

Water Retention Structure Alternatives Design, Operation, Cost

May 7, 2014

Technical Workshop Presentation

Dam and Fish Passage Design



Presentation Outline

- Status of Dam Design Study
- Water Retention Structure Options (building blocks)
 - Dams
 - Flood Retention– RCC
 - Multipurpose – RCC
 - Multipurpose – Rockfill
 - Fish Passage
 - Hydropower Potential Evaluation
- Preliminary Quantities and Class 5 Cost Estimates
- Formulation of Integrated Structure Alternatives

Dam Design Study Status

- Task 1.1.1 Dam Design Study - Completed
 - DRAFT Dam Design TM – March 13, 2014
- Task 1.1.2 Fish Passage Study
- Task 1.1.3 – Integrated Fish/Dam Structure
 - Prelim Quantities and Cost Estimates
 - Draft TM June 30, 2014
 - Final TM August 31, 2014

Initial Dam Structure Options – December 2013

- Flood Retention– RCC
- Multipurpose – RCC
- Flood Retention– Rock Fill
- Multipurpose – Rock Fill

Dam Structure Options Selected for further Evaluation

- Flood Retention RCC Dam (FR-RCC)
- Multipurpose RCC Dam (MP-RCC)
- Multipurpose Rock Fill Dam (MP-Rockfill)

Initial Fish Passage Options – December 2013

- 17 Upstream Fish Passage Options
 - CHTR Facilities
 - Fish Locks, Lifts, and Elevators
 - Fishways
 - Tunnels Through Dam
- 13 Downstream Fish Passage Options
 - Head of Reservoir Collection Facilities
 - Forebay Collectors
 - Surface Spill Passage
 - Tunnels Through Dam

Fish Passage Options Selected for Further Evaluation

- Upstream Passage
 - CHTR Facility
 - Conventional Fishway
 - Experimental Fishway
 - Tunnels Through Dam
- Downstream Passage
 - Combination Collection Facilities
 - Forebay Collector
 - Tunnels Through Dam

Dam Structure Options

FR-RCC

MP-RCC

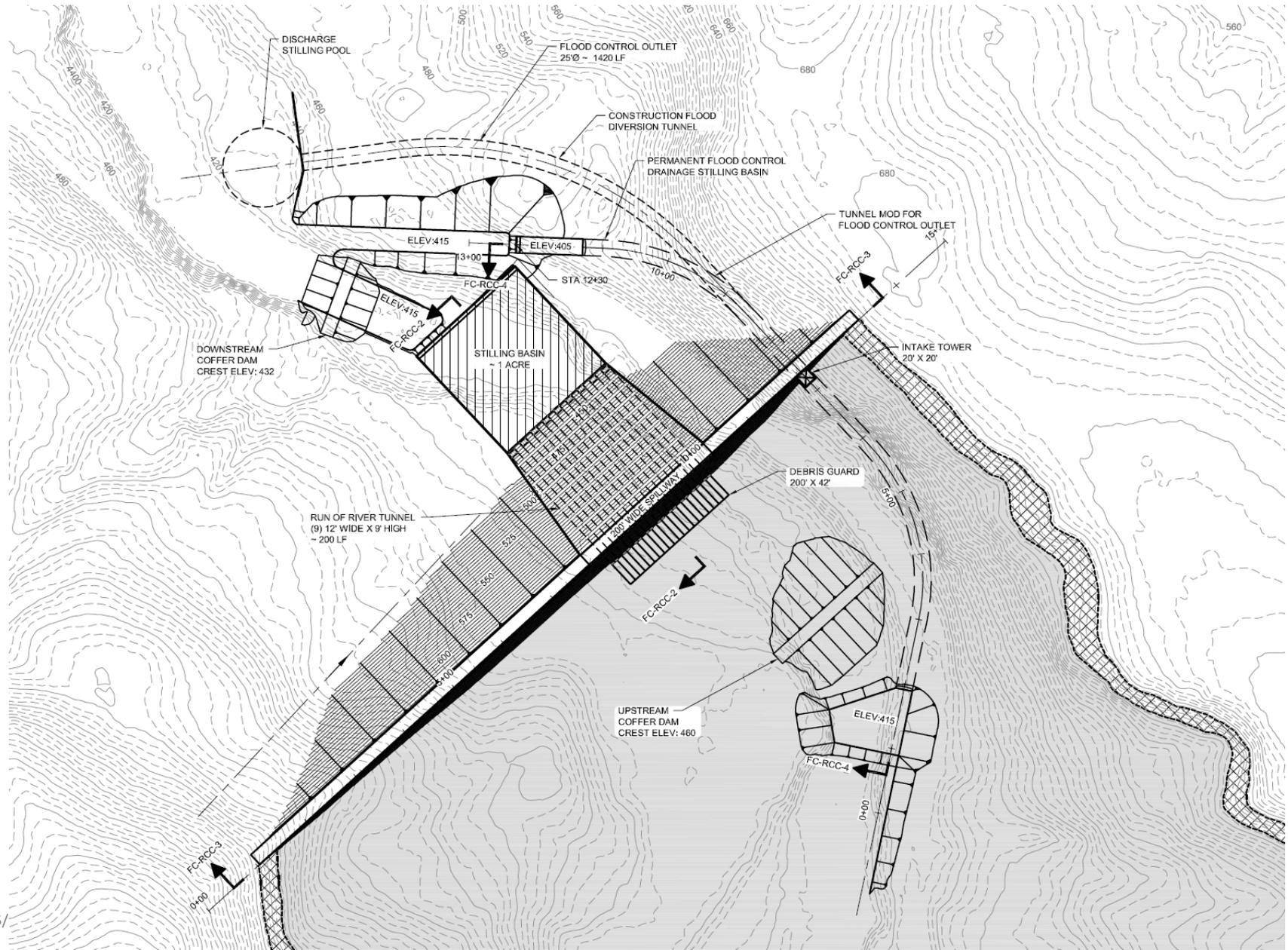
MP-Rockfill



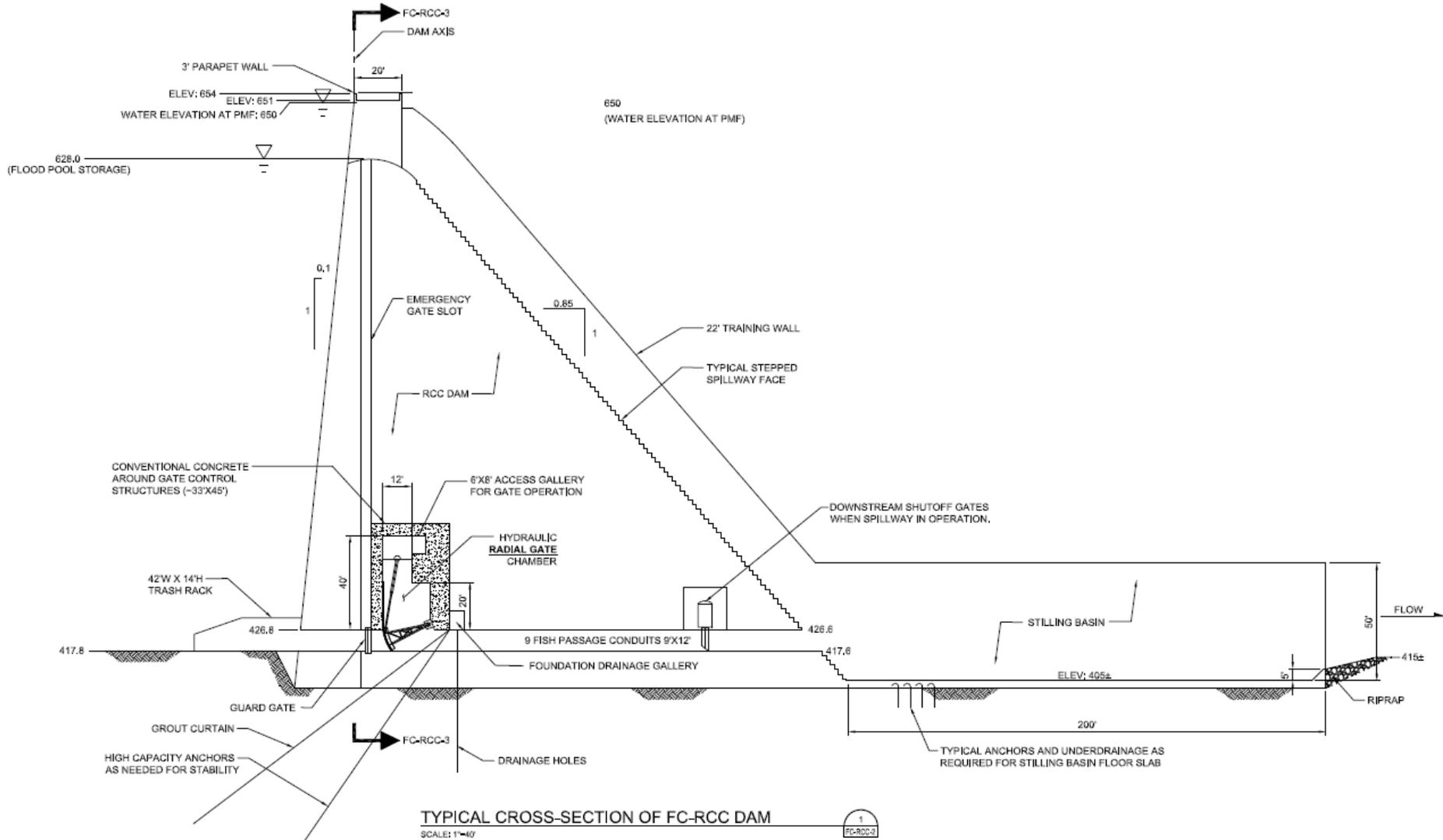
Flood Retention RCC Dam



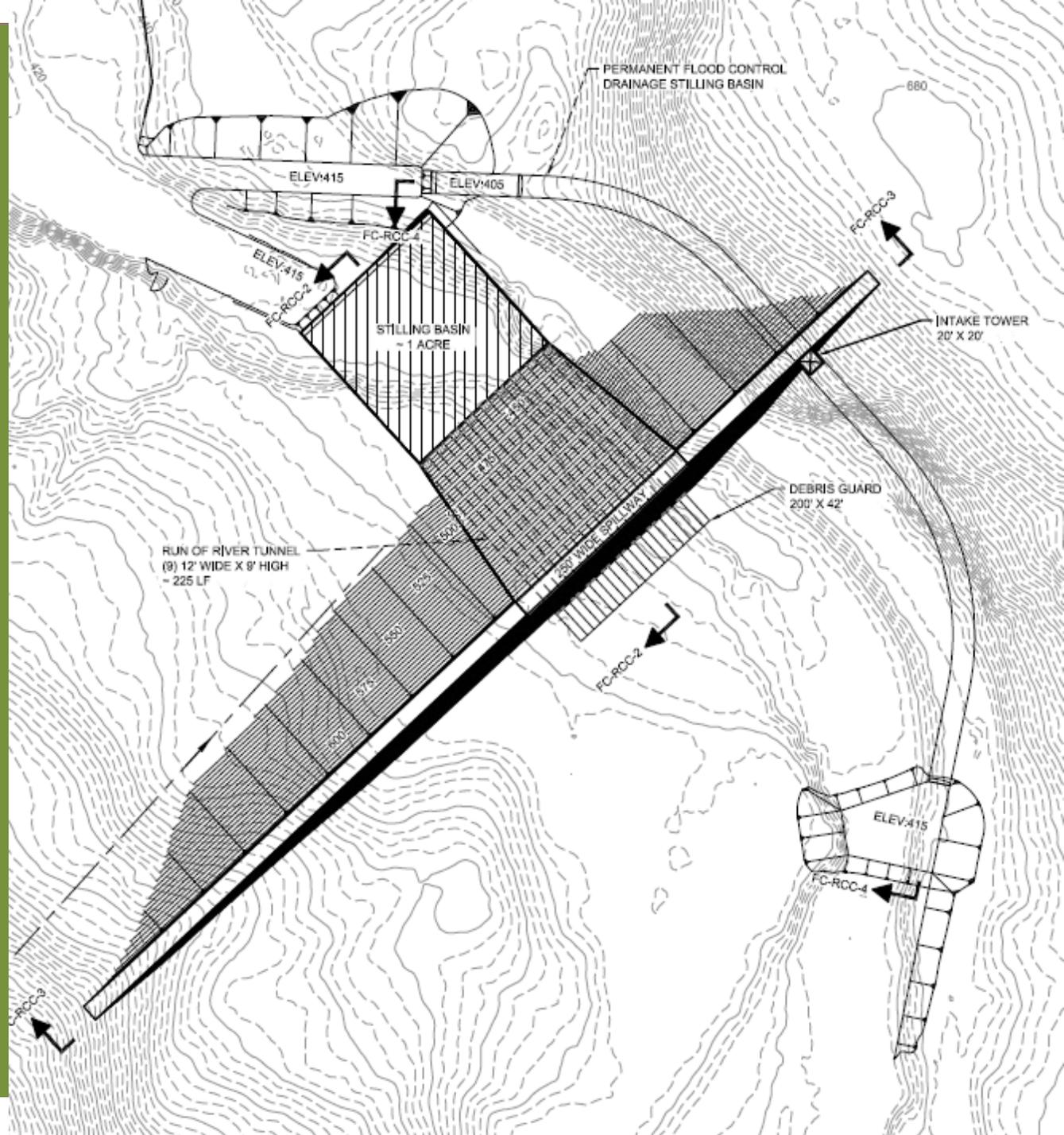
Flood Retention RCC Dam



Flood Retention RCC



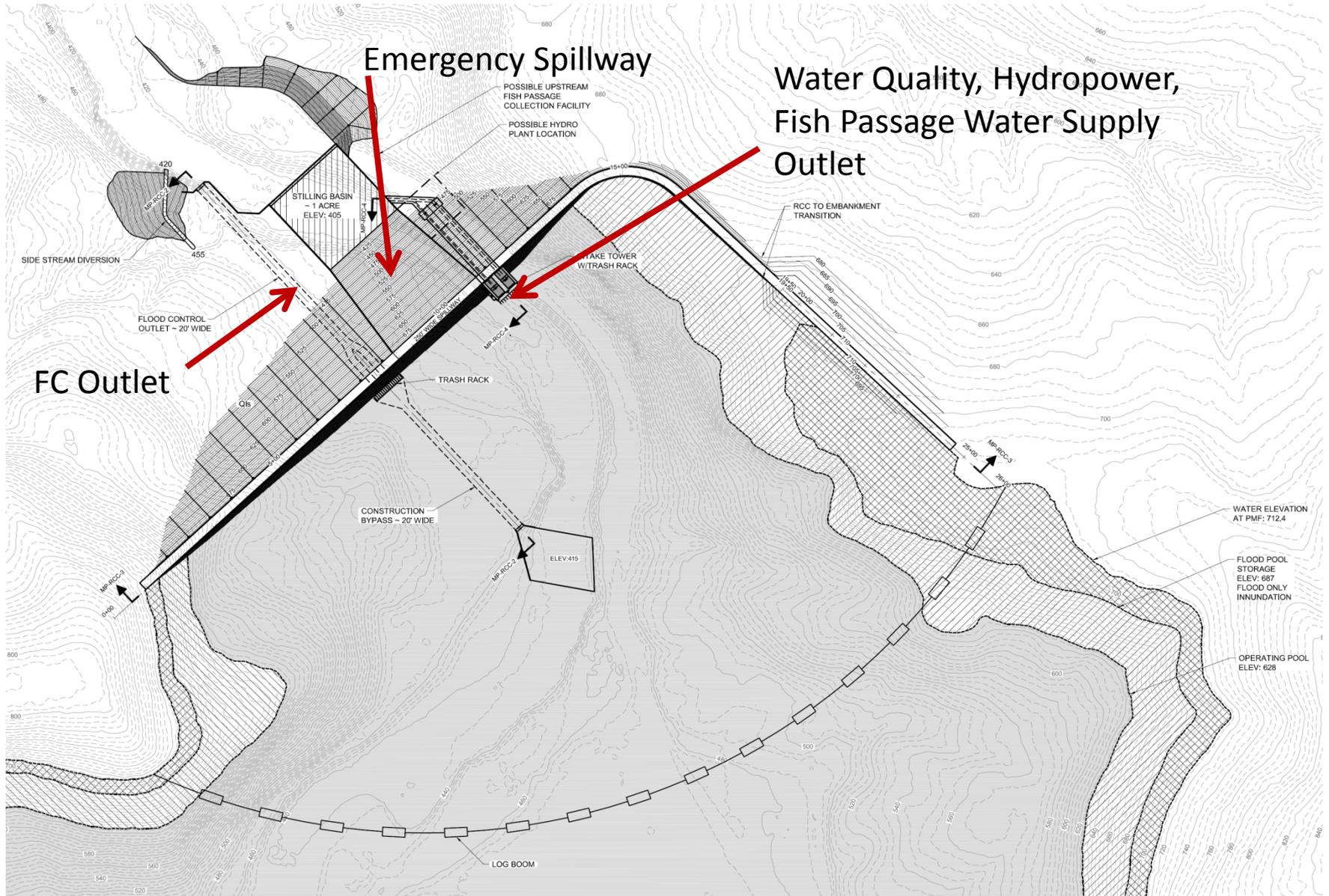
Integrated Dam/Fish Structure



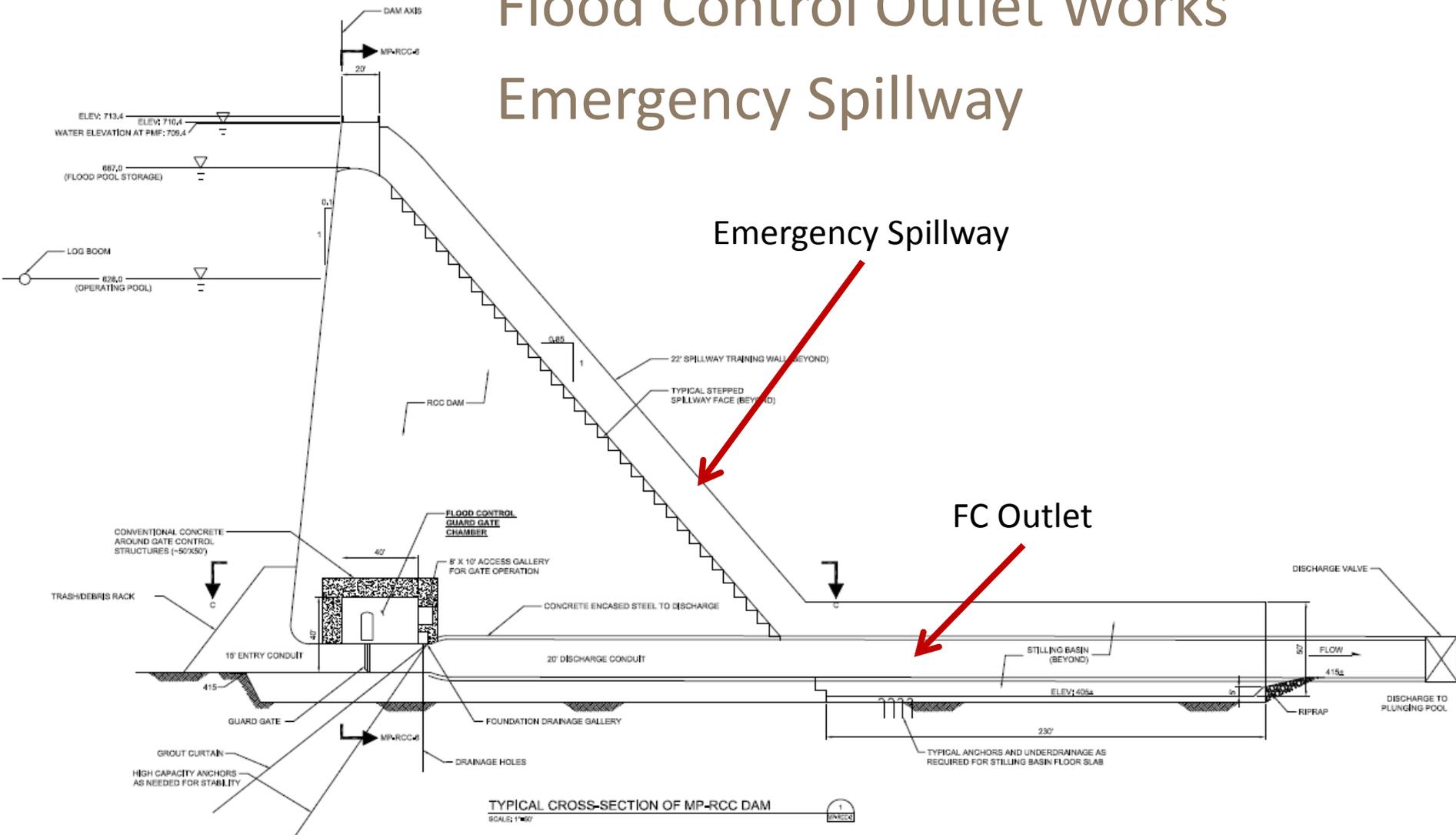
Multi-Purpose RCC Dam



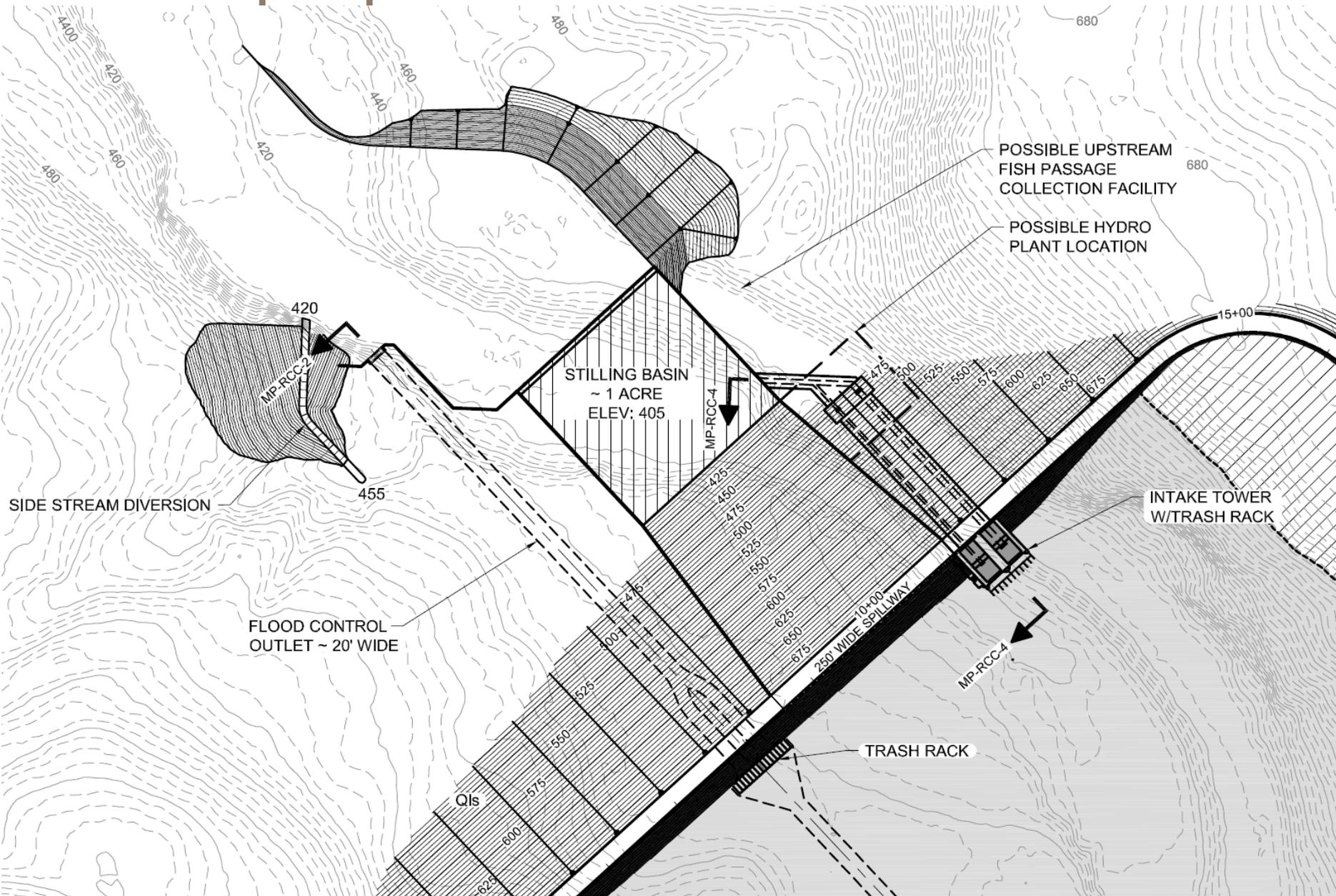
Multi-purpose RCC Dam



Multi-purpose RCC Flood Control Outlet Works Emergency Spillway



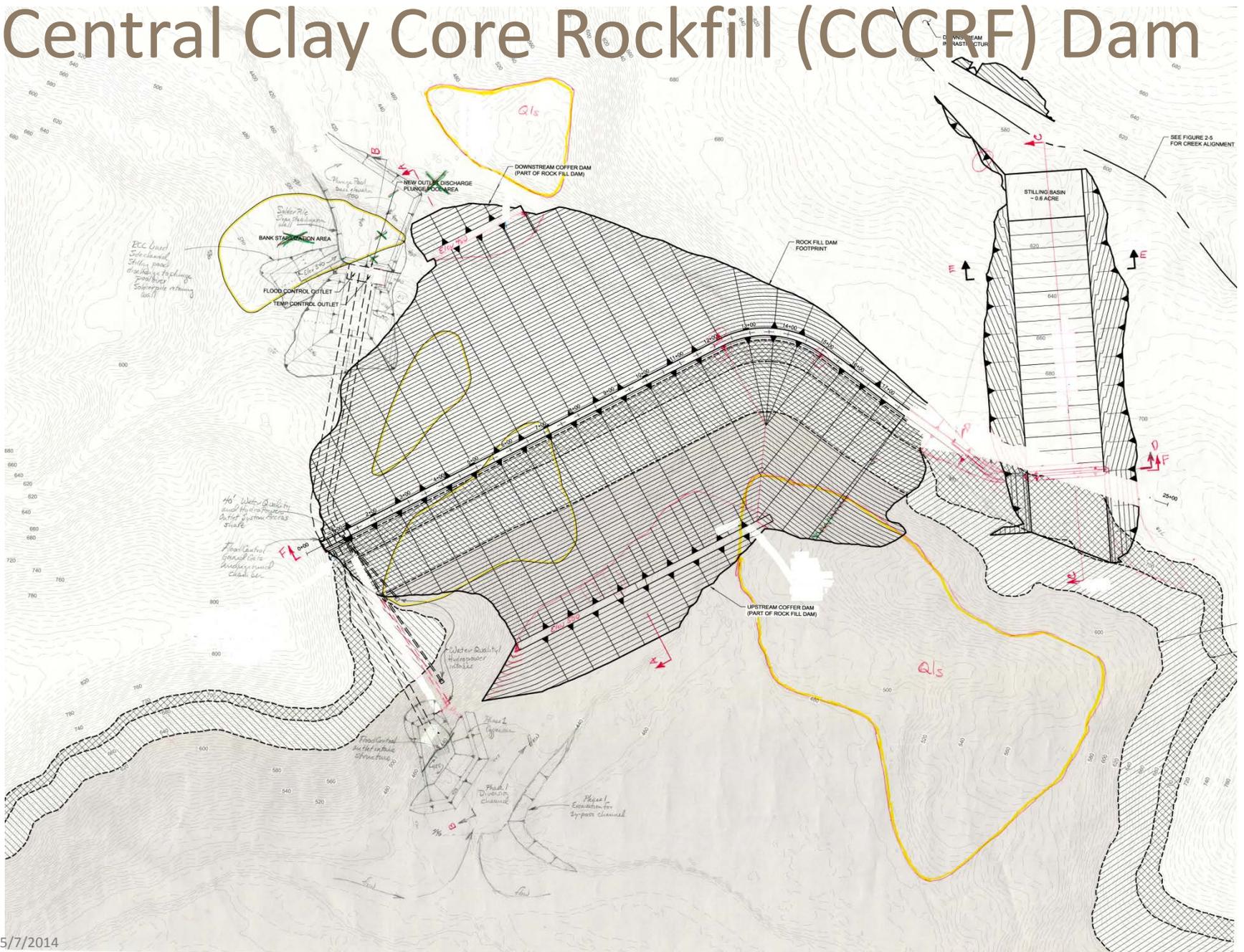
Multi-purpose RCC Dam



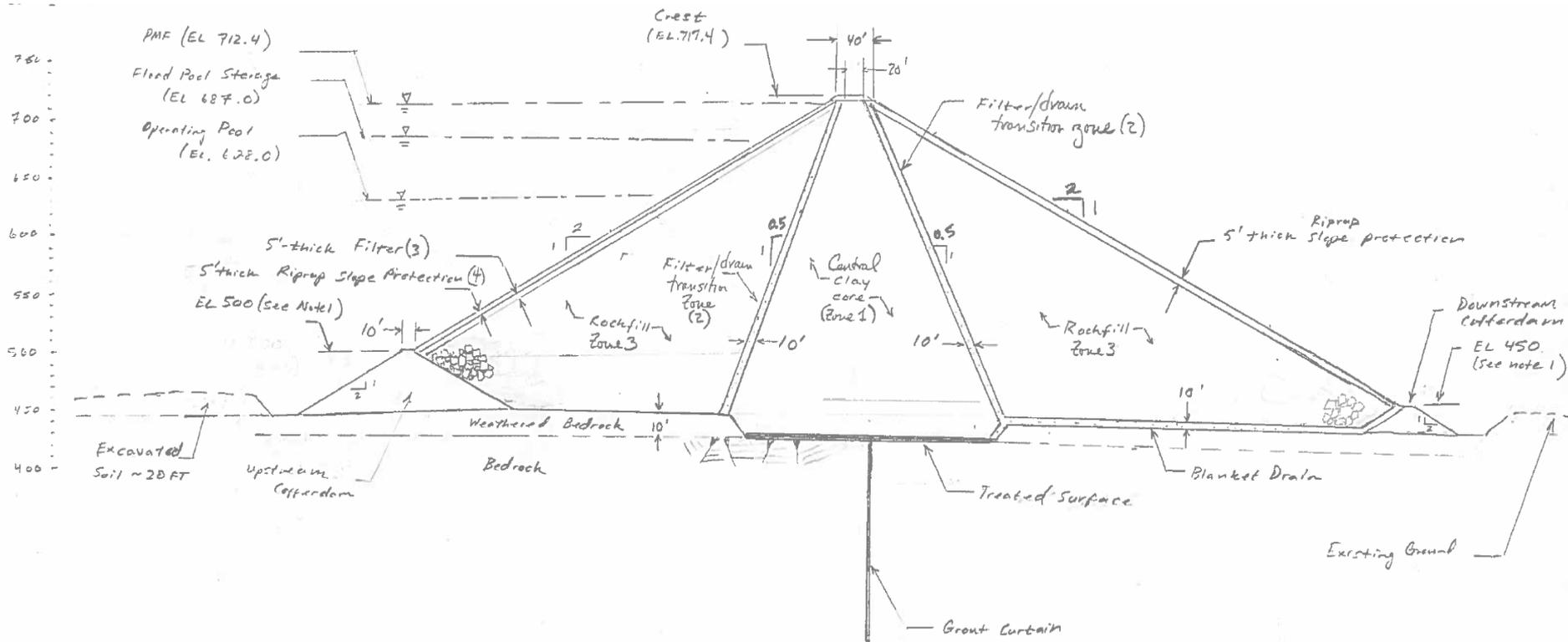
Multi-Purpose Rockfill Dam



Central Clay Core Rockfill (CCCRF) Dam

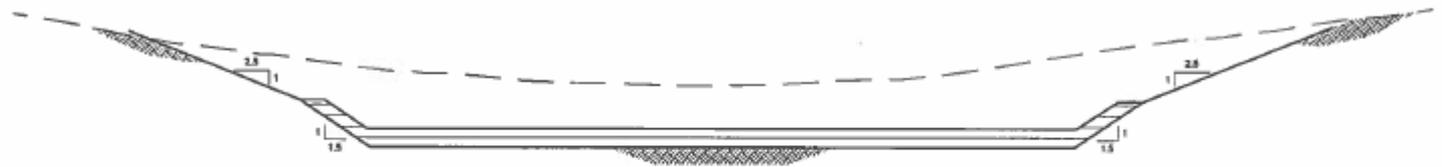


Typical Embankment and Spillway Section

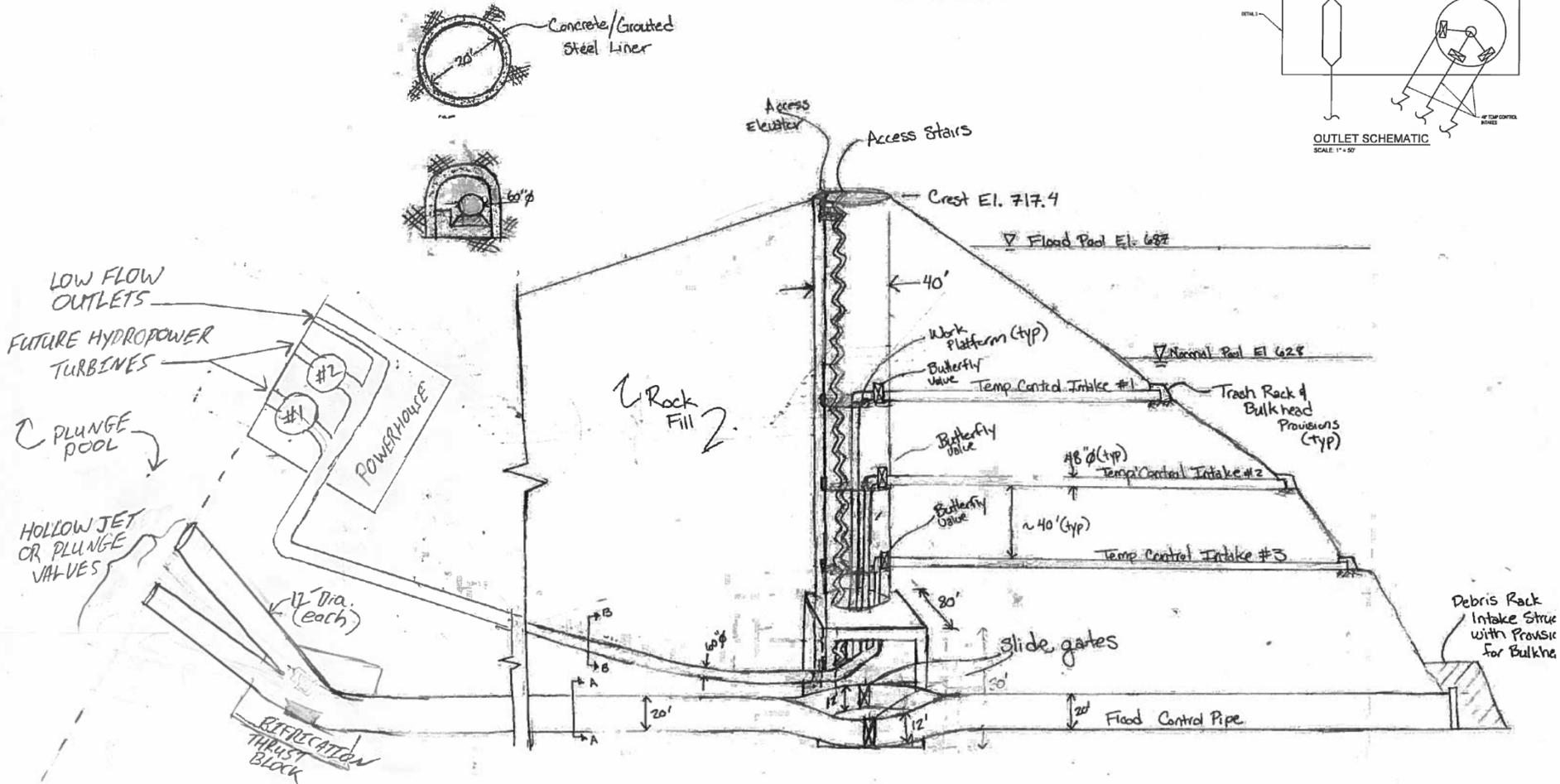
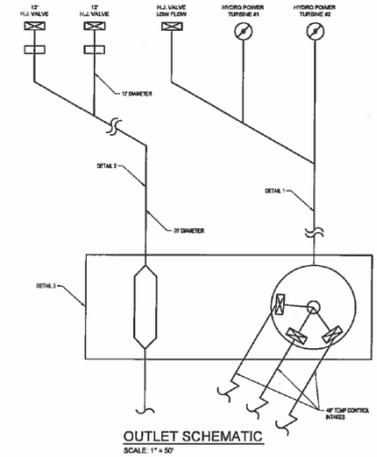


Notes:

1. Crest ...



Outlet Configuration

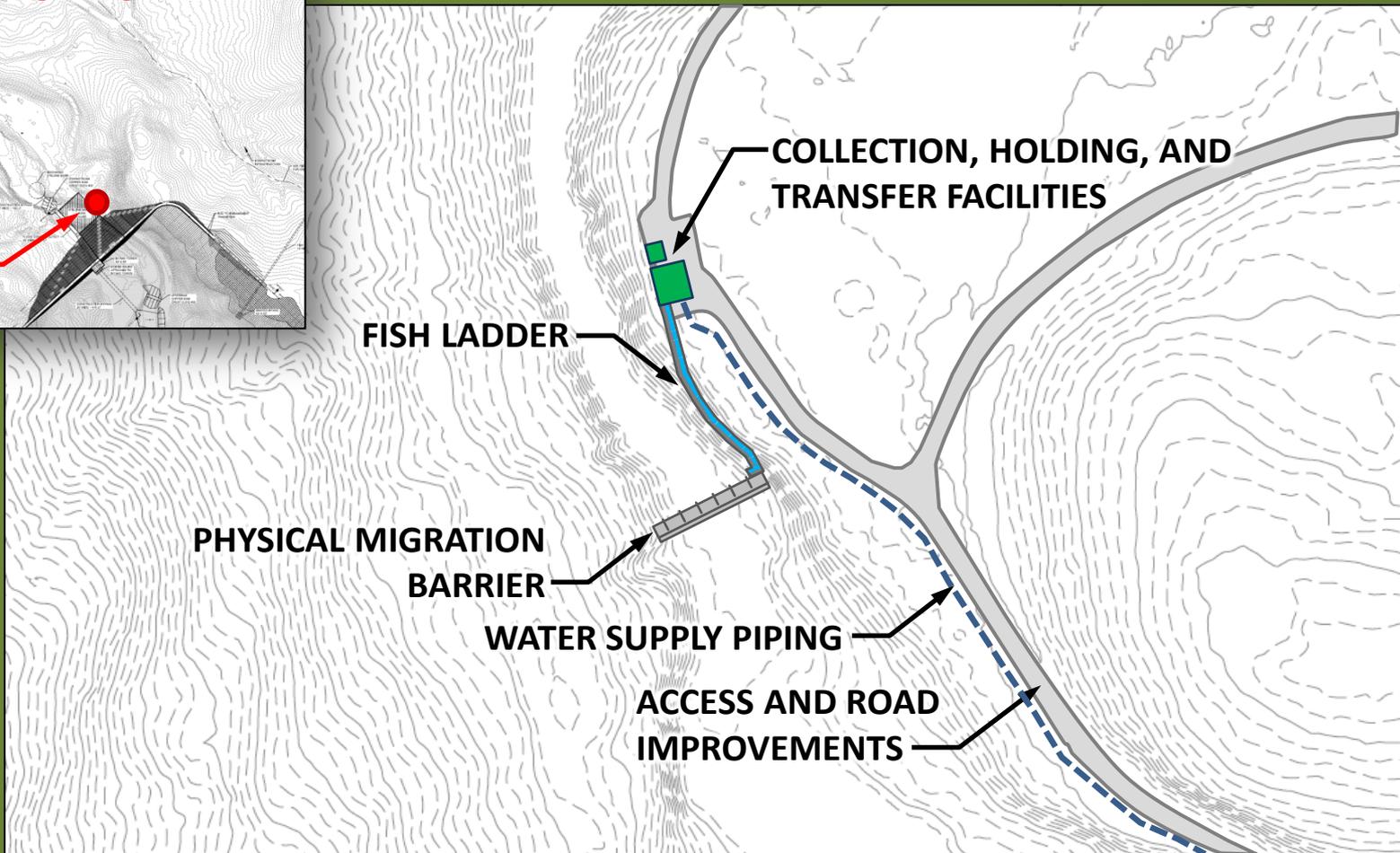
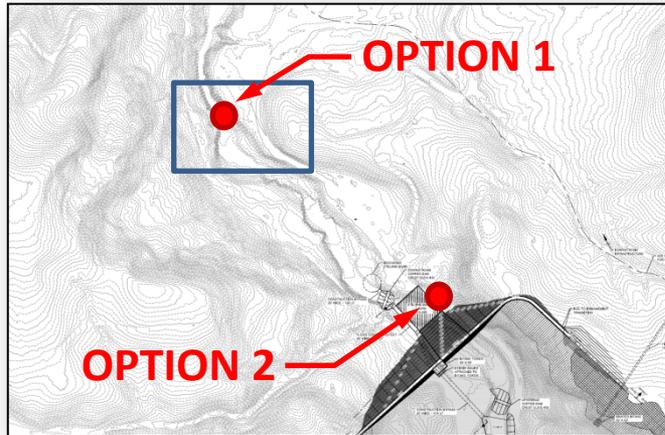


Fish Passage Options

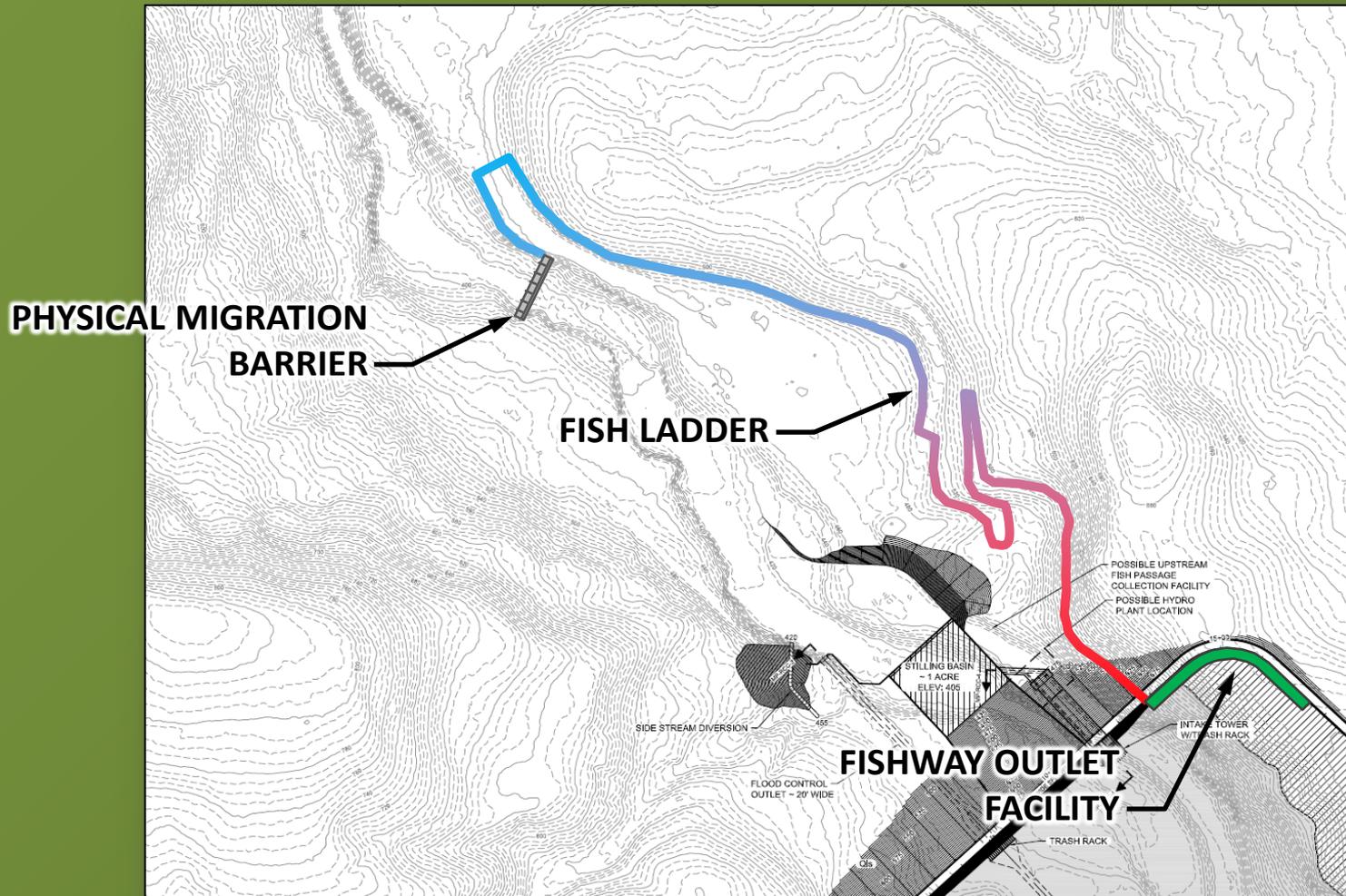
Upstream and Downstream Passage



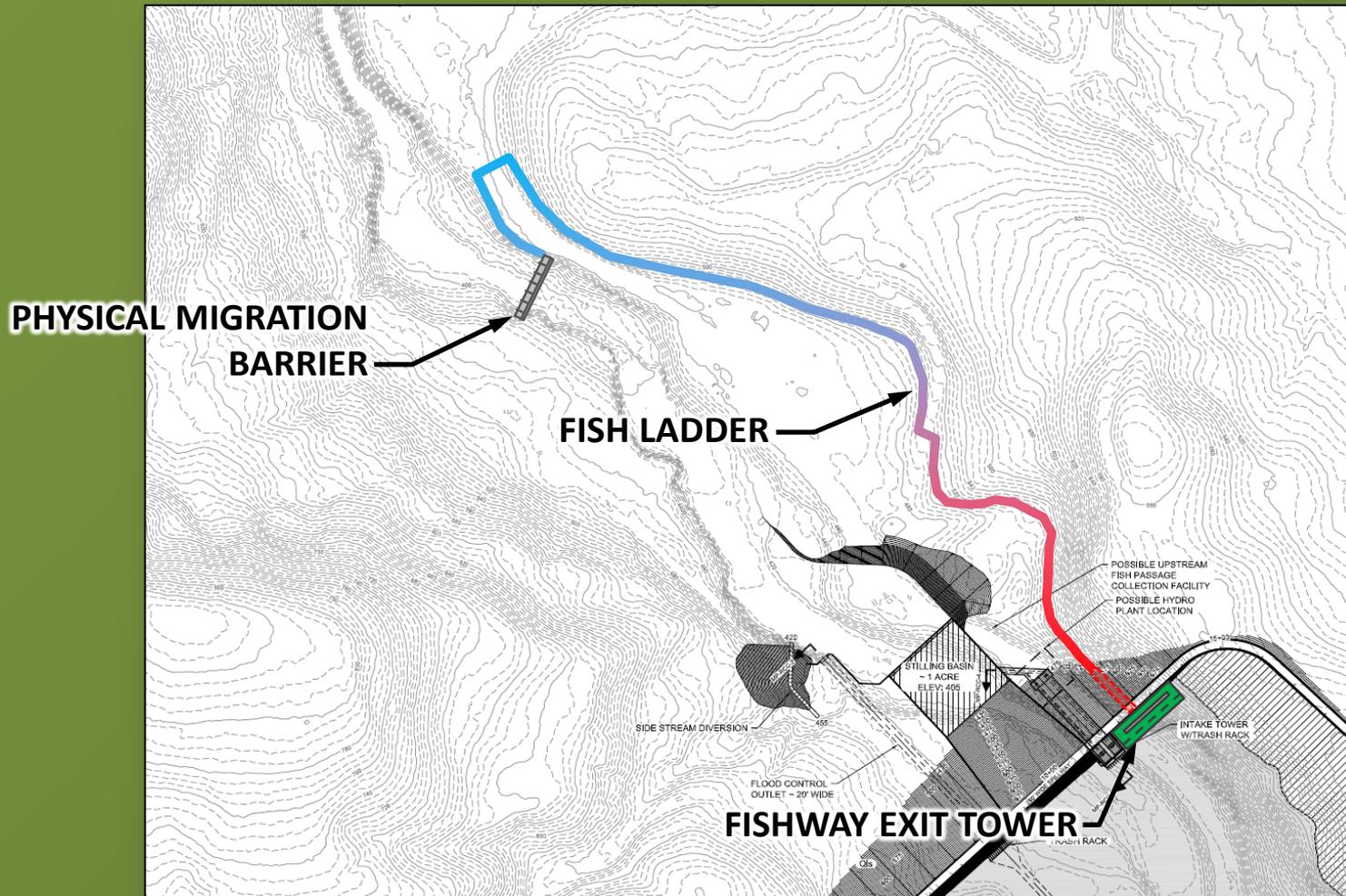
Multi-Purpose Dam Fish Passage Options - CHTR



Multi-Purpose Dam Fish Passage Options – Conventional Fishway

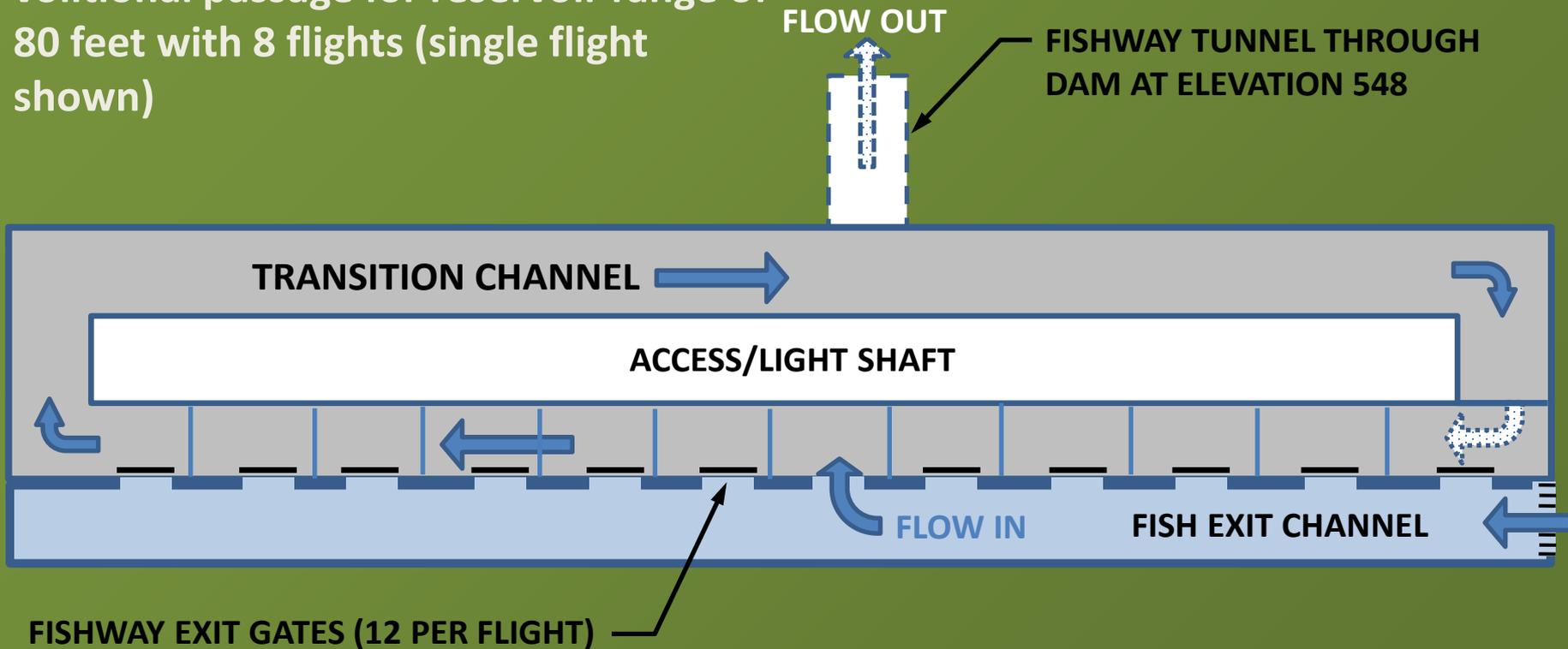


Multi-Purpose Dam Fish Passage Options – Experimental Fishway

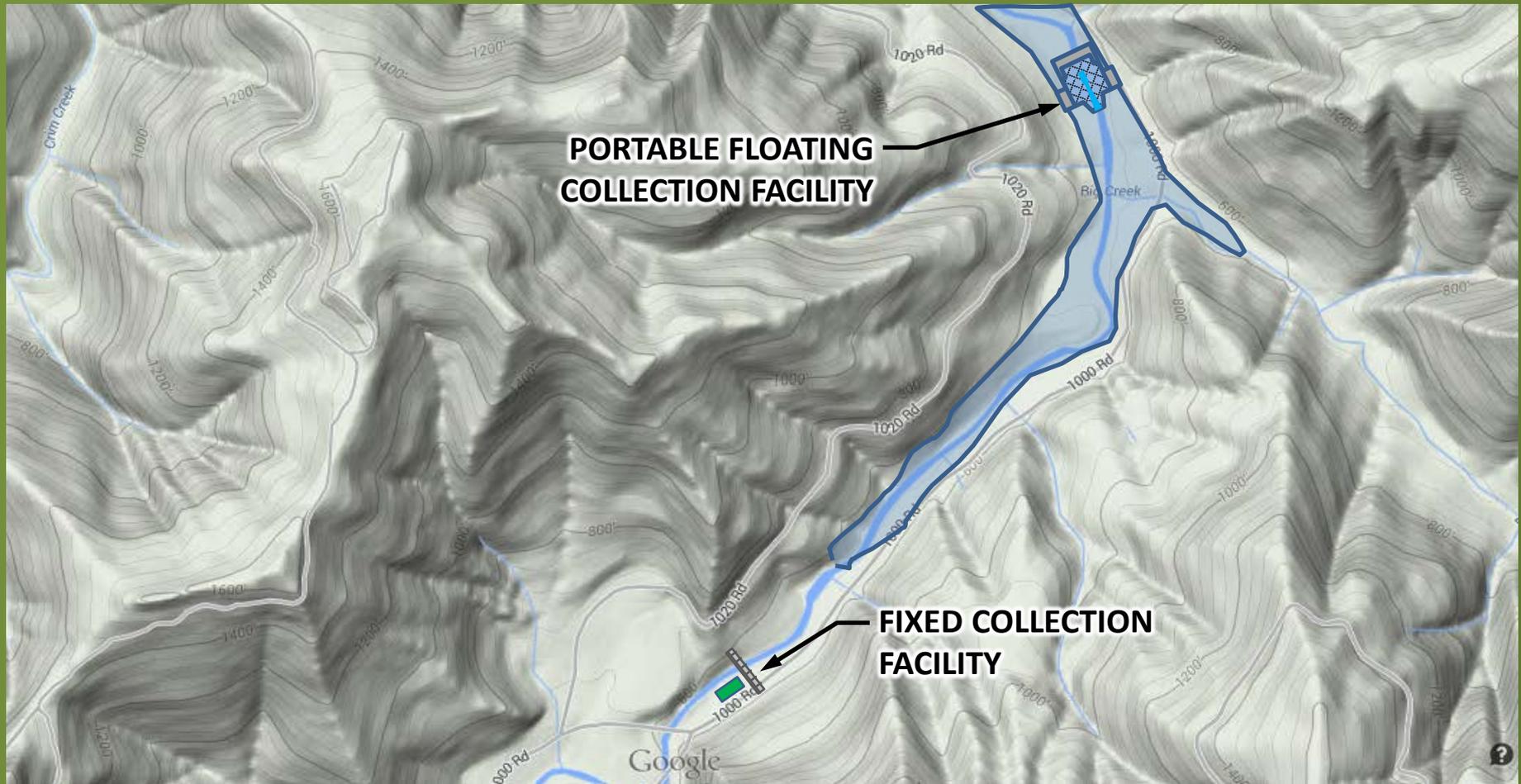


Multi-Purpose Dam Fish Passage Options – Experimental Fishway

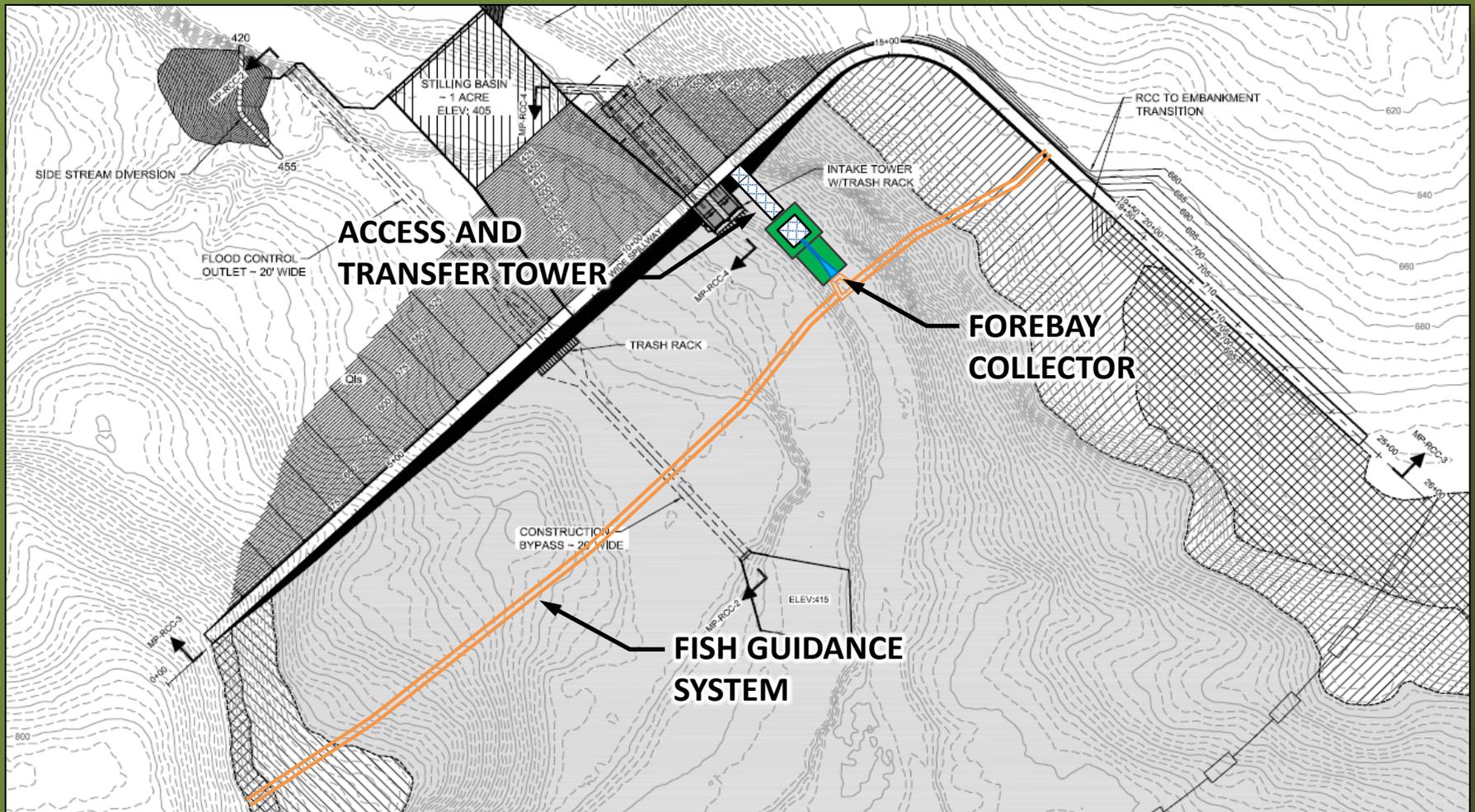
“Spiral” Fishway Tower providing
volitional passage for reservoir range of
80 feet with 8 flights (single flight
shown)



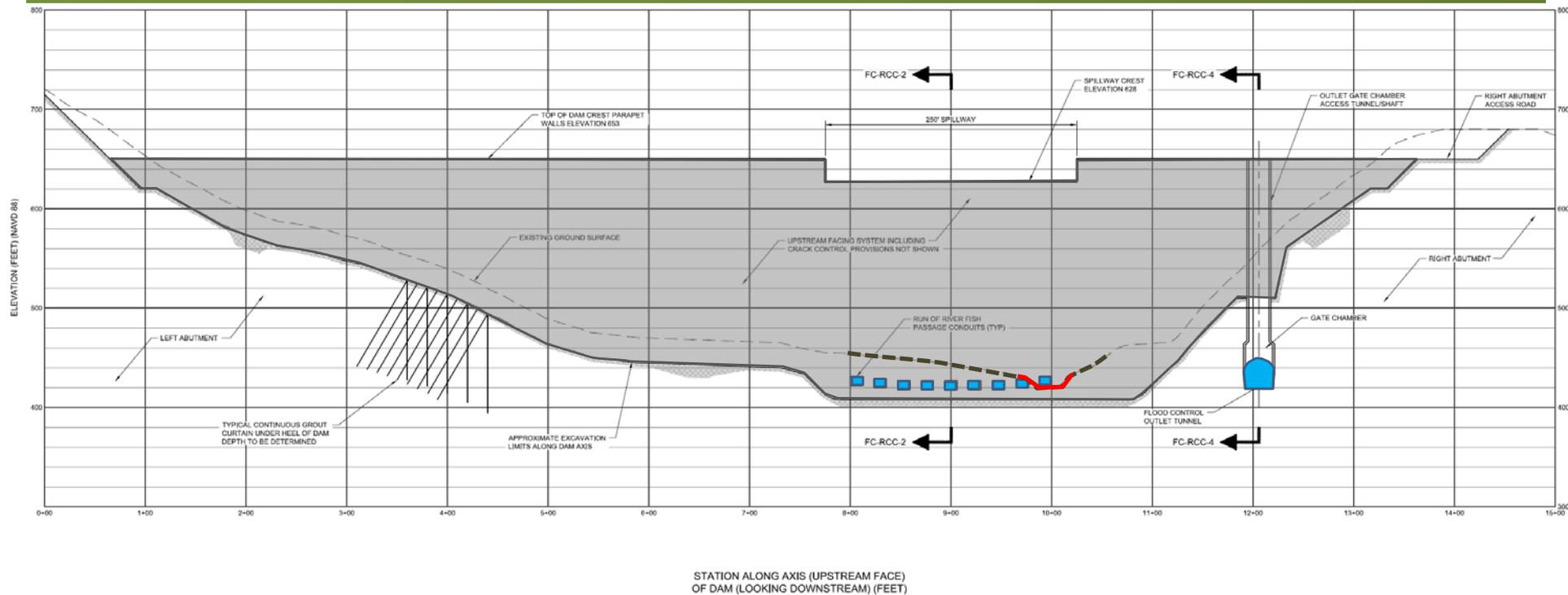
Multi-Purpose Dam Fish Passage Options – Head of Reservoir Combination Collection Facilities



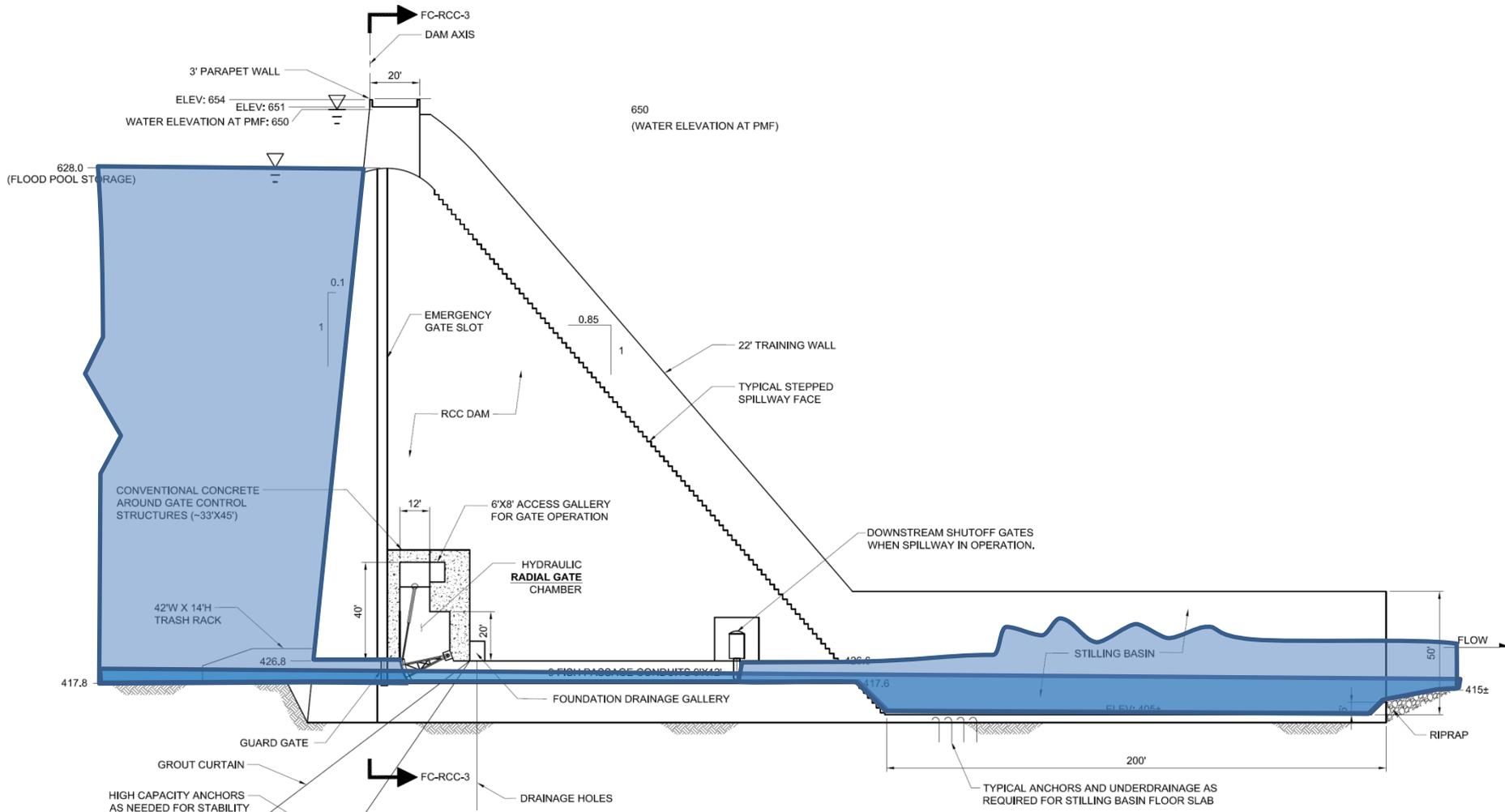
Multi-Purpose Dam Fish Passage Options – Forebay Collector



Flood Retention Only Dam Fish Passage Option – Fish Passage Tunnels



Flood Retention Only Dam Fish Passage Option – Fish Passage Tunnels



Hydropower Potential Evaluation

*Evaluation of the potential for the future addition of a
hydropower facility to the multi-purpose dam*



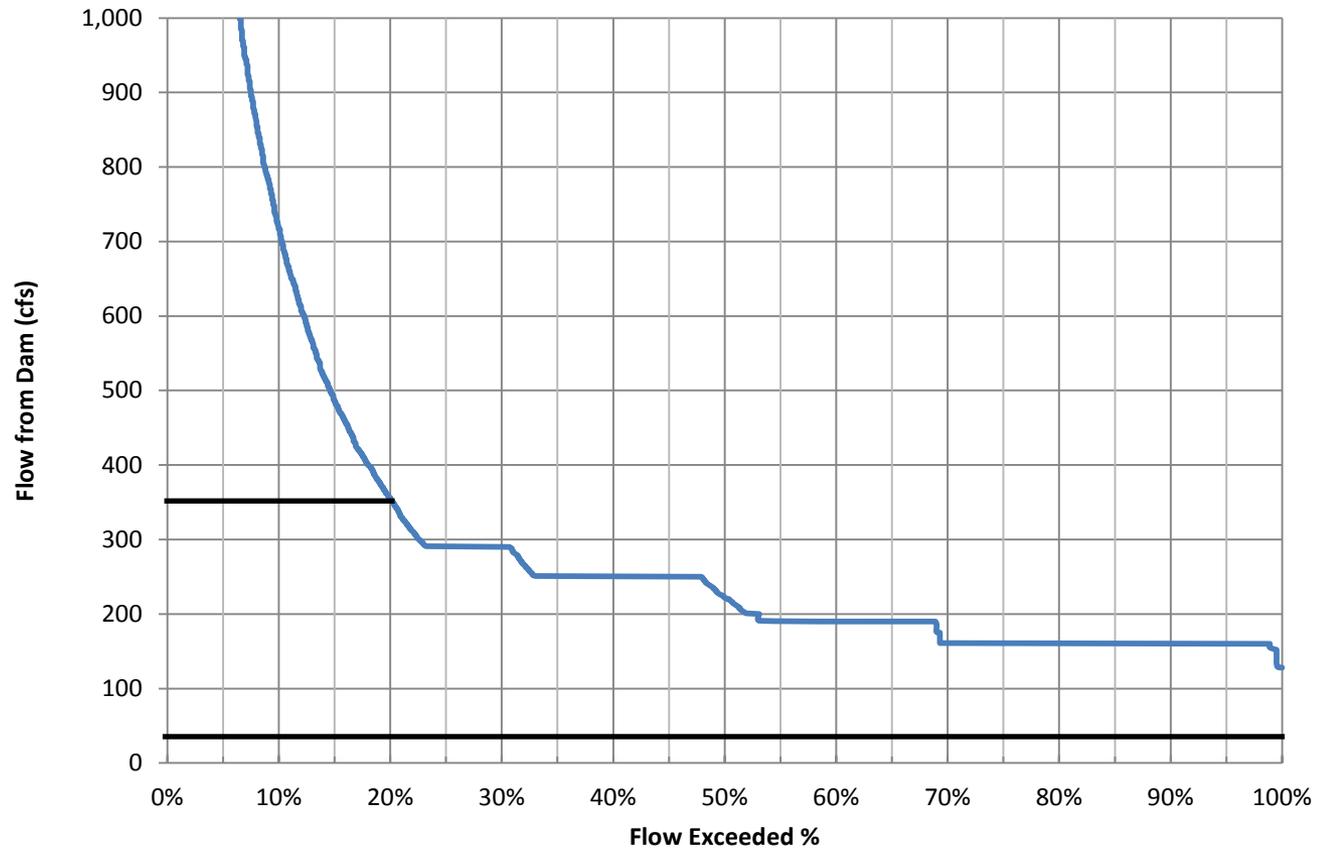
Hydropower Analysis Assumptions

- Hydropower facilities: not included in dam project – but could be added in the future
- Dam operations priorities: flood control and habitat enhancement
- Energy generation: used daily stage flow from dam operations model for 24 year (1989 -2012)

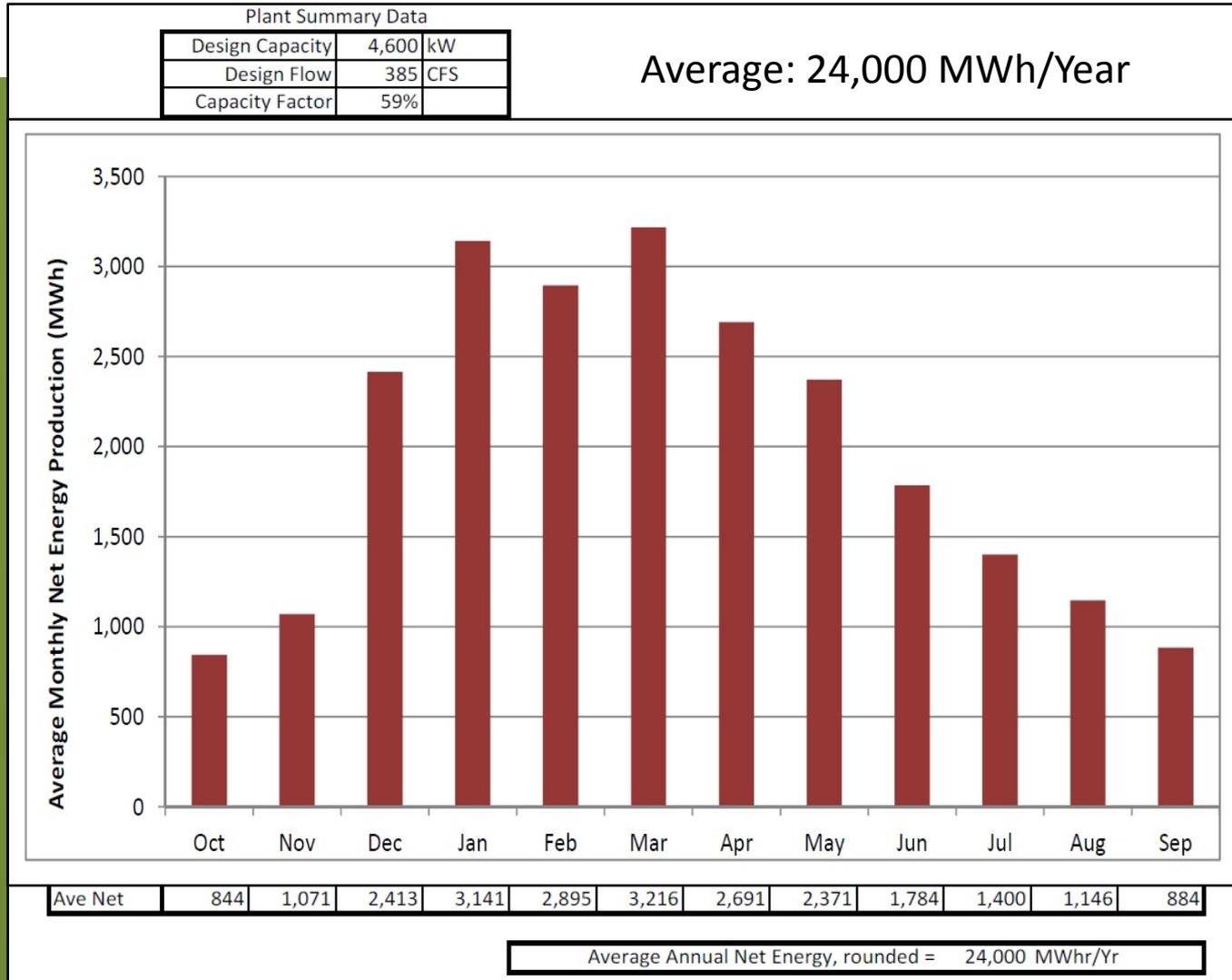
Hydropower Characteristics

- Located below the dam site
- Future connection to dam outlet works
- One or two turbines – 5 MW capacity
- Hydraulic capacity of approximately 400 cfs
- Head 180 feet to 200 feet
- 7,800' transmission line to connect to a south Pe Ell substation

Daily Flow Exceedance Curve

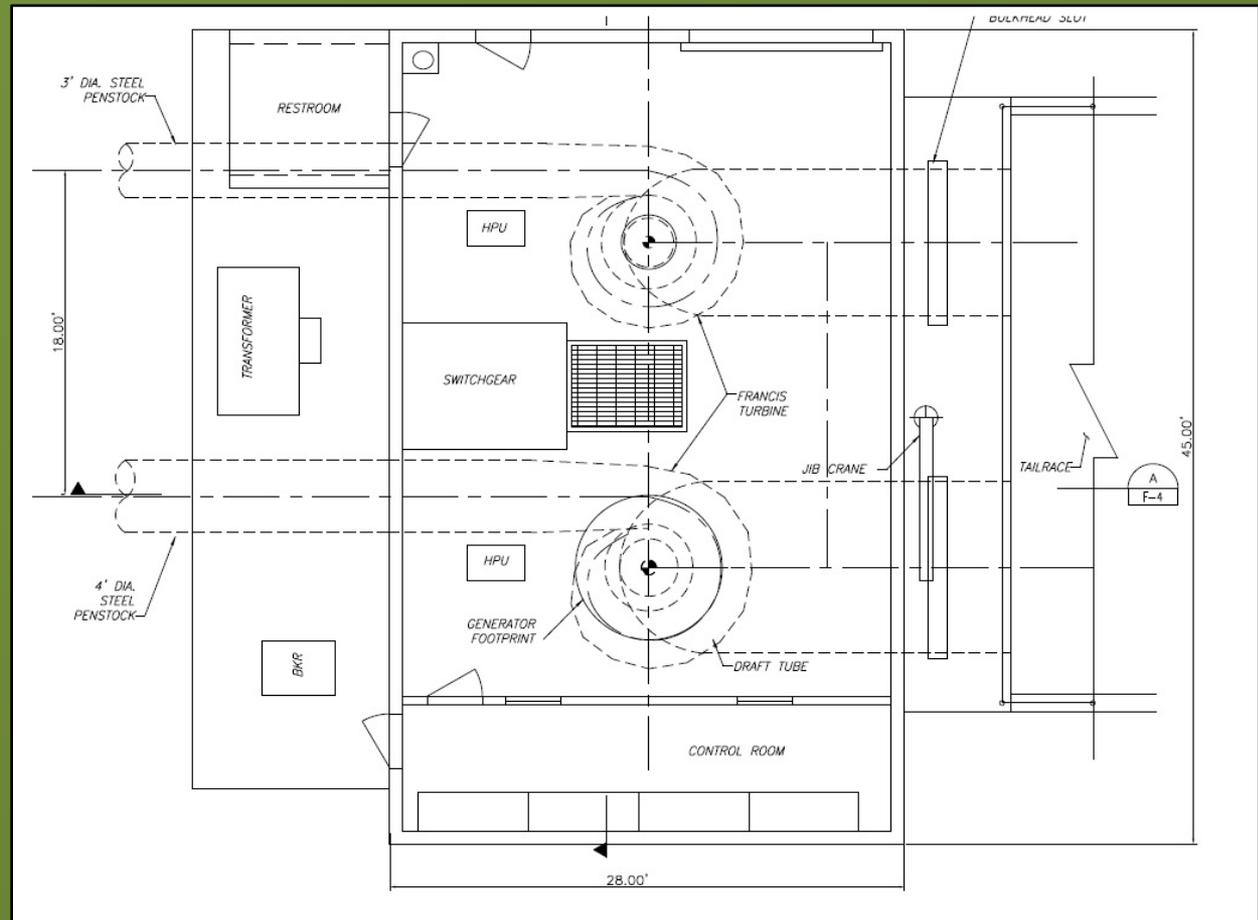


Hydropower Energy Generation Estimate



Powerhouse Concept Plan (2 units)

- 5 MW with one or two turbines
- Likely Francis or possibly one Kaplan turbine
- 30' x 50' to 50' x 70' powerhouse area



Preliminary Quantities and Class 5 Cost Estimates

Dam Structures

Fish Passage

Hydropower



Class 5 Cost Estimate Assumptions

- Expected Accuracy Range +40/-20%
- 2014 Dollars
- Included in Cost Estimates
 - Base Construction Cost
 - Contingencies for:
 - Design Unknowns (i.e. bridges, roads, landslide stabilization, debris management provisions)
 - Construction Change Orders/Claims
 - Design and Site Investigations
 - Permitting
 - Construction Management and Engineering Support
- Not Included in Cost Estimates
 - Operation and Maintenance Costs
 - State Administration Cost and Taxes

Dam Structure Options



FR-RCC Dam

Bid Item	Description	Quantity	Unit	Lower Bound Unit Cost	Upper Bound Unit Price	Lower Bound Cost	Upper Bound Cost
Phase 1 - Prep Work							
1	Clearing and grubbing, reservoir clearing, stripping topsoil, reclamation of disturbed areas	25	Acre	\$29,560.00	\$ 29,560.00	\$ 739,000	\$ 739,000
2	Flood Control Outlet Tunnel 20 ft wide	1,420	LF	\$ 7,670.00	\$ 7,670.00	\$ 10,891,400	\$ 10,891,400
3	Excavation - General	112,000	CY	\$ 6.50	\$ 6.50	\$ 728,000	\$ 728,000
4	Control Structures - Reinforced Concrete	2,000	CY	\$ 700.00	\$ 740.00	\$ 1,400,000	\$ 1,480,000
5	Control Structures - Gates (Fab and Construct)	1,578,000	LB	\$ 12.00	\$ 20.00	\$ 18,936,000	\$ 31,560,000
6	Fill - Cofferdams	26,000	CY	\$ 6.50	\$ 6.50	\$ 169,000	\$ 169,000
	Subtotal					\$ 32,863,400	\$ 45,567,400
Phase 2 - Main Dam							
7	Excavation - Foundation General	458,519	CY	\$ 6.50	\$ 6.50	\$ 2,980,374	\$ 2,980,374
8	Excavation - Foundation Rock	111,488	CY	\$ 34.50	\$ 34.50	\$ 3,846,336	\$ 3,846,336
9	Fill - Roller Compacted Concrete	746,641	CY	\$ 90.00	\$ 149.00	\$ 67,197,690	\$ 111,249,509
10	Fill - Foundation Backfill	312,720	CY	\$ 4.50	\$ 4.50	\$ 1,407,240	\$ 1,407,240
11	Conventional Concrete Reinforced	25,000	CY	\$ 700.00	\$ 740.00	\$ 17,500,000	\$ 18,500,000
12	Conventional Concrete Non-Reinforced	75,000	CY	\$ 400.00	\$ 476.00	\$ 30,000,000	\$ 35,700,000
13	Foundation Treatment - Grout Curtain	15,000	LF	\$ 16.50	\$ 16.50	\$ 247,500	\$ 247,500
14	Fish Passage Gates - Radial (Fab and Construct)	450,000	LB	\$ 12.00	\$ 20.00	\$ 5,400,000	\$ 9,000,000
15	Fish Passage Gates - DS Vertical (Fab and Construct)	378,000	LB	\$ 12.00	\$ 20.00	\$ 4,536,000	\$ 7,560,000
	Subtotal					\$ 133,115,140	\$ 190,490,959
Other							
16	Bulkheads	206,000	LB	\$ 12.00	\$ 20.00	\$ 2,472,000	\$ 4,120,000
	Subtotal					\$ 2,472,000	\$ 4,120,000
	Total Base Construction Cost (BCC)					\$ 168,450,540	\$ 240,178,359
	Design Contingency					\$ 42,112,635	\$ 72,053,508
	Construction. CO/C Contingency					\$ 13,476,043	\$ 19,214,269
	Subtotal					\$ 224,039,218	\$ 331,446,135
	Permitting					\$ 6,721,177	\$ 19,886,768
	Design and Site Characterization					\$ 14,562,549	\$ 29,830,152
	Engineering Support During Construction					\$ 20,163,530	\$ 39,773,536
	Total Cost					\$ 265,486,473	\$ 420,936,591

MP-RCC Dam

Bid Item	Description	Quantity	Unit	Lower Bound Unit Cost	Upper Bound Unit Price	Lower Bound Cost	Upper Bound Cost
Phase 1 - Prep Work							
1	Clearing and grubbing, reservoir clearing, stripping topsoil, reclamation of disturbed areas	28	Acre	\$ 29,560.00	\$ 29,560.00	\$ 827,680	\$ 827,680
2	Flood Control Outlet Cut/Cover	1,200	LF	\$ 2,000.00	\$ 2,400.00	\$ 2,400,000	\$ 2,880,000
3	Excavation - Outlet General	255,000	CY	\$ 6.50	\$ 6.50	\$ 1,657,500	\$ 1,657,500
4	Excavation - Outlet Rock	55,000	CY	\$ 34.50	\$ 34.50	\$ 1,897,500	\$ 1,897,500
5	Fill - Cofferdams	26,000	CY	\$ 6.50	\$ 6.50	\$ 169,000	\$ 169,000
6	Control Structures - Reinforced Concrete	5,000	CY	\$ 700.00	\$ 740.00	\$ 3,500,000	\$ 3,700,000
7	Control Structures - Gates	170,900	LB	\$ 12.00	\$ 20.00	\$ 2,050,800	\$ 3,418,000
8	Regulating Intake Tower - Reinforced Concrete	20,000	CY	\$ 700.00	\$ 740.00	\$ 14,000,000	\$ 14,800,000
9	Regulating Intake Tower - Gates	22,000	LB	\$ 12.00	\$ 20.00	\$ 264,000	\$ 440,000
	Subtotal					\$ 26,766,480	\$ 29,789,680
Phase 2 - Main Dam							
10	Excavation - Foundation General	649,860	CY	\$ 6.50	\$ 6.50	\$ 4,224,090	\$ 4,224,090
11	Excavation - Foundation Rock	202,632	CY	\$ 34.50	\$ 34.50	\$ 6,990,804	\$ 6,990,804
12	Foundation Treatment - Grout Curtain	25,000	LF	\$ 16.50	\$ 16.50	\$ 412,500	\$ 412,500
13	Conventional Concrete Reinforced	20,000	CY	\$ 700.00	\$ 740.00	\$ 14,000,000	\$ 14,800,000
14	Conventional Concrete Non-Reinforced	64,000	CY	\$ 400.00	\$ 476.00	\$ 25,600,000	\$ 30,464,000
15	Fill - Roller Compacted Concrete	1,319,700	CY	\$ 90.00	\$ 149.00	\$ 118,773,000	\$ 196,635,300
16	Fill - Foundation Backfill	452,828	CY	\$ 4.50	\$ 4.50	\$ 2,037,726	\$ 2,037,726
	Subtotal					\$ 172,038,120	\$ 255,564,420
Other							
17	Fill - Wingdam Embankment	117,768	CY	\$ 4.50	\$ 4.50	\$ 529,956	\$ 529,956
18	Large Diameter Valves	1	LS	\$ 5,065,500	\$ 6,331,875	\$ 5,065,500	\$ 6,331,875
	Subtotal					\$ 5,595,456	\$ 6,861,831
	Total Base Construction Cost (BCC)					\$ 204,400,056	\$ 292,215,931
	Design Contingency					\$ 51,100,014	\$ 87,664,779.30
	Construction. CO/C Contingency					\$ 16,352,004	\$ 23,377,274.48
	Subtotal					\$ 271,852,074	\$ 403,257,985
	Permitting					\$ 8,155,562	\$ 24,195,479.09
	Design and site Characterization					\$ 17,670,385	\$ 36,293,218.63
	Engineering Support During Construction					\$ 24,466,686.70	\$ 48,390,958.17
	Total Cost					\$ 322,144,708	\$ 512,137,641

MP-Rockfill Dam

Bid Item	Description	Quantity	Unit	Lower Bound Unit Cost	Upper Bound Unit Price	Lower Bound Cost	Upper Bound Cost
Phase 1 - Prep Work							
1	Clearing and grubbing, reservoir clearing, stripping topsoil, reclamation of disturbed areas	82	Acre	\$ 29,560.00	\$ 29,560.00	\$ 2,423,920	\$ 2,423,920
2	Flood Control Outlet Tunnel 20 ft dia	1,500	LF	\$ 7,670.00	\$ 7,670.00	\$ 11,505,000	\$ 11,505,000
3	Excavation - General (Intake and Outlet)	96,800	CY	\$ 6.50	\$ 6.50	\$ 629,200	\$ 629,200
4	Excavation - Rock (Intake and Outlet)	49,700	CY	\$ 34.50	\$ 34.50	\$ 1,714,650	\$ 1,714,650
5	Fill - Cofferdams	254,000	CY	\$ 6.50	\$ 6.50	\$ 1,651,000	\$ 1,651,000
6	Control Structures - Reinforced Concrete	34,000	CY	\$ 700.00	\$ 740.00	\$ 23,800,000	\$ 25,160,000
7	Control Structures - Gates	140,000	LB	\$ 12.00	\$ 20.00	\$ 1,680,000	\$ 2,800,000
8	Regulating Intake Access Shaft	290	LF	\$ 25,000.00	\$ 32,000.00	\$ 7,250,000	\$ 9,280,000
	Subtotal					\$ 50,653,770	\$ 55,163,770
Phase 2 - Main Dam							
9	Excavation - Foundation General	2,145,000	CY	\$ 6.50	\$ 6.50	\$ 13,942,500	\$ 13,942,500
10	Foundation Treatment - Grout Curtain	18,000	LF	\$ 16.50	\$ 16.50	\$ 297,000	\$ 297,000
11	Foundation Treatment - Dental Concrete	31,000	CY	\$ 279.00	\$ 300.00	\$ 8,649,000	\$ 9,300,000
12	Fill - Central Clay Core (Zone 1)	1,982,556	CY	\$ 6.50	\$ 8.10	\$ 12,886,614	\$ 16,058,704
13	Fill - Filter Transition (Zone 2)	539,316	CY	\$ 45.00	\$ 53.80	\$ 24,269,220	\$ 29,015,201
14	Fill - Rockfill (Zone 3)	4,534,812	CY	\$ 25.00	\$ 34.50	\$ 113,370,300	\$ 156,451,014
15	Fill - Riprap (Zone 4)	227,880	CY	\$ 28.00	\$ 34.50	\$ 6,380,640	\$ 7,861,860
	Subtotal					\$ 179,795,274	\$ 232,926,278
Other							
16	Steel Pipe - Temp. Intake Tunnels (48") Drill	1,500	LF	\$ 2,300.00	\$ 2,800.00	\$ 3,450,000	\$ 4,200,000
17	Temperature Intake Tunnel (15' Horseshoe)	700	LF	\$ 19,000.00	\$ 22,000.00	\$ 13,300,000	\$ 15,400,000
18	Steel Pipe - Temperature Intake Tunnel (60")	700	LF	\$ 1,350.00	\$ 1,500.00	\$ 945,000	\$ 1,050,000
19	Spillway Excavation	347,000	CY	\$ 6.50	\$ 6.50	\$ 2,255,500	\$ 2,255,500
20	Spillway RCC	36,000	CY	\$ 90.00	\$ 149.00	\$ 3,240,000	\$ 5,364,000
21	Large Diameter Valves	1	LS	\$ 5,178,000	\$ 6,472,500	\$ 5,178,000	\$ 6,472,500
	Subtotal					\$ 28,368,500	\$ 34,742,000
	Total BCC					\$ 258,817,544	\$ 322,832,048
	Design Contingency					\$ 64,704,386	\$ 96,849,615
	Construction. CO/C Contingency					\$ 20,705,404	\$ 25,826,564
	Subtotal					\$ 344,227,334	\$ 445,508,227
	Permitting					\$ 10,326,820.01	\$ 26,730,493.61
	Design and site Characterization					\$ 22,374,776.68	\$ 40,095,740.41
	Engineering Support During Construction					\$ 30,980,460.02	\$ 53,460,987.22
	Total Cost					\$ 407,909,390	\$ 565,795,448

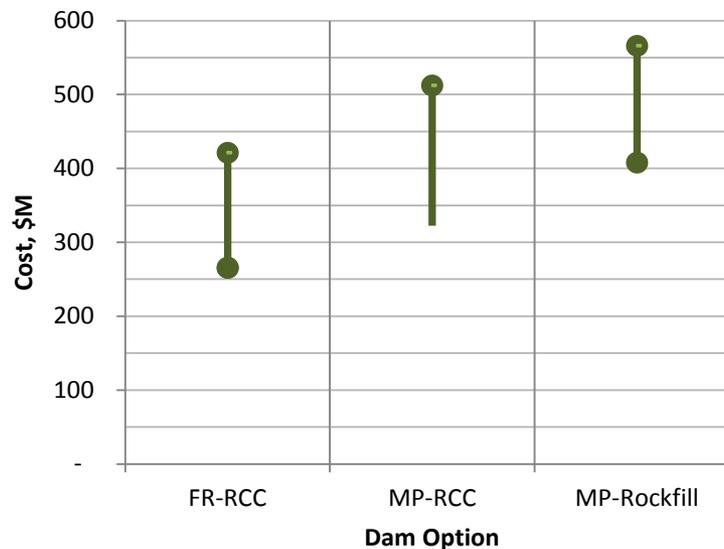
Key Unit Prices

Bid Item	Description	Unit	Lower Bound Unit Price	Upper Bound Unit Price
1	Clearing and grubbing, reservoir clearing, stripping topsoil, reclamation of disturbed areas	Acre	\$ 29,560.00	\$ 29,560.00
2	Steel Pipe - Flood Control Outlet	LF		
3	Fill - Cofferdams	CY	\$ 6.50	\$ 6.50
4	Control Structures - Gates/Bulkheads Fab	LB	\$ 12.00	\$ 20.00
5	Regulating Intake Tower - Gates Fab	LB	\$ 12.00	\$ 20.00
6	Excavation - Foundation General	CY	\$ 6.50	\$ 6.50
7	Excavation - Foundation Rock	CY	\$ 34.50	\$ 34.50
8	Foundation Treatment - Grout Curtain	LF	\$ 16.50	\$ 16.50
9	Conventional Concrete Reinforced	CY	\$ 700.00	\$ 740.00
10	Conventional Concrete Non-Reinforced	CY	\$ 400.00	\$ 476.00
11	Dental Concrete	CY	\$ 250.00	\$ 325.00
12	Fill -Roller Compacted Concrete	CY	\$ 90.00	\$ 149.00
13	Embankment Fill - Foundation Backfill/Wingdam	CY	\$ 4.50	\$ 4.50
14	Fill - Central Clay Core (Zone 1)	CY	\$ 6.50	\$ 8.10
15	Fill - Filter Transition (Zone 2)	CY	\$ 45.00	\$ 53.80
16	Fill - Rockfill (Zone 3)	CY	\$ 25.00	\$ 34.50
17	Fill - Riprap (Zone 4)	CY	\$ 28.00	\$ 34.50
	Design Contingency applied to BCC		25%	30%
	Construction. CO/C Contingency applied to BCC		8%	8%
	Permitting applied to Construction Cost Subtotal (CCS)		3%	6%
	Design and site Characterization applied to CCS		7%	9%
	Engineering Support During Construction applied to CCS		9%	12%

Dam Structure Cost Summary

Dam Type	Lower Bound Cost, \$M	Average Cost, \$M	Upper Bound Cost, \$M
FR-RCC	265	343	421
MP-RCC	322	417	512
MP-Rockfill	408	487	566

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



Fish Passage Cost Summary

Fish Passage Option	Lower Bound Cost, M\$	Middle Cost, \$M	Upper Bound Cost, M\$
CHTR	9.9	12.3	17.3
Conventional Fishway	29.3	36.6	51.3
Experimental Fishway	39.8	49.7	69.6
Combo Collection Facilities	17.0	21.2	29.7
Forebay Collector	26.4	33.0	46.2
Fish Passage Tunnels	Included with the cost of the FR-RCC dam option.		

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

Approximate 2014 Budgetary Hydropower Costs

- Construction Cost: \$14 to \$18 million
- Add 30 to 35 percent allied costs for permitting/licensing, engineering, construction management, finance, legal/administration: \$5 million
- Additional fish screening requirements could add cost (\$1 to \$2 million)

Hydropower project budgetary cost:
\$20 to \$25 million

Formulation of Integrated Structure Alternatives



Dam and Fish Passage Options

Dam Structures

- Flood Retention RCC
- Multi-Purpose RCC
- Multi-Purpose Rockfill

Fish Passage

- Upstream Passage
 - CHTR Facility
 - Conventional Fishway
 - Experimental Fishway
- Downstream Passage
 - Combination Collection Facilities
 - Forebay Collector

Examples of Integrated Dam/Fish Passage Alternatives

- Alternative A:
 - FR-RCC
- Alternative B:
 - MP-RCC Dam
 - CHTR Facility (upstream passage)
 - Combination Collector Facilities (downstream passage)
- Alternative C:
 - MP-RCC Dam
 - Conventional Fishway (upstream passage)
 - Forebay Collector (downstream passage)
- Alternative D:
 - MP-Rockfill Dam
 - Experimental Fishway (upstream passage)
 - Forebay Collector (downstream passage)

Integrated Structure Cost Comparison

Alternative	Preliminary Class 5 Cost Estimate 2014 \$M, Average Estimated Value and +/- Range				
	Dam	Fish Passage Upstream	Fish Passage Downstream	Hydropower	Total
A	343 265-421				343
B	417 322-512	13 10-18	22 17-30	22 20-25	474
C	417 322-512	37 30-52	33 27-47	22 20-25	509
D	487 408-566	50 40-70	33 27-47	22 20-25	592

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

Path Forward



Incorporating New Info

Geotechnical Investigations

- Landslides
- Proposed RCC Dam Site Explorations
- Aggregate Source Evaluation

Task 1.1.3 Schedule

Alternatives Tech Memo – Draft	June 30, 2014
Alternatives Tech Memo – Final	August 31, 2014

Note: Dam Design (1.1.1) and Fish Passage (1.1.2) Final Technical Memos also due August 31, 2014

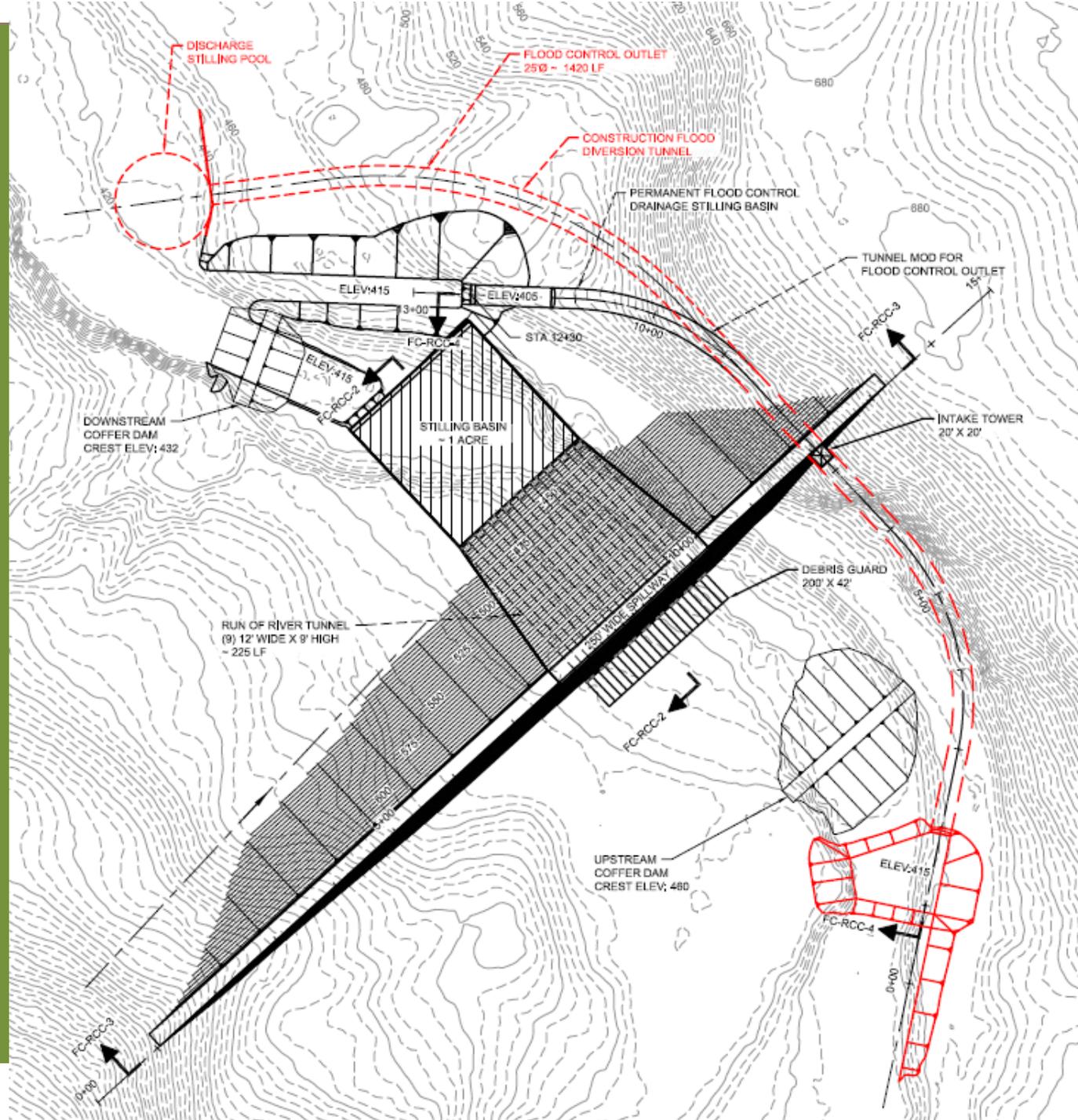
Questions and Discussion



FLOOD RETENTION – RCC

POTENTIAL CONSTRUCTION SEQUENCE:

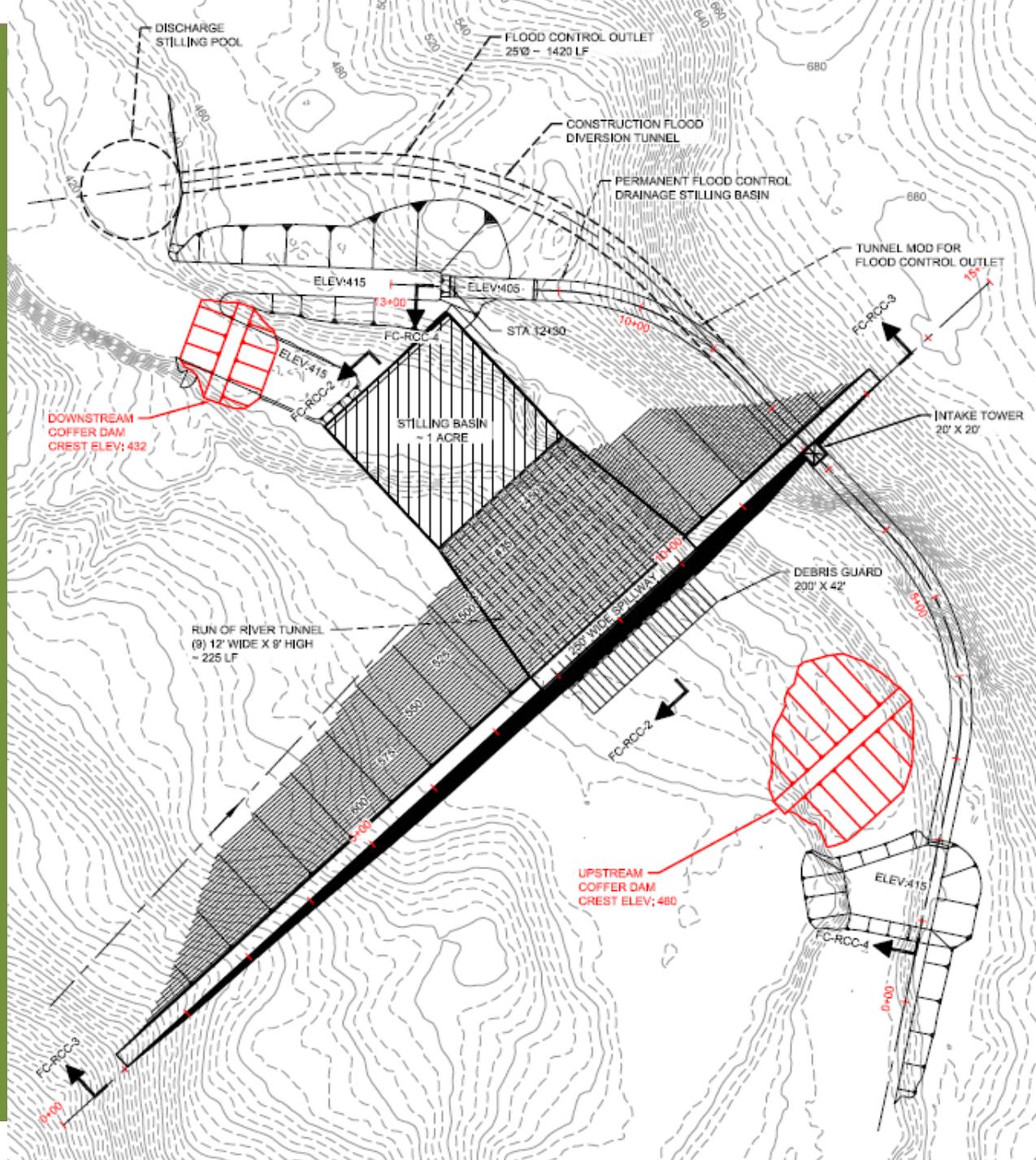
- Install Tunnel Diversion
- Create Entry and Discharge Stilling Pool



FLOOD RETENTION— RCC

POTENTIAL CONSTRUCTION SEQUENCE:

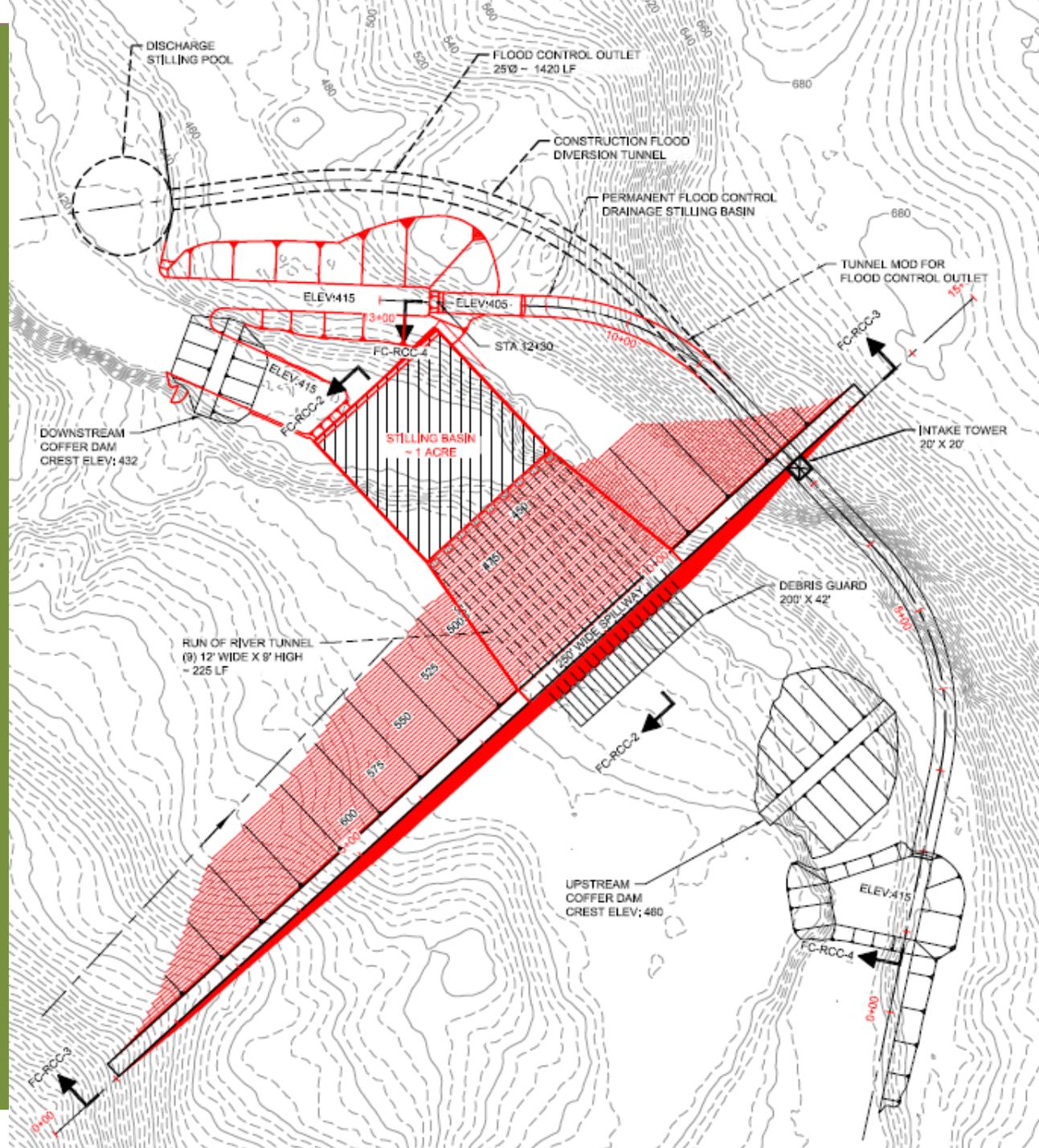
- Install Cofferd Dams
- Begin Diversion Through FC Outlet Tunnel



FLOOD RETENTION— RCC

POTENTIAL CONSTRUCTION SEQUENCE:

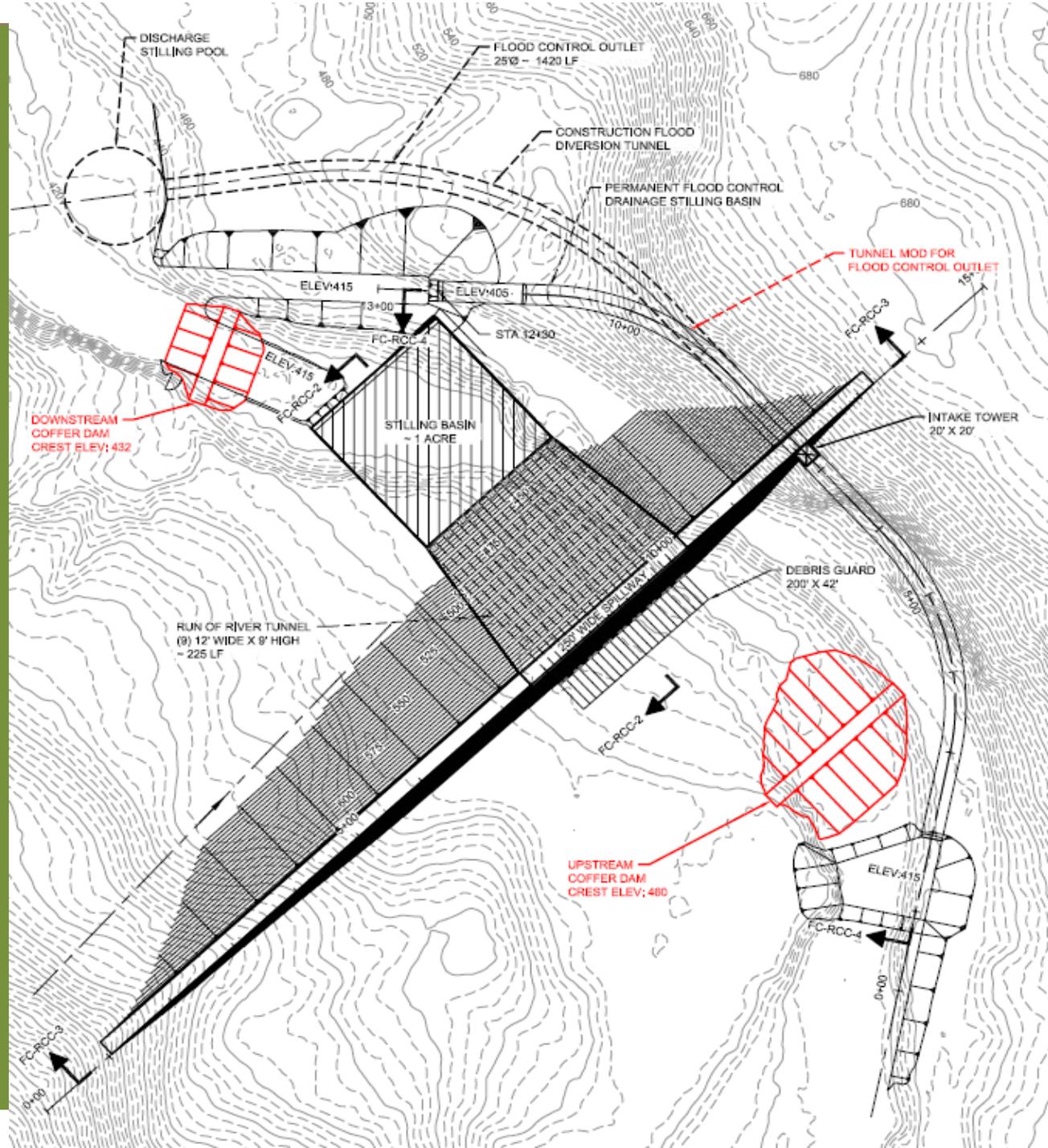
- Install Lower Fish Outlets.
- Install RCC Dam
- Install Spillway and Stilling Basin
- Complete Intake Tower, Debris Guards
- Install Flood Control Outlet Modification



FLOOD RETENTION— RCC

POTENTIAL CONSTRUCTION SEQUENCE:

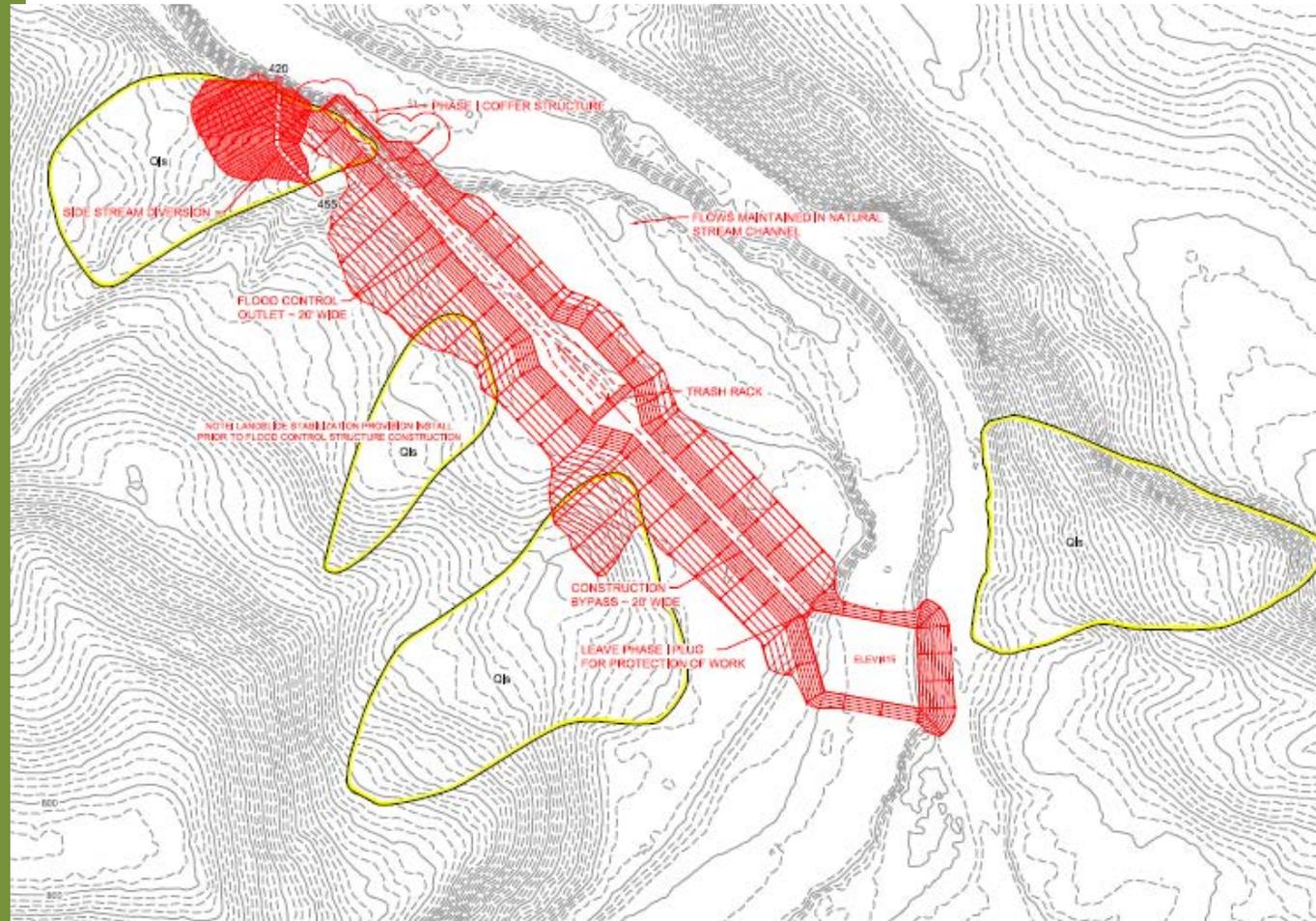
- Remove Cofferdams
- Begin Diversion through Fish Passage
- Complete FC Outlet Downstream Connection
- Install Other Fish Passage Systems



Multi-Purpose RCC

POTENTIAL CONSTRUCTION SEQUENCE:

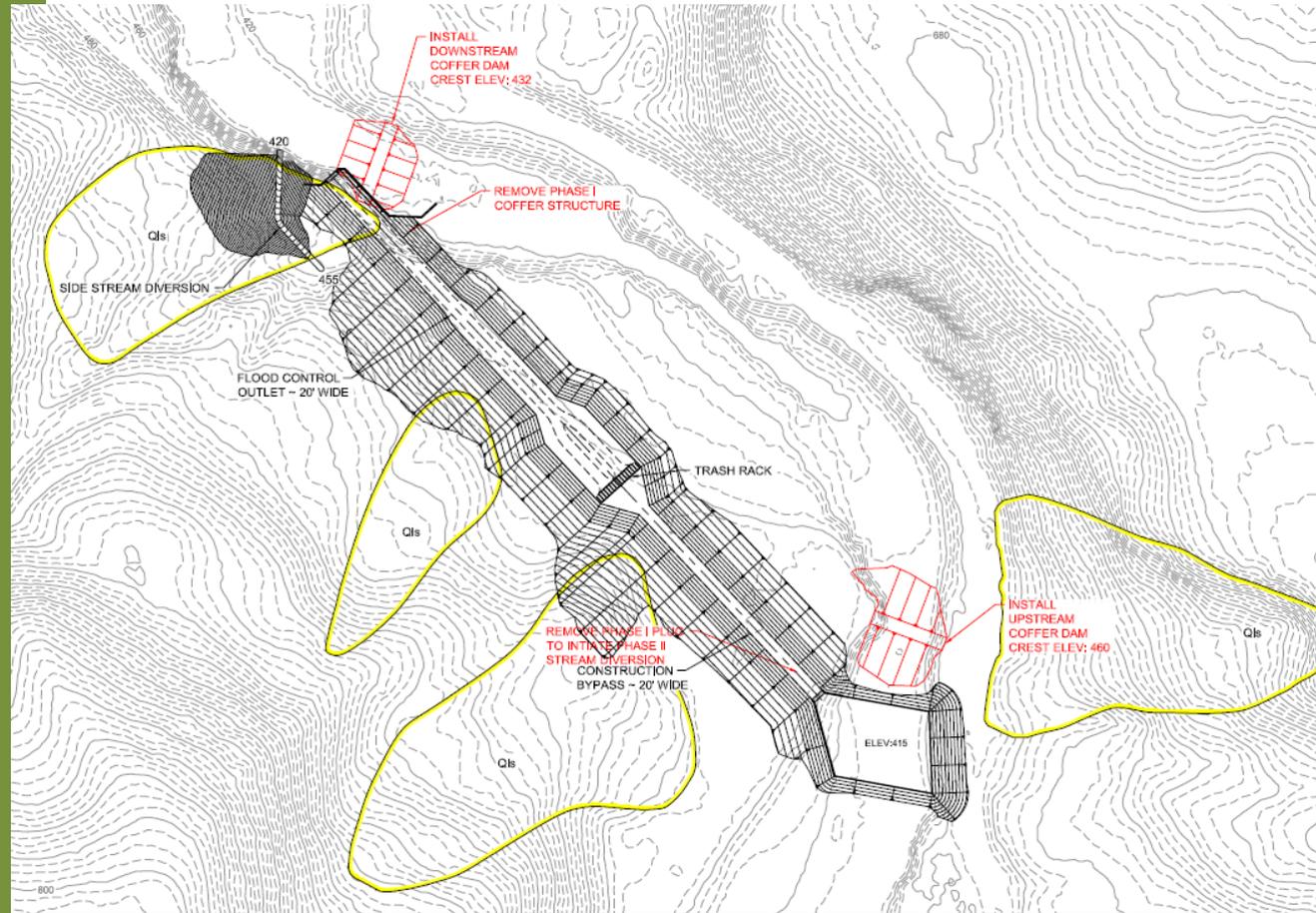
- Install Flood Control Outlet
- Create Entry and Discharge Stilling Pool



Multi-Purpose RCC

POTENTIAL CONSTRUCTION SEQUENCE:

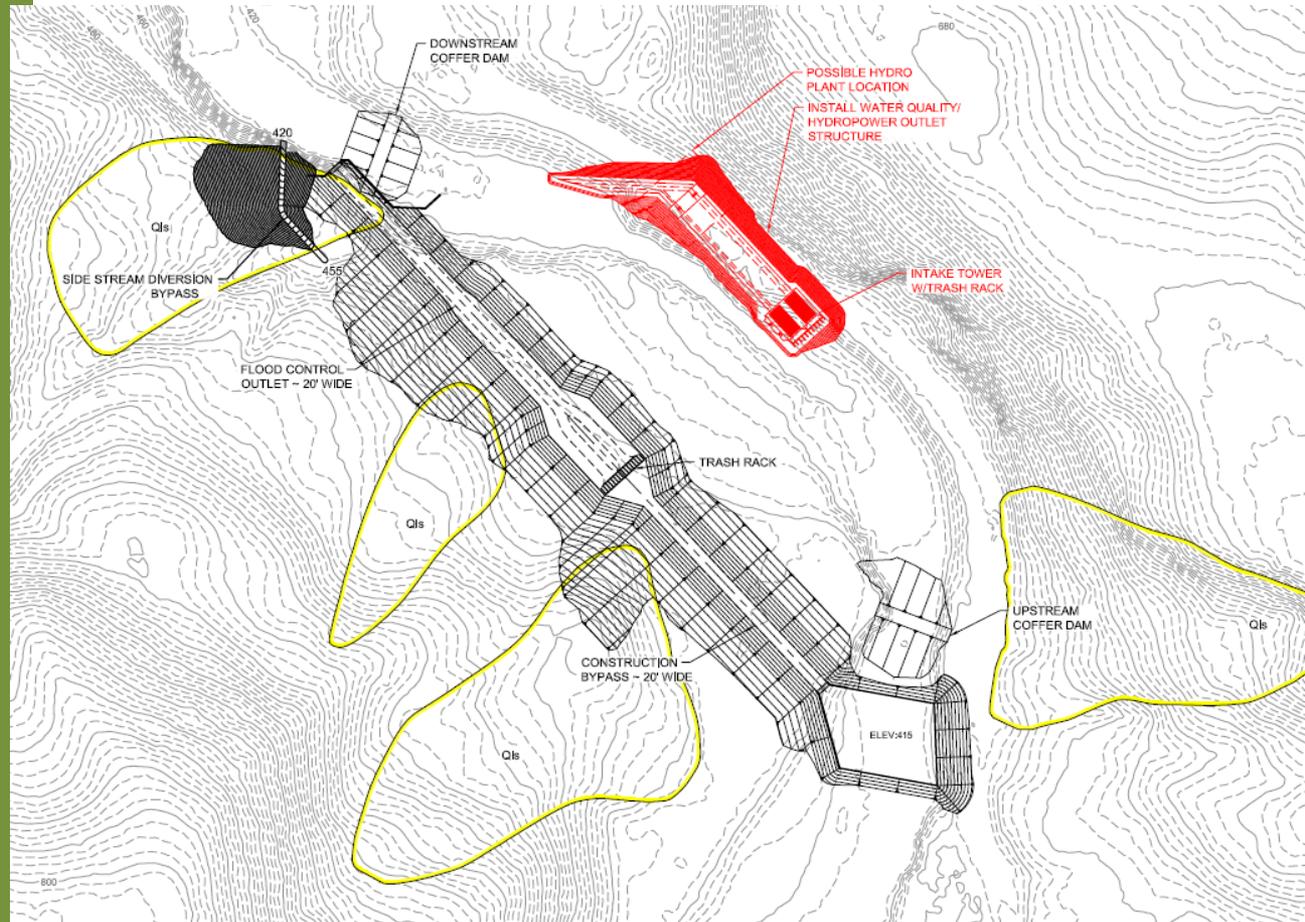
- Remove Plug and Phase 1 Cofferdam Structure
- Install Phase 2 Cofferdams
- Begin Diversion Through FC Outlet



Multi-Purpose RCC

POTENTIAL CONSTRUCTION SEQUENCE:

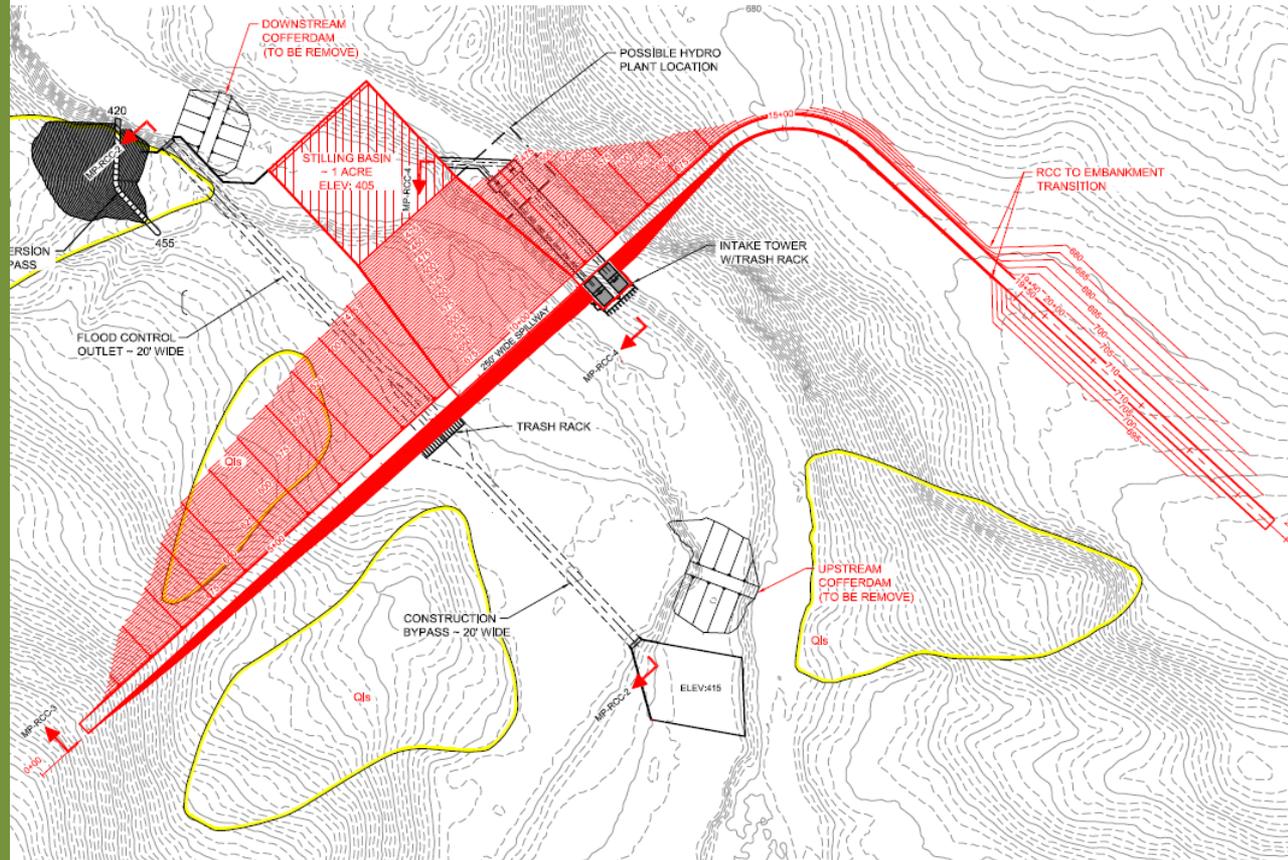
- Install WQ/Hydropower Outlet Structures
- Install RCC Dam
- Install Spillway and Stilling Basin,



Multi-Purpose RCC

POTENTIAL CONSTRUCTION SEQUENCE:

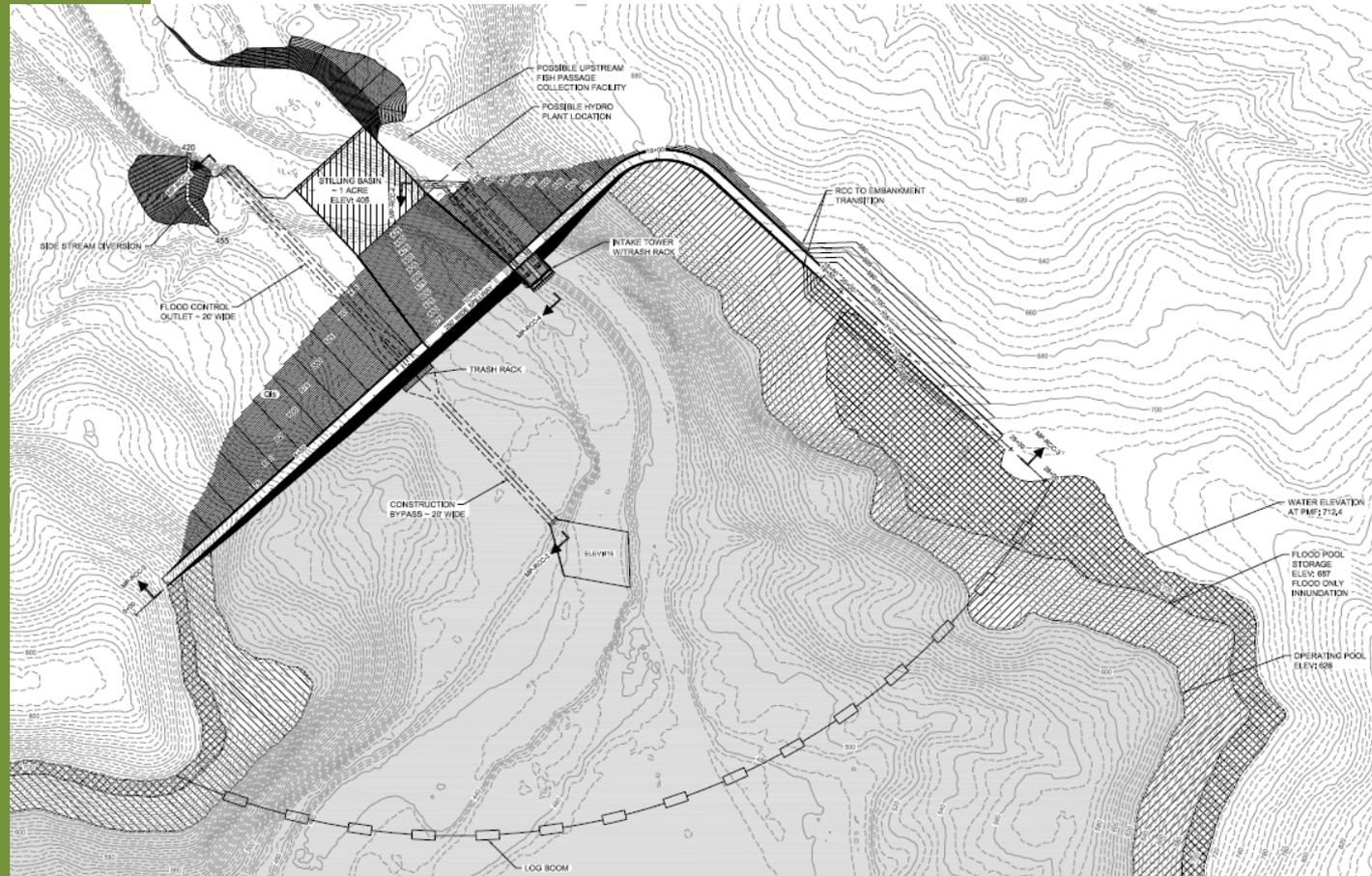
- Install RCC Dam
- Install Spillway and Stilling Basin
- Complete WQ and Hydropower Outlet and power house
- Install Fish Passage Systems



Multi-Purpose RCC

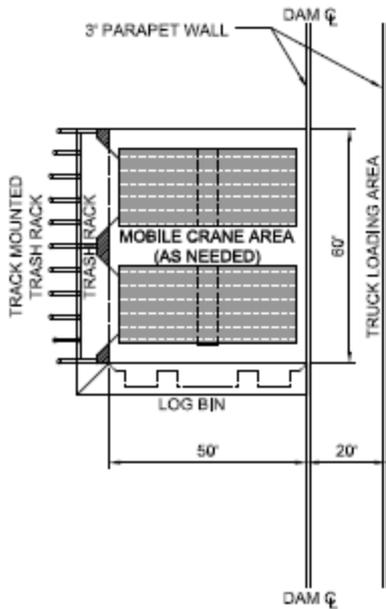
POTENTIAL CONSTRUCTION SEQUENCE:

- Remove Cofferdams
- Complete Downstream Channel Modifications

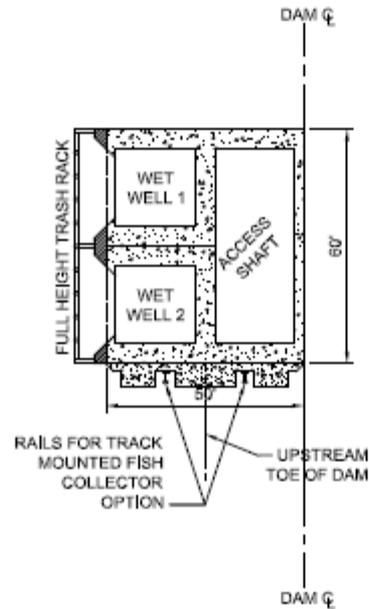


Multi-purpose RCC

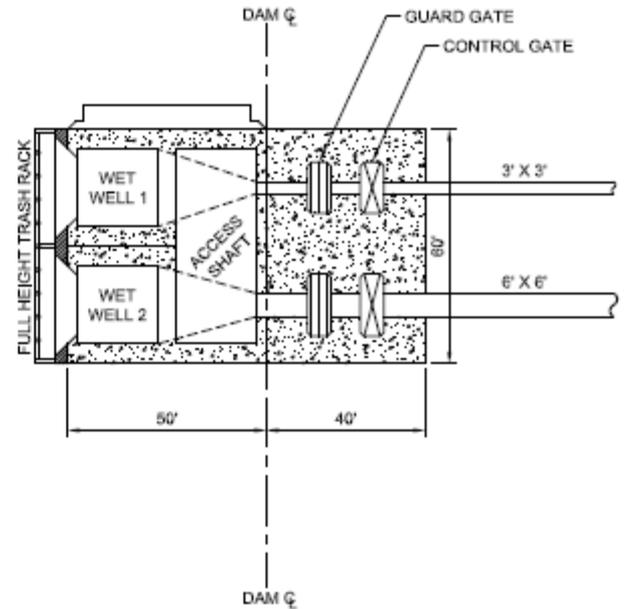
Water Quality/Hydropower/Fish Passage Water Supply Outlet Works



SECTION A-A

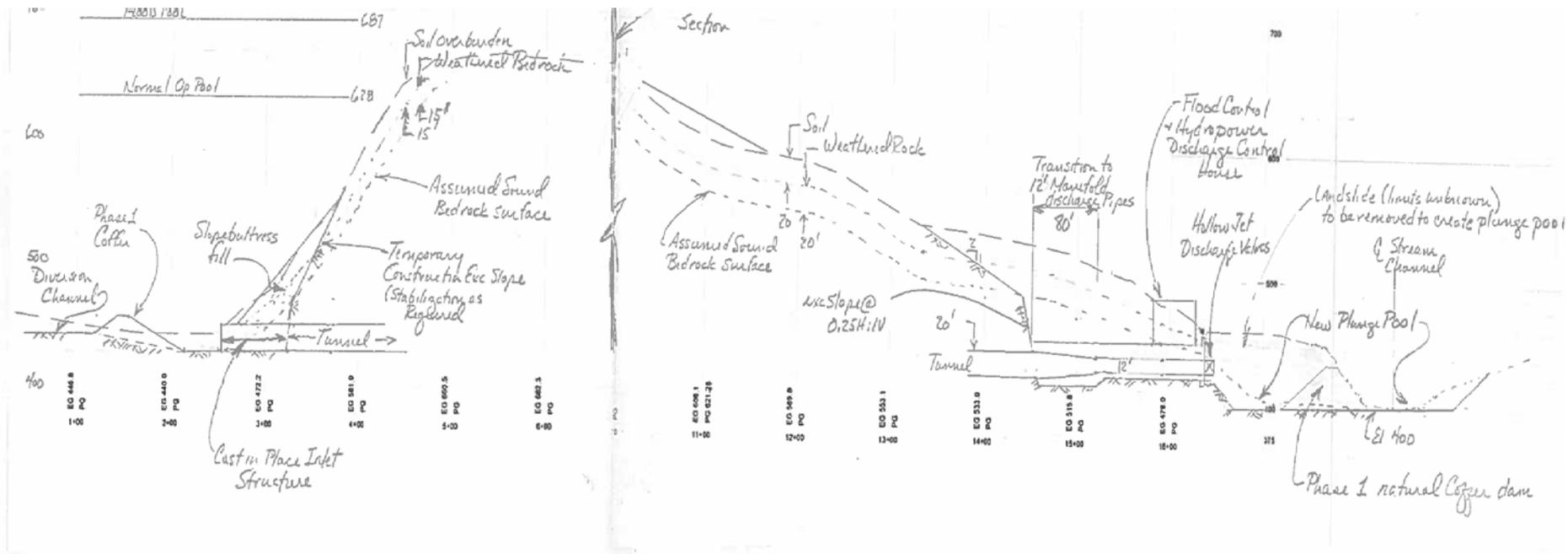


SECTION B-B



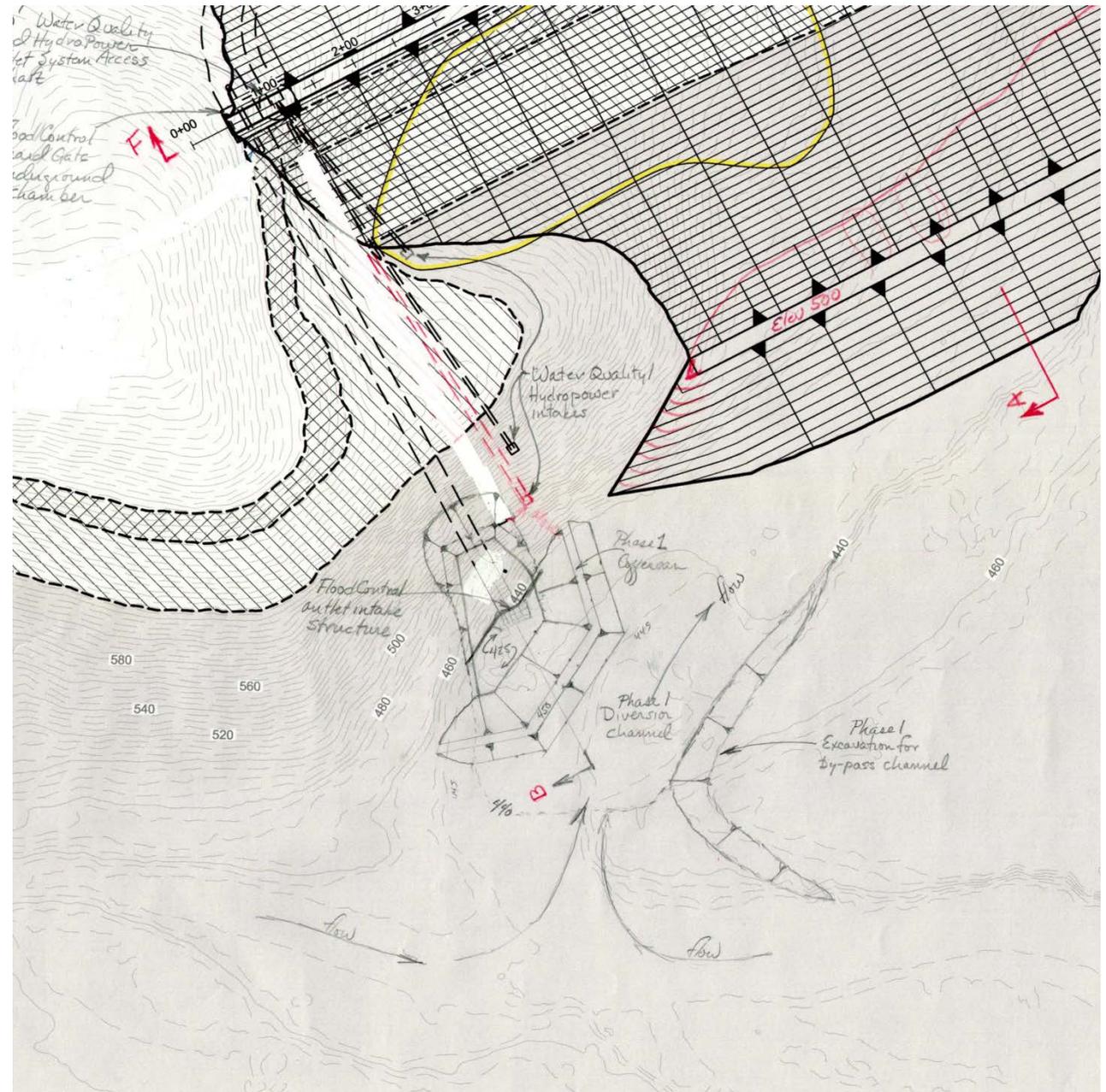
SECTION C-C

Flood Control Outlet Profile

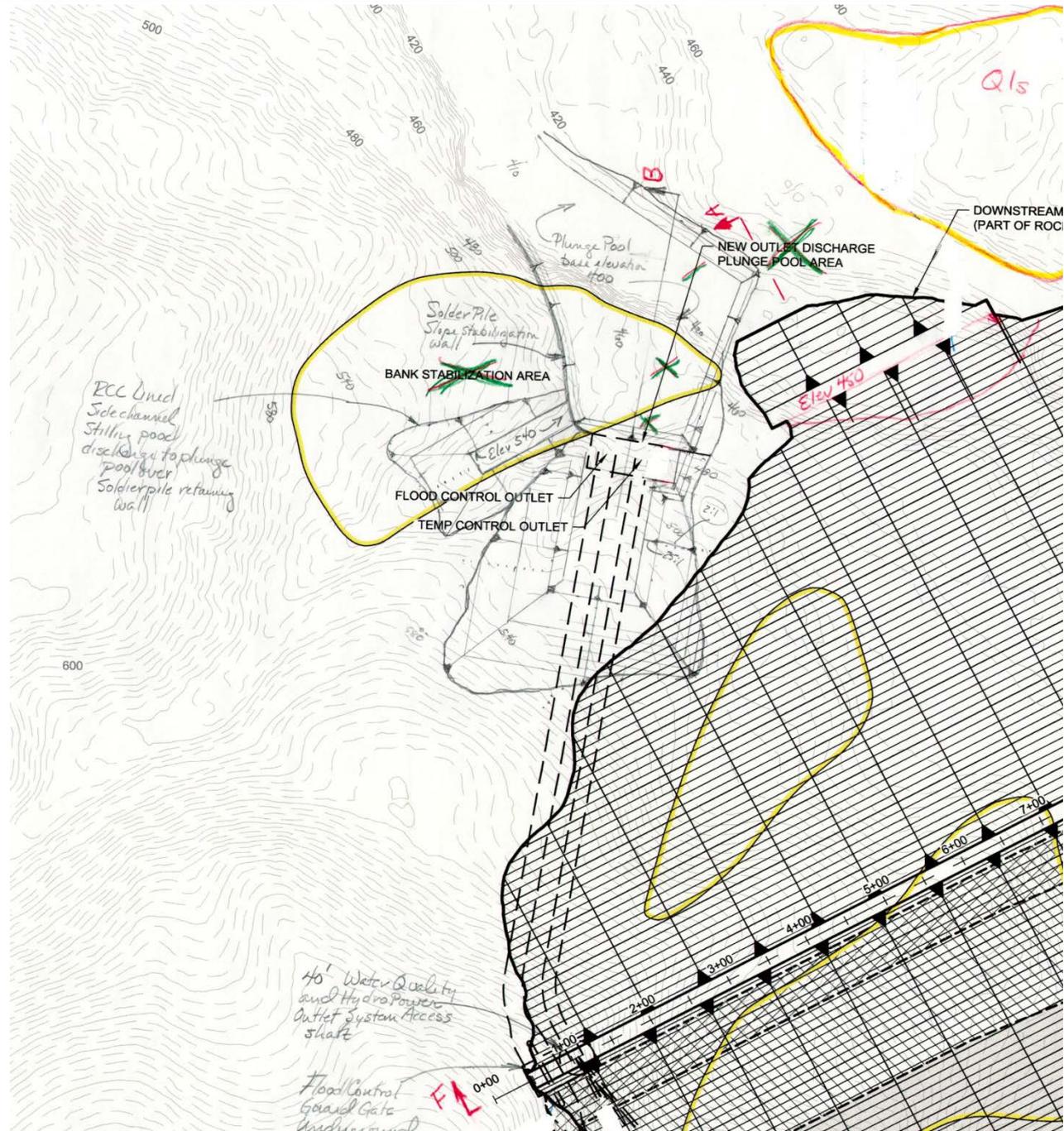


Section B-B
Left Abutment Flood Control

Intake

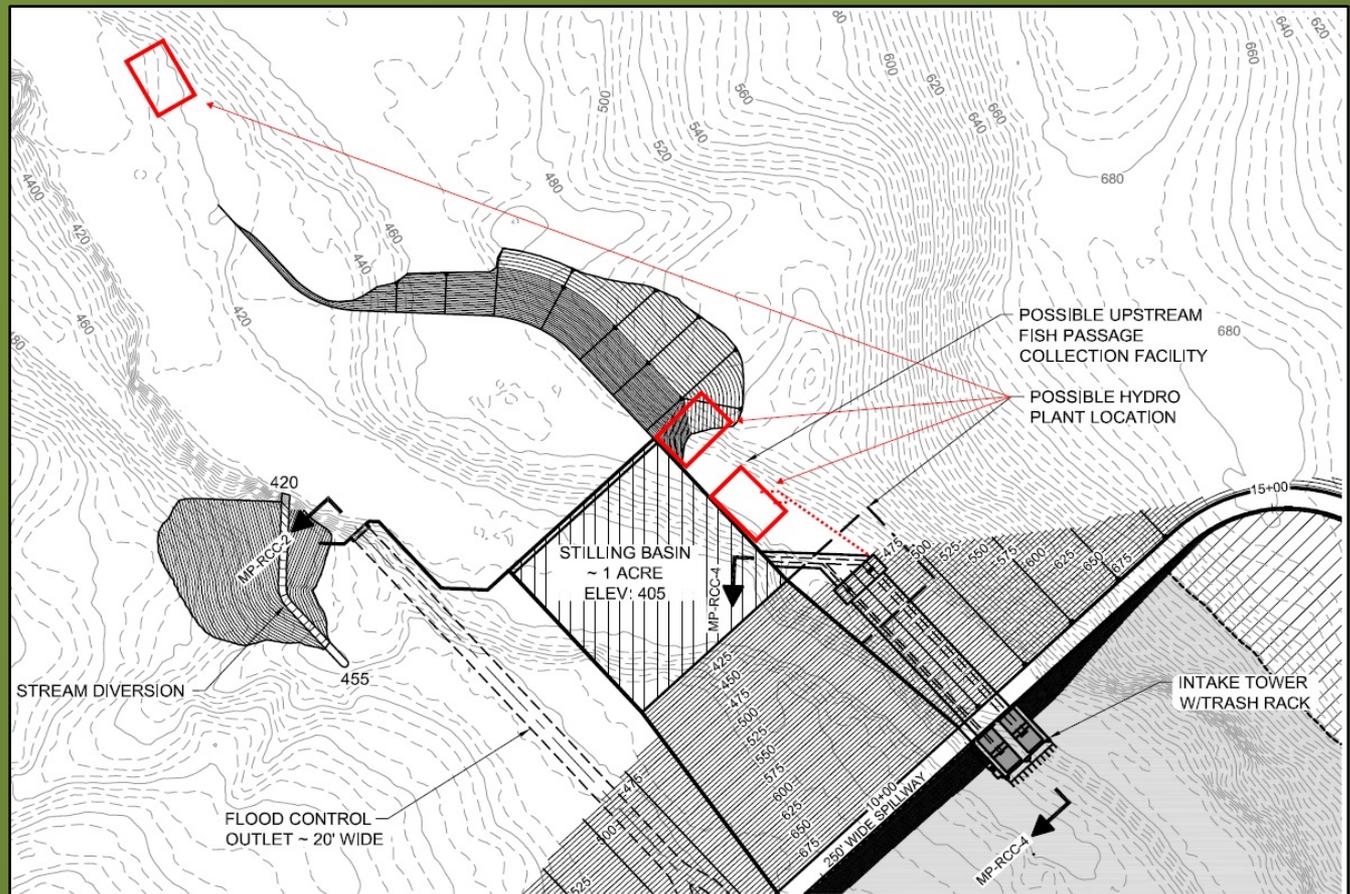


Outlet

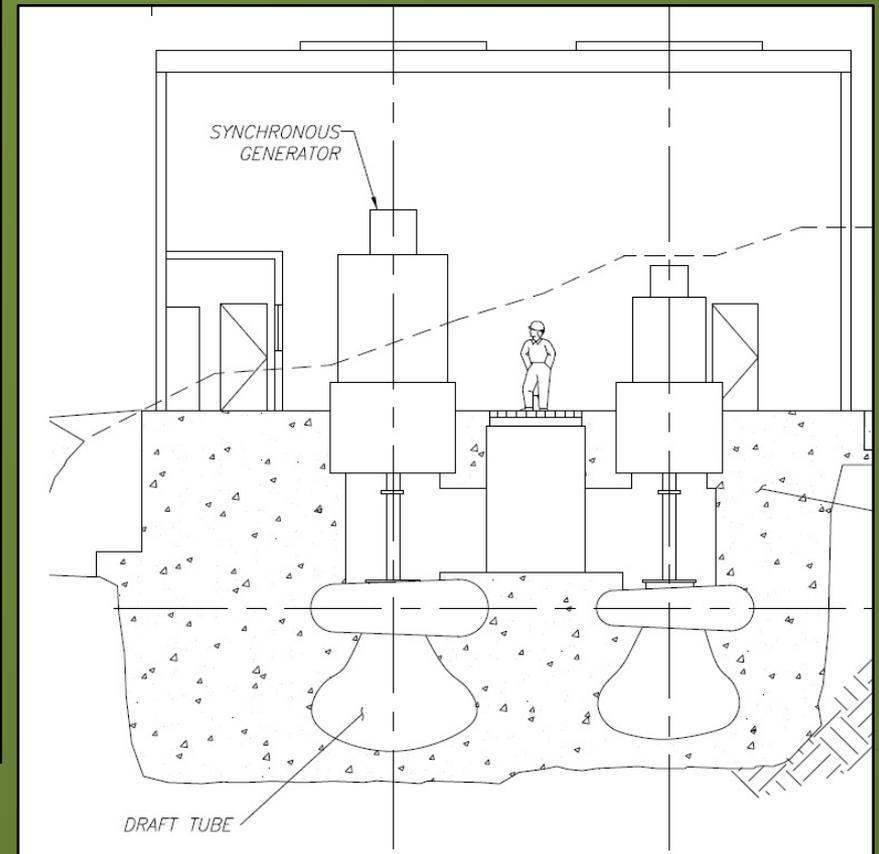
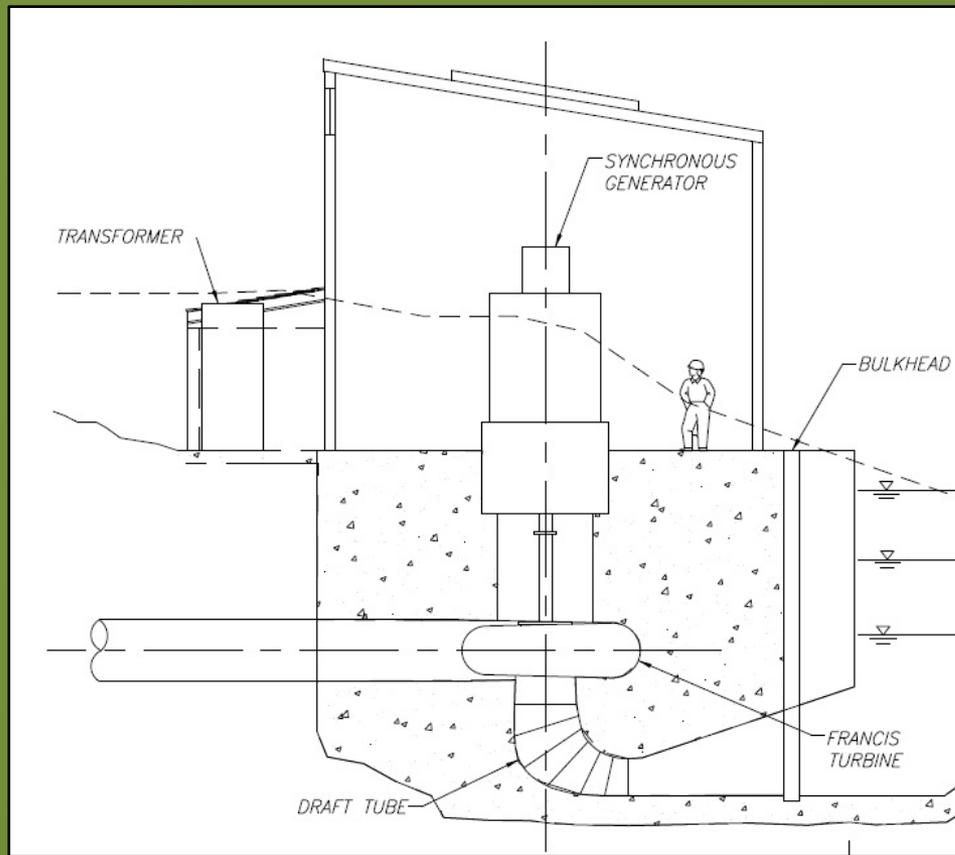


Potential Powerhouse Sites

- Future installation below the dam
- Bifurcate penstock(s) from outlet works



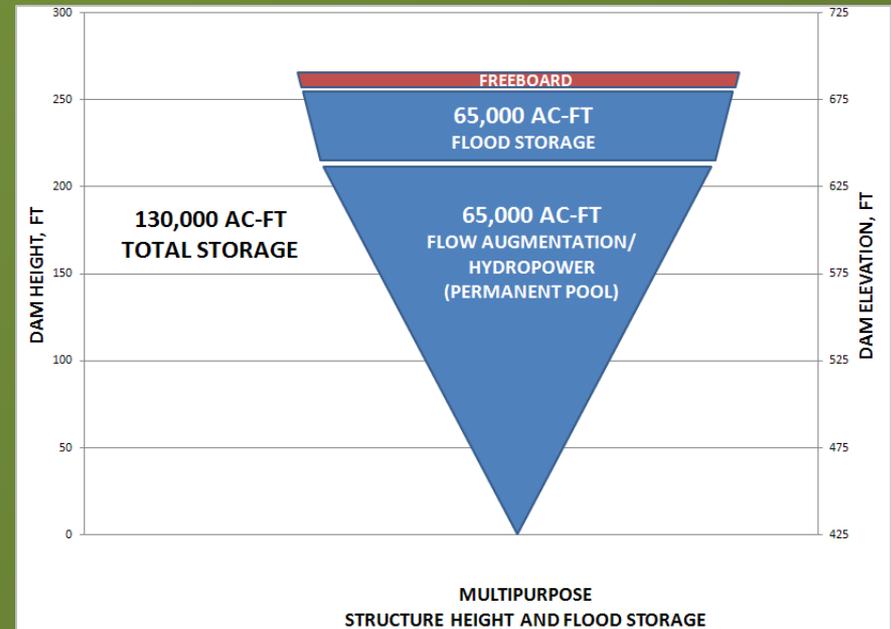
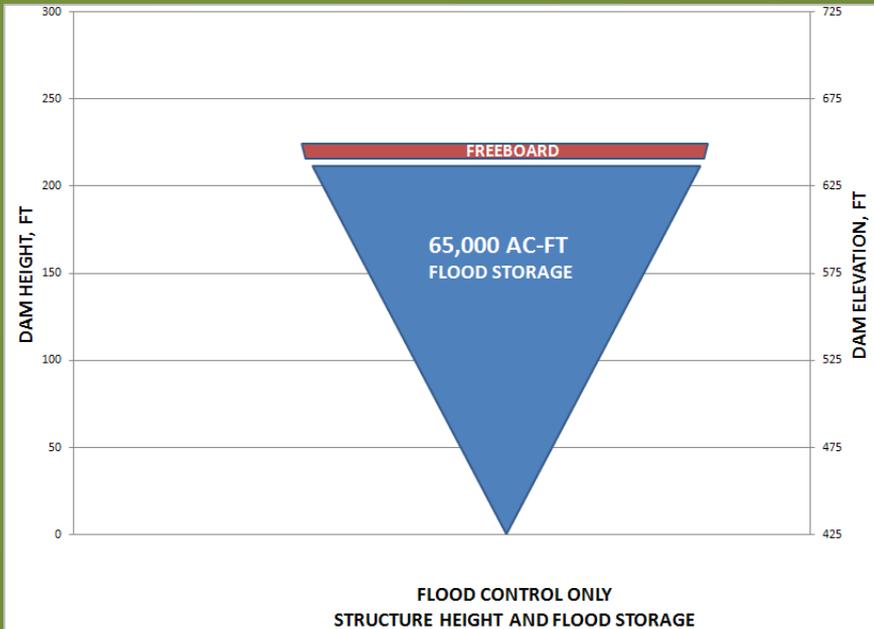
Typical Francis Powerhouse Sections



Integrating Information from Ongoing Studies

- Sediment and Debris Transport (received)
- Reservoir Operations (received)
- H&H Study (initial results received)
- Environmental Study
- Hydropower

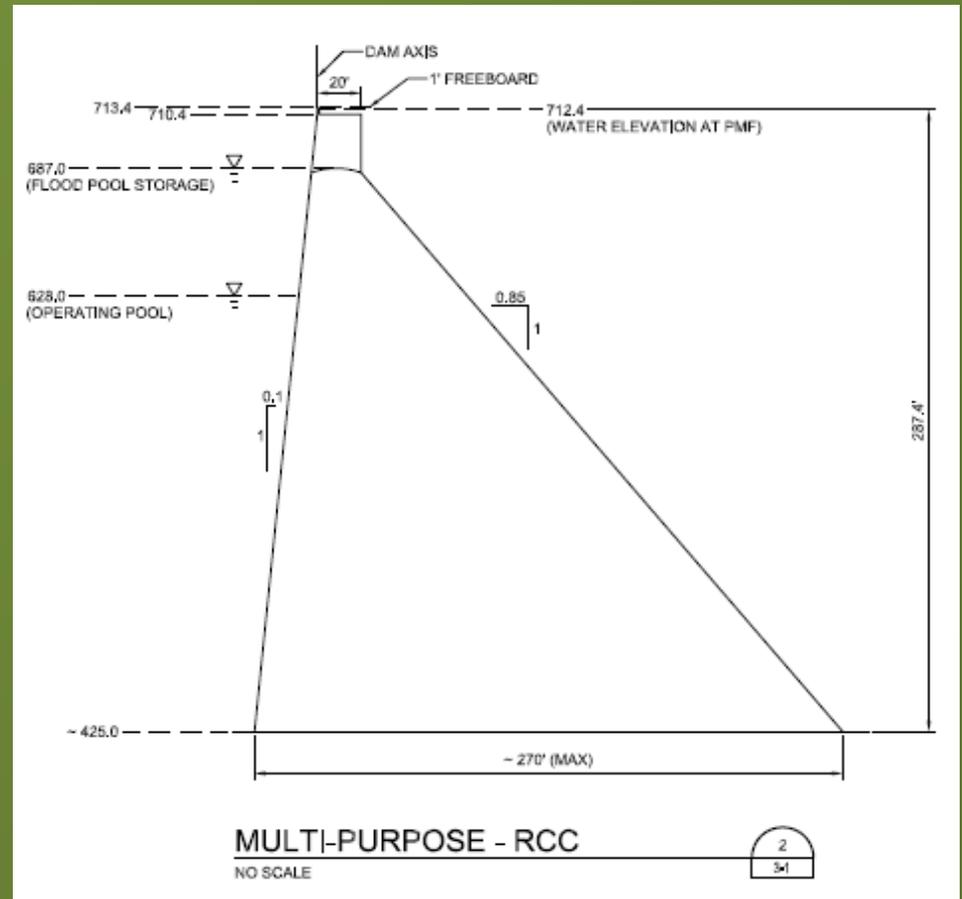
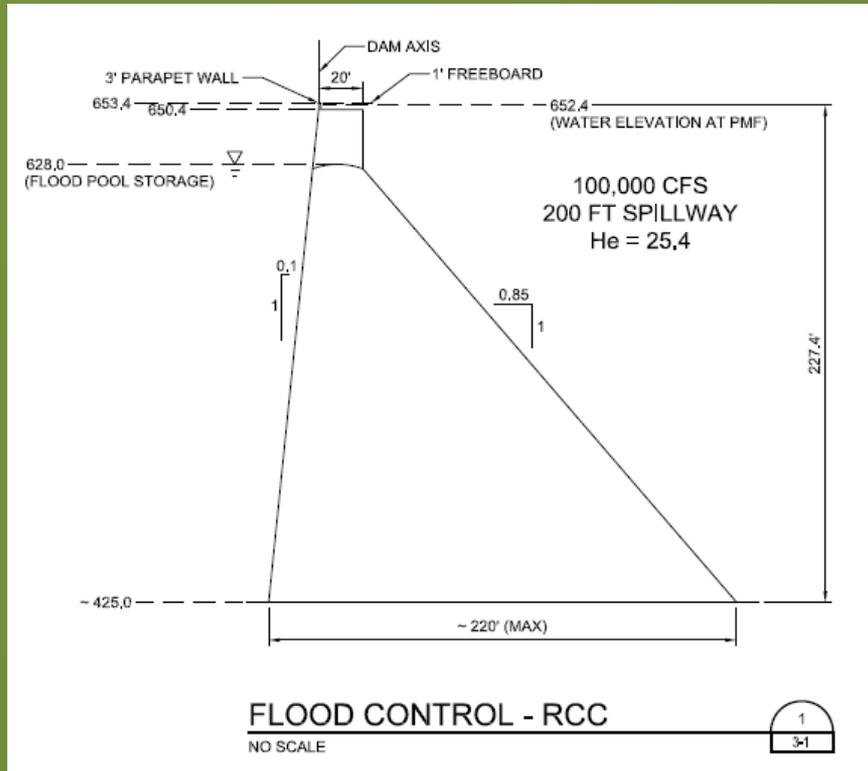
Basis of Design – Key Assumptions



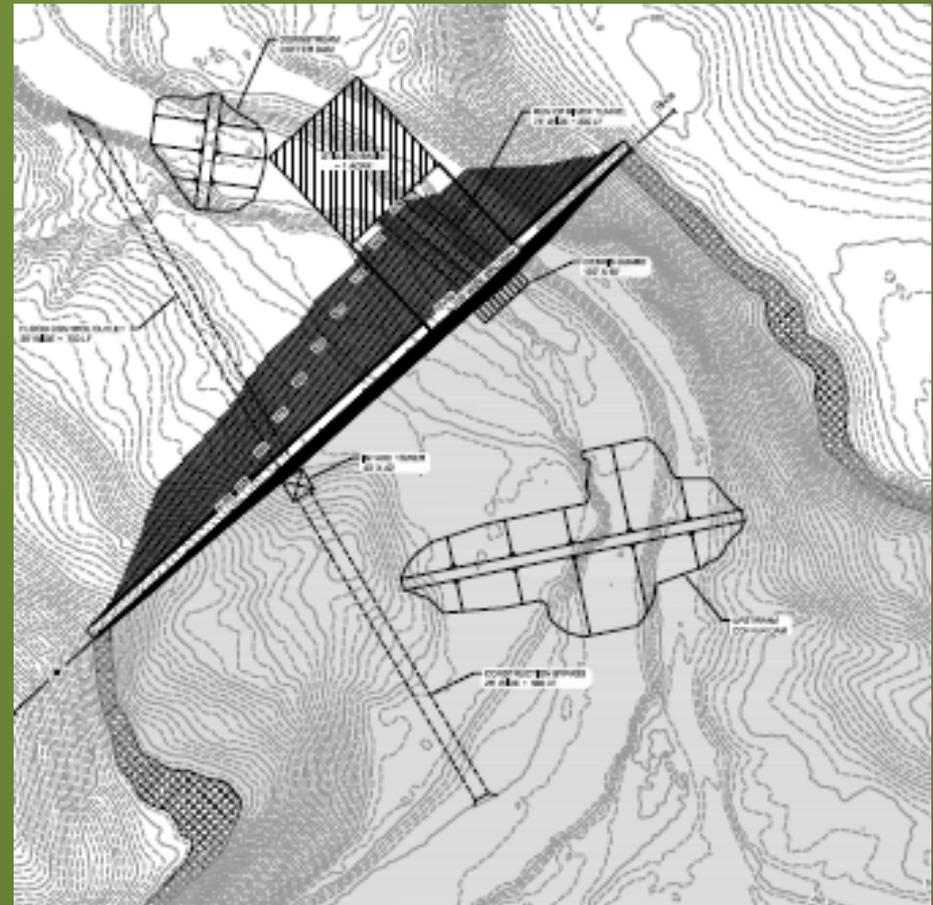
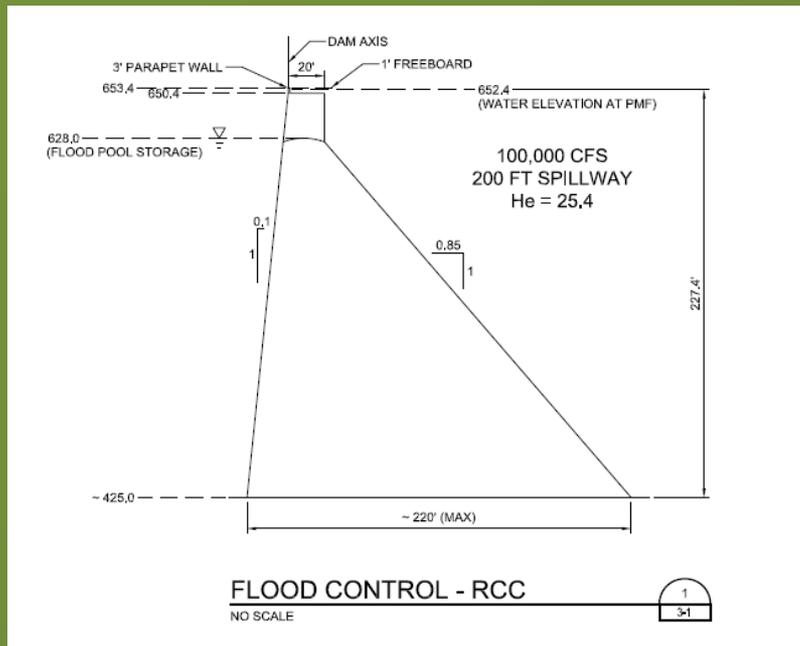
Flood Retention Crest Elevation: 654

Multipurpose Crest Elevation: 714

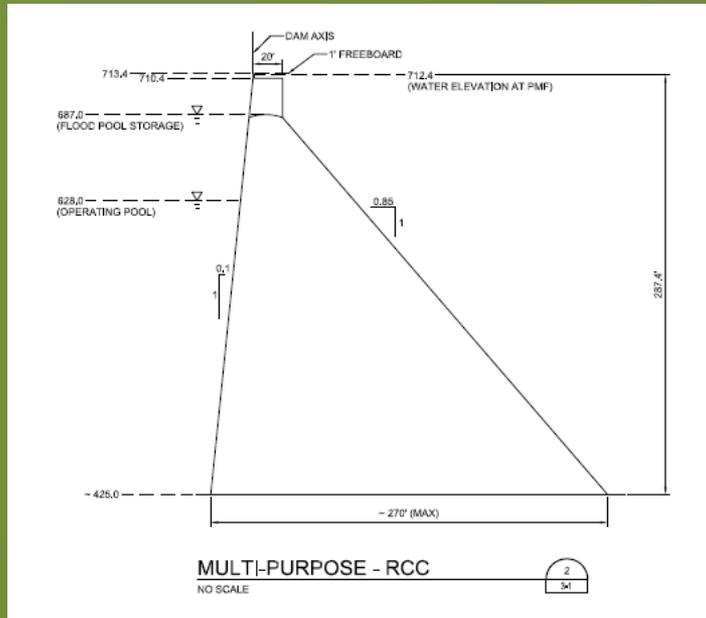
Dam Height and Pool Elevations



Flood Retention – RCC



Multipurpose – RCC



Basis of Design – Key Assumptions

- Flood Control Outlet Sizing:
 - 5,000 to 13,200 cfs (5-10 year storm event for construction diversion)
 - 25-foot dia.
 - Flood operations intended to meet downstream rating curve. With water at ogee crest flow though flood control outlet is approximately 30,000 cfs with no widening of the channel downstream.
- Fish Passage Tunnels (FR Only):
 - Up to 2,000 cfs
 - 2 feet/sec for a 200 foot long tunnel
 - Nine 12 feet x 9 feet outlets
- Spillway Capacity and Stilling Basin:
 - 100,000 cfs and 250 foot width, Converging to 200 feet wide stilling basin
 - Maximum 6 foot step height
- Cofferdams:
 - Upstream: 35 feet high
 - Downstream: 12-15 feet high

Incorporating New Info



Geomorphology and Sediment Transport – TM Published March 7th, 2014

- Sediment
 - Initial Geomorphology and Sediment Transport TM assumes that all sediment would be stored in a multipurpose reservoir
 - 50-80% of sediment would be flushed through a Flood Retention Reservoir.
 - ~ 35,000 tons (25,000 cubic yards) per year.
 - 2007 yielded ~2,000,000 tons (1,500,000 cubic yards) of sediment to watershed due to landslides
- Debris
 - Logs moving between 9 to 10,000 cfs at the Doty Gage.
 - 2007 Event yielded ~115 acres of wood (inventoried as log jams in river) (230 acre-feet or 345,000 cubic yards of debris).
 - Significant woody debris removal operations on a 10-25 year interval.

Incorporating New Operations Info

- FC Only Operating Rules (Plan Summary Feb 24th, 2014)
 - Inflow = Outflow (except during large floods)
 - When flows predicted as “Major Flood” stage of 38,800 cfs (Grand Mount gage) within 48 hours, the reservoir outflow will be sharply reduced.
 - The outflow is reduced at a rate of 200 cfs per hour until the reservoir outflow reaches 300 cfs to reduce fish stranding, 300 cfs is recommended winter flow.
 - Two days (48 hours) after flow drops below flood stage at Grand Mound, the reservoir release rate will increase at a rate of 1,000 cfs per hour to evacuate the reservoir.

Incorporating New Operations Info

- **Multipurpose** Operating Rules (Plan Summary Feb 24th, 2014)
 - *Large Flood Events*

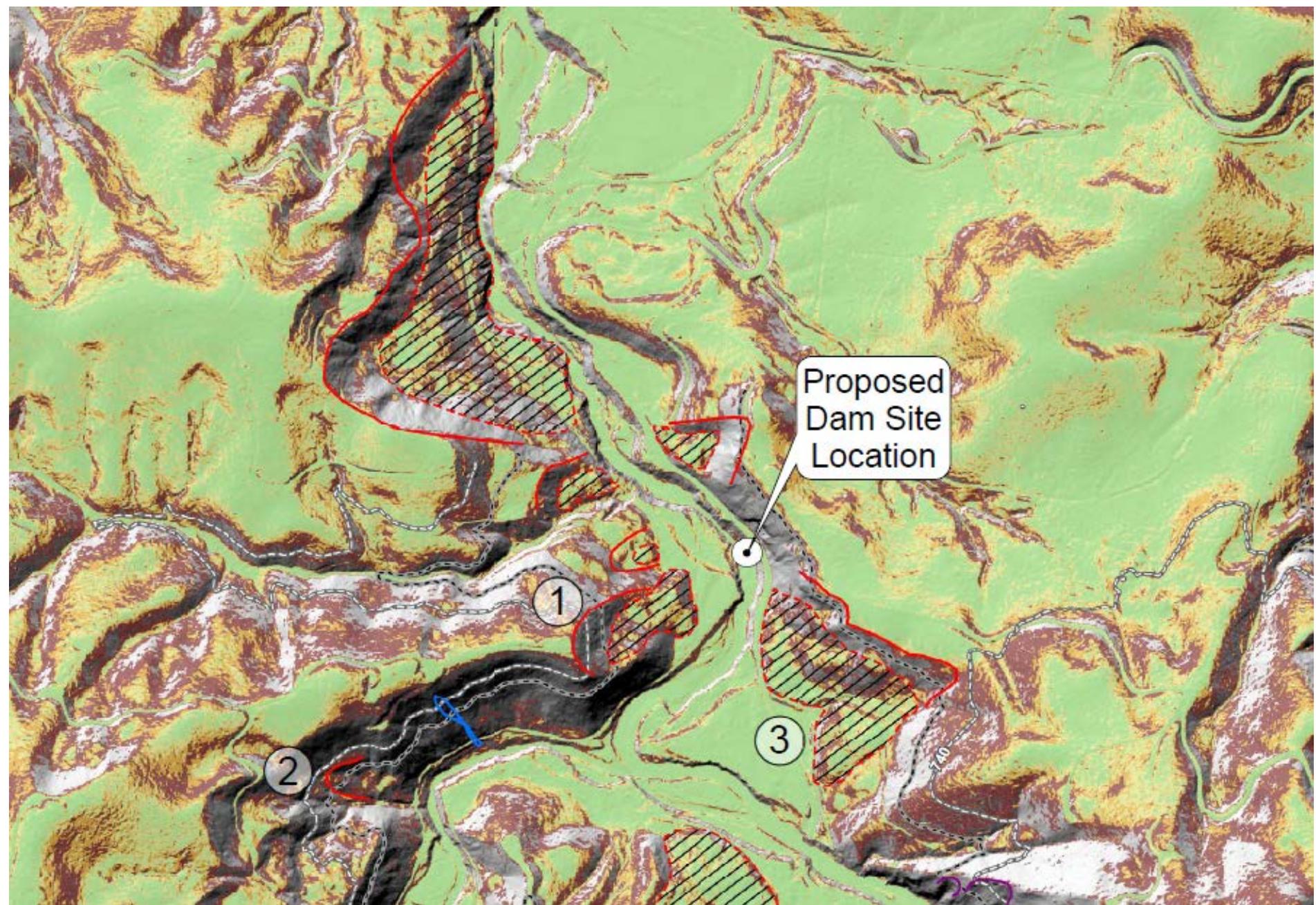
Similar to FC Only. If the flood storage pool is being utilized during a flood, releases following the flood are increased at a rate of 1,000 cfs per hour to evacuate the flood storage pool.
 - *Smaller (Non-Flood Causing) Storm Event*

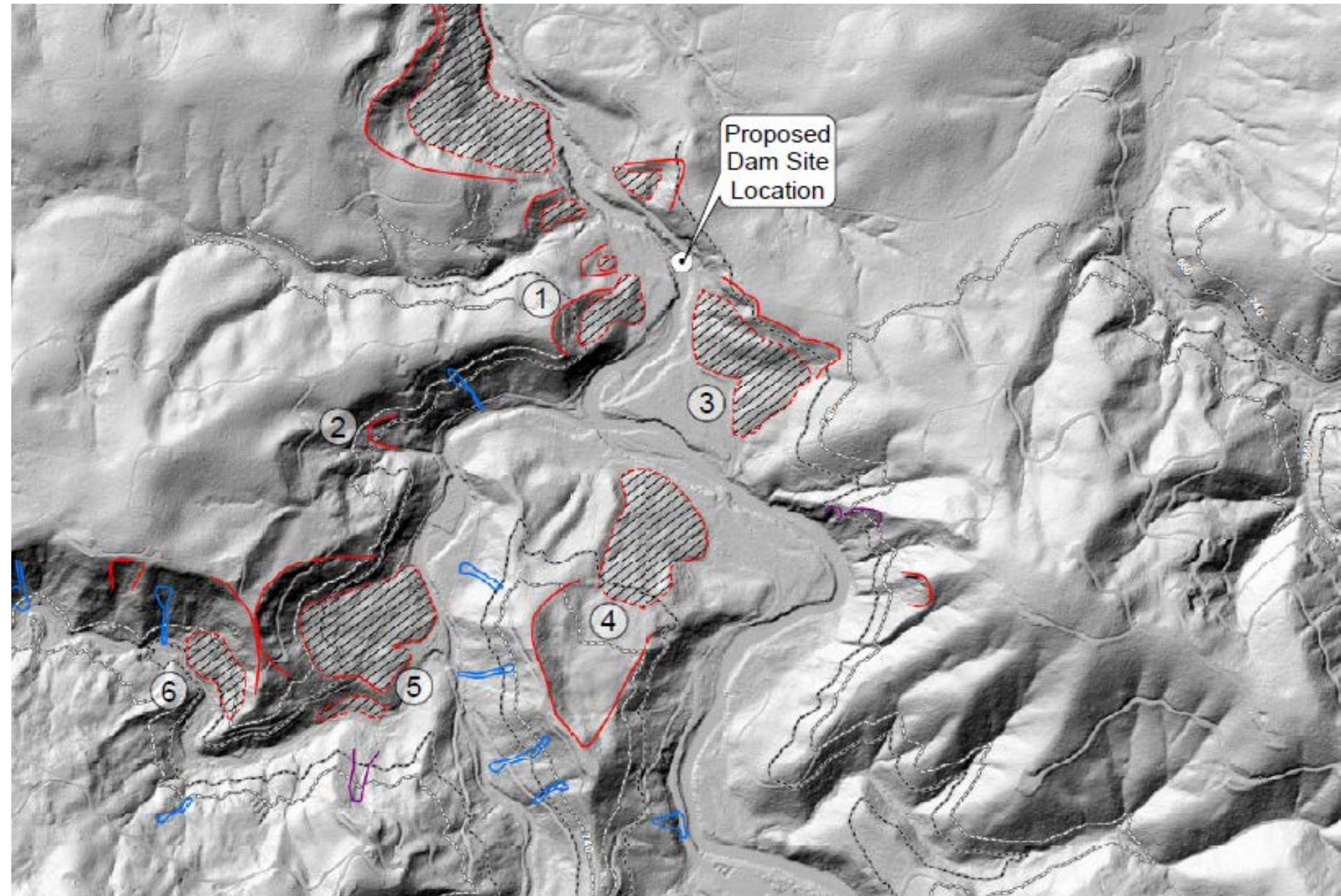
Allowed to pass through as long as the flow at Grand Mound is not predicted to be in a flood condition.
 - *Low Conservation Pool*

Reservoir releases are reduced by 20% when conservation pool not met.
 - *Instream Flows*

Recommended Instream Flow – Multi-Purpose Alternative

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





Multi-Purpose Dam Fish Passage Options - CHTR

- Upstream 1: CHTR
- Two potential locations: At face of dam or downstream of dam.
- Physical migration barrier
- Vertical slot ladder approximately 330 feet long
- Water supply piping conveyed from dam outlet works
- Collection, holding, and transfer facilities
- Transport vehicle
- Access and road improvements

Multi-Purpose Dam Fish Passage Options – Conventional Fishway

Upstream 2: Conventional Fishway

Concept Design Assumptions:

- Head differential = 198 ft
- Entrance length = 30 ft
- Transition to Reservoir = 30 ft
- Pool length = 10 ft
- Head drop per pool = 0.9 ft
- Resting pool required every 100 ft
- Resting pool length = 20 ft

Results:

- 220 pools
- 25 Resting pools
- 2980 ft fishway downstream of dam
- Fishway exit structure in reservoir
 - 8 automated gates 6 ft tall
 - Accommodates approx. 30 ft forebay fluctuation

Multi-Purpose Dam Alternative Fish Passage Options – Experimental Fishway

Upstream 3: Experimental Fishway

Concept Design Assumptions:

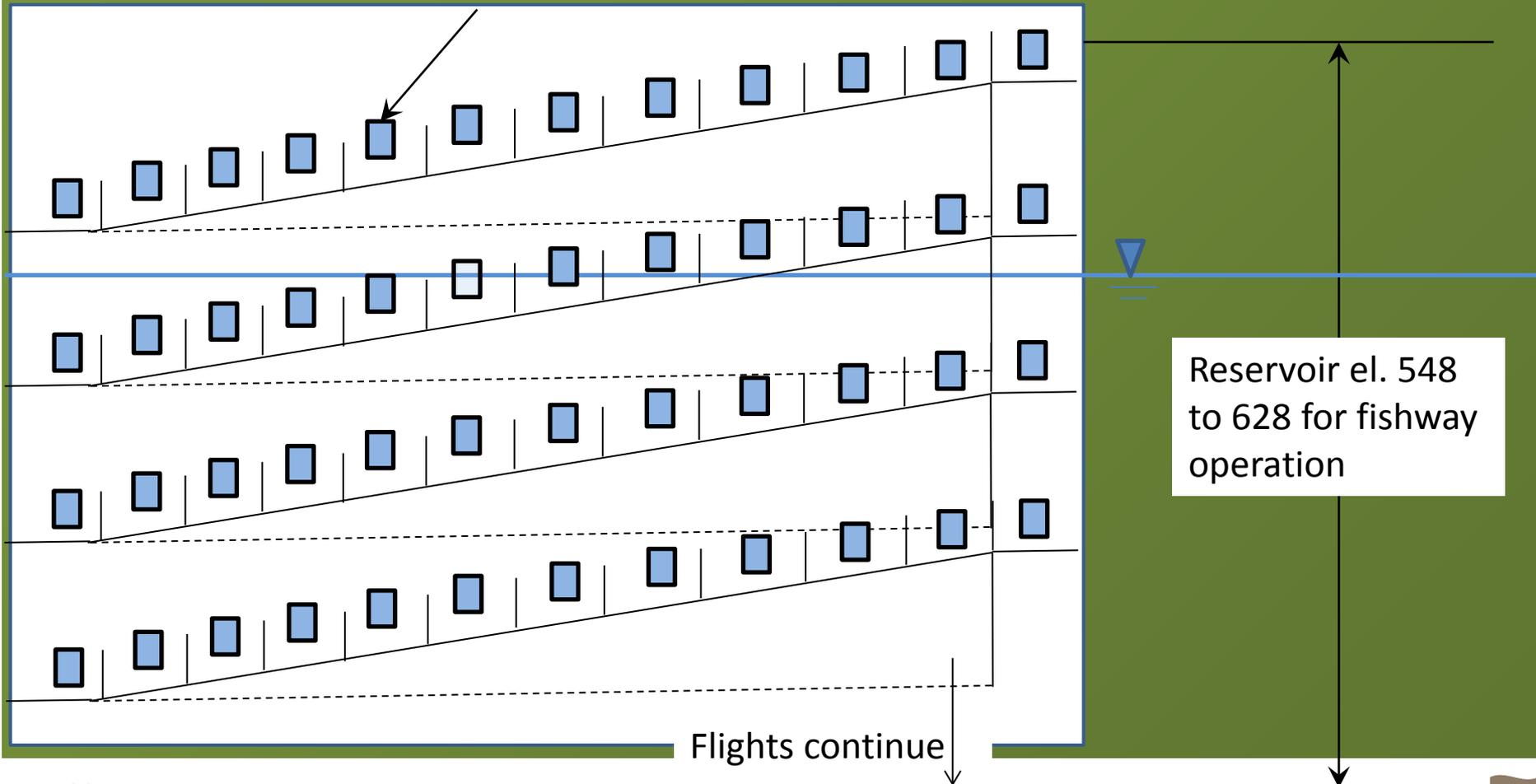
- Head differential = 148 ft
- Entrance length = 30 ft
- Transition to Reservoir = 80 ft
- Vertical slot length = 11 ft
- Head drop per pool = 0.9 ft
- Resting pool required every 100 ft
- Resting pool length = 20 ft

Results:

- 165 pools
- 19 Resting pools
- 2,300 ft fishway downstream of dam
- Fishway exit structure in reservoir
 - 20 automated gates 6 ft tall
 - Accommodates approx. 80 ft forebay fluctuation

Multi-Purpose Dam Fish Passage Options – Experimental Fishway

89 fishway exit gates at 0.9 ft elevation difference each



Multi-Purpose Dam Fish Passage Options – Head of Reservoir Combined Collector 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 mainstem
- The combination of collection facilities accommodates a wider range of species over a wider flow regime
- Access and road improvements

Multi-Purpose Dam Alternative 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

Flood Retention Only Dam 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