | 54 | 129 | 53 |
| >5.0 feet | 76 | 25 | 54 | 26 |
| | | | | |
| Assessed Value of Improvements Inundated ($Million) | $137 | $73 | $112 | $64 |

# Structures Affected

*Climate Change Scenario – 18% Increase in Flow*

| Summary of Structures At Risk of Flooding in Chehalis River Floodplain | | | |
|---|---|---|---|
| | | | |
| Number of Structures | Baseline | 100-Year w Climate Change | |
| | 100-Year | 100-Year | Change vs Base |
| Flooded | 1384 | 2202 | 59% |
| >1.0 feet | 829 | 1462 | 76% |
| >2.0 feet | 489 | 830 | 70% |
| >3.0 feet | 293 | 481 | 64% |
| >4.0 feet | 155 | 301 | 94% |
| >5.0 feet | 76 | 161 | 112% |
| | | | |
| Assessed Value of Improvements Inundated ($Million) | $137 | $255 | 86% |

# Summary of Operations

- Used 1 percent of time based on historic record
- Reduces flows by @15% for 10-100 year
- 100 year to 40 year event, 2 feet lower in Centralia

| | 100 Year | With Dam | Difference | Climate |
|---|---|---|---|---|
| Floodplain Structures | 1384 | 821 | 563 | 2202 |
| Value of Structures ($Mil) | $137 | $73 | $64 | $255 |

- Multi-purpose increases summer low flows by factor of 3-6.

# Highway Flooding

*Interstate 5, SR 6, US 12*

## Interstate 5

- Flooded up to 5 days in 100-year event, maximum depth +10 feet
- Flooded less than 1 day with dam/airport levee, maximum depth 1 foot
- Remaining flooding in 100-year event along Dillenbaugh Creek

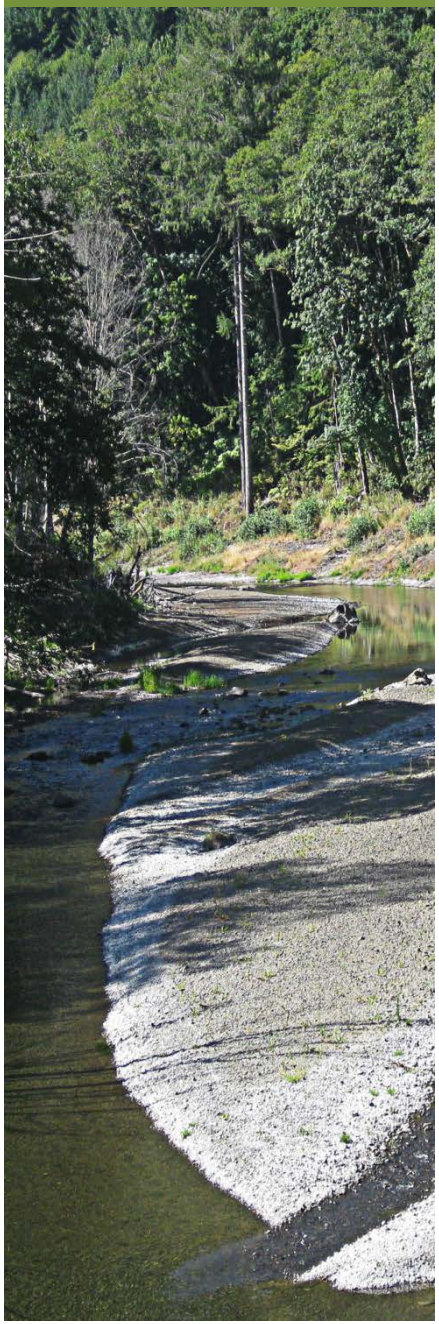
## Highway 6

- Flooded up to 14 hours at a 10-year recurrence level
- With dam, flooding reduced to 10 hours at a 20-year recurrence

## Highway 12

- Flooded by Chehalis backwater, one to seven days in 100-year event
- With dam flood levels reduced by 0.75 feet, duration of flooding reduced

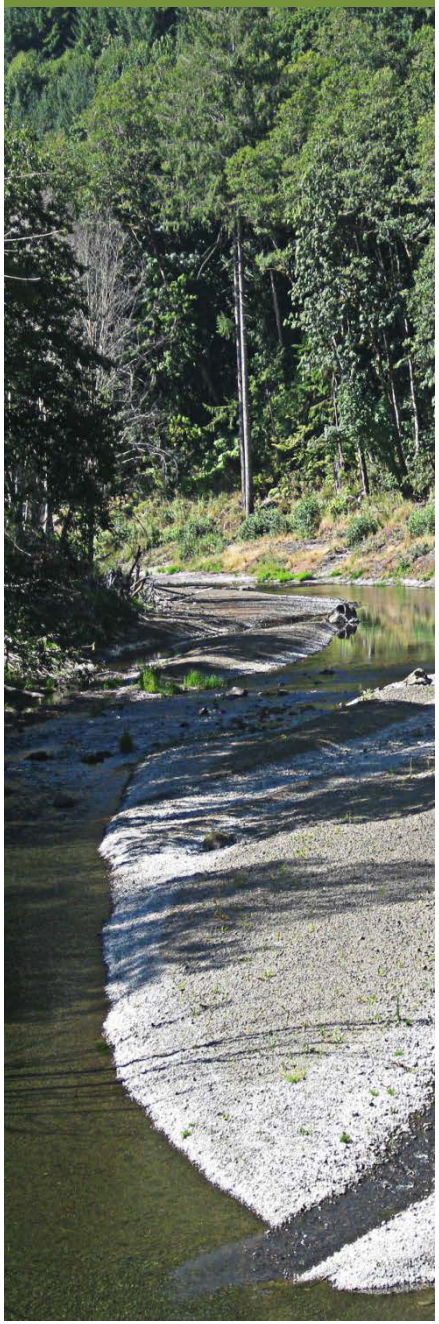
# Hydropower



# Multi-purpose Dam Potential Future Hydropower Benefits

- Located below the dam site
- Future connection to dam outlet works
- One or two turbines – 5 MW capacity
- Produce an average of 24,000 MWh/Year

# Costs of Water Retention Structures

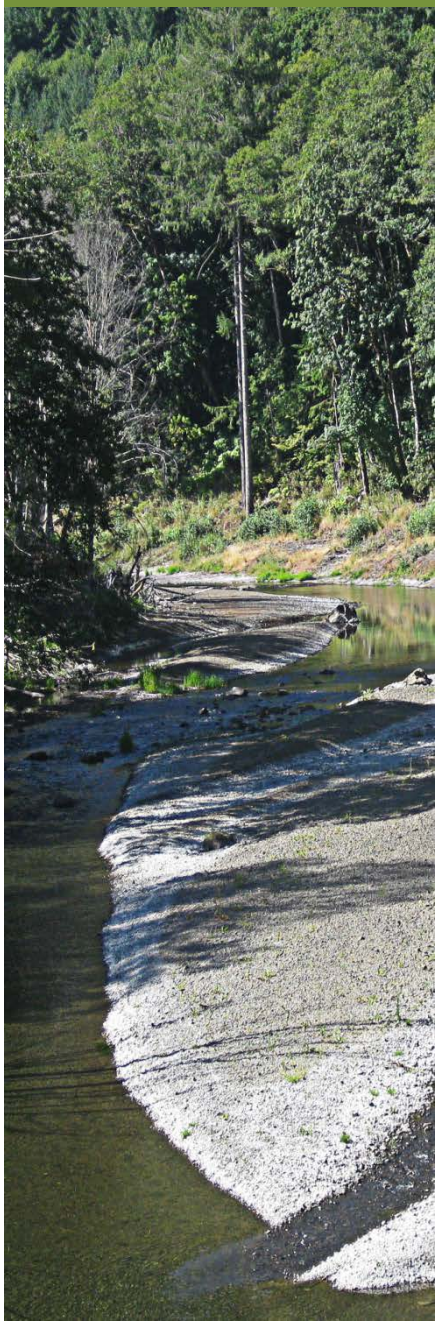


# Water Retention Cost Comparison (Mitigation costs not included)

| Alternative | Preliminary Class 5 Cost Estimate 2014 $M, Average Estimated Value and +/- Range | | | | |
|---|---|---|---|---|---|
| | Dam | Fish Passage Upstream | Fish Passage Downstream | Hydropower | Total Range |
| Flood Only | 265-421 | | | | 265-421 |
| Multi Purpose with Fish passage | 322-512 | 10-18 | 17-30 | 20-25 | 369-585 |
| Rock Fill Multi Purpose | 408-566 | 40-70 | 27-47 | 20-25 | 495-708 |

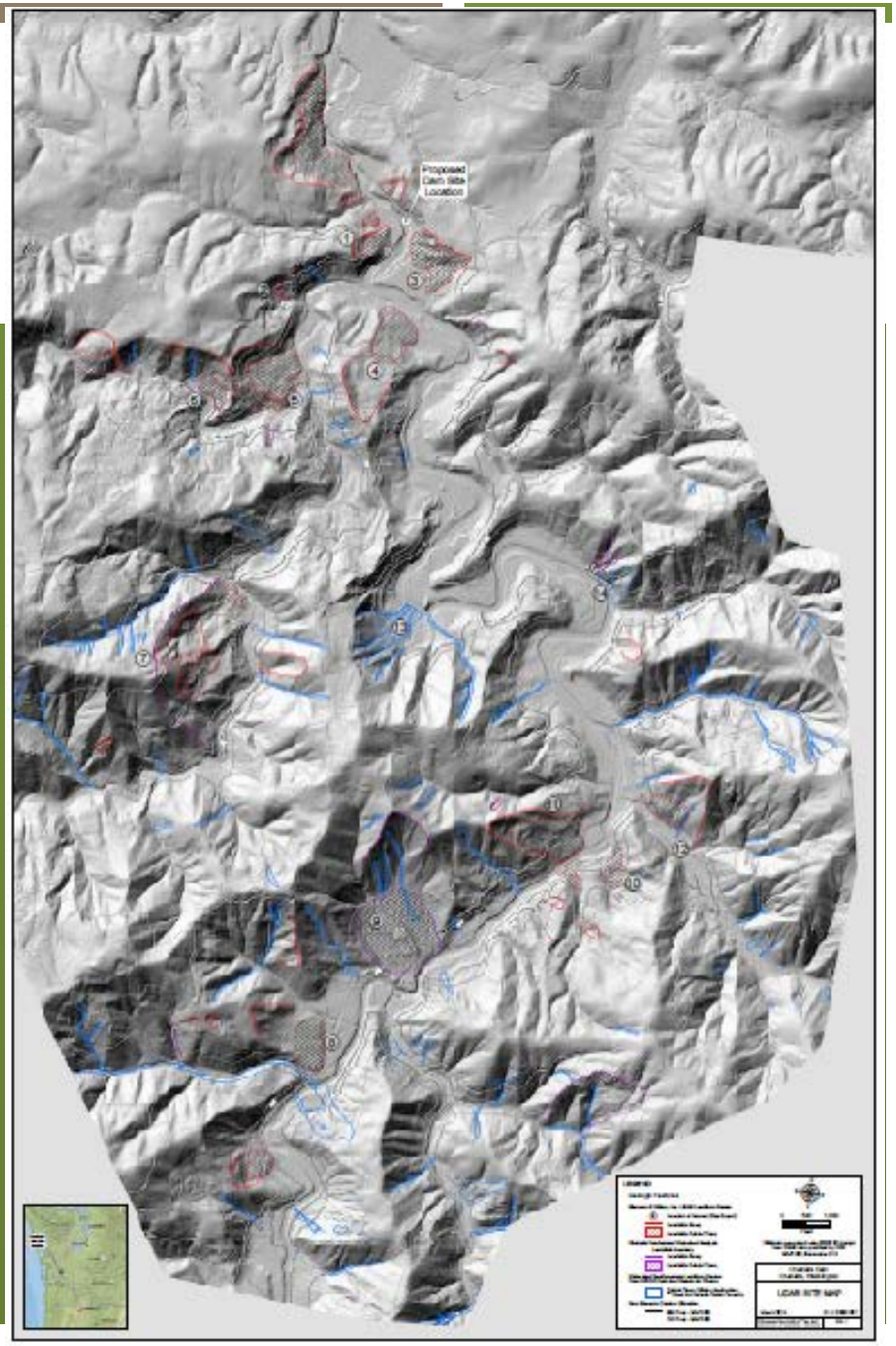
Note: These costs are preliminary Class 5 estimates for screening purposes only. They should not be used for budgetary purposes

# Slope Stability and Vegetation and Debris Management



# Reservoir Slope Stability

- Watershed GeoDynamics: Geomorphology study, estimates of sediment delivery to river from landslides
- Shannon & Wilson: Characterization of large landslides



# Mud Mountain Dam – Vegetation Mgt


# Mud Mountain Dam – Vegetation Mgt

- Initially logged; little vegetation management
- Vegetation and trees not cut or removed
- Log storage areas are cleared
- During flood LWD (from upstream sources) can be backed up for miles
- Floating booms to collect LWD
- Let LWD pass through outlet if possible
- 18 inch opening on bar rack

# Mud Mountain Dam – Debris Mgt




Log boom

# Mud Mountain Dam – Debris Mgt

- Lowering pool may be delayed following flood events that deliver large amounts of LWD
- LWD is made available to various stakeholders
- Excess LWD temporarily stored in reservoir
- Use boats to gather and haul LWD to storage areas
- USACE developing management plan to address LWD management, including disposal

# Mud Mountain Dam – Sediment Mgt

# Mud Mountain Dam – Sediment Mgt

- Soil, gravel, cobbles, and boulders flushed through low elevation tunnel through dam
- Recently, USACE passing additional flow through higher tunnel to facilitate downstream fish passage
- Material carried through tunnel damages steel liner

# Howard Hanson Dam

- Multi-purpose dam
  - Flood
  - Summer stream augmentation
  - Ecosystem restoration
  - Drinking Water (City of Tacoma)
- Pool increase starting Feb., maintained in summer
- Never overtopped spillway

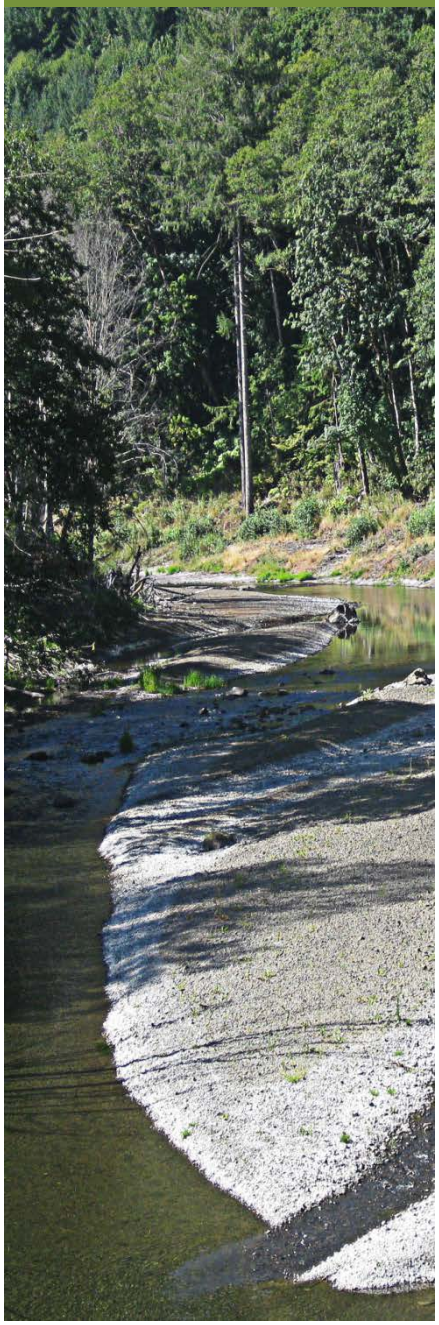
# Howard Hanson Dam




# Howard Hanson Dam – Vegetation and Debris Mgt

- Vegetation and trees not cut or removed
- LWD cannot pass through the dam
- Floating booms to collect LWD
- Booms anchored at multiple elevations
- Use boats to gather and haul LWD to storage areas
- 50% LWD reintroduced to river downstream
- Other LWD is available to various stakeholders
- Excess LWD stored in reservoir to decompose

# Aquatic Species Impacts



# Geomorphology Considerations

- Project operation could affect:
  - Peak flows (sediment transport)
  - Sediment input (reservoir storage, change in bank erosion)
  - Large woody debris input/transport
- Potential Key Geomorphology/Habitat Effects
  - Substrate (spawning gravel, interstitial rearing, etc.)
  - Channel forming processes (meander rate, LWD input, holding pools, etc.)
  - Floodplain and off-channel connectivity

# Geomorphic/Aquatic Habitat Effects

## Reach 1 – Reservoir

| Variable | Flood Retention Only | Multi-Purpose |
|---|---|---|
| Substrate/Spawning Gravel | Finer substrate/ transient delta – assumed 50% of spawning habitat lost | Inundated – 100% of spawning habitat lost |
| Channel Width/Depth | Likely wider/ shallower wetted channel | Inundated |
| Large Woody Debris | Wood trapped – transported around dam | Wood trapped – transported around dam |
| Channel Migration | n/a - confined | n/a - confined |

# Geomorphic/Aquatic Habitat Effects

## Confined Reaches – 2A, 2C, 4A, 4C

| Variable | Flood Retention Only | Multi-Purpose |
|---|---|---|
| Substrate/Spawning Gravel | Minor changes | Erosion/ coarsening |
| Channel Width/Depth | Minor changes | Possible narrower channel |
| Large Woody Debris | Likely less LWD | Likely less LWD |
| Channel Migration | n/a - confined | n/a - confined |

# Geomorphic/Aquatic Habitat Effects

## Unconfined Reaches – 2B, 3, 4B

| Variable | Flood Retention Only | Multi-Purpose |
|---|---|---|
| Substrate/Spawning Gravel | 2B - Continued aggradation/fining<br>3 - Minor changes<br>4B – Possible coarsening | Erosion/ coarsening |
| Channel Width/Depth | Minor changes | Possible narrower channel |
| Large Woody Debris | Likely less LWD | Likely less LWD |
| Channel Migration | Likely less channel migration | Likely less channel migration |

# Geomorphic/Aquatic Habitat Effects

Reaches 5, 6 – Downstream of RM 75

- Limited changes – bedrock control re-sets bedload transport
- Tributary input of water/wood sediment mute effects of flood control facilities

# Spawning Habitat in Reservoir Assumptions - FRO

- 18 out of 23 years studied the FRO reservoir does not impound water
- Average length of reservoir inundated = 1.4 miles (22% of total length). Other areas will be impacted by sediment deposition
- For fish impacts, assumed spawning habitat in 50% of reservoir length lost (FRO50)
- A sensitivity run assuming 100% of spawning habitat lost was also run (FRO100)

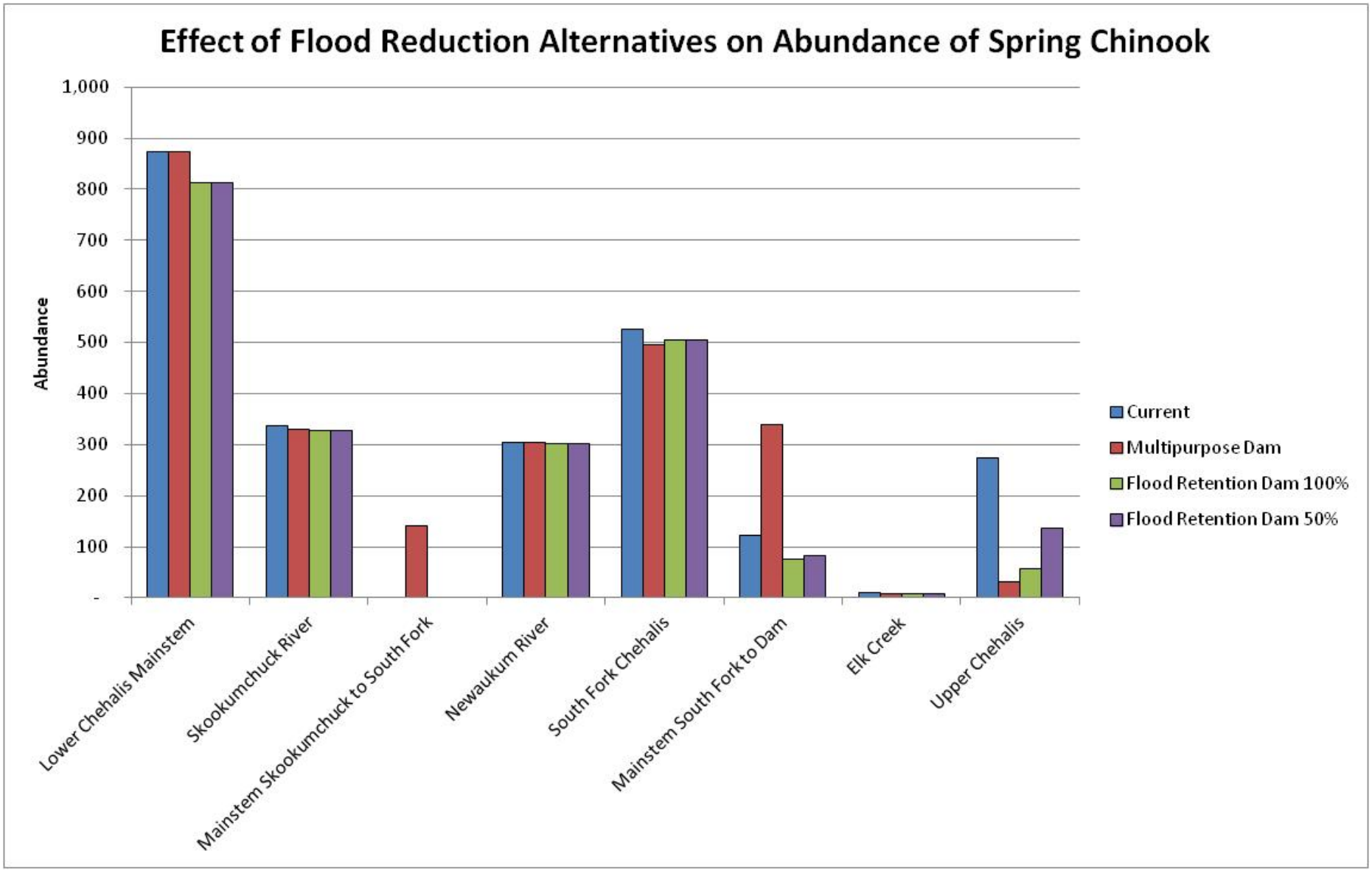
# Species

- 22 key species evaluated using variety of models in 3 categories
  - Salmon (EDT and Shiraz)
    - Spring Chinook, Fall Chinook, Coho and Winter Steelhead
  - Other fish (11)
  - Non-fish (7)

# Modeling Approach - Salmon

- Models are similar (habitat based models) but they are different tools
- Used to assess trends and make relative comparisons
- EDT
  - Entire basin and 4 species or runs
  - Population effects of a change (a point estimate)
- Shiraz
  - Mainstem only and 3 species or runs
  - Projects change to population into future (year 2100)(variability around a mean)

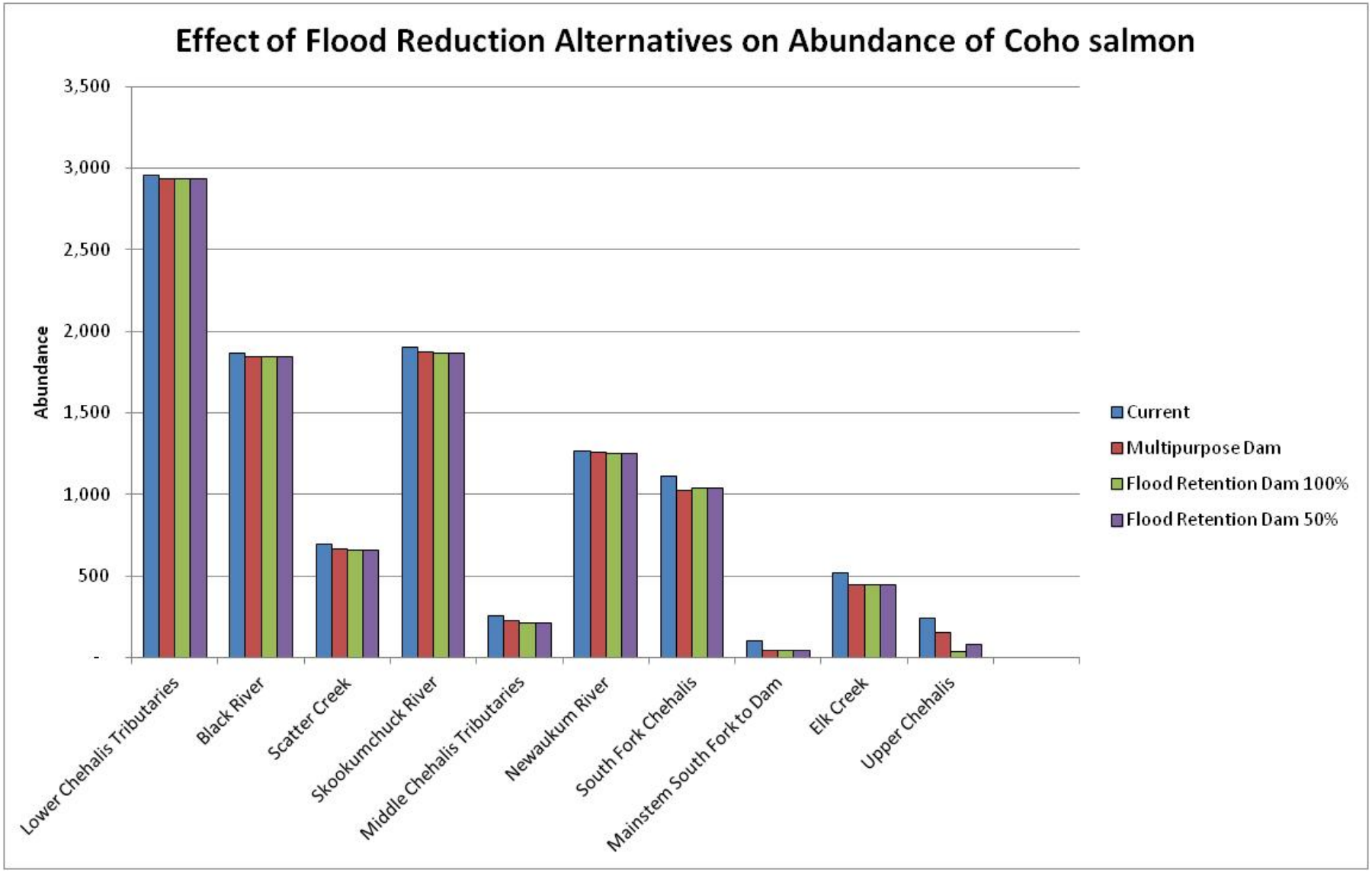
# Effects on Spring Chinook



# Effects on Spring Chinook

- Upper Chehalis River stocks impacted the most
- Effects of Multi-purpose > Flood Retention only
  - Loss of spawning/rearing habitat under reservoir footprint
  - No real benefit to spring Chinook salmon associated with rearing in Multi-purpose reservoir because they migrate downstream
- Some populations benefit from Multi-purpose below the dam
  - Due to multiple effects (temperature, reduced fine sediments)

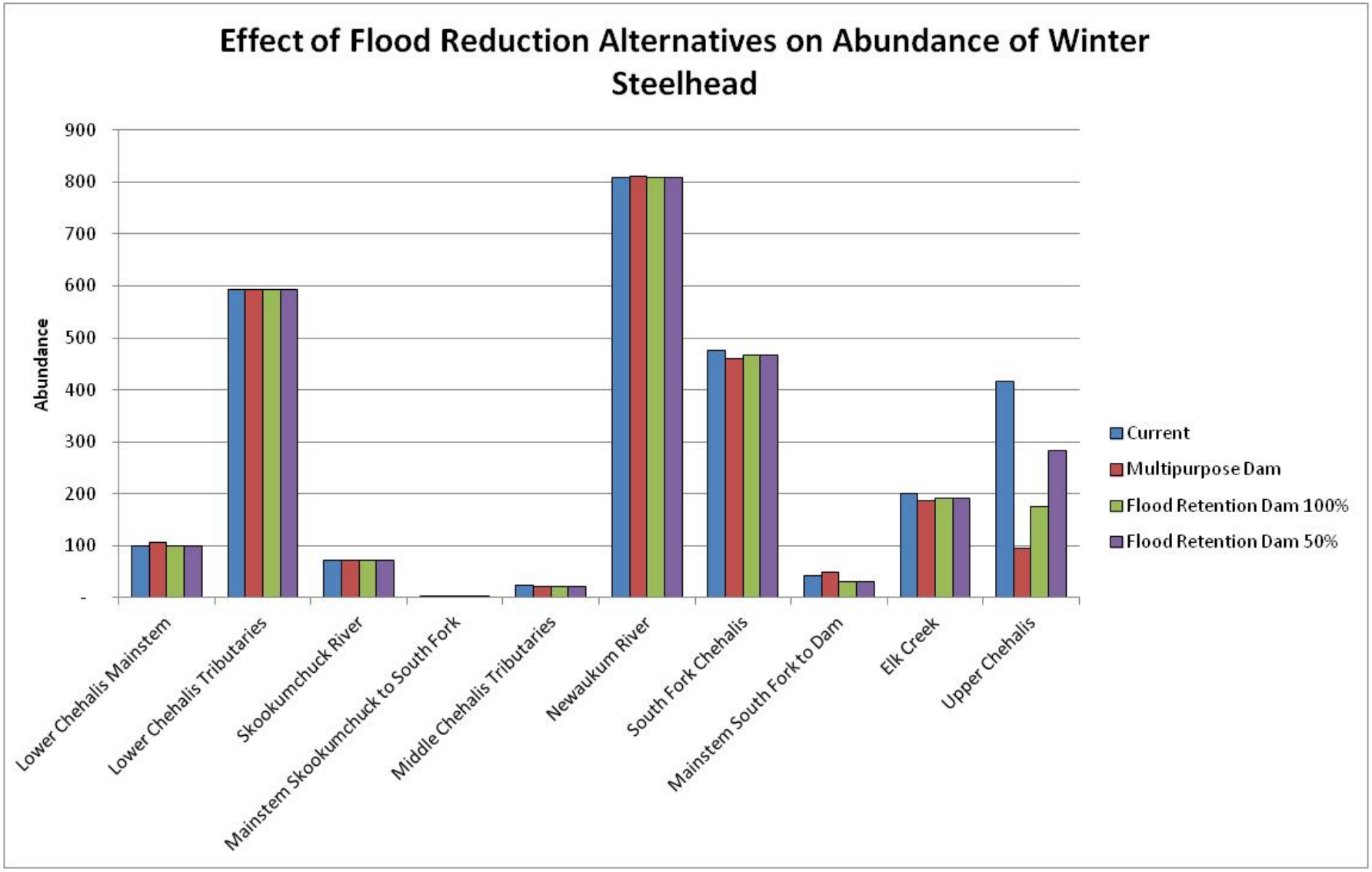
# Effects on Coho Salmon



# Effects on Coho Salmon

- Upper Chehalis River stocks impacted the most
- Effects of Flood Retention only > Multi-purpose
  - Loss of spawning rearing habitat under reservoir footprint
  - Large benefit to coho salmon associated with rearing in reservoir (based on Cowlitz Falls observations)
- Little benefit from Multi-purpose dam below the dam because coho are spawning later (compared to spring Chinook), so not as much temperature benefit

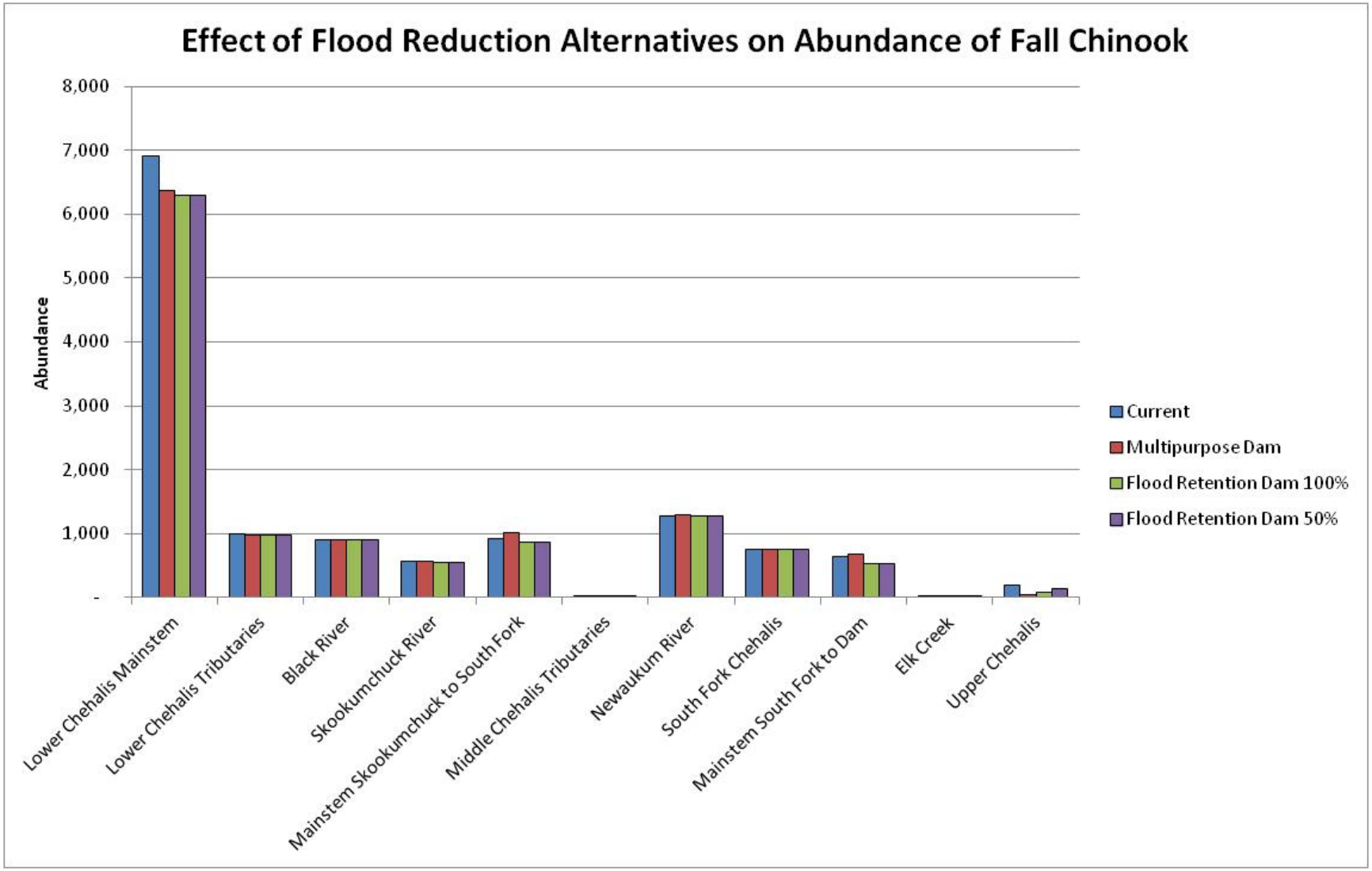
# Effects on Winter Steelhead



# Effects on Winter steelhead

- Upper Chehalis River stocks impacted the most
- Effects of Multi-purpose > Flood Retention
  - Loss of spawning rearing habitat under reservoir footprint
- No steelhead rearing in reservoir (based on Cowlitz Falls observations)
- Little benefit from Multi-purpose below the dam because winter steelhead spawn during winter, so no temperature benefit from dam

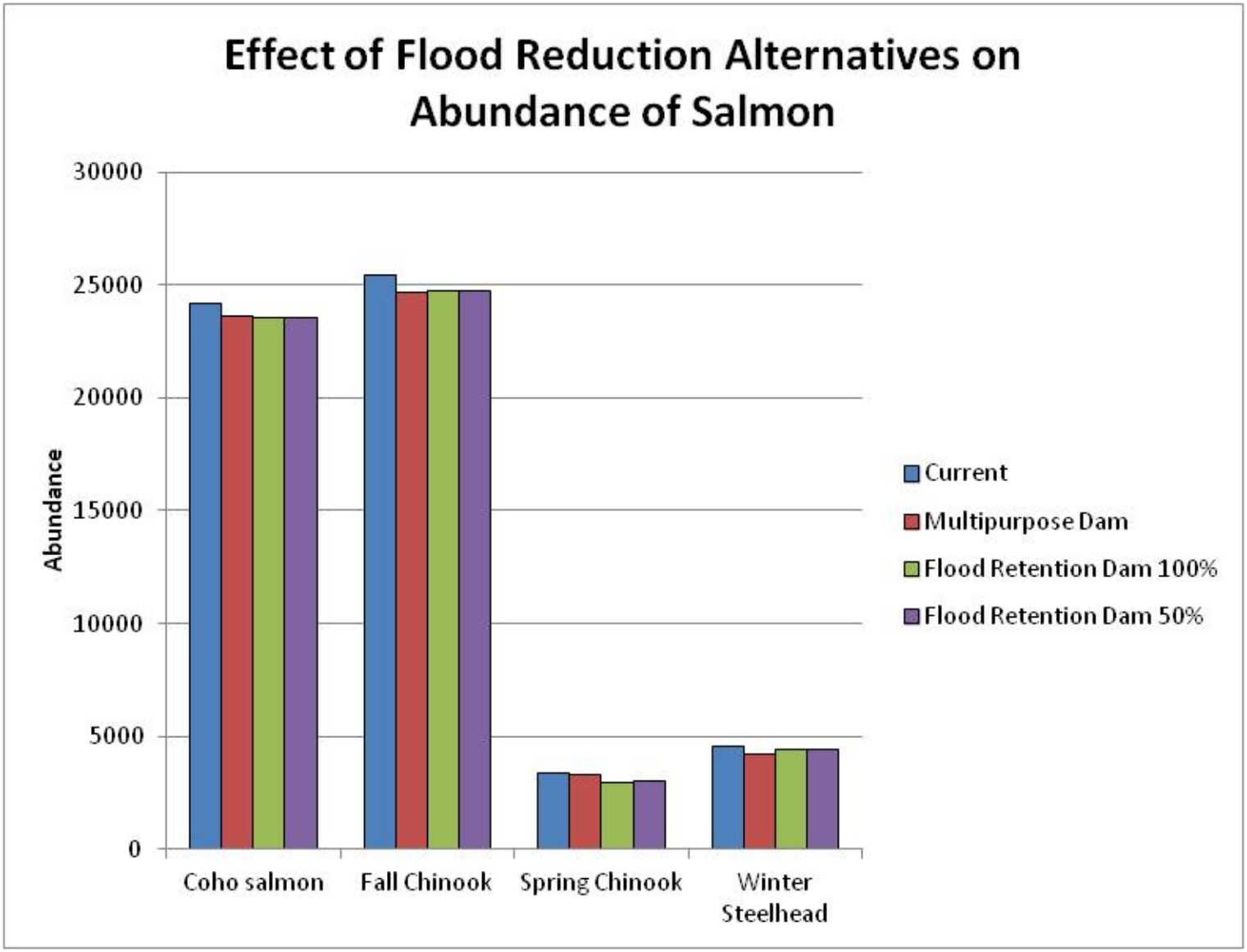
# Effects on Fall Chinook



# Effects on Fall Chinook

- Few fish in Upper Chehalis River
- Relatively small changes due to dams
- No real benefit to fall Chinook salmon associated with rearing in Multi-purpose reservoir because they outmigrate
- Little benefit from Multi-purpose dam below the dam because fall Chinook are spawning later (compared to spring Chinook), so not as much temperature benefit
- Lower Chehalis mainstem populations impacted from changes in flow, channel width

# Summary at Basin Scale - EDT



# Summary at Basin Scale - EDT

| Species | Current | Multi-purpose | Flood Retention 100% | Flood Retention 50% |
|---|---|---|---|---|
| Coho salmon | | -2% | -3% | -2% |
| Fall Chinook | | -3% | -3% | -3% |
| Spring Chinook | | -2% | -12% | -10% |
| Winter Steelhead | | -8% | -6% | -3% |

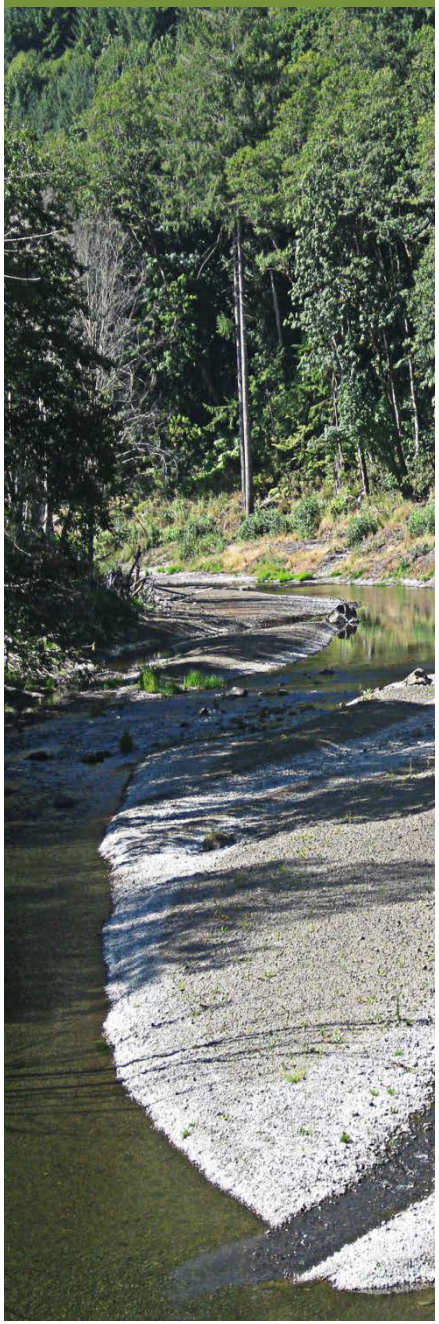
# Shiraz - Spring Chinook Calibrated Model 2014

- Updated information on many model inputs, including:
  - Juvenile fish rearing distribution in basin
  - Age of return
  - Updated flow and temperature information used in habitat capacity and habitat quality inputs
- Required adjusting the 2012 model calibration
- 2014 model calibration period ends with higher number of fish as the starting point for simulation
- During simulation, population trend was generally flat

# Summary

- Both flood retention structures would impact salmon and steelhead populations
- Shiraz (mainstem) results consistent with EDT
- Potential effects on other fish and non-fish species can only be described qualitatively at this point
  - Dams will effect floodplain connectivity, especially closer to dam

# Using the Results for Economic Analysis



# Summary of Key Results for Economic Analysis

- Operating rules for different options
- Benefits for reducing flood damage
- Change in 100 year flood based on climate change
- Effects on vegetation and habitat in the reservoir
- Effects on downstream geomorphology
- Potential impacts and benefits to salmon
- Impacts on other aquatic species

# Questions