Appendix F-1

Mirabel Fish Screen Reconfiguration Feasibility and Alternatives Study

Final Report - December 2009

Prepared for

SONOMA COUNTY WATER AGENCY

Prepared by

PRUNUSKE CHATHAM, INC.

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Summary of Study Results

Sonoma County Water Agency manages the Russian River diversion at Mirabel as a critical water supply component for providing high quality drinking water to over 600,000 people in Sonoma and northern Marin Counties. The inflatable dam serves to increase production capacity during peak demand months. Fish screening facilities ensure the safety of the fish in the river and permanent fish ladders provide fish passage when the dam is raised. (Information from http://www.scwa.ca.gov/water-supply/) As a result of the Biological Opinion issued by NMFS, the fish screening facilities have been found to perform less than adequately for full protection of fish and downstream migration.

This study was conducted to develop a preferred conceptual design that meets many of the project objectives while ensuring that the fish screening facilities adhere to contemporary fish screening design criteria. A Technical Advisory Committee composed of the Sonoma County Water Agency, National Marine Fisheries Service, and the California Department of Fish and Game provided guidance in refining the objectives and identifying alternatives.

Six concept alternatives were evaluated for meeting the project objectives. Schematic designs and critical details were developed for these concept alternatives to assess physical feasibility and to be able to evaluate the alternatives relative to the objectives. The preferred concept design alternative was determined through an interactive evaluation and was selected because it meets or exceeds the project objectives.

The preferred concept design alternative includes a new intake with an inclined flat plate fish screen system, an oversized screen for increased bypass flow control and capacity, and a bypass fishway in the form of a vertical slot fish ladder. It also includes a fish viewing chamber with a window which will allow for real-time monitoring along with excellent education and outreach opportunities. The preferred conceptual design alternative will be a significant improvement for the water supply system and ecosystem protection. This alternative best meets the project objectives and is considered feasible for construction.

The estimated construction cost of the preferred conceptual design alternative is in the range of $3.5M to $4.0M. The construction cost estimate is not a total project cost. Other project costs will be considered in the next phase of project planning and design.

The next step of the project is to begin detailed environmental evaluation and engineering design of the preferred conceptual design alternative. It is feasible to complete the design of the project by October 2011 and the construction of the project by October 2014, as required by the Biological Opinion.

Introduction

The Sonoma County Water Agency (Agency) operates and maintains the Mirabel area inflatable dam and water diversion facilities on the Russian River. The facilities are located downstream of Wohler Bridge as shown in Figure 1. Figure 2 shows the existing configuration of the dam and diversion from an aerial perspective and Figure 3 is a photograph of the dam and diversion facilities from the East bank during routine operations. The inflatable dam is used to impound the river to a water surface elevation of approximately 38 feet. This allows for a surface water diversion of up 100 cubic feet per second (cfs) through the intake structure, fish screens and pump station, into the adjacent infiltration ponds. The Agency generally raises the dam once in spring when flow in the river reaches 400 cfs and lowers the dam in the fall/winter when flow reaches 1,000 cfs.

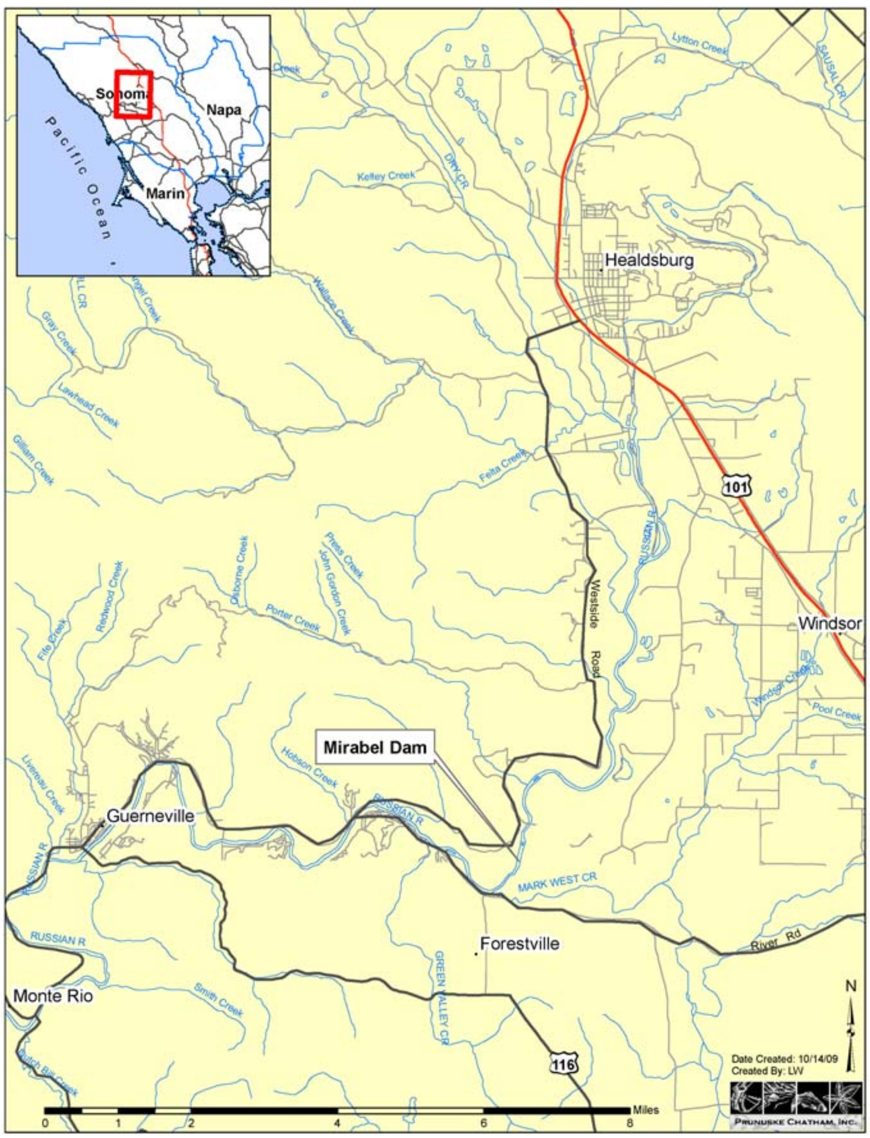

Figure 1 - Location Map

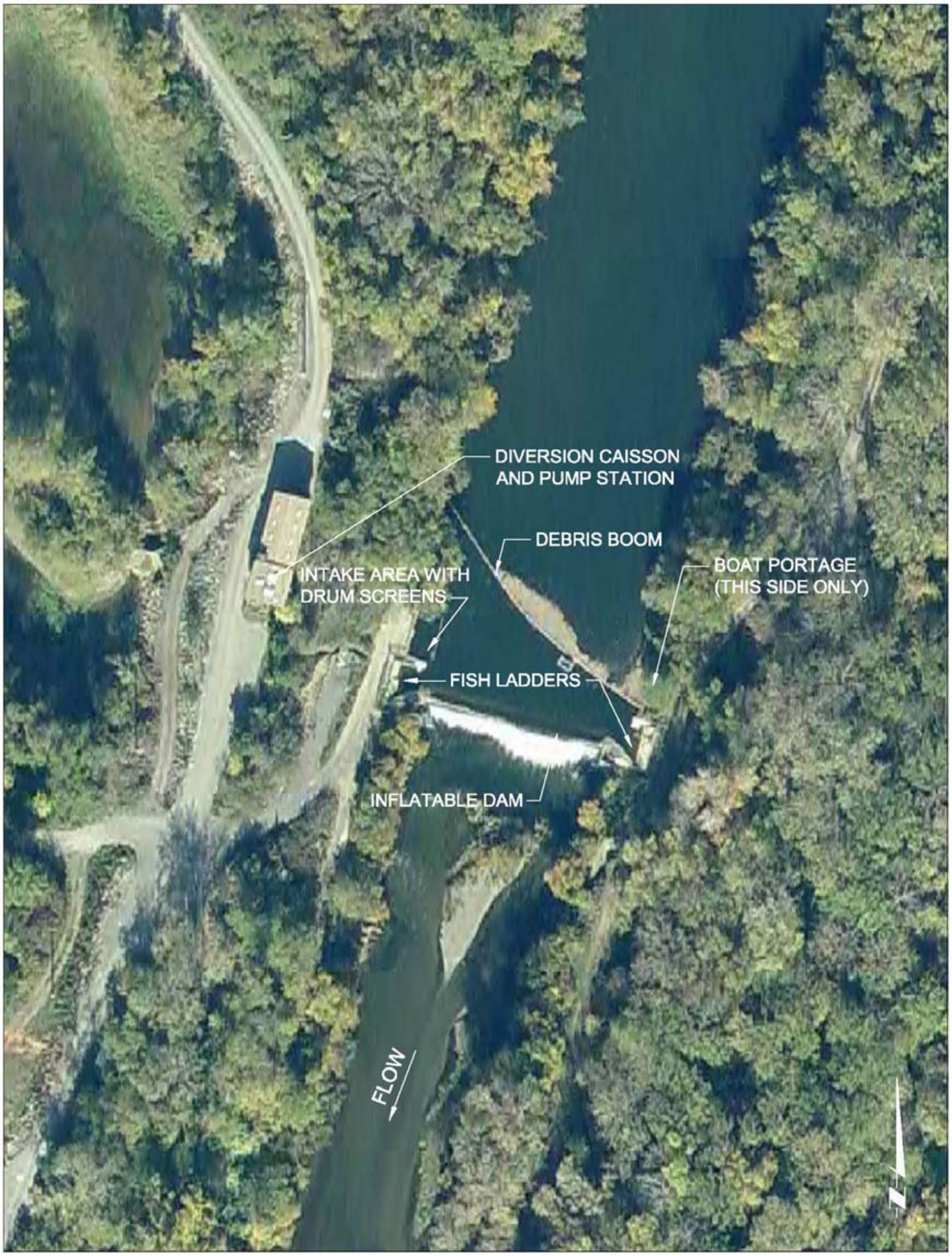

Figure 2 - Mirabel Diversion Facility

Figure 3 - Inflatable Dam under Normal Operation with Diversion on West Bank

The Agency is required to operate these facilities for long-term reliability, sound watershed stewardship, and good economy for its customers. The Agency is interested in supporting healthier fish populations, finding a solution to eliminate fluctuations in downstream flow rates that occur from notching of the inflatable dam, and replacing the fish screens to meet contemporary criteria as required by the National Marine Fisheries Service (NMFS) in the recent Russian River Biological Opinion (NMFS 2008). The Biological Opinion specifically says the Agency "shall complete design of the new fish screen at Mirabel within three years of the issuance of this biological opinion, and replace the fish screen within three years after completion of the design". The Biological Opinion was issued on September 24, 2008. In addition, the Agency would like to provide opportunities for public outreach and education. The first step to achieve these outcomes is this Fish Screen Reconfiguration Feasibility and Alternatives Study (Study) that was initiated in April 2009.

The fish screens and intake consist of two drums that rotate about a vertical axis with intake pipes directly under the drums (see Figures 4 and 5). A fish screen performance evaluation was conducted in 2000 under the Biological Assessment work leading up the Biological Opinion. This evaluation (Borcalli and Associates 2000) identified that the upstream screen takes more of the diversion flow than the downstream screen. Although this is expected given the intake pipe configuration (see Figure 6), it results in approach velocities through the upstream screen that are much higher than NMFS allows. The downstream screen was found to operate at the margin of acceptable approach velocities. The opinion of the evaluators was that "the fish screen structure will require modifications to alleviate the concern of impinging juvenile salmonids upon the screen face during the Agency's routine diversion operations."

Figure 4 - Intake Drum Screens at Low Water Level

Figure 5 - Intake at Normal Operating Water Level with Drum Screens Submerged

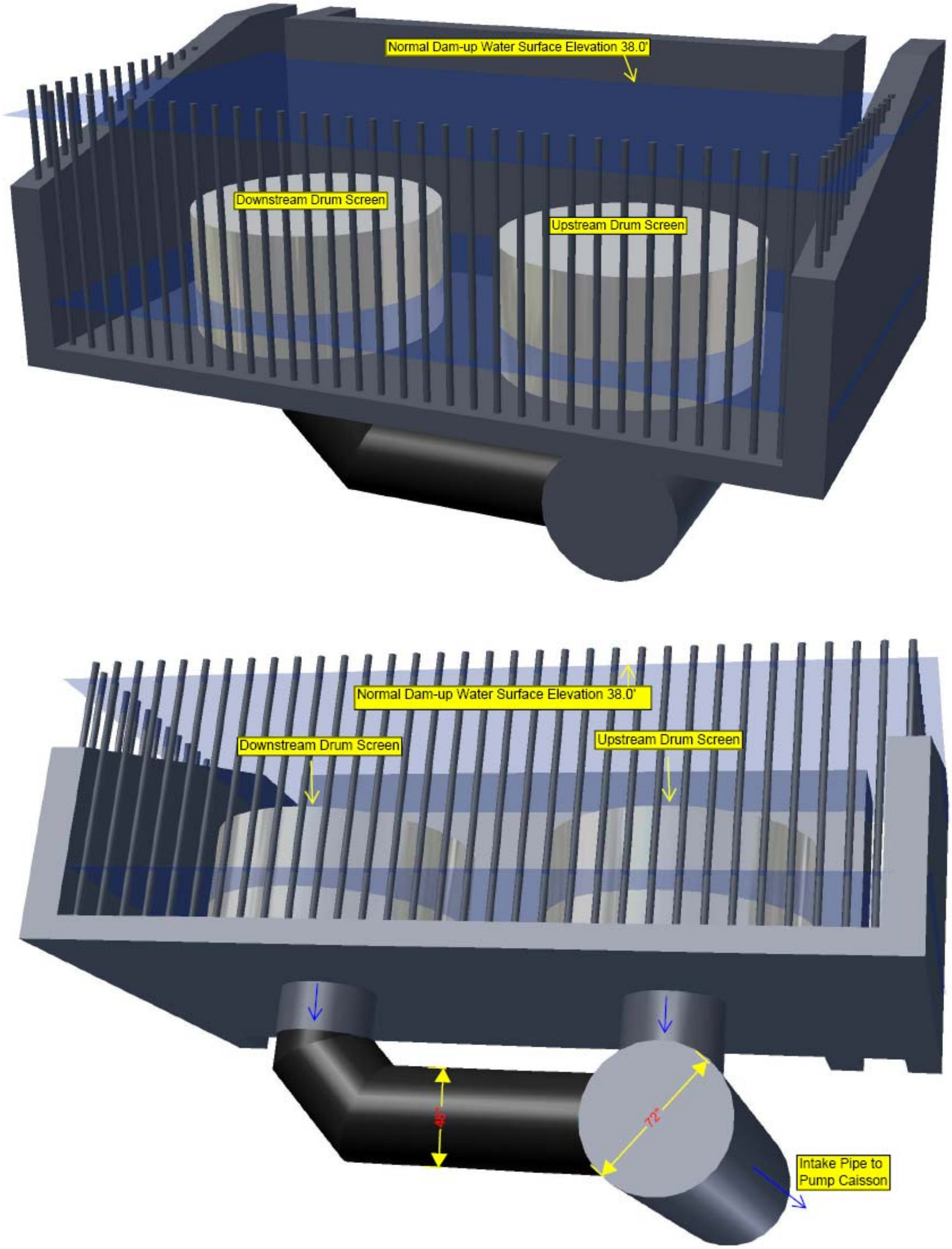

Figure 6 - Existing Intake Pipe Configuration below Drum Screens

The Agency is also required to maintain steady bypass flows downstream of the Mirabel dam. A study conducted by the Agency from 2001 to 2004 (Manning, et. al. 2005) showed significant improvement in downstream fish migration rates through notching of the inflatable dam. Figure 7 shows the dam in a notched configuration. This notching creates unsteady bypass flows as the dam material heats up from increased surface exposure to the sun and results in changing the notch shape in a diurnal fashion. Continued notching of the inflatable dam is also an undesirable operation from a structure fatigue standpoint and is not a long-term solution.

Figure 7 - Inflatable Dam in Notched Configuration

In addition to the above, the Agency would like its water contractors and the general public to have more opportunity to understand their efforts to recover salmonid populations. The Agency desires to use the Mirabel area facilities to contribute to such outreach and education.

Study Methodology and Process

The Study began in April 2009 with a scoping meeting between the Agency and the consultant team. A draft statement of objectives was developed and a range of project design concepts were discussed. After careful review of existing conditions information the advantages and disadvantages of the range of project design concepts were considered. The statement of objectives was also refined.

These project objectives include:

1. Provide for a fish screen that meets contemporary hydraulic design criteria (approach velocity = 0.33 fps; sweeping velocity = 2 times approach velocity) at the 100 cfs maximum diversion rate.
2. Maintain or improve downstream fish passage and provide for control of steady bypass flows. Control should be through the use of a fish friendly hydraulic structure or structures that can accommodate a range of expected bypass flow requirements.
3. Maintain existing diversion rate and operating water surface. (Elevation 38.0' is normal operating water surface, elevation 39.0' is maximum operable, elevation 36.0' is considered the minimum operable water level).
4. Provide a design that is compatible with and does not preclude opportunities for significant future dam modifications or replacement.
5. Maintain or improve upstream fish passage monitoring capability.
6. Maintain or improve upstream fish passage.
7. Provide for educational opportunity.
8. Maintain recreational river portage around dam and enhance portage with new facilities that also provide educational opportunities.
9. Identify a project that offers good value and reliable known costs over the next 50 years.
10. Provide for river diversion at low, non-impounded flows.

Schematic designs and critical details were developed for selected alternatives to assess physical feasibility and to be able to evaluate the alternatives relative to the objectives. These alternatives will be described in the next section of the report. A Technical Advisory Committee (TAC) was formed with representatives from the Department of Fish and Game (DFG), NMFS, and Agency technical support personnel. The first TAC meeting was held on July 20, 2009 in which the statement of objectives was reviewed and selected fish screen replacement alternatives were discussed. The meeting helped guide the concept designs toward a preferred alternative.

The preferred concept design alternative was determined through interactive evaluation with the Agency and was presented at a second TAC meeting on September 28, 2009. The TAC also reviewed the preferred concept design alternative in the field during a site visit. TAC feedback was positive for the concept design and it was agreed that it was the preferred concept to carry forward to the next phase of design. The preferred concept design alternative is described initially in the next section and more fully in a subsequent section of the report.

Concept Alternatives Considered

The first concept alternative considered was to simply retrofit the existing drum screens or intake. One variation of this could include fixing the drums in place so that they do not rotate, baffling behind the screen material, replacing the solid top of the drum with screen material, and other features to help reduce the chaotic nature of the hydraulics around the drums. This approach is considered experimental and would likely require many trial and error attempts at proving that the retrofit would meet fish screen criteria. It would also not meet many of the project objectives and was dropped from further consideration.

During the Biological Assessment work, and subsequent to the Mirabel fish screen performance evaluation, a concept design alternative of permanent modifications to the facility was developed (Borcalli and Associates 2001). This alternative was designed to strictly meet the objective of adhering to contemporary fish screen criteria. This 2001 concept alternative included a vertical, flat plate fish screen oriented on a diagonal to the bank and integrated into the existing intake structure with some concrete intake modifications at the upstream end. It also included mechanical straps to adjust the dam shape for more controlled hydraulics and flow over the dam. Based on recommendations from the dam manufacturer, the Agency has determined that the mechanical straps over the dam will not be allowed. This concept alternative was included with the others in the evaluation process but because it did not significantly improve downstream fish migration and bypass flow control it is not considered viable going forward. The fish screen configuration was used as a design basis in the other concept design alternatives.

The next concept design alternative that was considered is a newer type of modular fish screen system called a cone screen. Two removable cones screens would be placed into a retrofitted intake as shown in Figure 8. As part of this concept the intake pipes under the drum screens would be relocated to better balance the flows between them. Because this concept would require substantial reworking of the intake and does not meet many of the other project objectives it was not considered further.

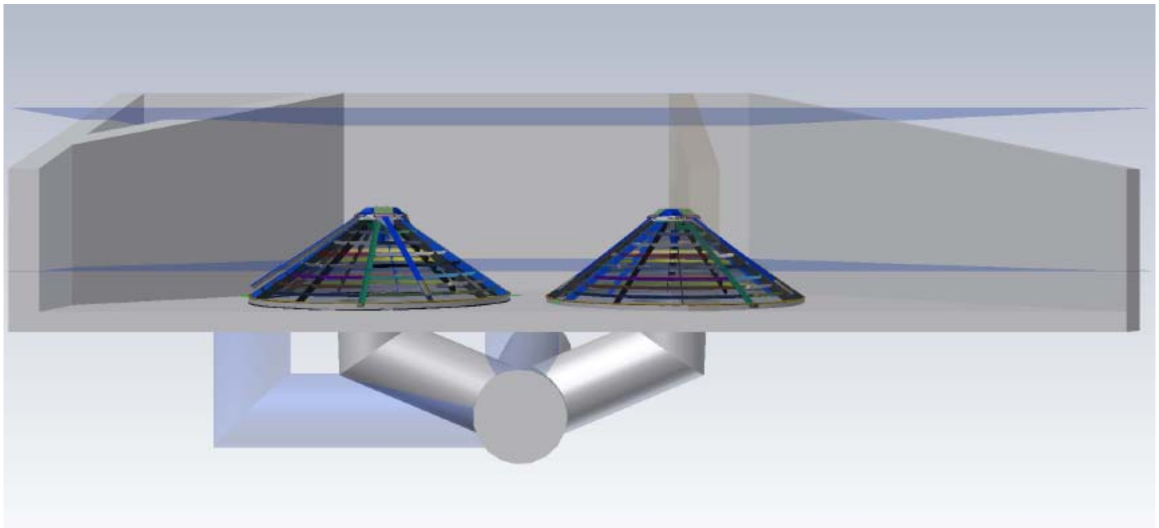

Figure 8 - Cone Screen Concept

Three more concept design alternatives were developed. These included a new inclined fish screen with a vertical slot fish ladder, a new vertical fish screen with pool-and-chute fish ladder, and a left bank bypass channel (opposite side of river) with a separate fish screen improvement inclusive of the above concepts. The ladders and bypass channel were primarily considered for enhancing the quantity and attractiveness of flow components for downstream fish migration. The bypass channel was analyzed for the left bank because there are two rows of sheetpile around the dam abutment about 20 feet apart that can form the sides of a bypass channel. It is understood that this area was used as a river bypass during the construction or repair of the dam.

A summary of the concept design alternatives evaluation relative to the project objectives is shown in Table 1. A revision of one of the concept design alternatives (number 4) was carried forward as the preferred alternative. An explanation of the basis for the preference and a detailed description of the concept design are provided in the next sections of this report.

Table 1 – Concepts and Project Objectives Evaluation

		Objectives											
		1	2	3	4	5	6	7	8	9	10		
	Concept	Provide for a fish screen that meets contemporary hydraulic design criteria at the 100 cfs maximum diversion rate.	Maintain or improve downstream fish passage and provide for control of steady bypass flows.	Maintain existing diversion rate and operating water surface.	Provide a design that is compatible with and does not preclude opportunities for significant future dam modifications or replacement.	Maintain or improve upstream fish passage monitoring capability.	Maintain or improve upstream fish passage.	Provide for educational opportunity.	Maintain recreational river portage around dam and enhance portage with new facilities that also provide educational opportunities.	Identify a project that offers good value and reliable known costs over the next 50 years.	*Provide for river diversion at low, non-impounded flows. (added May 14)*	General Pros	General Cons
1	Retrofit existing drum screens and dam	Experimental - may require trial and error fixes and hydraulic evaluations to prove.	Maintaining or improving depends on dam retrofit. Straps may be experimental.	Maintained with existing Denil ladders.	Yes	Maintained at existing Denil fish ladders.	Maintained	Limited to interpretive signage.	Maintained. Enhanced if river portage is also included on right bank (intake side) with interpretive signage.	Maybe - trial of drum or intake box retrofits could add up in long term.	Limited to existing condition.	Limited modification of existing intake (e.g., minimal concrete work). Possibly low costs.	May not solve hydraulic performance problems. Still needs improved, fish friendly bypass flow control structure through dam retrofit or other configuration.
2	2001 Borcalli new vertical fish screen and intake reconfiguration with dam retrofit (straps)	Yes	Maintaining or improving depends on dam retrofit. Straps may be experimental.	Maintained with existing Denil ladders.	Yes	Maintained at existing Denil fish ladders.	Maintained	Limited to interpretive signage.	Maintained. Enhanced if river portage is also included on right bank (intake side) with interpretive signage.	Yes	Limited by fish screen sill elevation.	Contemporary fish screen configuration.	Requires substantial modification of existing intake. Still needs improved, fish friendly bypass flow control structure through dam retrofit or other configuration.
3	Cone screens with intake retrofit	Yes - if caisson intake pipes are reconfigured.	Maintaining or improving requires added component such as dam retrofit or other configuration.	Maintained with existing Denil ladders.	Yes	Maintained at existing Denil fish ladders.	Maintained	Limited to interpretive signage.	Maintained. Enhanced if river portage is also included on right bank (intake side) with interpretive signage.	Yes	Yes - similar to existing condition. Could be improved by lowering intake floor when reconfiguring caisson intake pipes.	Contemporary fish screens with ease of maintenance and good reliability. Limited construction footprint with modification of existing intake.	Still needs improved, fish friendly bypass flow control structure through dam retrofit or other configuration.
4	New vertical slot fish ladder with new integrated intake/screen	Yes	Improved - Vertical slot ladder capacity is approx. 50 cfs and auxiliary flow can increase total bypass flow without spill over dam to 150 cfs. Will need bypass slot/weir at dam abutment since ladder inlet is 100 ft upstream of dam.	Maintained. There are advantages to a lower operating water surface for a shortened ladder.	Yes. There are advantages to include dam replacement coincident with construction of new fish ladder and screen.	Improved through use of full depth monitoring/viewing chamber.	Improved with vertical slot ladder that allows for different hydraulic patterns compared to the Denil ladders and full depth slot may favor wider range of species preferences. Possible reduced delay for salmon.	Yes - underwater, full depth viewing chamber can provide excellent educational opportunity in addition to interpretive signage.	Maintained. Enhanced if river portage is also included on right bank (intake side) with interpretive signage.	Values and costs not assessed at this time.	Yes - depends on intake floor/fish screen sill elevations.	Smallest footprint for a new ladder. Enhanced upstream fish passage and diversity of upstream fish passage when combined with existing left bank Denil ladder. May be able to take all of minimum bypass flows through new ladder and auxiliary flow components. Improved monitoring and active underwater viewing/educational component.	Requires substantial reworking of existing intake and river bank. Inlet location relative to dam may still cause some downstream passage delay compared to an inlet closer to the dam. River training structures and/or channel maintenance may be needed for sediment accumulation near new inlet.
5	New pool-and-chute fish ladder with new integrated intake/screen	Yes	Improved - Ladder to take majority or all of minimum bypass flow. This large pool-and-chute ladder can handle over 85 cfs alone. Will need bypass slot/weir at dam abutment since ladder inlet is 120 ft upstream of dam.	Maintained. There are advantages to a lower operating water surface for a shortened ladder.	Concept calls for reconfiguring right abutment and shortening dam. New fish ladder can be pushed into bank to avoid right abutment work but trade-off is more bank reconfiguration with bigger retaining walls. There are advantages to include dam replacement coincident with construction of new fish ladder and screen.	Improved through use of full depth monitoring/viewing chamber.	Improved passage for other species and life stages. Possible reduced delay for salmon.	Yes - underwater, full depth viewing chamber can provide excellent educational opportunity in addition to interpretive signage.	Maintained. Enhanced if river portage is also included on right bank (intake side) with interpretive signage.	Values and costs not assessed at this time.	Yes - depends on intake floor/fish screen sill elevations.	Enhanced upstream fish passage and diversity of upstream fish passage when combined with existing left bank Denil ladder. May be able to take all of minimum bypass flows through new ladder. Improved monitoring and active underwater viewing/educational component.	Large footprint. Requires substantial reworking of existing intake and river bank. Inlet location relative to dam may still cause some downstream passage delay compared to an inlet closer to the dam. River training structures and/or channel maintenance may be needed for sediment accumulation near new inlet.
6	Left bank bypass channel with separate fish screen improvement	Would need to be combined with fish screen improvement option which could include any of the first three concepts.	Improved - Channel can be sized to take majority or all of minimum bypass flows. Denil ladders at dam can be maintained for additional bypass routes and flow.	Maintained. There are advantages to a lower operating water surface for a shorter bypass channel.	Yes	Maybe maintained - monitoring efficiency may be reduced with large channel inlet configuration. Existing Denil fish ladders can be retained.	Improved passage for other species and life stages. Possible reduced delay for salmon.	Yes - Interpretive signage. Underwater viewing windows may still be possible with an in ground chamber.	Bypass channel may provide boat-pass. Safety and nuisance factors will need to be considered. Quicker pass-by and not getting out of boat will limit interpretive signage observing.	Values and costs not assessed at this time.	Depends on fish screen improvement option.	Enhanced upstream fish passage and diversity of upstream fish passage when combined with existing left bank Denil ladder. May be able to take all of minimum bypass flows through new channel. Enhanced recreational opportunity if used as a boat-pass. Channel may provide enhanced temporal habitat compared to adjacent river.	Requires modification of left river bank between sheet pile walls. Sheet pile walls may also need substantial reconfiguration for longer, better performing channel. Monitoring reliability may be decreased.

Prepared by J. Mann, Prunuske Chatham, Inc. - July 17, 2009

Basis for Preferred Concept Design Alternative

In working through the concept design alternatives it became increasingly apparent that the objectives of improving downstream fish passage and providing for control of steady bypass flows were equally as important as providing a fish screen that meets contemporary hydraulic design criteria. It was also found that a new fish screen meeting criteria can be easily designed with a substantial modification of the intake so long as a fish-friendly passageway component for flow bypass can be combined with the new intake structure. The challenge was not in providing an adequate fish screen so much as providing for attractive fish migration and bypass flow control and increased capacity. In essence, the integration of a new fish screen, and its associated hydraulics, with a large bypass for downstream fish passage was an important concept design strategy.

Many variations and options of a fish-friendly configuration that also provided good bypass flow control and capacity were considered. These included replacing all or part of the dam with overflow gate systems, integrating a gate and control system just outside of either dam abutment, and relocating the diversion into a canal. These options vary in degrees of fish-friendliness and flow capacity and control but in general, the more fish-friendly any individual component or system may become the less capacity and control for bypass flow it tends to have. A balance of the two aspects was obtained by focusing the design strategy on developing a large capacity fish-friendly bypass structure. The friendliest structure for fish passage, other than a natural channel, is a fishway (fish ladder). The advantage of fishways, with well-defined flow ranges, is that they can be located in smaller areas by folding their hydraulic profile into a smaller footprint when compared to a natural channel.

A revision of the inclined fish screen with a vertical slot fish ladder was developed and better matched the project objectives compared to previous concepts. The components of this revised concept include a new intake with an inclined flat plate fish screen system, an oversized screen for increased bypass flow control and capacity, and a bypass fishway in the form of a vertical slot fish ladder. The preliminary drawings for this concept design are shown in Appendix A.

The evaluation of the project objectives with the preferred concept design is listed here (bold indicates assessment of how the design meets each project objective):

1. Provide for a fish screen that meets contemporary hydraulic design criteria at the 100 cfs maximum diversion rate. **Yes, screen oversized for improved bypass flow control.**
2. Maintain or improve downstream fish passage and provide for control of steady bypass flows. Control should be through the use of a fish friendly hydraulic structure or structures that can accommodate a range of expected bypass flow requirements. **Improved – bypass fishway flow**

capacity can be significantly increased compared to existing Denil fishway and auxiliary flow from bypass pipe can increase total bypass flow capability with improved control and without spill over dam (flow calculations to be completed in next phase of design).

3. Maintain existing diversion rate and operating water surface. (Elevation 38.0' is normal operating water surface, elevation 39.0' is maximum operable, elevation 36.0' is considered the minimum operable water level). **Maintained – bypass fishway can more easily accommodate water surface elevation ranges compared to existing Denil fishways.**
4. Provide a design that is compatible with and does not preclude opportunities for significant future dam modifications or replacement. **Yes**
5. Maintain or improve upstream fish passage monitoring capability. **Improved through use of full depth monitoring/viewing chamber.**
6. Maintain or improve upstream fish passage. **Improved with vertical slot ladder that allows for different hydraulic patterns compared to the existing Denil fishway and full depth slot may favor wider range of species preferences. Possibly improved performance and higher capacity for salmon.**
7. Provide for educational opportunity. **Yes - underwater, full depth viewing chamber can provide excellent educational opportunity in addition to interpretive signage on the river bank.**
8. Maintain recreational river portage around dam and enhance portage with new facilities that also provide educational opportunities. **Maintained. Enhanced if river portage is also included on right bank (intake side) with interpretive signage.**
9. Identify a project that offers good value and reliable known costs over the next 50 years. **Yes**
10. Provide for river diversion at low, non-impounded flows. **Yes - with intake floor at elevation 25.0' and fish screen sill elevation at approx. 25.5' up to approximately 30 cfs of diversion capability (river water surface at 28.0' and submerged depth of fish screens at 2.5').**

Some general advantages of the preferred concept design alternative include:

1. Higher certainty of hydraulic performance and meeting fish screen criteria.
2. Higher level of bypass flow control compared to existing condition. This configuration will be able to take all of minimum bypass flows through new bypass fishway and auxiliary flow components.
3. Enhanced upstream fish passage and diversity of upstream fish passage, especially when combined with existing left bank Denil fishway.
4. Improved monitoring and active underwater viewing and educational component.
5. Smaller footprint for a new fishway compared to other ladder types.

Some disadvantages of the preferred concept design alternative may include:

1. Requires reworking of existing intake and river bank.
2. River training structures and/or channel maintenance may be needed for sediment accumulation near new intake.
3. Bypass fishway entrance (downstream end) requires substantial depth.
4. Bank grading and tall retaining walls may be required in addition to new walls for intake and bypass fishway.

Description of Preferred Concept Design Alternative

Drawings for the preferred concept design alternative are included in Appendix A. A summary of hydrology that was used as a preliminary basis of design is included in Appendix B.

Diversion Intake and Fish Screen Configuration

Sheet 1 of the concept drawing shows the plan and elevation view of the proposed fish screen layout. The inclined fish screen was conceptually designed using the DFG Fish Screening Criteria (CDFG 2000) and the NMFS Fish Screening Criteria for Anadromous Salmonids (NMFS 1997). The intent of the fish screening criteria is to provide design guidelines and criteria that result in juvenile fish being prevented from entrainment in, or impingement upon, a water diversion's intake. This is basically to make the diversion hydraulically transparent to the fish and to not alter their natural biology. In this case, the target fish being excluded from the diversion intake are salmonid fry. Because of the life history of juvenile salmonid fish in the Russian River, and that diversion operations may occur during the early spring when juvenile fish are present, the fry criteria portion of the screen criteria is used. NMFS will normally assume that fry-sized salmonids are present at all sites unless adequate biological investigation proves otherwise.

The fish screening criteria determines the required area of the screen by the amount of water diversion occurring and where the intake is placed (river, canal, tidal, etc.) for the maximum approach velocity allowed. Approach velocity is the water velocity vector component perpendicular to the screen face. With a maximum allowable approach velocity of 0.33 ft/s for screens in streams and rivers, and a maximum pumped diversion of 100 cfs, the minimum required wetted screen area is 303 square feet. Adding 25 percent to the required wetted area to compensate for a reduction of screen area due to structural members is a common design practice. The required screen area then becomes approximately 380 square feet.

The proposed intake screen will consist of removable panels of stainless steel profile bar set into the reinforced concrete intake structure. The intake screen consists of four 14-ft x 10-ft panels, with a total area of 560 square feet. A photo of an example screen panel is shown in Figure 9. Not all of the screen area is submerged during normal diversion operations. The proposed design has the panels sitting on a concrete sill that elevates them above the forebay floor. This allows for some variability from sediment that may accumulate and for a brush cleaning arm to extend slightly beyond the screen face for complete cleaning coverage. Additionally, the proposed design configuration will allow for some freeboard on the screen for slight variation in operating water surface elevation and pump flow curves.

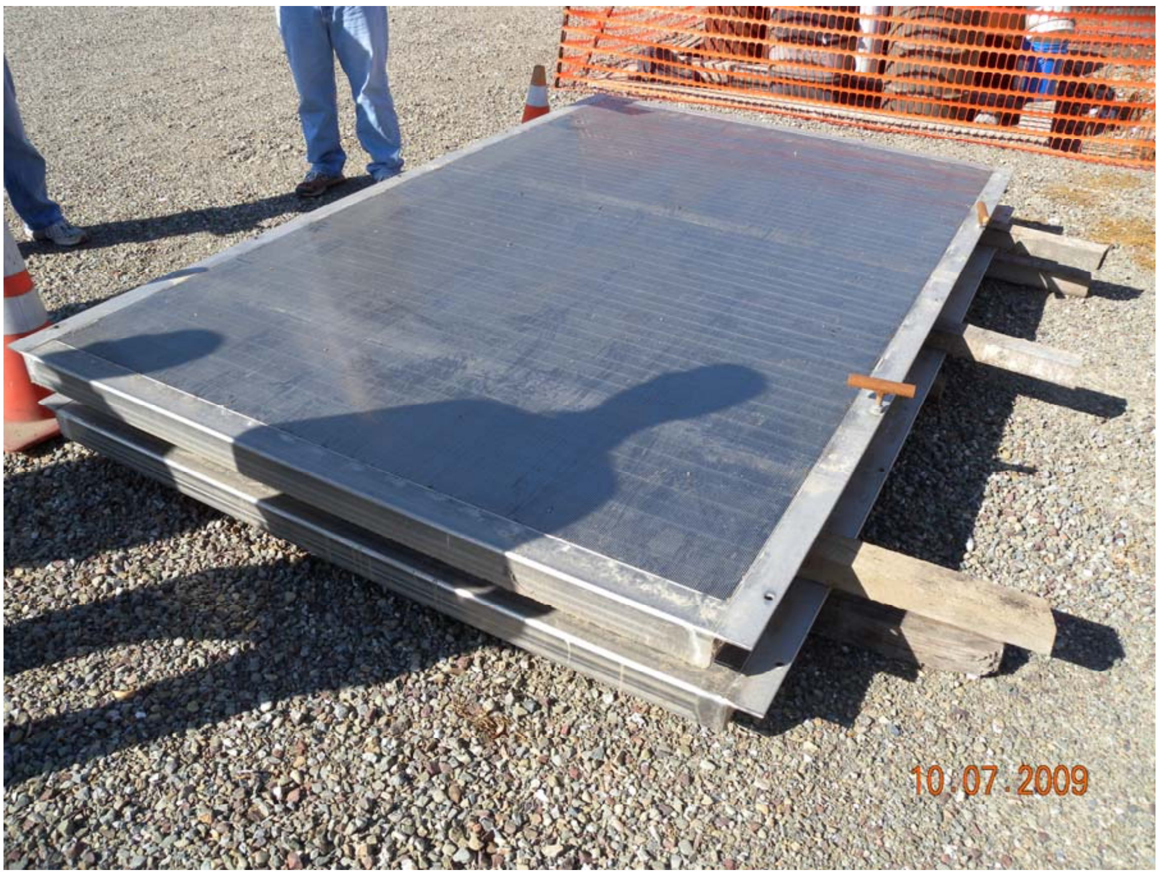

Figure 9 – Example Intake Screen Panel

The oversizing of the screen area also allows for a bypass flow control pipe to be considered between the intake and the pump caisson as shown on the concept design. Operators of the facility have expressed a desire to have more bypass flow quantity control. They are currently limited to about 20 cfs of flow control from the existing intake bypass. Regulating the flow in that bypass at low flows is not conducive to the hydraulics for fish passage in the existing intake. A new, precisely controlled bypass valve and pipe for increased flow as conceptually designed would likely be limited only by the availability of excess screen area after subtracting out the area required for the diversion pumping rate. If the diversion rate is maxed out at 100 cfs there will be approximately 180 square feet of screen area for about 60 cfs of bypass flow. Lowering the pumping rate of the diversion on occasion, usually in 20 cfs increments based on water supply demand, will allow for increased bypass flow and more precise control. Another advantage to the bypass pipe with its inlet located behind the intake screen is that it can be the source of auxiliary water for the fishway entrance (the outlet at the downstream end). The auxiliary flow and bypass fishway will be explained in the next section of the report. Detailed hydraulic analysis for the bypass flow control pipe and optimization of screen size with respect to bypass flow control requirements will be conducted in the next phase of design.

For water supply reliability during drier winter and spring conditions the Agency may need to divert water from the free-flowing river when the inflatable dam is down. The pumping capability when the dam is down is lessened because of the lack of head from the impoundment and is determined by the river flow and water surface elevation. Appendix B contains an estimated dam-down rating curve of the river channel and Figures 10 and 11 show the river with the dam down at different flow rates in which dam-down diversions could occur. The lowered forebay floor and intake screen sill elevations of the proposed concept design may allow for adequate screen area during these lessened diversion operations depending on the pumping capability and water supply demand. The diversion pump station currently contains two 100 horsepower and one 50 horsepower pumps that when combined in operation have a 100 cfs capacity with the design head and dam-up conditions (water surface elevation of 38 feet). The pumping capacity is lessened when the dam is down and dependent upon the river water surface elevation. It is expected that dam-down diversion rates will be in the range of 15 to 40 cfs depending on pump operations. Detailed hydraulic analysis for the intake elevations and optimization of screen area with respect to dam-down diversion operations will be conducted in the next phase of design.

Figure 10 – 4/30/2009 – Free Flowing River at ~ 250 cfs and Water Surface El. of 28.7'

Figure 11 – 2/13/2002 – Free Flowing River at ~ 1,100 cfs (Hacienda Gage) After Peak Flow of 44,000 cfs on January 3rd., Estimated River Depth = 3 ft

The fish screening criteria requires that the sweeping velocity be greater than the approach velocity. Sweeping velocity is the water velocity vector component parallel and adjacent to the screen face. Observed sweeping velocities at the location of the proposed fish screen are near zero during normal diversion conditions with the inflatable dam in the up position and depending on incoming river flow. Because of the impounding effect of the dam and these slow velocities, the sweeping velocity criteria may not be met during some flow conditions. In addition to downstream fish migration attraction hydraulics, as explained previously, this is an important consideration in locating the bypass fishway relative to the intake screen face. The concept design locates the bypass fishway at the downstream end of the intake screen to provide a drawing of flows along the face of the screen as sweeping velocity. The influence of this drawing effect is determined by the amount of flow going down the bypass fishway and the geometry of the intake relative to the bypass fishway inlet. Detailed hydraulic modeling and analysis will occur during the next phase of design to ensure sweeping velocities and distribution of approach velocities are satisfactory. Training walls or other appurtenances for enhancing sweeping velocities will be considered at that time. The Agency will include in the design phase of the project a requirement for such a modeling effort.

The fish screening criteria also requires uniform flow distribution over the surface of the screen. The configuration of the intake relative to the river channel and river hydraulics is usually the first step in ensuring uniform flow distribution. In this case, because the river velocities are very low during routine diversion operations (dam-up), the intake was designed to be symmetrical about the caisson pipe and the transition plenum component added to help transition flows as equally as possible. This design approach for considering hydraulics at the macro-scale was taken in the absence of a detailed study to optimize the intake configuration. A detailed study can be conducted as part of other hydraulic modeling and analysis efforts mentioned previously. Some intake screen designs use porosity plates, louvers, baffles, isolation walls, and valves, or combinations of these components to ensure uniform flow distribution. The proposed concept design has four equalization bays, one for each screen panel. The bays are connected to the transition plenum and individually controlled with a valve. This allows for flow control and hydraulic tuning of the individual screen panels. While this will likely help with tuning of the macro-scale hydraulics, other components in the individual bays may be needed to fine tune the micro-scale hydraulics (juvenile fish scale size). Porosity plates are an example of a component that may be installed behind the screen to ensure an even flow distribution over the face of each individual screen panel.

The intake screen will have a cleaning system that will be determined in the next phase of design. A flat plate screen with this kind of river location and with this type of operational condition typically has a sweeping brush system controlled by a motor located on top of the intake structure. Other cleaning systems like air backwash or water backwash may also be considered. Stage sensors on both sides of the screen panels can be installed to ensure cleaning system frequency is adequate and to ensure flow equalization.

A debris rack will be required in front of the intake screen to prevent damage to the screen face from large floating debris. The debris rack will be built with 12-inch wide openings between vertical members. This allows for the least amount of flow restriction and allows enough room for fish passage through the members without sacrificing too much in debris catching efficiency. Provisions for cleaning the debris rack may include a superstructure on top of the rack for maintenance and mechanized equipment for debris removal. The exact placement and configuration of the debris rack will be determined in the next phase of design.

Bypass Fishway Configuration

Removing the existing Denil fishway and replacing it with a larger and better performing fishway will provide greater bypass conveyance capacity during routine diversion operations. It will improve fish passage while avoiding significant changes to the water diversion operations. The bypass fishway consists of a new vertical slot reinforced concrete fish ladder and an auxiliary water supply system that provides increased attraction flow at the fishway entrance (downstream end). Vertical slot fish ladders are commonly used for salmon and steelhead, among other fish species, throughout California and the West Coast of North America. A vertical slot fish ladder consists of a sloped, rectangular channel separated by vertical slot baffles. The baffles are located at even increments to create a step-like arrangement of resting pools. The design is self-regulating and provides nearly constant velocities, flow depths, and water surface differentials at each baffle throughout a range of operating conditions.

This new bypass fishway is an integral component of the new intake screen in that the fishway inlet is immediately downstream of the screen panels. This provides juvenile fish an attractive and safe pathway as they migrate downstream and is a major accomplishment of downstream fish passage objectives. The vertical slot configuration is well-suited for this application because it provides a full depth for fish to use as they move either upstream or downstream. The higher conveyance capacity of the bypass fishway also improves upstream fish passage by enhancing attraction at the entrance. The larger size and inherent hydraulics of vertical slot fishways also provides improved upstream passage for a wider range of fish species and life stages.

The footprint of the new fishway will be larger than the existing Denil fishway but will have a turn along its length to keep the entrance near the same location. The increased flow capacity and location of the entrance enhances the ability for fish to find the ladder. Exact placement of the entrance and its configuration relative to the dam spill under different river flow conditions will be optimized during the next phase of design.

During normal water diversion operating conditions with a water surface elevation of approximately 38.0 feet (when the dam is up and the river is impounded) the bypass fishway will convey approximately 50 to 80 cfs, depending on final design. Currently, the inflatable dam, the intake bypass openings, and the Denil fishways control the water surface elevation in the river and bypass flow quantity. The capacity of each Denil is approximately 20 cfs and the intake bypass openings can pass another 20 cfs. So a total bypass flow capability, without spill over the dam, with the existing facilities is approximately 60 cfs. With the new bypass fishway and bypass flow control pipe (as described with the intake screen improvements) this total bypass flow can be more than doubled over existing conditions without spill over the dam. The exact amount will depend on final configurations of the bypass fishway and the ultimate capacities of the bypass flow control pipe and auxiliary water system. A vertical slide gate may be installed on the east bank Denil fishway to help control bypass flow rates during routine diversion operations. These capacities will be determined during detailed hydraulic analysis in the next phase of design.

Diagrams with the proposed conceptual design alternative have been illustrated to help understand preliminarily, the flow routing and new component capacities under different river flows and operating condition scenarios. These diagrams are provided in Appendix B.

The bypass fishway design also includes viewing chamber and window located on the side of the ladder near the intake. This chamber and window allows for fish migration monitoring and would replace the monitoring video box that is currently used to count Chinook salmon migrating upstream through the Denil fishways. The monitoring video box for the Denil fishway on the East side would remain. Because the bypass fishway is a vertical slot ladder and fish may pass at any depth the window will need to be full depth. The video monitoring equipment used with the new fish ladder will need to be spread out over this depth depending on camera field of view and quality of fish recognition needed. To improve fish recognition (species and size) a background wall and flow separation gratings can be installed temporarily that will allow fish to be closer to the window. An example of a viewing chamber, window, marked background wall, and monitoring camera is shown in Figure 12.

Figure 12 – Fishway Monitoring Chamber and Viewing Window, Woodbridge Dam near Lodi

The viewing chamber and window will also allow for live, in-person monitoring of fish and increased educational and interpretive opportunities. California aquariums were contacted for feasibility determination of such a large window. Reynolds Polymer Technology, Inc. of Grand Junction, Colorado has been supplier of large windows to aquariums and some fishways. The exact size and design details, along with operating and maintenance considerations for the fishway viewing window will be determined in the next phase of design.

Operations and Maintenance Considerations

An operations and maintenance plan will be developed as part of the next phase of design. It will be reviewed and approved by DFG and NMFS prior to design completion. Operational capability and control is expected to increase with the proposed conceptual design alternative and maintenance demands will likely be the same as existing conditions. Since the vertical slot bypass fishway is self-regulating the flow controls will be with the bypass pipe and auxiliary water system. Flow sensors on the bypass pipe and valve controls will be required to maintain accurate bypass flow releases.

To ensure fish screen approach velocity criteria are met, stage sensors can be installed on the upstream and downstream side of the screen panels. Flow sensors can also be installed on the valves of the flow equalization bays to monitor the flow through the panels. These sensors can serve to actuate controls for flow, alarms, or shut down the pump station if an undesirable condition is sensed. The sensors will also serve to monitor the small debris accumulation on the screen panels and help to determine the performance of the screen cleaning system on a real-time basis. Periodic maintenance and cleaning of the screens will be necessary, similar to what occurs now with the drum screens.

Functional reliability can be increased with designed-in features of the intake and to allow for easier screen maintenance. For example, screen panel removal and cleaning during diversion operations can be accomplished by inserting a blank panel behind the screen panel and removing and replacing the screen panel with a clean one. Cleaning typically includes pressure washing the panels to remove small debris and algae buildup.

Large debris accumulation on the debris rack will require routine removal, typically at the onset of diversion operations. Sediment accumulation on the intake forebay floor may occur during river floods and needs to be considered during final design to minimize potential maintenance requirements. Sediment accumulation in the bypass fishway will likely flush out as flows increase in the ladder, similar to what occurs now with the Denil fishways. Resilience to flood damage of the improvements will likely be the same or slightly better when compared to the existing condition.

Steel grating will be used to cover the top of the bypass fishway to help ensure the safety of personnel working on or around the structure, and to help prevent large debris from entering the bypass fishway when the river is in flood stage. The grating will also be used as a walkway and working platform to access different parts of facility for maintenance activities.

Preliminary Construction Cost Estimate

The preliminary cost estimate for construction is based on the work conducted as part of this Study, the conceptual drawings and current industry standard construction costs. Comparisons were also made with recent, similar fish passage projects. The cost estimate is subject to review by the Agency. The quantities and costs illustrated are preliminary and not intended for bidding or construction purposes as final design work may result in changes to any or all quantities and costs. The final cost estimate will ultimately be determined by the final design engineer and the Agency.

For a conservative estimate it was assumed that the project construction may need to occur in two separate phases over two different years of the in-stream construction work window (June to October). The order of construction is that the intake screen will be constructed as a first phase with limited, temporary components and then the fishway bypass will be added in the second phase. Construction of both phases is likely possible with one in-stream construction work window of five months and the cost savings for one versus two years of construction is mainly within some of the general costs like mobilization and some of the construction preparation costs like dewatering associated with each phase. The estimated construction cost of the preferred conceptual design alternative is within the range of $3,500,000 to $4,000,000.

The construction cost estimate does not include the following costs that are typically part of total project costs and will need to be considered in the next phase of project planning and design:

- Final engineering design, permitting or other environmental compliance work
- Construction procurement, management, administration and inspections
- Pumps or other equipment that may be necessary for temporary surface water supply diversion during the construction (it is expected that the emergency intakes downstream of the dam will be used for the temporary diversion)
- Any mitigation that may be required for the project
- Annual operations and maintenance costs

Project Preliminary Schedule Estimate

As mentioned previously, construction for the preferred conceptual design alternative is estimated to occur within a five month (summer) in-stream construction work window. However, environmental compliance, engineering design, and permitting will be required prior to construction. Below is an estimated project schedule assuming that funding availability does not restrain the timeline. The Biological Opinion requires that the Agency complete design of the project by October 2011 and construct the project within three years after completion of the design. If design of the new intake screen and bypass fishway are completed in 2011 the construction of the project could occur anytime during the summers of 2012, 2013, and 2014.

End of 2009	Agency reviews feasibility and provides direction for the next phase of the project
2010 -2011	Engineering design environmental compliance, and permitting
2012 -2014	Construction and commissioning

Final Design Considerations

The concept drawings contained in this report will be used as a basis during the final design process. Additional surveys may be necessary because of changes in the site conditions since this Study was conducted. Detailed hydraulic analyses will be needed to gain additional information required for final design. Final designs will be subject to approval by DFG, NMFS, and others.

Final design work will be governed by the following codes and standards:

- Structural design will comply with the latest Uniform Building Code requirements.
- Concrete design will comply with the latest American Concrete Institute Building Code Requirements for Reinforced Concrete Design.
- All current applicable Cal OSHA safety standards will be met.
- All environmental permit conditions will be met.

Final designs will adhere to the following requirements and criteria:

- An operations and maintenance manual should be made available for review by DFG and NMFS prior to design completion.
- Follow NMFS and DFG fish screen design criteria and widely recognized fishway design guidelines.
- The elevations shown in drawings are based on as-built and survey information provided by the Agency. Descriptions and elevations of control points can be obtained from the Agency.
- Actual concrete thickness, foundation requirements, and reinforcement requirements will be determined by the final design engineer.
- Some concrete, grading, and other work was included for cost estimating purposes but are not shown on the concept drawings. Actual dimensions and extent of work required for construction will be determined by the final design engineer.
- Fences, railings, gratings and other components for safety, security and maintenance will require consideration in the final design.

Bank grading and changes to the alignment of the emergency pump intakes access road downstream of the dam will likely be required to facilitate ingress and egress for vehicles. Retaining walls may be needed to handle steep or abrupt grade changes in and around the new works. Access ramps into the river for channel maintenance and boat portage at the upstream and downstream ends of the new works should be considered in the next phase of design.

Detailed hydraulic analysis of the river that occurs for the optimization of the intake screen configuration and bypass fishway will likely result in elevation differences of those components as compared to the concept design drawings.

Special Considerations

The Mirabel inflatable dam and river diversion is located within a Federal Emergency Management Agency Flood Insurance Rate Map Zone AE, special flood hazard area and floodway. The Russian River floods frequently at this location and overtopping of the intake, dam abutments and fishways is a common occurrence. The replacement of the intake and construction of a new fishway bypass within the river channel's cross section is not expected to raise the 100 year base flood elevation within this reach of the river. This must be verified in final design and the provisions of Code of Federal Regulations Chapter 44, Part 65 (Identification and Mapping of Special Hazard Areas) considered.

Construction Considerations

Construction access for the site is from the Westside Road gate and the Agency's access roads in the Mirabel area. An access road to the intake and dam exists on the West side of the river near the pump station. All access roads are surfaced with gravel and are presently in good condition. Staging areas for the construction are available near the pump station. The limits of construction, staging areas, and access roads will be determined in the next phase of design.

Excavation will be required at the project site for the intake screen and bypass fishway. Excavated material will either be reused at the project site or hauled off to a disposal site, which will be determined by the Agency. The excavation will require the construction area to be dewatered for preparing the foundation and placing concrete. A dewatering and river flow control plan will be developed in the next phase of design. A cofferdam would be required to isolate the work area for construction of the new intake and the bypass fishway. Given the composition of the subgrade in this area seepage from the river is expected to be significant. Use of sheetpile as cofferdam to isolate the construction activity and control seepage into the work area may be necessary. Water pumped from the work area may be allowed to be discharged into the adjacent infiltration ponds where water would percolate readily and prevent sediment from entering the river.

A species protection plan will also be required. Aquatic species will need to be relocated from the dewatered area. Adequate fish passage for the construction window should be incorporated in the dewatering plan if diversion of the river flow around the whole channel will be required or the dam is used to impound the river during construction. This may be accomplished by utilizing the existing East bank Denil fishway if full or partial impoundment occurs during construction. Maintaining the water surface elevation in the river upstream of the dam may be desirable during the summer for increased infiltration rates for water supply demand. The existing emergency pumps intakes downstream of the inflatable dam may need to be used for temporary surface water diversion during construction, depending on water supply demand and Agency operations.

Construction of the improvements would be of conventional construction with generally available materials, equipment and labor. The work includes earthwork, reinforced concrete construction, pipeline installation, miscellaneous mechanical and metalwork installation, electrical controls, and associated electrical services. Concrete would come from common suppliers in the area and rock for slope protection is locally available. Permanent cut slopes will be shaped, graded, and vegetated, as appropriate, to ensure the slopes remain stable and erosion is controlled. Existing roads will be regraded and resurfaced with gravel as necessary for pre-project use and future use related to the project. All areas temporarily disturbed by construction will be restored to pre-project conditions. Staging areas will be restored to the previous condition.

Conclusions and Recommendations

The Association of California Water Agencies Board of Directors has recently (Nov. 2008) adopted policy principles embracing environmental and economic sustainability as equal priorities for water management in California. The principles express strong support for policies that promote significant improvements in both water supply reliability and ecosystem health. One of the principles outlines that investments in fish screens, fish ladders, and habitat improvement projects are investments in sustainability because the reliability of the water supply system and the health of the ecosystem are inextricably linked. It is also recognized that investments in water system improvements made in an environmentally sustainable system serves the economic interests of all water users, can significantly lower conflict levels between water supply and environmental objectives, and assure the long-term reliability of available supplies.

The preferred conceptual design alternative will be a significant improvement for the water supply system and ecosystem protection. This alternative best meets the project objectives and is considered feasible for construction. Final feasibility determination will likely occur in the next phase of design and requires analyzing the project relative to environmental impacts and funding availability. Performing more detailed hydraulic analysis and modeling will be required to optimize the configuration of the preferred conceptual design. A two-dimensional (2D) hydraulic model is recommended at a minimum. A 2D or 3D model is particularly useful for analyzing flows with in-stream structures and complex geometries. It can help to analyze circulation patterns, local velocities and variations, and flow over and around structures.

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Manning DJ, Mann JA, White SK, Chase SD, Benkert RC, 2005 - Steelhead Emigration in a Seasonal Impoundment Created by an Inflatable Rubber Dam. North American Journal of Fisheries Management: Vol. 25, No. 4 pp. 1239–1255.

National Marine Fisheries Service (NMFS), Southwest Region, 2008 - Endangered Species Act Section 7 Consultation Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River watershed.

NMFS, 1997 – Fish Screening Criteria for Anadromous Salmonids.

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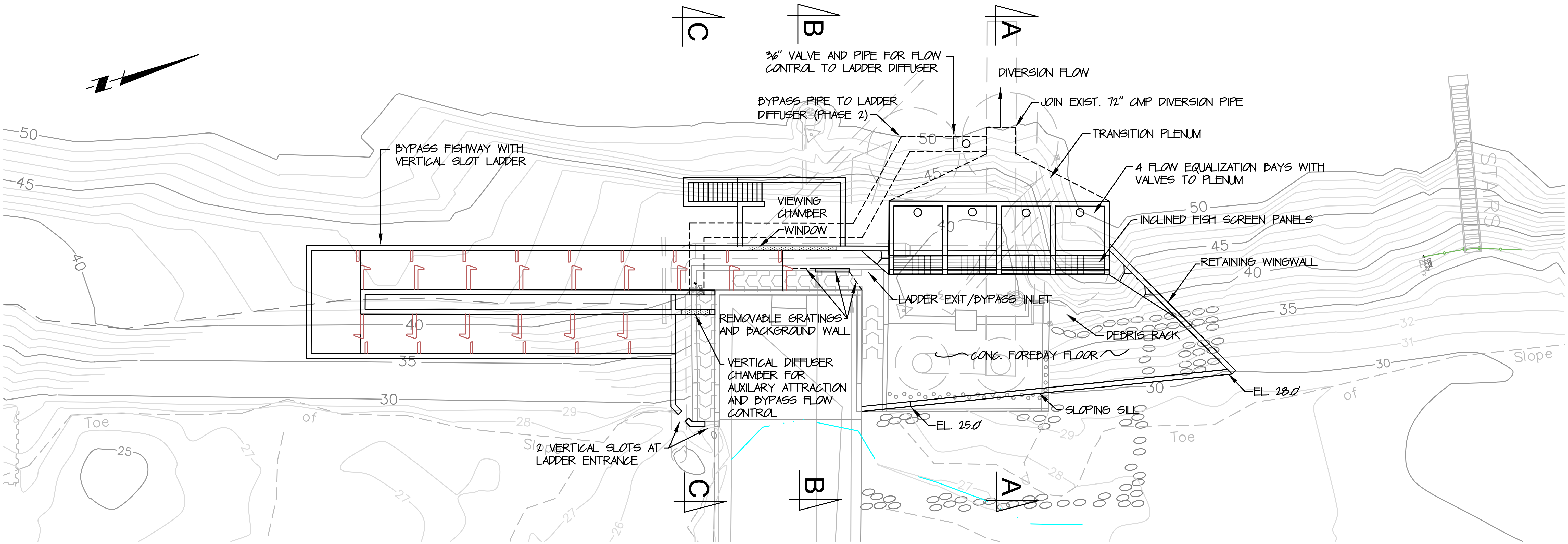
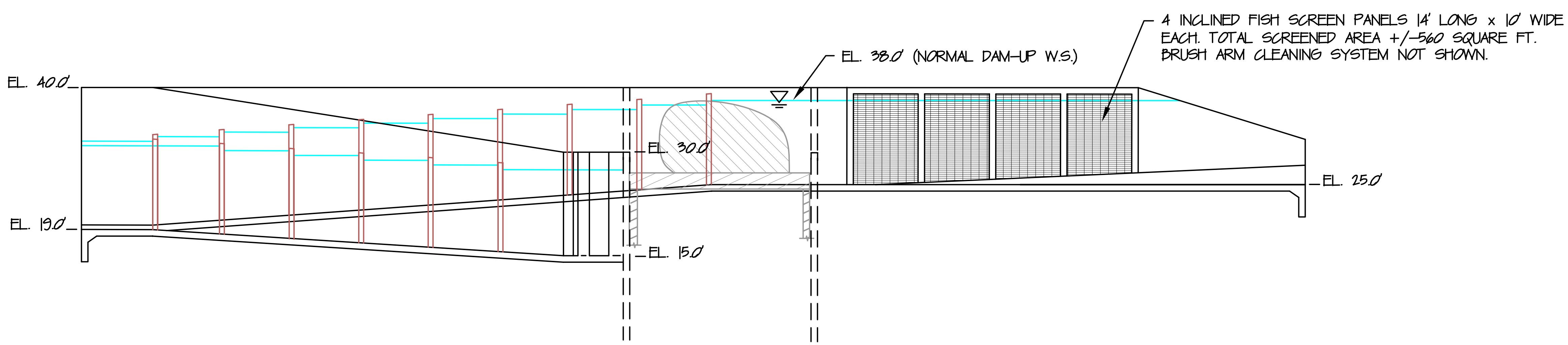
Appendix A

Preferred Concept Design Alternative



PLAN



PROFILE

PRELIMINARY
DATE : Sep 24, 2009

PRUNUSKE CHATHAM, INC.
400 MORRIS STREET, SUITE G
SEBASTOPOL, CA 95472
(707) 824-4600

DATE: SEPT. 10, 2009
SCALE: 1" = 20'
DESIGNED BY: JMANN
DRAFTED BY: JP
CHECKED BY: JMANN

REVISIONS	DATE	BY

PREPARED FOR:
SONOMA COUNTY WATER AGENCY
MIRABEL FISH SCREEN RECONFIGURATION AND ALTERNATIVES STUDY

INCLINED FISH SCREEN WITH BYPASS FISHWAY CONCEPT ALTERNATIVE

SHEET 1 OF 2

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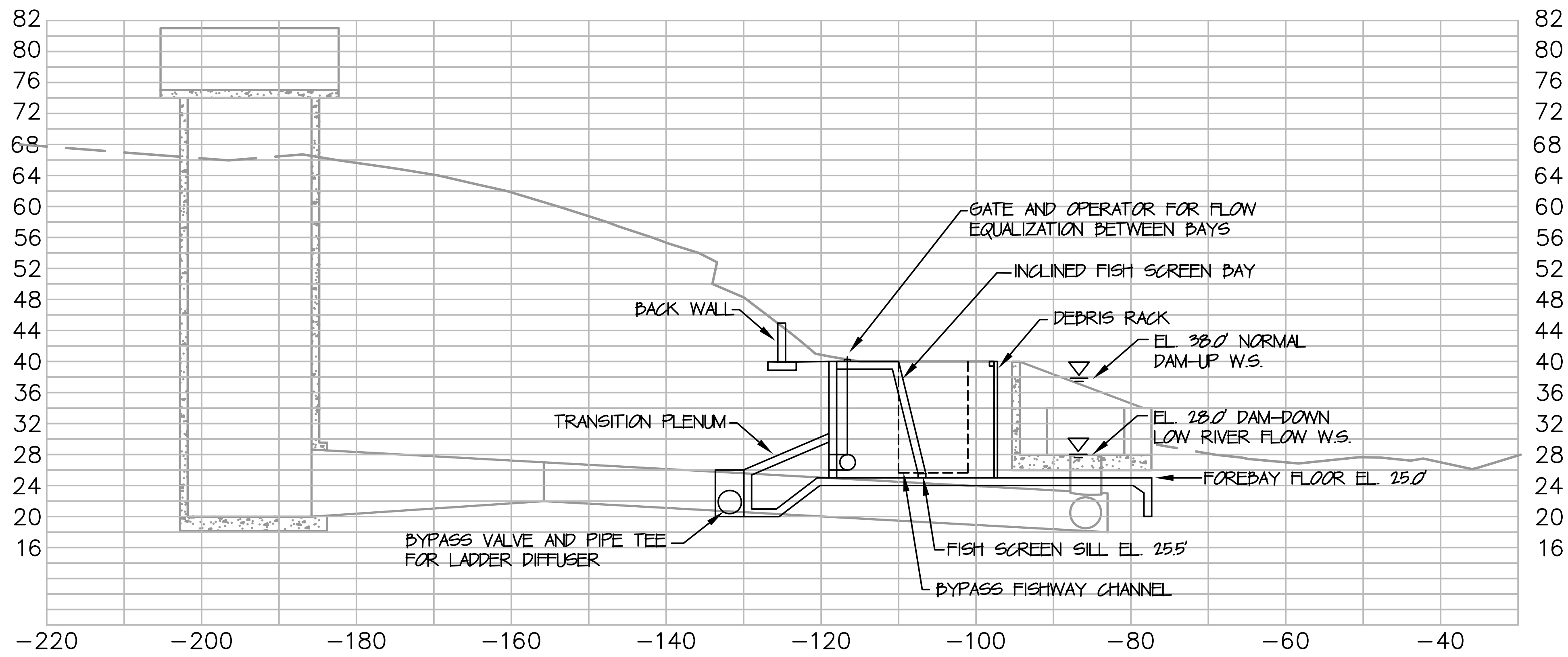
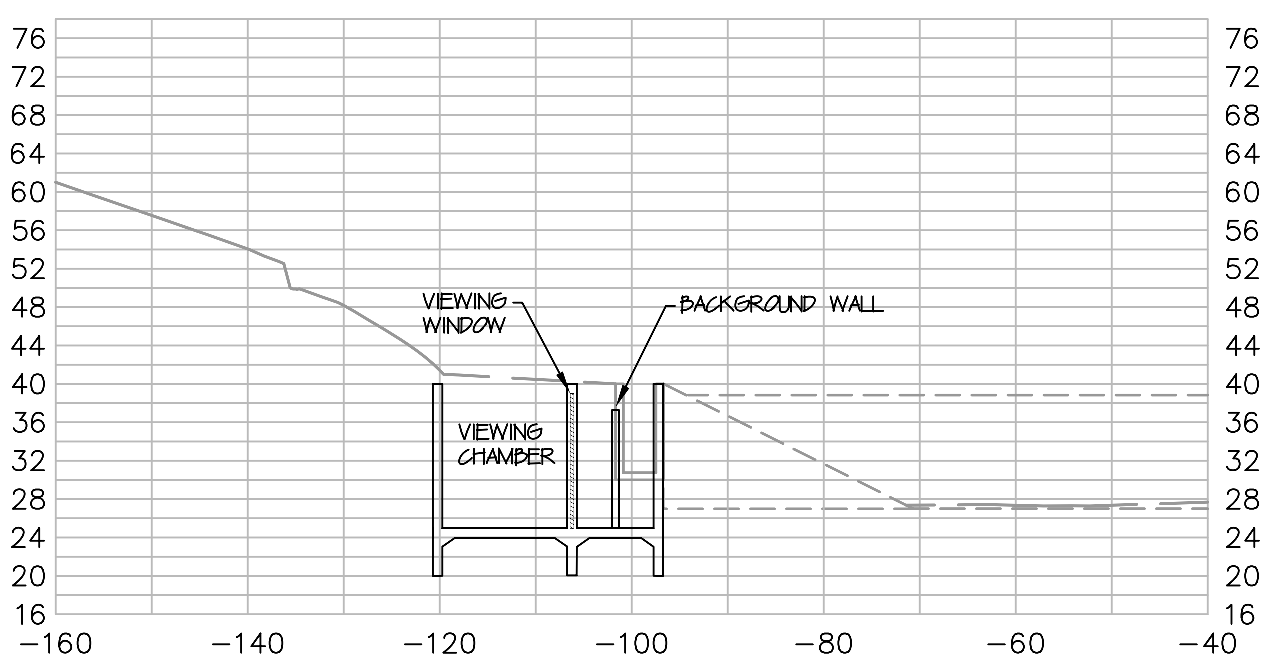
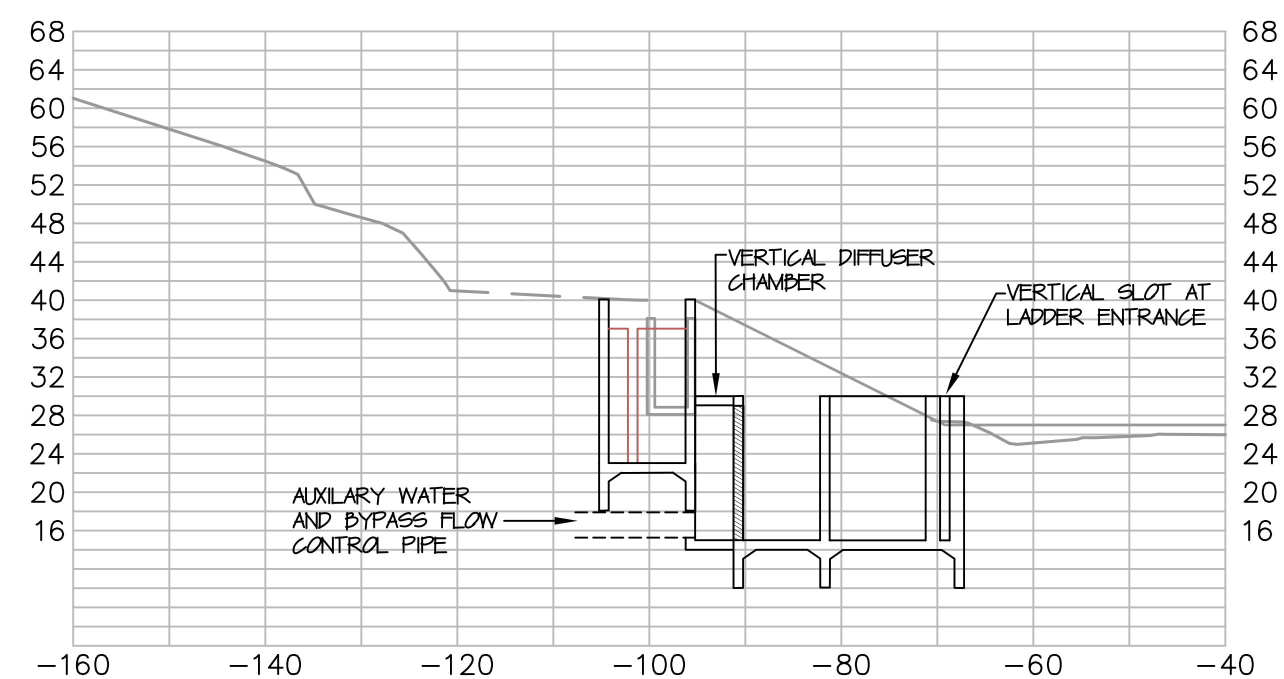


SECTION A-A



SECTION B-B



SECTION C-C

PRELIMINARY
DATE : *Sep 23, 2009*

PRUNUSKE CHATHAM, INC.
400 MORRIS STREET, SUITE G
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(707) 824-4600

DATE: SEPT. 10, 2009
SCALE: 1" = 20'
DESIGNED BY: JMANN
DRAFTED BY: JP
CHECKED BY: JMANN

REVISIONS	DATE	BY

PREPARED FOR:
SONOMA COUNTY WATER AGENCY
MIRABEL FISH SCREEN RECONFIGURATION AND ALTERNATIVES STUDY

INCLINED FISH SCREEN WITH BYPASS FISHWAY CONCEPT ALTERNATIVE

SHEET 2 OF 2

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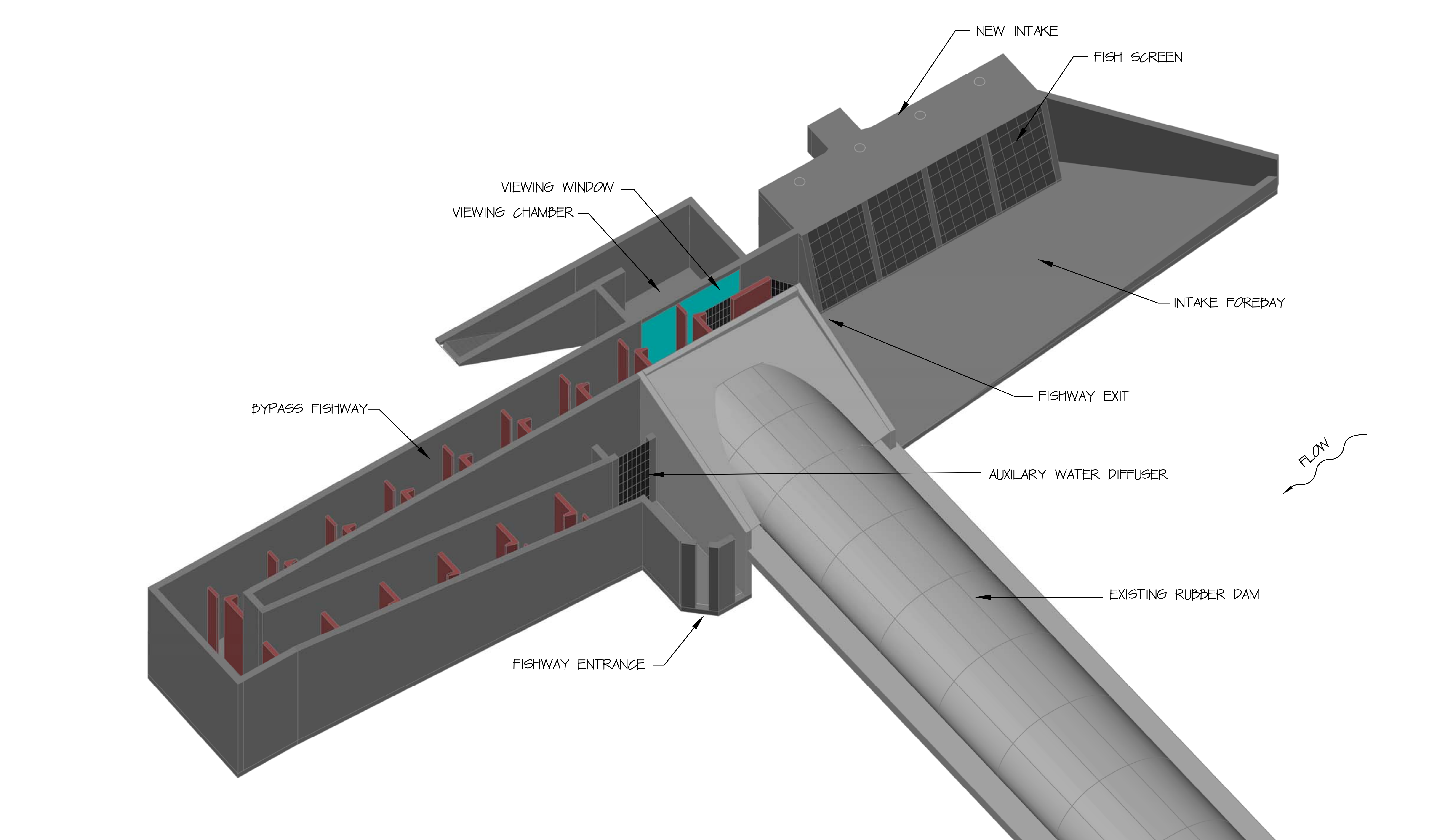

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[Xref files:] [Image files: mriabel; mriabel.bmp2; Pci_logo_for_plans.jpeg;] [Plot Date:Nov 06, 2009 12:10pm]

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MIRABEL FISH SCREEN RECONFIGURATION AND ALTERNATIVES STUDY

INCLINED FISH SCREEN WITH BYPASS FISHWAY CONCEPT ALTERNATIVE ISOMETRIC VIEW

FIGURE
1

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Appendix B

Hydrology Summary
River Channel Rating Curve
Flow Routing and Capacity Diagrams

Russian River at Mirabel Hydrology Summary – version date: 9/25/09

Historical flow data sources include the USGS gages upstream of Wohler, which is upstream of the Mirabel area. The most immediate upstream gages are USGS 11464000, Russian River near Healdsburg, and USGS 11465350, Dry Creek near mouth near Healdsburg. Another USGS gage, number 11463980, Russian River at Digger Bend near Healdsburg, is upstream of USGS gage 11464000 and is a low flow (recorded data below 400 cfs) only gage. The Dry Creek gage is also a low flow only gage with recorded data only below 200 cfs.

During the dry season (June through October), most of the flow in the Russian River is water released from Lakes Mendocino and Sonoma. The coincident records of USGS gages 11464000 and 11465350 were combined to estimate the total flow at Wohler in select periods of the year to perform flow duration frequency analysis. The coincident period of record is October, 1981 to April, 2009. There are some periods of time during the record in which there is no data. The dates and data for those times were not used in the analysis. It should be noted that this is only an estimate since there are contributing streams and diversions between the gages and Wohler. In addition, the SCWA diverts water at Wohler and the reach loses flow depending on the operation of collectors (pumping plants) along the river.

The flow duration analysis resulted in the following flow exceedances:

11464000 and 11465350 Combined Flow (cfs) *

Percent of time flow is equaled or exceeded*	Entire Year	April through November	April through October	April only	May only	June only	July only	August only	September only	October Only	November Only	December Only
1%	1598	1238	1187	1838	1587	811	493	349	390	1556	1485	1898
10%	766	545	557	1012	871	558	376	323	319	651	499	1133
50%	302	284	281	550	385	304	271	269	259	286	307	422
90%	209	206	204	303	239	202	216	217	194	195	218	213
99%	156	156	154	180	149	126	186	179	168	163	184	180

* Dry Creek gage data limited to 200 cfs and below. Flows during months other than summer may actually be higher in response to storms and will skew exceedance calculations during April, May, November, December, and possibly June and October.

These would approximate the river flow statistics in the Wohler and Mirabel areas and can be used as a surrogate for the flow coming into the Mirabel facility to design new facilities or for determining ranges of operation and design. The maximum diversion rate is 100 cfs though the Mirabel intake and the actual diversion depends on the number of operating pumps at the River Diversion Structure (RDS). Most diversions do not occur at the maximum rate at the beginning of the diversion season.

Minimum streamflows are specified in the State Water Resources Control Board's (SWRCB) Decision 1610, which stipulates that the annual minimum instream summer flow in the Russian River downstream of Dry Creek is:

- 125 cfs during normal water supply conditions;
- 85 cfs during dry water supply conditions; and
- 35 cfs during critical water supply conditions.

These are subject to change pending the outcome of the recent D1610 petition.

Russian River at Mirabel Hydrology Summary – version date: 9/25/09

The Sonoma County Water Agency also maintains a water level gage called RDS just upstream of the Mirabel Dam and intake indexed to the structure and ground elevations. Data from 5/27/2003 to 4/29/2009 was analyzed for correlation to flow data. A statistical summary of the data is included here:

RDS Gage Mean – 36.3' (all parts of years)
RDS Gage Median – 38.0' (June to October for normal dam operating years)
RDS Gage Max – 62.9' (December 14 and 25, 2003 and January 1-2, 2006)
RDS Gage Min – 27.4' approximate base of dam/river control, represents very low flow periods

The nearest downstream gage is the USGS 11467000, Russian River near Guerneville, and is also referred to as the Hacienda gage. Between the Mirabel site and this gage there is a very large contributing watershed, Mark West Creek and tributaries. The tributaries include Santa Rosa Creek and tributaries along with the Laguna de Santa Rosa and its tributaries. The watershed area of the Hacienda gage is 1,338 mi^2. USGS gage 11466800 is located on Mark West Creek approximately 3 miles upstream of the Russian River confluence. The drainage area at this gage is 251 mi^2. Daily discharge data is available for gage 11466800 since October 2005. The data from this gage was subtracted from concurrent daily flow data of the Hacienda gage to estimate the flow at Mirabel during the period of January to April 2009. This data from the USGS is provisional and subject to revision when officially published for the water year (October 2008 – September 2009).

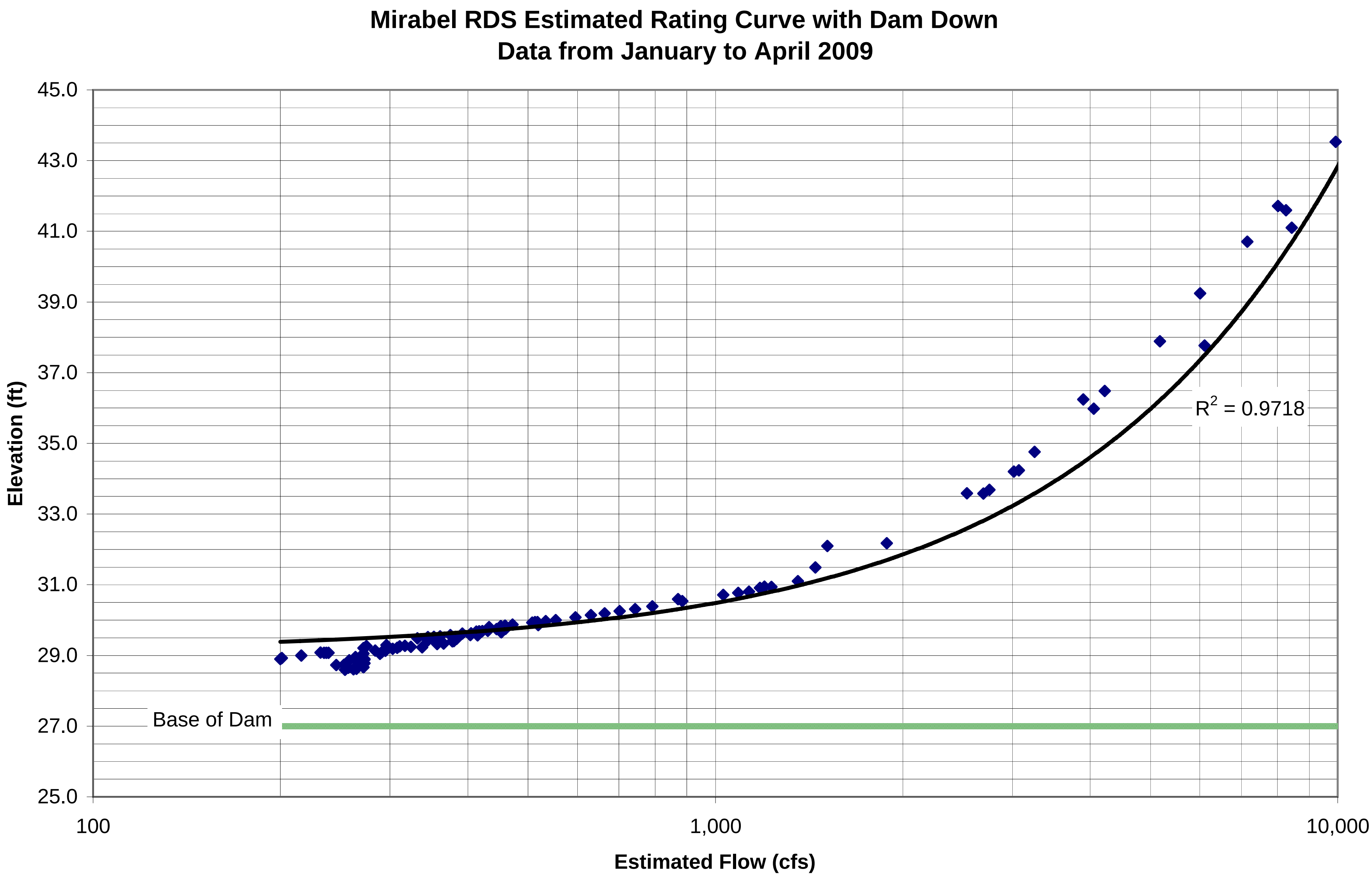
To evaluate water surface elevations that can be used for design, a rating curve was developed for the river from data when the inflatable dam was down. The curve was developed using the estimated flows as described in the previous paragraph matched to the concurrent RDS gage level data. This data provided by SCWA is preliminary and is not reviewed in accordance with quality control/quality assurance procedures. The correlated data is presented in the following table.

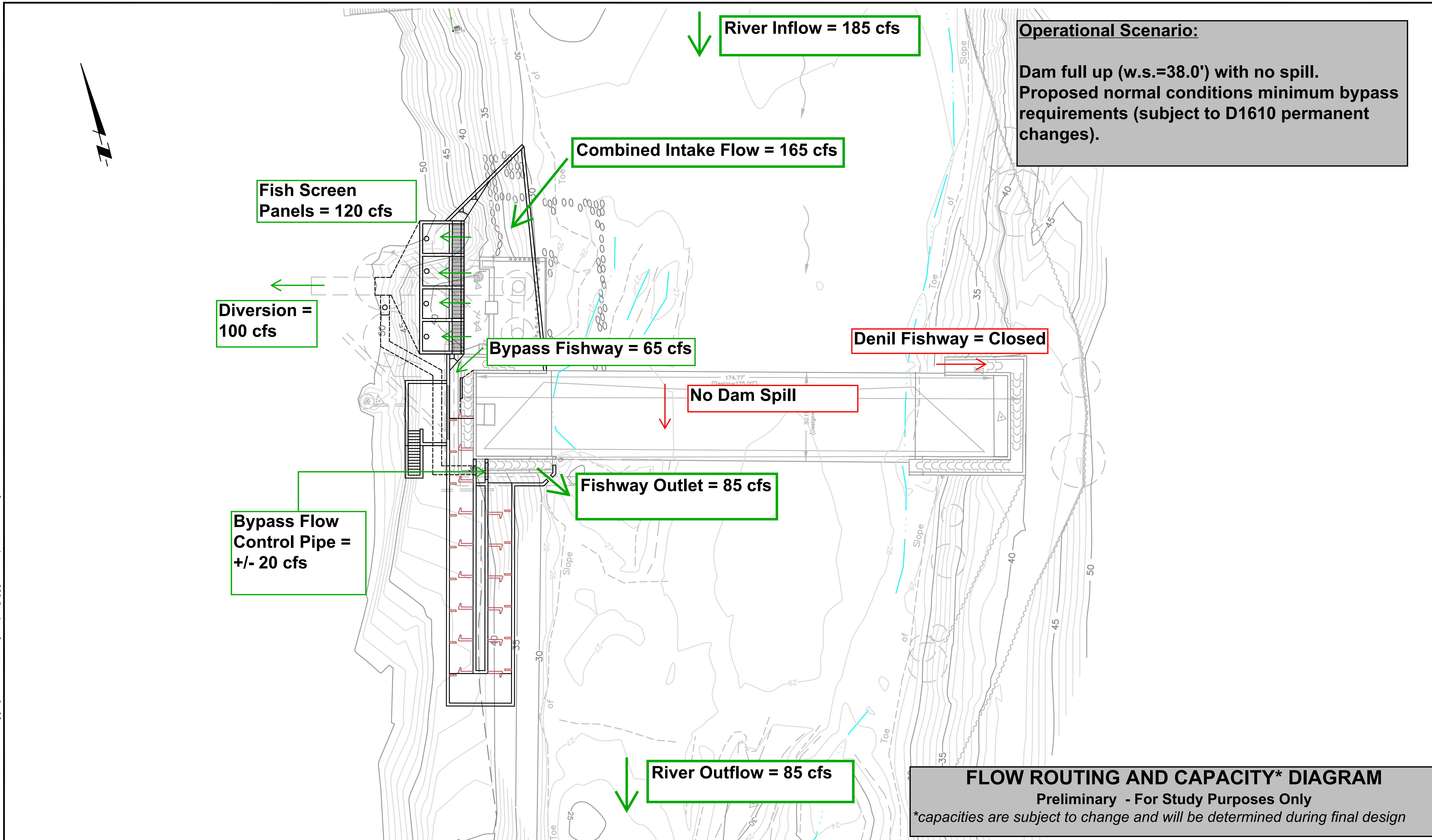
January - April 2009 Date	RDS Water Surface Elevation (ft)	Mirabel Estimated Flow (cfs)
1/1/2009	29.7	445
1/2/2009	29.7	417
1/3/2009	29.7	418
1/4/2009	29.8	460
1/5/2009	29.7	431
1/6/2009	29.7	417
1/7/2009	29.7	450
1/8/2009	29.7	422
1/9/2009	29.6	392
1/10/2009	29.6	375
1/11/2009	29.5	361
1/12/2009	29.5	353
1/13/2009	29.5	345
1/14/2009	29.5	332
1/15/2009	29.3	317

1/16/2009	29.2	308
1/17/2009	29.2	303
1/18/2009	29.1	295
1/19/2009	29.1	291
1/20/2009	29.0	289
1/21/2009	28.9	273
1/22/2009	28.8	266
1/23/2009	28.9	273
1/24/2009	28.8	273
1/25/2009	28.7	272
1/26/2009	28.6	265
1/27/2009	28.6	262
1/28/2009	28.6	254
1/29/2009	28.7	246
1/30/2009	29.1	239
1/31/2009	29.1	237
2/1/2009	29.1	235
2/2/2009	29.1	232
2/3/2009	29.0	216
2/4/2009	28.9	200
2/5/2009	28.9	201
2/6/2009	29.3	275
2/7/2009	29.6	404
2/8/2009	29.4	345
2/9/2009	29.3	296
2/10/2009	29.2	272
2/11/2009	29.4	345
2/12/2009	29.9	519
2/13/2009	30.6	871
2/14/2009	31.5	1448
2/15/2009	34.2	3073
2/16/2009	41.6	8260
2/17/2009	43.8	10270
2/18/2009	41.7	8020
2/19/2009	36.2	3900
2/20/2009	33.6	2536
2/21/2009	32.2	1886
2/22/2009	37.8	6110
2/23/2009	49.4	17250
2/24/2009	48.9	16510
2/25/2009	40.7	7160
2/26/2009	37.9	5180
2/27/2009	36.0	4055
2/28/2009	34.2	3018
3/1/2009	33.7	2755
3/2/2009	41.1	8440
3/3/2009	45.1	11910
3/4/2009	43.5	9930
3/5/2009	39.2	6010
3/6/2009	36.5	4224
3/7/2009	34.8	3259
3/8/2009	33.6	2695

3/9/2009	N.A.	2255
3/10/2009	N.A.	1942
3/11/2009	N.A.	1698
3/12/2009	32.1	1514
3/13/2009	31.1	1357
3/14/2009	30.9	1231
3/15/2009	30.8	1132
3/16/2009	30.8	1088
3/17/2009	30.9	1199
3/18/2009	30.9	1179
3/19/2009	30.7	1030
3/20/2009	30.6	N.A.
3/21/2009	30.5	N.A.
3/22/2009	30.5	N.A.
3/23/2009	30.6	N.A.
3/24/2009	30.5	885
3/25/2009	30.4	792
3/26/2009	30.3	743
3/27/2009	30.3	702
3/28/2009	30.2	664
3/29/2009	30.1	631
3/30/2009	30.1	596
3/31/2009	30.0	554
4/1/2009	30.0	534
4/2/2009	29.9	518
4/3/2009	29.9	513
4/4/2009	29.9	508
4/5/2009	29.8	459
4/6/2009	29.8	433
4/7/2009	29.7	413
4/8/2009	29.9	472
4/9/2009	29.8	452
4/10/2009	29.8	458
4/11/2009	29.7	453
4/12/2009	29.6	415
4/13/2009	29.6	405
4/14/2009	29.5	384
4/15/2009	29.4	378
4/16/2009	29.4	380
4/17/2009	29.3	366
4/18/2009	29.3	357
4/19/2009	29.2	338
4/20/2009	29.2	324
4/21/2009	29.3	311
4/22/2009	29.2	297
4/23/2009	29.1	284
4/24/2009	29.1	272
4/25/2009	29.0	264
4/26/2009	28.9	258
4/27/2009	28.7	253
4/28/2009	28.7	257

N.A. = Not Available


Mirabel RDS Estimated Rating Curve with Dam Down
Data from January to April 2009
Elevation (ft)
45.0
43.0
41.0
39.0
37.0
35.0
33.0
31.0
29.0
27.0
25.0
100
1,000
10,000
Estimated Flow (cfs)
Base of Dam
R^2 = 0.9718



FLOW ROUTING AND CAPACITY* DIAGRAM

Preliminary - For Study Purposes Only

**capacities are subject to change and will be determined during final design*

PRUNUSKE CHATHAM, INC.
400 MORRIS STREET, SUITE G
SEBASTOPOL, CA 95472
(707) 824-4600

DATE: SEPT. 10, 2009
SCALE: 1" = 30'
DESIGNED BY: JMANN
DRAFTED BY: JP
CHECKED BY: JMANN

REVISIONS	DATE	BY

PREPARED FOR:
SONOMA COUNTY WATER AGENCY
MIRABEL FISH SCREEN RECONFIGURATION AND ALTERNATIVES STUDY

INCLINED FISH SCREEN WITH BYPASS FISHWAY CONCEPT ALTERNATIVE

1

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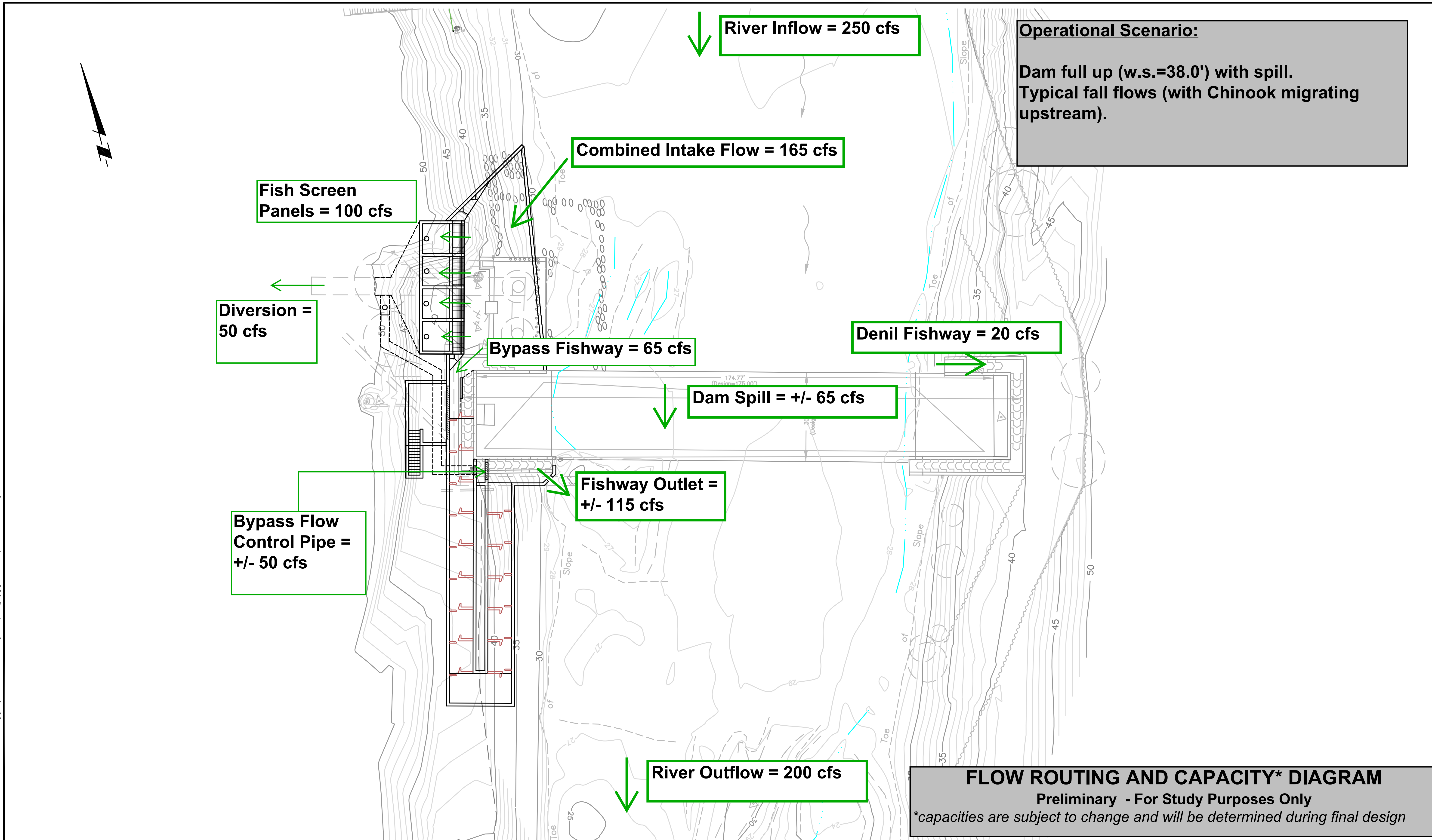

Operational Scenario:

Dam full up (w.s.=38.0') with spill.
Typical fall flows (with Chinook migrating upstream).

FLOW ROUTING AND CAPACITY* DIAGRAM

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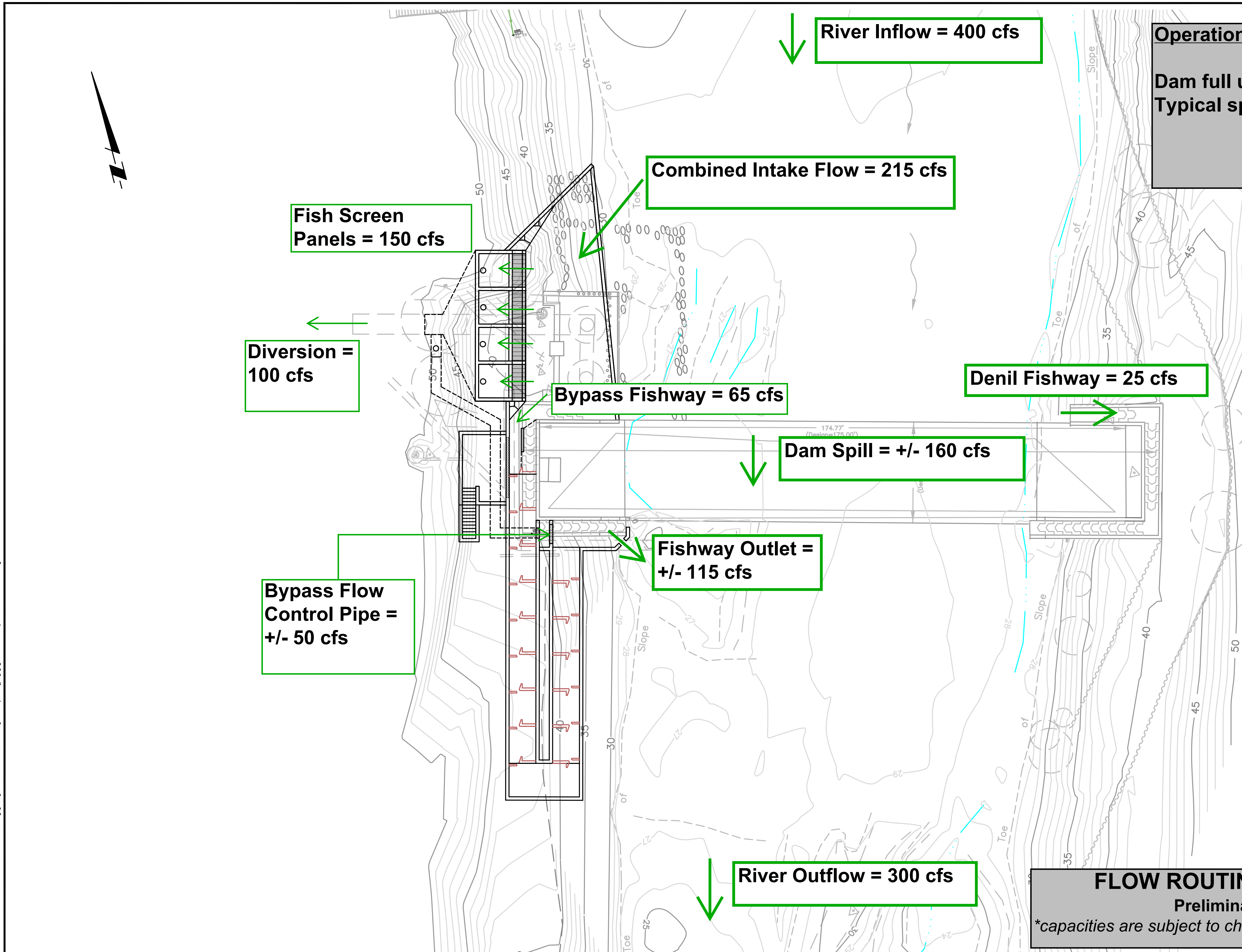
Operational Scenario:

Dam full up (w.s.=38.0') with spill.
Typical spring flows.



FLOW ROUTING AND CAPACITY* DIAGRAM

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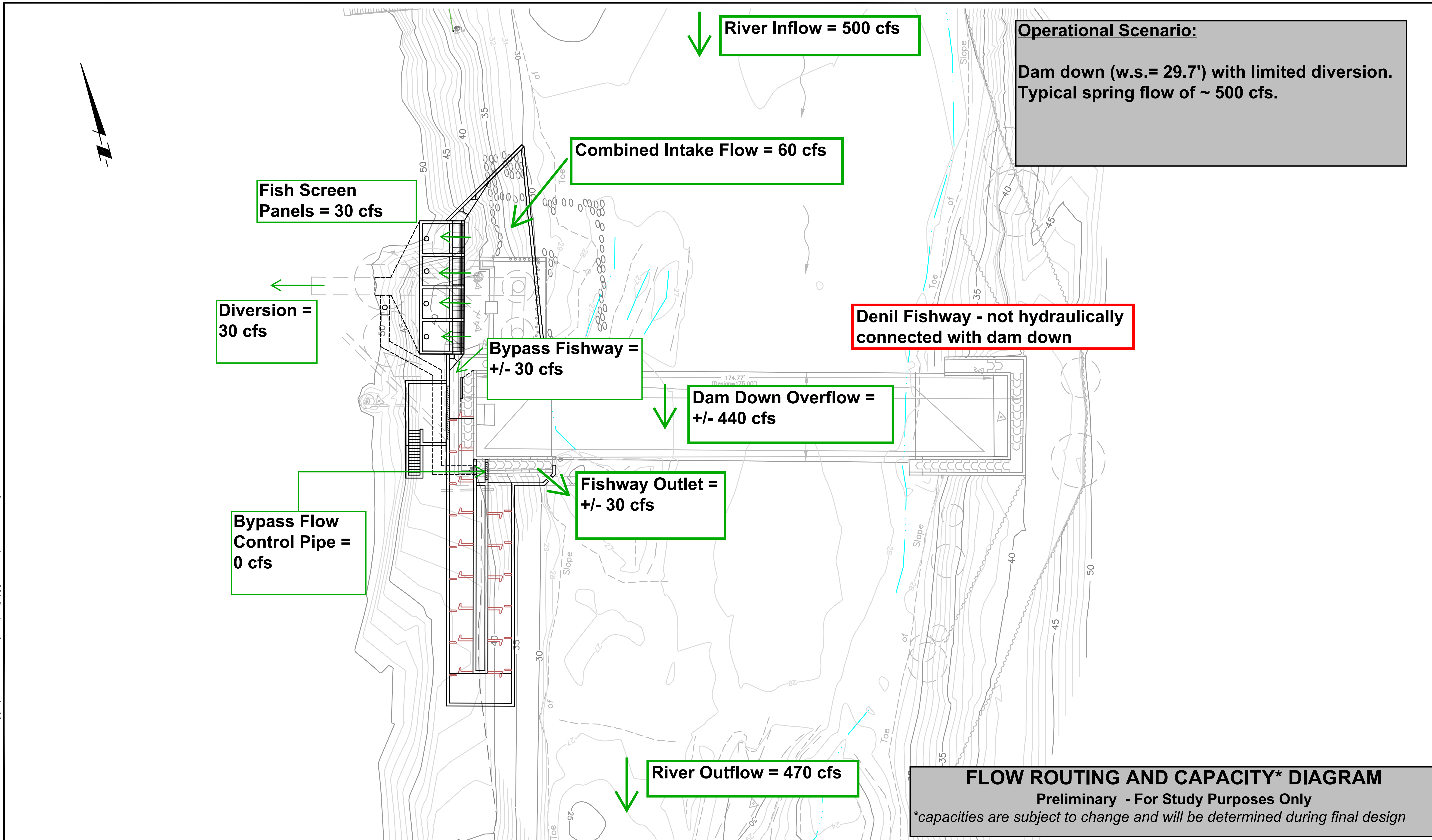

Operational Scenario:

Dam down (w.s.= 29.7') with limited diversion.
Typical spring flow of ~ 500 cfs.

FLOW ROUTING AND CAPACITY* DIAGRAM

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